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**TECHNICAL SUPPORT FOR GEOPRESSURED—
GEOTHERMAL WELL ACTIVITIES IN LOUISIANA**

Final Report for the Period September 27, 1978—
December 31, 1980

By
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August 31, 1981

Work Performed Under Contract No. AS05-78ET27160

Louisiana State University
Baton Rouge, Louisiana

U. S. DEPARTMENT OF ENERGY
Geothermal Energy

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TECHNICAL SUPPORT FOR GEOPRESSURED-GEOTHERMAL
WELL ACTIVITIES IN LOUISIANA
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FOR THE PERIOD
SEPTEMBER 27, 1978 - DECEMBER 31, 1980

By

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10. *Chlorophyll *a** and *Chlorophyll *b** were determined by the method of Lichtenthaler and Whistler (1973).

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EXECUTIVE SUMMARY

This is a report of technical support, and research activities conducted under the Department of Energy Contract No. DE-AS05-78ET-27160 over the term August 1, 1978, through December 31, 1980. The objective of this contract was to provide coordination assistance of the research and development effort in the Louisiana Gulf Coast Geopressured-Geothermal Program, particularly technical support for the development of the geopressured test-well program and management and supervision of a comprehensive environmental monitoring program for the wells drilled in Louisiana. Achievement of this objective required, in part, the development of a drilling and well testing plan and an environmental monitoring plan. The initial coordination and technical support effort was directed toward a drilling site identified at Lafourche Crossing. This site was not drilled and tested, however, so the contract activity was directed toward other sites that were drilled.

The research conducted over the original contract and subsequent continuation amendments provided analysis and support in several subject areas. Test well data support was provided in rock mechanics studies and subsidence simulation. Resource assessment provided detailed geologic studies of specific sites and regional geologic analysis. Environmental monitoring work established the monitoring systems and baseline environmental measurements for sites. Finally, systems analysis utilized data and estimates from all researchers involved to evaluate the potential of identified sites.

INTRODUCTION

Louisiana State University (LSU) has been actively participating in the U.S. Department of Energy (DOE) Geopressured-Geothermal Energy Research and Development Program since it was initiated in 1975. Much of this research was conducted by departments at LSU through individual contracts with the Department of Energy and with the Louisiana Department of Natural Resources. In 1978, a need for a coordinative effort was identified to provide coherence and communication among the various projects addressing the geopressure-geothermal resource. It was also realized that a physical test in the form of a test well would be a necessary element in any full-scale research and development effort. This contract then was initiated as a technical support effort to provide coordination and test well planning activities. Specifically, the primary objectives were as follows:

- To coordinate ongoing and new technical projects at LSU to support the development of a geopressured test well program in Louisiana.
- To provide technical advice for the drilling and testing of a geopressured test well at LaFourche Crossing.
- To coordinate all data interpretation and assessment for the LaFourche Crossing test.
- To manage and supervise a comprehensive environmental monitoring program for each designed test well.

The original project was organized into three parallel functions as follows:

During the period 1978-1979, the coordination function included the

monitoring of activities in resource assessment, legal evaluation, environmental studies and operations research and systems analysis. These research efforts were undertaken by LSU personnel from the Departments of Geology, Petroleum Engineering, Chemical Engineering, Industrial Engineering, the Institute for Environmental Studies and the Louisiana Geological Survey. As a result of this coordination effort it soon became apparent that many of the activities could be brought under the same contract and the original contract was amended to include those activities. This amendment included supplemental funding and an extension of the contract to a termination date of December 31, 1980.

During 1980, and to the termination of the contract the following functions have been executed:

Test Well Data Assessment

Resource Assessment and Coordination of
Geologic Studies

Environmental Monitoring

Supporting Research and Technology
Assessment

The subject of this report is the achievements realized in the various functions. The balance of the report is organized by the above functions with a section devoted to each. A few comments about them, however, are appropriate before proceeding.

The Test Well Data Assessment function had essentially two objectives 1) to develop a drilling and test well plan for LaFourche Crossing and 2) to analyze and assess the data resulting from that test. The drilling and test well plan was completed and delivered. The LaFourche Crossing Test Well, however, was not drilled during this contract. Consequently, the data analysis was based on the Brazoria Texas well

and the balance of the modeling work was theoretical. This activity is covered in Section III.

The Resource Assessment and Coordination of Geologic Studies was designed to continue in FY81 which it has under a separate contract. The major objective of this function was a regional assessment of the geopressured-geothermal resource in Louisiana. Accomplishments toward that goal are described in Section IV.

The Environmental Monitoring function was to manage and supervise environmental monitoring of the LaFourche Crossing well. Since that test was not realized the environmental efforts were targeted toward the Parcperdue and Sweet Lake sites at DOE's request. The results of this work is described in Section V.

Section VI reports on the activities conducted under the function of Supporting Research and Technology Assessment. The major effort under this function was to improve the technoeconomic model, improve estimates of methane in solution and to evaluate newly identified sites.

TEST WELL DATA ASSESSMENT

General

Essentially all activities planned under this function were directed toward the LaFourche Crossing Well. The well has not yet been drilled and, thus, there has been no data to analyze and assess. However, the expertise developed in the study of the LaFourche Crossing Well, initially planned to be the first designed geopressured-geothermal well in Louisiana, has simply been transferred to the design and testing of other wells.

In the past few years, largely due to the studies pursued under this function, test well designs have become essentially standardized, flow testing is better understood, fluid analyses, coring and core handling procedures have been agreed upon, rock mechanics testing has largely been standardized without sacrificing the prerogative of a particular laboratory to pursue studies of a more fundamental nature, and, finally, LSU has recently developed in-house capabilities for reservoir simulation.

Design of the LaFourche Crossing Wells

Background

For more than a decade, the Petroleum Engineering Department of LSU has been concerned with the technique of drilling conventional oil and gas wells into the geopressured zones, and as a result of this effort, the design of these wells is now essentially standardized and blowouts are rare.

A geopressured well design takes into account the fact that the well must be cased into the transition zone between hydropressure and geopressure before drilling proceeds further. If this is not done, the mud weight required to contain the geopressured will be sufficient to fracture the formation in the hydro pressured regions above, circulation will be lost and a blowout possible.

Geopressured-geothermal well designs differ from conventional hydrocarbon wells drilled into the geopressured zones in that they must be designed to produce great volumes of hot brine. Production tubing must be larger and the problem of thermal expansion of casing must be

solved. The thermal expansion problem is solved by cementing the bottom portion and exerting an overpull equal to the compressive stress expected from constrained thermal expansion, then continuing with the cementing. In production, then, when heated, the casing will be in moderate tension.

The Design Proposal for the LaFourche Crossing Wells

It was originally planned that the LaFourche Crossing effort would be a function of the Louisiana Department of Natural Resources under contract with the DOE, with LSU, under a separate contract, furnishing technical support. The LaFourche Crossing wells were designed under this separate LSU contract by C. Allen Bell, P. E., Inland Enterprises, Inc., P. O. Box 307, Ball, LA, 71405, who acted as an independent consultant. The detailed design, drilling, coring, casing, cementing and completion procedures for both the production and disposal wells were incorporated into Appendix A of the DNR proposal of April, 1980, entitled "A Revised Proposal for Drilling and Testing the LaFourche Crossing GP/GT Prospect Louisiana." Since this material is so voluminous, it is not included in, nor appended to, this report. It will be very valuable when the well is actually drilled.

LSU also furnished the DOE with a documented cost analysis of the LaFourche Crossing Wells (in 1980 dollars). Costs were obtained from vendor catalogs, from letters from suppliers, and from annotated telephone conversations. Included were costs for site preparation, drilling tools, mud and chemicals, rental equipment, cement and cementing services, transportation, home office supervision and office planning, tubular goods, well head equipment, casing equipment, completion equipment, drilling foreman's salary and expenses and contingencies for both the production well and the two disposal wells. No gravel-pack completion of the production well was planned but a major item in the overall cost was a contingency plan for workover and gravel-pack (\$2,071,832). Included in the pricing estimate were expenses for a 12 month testing period.

With inflation and increased competition resulting from the fact that drilling activity has greatly increased in the past two years, this cost appraisal may have only marginal future value.

The Testing and Scientific Programs

Under this DOE contract, LSU provided the Louisiana Department of Natural Resources with a complete testing and scientific program for the LaFourche Crossing production and disposal wells.

Detailed plans were made for clean-up operations, an initial build-up test, a first flow test followed by a shut-in, and a second, extended flow test during which the flow was to be incremented until a rate of 50,000 BWPd was reached and sustained for 70 days.

The overall purpose of the planned testing and scientific procedures was, of course, to find out if this particular geopressured-geothermal well had economic viability; whether it could competitively supply energy, principally from methane gas production. Toward this objective, the tests were planned to answer many questions and to furnish the hard information necessary to assess the resource. Among the questions were these: Will sand production, scaling and corrosion be problems? If so, how can these problems be solved? What is the gas content? What are the bottom-hole and surface flowing temperatures and pressures at various rates of production? Are there hazardous chemicals in the produced brine? Will the disposal wells clog due to precipitation? What are the boundaries of the reservoir? What is its predicted production life? What are the primary drive mechanisms besides those due to expansion of the water? Are reservoir compaction, free gas bubble expansion and shale dewatering significant?

The geology of the LaFourche Crossing site is now better understood due to the work of Dr. Don Bebout, but there are still additional questions which may be answered by the now planned seismic surveys. Certainly the reservoir is smaller than once anticipated. Also, judging from the most recent results of rock testing of samples of cores from the Pleasant Bayou Wells, reservoir compaction is likely to be far less than estimated earlier. Thus it is possible that the actual flow testing will be considerably revised from that originally planned.

Coordination

A committee with representatives from LSU, University of Texas at Austin, Institute of Gas Technology, Gas Research Institute, DOE, the Terra-Tek Laboratories and the Louisiana Geological Survey has agreed upon a set of guidelines for rock mechanics laboratory test-

ing for geopressured-geothermal wells. The guidelines were developed to insure a basic understanding of the mechanics of these aquifers. Specifically they will be useful in:

- (1) identifying and anticipating problems associated with changes in porosity, permeability, rock chemistry and strength which are related to reservoir production
- (2) providing a correlation and understanding of reservoir properties as determined from well tests and logs
- (3) providing a basis (by understanding of physical mechanisms) for long-term production predictions that are made by computer analysis where, otherwise, only empirical predictions could be made.

The guidelines cover all aspects of the endeavor: core sampling and handling; rock mechanics testing (short term and long term in situ); and petrographic and fluid chemistry changes associated with deformation.

Reservoir Simulation

It was originally planned that the simulation of the LaFourche Crossing Well would be performed under a subcontract with a commercial organization. In the past year, however, the Petroleum Engineering Department at LSU has become involved in the LSU technical support program. Drs. Adam T. Bourgoyne and Zaki A. Bassiouni are now responsible for this phase of the work.

The LSU simulator is simpler than that used by Systems, Science and Software, Intercomp, and UTA, the philosophy being that a more elaborate model is not warranted when one considers there is great uncertainty regarding the values of the physical parameters required in more sophisticated models. It is a 2D (in the plane of the aquifer) single phase solution of the diffusivity equation. Boundaries are imposed by image wells.

It has been used in preliminary studies of the LaFourche Crossing and the South Pecan Island wells. The results of this study entitled "Prediction of Maximum Flow Rates from Geopressured Aquifers" will be presented at the 56th Annual Fall Technical Conference and Exhibition of the Society of Petroleum Engineers of the AIME, San Antonio, Texas,

October 5 - 7, 1981. This paper describes simulations run at a constant (minimum) surface pressure so as to maximize the rate of energy production. It indicates that the parameters which have the most effect on the production rate are tubing size, formation damage, and the reservoir characteristics of porosity and fluid pressure. Reasonable variations in permeability, viscosity and well location in the aquifer affected the production rate only slightly.

RESOURCE ASSESSMENT

Introduction

The success of the U. S. Department of Energy-sponsored project to produce thermal energy and methane from aquifers in the geopressed zone of the Texas and Louisiana Gulf Coast (Fig. 1) is dependent upon identifying thick sandstone reservoirs with large areal extent, high temperature, high porosity and permeability, and low salinity. Regional and detailed geological and engineering studies at the Bureau of Economic Geology, University of Texas at Austin, and Louisiana State University/Louisiana Geological Survey have indicated that reservoirs containing the optimum conditions in all categories are not common or, perhaps, do not exist.

The location of major sandstone accumulations in the various Tertiary formations (Fig. 2) depends upon the paleoclimate and the location of major river systems which were responsible for delivering the sand and mud to the ancient coastline to be deposited in river deltas or barrier-bar systems. Through geological time, these river systems and sites of accumulations shifted (Fig. 3). The first sediments to be deposited gulfward of the older, buried Lower Cretaceous shelf margin (Fig. 1) became the oldest growth-faulted and geopressed sandstones and shales in that area. The stability of the Lower Cretaceous carbonate shelf landward of the shelf edge prevented growth faulting there. In Texas, the oldest known geopressed section consists of Tertiary Wilcox sandstones and shales; in Louisiana, the Upper Cretaceous Tuscaloosa section is geopressed. Gulfward of the Lower Cretaceous shelf edge, prograding deltaic and shoreline sands and muds were deposited on soft, unstable basinal mud (Fig. 4), and growth faulting was initiated (Fig. 5). The formations to reach this position onshore are the Tuscaloosa, Wilcox, Vicksburg/Frio, and Fleming (Fig. 2).

Regional Geological Studies

Over the past five years many potential geopressed-geothermal test well sites have been identified in Louisiana; location of these sites has been based on consultation with geologists from industry, state government and federal government who were aware of favorable

Figure 1. Geopressed zone along the Texas and Louisiana Gulf Coast.

SYSTEM	SERIES	GROUP/ FORMATION
QUATERNARY	RECENT PLEISTOCENE	UNDIFFERENTIATED HOUSTON
TERTIARY	PLIOCENE	GOLIAD
	MIOCENE	FLEMING
		ANAHUAC
	? — ?	
	OLIGOCENE	FRIO
		VICKSBURG
	EOCENE	JACKSON
		CLAIBORNE
		WILCOX
		MIDWAY
CRETACEOUS	UPPER	NAVARRO
		TAYLOR
		AUSTIN
		TUSCALOOSA

Figure 2. Upper Cretaceous and Tertiary formations of the northern Gulf Coast. Formations with the lined pattern occur in the geopressed zone.

Figure 3. Major sediment depocenters during the Upper Cretaceous and Tertiary along the northern Gulf of Mexico.

Figure 4. Diagrammatic cross section across the geopressured zone of south Louisiana.

Figure 5. Major subsurface faults along the Texas and Louisiana Gulf Coast.

areas through personal contacts or experience. This method led to the identification of many sites but did little to establish favorable trends or to organize the prospective test-well sites into these trends. The recognition of trends adds the important dimension of permitting prediction away from known areas.

Regional dip cross sections (Fig. 6 to 15) form the framework for regional studies. The cross sections commence at 3000 feet below sea level. Formation correlations are based primarily on standard micropaleontological markers which have been used by industry for many years. More detailed correlations based on shale-resistivity markers are feasible but wells must be much more closely spaced than possible on these regional sections. Only major growth faults are shown; many of the faults shown actually represent many smaller faults too numerous to include at this scale. The top of geopressure is indicated where the drilling mud weight, plotted to the right of the electrical log, exceeds 13 ppg and the shale resistivity decreases. The 100°C and 150°C temperatures have been projected from measured bottom-hole temperatures, also plotted to the right of the electrical log. The corrected temperature is shown in parentheses beneath the measured temperature.

By combining the indications of the top of geopressure and the location of thick sandstones from the cross sections, and sandstone-percent maps (Figs. 16 to 20), geopressured-geothermal corridors are identified across south Louisiana (Fig. 21). Corridors are areas in which thick sandstone units could be expected to occur within the geopressured zone and, of course, are continuous with those recognized in Texas (Bebout, 1977).

These cross sections are considered as a reference into which any well or location can be projected and the sandstone of interest easily identified as to age, formation, and position within a fault block; predictions can also be made as to the lateral extent of the potential aquifer. These sections are the first step in regional mapping of sandstones and identification of geothermal fairways and prospects. They are also useful in the initial evaluation of proposed wells of opportunity.

Figure 6. Location of regional dip and strike sections. Sections AA' to II' are included in this paper (Figs. 7 to 15).

Figure 8. Dip cross section BB'.

Figure 10. Dip cross section DD'.

Figure 12. Dip cross section FF'.

Figure 13. Dip cross section GG'.

Figure 14. Dip cross section HH'.

Figure 16. Sandstone percentage in the Wilcox Formation, west Louisiana.

Figure 17. Sandstone percentage in the Frio Formation, west Louisiana.

Figure 18. Sandstone percentage in the Lower Miocene, west Louisiana.

Figure 19. Sandstone percentage in the Middle Miocene, west Louisiana.

Figure 20. Sandstone percentage in the Upper Miocene, west Louisiana.

Figure 21. Geopressed geothermal corridors, south Louisiana.

Geological Constraints

General statement

Through the construction of the regional cross sections and compilation of other subsurface data obtained from oil and gas wells, a much better insight into the nature of the aquifers in the geopressured zone has been developed. Through the examination of these data, certain geological constraints have been identified which make it doubtful that the "ideal" geopressured-geothermal reservoir with 3 cubic miles of sandstone volume, permeability of greater than 20 millidarcys, temperature of 300°F, and salinity of 20,000 to 80,000 ppm total dissolved solids will be found. On the other hand, these data do indicate that enormous sandstone reservoirs capable of producing large volumes of water do occur in the geopressured zone. However, actual data on the nature of the fluids in these aquifer are not available except from the DOE-funded Designed Wells and Wells of Opportunity. Data from the DOE wells are contributing invaluable information concerning the nature of the geopressured aquifers.

Lateral extent of geopressured sandstones

The initial constraint on reservoir size is imposed by the various depositional models, judging from the study of modern areas. Superimposed upon the depositional models are the numerous contemporaneous growth faults which are assumed to be barriers to lateral fluid flow. The major growth-fault systems in the Gulf Coast (Fig. 5) are complex and result in the subdivision of sandstone-prone areas into units generally averaging less than 50 square miles in area. Detailed study invariably results in the identification of many additional faults and further reduction in the size of the area of lateral continuity (Bebout et al., 1979; McCulloh and Pino, 1981; and Flournoy and Ferrell, 1980). There may be fluid flow across a fault if sandstones not genetically related are juxtaposed.

Sandstone reservoir thickness

In general, sandstone units are found thinner and less abundant with increasing depth. Exceptions to this overall trend result from variations in sediment supply, climate, and subsidence rates during

specific geologic times and consequent differences in the amount of progradation of sand units into the Gulf. Norwood and Holland (1974) illustrate the general changes in sandstone thickness and occurrence for the offshore Pleistocene (Fig. 22). Norwood and Holland show thick sandstone and thin shale in the hydro pressured zone, interbedded sandstone and shale in the transition zone, and thick shales and thin sandstones in the geopressured zone. This general trend is substantiated by the trends shown on the regional cross sections across south Louisiana (Figs. 7 to 15) and Texas (Gregory et al., 1980). These cross sections also show important exceptions where thick sandstone units occur deep in the geopressured zone in Section C, Well 9 (Fig. 9), and Section D, Wells 11 and 12 (Fig. 10). Although the thick sandstone units in the geopressured zone do not conform to the general trend, they are not at all rare; however, it is important to emphasize that thick geopressured sandstones are the exception to the regional model and do not occur everywhere.

Top of geopressure

The top of geopressure occurs just beneath the massive sandstones, as shown by Norwood and Holland (Fig. 22) and discussed in the previous section. The top is picked more precisely at the distinct break to a lower resistivity in the shale section (Fig. 23), reconfirmed by the point at which drilling muds heavier than 13 ppg were used (Figs. 7 to 15). The depth to the top of geopressure (Fig. 24) depends upon the amount of porous sandstone present in the section. Gregory et al. (1980) describe this phenomenon along the Upper Texas Gulf Coast where the top of geopressure is deeper than -10,000 feet along the Wilcox sandstone trend, between -8000 to -10,000 feet downdip where Wilcox prodelta and shelf shales predominate, and again deeper than -10,000 feet along the Frio sandstone trend. This relationship of pressure to the amount of sandstone within each formation continues to the east into Louisiana, but is not so well defined because of the large number of salt domes which interrupt the pattern.

In general, the depth to the top of geopressure is shallower along the Lower Texas Gulf Coast and deeper to the northeast into Louisiana; for example, the top of geopressure ranges in depth from

Figure 23. Shale-resistivity plots for selected wells in south Louisiana.

Figure 24. Top of geopressure along the Texas and Louisiana Gulf Coast.

-7,000 to -12,000 feet along the Lower Texas Gulf Coast and from -9,000 to greater than -18,000 feet in Louisiana.

