UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Outer Continental Shelf Field and Reservoir Analysis and Consultant Programs in the Gulf of Mexico

By Thomas G. Clarke

Open-File Report 81-713

1981

Contents

Outer Continental Shelf Field And Reservoir Analysis and Consultant Programs in the Gulf of Mexico

By Thomas G. Clarke

ABSTRACT

A need was stated and a national law established by the Congress (The Outer Continental Shelf Lands Act Amendments of 1978) for the orderly collection of oil and gas reserves in the federal offshore lands.

Basic geological, geophysical, and engineering data are provided to the USGS by offshore lessees and operators. An independent inhouse analysis of the individual reservoirs of each field for reserves estimates follows. Each reserve area is revised as new data are received from development wells. Oil and gas reserve estimates are expected to change significantly as the field and reservoir analysis program continues.

In late 1977, an inventory program was initiated for all fields in the Gulf of Mexico. Contracts were awarded to six industry consultants for 64 oil and gas field reserves studies. Concerted inhouse effort supplemented the consultant effort. A comprehensive statement of work outlining the requirements for the consultants is included.

A viable Field and Reservoir Analysis Program is essential for development of a national energy policy. Such a program is necessarily an important contributory function to lease sale evaluation, development and production rate control, unitization and enhanced recovery, and the Outer Continental Shelf Information Program for the States and locally affected areas.

INTRODUCTION

Historical Collection of Reserve Data

The Federal Government in recent years has used the oil and gas reserve estimates compiled by the American Petroleum Institute (API) and the American Gas Association (AGA). More recently, reliance by Government on such industry statistics has been questioned by Congress, The General Accounting Office, and others. Typical criticisms were directed at industry, which was thought to have (1) underestimated reserves for its own interest, (2) made estimates which lacked accuracy because of documentation methods, and (3) published estimates which were not of sufficient detail for Government planning.

There was criticism of duplication of reserve estimates, as well, since several Government Agencies collected estimates by their individual reserve questionnaires. Agencies involved were the Federal Energy Administration (FEA), Federal Trade Commission (FTC), Federal Power Commission (FPC), Securities Exchange Commission (SEC), and the U.S. Geological Survey (USGS). All collected various forms of estimates to coincide with inhouse needs or requirements.

With such background, an Ad Hoc Interagency Committee on Oil and Gas Reserves Survey was formed that studied, held hearings, and concluded, in 1976, that future resource and reserve data should be collected by FEA (now in the Department of Energy) and USGS. In late 1976, the Director of the USGS, upon recommendation of the Acting Chief, Conservation Division, approved the creation of the Federal Minerals Inventory Section. This section was a staff function of the Assistant Division Chief,

Resource Evaluation, Conservation Division, and consisted of a multi-disciplinary unit responsible for development and maintenance of procedures and techniques to be used in estimating Federal resources and reserves of oil and gas, geothermal energy, coal, oil shale, tar sand, sodium, potash, phosphate, and other leasable minerals on leased federal lands.

More recently, through a reorganization within the Conservation Division, the Federal Minerals Inventory Section was replaced by a multiple system of duties handled by an offshore group (oil and gas) and an onshore group (oil, gas, shale oil, tar sands, coal, and other). The offshore oil and gas resources and reserve statistics are now administered by the Resource Estimates Section.

The energy situation since the 1973 oil embargo has brought about an unprecedented domestic interest in obtaining consistent, accurate, and current resource and reserves data. The Congress and the Administration support the general concept of Federally financed and conducted inventories of energy and mineral resources. Accordingly, the Conservation Division has developed an extensive program for maintaining an update of Outer Continental Shelf (OCS) oil and gas resources and reserves. This was mandated when Congress passed the Outer Continental Shelf Lands Act Amendments of 1978. The program can be expected to contribute to an objective basis for very important near-future and long-term policy-decision mechanisms. An objective was thus defined: to develop and maintain accurate, dependable estimates of Federal OCS oil and gas reserves in developed and developing fields.

Criteria and Needs Defined

The Conservation Division, in carrying out its evaluation and regulatory responsibilities, relies heavily upon statistical data on oil and gas reserves. Current estimates of oil and gas reserves, with accompanying maps and reservoir data, provide a vital data base for the evaluation of tracts offered in OCS lease sales. Oil- and gas- reserve information is basic to USGS monitoring of diligent lease development, maximum efficient rates (MER) of production, unitization, enhanced oil recovery, and the OCS Information Program.

Concerted USGS inhouse effort, in compliance with a Congressional mandate for additional work by consultants, provided the basic, essential reserves library of information, which is maintained and updated as a viable program.

Maintenance of the OCS oil- and gas-reserves estimation program is of utmost importance in the formulation of an effective energy-policy strategy. An awareness by the Congress and the Department of this activity is necessary to maintain a continually increasing level of excellence, in keeping with basic USGS policy aims.

Maintenance of reserves studies of an ever-expanding number of new OCS fields requires that the additional new reservoirs (as well as many older ones) be overseen and the data be updated as increased drilling occurs. The Interior Department's more recent accelerated OCS leasing policy will result in an even larger number of fields being discovered. The increased activity will enhance the continuing efforts of the Department of the Interior (DOI) and the Department of Energy (DOE) in lease and production monitoring.

Authorization for Collection

This program is consistent with public law 95-372, the Outer Continental Shelf Lands Act Amendments of 1978, section 606. The Congress has mandated a continuing investigation for the purpose of determining the availability of oil and natural gas located or produced on the OCS. This is to include oil and gas reserves by field and reservoir undiscovered resources.

Outer Continental Shelf Lands Act Amendments of 1978, public law 95-372.

Excerpts authorizing the USGS effort are as follows:

Investigation of Availability of Oil and Natural Gas from the Outer Continental Shelf

Sec.606. (a) The Congress hereby finds that--

(1) there is a serious lack of adequate basic energy information available to the Congress and the Secretary of the Interior with respect to the availability of oil and natural gas from the Outer Continental Shelf;

(2) there is currently an urgent need for such information;

(3) the existing collection of information by Federal departments and agencies relevant to the determination of the availability of such oil and natural gas is uncoordinated, is jurisdictionally limited in scope, and relies too heavily on unverified information from industry sources;

(4) adequate, reliable, and comprehensive information with respect to the availability of such oil and natural gas is essential to the national security of the United States; and

(5) this lack of adequate reserve data requires a reexamination of past data as well as the acquisition of adequate current data.

(b) The purpose of this section is to enable the Secretary of the Interior and the Congress to gain the best possible knowledge of the status of Outer Continental Shelf oil and natural gas reserves, resources, productive capacity, and production available to meet current and future energy supply emergencies, and to aid in establishing energy pricing and conservation policies.

(c) The Secretary of the Interior shall conduct a continuing investigation, based on data and information which he determines has been adequately and independently audited and verified, for the purpose of determining the availability of all oil and natural gas produced or located on the Outer Continental Shelf.

(d) The investigation conducted pursuant to this section shall include, among other items--

(1)(A) a determination of the maximum attainable rate of production (MAR) of crude oil and natural gas from significant fields on the Outer Continental Shelf; and

(B) an analysis of whether the actual production has been less than the MAR and, if so, the reasons for the differences;

(2) an estimate of the total discovered crude oil and natural gas reserves by fields (including proved and indicated reserves) and undiscovered crude oil and natural gas resources (including hypothetical and speculative resources) of the Outer Continental Shelf;

(3) the relationship of any and all such information to the requirements of conservation, industry, commerce, and the national defense; and

(4) an independent evaluation of trade association procedures for estimating Outer Continental Shelf reserves, ultimate recovery, and productive capacity for years in which trade associations made

such estimates. In order to provide maximum opportunity for evaluation and continuity, the Secretary shall obtain all the available data and records, including a description of the methodology and estimating procedures, which the trade association used in compiling their data with respect to the reserves.