Temperature

Plots of bottom-hole temperatures recorded on well logs make possible the prediction of subsurface temperature trends with depth in Texas and Louisiana (Fig. 25). Temperatures have been recorded also on the regional cross sections (Fig. 7 to 15) and interpolated to 200°F and 300°F. The 200°F isotherm occurs near the top of geopressure and generally ranges in depth from -10,000 to -12,000 feet. However, the 200°F isotherm occurs as shallow as -8,000 feet in the Frio and Wilcox formations. The 300°F isotherm occurs between -13,000 and -18,000 feet.

The geothermal gradient in the geopressured zone of the Miocene and Frio decreases from greater than 2.5°F/100 ft. along the Lower Texas Gulf Coast, to 1.8 to 2.1°F/100 ft. along the Upper Texas Gulf Coast and west Louisiana, to 1.2 to 1.3°F/100 ft. in east Louisiana; consequently, the 300°F isotherm occurs at -13,000 to -15,000 feet in Texas and west Louisiana, but at -15,000 to -18,000 feet in east Louisiana.

Porosity-permeability

Porosity decreases with depth uniformly and, in general, predictably. Loucks, Dodge, and Galloway (1979) showed this trend very clearly in the lower Tertiary by using many diamond-core analyses from the Texas Gulf Coast (Fig. 26). A similar trend in Louisiana is displayed using diamond-core analyses from Core Laboratories data (Fig. 27). However, it is important to note that there are wide variations in porosity at any depth because of differences in original composition of the sand, burial history of differences in original composition of the sand, burial history of the sediment, and formation fluid composition and movement.

Porosity plots for individual formations by parish (Fig. 28) are probably more meaningful for evaluation prospects locally. For example, in Cameron Parish, site of the Gladys McCall test well, porosities ranging from 15 to 30 percent can be expected at the proposed reservoir depth. Similarly, in LaFourche Parish, proposed sites of another test well, the porosities at the projected reservoir depth

Figure 25. Bottom-hole temperature plots for selected wells in south Louisiana.

Figure 26. Porosity versus depth from whole-core analyses for lower Tertiary formations along the Texas Gulf Coast (from Loucks, Dodge, and Galloway, 1979).

Figure 27. Porosity versus depth from wholecore analyses for Oligocene and Miocene sandstones of south Louisiana.

Figure 28. Porosity plots for selected parishes of south Louisiana.

will range between 20 and 25 percent. Porosity plots of this type are now available for all parishes in south Louisiana and have already been published for subdivisions comprised of groups of counties in Texas (Gregory et al., 1980).

Permeability plots (Fig. 29), using the same samples as those used for porosity, show considerably more variation; consequently, permeability is more difficult to predict.

Salinity

In general, salinity increases with depth and is highest in the hydropressed zone just above the geopressed zone. Here, in the major hydrocarbon-producing zone, salinity is generally 100,000 ppm or greater. In the geopressed zone, the salinities are highly variable and range from more than 100,000 ppm to less than 20,000 ppm. Controls on the formation fluid salinity are poorly known, but reservoir porosity and permeability, aquifer size, the nature and spacing of bounding growth faults, and fluid movement along the faults and out of overlying and underlying shale units during burial are probably important factors.

Conclusions

Regional and site-specific geological studies indicate that aquifers in the geopressed zone which meet all of the specifications of the ideal model are difficult to find, or perhaps do not exist at all. Therefore, tests of aquifers with widely varying reservoir parameters are now necessary in order to identify the most efficient reservoir type, within practical limitations. To this end, the DOE Wells of Opportunity and Designed Test Well Programs are aimed at examining a variety of reservoir situations. For example: in the Designed Test Well Program, the Austin Bayou and Sweet Lake Prospects have thin sandstones with wide lateral distribution and fluids with high salinity; the Pargperdue Prospect is especially designed to investigate the drawdown characteristics of a thin and areally limited sandstone reservoir; the Rockefeller Refuge Prospect has an extremely thick sandstone, possibly with limited areal extent and high-salinity fluids; and the LaFourche Prospect will encounter thin sandstones in a complexly faulted area with low-salinity fluids. Geological studies continue in Texas and Louisiana to identify additional favorable test well sites.

Figure 29. Permeability plots for selected parishes of south Louisiana.

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ENVIRONMENTAL MONITORING

Overview

Geopressured-geothermal energy development in the Gulf Coast is a recent undertaking. Therefore, very little is known about the environmental impacts resulting from short or long term geopressured-geothermal energy production. The environmental monitoring phase of this DOE project was established to determine and evaluate environmental problems resulting from the production and disposal of geopressured-geothermal brines.

The technology used to tap the geopressured-geothermal resources of the Gulf Coast are similar to that used in oil and gas development. Changes in air quality, surface and ground water quality, subsidence and seismic activity may result during the development of geopressured-geothermal resources.

Impairments of air quality could result from the uncontrolled venting of produced gases. Water quality may be affected during geopressured-geothermal brine production and reinjection. Natural subsidence and fault movement in the prospect area may be enhanced by decreases in the natural fluid pore pressures of the production horizon.

Overall, the greatest environmental concerns relate to subsidence and fault activation; air quality and water quality effects are expected to be minor.

Status of Environmental Monitoring Programs

Under the present contract (DE AS05 78ET27071) environmental monitoring plans were designed and implemented in two geopressed prospects which were selected for testing during 1979-1980. The University began establishing an environmental monitoring program at the DOW Chemical test site near Parcperdue during October 1979. Environmental monitoring studies at the Magma Gulf/Technadril site near Sweet Lake were initiated in March 1980. The results of baseline studies performed at the Parcperdue and Sweet Lake test sites through December 31, 1980, are described in the following sections.

Parcperdue

The Parcperdue test site is located in the North Parcperdue oil and gas field, approximately 15 miles south of Lafayette. Land use in the area is primarily agricultural, dominated by pastureland and irrigated rice fields. The site is approximately 20 feet above mean sea level in an area of very low relief between the Vermilion River to the west and Bayou Parcperdue to the east (Figure 1).

During the fall of 1979, LSU investigators conducted several site visits and low altitude aerial surveys to determine drainage patterns and land use/land cover. A review of available published and unpublished environmental data collected in the vicinity of the prospect was also conducted. Considering both site characteristics and the potential environmental impacts of resource testing, an environmental monitoring plan was prepared for the Parcperdue well test. This plan is presented in Appendix A to this report. In accordance with this plan, field stations were established to monitor air quality, surface and ground water quality, seismicity and subsidence within the prospect. Locations of field monitoring stations are given in Figure 2. Instrumentation, laboratory analysis, and results of environmental monitoring studies at the Parcperdue site are presented below.

Air Quality An ambient air quality and meteorological monitoring station was established approximately 1600 feet northwest of the

Figure 1. The Parcperdue Test Site.

production well site (Figure 2). Historical wind data (1959-1960) reported at Baton Rouge and Lake Charles by the National Weather Service indicate that prevailing winds are generally from the south-east.

The air quality monitoring station was installed and operated by KEMRON Environmental Services of Baton Rouge. All instrumentation necessary for monitoring air quality and meteorology was installed by KEMRON during March 1980, but due to delays in the installation of a telephone line for data transmission, the continuous air monitoring station was not operative until July 1, 1980. The station provided continuous records of hydrogen sulfide, sulfur dioxide, non-methane and total hydrocarbons in accordance with the Ambient Monitoring Guidelines for the Prevention of Significant Deterioration (PSD) published by the U. S. Environmental Protection Agency, May 1978 (EPA - 450/2-78-019). Meteorological data from continuous recorders included wind speed, wind direction, temperature and precipitation.

The following is a description of instrumentation used to monitor air quality and meteorological data at the Parcperdue test site.

Sulfur Dioxide Monitor Sulfur dioxide was monitored using a pulsed fluorescence technique designated as an EPA Equivalent Method. This analyzer exceeded the specifications in 40 CFR 53, Table B-1, "Performance Specifications for Automated Methods". The analyzer works by exposing a sample of ambient air to high intensity ultra-violet light which excites just the sulfur dioxide molecules in the air sample. The energized molecules emit specific illumination which is measured by means of photomultiplier tube. The emitted light is linearly proportional to the concentration of SO_2 in the sample. The ambient air SO_2 monitor was manufactured by Thermo Electron Corporation.

Hydrogen Sulfide Monitor Hydrogen sulfide was monitored by employing a continuous monitor which operated on pulsed fluorescence detection of hydrogen sulfide in the ambient air. This was accomplished by a sample train with a special in-line filter which removed

all sulfur dioxide from the sample. The hydrogen sulfide passed through this filter unimpeded. The sulfur dioxide-free sample then entered a converter chamber where the hydrogen sulfide was catalytically converted to sulfur dioxide. The resultant sulfur dioxide molecules were energized by high intensity pulsed ultra-violet light source. The energized molecules emit a specific illumination which was measured by a proportional to the concentration of light is linearly proportional to the concentration of hydrogen sulfide in the sample.

A meter reading and a electronic analog signal for the output was provided by electronic solid state amplification of the output of the photomultiplier tube, with signal conditioning for the elimination of signal noise. The system has a precision of better than 0.01 ppm (Volume/Volume) and an accuracy of better than 5% full scale (Volume/Volume). This hydrogen sulfide analyzer was also manufactured by Thermo Electron Corporation.

Environmental Chromatograph Continuous monitoring of methane total hydrocarbons used the Reference Method for hydrocarbons corrected for methane published in 40 CFR 50. This was accomplished by the use of a Beckman Instrument Company 6800 Environmental Chromatograph or equivalent. Three data channels were generated from the system:

- a. Total hydrocarbon response as calibrated against methane in air response
- b. Methane concentration as calibrated against methane in air response
- c. Non-methane hydrocarbon (difference between total hydrocarbons and methane concentration).

Meteorological Monitors The monitoring site was equipped with Meteorology Research Incorporated (MRI) wind instrumentation for measuring wind direction, wind speed, temperature, and precipitation. The MRI system used was a Model 1074 system which was mounted on a 10-meter meteorology tower.

Monitoring instruments were certified by EPA as Reference or Equivalent Methods for each of the parameters monitored where certification was appropriate. The inlet manifold for collecting

ambient air samples was placed approximately 3.5 meters above ground surface and clear of the environmental shelter as specified by EPA. The air quality monitoring instruments were contained in an environmental shelter which was maintained at a temperature of 25° Celsius.

Air quality and meteorological data at the Parcperdue site were reported by KEMRON on a monthly basis. The monthly reports include the following tables for each of the four pollutants monitored:

- 30 highest 10-minute, 1-hour, and 3-hour concentrations
- daily maximum and average concentration
- wind direction versus concentration
- wind velocity versus concentration
- time of day versus average concentration
- frequency distribution of 10 minute average
- maximum daily differentials

The report submitted by KEMRON for the month of July is included as Appendix B to this Final Report. Other monthly reports are available upon request from the Louisiana Geological Survey at LSU.

Sulfur dioxide (SO₂) and non-methane hydrocarbons were the only pollutants monitored for which National Ambient Air Quality Standards (NAAQS) have been established by EPA. The following are standards for integrated values of SO₂ and non-methane hydrocarbon concentrations in ambient air:

Sulfur Dioxide

Primary:	Annual arithmetic mean	80 microgm/n ³
	Max. 24-hour concentration	365 microgm/n ³
Secondary:	Max. 24-hour concentration	260 microgm/n ³

Non-Methane Hydrocarbons

Primary:	Max. 3-hour concentration (6 am - 9 pm)	160 microgm/n ³
Secondary:	Same as primary	

Neither primary nor secondary NAAQS for SO₂ were exceeded during the six month period of baseline data collection at the

Parcperdue site. The highest 24-hour average concentration was 21 micrograms/m³ reported on December 22, 1980. The wind direction was generally 0° - 130° (north to southeast) during periods that SO₂ was reported. The Baton Rouge metropolitan area is located approximately 55 miles northeast (62°) of the site; New Orleans is located 110 miles almost due east (90°) of the site. There was no apparent trend in the time of day that SO₂ was recorded during the six-month period.

Standards for non-methane hydrocarbons were exceeded on an average of four to five days each month at the Parcperdue site. The highest concentration of non-methane hydrocarbons reported during the NAAQS period (6:00 am to 9:00 pm) was 778 micrograms/m³ on August 23, 1980. It should be noted here that hydrocarbons, at levels reported at the Parcperdue site, may have no direct effect on human health. Standards have been established for these compounds because they contribute to the formation of ozone by reacting with nitrogen oxides in sunlight. Nineteen parishes in Louisiana have been designated by EPA as a "non-attainment" region for ozone.

Total hydrocarbons were recorded each day at the site and averaged between 704 and 2107 micrograms/m³ over a 24-hour period. The time of day when both methane and non-methane hydrocarbons were reported was basically the same each day, from 5:00 pm to 8:00 am, including weekends. The wind direction from which hydrocarbons came varied. However, most methane and non-methane hydrocarbons were reported when wind speeds were very low, between 0 and 1 mph.

Hydrogen sulfide (H₂S) was reported daily in minor concentrations at the Parcperdue site during July-December 1980. The average 24-hour concentration was between 8 and 11 micrograms/m³ each month. There were no apparent relationships between H₂S concentrations and wind direction or time of day.

Water Quality Monitoring In order to assess baseline water quality conditions in the Parcperdue prospect, ground and surface water quality monitoring were conducted prior to resource testing. Water samples were collected each month during calendar year 1980 and

analyzed by Petroleum Laboratories, Inc. of Lafayette. Water sample collection, handling, and analyses were consistent with those recommended by EPA in the "National Handbook of Recommended Methods for Water-Data Acquisition" (1977).

Surface Water Surface water sampling stations were selected using aerial photography and field reconnaissance. The initial field survey of drainage indicated a very complex system of rice irrigation and drainage canals and ditches. A walk through the drainage area after a heavy rain reveals that surface runoff flows from the site into LeBlanc ditch, which is hydraulically connected to Vermilion River and Bayou Parcperdue, west and east of the site, respectively. An interesting observation was that, at the point of convergence with LeBlanc ditch, water flow was diverted in both east and west directions. It was for this reason that sampling stations were located at their respective positions (Figure 2). Three stations were down the hydraulic gradient from the site at strategic and sensitive points in the hydrologic system. One is located east of the confluence toward Bayou Parcperdue and two are located to the west, toward Vermilion River, the major aqueduct.

Field measurements recorded monthly at each station included pH, specific conductance, turbidity, temperature, dissolved oxygen, and water level. Where possible, those parameters were also tested in the laboratory. The following additional parameters were determined in the laboratory:

<u>Parameter</u>	<u>Detection Limit</u>	<u>Parameter</u>	<u>Detection Limit</u>
Na	(.002 mg/l)	Cl	(1.0 mg/l)
K	(.005 mg/l)	Ba	(.03 mg/l)
NH ₃	(.02 mg/l)	Pb	(.05 mg/l)
Mg ³	(.0005 mg/l)	As	(.01 mg/l)
SO ₄	(1.0 mg/l)	B	(.1 mg/l)
Cd ⁴	(.002 mg/l)	Hg	(.001 mg/l)
Mn	(.01 mg/l)	Total hardness	(0.5 mg/l)
Ca	(.002 mg/l)	Total organic carbon	(1.0 mg/l)

Water quality records for each of the three surface water sampling stations are given in Appendix C. Graphs of monthly sample

Figure 2. Field Monitoring Station, Parcperdue

Figure 3. Graphs of selected parameters for surface water stations near Parcperdue.

Figure 4. A typical electric log from the Parcperdue area (Texaco-Frank M. Bacque #1).

analyses (Figure 3) are indicative of many seasonal trends. The temperature at all sites reached a seasonal high between June and August, 1980. Turbidity was relatively high during the spring months, probably due to increased precipitation and runoff. Maximum levels of specific conductance were observed during early spring, early summer and early fall. It is questionable whether this was due to salt water intrusion or some other phenomenon.

Ground Water Suitable locations for ground water observation wells were determined using available subsurface information derived for well logs and piezometric surface maps published by the Louisiana Geological Survey. The type of information derived from well logs is dependent upon the time and purpose of well drilling. For example, those wells used for industrial purposes, either for exploration, rig supply or underground injection are usually deeper and logged electrically, whereas those wells used for irrigation are shallow and were logged physically (from cuttings). Water quality data available mainly for several irrigation and observation wells in the prospect was useful in log interpretation. Recent water quality data included the depth of water production, static water level, specific conductance, pH, total hardness, total dissolved solids and the content of certain ions, including SiO_2 , HCO_3 , SO_4 , NO_3 , PO_4 , CO_3 , CO_2 , Fe, Ca, Mg, Na, K, Cl, F, Mn, B, and Br.

A few electric logs with shallow stratigraphic information in the vicinity of the Parcperdue test site were recovered from available files. A typical log (Figure 4) gives a general idea of the stratigraphy in the area. A fresh water sand, probably silty, extends from the surface down to a depth of approximately -500 feet (msl). A 200 foot thick shale (or clay) separates this sand from a deeper (also fresh water) sand that extends down to contact another shale (clay unit). Below this unit, a saltwater interface is probable, indicated by a shift in the shale base line to the right and sand SP inflection.

Many such logs were correlated (Figure 5) to determine the shallow (less than 1,000 ft.) stratigraphy adjacent to and through the test site. In general, a thick upper sand exists from the surface to -500 or

Figure 5. A general stratigraphic cross section through the Parcperdue test site.

650 feet. This sand is underlain by a clay or shale which may contain sandy silty lenses in some areas. This shale, up to 200 feet thick, is separated from a lowermost shale by 150 to 250 feet of sand. Note that saline water is not mapped on this cross section. This fact, at first, derived by electric log interpretation, was confirmed using available water quality data (Table 1). In this table, chloride concentrations were not significantly high for any of the wells cited.

Piezometric surface maps are essentially contour maps of the static water level across an area. It is generally understood that the ground water flow direction is toward the lowest water level. These maps were used to determine the most likely direction of ground water flow through the test site. This method is usually very accurate if successive years of piezometric surface mapping yield consistent results.

Ground-water flow through the Parcperdue test site has consistently been west-southwest to west-northwest, based on piezometric surface maps published by the Louisiana Geological Survey between 1954 and 1962. For this reason, ground-water observation wells were selected west of the production well site.

Fortunately, two wells already existed in proximity to the test site. These wells, owned by the land owner, are 50 and 100 feet deep, respectively. Sampling, which began at these two wells in January, 1980, was to last until sampling could be shifted to newer, deeper wells. A new 180 foot well was drilled by LSU in August of 1980 (#1 in Fig. 2) and replaced the 50 foot well. Sampling at the 100 foot and the 180 foot wells continued through calendar year 1980.

Ground water samples were collected each month and analyzed, using EPA approved methods and quality assurance procedures (EPA-600/4-79-019). Ground water levels were reported in each well at the time of sample collection. Analyses performed on each sample were the same as those conducted for surface water.

The results of ground-water sample analyses are presented in Appendix C. Data for selected parameters (temperature, turbidity and specific conductance) were graphed to obtain a general understanding of seasonal ground-water trends and baseline information (Figure 6).

Table 1. Representative water quality data for water wells near the Parcpardue test site.

Well No.	Depth	Date	Water Level	SC	PH	CaCO ₃	TDS	SiO ₂	HCO ₃	SO ₄	NO ₃	PO ₄	CO ₃	CO ₂	Fe	Ca	Mg	Na	K	Cl	F	Mn	B	Br
LF-568A	636'	09-18-74		471	7.4	230	302	28	280	9.4	--	--	0	18	.46	20	8.3	83	2.5	10	.3	.11	--	--
LF-568B	798'	08-29-74		630	6.9	271	369	33	330	.2	--	--	0	67	.41	23	11	96	4	37	.6	.1	--	--
LF-566A	451'	04-25-69		378	7.9	205	---	39	250	3.8	.2	--	0	5	1.2	55	10	15	1.2	3.8	.2	.4	--	--
LF-566B	780'	04-23-69	33.31	763	7.6	320	451	27	390	.4	.1	--	0	16	.87	32	13	120	2.4	61	.7	.11	--	--
LF-564A	720'	05-25-79		1120	--	---	---	--	---	---	--	--	0	--	---	--	--	--	---	180	--	---	--	--
LF-564B	907'	10-14-68		606	7.7	271	370	35	330	0.	.0	--	0	10	.48	12	4.4	120	1	36	.3	---	--	--
LF-571A	926'	06-17-75		556	8	230	327	32	280	---	--	--	0	4.5	.32	21	9.1	88	1.9	35	.2	.1	--	--
LF-571B	650'	07-07-75		501	7.9	230	296	35	280	---	--	--	0	--	.09	46	15	40	1.7	22	.2	.09	--	--
VE-532	215'	10-23-51		745	7.4	295	---	--	360	0.	--	--	-	23	---	--	--	--	---	80	--	--	--	--
VE-660A	320'	05-13-69		414	7.7	---	256	31	270	.6	.2	--	0	--	.77	48	15	21	.8	20	.3	.15	--	--
VE-660B	611'	05-05-69	14.36	937	8	---	512	29	230	189	.0	--	0	--	1.2	84	22	71	1.6	190	.2	.19	--	--

Depth in feet
Water level: feet below ground surface
Specific conductance (SC) in umhos/cm
pH in standard units
All other values in mg/l

Figure 6. Graphs of selected parameters for observation wells in the Sweet Lake area.