Methodology and Data Handling

Basic geological, geophysical, and engineering data acquired during exploration, development and production operations are provided to the USGS field office by OCS operators under the terms of lease agreements. These data are basically quantitative, and include horizon depths, electric log responses, well pressures, production records, etc., with little, if any, subjective interpretation.

The USGS independently compiles and analyzes the data to prepare type logs, maps, and a well history library necessary to estimate reserves. Reserve estimates are calculated for individual reservoirs. Field reserve estimates are thus an aggregation of the estimates of its contained reservoirs.

Initially, reservoir reserve estimation involves in-place hydrocarbons calculated by the Volumetric Method, which utilizes available geological and engineering data. The amount of the original oil and gas in-place is estimated from rock and reservoir characteristics. The recoverable reserves are then estimated as a percentage of the oil and gas in-place based on flow and pressure data and experiences gained from fields in the area.

A reservoir in production for a sufficient period continually presents additional data that allows a more precise and accurate reserve estimation by such engineering methods as Material Balance, Decline Curve, and Mathematical Reservoir Simulation. The data are least complete and the reserve estimate is least accurate for the most recently developed reservoirs. The data record becomes more complete and the estimates more accurate with increasing production and well pressure data. The data are most complete and most accurate when the reservoir has been exhausted and the original recoverable reserves determined absolutely.

Distribution of Data

USGS field reserve analysis estimates and supporting data are compiled and stored in a computerized storage and retrieval system called the FRRE system, the "Field and Reservoir Reserve Estimates."

The system provides printout reports as required and includes original recoverable reserves, current production, cumulative production, and remaining recoverable reserves for OCS fields by reservoir and lease. These data are highly proprietary and available only to authorized parties. Numerous specialized nonproprietary reports can be generated by the FRRE system in response to specific management requests.

The Conservation Division has defined several Automated Data Processing (ADP) systems goals for the storage and retrieval of offshore data. The systems goals defined are:

- Create an ADP system capable of storage, retrieval, and processing, sufficient for the support of the mission to estimate

and predict reserves in the OCS Regions of the Gulf of Mexico and California. Newer offshore areas will be included as hydrocarbons are discovered.

- Provide system methods for collection, storage, retrival and analysis of the geological and engineering data.

- Provide a system capable of producing the necessary reports, plots, and maps to support the mission of the Gulf of Mexico OCS Region. This system will provide data to the cartographic system on a daily basis and use the graphical routines of that system to present the data.

Additional subobjectives were defined through analysis of previous efforts as:

- Ability to capture, store, and retrieve pertinent data from other system efforts.

- Methods to add new elements or new records without re-creation of programs and computer files.

A Well Reservoir Analysis System would be designed to provide timely and meaningful data in the following major application areas:

Preparation of sand and field maps;
Conversion of MD to TVD (measured depth to true vertical depth)
Well history data
Well production data
Reserve data by field, reservoir, and lease
Reservoir data
Plots
Reserve analysis programs

Each of the above areas will represent a component of the total system and the total system will be interrelated into other data bases.

The data collection and updating is designed to process, edit, and direct the input data to the appropriate subsystem component. This means the system will have the flexibility, on any given processing point, to accept data for all the application areas.

The edit and update phase interrogates all input data for errors on the basis of predefined edit criteria for each component and displays errors back to the cathode-ray tube (CRT) operator immediately for correction.

The ad hoc inquiry reporting phase will provide the system users the ability to make special request inquiries of information contained and supported by the data bases. However, to prevent costly system design and programming efforts, this processing phase will be accomplished by utilizing a user-oriented language.

The design of this system will benefit the U.S. Geological Survey in the following ways:

Data will be stored in the computer in a relational fashion, rather than by form or office, therefore eliminating duplication.

Inputting of data will be done by personnel utilizing CRTs, therefore editing and updating the data base immediately, rather than overnight.

CRT's will be placed in work areas, thus providing immediate access to data for reference or analysis by the geologist or engineer. Users will be provided a user language to access and query the data base.

The Well Reservoir Analysis System can and should also involve the FRRE System (Field and Reservoir Reserve Estimate), and the WSPS System (Well Status and Production System). All of these existing data files need to be interrelated to maximize the utilization of the data collected and to minimize storage and the complications involved in intricate data relationships (such as well name, API number, and reservoir). By combining Well History files, the Field and Reservoir Reserves Estimate system, and Well Status and Production System into one comprehensive local system, the ADP Section could provide much better throughput, turnaround, report generation, minimize problem areas, and provide quick access to the data. This will also be cost justified.

Combining the aforementioned systems will provide the users with a powerful tool which is the timely and accurate access to computer-stored information. The flexibility of the system is enhanced by its capabilities for immediate response to data errors, allowing corrections and visual verification before invalid data can be added to a file.

Annual reports of OCS oil and gas reserves are currently prepared for both the Gulf of Mexico and the Pacific Coast Regions. These reports summarize information on oil and gas reserves esimates for fields within specific geographical areas. They are released to the general public as Open-File reports and are announced in news releases through the Department of the Interior Public Information Office.

Impact on Current Published Reserves Statistics

Reserve estimates currently published can be expected to change significantly as the field and reservoir analysis program continues.

Reserve estimates included in published figures for fields that have some completed wells, but with drilling still in progress are, in general, based on preliminary field-wide volumetric methods. Normally, estimates of this type can be expected to "grow" when production data are obtained and used with more precise estimation methods such as material balance, pressure-decline curves, etc. Definition of previously unknown or documented faults, oil/water contacts, etc. more often changes the statistics. Since remaining recoverable reserves are calculated as the difference between the estimated original recoverable reserves and cumulative production, development drilling and completion of reservoir-by-reservoir analysis on these fields should have a significant impact on the accuracy of published reserve estimates.

A number of fields have been identified which are insufficiently developed to warrant estimation of reserves. Development drilling and the addition of these fields will contribute to the published total estimate of original reserves. Currently, approximately 50 new fields are added to the analysis program each year.

OFFSHORE CONTRACT CONSULTANT SYSTEMS AND PROCEDURES FOR FIELD AND RESERVOIR ANALYSIS PROGRAM

Background and Authorization

Upon request of the Congress and in order to update and complete an inventory of OCS fields in the Gulf of Mexico, the Conservation Division in late 1977 initiated an OCS Gulf of Mexico contract program. Its purpose was to conduct an investigation, study, and analysis of oil and gas reserves of selected fields in the Gulf of Mexico offshore Louisiana area. Award of the contracts was in August 1978. Sixty-four fields were selected for contract study to supplement an accelerated inhouse effort in the Metairie, Louisiana, office.

Preliminary Procedures and Organization

Notice of invitation for consultant organization participation in such proposal was issued later in 1977 in a well-known trade journal. A preproposal conference was held in the Metairie office in April 1978. Its aim was to pursue the request-for-proposals format, identify prospective offerors, and to clarify questions that might be asked, such as those regarding prestatement of work.

Each organization desiring participation was invited to submit a proposal for conducting an investigation, study, and analysis of oil and gas reserves in the Outer Continental Shelf of the Gulf of Mexico in the offshore Louisiana area. The proposed procurement plan was designed to cover eight distinctive and severable areas identified on an index map with accompanying field groups. Each field group consisted of eight separate oil and gas fields.

The anticipated performance time for completion of the project was 12 months after the effective contract date. One final report was due 30 days after USGS approval of an initial draft report. Each organization indicated an estimated time of completion of the proposed effort in less than 12 months without additional costs, or, if more than 12 months, with justification for the necessity for a longer performance time.

It was anticipated a cost-plus-fixed-fee contract would be utilized for the proposed procurement. Individual operators had the option to propose on one or more field groups, since the total project covered eight distinctive and severable field groups. Cost and technical proposals were to be appropriately structured so that a single field group could be evaluated individually where an offeror selected to propose on more than one field group.

The proposal submitted in accordance with the invitation to bid was to be submitted in two volumes: (1) the technical proposal of work procedures and (2) the cost proposal.

In order to award contracts to the best qualified offerors, several evaluation factors were utilized to evaluate the technical proposals, listed in descending order of importance below:

1. Relevant oil and gas reserve experience in the Gulf Coast and offshore areas.
2. Availability of adequate resources to accomplish the work requirements by professionally trained and experienced personnel in petroleum engineering and petroleum geology.

3. Comprehensive understanding of the requirements of the statement of work as depicted by the contractor's proposal.
4. Capability of the proposed management team to direct a project of this nature.
5. Knowledge of the geologic provinces of the Gulf Coast and offshore geographic areas.

The offerors were evaluated and rated by a Technical Evaluation Committee consisting of USGS Metairie and Reston personnel. Final evaluation was on the basis of the merit of submitted proposals in meeting the requirements of the statement of work as measured against the evaluation criteria. The committee retained the option of requesting oral or written discussion with the offerors within the competitive range, price, or other factors considered, only to the extent necessary to resolve uncertainties should they be determined to exist. While the price offered was one of the factors in selection of a contractor, the actual proposal selected was one which was considered to be of the greatest value to the Government in terms of probable performance, program utility, and cost.

Contractor proposals were forwarded to the USGS Procurement and Contracts Section in Denver, Colorado, to arrive in hand around May 1, 1978.

Final Implementation and Contract Duties

The statement of work defined the standards and requirements necessary for the contractor to follow. While the main contract is highly detailed and lengthy, the statement of work (with accompanying samples of data forms) summarizes very completely the spirit of the longer contract

format. The contract was the result of several weeks of joint and intense study by several Metairie and Reston personnel.

A consultant venture of this type and magnitude in the OCS is a first experience for the Conservation Division. Total monies extended to contracts were $6,120,330. For future reference, the statement of work follows.

ARTICLE I - STATEMENT OF WORK

1.1 The Contractor shall provide all labor, materials, and facilities necessary to perform a comprehensive investigation, study, and analysis of Government furnished geological and geophysical (G & G) data and related information as further described hereinafter which pertains to known oil and gas fields located on the Outer Continental Shelf in the Gulf of Mexico offshore of Louisiana and further identified in Enclosure (1) hereto. [Enclosures to main contract are not included in this report.] Based upon the findings derived from the foregoing investigation, study, and analysis, the Contractor shall determine for each reservoir the amounts of oil and gas expected with reasonable certainty to be recoverable in future years under currently existing economic and operating conditions. Such amounts of oil and gas, defined as "proven reserves", shall include those reserves classified as proved and developed, as well as undeveloped reserves which are known to exist either "behind casing" or in undeveloped fault blocks. Supplemental or secondary reserves from known or proposed projects are to be included in the determinations.

1.1.1 In making the determinations as specified above, the contractor shall ascertain the amount of original hydrocarbons in place, the original recoverable oil and gas reserves, and the amount

of remaining recoverable reserves. The required reserves, and the amount shall be made using the Volumetric Method, and, where data are available, the Contractor shall also calculate said reserves by other methods, including (i) Material Balance, (ii) Decline Curve, and (iii) Pressure Cumulative Production Plots.

1.1.2 The Contractor shall be required in the performance of this contract to search out and identify the necessary G & G data and requisite information from sources which will be made available by the Government to the Contractor subject to the special provisions as set forth in Section 10.0, entitled "Government-Furnished Material."

1.2 Based upon the information, calculations, and determinations derived under Section 1.1 above, the Contractor shall prepare and furnish the supplies described under subparagraph Section 1.2.1.1 through 1.2.1.7 below for each reservoir of oil and gas which lies within the oil and gas fields identified in Enclosure (1) hereto. "Depleted" sands are to be considered in the same manner as productive sands.

1.2.1 The supplies to be prepared and furnished hereunder are considered to be preliminary, and after said supplies are reviewed and approved by the cognizant Government Technical Officer, they shall be returned to the Contractor for corrective revision and for incorporation into the final report(s) which is required under Article II. The Government shall have fifteen working days to review, approve, or recommend changes to the preliminary data after receipt of same. If such notice is not received in fifteen working days, the data shall be deemed to be approved.

1.2.1.1 Geologic Data Sheet. A geologic data sheet similar to Enclosure (3) shall be prepared and furnished for each producing or potentially productive horizon over 10 feet in thickness and with an estimated (from logs) water saturation of less than 60 percent. One such sheet shall be required for each sand, or series of thin sands which exceeds ten feet. The required data shall include the following information:

- Top of sand
- Bottom of sand
- Sand counts - net pay and net value
- Log readings and calculations, including porosity, Rw, Ro, and Sw
- Fault picks

Subsea depth corrections shall be required for all measured depth points.

1.2.1.2 Type Log. A type log shall be prepared and furnished for each oil and gas field identified in Enclosure (1) hereto. The type log shall accurately illustrate the electric log responses at a typical stratigraphic development of each horizon mapped, the name of the horizon, and its top and bottom.

1.2.1.3 The following maps shall be prepared and furnished in an original plus six copies at the scale of 1" = 2,000', or larger if necessary to legibly display the map data:

a. Structure Map(s)*. Structure map(s) shall be prepared and furnished which depict the top of each pay sand for each producing or potentially productive horizon. A structure map shall also be prepared and furnished on the base of each pay sand when needed, but in every case, a structure map shall be furnished on the base when the sand varies in thickness by more than 25 percent within the hydrocarbon-bearing portion and when a gas cap is present.

b. Isopachous Map(s)*. Isopachous map(s) shall be prepared and furnished for each producing or potentially productive horizon. A separate map shall depict the net gas sand and/or net oil sand for each reservoir and for each hydrocarbon present. A net clean sand isopachous map shall be made when necessary but in every case where the sand varies in net amount more than 25 percent.

* Structure and isopachous map(s) shall be of the same scale.

1.2.1.4 Well Histories data and information shall be compiled for each well identified, and the data shall be reported in the form of a tabular well sheet using the form set forth in Enclosure (4) hereto.

1.2.1.5 Reserve Data Sheets put in the formats set forth under Enclosures 5 and 6 hereto shall be prepared and furnished for each separate oil and gas reservoir investigated in the performance of this contract. The required reserve calculations shall be made in every case using the Volumetric Method, and, where data are available, such calculations shall also be made by the Material Balance and Decline Curve Methods. Both associated and nonassociated gas reserves shall be calculated and recorded. Reserve estimates are required to be made on all producing and potentially productive horizons. An estimate of original, in-place hydrocarbon shall be made from volumetric calculations and recorded both by reservoir and by lease. Said estimates shall be made to the lowest known occurrence of hydrocarbons where no water contact is present. If the reservoir is untested, side wall core data, if available, shall be used to distinguish between oil and gas.

1.2.1.6 Reservoir Production Plots shall be prepared and furnished for each separate reservoir investigated in the performance of this contract. For oil reservoirs, the following required data shall be graphically displayed on semilog graph paper: flow rate-time graphs of oil, gas, water and any injection fluids shall be plotted with time expressed in months. In addition, bottom-hole pressures and cumulatives production of all fluids shall be shown graphically related to time in terms of months. For gas reservoirs, similar semilog graphics shall be prepared showing gas, condensates, water rates and cumulatives, as well as "P/Z" versus cumulative gas.

1.2.1.7 Bulk Volume Determinations shall be provided for both the oil portions as well as the gas of gas-cap-type reservoirs. Calculations shall be reported as acres and acre-feet for both oil and gas reservoirs.

ARTICLE II - REPORTS

2.1 General Discussion. As part of the work to be performed pursuant to this contract, the Contractor shall submit to the Geological Survey the following reports in accordance with the delivery schedule set forth in Article III - Delivery and Performance.