Figure 7. The Parcperdue geothermal fault block and the historical leveling line. Parcperdue test site well, DOW-DOE Sweezy #1.

Due to the sparsity of data for the 180 foot and 50 foot wells, this interpretation is only complete for the 100 foot well. Ground-water temperature holds relatively steady throughout the year with only slight downward fluctuations in early spring and early winter. The graph of turbidity depicts major seasonal highs during the late winter and late fall months. This may indicate a nearby fluvial recharge source for the aquifer under observation. A nearby recharge source is highly probable owing to the proximity of this thick sandy aquifer to the surface. Specific conductance in the deeper well is highest and has a greater range of values, as would be expected. In the 100 foot well, specific conductance increased slightly during the early summer months.

Subsidence and Microseismic Monitoring Subsidence and seismicity are key environmental issues associated with the production of geopressured-geothermal fluids in the Gulf Coast region. Reduction in pore pressure within a geopressured formation may reactivate dormant faults and increase active faulting in the vicinity of the production reservoir. A cone of depression may develop in the land surface centered on the production well. The subsurface disposal of large volumes of geothermal fluids may also impact land surface elevation and faulting.

Baseline studies of subsidence and seismicity were conducted at the Parcperdue test site during 1978-1979. The results of these studies are described below.

Subsidence Studies In order to evaluate the potential subsidence impacts of geopressured-geothermal fluid withdrawal, an analysis of predevelopment subsidence was necessary. Historical elevation data was obtained for this baseline analysis from the National Geodetic Survey (NGS) in Rockville, Maryland. In addition, twenty-four new elevation benchmarks were established in the vicinity of the planned test site and northward from the site along Highway 339, to a point where a survey line would be tied to the existing NGS First-order network (Figure 7). This line was surveyed by Meyer and Associates, a Lake Charles firm under contract to the University, during November, 1980.

Releveling data for the existing NGS First-order line nearest the test site (along Highway 339) was sparse, due to the distance of the site from population and industrial centers. For this reason, a more regional analysis of historical changes in elevation is now in process. Elevation data for the Lafayette/Parcperdue region was collected for the following years: 1918, 1934, 1938, 1955, 1965, 1968, 1969, 1972 and 1980 (see Appendix D).

Although multiple years of elevation data were available for the region, all lines and line segments were never completely surveyed during any single year. The most complete survey of the region was performed in 1955. Furthermore, certain varying assumptions were made by the survey crews during the leveling of each line or line segment. The survey crew generally selected a benchmark as a point of reference and assumed zero (0) movement from the preceeding leveling year. The same reference mark was seldom used during successive leveling years.

To correct for this error, the NGS (Emory Balazs, Rockville, Maryland, personal communication) recommends normalizing the data. Using this approach, a single benchmark located beyond the production area is selected as a fixed point of reference. Elevation of other benchmarks along the survey line are normalized to the steady benchmark. To normalize the data for subsequent years, one year of elevation data is used as a baseline. The 1980 line of leveling between Lafayette and the Parcperdue test site was handled this way, using 1968 data as a baseline (Figure 8). Recall that the data is normalized, therefore movement illustrated in the figure is relative. An anomalous amount of subsidence (-95 mm) is indicated approximately halfway along the line. Otherwise, the most significant observation to this study is a subsidence trough in the vicinity of the Parcperdue prospect. As drilling of the test site had not commenced prior to releveling of this line, this subsidence cannot be attributed to test well operations. Natural movement of the fault block which defines the geopressured reservoir, however, is a possible cause.

Microseismic Monitoring During January 1980, Teledyne-Geotech was awarded a contract to perform microseismic monitoring at the Parcperdue test site. A reconnaissance noise survey of the site was completed during March 1980. Based upon the results of the survey,

Figure 8. Relative movement for benchmarks along the leveling line between Lafayette and the Parcperdue geothermal test site.

Figure 9. Location of photograph and sensor site, Parcperdue.

Figure 10. Cultural noise source regions, Parcperdue.

locations were selected for a network of five permanent, telemetered seismograph stations which were installed during May, 1980. Due to delays in the installation of a telephone line to the central recording facility, continuous data collection did not begin until August 8, 1980.

The following three sections described the results of the reconnaissance noise survey, the permanent monitoring network, and the results of the August 8 - December 31, 1980, monitoring program.

1. Reconnaissance noise survey. Temporary, continuously recording seismograph stations were established at eight locations within a 2.5-kilometer radius of the planned Parcedue test well. These locations are shown by the diamond shape symbols on the map in Figure 9. At each location, a Geotech S-13 vertical motion sensor was left to record noise data for an adequate period of time to include both a sample of culturally quiet (nighttime) background noise and high level (daytime) cultural activity.

An analysis of the spectral curves representative of background noise from the eight sensor site locations indicated a distinct difference in amplitude levels near 5 Hz at sites to the north of the planned well test sites as compared to the three most southern locations. Spectral samples from the sites in the northern part of the surveyed area (sites 1, 2, 3, 4, and 8) all contained prominent peaks near 5 to 6 Hz, which were diminished by as much as 20 dB in the spectra from sites 5, 6, and 7 which lie in the southern portion of the area.

The source of the 5 to 6 Hz noise peak observed at sites 1, 2, 3, 4, and 8 could not be identified by the single channel recordings at the temporary sites. A comparison of the 5 Hz peak level to the 6 Hz level at each individual site location indicated two separate noise sources. One source, associated with the 5 Hz peak, appears to be north of the well location, possibly from the direction of the Texas Gas Plant. The source of the 6 Hz peak, however, appears to be near the center of the surveyed area.

Assuming that the source (or sources) of the background noise is cultural rather than resulting from movement along the growth faults of the area, then it is probable that the high noise level of

the northern part of the surveyed area would be detrimental to the detection of microseismic signals. The 5 to 6 Hz band is well within the frequency range of the anticipated microseismic activity, and may be very near the peak of the signal spectral amplitudes. On the other hand, as shown in figure 10, to situate all sites toward the south of the proposed test well would result in an array "off center" from many of the zones of potential activity. This would have resulted in loss of accuracy in locating the seismic events which occur outside the array.

Another consideration against moving all sites southward was the possibility that the fault planes are refracting wavelengths associated with the 5 and 6 Hz peaks, and hindering their propagation toward the south. In this case, microseismic signals occurring in the well area might go undetected by an array positioned in the southern portion of the surveyed area. Therefore, Teledyne-Geotech recommended that the initial monitoring array configuration consist of two sites in the northern part of the surveyed area, two sites situated in southern portion of the area, and one site at the center of the array near the test well. Figure 11 is a schematic plan of the original permanent array configuration. A detailed report prepared by Teledyne-Geotech describing background noise at the Parcperdue site is presented as Appendix E to this report.

2. Description of permanent monitoring array. The installation of five surface seismographs in the Parcperdue area was completed by Teledyne-Geotech during the period May 27 - May 31, 1980. Geotech Model 18300 seismometers were installed in watertight sections of 8-inch-diameter PVC pipe buried approximately 3 feet deep at the locations shown in Figure 2. Batteries and voltage controlled oscillators (VCO's) for each unit were installed in nearby buildings or in shelter boxes constructed on site. The VCO output lines were run to the nearest telephone pole or left in a position to which telephone company personnel could run their lines. The units were activated and data was available at the VCO output terminals. When the final telephone splice was completed on August 8, data was recorded immediately.

During November, 1980, 100 foot deep boreholes were drilled at sites 2 and 3. Geotech Model S-500 seismometers were installed in these holes to improve signal-to-noise ratios. The geographical coordinates and the Y (north-south) and X (east-west) coordinates of the individual sensor sites are listed in Table 2. X, Y coordinates for a flat earth are measured relative to sensor site 1.

Table 2. Site coordinates

Site	Latitude			Longitude			Y(km)	K(km)
	Deg	Min	Sec	Deg	Min	Sec		
1	30	3	14	92	2	11	0.0	0.0
2	30	4	36	92	1	53	2.520	0.484
3	30	2	48	92	0	28	-0.797	2.768
4	30	2	4	92	2	39	-2.151	-0.752
5	30	3	58	92	3	13	1.352	1.666

Data from sites 2, 3, 4, and 5 were transmitted via local telephone lines to site 1 where the 5 channels were multiplexed together. The multiplexed signals were then transmitted via voice-grade telephone line to the Garland, Texas office of Teledyne-Geotech. At the Garland office the signals were discriminated and seismic outputs were recorded simultaneously on magnetic tape and 16 mm film.

The film records were reviewed daily to tabulate microseismic activity and to assess the general quality of the data. Signals which appeared at only one site are assumed to be noise near that site and were ignored. Those signals which appeared to be due to seismic exploration shots, thunder, or blasting (possibly at Jefferson Island salt dome) were listed separately. All other events were analyzed using MEHYPO, a digital computer program which determines magnitude, hypocenter, and reliability parameters of the local events. Epicenters were computed only for events observed at three or more stations because of possible ambiguities of solutions based on data from fewer stations.

Local seismic magnitudes were determined based upon maximum surface wave amplitude and calculated using the following equation:

$$M_L = \log_{10} (A/2) - 1.75 + 0.8 \log_{10} (X)^2$$

where M_L is the local magnitude

Table 3
Parcperdue Event Log

1980

<u>Date</u>	<u>Universal Time (UTC)</u> <u>Day: Hour: Minute</u>	<u>Comments</u>
August 7	0:46:33	Lightning
August 17	12:8:53	Thunder
August 30	12:50:43	M = 1.71
August 30	13:29:15	M = 2.19
September 2	10:31:46	Low Frequency
September 6	20:12:23	Lightning
September 7	19:50:16	Natural, M = 1.49
September 10	15:51:10	Regional
September 17	16:30:35	M = 2.53
September 18	15:31:10	Regional
September 19	15:30:17	Natural
September 20	10:22:49	Natural, M = 2.2
September 20	10:30:49	Natural, M = 1.8
October 18	4:16:35	Well noise, M = 1.49
October 26	4:32:1	Well noise, M = 1.33
October 27	20:6:51	Natural
October 31	5:12:15	Well noise
November 2	5:27:16	Well noise
November 6	16:20	Well noise
November 15	5:9:46	Night shot, M = .93
November 15	14:11:16	Well noise
November 17	3:33:15	Thunder
November 20	11:47:15	Distant Source, M = 1.71
November 23	23:15:43	Well noise
November 24	10:36:10	Well noise
November 25	19:20:6	Well noise
November 26	6:51:43	Well noise
November 27	1:34:2	Well noise
November 28	14:34:00	Well noise
November 29	10:20:00	Well noise
November 30	11:16:00	Well noise

where A is the peak maximum wave amplitude in nanometers (10^{-9} meters)

where $X = [(\text{epicentral distance})^2 + (\text{hypocentral depth})^2]^{1/2}$
(in kilometers) (in kilometers)

and $X = \text{must be } \geq 1.0$

The constant -1.75 in the above equation assumes a maximum amplitude to P-wave amplitude ratio of 40. Thus, a magnitude 0 event at 1 km distance would generate surface waves with a peak to peak amplitude of 113.2 mm and p waves with a amplitude of about 2.8mm.

3. Results. No naturally occurring seismic events with sufficient amplitude for detection of local subsurface sources were recorded during August - December, 1980. However, a variety of background signals demonstrated the capability of the monitoring system and data analysis procedures (Figure 12). These include: 1) seismic signals far beyond the reservoir area such as the Jefferson Island salt dome collapse, and regional and teleseismic events, 2) explosions, such as seismic exploration shots, 3) acoustic signals from well drilling and other cultural activity, and 4) thunder. Table 3 lists the times for event types observed.

Events from four distant sources were observed on both the Parcperdue and Brazoria County, Texas, arrays. One of the strongest signals recorded by the seismometers was Jefferson Island salt dome collapse on November 20th, 70 miles southeast of the Parcperdue site. At 11:47 Universal Time, a magnitude of 3 was recorded by all the stations; Figures 13 shows the filtered signals for the Jefferson Island dome collapse.

Seismic exploration shot signals were observed every few minutes almost continuously during daylight hours. However, a series of 16 signals similar to shots were recorded near 23:00 local time on 15 different nights. They were located at the two sites plotted in Figure 10.

Numerous acoustic signals having frequency content from 1.7-5 Hz were observed. This is a somewhat lower frequency range than expected

Figure 11. Original array configuration, Parcperdue test site.

WHAZORIA CO.

SITE 1 101K

SITE 2 101K

SITE 3 118K

SITE 4 126K

SITE 5 151K

PARCERDUE

SITE 1 58K

SITE 2 55K

SITE 3 72K

SITE 4 52K

SITE 5 46K

Figure 12. Background noise samples with microseismic event (magnitude 1.6),
1 January 1981 03:32:29 UCT (31 December 1980 21:32:29.29 CST).

for thunder. Also, they are quite numerous in November and December when thunderstorms are rare. The signals seemed to originate from the three regions outlined in Figure 10 and a few were located and plotted. At least two of these regions include well sites which may be sources of acoustic noise. Thus, the dates for these events are tentatively listed as well site noise in Table 3. Activity occurs dominantly during daylight hours, but sometimes continues around the clock.

Thunder signals have also been observed on the dates listed, primarily in the early fall. Frequencies are generally 9 Hz or higher. Many of these signals have tell-tale electrical interference on the records preceding the acoustic signals. The thunder signals correlate with thunder reported at Baton Rouge as well as with similar activity recorded by the array in Texas.

In summary, during the operational period of August 1st through December 31, 1980, the seismic array at Parceperdue recorded no detectable local microearthquakes. The minimum magnitude earthquake detectable by the Parceperdue array is estimated to be 2.2.

Sweet Lake

The Sweet Lake geopressured-geothermal prospect is located in a basin on the north flank of the Hackberry-Big Lake-Sweet Lake salt ridge 14 miles southwest of Lake Charles, Louisiana. Land use in the area is mainly agricultural, consisting of rice or soybean fields and pasture land. The prospect lies on the southern edge of Pleistocene Prairie Terrace bordering recent coastal wetlands. As a result, elevation and relief are low with a hydrologic gradient to the south through man-made canals and levees used for irrigation and drainage.

During November and December of 1979, LSU investigators conducted several site visits and a low altitude aerial survey to determine drainage patterns and land use/land cover within the prospect. Next, a review of available published and unpublished environmental data collected in the vicinity of the prospect were conducted. Considering site characteristics and the potential environmental impacts of resource testing, an environmental monitoring plan was then prepared for the Sweet Lake well test (Appendix F). According to these specifications, field stations were established to monitor air quality, seismicity, and subsidence within the prospect. Locations of field monitoring stations are shown in Figure 14. Instrumentation, laboratory analysis, and results of environmental monitoring studies at the Sweet Lake site are presented below.

Air Quality An ambient air quality and meteorological monitoring station was established approximately one mile northwest of the production well site (Figure 14).

The air quality monitoring station was installed and operated by Core Laboratories, Incorporated, of Lake Charles, Louisiana. The instrumentation necessary for monitoring air quality and meteorology was installed by Core Laboratories during July, 1980. The station provided continuous records of hydrogen sulfide, sulfur dioxide, non-methane hydrocarbons, and total hydrocarbons in accordance to previously stated EPA guidelines. The meteorological data was also the same as that collected at the Parcperdue test site (see Parcperdue air quality studies, p. 51-53). The following is a description of instrumentation used to monitor air quality and meteorology at the Sweet Lake test site.

1. Sulfur dioxide (SO_2) was monitored using a flame photometric

technique designated as an EPA equivalent method. The sulfur dioxide was measured when the monitor was equipped with a hydrogen sulfide scrubber allowing the measurement of sulfur dioxide in an activated state.

2. Hydrogen sulfide was monitored by the same analyzer used to monitor sulfur dioxide, but equipped with a sulfur dioxide scrubber which allows the specific measurement of hydrogen sulfide. This method has been approved by the EPA.

3. The monitoring of total hydrocarbons and non-methane hydrocarbons was accomplished by the use of the Meloy Model HC 500-2C Hydrogen Analyzer, which is an approved EPA method. This analyzer uses the flame ionization detector (FID) as described in 40 CFR 50. The analyzer contains a high temperature oxidizer to oxidize non-methane hydrocarbons allowing only methane hydrocarbons to be measured. The analyzer compares the methane hydrocarbons to the total hydrocarbons, determining the non-methane hydrocarbons.

4. Meteorological data (wind direction, wind speed, temperature and rainfall) was collected using Texas Electronics equipment. These sensors exceed all EPA specifications for PSD monitoring.

The ambient air monitoring instrumentation conformed to EPA standards and where applicable, instrumentation was designated as reference or equivalent or utilized designated methods of analysis.

Air quality and meteorological data at the Sweet Lake site were reported by Core Labs on a monthly basis. The monthly reports include the following tables and graphs for each of the four pollutants monitored:

- Maximum and average concentrations
- Day of month versus concentration
- Thirty highest 3-hour average concentrations
- Wind direction versus average concentration
- Hourly averages

The report submitted by Core Labs for the month of July is included as Appendix G to this Final Report.

Sulfur dioxide and non-methane hydrocarbons were the only pollutants monitored for which NAAQS have been established by the EPA (see Part - air quality).

Neither primary nor secondary NAAQS for sulfur dioxide were

exceeded during the six month period. The highest 24 hour average concentration was 14 micrograms/m³ reported on September 12, 1980. The wind direction was generally from the northwest to the north (270° to 360°) when SO₂ was reported. The sulfur dioxide was generally recorded in the day from 7:00 am to 5:00 pm during the six-month period.

Standards for non-methane hydrocarbons were exceeded on an average of four days each month. The highest concentrations of non-methane hydrocarbons during the NAAQS period was 8,747 micrograms/m³ on December 4, 1980. The extremely high concentrations occurred only during 2 months, September and December, and came primarily from the test well direction (90° to 157.5°) which is .7 miles from the monitoring station.

Total hydrocarbons were recorded at the site every day and ranged from 0 to 2,692 micrograms/m³ over a 24-hour period. The time of day when both methane and non-methane hydrocarbons were reported was basically the same each day, from 8:00 pm to 9:00 am. The wind direction from which the hydrocarbons came varied but were generally from the southeast to the northwest (135° to 292.5°).

Hydrogen sulfide was reported in minor concentrations at the Sweet Lake site from July to December. The average 24-hour concentration was between 0 and 2 micrograms/m³ during the six month period. The concentrations of H₂S occurred from 1:00 am to 10:00 am during the day but there was no apparent relationship between concentrations and wind directions.

Water Quality Monitoring Baseline water quality conditions in the vicinity of the Sweet Lake test site were determined for the calendar year 1980. Ground and surface water samples were collected and analyzed by KEMRON Environmental Services of Port Neches, Texas. The handling of all water samples was consistent as recommended by EPA in the "National Handbook of Recommended Methods for Water-Data Acquisition" (1977). Results of these analyses are present in Appendix H of this report.

1. Surface Water. Field reconnaissance at the Sweet Lake site indicated a major north to south drainage component in the immediate vicinity of the site. Man-made rice irrigation canals and hydrologic barriers within the section delineates the drainage well. The southern hydrologic barrier, Precht Road, is truncated by one ditch into which all of the southern drainage component converges. One surface water sampling station was located at this point (Fig. 14). Two other stations were placed south of Precht Road. One is located at the Square Lake flow

Fig. 14 Field monitoring locations, Sweet Lake Test Site.

entrance and the other within the main body of Sweet Lake. These latter two stations were designed to further define seasonal trends adjacent to and within the prospect (i.e., salt water intrusion and fresh water runoff).

Field and laboratory measurements for the Sweet Lake test site were identical with those taken at the Parcedue site. The results of monthly sample analyses for the period May through December, 1980, are listed with calculated year-end averages in tables of Appendix H. As geothermal fluid production had not commenced at the site, the data was analyzed solely for baseline information and seasonal trends. Graphs of temperature (Fig. 15) illustrate that the temperature at all stations attained a seasonal high during August and September and dropped off to a low in November. This rise in temperature during December was not expected but can be explained by a number of factors, such as fluid mixing/dilution or an increase in the sediment load of the water. The former is indicated by an increase in turbidity for two of the stations and when turbidity increases, so usually does the sediment load. An increase in fresh water outflow in the region may also be indicated (Fig. 15). Specific conductance reaches a seasonal high in November and declines in December, possibly due to runoff from the uplands. This graph, furthermore, may illustrate the effect of salt-water intrusion in the area. Notice that specific conductance near the bridge is hardly affected, whereas the lakes show a larger increase in specific conductance.