2.2 Reporting Period. All reporting periods shall end on the last day of a calendar month.

2.2.1 For contracts awarded (i.e., effective date) on or prior to the fifteenth (15th) of a calendar month, the initial reporting period shall end on the last day of the calendar month during which the contract became effective.

2.2.2 For contracts awarded (i.e., effective date) on or after the sixteenth (16th) of a calendar month, the initial reporting period shall end on the last day of the month immediately following the month during which the contract became effective.

2.3 Monthly Technical Letter Report. The contractor shall prepare and furnish a Monthly Progress Report which shall summarize the activity and current status of work and a projection of work for the following month, along with the cost information under this contract. Said reports shall be submitted by the tenth day of each month following the first full month after date of contract award. Said reports shall be submitted in triplicate and shall be patterned after the "sample report" shown in Enclosure (2) hereto. A separate monthly progress report shall be prepared and submitted for each separate oil and gas field group identified in Enclosure (1) hereto in the event individual firms are awarded more than one field group.

2.4 Monthly Finance Letter Report. The Contractor shall prepare and submit monthly financial reports which will summarize in tabular form the expenditures for the current month and the cumulative expenditures through the current month. The report shall contain a detailed actual-cost breakdown in the same categories which appeared in the Contractor cost proposal both for the current month and cumulatively through the current month. A graph comparing actual and planned cumulative expenditures versus time will be included. Any gross deviations should be explained. In addition, any outstanding commitments as of the end of the reporting period shall be reflected in this report.

2.5 Final Report

2.5.1 The Contractor shall prepare and furnish a Final Report covering each separate oil and gas field identified in Enclosure (1) hereto. Said report(s) shall be prepared in two (2) volumes: In Volume One, the Contractor shall include all text material which shall adequately describe the course and methodology of the investigation, including a discussion of methods used in defining the reserves, relevant comment on the resource data, appraisal of the reserve estimates, practical limitations on the data and reserve estimates, discussion of probable errors, ranges of value for the reserve estimates, and any other relevant ancillary material and information, including graphics, needed to clarify and explain the results achieved in the performance of this contract. In volume two, the Contractor shall include all finally approved data sheets, logs, maps, well histories, and plots which are described under Section 1.2 above, as well as any other data compliations or special graphics which are deemed necessary to clearly show the findings derived under Section 1.1 above. The Final Report shall initially be provided to the Government in draft form for review and approval in two copies. The Government will be allowed thirty calendar days to review the draft and to notify the Contractor of approval or of recommended changes to be made in the final copy. If the Government does not approve or recommend changes within these thirty days of receipt of the draft, the draft will be deemed approved. Within thirty calendar days of receipt of a notice of approval from the Government contracting officer, the Contractor shall furnish final copies as specified below.

2.5.2 The Contractor shall prepare and furnish one (1) original and six (6) copies of the final report(s) required hereunder. The final report(s) shall be looseleaf bound. Where practical all graphics shall be page-size, (8 1/2" x 11"); however, foldouts and/or pockets may be used for large maps, tables, etc., if necessary to ensure legibility. The title page of the final report(s) shall contain the following disclaimer:

> "This final report has not been edited or reviewed for conformity with Geological Survey standards or nomenclature. Neither the Contractor nor the U.S. Geological Survey shall be liable for any damages arising partially or wholly from reliance by any user on any information, data, or other work product supplied by the contractor or the U.S. Geological Survey."

2.5.3 As a part of the final report(s), the Contractor shall prepare and furnish one (1) reproducible final drafted transparency at base map scale of all maps on Mylar or other dimensionally stable transparent material, and one (1) reproducible transparency of all maps at report scale if said maps are unique.

ARTICLE III - DELIVERY AND PERFORMANCE

3.1 The investigation, study, analysis, and determinations which are required to be completed under Section 1.1 shall be performed in a timely manner in order that the requirements of Sections 1 and all required reports can be completed and delivered as specified below.

3.2 The monthly progress and financial report required under Article II Reports shall be delivered by the 10th day of each month throughout the duration

of this contract, commencing with the reporting period requirements on the second full month as set forth in Section 2.2.

3.3 The preliminary documents and Final Reports specified to be furnished under Sections 2 and 4 respectively shall be delivered in accordance with the following delivery schedule (an example):

Field Group A	Preliminary Documents (Sec. 2)	Final Reports (Sec. 4)
1. Grand Isle Block 16 Field	120 days*	150 days*
2. Eugene Island Block 126 Field	180	210
3. Ship Shoal Block 204 Field	210	240
4. Ship Shoal Block 230 Field	240	270
5. West Delta Block 105 Field	270	300
6. Eugene Island 238 Field	300	330
7. Main Pass Block 133 Field	330	360
8. Vermillion Block 191 Field	360	390

* Indicates the number of days after the effective date of the contract.

The delivery schedule specified above shall apply similarly to all separate field groups which are identified in Enclosure (1) hereto.

3.4 Distribution of Reports.

3.4.1 One (1) copy of each report, in final form as required by this contract, shall be delivered prepaid to:

U.S. Geological Survey
Procurement and Contracts Section
Box 25046, MS 204B, Federal Center
Denver, Colorado 80225

Attention: Contracting Officer
Contract No.

3.4.2 All remaining copies of reports, not otherwise distributed in accordance with provisions of this section, shall be delivered prepaid to the Government Contracting Officer's Representative designated by the

Contracting Officer (see Article VII - Contracting Officer's Reresentative).

ARTICLE IV - COSTS AND PAYMENTS

4.1 The total cost of the work to be performed under the contract is estimated to be _____. The Contractor shall receive a fixed fee of _____ for a total estimated cost-plus-fixed-fee of _____.

4.2 Subject to the provisions of Paragraph (e), Clause No. 5, "Negotiated Overhead Rates," the following negotiated rates shall be used as provisional vouchering rates pending establishment of final negotiated rates:

Labor Overhead - 183%

4.3 It is further agreed and understood that the Government's maximum ceiling liability for overhead is limited to 183% of allocable and allowable costs. Appropriate adjustment will be made to the provisional rates at the end of each accounting period not to exceed the Government maximum liability set forth herein.

4.4 Vouchers. All vouchers shall reflect the exact dates covered (e.g., 1-28 September 1999). The cost categories set forth in the vouchers shall correspond, by nomenclature, to the cost categories set forth in the cost proposal on which the cost figures included in Section 4.1 are based. All vouchers shall reflect itemized cumulative totals of costs incurred on the contract to the date of that voucher. The voucher shall also contain itemized totals for the billing period of that voucher.

ARTICLE V - CONDITIONS OF OPERATIONS BY CONTRACTOR

5.1 The Contractor assures the Government that the work performed by its personnel under this contract will be done in a proficient manner and conform to high professional standards.

5.2 The Contractor shall be responsible for the payment of salaries and allowances to personnel assigned by it to work under this contract and for the payment of any other expenses authorized under the terms of this contract. All administrative arrangements for personnel assigned to work under this contract will be the responsibility of the Contractor.

5.3 The Contractor shall not, without the prior written approval of the Contracting Officer, lease or rent equipment for use under this contract if the charge for such equipment exceeds $1,000.00. The Government may, at its option, furnish such equipment as it may from time to time deem necessary or desirable for use in performing the work under this contract. The Contractor shall be responsible for the proper use, care, and safe return (ordinary wear and tear excepted) of all nonexpendable equipment or property purchased or rented by the Contractor or furnished by the Government.

5.4 Upon completion of the contract, the Contractor shall furnish the Contracting Officer a list of all equipment purchased (including cost) where the cost of such equipment exceeded $300.00. Final disposition of this equipment will be made by the Contracting Officer.