2. Ground Water. Electrical logs from the Sweet Lake area were analyzed for general lithology and pore water chemistry. A typical electrical log (Fig. 16) was interpreted as follows:

The upper 700 feet of the column is dominantly shale or clay, with the exception of a small fresh water sandy interval at -120 feet mean sea level (msl) and a couple of sandy shales at -250 and -500 feet msl, respectively. A much thicker fresh water sand was encountered between -700 and -860 feet msl. Below -860 feet, a shift in the shale baseline (SP curve) to the right is coupled with sand inflection. Gradual attainment of minimum resistivity values (resistivity curve) indicates a transition in pore water chemistry to a salinity maximum (for the scope of this study) at approximately -1360 feet msl.

Electrical logs and drillers logs were used in combination and were correlated across the Sweet Lake area (Figure 17). The stratigraphy

Fig. 15 Graphs of selected parameters for surface water stations near Sweet Lake.

Fig. 16 A typical electric log from the Sweet Lake Area: Nicklos Oil and Gas, Miami Corp. #2.

Fig. 17 Stratigraphic cross-section through the Sweet Lake test site

of the area is similar to the vertical sequence typified in the preceding log interpretation. The upper shale or clay unit is from 50 to 500 feet thick and contains a few sand lenses which can be up to 150 feet thick. This upper shale extends down to -200 feet msl at its thinnest point and -750 feet msl where thicker. A fresh water sand, 100 to 400 feet thick, is encountered below the shale and extends down to -500 and -900 feet msl, shallowest and deepest, respectively. Another shale, 10 to 200 feet thick, separates this fresh water sand from salt water sand which is dominant below depths of from -650 to -900 feet msl.

The validity of this interpretation can be verified with a look at available water quality data (Table 4). A well tapping the salt water sand (CN-88) is producing water with a specific conductance of 4270 umhos/cm, 2400 ppm total dissolved solids, 865 ppm Na, and 1270 ppm Cl. Inversely well no. CN-22 is tapping the fresh water sand. Total dissolved solids and Na contents are not available for that well, but specific conductance and Cl are very low (574 umhos/cm and 399 ppm, respectively).

Ground water flow through the Sweet Lake test site is consistently north to north-northwest based on piezometric surface maps published from 1954 to 1962. This results in a hydraulic gradient toward Lake Charles, presumably due to consistently high pumping rates in the Lake Charles area.

The first ground water observation well (#3 in Fig. 14) was drilled approximately 200 feet north-northwest of the production well site. This observation well, completed at 435 feet, was logged electrically by the USGS (Fig. 18). In general, the drill bit encountered clay from the surface to approximately 200 feet. Fine-grained sand, encountered at 200 feet, graded into pea gravels at the bottom of the hole. This well is screened in the bottom ten feet of the hole. Two other wells (#1 and #2) were then drilled and screened at the top of the Sand, at -280 feet msl. They are located approximately 100 feet north of the disposal well and 150 feet north-northwest of the production well, respectively.

Data for the calendar year, 1980, was sparse due to a late start in the sampling program. However, some trends were still obvious during the three month sampling period (Fig. 19). Groundwater temperature was highest for all wells during the month of December. Turbidity was lowest during December. Specific conductance varies somewhat between

Table 2. Representative water quality data for water wells near the Sweet Lake test site.

Well No.	Depth	Date	Water Level	SC	pH	CaCO ₃	TDS	SiO ₂	HCO ₃	SO ₄	NO ₃	PO ₄	CO ₃	CO ₂	Fe	Ca	Mg	Na	K	Cl	F	Mn	B	Br
Cn-88a	953	2-11-64	42.44 GL	4270	7.6	154	2400	35	301	9.6	--	0.04	0.0	--	1.4	3.4	35.0	865	7.0	1270	0.1	0.13	0.08	1.6
Cn-114A	288	11-16-72	21.62 GL	911	8.3	84	540	32	358	0.4	0.1	--	0.0	--	540	18.0	9.5	180	4.0	130	0.4	10.0	--	---
Cn-114B	393	11-15-72	21.85 GL	1790	8.3	160	1040	27	384	0.2	0.1	--	0.0	--	340	36.0	16.0	310	1.5	380	0.4	10.0	--	---
Cn-92	453	12-23-64	31.88 P	1190	7.6	161	689	25	312	40.0	0.0	0.0	0.0	--	0.13	36.0	17.0	187	2.2	182	0.1	0.04	0.3	---
Cn-92	453	8-02-79	---	1810	-	---	--	--	---	--	0.3	--	---	--	--	--	--	---	---	410	---	--	--	1.4
Cn-90	401	3-24-64	20.40 GL	1160	7.9	116	652	26	288	1.6	0.2	0.34	0.0	--	0.16	26.0	12.0	212	2.1	230	1.1	0.01	0.09	0.1
Cn-90	401	3-28-79	---	987	-	---	--	--	---	--	--	--	---	--	--	--	--	---	---	160	---	--	--	0.5
Cn-10	376	7-14-48	6.00 GL	1250	8.5	182*	--	--	272	--	--	--	---	--	3.3	--	--	---	---	242	0.2	--	--	---
Cn-10	376	5-25-50	6.00 GL	1210	7.6	104	690*	26	305	0.3	1.0	--	0.0	12.0	0.12	27.0	8.7	219	17.0	241	0.1	--	0.14	---
Cn-22	388	7-14-48	---	574	8.5	73*	--	--	256	--	--	--	---	--	1.0	--	--	---	---	39	0.0	--	--	---

*In CaCO₃ column; old analyses used soap.
In TDS column; calculated sum.

Depth in feet
Water level: feet below ground surface
Specific conductance (SC) in umhos/cm
pH in standard units
All other values in mg/l

Fig. 18 Electric log of Sweet Lake observation well

wells. Well #3, the deepest well, attains the highest specific conductance. The sand trapped by this well is deeper and thus more affected by salt water intrusion. The specific conductance data for well #2 was very similar to the data of well #3. Although well #2 was the shallower well of the two, they are probably hydraulically connected. Well #1 is either hydraulically restricted with respect to the other two wells or is closer to a fresh water recharge source.

3. Subsidence and Microseismic Monitoring Baseline studies of subsidence and seismicity were conducted at the Sweet Lake test site during 1979-80. The study included an analysis of historical leveling data as well as the installation of additional benchmarks and seismometers around the test site. Methods for benchmark setting and leveling were consistent with those recommended by the National Geodetic Survey (NGS).

Subsidence Studies A first-order NGS vertical control line is located within 1/4 mile of the Sweet Lake test site, along Highway 384 which transects the prospect from east to west. Another first-order survey line is located east of the test site along Highway 27 (Figure 20). The line along Highway 27 was established by NGS in 1965 and surveyed during 1965 and 1968. The Highway 384 line was established and surveyed by NGS during 1968. Portions of both lines were releveled under the DOE geopressured test well program during 1980, prior to flow testing and in accordance with NGS specifications for first-order precise leveling.

Leveling data was collected for the years 1965 and 1968, and was incorporated into a baseline subsidence analysis along with the 1980 project leveling. This data (Appendix I) was normalized to a reference benchmark and year. The normalized data indicates movement of the benchmarks along the leveling line. Uplift has been recorded along highway 27 from benchmark Q214 to south of highway 384 (Fig. 21). This could be due to movement of the Sweet Lake Salt Dome located 5.2 miles southeast of the test site. On the other hand, a leveling line along highway 384 toward and through the test site and perpendicular to highway 27 indicates that subsidence has occurred in the immediate vicinity of the test site (Fig. 27). The cause for this subsidence is questionable. Perhaps unmapped faults cross the area or previous oil, gas and ground water production in the area has created a core of depression. Needless to say, the data in the area is sparse and little can be done with such scattered information. This

Fig. 19 Graphs of selected parameters for observation wells at the Sweet Lake test site.

Fig. 21 Relative movement along a line of benchmarks along Highway 27 from Interstate 10 to the vicinity of Sweet Lake, LA.

Fig. 22 Relative Movement along a leveling line which runs through the Sweet Lake test site.

alone confirms the need for continued and renewed interest in subsidence monitoring of geopressured-geothermal prospects. A number of releveling years is necessary to determine the movement trend before and after geothermal production.

An example of the results of a more regular releveling program is illustrated in Fig. 23. The graph illustrates the amount and direction of movement per year relative to 1955 for an area between Lake Charles and Sulphur. Notice that in Figure 23 the movement trend for the area is downward. This subsidence trough is located in the vicinity of the Lockport oil and gas field.

Other normalization methods are being studied. One such method was to hold a reference benchmark steady at one elevation for every year of leveling and to adjust all benchmarks along the line to that elevation. Using this method, graphs of surface elevation were obtained (Fig. 24) rather than graphs of elevation change. One advantage to this method is that a large number of benchmarks can be utilized since the baseline is sea level. The data, however, is less illustrative and much more difficult to interpret. The same benchmarks were not necessarily leveled each year and, therefore, a wider spacing between data points was obtained. For instance, the data for 1955 (Fig. 24) exhibits a proliferation of peaks and valleys between Sulphur and Lake Charles, whereas the 1981 data is essentially smooth. The one observation that can be derived from this data is the existence of a topographic low or series of lows between Sulphur and Lake Charles. Lake Charles and Sulphur are both topographically high.

4. Microseismic Monitoring. Woodward-Clyde Consultants was selected to perform microseismic monitoring in the vicinity of the Sweet Lake test site. The Sweet Lake seismic network became operational in late March, 1980. Early background data, natural and cultural noise, was collected in March and April to established seismically quiet locations for the permanent seismic stations. Portable monitoring equipment consisted of Sprengnether, Inc. MEQ-800 units; one instrument was deployed in March, 1980, and two additional units were stationed in June, 1980. Data recovery was good, but intermittent as a result of mechanical failures. The portable seismometers collected and produced baseline data from late March, 1980 to late July, 1980.

Fig. 23 Subsidence trends between Sulphur and Lake Charles.

Fig. 24 Topographic cross-sections between Sulphur and Lake Charles.

The permanent seismic network was installed from July 26th to July 30, 1980. The monitoring array consists of eight permanent field stations as shown in Figure 14; station coordinates and depth to seismometers are listed in Table 5. Field stations consisted of a seismometer and a standard seismic telemetry package and power supply. The seismometers, installed in bore-holes ranging from 65 to 90 feet below ground surface, are Mark Products L4A 2 Hz seismometers (Fig. 25).

The standard seismic telemetry packages are those manufactured by Sprengnether, Inc. (Fig. 26). Telemetry packages included an amplifier and voltage-controlled oscillator (VCO) that provides for continuous data transmission via telephone lines. Data from each field station is transmitted on a different carrier frequency, and all frequencies are multiplexed and transmitted to the central recording facility on a multi-point telephone lines. The VCO frequencies used for data transmission are 680 Hz, 1020 Hz, 1360 Hz, 1700 Hz, 2040 Hz, 2380 Hz, 2720 Hz and 3060 Hz. Field telemetry packages are powered by 12 volts DC provided by air cell batteries.

Appurtenant equipment includes a time-code generator and time-code reader for recording and playing back station data on a common time base. Recorded time is the basis for analysis of seismic data and hypocentral (or location) determinations.

The seismic data is collected and transmitted at each station using standard seismic telemetry via telephone lines to the central recording facility at Woodward-Clyde Consultants office in Baton Rouge, Louisiana. Data is recorded on magnetic tape based on a continuous 24-hour day period. In addition to the Honeywell 101 magnetic tape recording system, at any one time, selected station data can be recorded on three hard copy drum recorders.

Drum records are scanned to detect possible naturally-occurring seismic activity on a daily basis. Upon detection of possible events, all station data is played back from magnetic tape into hard copy format through an oscillograph. Station data is further reviewed and analyzed for hypocenter and other characteristic properties using FASTHYPO, a modified version of the earthquake location program HYPOELLIPSE.

Initial baseline monitoring with portable seismometers revealed a variety of seismic noise; the sources ranged from day time cultural noise to nearby geophysical surveys. These seismic events are based on overall

TABLE 5

SWEET LAKE SEISMIC MONITORING NETWORK

<u>Site</u>	<u>Latitude (N)</u>			<u>Longitude (W)</u>			<u>Depth of Seismometer (ft)</u>
	<u>Deg</u>	<u>Min</u>	<u>Sec</u>	<u>Deg</u>	<u>Min</u>	<u>Sec</u>	
CPT	30	02	37	93	12	47	70
CPF	30	00	04	93	08	02	90
CLB	30	01	16	93	08	43	65
SFY	30	00	50	93	10	56	70
HWN	30	01	05	93	05	19	90
WLR	30	03	34	93	07	41	75
JCF	30	02	16	93	07	01	75
HWS	29	59	33	93	05	17	75

Fig. 25 Simplified station design

Fig. 26 Block schematic diagram of a WCC telephone telemetry system.

seismic signature, amplitude, code length and time of occurrence. Three microseismic events of negligible magnitude were detected on May 1st and May 9th (Table 6). Epicenters could not be determined, since data from at least three stations is required to locate an event. All other events recorded from March through July, 1980, were classified as artificial seismic events.

Telemetered data from the permanent network was transmitted beginning July, 1980. From July through October, no naturally-occurring or suspect seismic events were detected by the network; however, artificially-induced seismic activity was intermittently recorded during this period. Again, these events are attributed to geophysical surveys and cultural background noise.

During November and December, short, artificially-induced events were observed and were attributed to local geophysical surveys. Several teleseisms, or distant earthquakes of magnitude greater than 5, were recorded and are listed in Table 6. Of particular interest is the seismic record of the Jefferson Island salt dome collapse, 63 miles east of the Sweet Lake site. On November 20, 1980, 11:26 UTC, seismic activity lasting nine (9) minutes was attributed to the salt dome collapse.

Analysis of seismograms reveal 3 unique seismic signatures: geophysical blasting, true microseisms and distant teleseisms. An example of each type of seismic activity is shown in Figures 27, 28, and 29. The signal produced by blasting is characterized by large surface waves; whereas true seisms and teleseisms produce S and P waves.

In summary, the Sweet Lake monitoring system revealed minimal seismic activity. No direct correlation existed between geopressure-geothermal well operations and local seismic activity based on analysis of the Sweet Lake drilling schedule and seismic arrival times. Seismograms revealed a high amount of background noise attributed to local cultural activity, nearby geophysical surveys, and drilling activity at the test well. This noise exhibits low energy with magnitudes less than two.

This first year data baseline will be further utilized when fluid production tests are completed to study growth fault movement and displacement relationships for induced events within the Gulf Coast region. This information will also affirm the relationship between seismic displacement and subsequent or potential ground subsidence.

Table 6

Sweet Lake Even Log

1980

<u>Date</u>	<u>Universal Time (UTC)</u> <u>Day: Hour: Minute</u>	<u>Comments</u>
May 1	23:57:23.5	Possible natural occurring seismic event
May 9	05:07:08	Possible natural occurring seismic event
May 9	05:09:46	Possible natural occurring seismic event
November 1	306:22:57	Teleseism
November 8	313:10:33	Lasted 19 minutes
November 19	324:20:01	Very small
November 20	325:16:36	Possible record of Salt Dome Collapse Lasted 9 minutes (Jefferson Island)
November 28	333:14:30	Teleseism
December 1	336:14:48 336:17:33	Teleseism Questionable
December 11	346:18:25	Teleseism
December 14	349:22:15	Teleseism
December 15	350:08:26 350:10:14	Teleseism Teleseism
December 17	352:20:46	Teleseism
December 31	366:18:14	Teleseism

Examples of Blasting

Figure 27 Seismogram showing short, artificially induced seisms caused by geophysical surveys.

Lake Fcigneur Collapse

CPF 1020/200
325:16:27/2010

Figure 28 Seismogram showing Lake Peigneur Jefferson Island Salt Dome Collapse, Nov. 20, 1980, 11:26 UTC.

1

 

SUPPORTING RESEARCH AND TECHNOLOGY ASSESSMENT

Overview

This particular function within the contract had the broadest perspective of any under the contract. Whereas, other components of the research addressed specific disciplinary subject areas, such as rock mechanics or geology, this function analyzed the system as a whole. Consequently, the professionals working on this portion of the contract represented such diverse disciplines as Chemical Engineering, Industrial Engineering, Economics and Sociology. Work conducted under this function required inputs from the other study efforts and provided an analysis of the impact of individual findings on a total prospect development. The origin of this effort can be found in the results of a previous contract supported by DOE on Operations Research and Systems Analysis of Geopressured-Geothermal Energy in Louisiana (Contract No. FG08-78ET27085). A major analytical tool (developed under that contract) called the LSU Technoeconomic Site Simulation Model was maintained and improved under this contract and will be discussed in this portion of the report.

The study of socioeconomic impacts has been continued under this contract and is reported on below. Finally, as new high-grade geopressured-geothermal test sites have been identified by the Petroleum Engineering Department at LSU they have been added to the prospect data base and analyzed.

Revisions to Methane Solubility Subprogram

Introduction In February, 1980, (the fourth month of the subject contract period), Mr. Leonard Coco, a graduate student in chemical engineering, began his M.S. research project on the correlation of methane solubility data. This research project was sponsored by the systems analysis contract, and its objectives were to gather together all available published data on the solubility of methane in water and sodium chloride brine; to make improvements and refinements to the correlation method proposed by A. E. Johnson (1980), to find an overall correlation for the entire data set, and to incorporate the results into the computer subprogram SOLUTE for use in the technoeconomic model of the systems analysis project.

Mr. Coco completed this research during the contract period, including the incorporation of the resulting correlation into subroutine SOLUTE. However, his M.S. thesis has not yet been written, nor has a comprehensive article for publication. In this year-end report, the work which he performed is described in summary form, and comparisons of the correlation results with experimental data and other published correlations are presented. A more detailed report of the work will become available upon completion of the M.S. thesis, and a paper will be presented at the Fifth Geopressured-Geothermal Conference, October 13-16, 1981, Baton Rouge, Louisiana.

Summary of Work Done On Correlation of Methane Solubility The following major items were accomplished in this thesis research project:

- (1) The data published by Culbertson and McKetta (1951), O'Sullivan and Smith (1970), Price (1979), Blount et al (1979), Sultanov et al (1972), and Namiot et al (1979) were incorporated into a data base for use in the correlation.
- (2) An equation of state for methane and water mixtures proposed by Nakamura, Breedveld, and Prausnitz (1976), was programmed to provide for calculation of fugacity coefficients for water and methane in the vapor phase.
- (3) Other physical properties subroutines were developed for water vapor pressure (Keenan and Keyes, 1978), and liquid molar volumes (Rosel equation in Yaws, 1977).
- (4) Using the water only data from the above sources, an equation for Henry's law coefficient for methane in water was obtained

as a function of temperature, total pressure, and methane concentration.

- (5) Using the data for sodium chloride-water solutions from the above sources, an equation for the salting-out coefficient for methane as a function of temperature and salinity of the brine was obtained. (Pressure had no effect)
- (6) The resulting correlation equations were incorporated into subroutine SOLUTE to provide a comprehensive subprogram for any given temperature and pressure.

Description of Correlation Method The solubility of methane gas in a liquid at equilibrium can be calculated by the following equation, which is based on fundamental thermodynamic equilibrium relationships (Johnson, 1980):

$$x_{\text{CH}_4} = f_{\text{CH}_4}^{\text{v}} / H_{\text{CH}_4} \quad (1)$$

where

x_{CH_4} is the mol fraction methane in solution in the liquid phase

$f_{\text{CH}_4}^{\text{v}}$ is the fugacity of methane in the vapor phase, atmospheres

H_{CH_4} is Henry' Law coefficient for methane in the liquid phase, atmospheres

To use equation (1) for predicting the solubility of methane in sodium chloride-water solutions, one must be able to calculate both of the terms on the right hand side of the equation. In this work, an equation of state proposed by Nakamura et al (1976), was used to calculate methane and water fugacity coefficients (both methane and water are present in the vapor phase at equilibrium), and the fugacity of the methane was calculated by the following fundamental equation:

$$f_{\text{CH}_4}^{\text{v}} = \phi_{\text{CH}_4} y_{\text{CH}_4} P_t \quad (2)$$

where

ϕ_{CH_4} is the fugacity coefficient of methane in the vapor phase

y_{CH_4} is the mol fraction of methane in the vapor phase

P_t is the total pressure, atmospheres

To correlate the experimental data, equations (1) and (2) were used to calculate experimental values of Henry's Law coefficient for each data point, and these experimental values were correlated as a function of temperature, pressure, salinity, and mol fraction of dissolved methane. The effect of salinity was treated separately from the other variables by means of the familiar "salting-out" coefficient

$$H_{\text{CH}_4} = H_{\text{CH}_4}^{\circ} 10^{-mK} \quad (3)$$

where

$H_{\text{CH}_4}^{\circ}$ is Henry's Law coefficient for methane dissolved in water only, at the temperature and pressure of interest

K is the salting-out coefficient for methane in brine solutions

m is the molality of the sodium chloride brine solution

Correlation Results Data from the following sources were used in this work:

<u>Authors</u>	<u>Date</u>	<u>Solution Type</u>	<u>Number of Data Points</u>
Culberson-McKetta	1951	water only	72
O'Sullivan-Smith	1970	water-NaCl	50
Sultanov et al	1972	water only	71
Namiot et al	1979	water-NaCl	14
Price	1979	water only	71
Blount et al	1979	water-NaCl	492

It was found that the data from Blount et al, which was extensive, particularly with respect to salinity, unfortunately did not agree with the data from the other sources. The experimentally calculated Henry's Law coefficients for the Blount data were consistently lower (by about 20-25%) than those calculated from data of other investigators. Consequently, the water only data of Blount et al, were not included in the data base used to develop the correlation for Henry's Law coefficient for methane dissolved in pure water.

The salting-out coefficients calculated from the Blount data,

however, appeared to be consistent with those calculated from data of O'Sullivan-Smith (1970) and Namiot et al (1979), (the only other investigators of water-NaCl solutions). This suggested that some kind of consistent bias has been introduced during the mathematical treatment of the raw data by Blount, which cancelled out when salting-out coefficients were calculated. It was therefore decided to include the salting-out coefficients calculated from Blount data in the data base used to develop a correlation for the salting-out coefficient.

Pure Water Correlation

The correlation of the Henry's Law coefficients for the water only data base (all sources except the Blount data) resulted in the following equation:

$$\begin{aligned} \ln (H_{\text{CH}_4}^{\circ}) = & a_0 + \frac{a_1}{R_c} \left(\frac{1}{T} - \frac{1}{T_0} \right) + \frac{a_2}{R_c} (T - T_0) + \frac{b}{R_g T} (1 + cP) (P) \\ & + \frac{d}{R_c} (x_{\text{H}_2\text{O}}^2 - 1) \end{aligned} \quad (4)$$

where

$H_{\text{CH}_4}^{\circ}$ is Henry's Law coefficient for methane in solution in pure water

$a_0, a_1, a_2,$ are parameters determined by non-linear least squares fit to the experimental data (see table below)

b, c, d

T is the temperature, deg. K, of the system

P is the atmosphere pressure of the system

$x_{\text{H}_2\text{O}}$ is the mol fraction of water in the liquid phase at equilibrium

R_c is the gas constant, 1.987 cal/(g mol) (K)

R_g is the gas constant, 82.05 (cc) (atm)/(g mol) (K)

The values of the parameters in equation (4) which best fit the data are given in the following table:

Results of Least Squares Fit of Salinity
Data for Methane-Water System

<u>Parameter</u>	<u>Value</u>	<u>5% Conf. Lim.</u>	<u>Comments</u>
a_0	10.407 Ln atm.	± 0.0197	This is $\ln H^{\circ}$ at $P = 0, T = T_0,$ $x_{\text{H}_2\text{O}} = 1$

Results of Least Squares Fit of Salinity
Data for Methane-Water System

Parameter	Value	5% Conf. Lim.	Comments
a_1	-6814.8 cal/(g mol)	± 199.9	These two parameters account for effect of temperature on H° . Since their effects are opposite, a maximum occurs at 376.6 K.
a_2	-0.9533 cal/(g mol)	± 0.0105	
b	$62.329 + .007338$ $(T - T_0)$ cc/(g mol)	$+5.79$	This parameter accounts for the primary effect of pressure on H° . It is the partial molar volume of methane in the liquid phase solution.
c	$-0.00009149 \text{ atm}^{-1}$	$\pm .0000393$	This parameter, the compressibility of methane in the liquid phase solution accounts for the curvature of $\ln H^\circ$ vs. pressure.
d	$22.728 - 549.82$ $\ln \frac{T}{T_0} + 0.9006 (T - T_0)$ cal/(g mol) (K)	± 6.85	This parameter, Margules' coefficient, accounts for the effect of the methane content of the liquid phase upon $H_{CH_4}^\circ$ ¹² .
T_0	465.5 K	—	Reference temperature chosen for the equation.

Equation (4) above accounts for the effects of temperature, pressure, and methane content of the liquid phase upon the escaping tendency of methane from a liquid solution of water only and methane by predicting the Henry's Law coefficient for the dissolved methane. The mathematical forms chosen to represent this relationship were based on fundamental thermodynamic equations (Keenan and Keyes 1978), so that the six parameters a_0 , a_1 , a_2 , b , c and d represent meaningful physical or thermodynamic quantities. It was found that the overall fit of the equation to the experimental data could be statistically improved by

allowing for temperature variation of parameters b and d as shown in the parameter table.

Salting-out Effect

The result of correlating the effect of salt (NaCl) content upon Henry's Law coefficient using equation (3) gave the following results:

$$K = K_0 + K_1 (T - T_0) + K_2 (T - T_0)^2 (1.0 - 0.045m) \quad (5)$$

where

K = salting-out coefficient for methane in salt solutions

m = molality of the salt solution, gm mols NaCl per 1000 gms water

$K_0 = 0.08022 \pm 0.00973$, molality⁻¹

$K_1 = 0.0002751 \pm 0.0000653$, (molality)⁻¹ (deg.K)⁻¹

$K_2 = 4.39 \times 10^{-6} \pm 1.59 \times 10^{-6}$, (molality)⁻¹ (deg.K)⁻²

T_0 = Reference temperature, 455.65 deg.K

No pressure dependence was found for K , but the final equation (5) shows a definite temperature dependence and a slight effect of salt content.

Comparisons of the LSU Correlation With Those of Haas and Blount

The primary objectives of this work were to (1) produce a correlation which was fundamentally rather than empirically based, and (2) utilize as much as possible all available data. By using the water only data from all sources except Blount, and by using the salt solution data from all sources including Blount, this objective was achieved. Regardless of its fundamental soundness, the practical value of the resulting correlation depends primarily upon whether it fits the available source data at least as well as either of the other two published correlations. If so, then the more fundamental basis of the LSU correlation suggests that it should be a more reliable predictor of methane solubility, particularly should extrapolations outside the region of the data be necessary.

Monte Carlo

The uncertainty associated with developing a geopressured-geothermal site is, in large part, why this study is under government funding and demonstration. In contrast, the risks associated with conventional oil and gas production are much better defined because of the historical record which assists in assigning those risks. The lack of a historical record of risks in producing geopressured gas requires a fundamental approach to risk evaluation. Since production is ultimately determined by the physical characteristics of the reservoir, it is the uncertainty associated with those characteristics and their interaction that determines the overall "dry-hole" risk of a specific site. A method of estimating this total risk, based on available geological, seismological, and well logging data is being incorporated into the LSU Technoeconomic model.

The method being used to make this estimate is referred to as a "Monte Carlo" simulation. A deterministic model is one in which a set of fixed input parameters are used in a mathematical algorithm or algorithms to produce a set of fixed output values. A Monte Carlo model, on the other hand, begins with a fixed set of probability distributions for each of the input parameters, from which an individual value for each parameter is selected at random. This set of randomly selected parameters is then processed to produce a set of output variables. If this process is repeated many times, possibly 500, then an approximation to the distribution of the output variables is obtained. This output distribution allows the reporting of:

1. The average mean value of the output parameter
2. The minimal order statistic
3. The maximal order statistic
4. The probability of achieving any specific output value.

To incorporate the Monte Carlo technique into the LSU model requires acquiring the characteristic input distributions for each of the reservoir parameters. Since there is no existing estimate of these distributions, a simple distribution was used, the triangular distribution. This distribution is depicted below:

This distribution is completely described by the values P (pessimistic), ML (most likely), and O (optimistic). These values can be assigned either completely subjectively based upon expert judgment, or semi-objectively, when some data are available for the parameter values from well logs in the region. This Monte Carlo method was tested using hypothetical input values for the reservoir subroutine only from the technoeconomic model. This test indicated that the reservoir subroutine should be modified to shorten computation time to allow 500 to 1000 simulations. The difficulty arose from the fact that the original reservoir subroutine calculated the flow rates and pressures for each day of production, i.e., for 7300 days over the 20 year production horizon. When coupled with a 1000-run Monte Carlo simulation results in 7.3 million simulated days requiring approximately 2000-3000 cpu seconds. This difficulty was alleviated by modifying the reservoir subroutine to solve explicitly for the number of days that each flow level can be sustained before the well head pressure drops below the minimum required rather than calculating flow and pressure on a daily basis. Effort is now underway to incorporate this modified reservoir subroutine into a revised version of the technoeconomic model that makes all computations essentially on an annual basis. In addition to acquiring the various input distributions, by conferring with petroleum geologists and engineers, work is also underway to obtain distributions of selected economic variables. The results of the Monte Carlo simulations will be reported in 1981 under the DOE contract which replaces this one.

Socioeconomic Impact Assessment

The plans for the second project year for this section of the research effort focused on an analysis of methodological procedures and techniques employed in the assessment of the socioeconomic impacts to the areas surrounding geopressured-geothermal energy development sites. Specifically, the goals included a refinement of these research procedures and to begin research efforts directed toward the development of a general model for assessing socioeconomic impacts applicable to a wide range of different energy development technologies.

An Analytical Framework

Research to date has suggested that the factors which influence the impact of energy development may be grouped into two broad categories: those associated with the host location, "site-specific" factors, and those factors associated with the scale of the facility, often labeled "technology-specific" factors. Using this framework, we have isolated and investigated a variety of different issues central to the analysis of socioeconomic impacts. We argue that the satisfactory resolution of issues such as these is crucial to a valid analysis of socioeconomic impacts. These issues are presented and discussed below.

Site-Specific Issues

There are four salient issues relative to the site surrounding the energy development: two of major consequence--the choice of a unit of analysis and the choice of variables to represent the socioeconomic environment; and two of less significance--the timeliness of available indicators and the problem of different data sources.

Choice of a Unit of Analysis

An important issue facing the impact analyst is the choice of a geographic unit of analysis for his/her research. Because most analyses depend upon available data, the choice is usually constrained to geopolitically bounded units such as townships, municipalities and counties. However, the particular unit of analysis chosen can have an important influence on the outcome of the research. This fact may be seen by using the case of the siting of a large gas-separation plant within a county containing a small town.

If the town alone were chosen as the unit of analysis, very large potential impacts (both positive and negative) would emerge from the analysis. However, if the county as a whole were used, the projected impacts would be less important. Thus, the magnitude of impacts resulting to the socioeconomic environment of the host area are dependent, in part, on the definition of the boundaries of the area. Impact analysts must be sensitive to the implications of this fact.

Choice of Variables

Another important "site specific" issue is the choice of variables to represent the socioeconomic environment of the host area. The analysis of impacts to key dimensions of the socioeconomic environment is precluded if variables representing these dimensions are not included in the analysis. Choice of variables, however, is complicated by the fact that the socioeconomic environment is a complex entity and literally hundreds of variables are available. This situation is made even more untenable by the fact that different energy technologies may have impacts on the different aspects of the socioeconomic environment of the host area. Thus, the analyst must be careful to include all salient dimensions of the environment of the host area in his/her analysis.

Timeliness of Indicators

Another important concern for the impact analyst is the fact that the information which he/she uses in the analysis may have been collected at very different points in time and may be quite dated. This is particularly true if the analyst uses the federal census for data late during a decade. For some indicators, this is less of an impediment because the federal government updates these measures periodically; for other measures, such as educational attainment of the population, data are only gathered at the beginning of each decade. This problem is exacerbated when the host area has undergone rapid growth during the decade. The impact analyst must be careful, then, not to confuse the fact that the data are no longer representative of the host area with an energy development related impact to the host area.

Data Source Problems

The last site-specific issue is the problem of integrating data from different sources. The impact analyst, of necessity, must use data from a variety of different sources to characterize the environment of the host

area. Often these data are not strictly comparable in that they were collected by different agencies for different purposes. The data may not even encompass the same geo-political area. Thus, another potential source for extraneous variation in the impact analysis is the data source problem. The analyst must consider the impact of such differences on his/her outcomes.

Technology-Specific Factors

The second set of issues which influence the impact of energy development concerns the parameters of the proposed development itself. There are two major issues here: specifying the precise nature of the proposed development, and accurately estimating the pace (or time-frame) of the development.

The Nature of the Proposed Development

For the impact analyst to accurately predict the impact of a given energy development site to a host area, he/she must first carefully delineate the nature (scale) of the proposed facility. This problem is particularly severe for relatively new energy development technologies, since it is often more difficult to make these estimates in advance than it is for more well-known kinds of energy development. Yet, the accuracy of the projection of impacts to the host area is heavily dependent upon the validity of such estimates. Even in the case of the more well-known technologies, particular applications often generate deviations from the "normal" case. Inaccurate characterizations of the nature of the proposed development (no matter their source) create additional barriers to the accurate assessment of impacts.

The Pace of Development

Another crucial problem facing the impact analyst is making a careful estimate of the pace at which the development will occur. For most energy development alternatives, the pace of development will vary during the course of the development. For example, some researchers analytically divide development into phases, such as "construction phase" and "operational phase." Accurate analysis of impacts to the host environment depends heavily upon a precise forecast of the duration of the different phases of the development as well as for the total. However, such precision is often made more difficult by extraneous influences such as delays due to weather, materials shortages, labor unrest, and permitting. Without accurate "pace" estimates, however, the assessment of impacts to the host area are tenuous at best.

Conclusions

Research during the second project year has isolated and analyzed six methodological issues critical to the accurate assessment of socioeconomic impacts to the environments surrounding geopressure-geothermal energy development sites. We have argued that an awareness of these problems and an adequate resolution of each is essential for an accurate assessment of impacts to these areas. We plan to continue our efforts to add further clarity to such issues since they are central to the analysis of the socioeconomic impacts of energy development.

Site Specific Evaluations Made with Technoeconomic Model

Introduction

Specific geopressured sites have been evaluated utilizing a technoeconomic simulation model developed at LSU under DOE contract number FG08-78ET27085. A detailed description of this model and its capabilities can be found in the final report of that contract entitled "Operations Research and Systems Analysis of Geopressured-Geothermal Energy in Louisiana" DOE document number DOE/ET/27085-1. Briefly, the Fortran language model simulates the operating characteristics of a bounded, radial aquifer in two dimensions and predicts gas flow, brine flow, costs, and revenues over a 20 year production life. The model was used in 1979 to make an economic evaluation of six sites identified and described in William Bernard's "Evaluation of Five Potential Geopressure-Geothermal Test Sites in Southern Louisiana", Baton Rouge, La.: Petroleum Engineering Department, LSU, prepared for DOE contract number EY-76-5-05-4889. This analysis is reported in Appendix 2 of DOE/ET/27085-1.

Since that time Zaki Bassiouni has identified six additional high grade sites and described them in "Evaluation of Potential Geopressure-Geothermal Test Sites in Southern Louisiana", Baton Rouge, La.: Petroleum Engineering Department, LSU, 1980. The sites identified are Bayou Hebert, Kaplan, Grand Lake, Lake Theriot, South White Lake and Solitude Point. These six sites have been simulated during the course of this contract and the results of those simulations are reported below.

TABLE 1

DATA BASE ADDITIONS — BASSIOUNI SITES

	<u>Bayou Herbert</u>	<u>Grand Lake</u>	<u>Kaplan</u>	<u>Lake Theriot</u>	<u>Solitude Point</u>	<u>South White Lake</u>
<u>Area (acres)</u>	46,080	31,360	61,440	30,720	43,618	32,640
<u>Thickness (feet)</u>	451	475	275	463	1,000	525
<u>Cubic Volume (mi³)</u>	6.15	4.41	5.00	4.21	12.91	5.07
<u>Porosity (%)</u>	16	18	23	28	9	12
<u>Permeability (Md)</u>	45	21	273	103	5	68
<u>Reservoir Pressure (PSI)</u>	11,600	12,600	12,770	11,620	15,000	10,400
<u>Temperature (°F)</u>	230	240	259	232	328	281
<u>Depth (feet)</u>	14,500	15,200	15,900	14,900	19,000	16,200
<u>Salinity (PPM)</u>	87,000	100,000	57,000	46,000	60,000	150,000

Base Case Assumptions

The physical parameters of the six sites that are used as input in the reservoir simulation are depicted in Table 1. Most of the sites have reasonably good levels of porosity and permeability with the exception of Solitude Point which has porosity of .09 and permeability of 5 millidarcys. Salinity is a problem in Bayou Hebert, Grand Lake and South White Lake. The high salinities of these prospects will probably contribute significantly to low methane solution values. Methane solubilities utilized in the simulations are computed within the model and differ from those reported by Bassiouni. The temperature of the brine is relatively low ranging from 230°F to 328°F making utilization of the thermal energy questionable at best.

The economic input parameters are based on a physical configuration consisting of one production well with an average production depth of 15,000 feet, separation equipment to process 40,000 BBL/day of brine, and two disposal wells including pumps. The cost of this equipment is detailed in the tabulation below:

Production Well	\$5,000,000
Producing Depth of 15,000'	
with 5.5" wellhead diameter	
Disposal Wells (2)	\$1,000,000
Disposal Depth 6,000'	
Surface Equipment	
Production	\$300,000
Gas Processing	\$100,000
Disposal Pumps	\$700,000
TOTAL (Surface Equipment)	<u>\$1,100,000</u>
TOTAL	\$7,100,000

The costs above were taken from Swanson (1980) and correspond closely to costs obtained from other sources. For example, Petroleum Engineer International in its annual survey of deep wells reports an average cost of \$4,931,000 for wells with an average total depth of 17,378 in 1980 in Louisiana, for wells drilled on land. For a 40,000 BBL/D facility NPC (1980) estimated that the separators, tanks and pumps would cost \$1,400,000 and the gas compression equipment, \$100,000.

The \$1,100,000 cost assumed for surface equipment in this analysis seems to be reasonably in line with other sources.

Operating costs are assumed to be a function of the amount of brine processed and takes a value of 4.2¢ per BBL in 1980. This cost is then

inflated over the life of the project at a rate of 4.4% per year. Swanson (1980) stated that disposal cost should be in the range of 4¢ to 6¢ per BBL for subsurface disposal. The NPC (1980) report used a figure of 5.1¢ per BBL for a 40,000 BBL/day flow rate. The details of the operating cost in 1980 are as follows:

ITEM	¢/BBL
General & Administrative	1.94
Well Operation & Maintenance	1.14
Disposal Power Cost	1.11
TOTAL	4.19

The final major assumption expressed in dollars is the price of methane. Gas produced from geopressed brines was deregulated in November, 1979, and consequently has no ceiling price. Gas (high cost) produced from formations deeper than 15,000' was deregulated at the same time and high cost gas contracts form the basis for the price assumption in the simulations. The price of high cost gas in Louisiana has at times exceeded \$8.00 MCF in recent months. An industry rule of thumb, however, has been to tie the price to the price of No. 2 Diesel fuel expressed in \$/MMBTU using a conversion factor of .1386 MMBTU per gallon of No. 2 Diesel. The average price of No. 2 Diesel in November and December of 1980 was \$6.17/MMBTU (Monthly Petroleum Product Price Report, February, 1981, DOE/EIA-0032(81/02)). This was the 1980 price assumed which was then increased at a rate of 6.4% per year. Although the rates of inflation assumed are optimistic in that they are low, they do represent the relative difference in the rate of change in gas prices compared to costs. For example, Chase Econometrics Associates, Inc., forecast in May, 1980 that producer prices for gas fuels would increase at twice the rate of unit labor costs over the period 1980 to 1999. In these simulations the rate of price increases is 1.5 times the rate of cost increases.

The other assumptions in the economic model are those described in detail in Johnson et al (1980). A few of the more important will be reviewed. The depreciation schedule used is over a term of ten years and is the sum-of-the-digits method. An investment tax credit of 10% is used along with a 10% depletion allowance against the gas income. A royalty of 8% of the value of the gas is paid to the landowners and a severance tax of 7¢/MCF is remitted to the State of Louisiana. Intangible investment, assumed

as 2/3 of the drilling cost, is expensed in the first year of operation and the corporate tax laws of the United States and Louisiana are applied to operation. It is further assumed that financing is 100% equity, making return on equity and investment identical.

The Bernard sites evaluated under a previous contract have been simulated under the 1980 assumptions. The results of two of the simulations are reported here for comparison to the site evaluations reported later in the report. The model was used to determine the internal rate of return (IRR) that produces a net present value of zero and the minimum amount of recovered methane per barrel to achieve a 15% IRR. The results are:

	<u>Johnson's</u>	<u>Southeast</u>	<u>Atchafalaya Bay</u>		<u>LaFourche</u>	<u>Rockefeller</u>
	<u>Bayou</u>	<u>Pecan</u>	<u>West</u>	<u>East</u>	<u>Crossing</u>	<u>Refuge</u>
IRR (%)	20.91	28.59	20.04	19.34	22.06	32.53
Minimum Methane (SCF/BBL)	17.21	17.21	17.21	17.21	18.98	17.21

All of the sites were predicted to flow at 40,000 BBL/day for the 20 year production horizon with the exception of LaFourche Crossing which had an average production rate of 31,600 BBL/day. This accounts for the fact that it was the only site that required 18.98 SCF/BBL of methane for a 15% return as opposed to 17.21 SCF/BBL for all of the other sites. The results of the simulation of the Bassiouni sites, the subject of this report, are similar as seen in the next section.