5.5 The Contractor represents that it is not now performing, has not performed, and does not at this time contemplate performing, for any other public or private agency, effort that duplicates work described in this contract for which effort the Contractor has been or will be compensated through funding by any such public or private agency. For purposes of this paragraph, duplicates refer to duplication of substantially all items specified in the statement of work.

5.6 The Contractor shall perform its work under this contract in an independent manner and use all reasonable effort to avoid any duplication of

work previously or currently being performed by the Contractor or by others, provided, however, Contractor may duplicate such previous or current work if in its best professional judgment it feels that such duplication is necessary to reach the desired results hereunder.

ARTICLE VI - KEY PERSONNEL

6.1 The following individual(s) are considered essential to the work being performed under this contract and substitution will not be made without prior written approval of the Contracting Officer:

6.2 The above designated key personnel shall devote to the project not less than 75% of the time specified in the proposal for each individual.

ARTICLE VII - GOVERNMENT CONTRACTING OFFICER'S REPRESENTATIVE

7.1 A Contracting Officer's Representative will be appointed at the time the contract is awarded. The Contractor will be furnished a copy of the memorandum of appointment. The Contracting Officer's Representative will receive, for the Government, reports and other material called for in this contract and will represent the Contracting Officer in the technical phases of the work. The Contracting Officer's Representative is not authorized to change any of the terms and conditions of this contract. Changes in the Scope of Work will be made only by the Contracting Officer by properly written modifications to the contract. Additional Contracting Officer's Representative(s) for other purposes as required may be designated in writing by the Contracting Officer. Copies of all designations will be furnished to the Contractor.

ARTICLE VIII - PRESERVATION, PACKAGING, AND PACKING

The supplies called for hereunder shall be preserved, packaged, and packed in accordance with good commercial practice and adequate to ensure safe delivery at destination.

ARTICLE IX - INSPECTION AND ACCEPTANCE

Inspection and final acceptance of all supplies and services to be furnished hereunder shall be made at destination.

ARTICLE X - SPECIAL PROVISIONS

10.1 New Technology, Methodology, and Improvements. In the event that the Contractor, prior to completion of the work hereunder and whether or not in connection with the performance of such work, develops:

10.1.1 Any improvement in the design or format of the items called for by this contract, which is not incorporated in the items to be delivered; or

10.1.2 Any alternative or improved techniques or methodologies for accomplishing the objectives of this contract, which is not employed in the performance hereof; the Contractor, unless otherwise required to report or disclose any such improvements or alternative or improved method to the contract, shall promptly give notice in writing to the Contracting Officer under any such improvement or method. Such notice shall include a general description sufficient to show the Contractor's best appraisal as to the prospective effect or influence which such improvement or method would have on the work required under this contract, if such improvement or method were incorporated as requirement thereunder.

10.2 Notice of Delays. In the event the Contractor encounters difficulty in meeting performance requirements, or when he anticipates difficulty in

complying with the contract delivery schedule or date, or whenever the Contractor has knowledge that any actual or potential situation is delaying or threatens to delay the timely performance of this contract, the Contractor shall immediately notify the Contracting Officer and the Contracting Officer's Representative in writing, giving pertinent details; provided, however, that this data shall be informational only in character and that this provision shall not be construed as a waiver by the Government of any delivery schedule or day or of any rights or remedies provided by law or under this contract.

10.3 Correspondence. All correspondence pertaining to this contract shall be addressed to:

Contracting Officer
U.S. Geological Survey
Branch of Procurement and Contracts
Denver Federal Center, MS 204B
Box 25046
Denver, Colorado 80225

A copy of all contract correspondence shall be addressed to the Contracting Officer's Representative to be designated at time of contract award and to the Conservation Division in Reston, Virginia. These addresses are shown below:

(1) U.S. Geological Survey
Conservation Division
Post Office Box 7944
Metairie, Louisiana 70010

Attn: (Name of Contracting Officer's Representative)

(2) U.S. Geological Survey
Conservation Division
Mail Stop 640
12201 Sunrise Valley Drive
Reston, Virginia 22092

Attn: Chief, Federal Minerals Inventory Section

ARTICLE XI - GOVERNMENT-FURNISHED MATERIAL

11.1 Subject to the provisions of Article XII, entitled "Safeguarding of Proprietary Data and Information", the Government shall make available to the Contractor for the performance of this contract items of technical data and information of a geologic or geophysical nature which pertain to the study area referenced under Section 1.1, hereof. Such data and information shall include,

when available, the following: well logs; well files; lease files; directional surveys; production information; plant reports; allocation summaries; MER files; pressure reports; base maps; facility information; plan-of-development files; and quarterly well-potential tests.

11.2 The Contractor shall examine Geological Survey files in the appropriate Conservation Division Regional Office prior to initiating specific requests for any of the above. Since much of the data and information needed for the contract is proprietary and confidential, all requests for such Government information shall be made in writing, and accurate transmittal and control records shall be maintained by the Contractor.

11.3 One (1) sepia and one (1) print of a base map showing lease boundaries at a scale of 1" = 2000' shall be provided by the Government for each field included in the contract task. Surface and bottom-hole locations of all wells will be spotted on the base maps. If base maps at different scales from the above are needed, they shall be prepared by the Contractor.

11.4 All Government information furnished to the Contractor shall be returned to the appropriate Government office of control within seven calendar days of receipt at the Contractor's facility, unless an extension is granted by the Contracting Officer's Representative in those situations where deemed necessary and appropriate. If certain Government furnished items are needed by the Contractor for extended periods, the Contractor shall make a copy of the needed items for use during the period of performance of each field study. The Contractor shall provide the below minimum security standards for all proprietary data in his custody, originals and copies, throughout the life of this contract.

11.5 Upon completion of each field study in the contract task, the Contractor shall return to the Government all remaining Government information furnished, as

well as all copies made of furnished information, data sheets, work maps, and any other ancillary material prepared and/or used in conducting the field study, unless otherwise directed in writing by the Contracting Officer's Representative.

ARTICLE XII - SAFEGUARDING OF PROPRIETARY DATA AND INFORMATION

12.1 In the performance of this contract the Contractor shall be furnished for use hereunder data and information which is considered to be confidential, and its unauthorized disclosure is a matter of serious concern. Accordingly, as a condition of this contract adequate safeguards and controls shall be provided to ensure against any unauthorized disclosure of this data and information either by acts or ommissions of the Contractors or by any of its officers, employees, or agents. The Contractor shall at all times treat said data and information as confidential and shall make no use of the data for any purpose other than the performance of this contract.

12.2 The Contractor shall provide either Sensitive Proprietary 'Open' and/or 'Closed' Storage Room(s) in keeping with the minimal security standards described in Enclosure 8 or the equivalent of these standards. These facilities shall meet all required standards for room construction, door locks and hinges, security containers, controlled access, combination and key control, windows, alarm systems, vents, smoke and fire detection and defensive mechanisms, etc., included in Enclosure 8. The Contractor shall also provide all minimal security standards or equivalent thereof for Sensitive Proprietary Work Area (s) (non-storage) and Sensitive Proprietary Visitor Control Station(s) as described in Enclosure 8 to all work areas utilized during this contract.

ARTICLE XIII - GOVERNMENT-FURNISHED FACILITIES

In order to facilitate the progress of work required under this contract, the Government shall provide for use by the Contractor during the performance period of this contract limited office facilities, including desk space, and telephone

service. The office space to be provided shall be limited to a maximum of two contractor personnel. Said facilities will be available for use only during normal working hours and not on weekends. Said facilities will be located in the Metairie, Louisiana, headquarters building, and are considered suitable only to provide the necessary facilities for normal liaison activity.

ARTICLE XIV - GENERAL PROVISIONS

The General Provisions listed below, a copy of which is attached hereto, are by this reference specifically made a part of this contract.