Economic Evaluation of Sites

Although the sites were evaluated using a number of different options in the Technoeconomic model, three evaluations are considered the most important and significant. The three major criteria for the evaluations are 1) the internal rate of return (IRR) given the physical parameters of the reservoir, 2) the minimum amount of methane in solution required to obtain a 15% IRR, and 3) the minimum area (or cubic volume) of the reservoir to obtain a 15% IRR. It is important to note that the IRR as defined here does not incorporate a risk premium for dry hole risk; it represents a real rate of return plus a small inflation premium. It should also be noted that although Solitude Point is included in the evaluations, its great depth (19,000') makes the \$5,000,000 well cost unrealistic and the results are probably overstated. The effect of the underestimate of the production well

expense is somewhat mitigated by the finding by Swanson (1980) that an increase in the cost of a production well from \$5,000,000 to \$8,000,000 increased the unit production cost of gas by only \$.11, from \$5.11/MCF to \$5.22/MCF.

Table 2 shows the IRR for each prospect that resulted from a simulation based upon the assumptions stated above. All but one of the prospects meet a minimum IRR of 15% and three are in the vicinity of 25%. South White Lake is by far the worst prospect with an IRR of 9.16%. This probably is due largely to the fact that the computed recovered methane only averaged 12.97 SCF/BBL for 1980-1999. The main two items contributing to this low solubility were that the bottom hole pressure was only 10,700 psi and the salinity was a high 150,000 ppm. Production rates were high or at their limit of 40,000 BBL/day with recoverability ranging from 0.95% of total water in place to 1.80%. This range is accounted for by the differences in porosity, cubic rock volume, and pressure. These IRR'S, with the exception of South White Lake, all exceed those reported in Johnson et al (1980) on the six Bernard sites.

The next critical variable examined is the average amount of methane recovered per barrel of water (in SCF/BBL) necessary to achieve a 15% IRR. As in the simulations described above, these were based on the standard assumptions previously described except that the effect of temperature, salinity and pressure on methane solubility was ignored. The simulation in essence provides the minimum methane solubility that can be tolerated if salinity is higher than expected, temperature is lower than expected or pressure is lower than expected. The operating characteristics of the sites are identical with those presented in the previous table with the IRR set at 15%. The results are presented below:

	<u>Bayou Hebert</u>	<u>Grand Lake</u>	<u>Kaplan</u>	<u>Lake Theriot</u>	<u>Solitude Point</u>	<u>South White Lake</u>
<u>Average Methane Recovered(SCF/BBL)</u>	17.21	17.21	17.21	17.21	17.21	17.28

The minimum average methane recovery required for a 15% IRR is 17.21 SCF/BBL. This is because the sites, except South White Lake, all flowed at 40,000 BBL/day and had the same investment cost, unit cost, and unit price. This required solubility is low compared to assumed levels in other studies and

TABLE 2

INTERNAL RATE OF RETURN AND SELECTED OPERATING
CHARACTERISTICS FOR THE SIX BASSIOUNI SITES IDENTIFIED

	<u>Internal Rate of Return (%)</u>	<u>Average Methane Recovered (SCF/BBL)</u>	<u>Average Flow Rate (BBL/DAY)</u>	<u>Proportion of Total Water in Place Produced (%)</u>
<u>Bayou Hebert</u>	20.17	21.08	40,000	1.13
<u>Grand Lake</u>	18.48	19.63	40,000	1.40
<u>Kaplan</u>	27.47	27.11	40,000	0.97
<u>Lake Theriot</u>	26.76	26.56	40,000	0.95
<u>Solitude Point</u>	24.51	24.69	40,000	0.96
<u>South White Lake</u>	9.16	12.97	39,438	1.80

is due to the strong production characteristics of the sites. This simulation combined with the results of the previous simulation provides the information for computing the elasticity of the rate of return to the average methane recovered per BBL (% change in IRR/% change in CH_4/BBL). This elasticity is in the neighborhood of 1.5 ranging from a low of 1.4 to a high of 1.9. In other words, for each one percent increase in the amount of gas in solution there is approximately a 1.5% increase in the IRR.

The final criterion examined was the minimum amount of drainage area in acres that would produce a 15% IRR, given the other physical characteristics of the reservoir. This minimum area, when coupled to the net producing sand, provides an estimate of the sand volume required. As can be seen in Table 3 the prospects require a minimum of 1 cubic mile of sand volume, except for Kaplan and Lake Theriot. The results for these two prospects, considering the required volume, is 1/3 of what was required for the others. Average production is much lower than 40,000 BBL/day with very low averages for Kaplan and Lake Theriot because very little production occurred after the 10th year. Figure 1 shows graphically the time path of production for Kaplan. The high permeability and relatively high methane solubility allow this prospect to achieve an approximate zero net present value at a 15% IRR in only about 10 or 11 years. It is the combined effect of these two variables that produce the time path of production when the minimum area is determined. For example, consider Solitude Point: although it has a higher recorded value of methane in solution, it must produce for twenty years to achieve a net present value of zero, with its final year's production rate at 3,331 BBL/day.

Summary

The analysis presented above of the Bassiouni sites represents only a portion of the simulations conducted and evaluated. A more complete review of the sites will be presented at the Fifth Annual Geopressure Geothermal Conference sponsored by the DOE, the Louisiana Geological Survey and Louisiana State University, Oct. 13 - 16, 1981, Baton Rouge, La. The findings of the simulations conducted are somewhat similar to the simulations of the Bernard sites. Two of the new sites can achieve a 15% IRR with a minimum cubic volume of approximately one-third cubic mile. The required methane

TABLE 3

MINIMUM AREA OF PROSPECT FOR 15% IRR
AND SELECTED OPERATING CHARACTERISTICS

	<u>Minimum Area (Acres)</u>	<u>Cubic Volume (mi³)</u>	<u>Average Production (BBL/Day)</u>	<u>Years Production Greater Than 5,000 BBL/Day</u>	<u>Average Methane Recovered SCF/BBL</u>
<u>Bayou Hebert</u>	7,381	1.00	26,969	18	18.21
<u>Grand Lake</u>	7,138	1.00	31,709	20	17.57
<u>Kaplan</u>	4,314	.34	15,655	9	21.48
<u>Lake Theriot</u>	2,458	.34	15,845	10	21.73
<u>Solitude Point</u>	3,296	.98	18,977	17	22.53
<u>South White Lake</u>	*	*	*	*	*

* Model could not converge to minimum because of low methane solubility.

Figure 1. Time path of production from minimum area at 15% IRR: Kaplan and Solitude Point, 1980-1999.

recovery per BBL for a 15% IRR is only 17.21 SCF/BBL. Finally, several of the sites had IRR's exceeding 20%, a rate of return that compares well with the usually assumed threshold of 15%.

Further work remains however in the simulation of these sites. The limitations currently inherent in the model are implicit in the assumptions outlined earlier. Specifically these are a fixed cost for production and disposal wells, and an IRR that does not include dry hole risks. In future evaluations these rigid assumptions will be relaxed. Drilling cost will become a function of depth and time based upon actual drilling experience in South Louisiana. The depth is a particularly important variable to incorporate since at depths greater than 15,000 feet the marginal cost of drilling exceeds \$1,000/ft. Time is also an important factor since present day costs must be established from past costs inflated at the appropriate rate of the increase in drilling. This is not insignificant, since drilling costs have been increasing at a rate in the vicinity of 30% per year in South Louisiana in recent years. Dry-hole risks will be considered in future evaluations beginning with a "risk-weighted" rate of return described in Newendorp (1975). Other methods will also be considered with the objective being to have an IRR that incorporates not only the real rate of return and the inflation premium, but also the risk premium. Additionally it is our intention to bring greater specificity to the design of the surface equipment used to process the brine to obtain better cost estimates of the surface equipment. These improvements along with others will provide the mechanism for a much improved evaluation of identified and new sites.

Summary

Much has been accomplished in the form of supporting research for evaluating the geopressured-geothermal resource from a total system perspective. Estimates of methane in solution derived from the technoeconomic model are much improved due to the application of a fundamental thermodynamic approach and substantial statistical analysis on experimentally generated data from other sources. Future evaluations of sites and regions will be enhanced through the use of probabilistic simulation made possible by the addition of a Monte Carlo capability to the model. This will allow a "risk assessment" to be made of each site and will allow a better determination of the likelihood of achieving a threshold IRR. Additional site specific data have been added to the prospect data base and these new sites have been evaluated under a deregulated gas price. The economic evaluation of these sites is encouraging, especially with regard to minimum volumes required. Through continued support by DOE in 1981, these improvements will be used in future research support of the DOE geopressured-geothermal program in Louisiana.

Future work will include a regional evaluation of the resource utilizing data derived from the complete regional geologic resource assessment. This regional evaluation will be both deterministic and probabilistic in nature. As additional site specific data become available, it will be added to the prospect data base and each new site will be evaluated. Production is expected during 1981 from one or more of the design wells in Louisiana and these wells will be simulated to provide further verification of the reservoir modeling portion of the simulator. Cost estimates of each new site evaluated will reflect site specific characteristics and a more refined surface equipment design.

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APPENDIX A

Environmental Monitoring Plan:

Parcperdue Test Well No. 1

 

ENVIRONMENTAL MONITORING PLAN:

PARCERDUE TEST WELL NO. 1

I. INTRODUCTION

Louisiana State University (LSU) will undertake management of environmental baseline and monitoring studies for geopressed test well activities in the North Parcedue Oil and Gas Field near Lafayette, Louisiana. The Dow Chemical Company, in cooperation with the U. S. Department of Energy (DOE), is currently planning to drill and test a well penetrating a limited geopressed reservoir in the Parcedue field at the location given in Figure 1. A schedule for the two-year drilling and testing program, which was initiated in October, 1979, is given in Figure 2.

The drilling and testing operations associated with the Parcedue geopressed well will be conducted within the scope of an Environmental Impact Assessment (EIA) which is currently being prepared by the Oak Ridge National Laboratory. In this EIA, the environmental implication of geopressed resource testing at Parcedue is evaluated for activities from well site preparation through site restoration after testing is complete.

II. ENVIRONMENTAL BASELINE AND MONITORING STUDIES

The purpose of collecting environmental baseline data is to provide a description of selected physical, chemical, and biological conditions against which later environmental monitoring data can be compared. This comparison will provide a basis for determining the net environmental change attributable to test well operations at any subsequent time.

The following data shall be collected to establish the baseline of ambient conditions prior to fluid production:

Air Quality

- existing air quality conditions
- local meteorological characteristics

Water Quality (surface and subsurface)

- existing water quality conditions
- water resource usage
- hydrologic patterns, surface and ground water levels

Subsidence

- subsidence history
- leveling surveys

Seismicity

- microseismic surveys

Ecosystem Quality

- biological surveys

In order to avoid duplication, information presented in the DOE/Oak Ridge Environmental Impact Assessment for the Parcperdue well test shall be incorporated where possible in the LSU environmental baseline evaluation. For example, very little additional work may be required to establish existing ecosystem quality.

An environmental monitoring program designed to provide comparative data during drilling and production phases will include the studies listed below. The asterisk indicates the studies that are contingent upon the occurrence of environmental changes (e.g., changes in air quality and/or standards violation in the case of air quality) and are not considered in the base scope of work.

Air Quality

- air quality monitoring
- pollutant dispersion modeling*
- continuous wind speed, wind direction, temperature and precipitation

Water Quality (surface and subsurface)

- water quality monitoring
- water level monitoring

Subsidence

- repeated leveling surveys

Seismicity

- continuous microseismic surveys

Ecosystem Quality

- biological surveys*
- bioassays*

Monitoring studies may be increased if environmental conditions, either natural or as a result of test well activities and geopressure fluid analysis require such adjustment. However, LSU will be obligated to demonstrate the inadequacy of the existing data collection program when seeking approval for additional studies.

The combined scope of environmental baseline and monitoring studies which are planned during the first year include the air quality, water quality, subsidence, seismic and ecological studies described below.

1. Air Quality. Air quality baseline studies will be performed to:
(1) determine ambient air quality prior to possible disturbance from test well activities; (2) identify any substance potentially derived from the geopressured fluid that may have an adverse effect on the environment, and establish baseline concentrations for these substances; (3) collect locally available meteorological data necessary for understanding dispersion and conversion patterns; and (4) provide baseline data compatible with later measurements needed to assure compliance with state and federal air quality standards.

Air quality monitoring will be performed to determine changes in air quality which may be related to well testing activities. Sampling and analysis for hazardous substances will be from a fixed automated monitoring unit located approximately 1 mile north-west of the test site (prevailing winds are from the southeast). Analyses

will include continuous measurement of sulfur dioxide, hydrogen sulfide, total hydrocarbons and methane. Meteorological data from continuous recorders shall include wind speed, wind direction, temperature and precipitation. In the event of significant atmospheric pollutant emissions, dispersion characteristics will be determined.

Analytical procedures for air quality monitoring will be consistent with designated Reference or Equivalent Methods published by the U. S. Environmental Protection Agency, Monitoring and Research Laboratory, Research Triangle Park, North Carolina, November 3, 1978. Analyzer performance shall conform to specifications for automated methods as described in 40 CFR, Parts 50 and 53.

2. Water Quality. Water quality baseline studies will be conducted to determine: (1) ambient water quality conditions in local bayous and canals and in shallow ground water prior to possible disturbance from test well activities; (2) baseline conditions for substances potentially present in the geopressured fluids; and (3) water resource usage and baseline concentrations for substances and physical properties for which state standards have been established.

Water quality monitoring studies will be performed so that changes in chemical and physical properties of surface and ground water can be determined. Surface water samples will be collected monthly; surface water levels will be recorded at the time of sample collection. Laboratory analyses to be conducted for each sample will include Na, K,

NH₃, SO₄, Cd, Mn, Ca, Cl, Ba, Pb, As, B, Hg, total hardness (calculated), and total organic carbon. Field measurements shall include pH, specific conductance, turbidity, temperature and dissolved oxygen.

Two observation wells will be drilled approximately 200 feet into the zone of fresh ground water. Ground-water samples will be collected each month. Field and laboratory analyses to be performed on ground-water samples will be the same as for surface waters.

Water level in the observation wells will be reported monthly.

Ground and surface water sample collection, handling, preservation and analysis will be consistent with methods published by the U. S. Environmental Protection Agency, "Manual of Methods for Chemical Analyzers of Water and Wastes" (1974), and the U. S. Geological Survey, "Recommended Methods for Water Data Acquisition" (1977).

3. Subsidence. Subsidence baseline studies will include an initial leveling survey to establish relative surface elevations, and an examination of historic leveling data and topographic maps to determine subsidence history in the vicinity of the test well.

The initial leveling survey shall consist of approximately 16.5 miles of First-Order precise leveling. Leveling profiles will be tied to National Oceanic and Atmospheric Administration (NOAA) elevation benchmarks which are located beyond the area of potential subsidence impact. Procedures to be used in establishing benchmarks in the vicinity of the test well will be in accordance with guidelines provided in the NOAA publication, "Specifications to Support Classification,

Standards of Accuracy, and General Specifications of Geodetic Control Surveys" (1978).

Subsidence monitoring will consist of first-order releveled surveys which will be conducted at 12-month intervals during production to document the occurrence of land-surface subsidence, if any, near the well site, or of differential surface movement along reactivated faults. First-Order releveled is planned during the second year environmental monitoring program, and is not considered in the base scope of work for this proposal.

4. Seismicity. Microseismic surveys will be performed to (1) determine background microseismic activity prior to disturbance from fluid production, and (2) monitor microseismic activity during fluid production. Baseline microseismic studies will include an initial reconnaissance survey to determine sources and levels of background microseismic activity. Data from this survey will be used to identify locations for permanent monitoring installations which will be least influenced by natural and cultural background noise.

Continuous microseismic monitoring will be performed using seismometers emplaced in sealed boreholes at approximately 4 feet below ground surface. Microseismic monitoring studies will provide the origin time of local seismic events, their estimated locations, and their relative magnitudes. The microseismic monitoring net will be operative approximately six months prior to fluid production.

5. Ecosystem Quality. Baseline ecological studies will rely on existing published and unpublished data to establish ranges and populations of plant and animal species in the vicinity of the test well. Additional biological surveys will be conducted in the event of significant impact to plant or animal life but are not considered part of the base scope of work.

III. ENVIRONMENTAL PROGRAM MANAGEMENT

The environmental monitoring program will be managed by Dr. Charles G. Groat, Director of the Louisiana Geological Survey and Professor of Geology, Louisiana State University. The management of environmental monitoring will include insuring that data collected is compiled, analyzed, and reported to the U. S. Department of Energy (DOE) on a quarterly basis, or more frequently, if necessary. LSU will provide for contractual arrangements with firms for performance of selected field and laboratory studies. Overall data interpretation and impact assessment will be performed by LSU investigators. LSU will also be responsible for determining if federal, state, and local environmental quality standards are being met, and will inform DOE in the event of non-compliance. LSU investigators will also inform DOE when an increase or decrease in baseline monitoring studies are required, justifying such changes in scope as they occur.

This Environmental Monitoring Plan outlines a one-year program of combined environmental monitoring and baseline studies. LSU will prepare quarterly status reports, including data summaries, and an annual report summarizing the results obtained during the first year. Based on analysis of the data, the development of the test well, and federal, state, and local regulations, LSU will propose a second year plan for continuing air quality, water quality, subsidence and microseismic

monitoring studies. In preparing this plan, LSU will determine whether or not it can be accomplished at a reduced level in any of the monitoring programs (e.g., increasing the interval between water samples, reducing the number of ions analyzed, increased level of air quality monitoring, etc.)

Figure 1. Location map of the North Parcperdue Oil and Gas Field (from the Dow Chemical Company).

Figure 2. Time schedule for the Parcupdue drilling and testing program (from the Dow Chemical Company).