"Monthly Progress Report"

Memorandum

To: Contracting Officer, Branch of Procurement and Contracts, Denver, Colorado
Technical Officer, Conservation Division, Metairie, Louisiana
Assistant Division Chief for Resource Evaluation, Conservation Division, Reston, Virginia

From: (Company)

Subject: Monthly Progress Report for (Month, Year); and Projection for _____ Contract No.

FIELD: (Name of field)

FIELD DATA:

Total number of pay sands _____

Total number of reservoirs _____

GEOLOGY:

Data sheets completed _____ (copy should be available)

	No. Required	No. Completed	% Completed	Projected Next Month
Structure maps (tops)				
Structure maps (base)				
Isopachous maps (net oil/gas)				
Net clean sand				

ENGINEERING:

Well completion histories				
Reservoir plots				
Production vs. time				
Pressure vs. time				
P/Z vs. cumulative production				
Reservoir reserve estimates				
Reservoir tabulation				

FINAL TECHNICAL REPORT: (Briefly state status if begun; use additional sheets if necessary.)

PERSONNEL CHANGES: (Include resumes; use additional sheets if necessary.)

PROBLEM AREAS: (Discuss in detail; use additional sheets if necessary.)

FUTURE WORK: (Discuss briefly; use additional sheets if necessary.)

_____

Signature of Responsible Party, Date

WELL DATA SUMMARY

Data to be Listed by Reservoirs

1. Reservoir Name
2. Well No. (e.g., A-5D, etc.)
3. Perforated Intervals - Measured Depth and Subsea Depth
4. Date of Initial Production
5. Date Production Terminated
6. Cumulative Production of:

   Oil, Gas, Condensate, and Water

7. Current Daily Average Rates

   Oil, Gas, Condensate, and Water

8. Reported Wellhead Pressure

Initial		Last or Recent		
Flowing	Shut In	Flowing	Shut In	Date

9. Measured Reservoir Pressure

Date	Depth/Datum	Pressure (psig)

RESERVOIR AND RESERVES DATA SHEET
FOR
OIL RESERVOIRS

Reservoir Data and Calculated Reserves as of (date)

Subject or Column Heading	Explanation or Definition and Units
Reservoir name	Name of sand, fault block, etc.
Type (U - undersaturated; G - assocaited gas cap)	Designate whether there is a gas cap.
Depth datum	Median depth of sand (ft. subsea)
Productive acreage	Acres
Average thickness	(ft.) average net pay, excluding shale, etc.
Porosity	Pore space in reservoir rock (fraction or percent)
Water saturation	Interstitial water, fraction of pore space (or percent)
Original presssure	Initial reservoir pressure (psig)
Temperature	Reservoir temperature ($^{\circ}$F)
Oil gravity	Use A.P.I. gravity scale
Original solution gas/oil ratios (GOR) (R_{si})	Cubic feet dissolved per barrel (stock tank reference)
Original formation volume factor	Reservoir volume/stock tank volume (ratio)
Original oil in place per acre foot	Barrels tank oil equivalent per acre foot (avg.)
Original oil in place (MSTB) - volumetric	Barrels per acre foot X acre feet of reservoir, thousand barrels, stock tank equivalent
Original oil in place by material balance	Volumetric balance calculation basis where amenable
Present reservoir pressure	Current reservoir pressure (psig)
Drive mechanism	Gas cap, dissolved gas, water or combinations

Recovery efficiency (expected)	Anticipated ultimate recovery, percent of original "oil-in-place"
Ultimate recoverable	Estimated total oil recovery, thousand barrels, by current drive mechansim
Cumulative production, oil	Thousands of barrels produced as of (date)
Cumulative production, gas (MMCF)	Million cubic feet produced as of (date)
Percentage depletion of ultimate oil	Or fraction: (cumulative/ultimate)
Remaining reserves, oil	Estimated "best estimate" of future oil production - thousands of barrels
Remaining reserves, gas	Estimated future solution/associated gas production (MMCF). (Excluding gas cap reserves listed on gas reservoir reserves summary)
Remaining oil reserves, decline curve	Decline curve forecast of future oil production
No. of producing wells	
No. of abandoned producers	
No. of injection wells	
Total penetrating wells	Exclude wells permanently plugged and abandoned
Current rate of production (Bbl./day)	
R/P (years)	Oil reserves/annual rate of oil production

SUPPLEMENTAL RECOVERY (when underway or proposed)

Recovery efficiency, supplemented	Anticipated total oil recovery, percent of original content, by current and expected supplemental drive methods
Additional reserve by supplemental means	Thousands of barrels
Type being used or proposed	e.g., water injection, gas injection, etc.

RESERVOIR AND RESERVES DATA SHEET
FOR
GAS RESERVOIRS

Reservoir Data and Calculated Reserves as of _____(date)_____

Subject or Column Heading	Explanation or Definition and Units
Reservoir	Name of sand, fault blk, etc.
Type	Designate as associated or nonassociated with oil
Depth Datum	Median depth of sand, ft. subsea
Productive Acreage	Acres
Average Thickness	(Ft.) Average net pay excluding shale etc.
Porosity	Pore space in reservoir rock (fraction or %)
Water Saturation	Interstitial water, fraction of pore space (or %)
Original Pressure	Initial reservoir pressure, psi.
Temperature	Reservoir temperature, °F.
Gas Gravity	"Specific" gravity relative to Air = 1.00
Deviation from Boyles law (initial)	"Z" factor in gas compression
Original Formation Volume Factor for Gas	Standard (@ 60°F & 15.025 psia) volume/reservoir volume, i.e.: standard cubic feet divided by reservoir cu. ft.
Original Gas in Place per Acre Foot-Volumetric Estimate	MMCF of standard reference gas per Acre foot
Original Gas in Place-Volumetric	Computed reservoir content of gas, Billion cu. ft. @ standard reference conditions of 60°F and 15.025 psia.
Original Gas in place by P/Z Plot	Pressure-cumulative performance graph
Reservoir Pressure	Current pressure, psi.
Drive Mechanism	Gas expansion, water drive, or combinations
Predicted Ultimate Recovery Efficiency	Anticipated ultimate recovery, percentage of original reservoir content "in place".

Ultimate Recoverable	Estimated ultimate recovery, billion cu. ft.
Cumulative Production Gas	Billion cubic feet produced as of (date).
Cumulative Production Condensate	Thousand barrels produced as of (date).
Depletion of Ultimate Gas Recovery	Or fraction (Cumulative/ultimate).
Remaining Reserves Gas	Estimated future gas production (Billion cu. ft.) as of (date)
Remaining Reserves Condensate	Future condensate, thousand bbl.
Remaining Reserves by Decline Curve	Decline curve forecast of reserve (future BCF)
Number of Producing Wells	
Number of Abandoned Producers	
Total Penetrating Wells	Exclude those permanently plugged and abandoned.
Rate of Production	Current rate of production Million cu. ft/day
R/P Ratio	Reserve gas/annual rate of production (years)

Data Security

When the Conservation Division began to acquire data from industry to support its resource evaluation and lease management functions, an expression of concern developed over the ability of offices throughout the Division to protect proprietary information. This concern increased significantly with the promulgation of regulations requiring submittal of reserves data from the OCS. Onshore, the need to improve the evaluation of coal and other energy related resources also created concern about procedures for protecting proprietary data. In answer to these concerns, a task force was established in February 1976 to recommend minimum standards for the security of proprietary information throughout the Conservation Division. With the help of the Branch of General Services, Administrative Division, a set of standards was formulated. This set of standards was distributed for comment and adopted in September 1976 as the Conservation Division Minimum Data Security Standards. In March 1977, the Standards were updated to more closely reflect security requirements for proprietary data. An initial review, based upon those Standards, of Conservation Division offices was completed, and notification of necessary changes were forwarded to the offices in 1977. The Standards adopted were used in the consultant programs. Copies of the complete Security Standards are available from the Conservation Division.

Headquarters and Field Office Oversight

The final award of USGS contracts was made to six oil and gas consultant contractors in late August 1978. Two contractors were each awarded two groups of fields for study (Total, 32), while four were awarded one field group each (Total, 32). During several weeks to follow, contractor representatives travelled to the Metairie, Louisiana, office for copies of well and lease maps, logs, engineering, and associated data. In some instances, especially of older fields on "advanced" pressure decline, some more current data was requested from lease operators. These steps became quite time consuming, but the data were delivered generally 2-4 weeks later. The contractors were directed to initially begin study on certain sample fields selected for future audit comparison of operator and USGS reserves statistics by the audit facility of the Energy Information Administration of the Department of Energy (EIA/DOE).

Technical Monitoring

Three supervisory engineers of the Chief of the Reserves and Development Section of the Metairie office and a geologist representative of the Reston Office were assigned oversight of contractor activity. Over the ensuing weeks, the engineers acted as USGS liaison for the individual contractor: to facilitate and accommodate his requests for needed information; to serve as mediator when problems or questions arose; and to provide evaluation and direction for the preparation of the draft and final reports to be received by USGS. The overall contract supervision was administered by the Contract and Procurement Section located in Denver. This office provided money disbursements to the contractors while maintaining an overall supervision of each contractor's performance.

One draft report, consisting of two volumes for each completed field were forwarded by the contractor to the Metairie Office for inspection and correction. Volume I included the methodology of the investigation, including a discussion of methods used in assessing reserves, practical limitation of the data, discussion of probable errors, ranges of value for the estimates, and other associated data. Volume II included maps, logs, well histories and supporting data and plats.

The draft report was appraised by the Metairie engineering and geological staff and the geological representative of the Reston Office. The report was appraised for completeness, quality, and statistical or graphic error within a 30-day review period. The engineering personnel were concerned most especially with the statistical data, while the map and associated graphic data were appraised by Metairie and Reston geological representatives. Upon completion of the review, the draft report was returned to the contractor who proceeded to make recommended changes for the final copy. In addition to the two final copies of each report delivered by the Contractor, sepia copies of maps, tables, and so forth were included for future reproduction by USGS as needed in updating the field areas.

Performance Problems

The contractor's bids were based primarily on the amount of work required for a given field size containing a given total number of wells and pay sands, recognizing also that other factors were to be considered. After beginning work, some contractors discovered that a review of a specific field indicated it contained more than the total number of wells originally estimated by USGS. All contractors underestimated the number of productive horizons and reservoirs as well as the total costs involved for completion of the individual project awarded.

Time and Cost Overruns

At varying periods throughout the program, specific contractors requested review of project performance and anticipated estimates of additional funding. Individual funding was provided upon a case-by-case review by USGS with a committment by the individual firm that such funding would result in a stipulated completion of the project originally awarded. It became apparent that a modification of the contract agreement between the contractor and USGS resulted in a trade of additional time of completion for additional cost. In a final analysis, approximately 82 percent completion of the total number of fields awarded was achieved for approximately 110 percent of the original contracts award costs. In reality, partially completed work on about two thirds of the remaining 20 percent of uncompleted fields resulted in an overall project completion evaluation in excess of the 82 percent completion rate previously mentioned. All of the partially completed fields, as well as those fields deleted from the program (no work by contractor) as a result of project review, were completed by inhouse Metairie geological and engineering staff.

Success of Effort

A project of this magnitude--a "first" for USGS and the contractors--was considered a successful effort. The Metairie Office personnel portrayed professional excellence in their oversight and diligence in pursuit of contract requirements. This resulted in a quality product useful to that office, the public, and other government agencies. Communication between all parties was outstanding. All but one of the contractors expressed a desire to again be considered should the USGS initiate a similar program. One subcontractor expressed a willingness to be considered.

The Consultant Program greatly contributed toward the completion of the backlog of producing fields not heretofore studied in detail.

Diligence Program

In the full evaluation of each field, the contractors were instructed to point up those areas within a field area which appeared to be untested, or have additional oil and gas potential. Such areas were noted in the final report along with estimated additional reserves which might be recovered at a time slot prior to abandonment of the field. Several areas were noted for consultation with the respective field operator. The additional areas of interest were located primarily in those fields which had a well-established production decline and were approximately midlife in depletion of field reservoirs. Full development of a field's productive capabilities is in keeping with the lease agreement of the operator.

SUMMARY AND CONCLUSIONS

A viable field and reservoir analysis program of updating and maintenance of an accurate oil and gas reserves data system for the federal offshore lands is an essential contribution to the development of a national energy policy. Such a contribution requires that the data base be properly updated and automated in compliance with the Offshore Lands Act Amendments of 1978. Currently, the federal offshore lands contribute approximately 25 percent and 10 percent, respectively, of the U.S. annual production of natural gas and petroleum liquids.

Operationally, the offshore Field Reservoir Analysis Program lends itself to the active support of four other major program efforts:

Lease Sale Evaluation

The evaluation of lease sale tracts relies heavily upon input from oil and gas reserve estimates. Up-to-date maps and reservoir data provide a vital data base for trend evaluation of tracts offered in OCS lease sales. Completeness of reserves data thus enhances the interpretative position of inhouse professional evaluation of proposed sale tracts.

Plans of Development and Production Rate Control

Current geologic interpretation, including structure maps of a field, engineering evaluation of reservoir characteristics, and reserve estimates are vital for

an intelligent decisionmaking concerning lease development and maximum efficient rate of production. Current data of this nature could also point up possible areas for diligence oversight--for determinations for maximum development of additional reservoirs or hydrocarbon accumulations in a field as a result of additional updated well-control information.

Unitization and Enhanced Recovery

A majority of the enhanced recovery projects are common to several leases. A library of current composite maps and data as provided with reserves studies are vital for an efficient review of unitization plans as well as the initiation of enhanced recovery projects.

Outer Continental Shelf Information Program

Vital planning information regarding future offshore oil and gas production is provided to State and local governments. This information is critical, since it involves possible staging areas of transportation systems, processing facilities, and other operations which might have a drastic impact upon the structure of community life.

SELECTED REFERENCES

American Association of Petroleum Geologists, 1971, Future Petroleum Provinces in the United States - Their Geology and Potential, Memoir 15, Vol. 1 and Vol. 2, edited by Ira H. Cram, Tulsa, Oklahoma.

American Association of Petroleum Geologists, 1975, Methods of Estimating the Volume of Undiscovered Oil and Gas Resources, edited by John D. Haun, Tulsa, Oklahoma.

American Petroleum Institute/American Gas Association/Canadian Petroleum Association, 1980, Reserves of Crude Oil, Natural Gas Liquids, and Natural Gas in the United States and Canada as of December 31, 1979, Vol. 34, Washington, D.C., 253 p.

American Petroleum Institute, 1981, Basic Petroleum Data Book, Petroleum Industry Statistics, Vol. 1, No. 1, Washington, D.C.

American Petroleum Institute, 1980, Two Energy Futures: A National Choice for the 80's: American Petroleum Institute, 166 p.

Congressional Office of Technology Assessment, 1980, World Petroleum Availability, 1980-2000, A technical Memorandum, Washington, D.C., 77 p.

Congressional Office of Technology Assessment, Enhanced Oil Recovery Potential in the United States, Washington, D.C.

Dalton, G. L., and others, 1981, Estimates of Undiscovered Recoverable Resources of Conventionally Producible Oil and Gas in the United States, A Summary: U.S. Geological Survey Open File Report 81-192, 17 p.

Exxon Corporation, 1980, The Offshore Search for Oil and Gas, Fourth Edition, Exxon Background Series, New York, 20 p.

Exxon Corporation, 1980, World Energy Outlook, Exxon Background Series, New York, 40 p.

Exxon Corporation, 1980, Energy Outlook 1980-2000, Houston, 16 p.