APPENDIX B
Air Quality Monitoring Data
July 1980
Parcperdue Test Site

 

AMBIENT AIR STUDY**FOR**

**LOUISIANA GEOLOGICAL SURVEY
LOUISIANA STATE UNIVERSITY
PARCERDUE GEOPRESSURED -
GEOTHERMAL TEST SITE**

JULY 1-31, 1980

BY:

**KEMRON ENVIRONMENTAL SERVICES
16550 HIGHLAND ROAD
BATON ROUGE, LOUISIANA 70808**

80-15194-09

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SECTION I
SULFUR DIOXIDE

TABLE I-A
MAXIMUM AND AVERAGE CONCENTRATION
(USING PEAK VALUES)
(MICROGRAMS PER CUBIC METER)

LA. GEOLOGICAL SURVEY, LSU
PARCERDUE TEST SIT

SULFUR DIOXIDE
JULY 01-31, 1980

DAY OF MONTH	MAX 1-HR	AVG 24-HR	TIME OF DAY (STD)	DIR (N.AZ.)	SPEED (MPH)
1	*	*			
2	*	*			
3	*	*			
4	*	*			
5	*	*			
WEEKLY :	*	*			
6	*	*			
7	*	*			
8	*	*			
9	*	*			
10	*	*			
11	2	1	2000	210	6
12	*	*			
WEEKLY :	2	1			
13	7	3	1700	240	2
14	4	2	1900	240	9
15	21	8	1200	290	7
16	16	6	700	310	5
17	8	3	700	60	2
18	28	6	900	60	8
19	31	8	1500	150	5
WEEKLY :	31	5			
20	*	*			
21	*	*			
22	9	6	1500	60	7
23	21	5	900	10	7
24	80	13	800	20	5
25	9	6	2400	80	3
26	5	2	1100	140	7
WEEKLY :	80	6			
27	4	3	700	200	2
28	0	0	2400	40	1
29	4	1	2400	270	4
30	45	11	900	300	6
31	14	6	1300	300	3
WEEKLY :	45	4			
MONTHLY :	80	5			

* NO DATA

TABLE I-B
MAXIMUM AND AVERAGE CONCENTRATION
(USING HOURLY INTEGRATED VALUES)
(MICROGRAMS PER CUBIC METER)

LA. GEOLOGICAL SURVEY, LSU
PARCERDUE TEST SIT

SULFUR DIOXIDE
JULY 01-31, 1980

DAY OF MONTH	MAX 1-HR	AVG 24-HR	TIME OF DAY (STD)	DIR (N.AZ.)	SPEED (MPH)
1	*	*			
2	*	*			
3	*	*			
4	*	*			
5	*	*			
WEEKLY :	*	*			
6	*	*			
7	*	*			
8	*	*			
9	*	*			
10	*	*			
11	0	0	2000	210	6
12	*	*			
WEEKLY :	0	0			
13	4	1	1700	240	2
14	1	0	1900	240	9
15	16	4	1200	290	7
16	13	3	700	310	5
17	5	1	700	60	2
18	18	2	1100	80	3
19	6	3	1500	150	5
WEEKLY :	18	2			
20	*	*			
21	*	*			
22	1	1	1500	60	7
23	8	2	900	10	7
24	58	8	800	20	5
25	7	3	2300	70	3
26	1	0	1100	140	7
WEEKLY :	58	3			
27	2	1	200	30	1
28	0	0	2400	40	1
29	1	0	2400	270	4
30	25	6	900	300	6
31	9	3	900	320	4
WEEKLY :	25	2			
MONTHLY :	58	3			

* NO DATA

FIGURE 1

DAY OF MONTH VERSUS CONCENTRATION (MICROGRAMS/CUBIC METER)

COMPANY : LA. GEOLOGICAL SURVEY, LSU DATES OF SAMPLING : JULY 01-31, 1980
 LOCATION : PARCERDUE TEST SITE PARAMETER : SULFUR DIOXIDE

FIGURE 2

DAY OF MONTH VERSUS CONCENTRATION (MICROGRAMS/CUBIC METER)

COMPANY : LA. GEOLOGICAL SURVEY, LSU DATES OF SAMPLING : JULY 01-31, 1980
 LOCATION : PARCPERDUE TEST SITE PARAMETER : SULFUR DIOXIDE

TABLE I-C

THIRTY HIGHEST
3-HOUR INTEGRATED CONCENTRATIONS
(MICROGRAMS/CUBIC METER)

COMPANY : LA. GEOLOGICAL SURVEY, LSU
LOCATION : PARCPERDUE TEST SITE
DATE : JULY 01-31, 1980
PARAMETER : SULFUR DIOXIDE

DAY OF MONTH	3-HOUR INTEG. CONC.	FIRST HOUR OF PERIOD DATA		
		TIME OF DAY (STD)	WIND DIRECTION	WIND SPEED
24	29	700	20	5
24	28	800	20	5
24	24	600	30	3
30	18	900	300	6
30	18	900	310	4
30	14	1000	310	7 *
18	14	1100	80	3 *
15	13	1100	300	8
30	12	700	290	2
15	12	1000	300	8
18	11	900	60	8 *
15	11	1200	290	7
24	11	900	30	7
16	10	600	310	4
16	9	500	300	5
16	8	700	310	5
15	8	900	300	9
18	7	1200	200	3 *
24	7	1100	50	8
31	7	800	300	5 *
15	7	1300	310	6
24	7	1200	50	8
25	7	2300	70	3 *
24	7	1000	40	7
25	7	2200	50	2
24	7	1300	50	8 *
24	6	1400	50	8 *
24	6	500	20	4
25	6	2100	190	2
24	6	1500	50	6 *

* MISSING DATA HOUR

TABLE II

 TIME OF DAY VS AVG. CONCENTRATION
 (MICROGRAMS PER CUBIC METER)

COMPANY : LA. GEOLOGICAL SURVEY, LSU
 LOCATION : PARCPERDUE TEST SITE
 DATE : JULY 01-31, 1980
 PARAMETER : SULFUR DIOXIDE

TIME OF DAY (STD HOURS)	AVERAGE CONCENTRATION	
	(PEAKS)	(INTEGRATED)
100	*	*
200	3.5	1.3
300	3.0	1.1
400	3.2	1.2
500	3.7	1.5
600	4.4	2.2
700	6.3	3.2
800	12.5	6.6
900	12.6	5.5
1000	6.5	3.6
1100	7.8	4.7
1200	5.6	3.3
1300	6.9	3.3
1400	4.2	2.1
1500	6.5	1.8
1600	4.5	2.1
1700	4.1	1.9
1800	3.7	1.7
1900	3.6	1.6
2000	3.9	1.7
2100	3.5	1.4
2200	3.0	1.2
2300	3.0	1.3
2400	3.0	1.3

* NO DATA

FIGURE 3

TIME OF DAY VERSUS CONCENTRATION
(MICROGRAMS/CUBIC METER)

COMPANY : LA. GEOLOGICAL SURVEY, LSU DATES OF SAMPLING : JULY 01-31, 1980
LOCATION : PARCERQUE TEST SITE PARAMETER : SULFUR DIOXIDE

TABLE III

WIND DIRECTION VS AVERAGE CONCENTRATION
(MICROGRAMS PER CUBIC METER)

COMPANY : LA. GEOLOGICAL SURVEY, LSU
LOCATION : PARCERDUE TEST SITE
DATE : JULY 01-31, 1980
PARAMETER : SULFUR DIOXIDE

DIRECTION (DEGREES)	PERCENT OF WIND OCCURRENCES	AVG. CONCENTRATION (PEAKS)	(INTEGRATED)
CALM	2.2	3.4	1.2
10	2.4	7.5	2.7
20	2.7	13.6	8.2
30	3.2	7.4	3.0
40	2.4	3.2	1.4
50	4.3	6.2	3.7
60	2.7	9.4	3.4
70	1.4	6.0	3.8
80	3.2	7.5	4.9
90	1.9	5.1	2.3
100	1.6	3.4	1.2
110	2.7	4.0	1.7
120	.5	2.0	.4
130	.5	2.2	.4
140	1.4	5.1	2.5
150	4.3	6.0	2.0
160	1.1	2.5	.9
170	1.4	3.6	1.4
180	2.7	3.2	1.1
190	3.2	3.4	1.5
200	3.2	2.0	.5
210	3.0	3.1	1.4
220	1.9	3.3	1.4
230	3.2	4.6	2.5
240	6.2	3.4	1.2
250	4.1	4.0	1.7
260	2.2	3.7	1.6
270	5.4	3.3	1.2
280	3.5	2.8	1.0
290	4.6	4.0	2.0
300	5.1	8.1	4.0
310	3.8	13.1	7.8
320	2.4	3.9	2.2
330	1.9	4.1	1.5
340	1.1	3.2	1.4
350	1.9	1.6	.5
360	.5	2.4	.3

FIGURE 4

WIND DIRECTION VERSUS AVERAGE CONCENTRATION
(MICROGRAMS/CUBIC METER)
(PEAK VALUES)

COMPANY : LA. GEOLOGICAL SURVEY, LSU DATE OF SAMPLING : JULY 01-31, 1980
LOCATION : PARCERDUE TEST SITE PARAMETER : SULFUR DIOXIDE

TABLE IV

 WIND SPEED VS AVERAGE CONCENTRATION
 (MICROGRAMS PER CUBIC METER)

COMPANY : LA. GEOLOGICAL SURVEY, LSU
 LOCATION : PARCERDUE TEST SITE
 DATE : JULY 01-31, 1980
 PARAMETER : SULFUR DIOXIDE

SPEED (MPH)	PERCENT OF WIND OCCURRENCES	AVG CONCENTRATION (PEAK)	AVG CONCENTRATION (INTEGRATED)
0	.3	**	**
1	10.5	2.9	1.1
2	17.0	3.7	1.6
3	17.8	3.8	1.9
4	13.8	4.9	2.1
5	11.1	8.3	4.3
6	9.2	5.6	2.5
7	8.9	8.3	3.9
8	5.4	7.9	3.8
9	2.7	3.7	1.8
10	1.4	2.2	.8
11	.5	6.4	3.2
12	.8	6.1	2.7
13	.5	5.0	1.5

** NO DATA

FIGURE 5

WIND DIRECTION VERSUS AVERAGE CONCENTRATION
(MICROGRAMS/CUBIC METER)
(INTEGRATED VALUES)

COMPANY : LA. GEOLOGICAL SURVEY, LSU DATE OF SAMPLING : JULY 01-31, 1980
LOCATION : PARCERDUE TEST SITE PARAMETER : SULFUR DIOXIDE

FIGURE 6

WIND SPEED VERSUS AVERAGE CONCENTRATION
(MICROGRAMS/CUBIC METER)

COMPANY : LA. GEOLOGICAL SURVEY, LSU DATES OF SAMPLING : JULY 01-31, 1980

LOCATION : PARCERDUE TEST SITE

PARAMETER :

SULFUR DIOXIDE

FIGURE 7

WIND ROSE

PERCENT OF TIME WIND WAS FROM A SPECIFIED DIRECTION

COMPANY : LA. GEOLOGICAL SURVEY, LSU DATE OF SAMPLING : JULY 01-31, 1980

LOCATION : PARCERDUE TEST SITE

PARAMETER :

SULFUR DIOXIDE

TABLE V

FREQUENCY DISTRIBUTION
(MICROGRAMS PER CUBIC METER)

COMPANY : LA. GEOLOGICAL SURVEY, LSU
LOCATION : PARCPERDUE TEST SITE
DATE : JULY 01-31, 1980
PARAMETER : SULFUR DIOXIDE

RANGE OF CONCENTRATION	PERCENT (PEAKS)	PERCENT (INTEGRATED)
20	96.6	99.3
40	99.1	99.7
60	99.7	100.0
80	100.0	100.0

BASIC STATISTICS - (HOURLY BASIS)

ARITHMETIC MEAN (PEAK VALUES) : 5.12
ARITHMETIC MEAN (INTEGRATED VALUES) : 2.39
GEOMETRIC MEAN (PEAK VALUES) : 3.43
GEOMETRIC MEAN (INTEGRATED VALUES) : .94
STANDARD DEV (PEAK VALUES) : 6.93
STANDARD DEV (INTEGRATED VALUES) : 4.44
STANDARD GEOM DEV (PEAK VALUES) : 2.42
STANDARD GEOM DEV (INTEGRATED VALUES) : 5.08

FIGURE 8

FREQUENCY DISTRIBUTION OF ONE-HOUR
CONCENTRATIONS

COMPANY : LA. GEOLOGICAL SURVEY, LSU DATES OF SAMPLING : JULY 01-31, 1980

LOCATION : PARCERDUE TEST SITE

PARAMETER :

SULFUR DIOXIDE

Kemron Environmental Services

KEMRON AEROMETRIC DATA BANK
KEMRON ENVIRONMENTAL SERVICES
16555 HIGHLAND ROAD
BATON ROUGE, LOUISIANA 70808
12/16/88 22:19:33

LA. GEOLOGICAL SURVEY, LSU
PARCERDUE TEST SITE
JULY 01-31, 1988

SULFUR DIOXIDE
CONCENTRATION IN PARTS PER MILLION

01-HOUR DATA LISTING
CENTRAL STANDARD TIME

DAY	AM												PM												DAILY		
	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	MEAN	NO.	
1																										.0000	0.
2																										.0000	0.
3																										.0000	0.
4																										.0000	0.
5																										.0000	0.
6																										.0000	0.
7																										.0000	0.
8																										.0000	0.
9																										.0000	0.
10																										.0000	0.
11																										.0000	0.
12																										.0000	0.
13																										.0000	0.
14																										.0000	0.
15																										.0000	0.
16																										.0000	0.
17																										.0000	0.
18																										.0000	0.
19																										.0000	0.
20																										.0000	0.
21																										.0000	0.
22																										.0000	0.
23																										.0000	0.
24																										.0000	0.
25																										.0000	0.
26																										.0000	0.
27																										.0000	0.
28																										.0000	0.
29																										.0000	0.
30																										.0000	0.
31																										.0000	0.
12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11				
AVG.	.0000	.0000	.0000	.0000	.0001	.0001	.0001	.0003	.0002	.0001	.0002	.0001	.0001	.0001	.0001	.0001	.0001	.0001	.0001	.0001	.0001	.0000	.0001	.0001			
NO.	0.	14.	14.	14.	14.	14.	14.	15.	13.	14.	12.	12.	10.	12.	16.	16.	15.	16.	17.	15.	15.	15.	15.				

SECTION II

TOTAL HYDROCARBONS

TABLE I-A
MAXIMUM AND AVERAGE CONCENTRATION
(USING PEAK VALUES)
(MICROGRAMS PER CUBIC METER)

LA. GEOLOGICAL SURVEY, LSU PARCERDUE TEST SIT			TOTAL HYDROCARBONS JULY 01-31, 1980		
DAY OF MONTH	MAX 1-HR	AVG 24-HR	TIME OF DAY (STD)	DIR (N.AZ.)	SPEED (MPH)
1	*	*			
2	*	*			
3	*	*			
4	*	*			
5	*	*			
WEEKLY :	*	*			
6	*	*			
7	*	*			
8	*	*			
9	*	*			
10	•	*			
11	•	*			
12	*	*			
WEEKLY :	*	*			
13	*	*			
14	*	*			
15	*	*			
16	•	*			
17	*	*			
18	*	*			
19	*	*			
WEEKLY :	*	*			
20	*	*			
21	•	•			
22	*	*			
23	*	*			
24	•	*			
25	*	*			
26	*	*			
WEEKLY :	•	*			
27	*	*			
28	*	*			
29	2872	2087	2300	250	4
30	4420	1876	300	260	1
31	4733	1964	2200	70	1
WEEKLY :	4733	1976			
MONTHLY :	4733	1939			

* NO DATA

FIGURE 1

DAY OF MONTH VERSUS CONCENTRATION
(MICROGRAMS/CUBIC METER)

COMPANY : LA. GEOLOGICAL SURVEY, LSU DATES OF SAMPLING : JULY 01-31, 1980

LOCATION : PARCPERDUE TEST SITE

PARAMETER :

TOTAL HYDROCARBONS

TABLE I-B
MAXIMUM AND AVERAGE CONCENTRATION
(USING HOURLY INTEGRATED VALUES)
(MICROGRAMS PER CUBIC METER)

LA. GEOLOGICAL SURVEY, LSU PARCERDUE TEST SIT			TOTAL HYDROCARBONS JULY 01-31, 1980		
DAY OF MONTH	MAX 1-HR	AVG 24-HR	TIME OF DAY (STD)	DIR (N.AZ.)	SPEED (MPH)
1	*	*			
2	•	•			
3	•	*			
4	•	*			
5	*	*			
WEEKLY :	*	*			
6	*	*			
7	*	*			
8	•	*			
9	*	*			
10	•	*			
11	•	*			
12	*	*			
WEEKLY :	•	*			
13	*	*			
14	*	*			
15	*	*			
16	*	*			
17	*	*			
18	*	*			
19	•	*			
WEEKLY :	*	*			
20	•	*			
21	*	*			
22	*	*			
23	*	*			
24	•	*			
25	*	*			
26	•	*			
WEEKLY :	•	*			
27	•	*			
28	•	*			
29	2201	1639	2300	250	4
30	2843	1339	400	230	2
31	2495	1285	500	340	1
WEEKLY :	2843	1421			
MONTHLY :	2843	1354			

* NO DATA

FIGURE 2

DAY OF MONTH VERSUS CONCENTRATION
(MICROGRAMS/CUBIC METER)

COMPANY : LA. GEOLOGICAL SURVEY, LSU DATES OF SAMPLING : JULY 01-31, 1980

LOCATION : PARCERDUE TEST SITE PARAMETER : TOTAL HYDROCARBONS

TABLE I-C

THIRTY HIGHEST
3-HOUR INTEGRATED CONCENTRATIONS
(MICROGRAMS/CUBIC METER)

COMPANY : LA. GEOLOGICAL SURVEY, LSU
LOCATION : PARCERDUE TEST SITE
DATE : JULY 01-31, 1980
PARAMETER : TOTAL HYDROCARBONS

DAY OF MONTH	3-HOUR INTEG. CONC.	FIRST HOUR OF PERIOD DATA		
		TIME OF DAY (STD)	WIND DIRECTION	WIND SPEED
30	2661	400	230	2
30	2581	300	260	1
30	2577	500	230	1
30	2316	200	210	2
29	2160	2300	250	4 *
31	2122	400	280	1
30	2114	600	250	1
31	2067	500	340	1
31	2064	300	260	1
30	2053	100	240	2 *
29	1990	2400	270	4 *
29	1939	2200	240	3
29	1690	2100	240	3
31	1675	200	240	1
31	1631	600	300	2
30	1606	700	290	2
31	1501	100	230	2 *
30	1380	2400	230	2 *
31	1355	2200	70	1
31	1333	700	260	2
29	1292	2000	240	3
31	1273	2100	110	3
30	1241	2300	230	3 *
31	1193	2000	80	4
29	1190	1900	280	2 *
31	1070	800	300	5 *
30	1035	2200	240	3
30	978	800	310	4
31	898	1900	10	3 *
30	846	2100	220	4

* MISSING DATA HOUR

FIGURE 3

TIME OF DAY VERSUS CONCENTRATION (MICROGRAMS/CUBIC METER)

COMPANY : LA. GEOLOGICAL SURVEY, LSU DATES OF SAMPLING : JULY 01-31, 1980

LOCATION : PARCERDUE TEST SITE

PARAMETER :

TOTAL HYDROCARBONS

TABLE II

 TIME OF DAY VS AVG. CONCENTRATION
 (MICROGRAMS PER CUBIC METER)

COMPANY : LA. GEOLOGICAL SURVEY, LSU
 LOCATION : PARCERDUE TEST SITE
 DATE : JULY 01-31, 1980
 PARAMETER : METHANE

TIME OF DAY (STD HOURS)	AVERAGE CONCENTRATION	
	(PEAKS)	(INTEGRATED)
100	*	*
200	1452.0	1167.0
300	2327.0	1458.3
400	2576.0	1897.7
500	2697.0	1951.1
600	2053.0	1730.8
700	2526.0	1754.3
800	1437.5	745.1
900	551.0	376.9
1000	284.0	178.8
1100	124.0	44.0
1200	218.0	162.6
1300	226.0	151.4
1400	*	*
1500	404.0	329.6
1600	246.5	202.7
1700	134.0	96.7
1800	145.0	59.2
1900	205.0	92.3
2000	929.0	354.9
2100	979.7	579.2
2200	1530.7	786.0
2300	1705.3	980.1
2400	1521.7	1122.0

* NO DATA

FIGURE 3

TIME OF DAY VERSUS CONCENTRATION
(MICROGRAMS/CUBIC METER)

COMPANY : LA. GEOLOGICAL SURVEY, LSU DATES OF SAMPLING : JULY 01-31, 1980

LOCATION : PARCERDUE TEST SITE

PARAMETER :

METHANE

TABLE III
**WIND DIRECTION VS AVERAGE CONCENTRATION
(MICROGRAMS PER CUBIC METER)**

COMPANY : LA. GEOLOGICAL SURVEY, LSU
 LOCATION : PARCPERDUE TEST SITE
 DATE : JULY 01-31, 1980
 PARAMETER : METHANE

DIRECTION (DEGREES)	PERCENT OF WIND OCCURRENCES	AVG. CONCENTRATION (PEAKS)	(INTEGRATED)
CALM	2.2	**	**
10	2.4	**	**
20	2.7	**	**
30	3.2	**	**
40	2.4	**	**
50	4.3	**	**
60	2.7	**	**
70	1.4	3145.0	1141.6
80	3.2	**	**
90	1.9	1662.0	752.2
100	1.6	**	**
110	2.7	847.0	697.6
120	.5	**	**
130	.5	**	**
140	1.4	**	**
150	4.3	**	**
160	1.1	**	**
170	1.4	**	**
180	2.7	**	**
190	3.2	**	**
200	3.2	**	**
210	3.0	794.8	509.2
220	1.9	1031.0	346.4
230	3.2	1508.7	1026.2
240	6.2	960.8	687.4
250	4.1	1248.8	1031.7
260	2.2	2326.0	1435.9
270	5.4	2026.0	1669.5
280	3.5	2098.0	1457.5
290	4.6	2728.0	2117.4
300	5.1	921.8	649.4
310	3.8	697.7	353.3
320	2.4	355.5	249.8
330	1.9	**	**
340	1.1	2659.0	1691.5
350	1.9	**	**
360	.5	**	**

** NO DATA

FIGURE 4

WIND DIRECTION VERSUS AVERAGE CONCENTRATION
(MICROGRAMS/CUBIC METER)
(PEAK VALUES)

COMPANY : LA. GEOLOGICAL SURVEY, LSU DATE OF SAMPLING : JULY 01-31, 1980
LOCATION : PARCPEADUE TEST SITE PARAMETER : METHANE

FIGURE 5

WIND DIRECTION VERSUS AVERAGE CONCENTRATION
(MICROGRAMS/CUBIC METER)
(INTEGRATED VALUES)

COMPANY : LA. GEOLOGICAL SURVEY, LSU DATE OF SAMPLING : JULY 01-31, 1980
LOCATION : PARCERDUE TEST SITE PARAMETER : METHANE

TABLE IV

WIND SPEED VS AVERAGE CONCENTRATION
(MICROGRAMS PER CUBIC METER)