Hewitt, J. E., and others, 1981, Estimated Oil and Gas Reserves, Gulf of Mexico Outer Continental Shelf, December 31, 1980: U.S. Geological Survey Open File Report 81-604, 12 p.

Independent Petroleum Association of America, 1980, The Oil Producing Industry in Your State, 132 p.

Kalil, F., 1981, Estimated Oil and Gas Reserves, Southern California Outer Continental Shelf, December 31, 1980: U.S. Geological Survey Open File Report 81-1042, 8 p.

Klemme, H. D., 1974. "One-Fifth of Reserves Lie Offshore," Oil and Gas Journal, Petroleum/2000, Vol. 75, No. 1, January 7, 1974.

Klemme, H. D., 1977, "World Oil and Gas Reserves from Analyses of Giant Fields and Petroleum Basins (Provinces)," in R. F. Meyer (ed.), The Future Supply of Nature-Mode Petroleum and Gas, Pergamon Press, New York, p. 217-260.

Lovejoy, W. F., and P. T. Homan, 1905, Methods of Estimating Reserves of Crude Oil, Natural Gas, and Natural Gas Liquids, The Johns Hopkins Press, Baltimore, Maryland.

National Petroleum Council, 1976, Enhanced Oil Recovery, An Analysis of the Potential for Enhanced Oil Recovery from Known Fields in the United States, 1976-2000, H. J. Haynes, Chairman, 1977, Washington, D.C.

Nehring, R., 1978, Giant Oil Fields and World Oil Resources, prepared for the Central Intelligence Agency: The Rand Corporation, 162 p.

Nehring, R., 1981, The Discovery of Significant Oil and Gas Fields in the United States, Appendixes, prepared for the U.S. Geological Survey/Department of the Interior and the U.S. Department of Energy: The Rand Corporation, 477 p.

Nehring, R., 1981, The Discovery of Significant Oil and Gas Fields in the United States, prepared for the U.S. Geological Survey/Department of the Interior and the U.S. Department of Energy: The Rand Corporation, 236 p.

U.S. Bureau of Mines and U.S. Geological Survey, 1980, Principles of a resource/reserve classification for minerals: U.S. Geological Survey Circular 831, 5 p.

U.S. Department of Energy, Office of the Oil and Gas Information System, 1980, U.S. Crude Oil and Natural Gas Reserves, 1978 Annual Reports, 76 p.

U.S. Department of the Interior, 1976, Energy Perspective 2, 220 p.

GLOSSARY*

Barrel - Liquid volume measure equivalent to 42 U.S. gallons.

Condensate - A mixture of hydrocarbons, mostly pentanes and heavier, that existed in the gaseous phase in natural underground reservoirs but are liquids under normal surface conditions.

Statistically a distinction is made between "condensate," which is commingled with the crude stream on the lease and not measured separately, and "lease condensate" and "plant condensate," which are measured separately.

Crude oil - A naturally occurring mixture of liquid hydrocarbons. Technically, crude oil both existed in the liquid phase in natural underground reservoirs and remains liquid at atmospheric presures after passing through surface separation facilities. For statistical purposes, volumes reported as crude oil also include small amounts of hydrocarbon liquids that existed in the gaseous phase underground and small amounts of nonhydrocarbons.

Development well - In general, a well drilled within the proved area of an oil or gas reservoir to the depth of a statigraphic horizon known to be productive.

Dry hole - An exploratory or development well found to be incapable of producing either oil or gas in sufficient quantities to justify completion as an oil or gas well.

* U.S. Department of the Interior, 1976.

Enhanced recovery - An imprecise term that usually refers to the additional production of crude oil that might result from the use of nonstandard techniques. In previous years, recovery was enhanced above that obtainable from natural reservoir energy (primary recovery) by pressure maintenance using waterflood or gas-injection techniques (secondary recovery). Now that these techniques are standard, enhanced recovery refers to the further increase in production that might be obtained by the use of a number of techniques that are still experimental or not generally applied.

Exploratory well - A well drilled to (1) find and produce oil or gas in an unproved area, (2) find a new reservoir in a field previously found to be productive of oil or gas in another reservoir, or (3) extend the limits of a known oil or gas reservoir.

Natural gas - A naturally occurring mixture of low molecular weight hydrocarbons, which are gaseous in form under normal conditions, and some nonhydrocarbon gases. Methane is almost always the major constituent. Natural gas exists in natural underground reservoirs in the gaseous phase or in solution with crude oil. When accompanying petroleum, natural gas contains heavier hydrocarbons known as wet gas. Customarily, most of the nonhydrocarbons and the heavier hydrocarbons are removed before the natural gas is sold as fuel.

Natural gas liquids - Those portions of reservoir gas which are liquefied at the surface in lease separators, field facilities, or gas-processing plants. Earlier in the history of the petroleum industry, the term covered those hydrocarbons, usually pentanes or higher, which are removed from the reservoir in the gaseous phase but are liquids under

normal surface conditions. Now the term has been extended to include lighter hydrocarbons, ethanes, propanes, and butanes, which are extracted in gas-processing plants but are gases under normal surface conditions.

OCS - Outer Continental Shelf.

Original Oil-In-Place - The estimated total crude oil in known reservoirs prior to any production, based on volumetric or material balance methods when sufficient factual data are available or, where data are not available, based on reservoir information believed to be comparable.

Petroleum - Technically, petroleum is that portion of the petroleum series of naturally occurring hydrocarbons which is liquid under normal conditons, and includes crude oil, and the heavier natural gas liquids. However, in industrial terminology, petroleum refers to the entire series, including the gases called natural gas, petroleum liquids, and the solids called asphalt and asphaltite.

Reserves - Identified deposits of mineral known to be recoverable with current technology under present economic conditions.

Categories of reserves:

1. Measured reserves: Identified resources from which an energy commodity can be economically extracted with existing technology, and whose location, quality, and quantity are known from geologic evidence supported by engineering evidence.

2. Indicated reserves: Reserves based partly on specific measurements, samples, or production data and partly on projections for a reasonable distance on geological evidence.

3. Inferred reserves: Reserves based on broad geologic knowledge for which quantitative measurements are not available. Such reserves are estimated to be recoverable in the future as a result of extensions, revisions of estimates, and deeper drilling in known fields. Indicated and inferred reserves are undifferentiated in this report.

Resources - Includes reserves as well as minerals that have been identified, but cannot now be extracted because of economic or technological limitations, as well as economic or subeconomic materials that have not as yet been discovered.

Undiscovered recoverable resources are quantities of a mineral commodity that may be reasonably expected to exist in favorable geologic settings, but that have not yet been identified by drilling. Exploration will permit the reclassification of such resources to the reserves category.

Unitization - Combining or consolidation of separately owned lease interests under the terms of a unit agreement for the joint exploration or development of a field and associated reservoirs. More often, the major lease interest owner will act as operator of the unitized area.

Well - A well is a hole drilled in the earth for the purpose of (1) finding or producing crude oil or natural gas, or (2) providing services related to the production of crude oil or natural gas.

SYSTEM OF MEASURED UNITS

(This report uses the English system of units. The English units can be converted to metric units by multiplying by the factors given in the following list.)

To convert English unit	Multiply by	To obtain Metric unit
Acres	0.4047	Hectares (ha)
	4.047×10^{-3}	Square kilometers (km^2)
Barrels (oil)	0.159	Cubic meters (m^3)
	1.590×10^{2}	Liters (l)
Barrels (36° API oil)	0.1342	Metric tons
Cubic feet	2.832×10^{-2}	Cubic meters (m^3)
	28.32	Liters (l)
Feet	0.3048	Meters (m)
Miles, statute	1.609	Kilometers (km)
geographical or nautical	1.852	Kilometers (km)
Square miles, statute	2.590	Square kilometers (km^2)