COMPANY : LA. GEOLOGICAL SURVEY, LSU
LOCATION : PARCERDUE TEST SITE
DATE : JULY 31-31, 1980
PARAMETER : METHANE

SPEED (MPH)	PERCENT OF WIND OCCURRENCES	AVG CONCENTRATION (PEAK) (INTEGRATED)	
0	.3	**	**
1	10.5	2133.1	1381.5
2	17.0	1457.3	1042.4
3	17.8	757.0	495.1
4	13.8	1379.5	829.7
5	11.1	657.0	348.6
6	9.2	489.5	374.5
7	8.9	284.0	178.8
8	5.4	**	**
9	2.7	**	**
10	1.4	**	**
11	.5	**	**
12	.8	404.0	329.6
13	.5	**	**

** NO DATA

FIGURE 6

WIND SPEED VERSUS AVERAGE CONCENTRATION (MICROGRAMS/CUBIC METER)

COMPANY : LA. GEOLOGICAL SURVEY, LSU DATES OF SAMPLING : JULY 01-31, 1980

LOCATION : PARCERDUE TEST SITE

PARAMETER :

METHANE

FIGURE 7

WIND ROSE

PERCENT OF TIME WIND WAS FROM A SPECIFIED DIRECTION

COMPANY : LA. GEOLOGICAL SURVEY, LSU DATE OF SAMPLING : JULY 01-31, 1980

LOCATION : PARCERDUE TEST SITE

PARAMETER :

METHANE

TABLE V

FREQUENCY DISTRIBUTION
(MICROGRAMS PER CUBIC METER)

COMPANY : LA. GEOLOGICAL SURVEY, LSU
LOCATION : PARCPERDUE TEST SITE
DATE : JULY 01-31, 1980
PARAMETER : METHANE

RANGE OF CONCENTRATION	PERCENT (PEAKS)	PERCENT (INTEGRATED)
20	.0	.0
40	.0	.0
60	.0	5.0
80	.0	7.5
100	.0	12.5
120	.0	12.5
140	7.5	12.5
160	10.0	20.0
180	10.0	25.0
200	10.0	25.0
220	15.0	25.0
240	20.0	25.0
260	20.0	25.0
280	20.0	25.0
300	22.5	25.0
320	22.5	25.0
340	22.5	32.5
360	22.5	35.0
380	25.0	35.0
400	25.0	35.0
420	27.5	37.5
440	27.5	37.5
460	27.5	37.5
480	27.5	37.5
500	27.5	37.5

BASIC STATISTICS - (HOURLY BASIS)

ARITHMETIC MEAN (PEAK VALUES) : 1313.55
ARITHMETIC MEAN (INTEGRATED VALUES) : 869.84
GEOMETRIC MEAN (PEAK VALUES) : 887.98
GEOMETRIC MEAN (INTEGRATED VALUES) : 548.35
STANDARD DEV (PEAK VALUES) : 941.71
STANDARD DEV (INTEGRATED VALUES) : 679.15
STANDARD GEOM DEV (PEAK VALUES) : 2.76
STANDARD GEOM DEV (INTEGRATED VALUES) : 3.03

FIGURE 8

FREQUENCY DISTRIBUTION OF ONE-HOUR
CONCENTRATIONS

COMPANY : LA. GEOLOGICAL SURVEY, LSU DATES OF SAMPLING : JULY 01-31, 1980

LOCATION : PARCERDUE TEST SITE

PARAMETER :

METHANE

KEMRON AEROMETRIC DATA BANK
KEMRON ENVIRONMENTAL SERVICES
16556 HIGHLAND ROAD
BATON ROUGE, LOUISIANA 70808
12/16/88 22:19:33

LA. GEOLOGICAL SURVEY, LSU
PARCERDUE TEST SITE
JULY 31-31, 1988

METHANE
CONCENTRATION IN PARTS PER MILLION

31-HOUR DATA LISTING
CENTRAL STANDARD TIME

DAY	AM												PM												DAILY MEAN	NO.	
	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11			
1																									0.0	0.	
2																									0.0	0.	
3																									0.0	0.	
4																									0.0	0.	
5																									0.0	0.	
6																									0.0	0.	
7																									0.0	0.	
8																									0.0	0.	
9																									0.0	0.	
10																									0.0	0.	
11																									0.0	0.	
12																									0.0	0.	
13																									0.0	0.	
14																									0.0	0.	
15																									0.0	0.	
16																									0.0	0.	
17																									0.0	0.	
18																									0.0	0.	
19																									0.0	0.	
20																									0.0	0.	
21																									0.0	0.	
22																									0.0	0.	
23																									0.0	0.	
24																									0.0	0.	
25																									0.0	0.	
26																									0.0	0.	
27																									0.0	0.	
28																									0.0	0.	
29																									0.0	0.	
30		2.2	2.6	3.5	3.3	3.1	3.2	1.3	0.6	0.3	0.1					0.1	0.1	0.1	0.1	0.2	0.8	1.2	1.6	2.5	2.5	1.7	5.
31		1.9	1.8	2.2	2.5	2.1	2.1	1.0	0.5			0.2	0.2		0.5	0.5				0.2	0.5	0.2	0.8	1.4	1.2	19.	
	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11			
AVG. 0.00																											
NO.	0.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	1.	1.	1.	1.	0.	1.	2.	1.	1.	1.	2.	3.	3.	3.	3.	

AVG. 0.000
NO. 0. 2. 2. 2. 2. 2. 2. 2. 2. 2. 1. 1. 1. 1. 0. 1. 2. 1. 1. 1. 2. 3. 3. 3. 3.

SECTION IV

NON-METHANE HYDROCARBONS

TABLE I-A
MAXIMUM AND AVERAGE CONCENTRATION
(USING PEAK VALUES)
(MICROGRAMS PER CUBIC METER)

LA. GEOLOGICAL SURVEY, LSU
PARCERDUE TEST SIT

NON-METHANE HYDROCARBO
JULY 01-31, 1980

DAY OF MONTH	MAX 1-HR	AVG 24-HR	TIME OF DAY (STD)	DIR (N.AZ.)	SPEED (MPH)
1	*	*			
2	*	*			
3	*	*			
4	*	*			
5	*	*			
WEEKLY :	*	*			
6	*	*			
7	*	*			
8	*	*			
9	*	*			
10	*	*			
11	*	*			
12	*	*			
WEEKLY :	*	*			
13	*	*			
14	*	*			
15	*	*			
16	*	*			
17	*	*			
18	*	*			
19	*	*			
WEEKLY :	*	*			
20	*	*			
21	*	*			
22	*	*			
23	*	*			
24	*	*			
25	*	*			
26	*	*			
WEEKLY :	*	*			
27	*	*			
28	*	*			
29	1139	829	2300	250	4
30	2166	820	300	260	1
31	2452	943	2200	70	1
WEEKLY :	2452	864			
MONTHLY :	2452	870			

* NO DATA

FIGURE 1

DAY OF MONTH VERSUS CONCENTRATION (MICROGRAMS/CUBIC METER)

COMPANY : LA. GEOLOGICAL SURVEY, LSU DATES OF SAMPLING : JULY 01-31, 1980

LOCATION : PARCERDUE TEST SITE

PARAMETER :

NON-METHANE HYDROC

TABLE I-B
MAXIMUM AND AVERAGE CONCENTRATION
(USING HOURLY INTEGRATED VALUES)
(MICROGRAMS PER CUBIC METER)

LA. GEOLOGICAL SURVEY, LSU
PARCERDUE TEST SIT

NON-METHANE HYDROCARBO
JULY 01-31, 1980

DAY OF MONTH	MAX 1-HR	AVG 24-HR	TIME OF DAY (STD)	DIR (N.AZ.)	SPEED (MPH)
1	*	*			
2	*	*			
3	*	*			
4	*	*			
5	*	*			
WEEKLY :	*	*			
6	*	*			
7	*	*			
8	*	*			
9	*	*			
10	*	*			
11	*	*			
12	•	*			
WEEKLY :	*	*			
13	*	*			
14	*	*			
15	*	*			
16	•	*			
17	*	*			
18	*	*			
19	*	*			
WEEKLY :	*	*			
20	*	*			
21	*	*			
22	*	*			
23	•	*			
24	*	*			
25	*	*			
26	*	*			
WEEKLY :	*	*			
27	*	*			
28	•	•			
29	580	495	2100	240	3
30	617	506	1700	230	2
31	803	483	500	340	1
WEEKLY :	803	495			
MONTHLY :	803	496			

* NO DATA

FIGURE 2

COMPANY : LA. GEOLOGICAL SURVEY, LSU DATES OF SAMPLING : JULY 01-31, 1980

LOCATION : PARCERDUE TEST SITE

PARAMETER :

NON-METHANE HYDROC

TABLE I-C

THIRTY HIGHEST
3-HOUR INTEGRATED CONCENTRATIONS
(MICROGRAMS/CUBIC METER)

COMPANY : LA. GEOLOGICAL SURVEY, LSU
LOCATION : PARCERDUE TEST SITE
DATE : JULY 01-31, 1980
PARAMETER : NON-METHANE HYDROCARBONS

DAY OF MONTH	3-HOUR INTEG. CONC.	TIME OF DAY (STD)	FIRST HOUR OF PERIOD DATA WIND DIRECTION	WIND SPEED	
31	615	300	260	1	
30	615	1500	290	2	*
30	614	1600	250	2	
31	613	400	280	1	
31	582	500	340	1	
30	581	1700	230	2	
31	575	800	300	5	*
31	540	700	260	2	
30	539	900	300	6	
30	537	1000	310	7	*
29	525	2100	240	3	
30	523	1800	230	1	
29	515	1900	280	2	*
31	515	1200	320	2	*
31	515	1100	280	3	*
30	515	2300	230	3	*
29	507	2300	250	4	*
30	501	2200	240	3	
30	500	800	310	4	
31	500	200	240	1	
30	497	2100	220	4	
30	494	2400	230	2	*
30	492	300	260	1	
31	492	600	300	2	
30	492	1900	210	3	
29	487	2000	240	3	
30	482	700	290	2	
29	481	2200	240	3	
30	478	2000	210	4	
30	477	200	210	2	

* MISSING DATA HOUR

FIGURE 3

TIME OF DAY VERSUS CONCENTRATION (MICROGRAMS/CUBIC METER)

COMPANY : LA. GEOLOGICAL SURVEY, LSU DATES OF SAMPLING : JULY 01-31, 1980

LOCATION : PARCERDUE TEST SITE

PARAMETER :

NON-METHANE HYDROC

TABLE II
**TIME OF DAY VS AVG. CONCENTRATION
(MICROGRAMS PER CUBIC METER)**

COMPANY : LA. GEOLOGICAL SURVEY, LSU
LOCATION : PARCERDUE TEST SITE
DATE : JULY 01-31, 1980
PARAMETER :: NON-METHANE HYDROCARBONS

TIME OF DAY (STD HOURS)	AVERAGE CONCENTRATION	
	(PEAKS)	(INTEGRATED)
100	*	*
200	675.0	427.2
300	1442.0	501.9
400	1071.0	535.0
500	1634.0	623.8
600	532.0	435.6
700	784.0	471.9
800	694.0	481.6
900	736.5	579.9
1000	636.0	526.0
1100	625.0	547.0
1200	667.0	520.3
1300	722.0	509.3
1400	*	*
1500	439.0	320.0
1600	572.5	454.3
1700	729.0	617.1
1800	738.0	610.6
1900	761.0	515.5
2000	711.0	445.7
2100	792.0	469.1
2200	1227.3	515.8
2300	1190.0	479.6
2400	722.3	446.6

* NO DATA

FIGURE 4

WIND DIRECTION VERSUS AVERAGE CONCENTRATION
(MICROGRAMS/CUBIC METER)
(PEAK VALUES)

COMPANY : LA. GEOLOGICAL SURVEY, LSU DATE OF SAMPLING : JULY 01-31, 1980

LOCATION : PARCERDUE TEST SITE

PARAMETER :

NON-METHANE HYDROCARBONS

TABLE III

WIND DIRECTION VS AVERAGE CONCENTRATION
(MICROGRAMS PER CUBIC METER)

COMPANY : LA. GEOLOGICAL SURVEY, LSU
LOCATION : PARCERDUE TEST SITE
DATE : JULY 01-31, 1980
PARAMETER : NON-METHANE HYDROCARBONS

DIRECTION (DEGREES)	PERCENT OF WIND OCCURRENCES	AVG. CONCENTRATION (PEAKS) (INTEGRATED)	
CALM	2.2	**	**
10	2.4	**	**
20	2.7	**	**
30	3.2	**	**
40	2.4	**	**
50	4.3	**	**
60	2.7	**	**
70	1.4	2452.0	643.9
80	3.2	**	**
90	1.9	1394.0	377.8
100	1.6	**	**
110	2.7	501.0	333.2
120	.5	**	**
130	.5	**	**
140	1.4	**	**
150	4.3	**	**
160	1.1	**	**
170	1.4	**	**
180	2.7	**	**
190	3.2	**	**
200	3.2	**	**
210	3.0	617.3	418.9
220	1.9	829.0	518.7
230	3.2	901.7	534.4
240	6.2	745.8	477.9
250	4.1	689.3	468.3
260	2.2	1248.3	491.8
270	5.4	709.0	449.0
280	3.5	1096.0	565.5
290	4.6	707.0	472.3
300	5.1	685.3	514.3
310	3.8	644.3	501.0
320	2.4	714.0	568.2
330	1.9	**	**
340	1.1	2415.0	803.1
350	1.9	**	**
360	.5	**	**

** NO DATA

FIGURE 5

WIND DIRECTION VERSUS AVERAGE CONCENTRATION
(MICROGRAMS/CUBIC METER)
(INTEGRATED VALUES)

COMPANY : LA. GEOLOGICAL SURVEY, LSU DATE OF SAMPLING : JULY 01-31, 1980

LOCATION : PARCERDUE TEST SITE

PARAMETER :

NON-METHANE HYDROC

TABLE IV

 WIND SPEED VS AVERAGE CONCENTRATION
 (MICROGRAMS PER CUBIC METER)

COMPANY : LA. GEOLOGICAL SURVEY, LSU
 LOCATION : PARC PERDUE TEST SITE
 DATE : JULY 01-31, 1980
 PARAMETER : NON-METHANE HYDROCARBONS

SPEED (MPH)	PERCENT OF WIND OCCURRENCES	AVG CONCENTRATION (PEAK)	(INTEGRATED)
0	.3	**	**
1	10.5	1303.6	547.5
2	17.0	791.0	485.2
3	17.8	747.4	470.4
4	13.8	808.3	503.3
5	11.1	670.5	540.0
6	9.2	569.0	419.8
7	8.9	636.0	526.0
8	5.4	**	**
9	2.7	**	**
10	1.4	**	**
11	.5	**	**
12	.8	439.0	320.0
13	.5	**	**

** NO DATA

FIGURE 7

WIND ROSE

PERCENT OF TIME WIND WAS FROM A SPECIFIED DIRECTION

COMPANY : LA. GEOLOGICAL SURVEY, LSU DATE OF SAMPLING : JULY 01-31, 1980

LOCATION : PARCERDUE TEST SITE

PARAMETER :

NON-METHANE HYDROC

FIGURE 6

WIND SPEED VERSUS AVERAGE CONCENTRATION (MICROGRAMS/CUBIC METER)

COMPANY : LA. GEOLOGICAL SURVEY, LSU DATES OF SAMPLING : JULY 01-31, 1980

LOCATION : PARCERDUE TEST SITE

PARAMETER :

NON-METHANE HYDROC

TABLE V

 FREQUENCY DISTRIBUTION
 (MICROGRAMS PER CUBIC METER)

COMPANY : LA. GEOLOGICAL SURVEY, LSU
 LOCATION : PARCERDUE TEST SITE
 DATE : JULY 01-31, 1980
 PARAMETER : NON-METHANE HYDROCARBONS

RANGE OF CONCENTRATION	PERCENT (PEAKS)	PERCENT (INTEGRATED)
20	.0	.0
40	.0	.0
60	.0	.0
80	.0	.0
100	.0	.0
120	.0	.0
140	.0	.0
160	.0	.0
180	.0	.0
200	.0	.0
220	.0	.0
240	.0	.0
260	.0	.0
280	.0	.0
300	.0	2.5
320	.0	7.5
340	.0	7.5
360	.0	10.0
380	.0	12.5
400	.0	15.0
420	.0	17.5
440	5.0	22.5
460	7.5	35.0
480	10.0	47.5
500	10.0	47.5

BASIC STATISTICS - (HOURLY BASIS)

ARITHMETIC MEAN (PEAK VALUES) : 870.40
 ARITHMETIC MEAN (INTEGRATED VALUES) : 495.32
 GEOMETRIC MEAN (PEAK VALUES) : 790.88
 GEOMETRIC MEAN (INTEGRATED VALUES) : 485.58
 STANDARD DEV (PEAK VALUES) : 465.96
 STANDARD DEV (INTEGRATED VALUES) : 97.54
 STANDARD GEOM DEV (PEAK VALUES) : 1.49
 STANDARD GEOM DEV (INTEGRATED VALUES) : 1.22

FIGURE 8

FREQUENCY DISTRIBUTION OF ONE-HOUR CONCENTRATIONS

COMPANY : LA. GEOLOGICAL SURVEY, LSU DATES OF SAMPLING : JULY 01-31, 1980

LOCATION : PARCERDUE TEST SITE

PARAMETER :

NON-METHANE HYDROC

KEMRON AEROMETRIC DATA BANK
KEMRON ENVIRONMENTAL SERVICES
16555 HIGHLAND ROAD
BATON ROUGE, LOUISIANA 70808
12/16/88 22:19:39

LA. GEOLOGICAL SURVEY, LSU
PARCERDUE TEST SITE
JULY 31-31, 1988

NON-METHANE HYDROCARBONS
CONCENTRATION IN PARTS PER MILLION

24-HOUR DATA LISTING
CENTRAL STANDARD TIME

DAY	12	1	2	3	4	5 AM	6	7	8	9	10	11	12	1	2	3	4	5	6 PM	7	8	9	10	11	DAILY MEAN	NO.
1																									0.0	0.
2																									0.0	0.
3																									0.0	0.
4																									0.0	0.
5																									0.0	0.
6																									0.0	0.
7																									0.0	0.
8																									0.0	0.
9																									0.0	0.
10																									0.0	0.
11																									0.0	0.
12																									0.0	0.
13																									0.0	0.
14																									0.0	0.
15																									0.0	0.
16																									0.0	0.
17																									0.0	0.
18																									0.0	0.
19																									0.0	0.
20																									0.0	0.
21																									0.0	0.
22																									0.0	0.
23																									0.0	0.
24																									0.0	0.
25																									0.0	0.
26																									0.0	0.
27																									0.0	0.
28																									0.0	0.
29																									0.0	0.
30		0.6	0.8	0.8	0.7	0.6	0.7	0.6	0.8	0.8	0.8				0.9	0.9	0.9	0.8	0.7	0.9	0.6	0.8	0.7	0.7	0.7	0.
31		0.7	0.7	0.8	1.2	0.7	0.7	0.8	0.9			0.8	0.8		0.8	0.4	0.9	0.9	0.8	0.7	0.8	0.7	0.7	0.8	0.8	19.
	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	0.7	16.
AVG	0.0	0.6	0.8	0.8	0.9	0.7	0.7	0.7	0.9	0.8	0.8	0.8	0.8	0.8	0.5	0.7	0.9	0.9	0.8	0.7	0.7	0.8	0.7	0.7		
NO.	0.	2.	2.	2.	2.	2.	2.	2.	2.	1.	1.	1.	1.	0.	1.	2.	1.	1.	1.	2.	3.	3.	3.	3.		

SECTION V**HYDROGEN SULFIDE:**

TABLE I-A
MAXIMUM AND AVERAGE CONCENTRATION
(USING PEAK VALUES)
(MICROGRAMS PER CUBIC METER)

LA. GEOLOGICAL SURVEY, LSU PARCERDUE TEST SIT			HYDROGEN SULFIDE JULY 01-31, 1980		
DAY OF MONTH	MAX 1-HR	AVG 24-HR	TIME OF DAY (STD)	DIR (N.AZ.)	SPEED (MPH)
1	*	*			
2	*	*			
3	*	*			
4	*	*			
5	*	*			
WEEKLY :	*	*			
6	*	*			
7	*	*			
8	*	*			
9	*	*			
10	*	*			
11	19	10	2000	210	6
12	*	*			
WEEKLY :	19	10			
13	37	23	400	290	2
14	41	27	1800	260	6
15	37	22	1700	260	5
16	24	12	2100	110	5
17	61	41	1700	120	4
18	26	14	2100	30	5
19	43	20	1600	150	7
WEEKLY :	61	23			
20	*	*			
21	*	*			
22	17	15	1600	150	2
23	41	22	1300	0	8
24	44	22	1400	50	8
25	63	38	2300	70	3
26	37	26	300	130	3
WEEKLY :	63	24			
27	34	25	1800	220	5
28	36	26	2400	40	1
29	44	34	2400	270	4
30	27	22	800	310	4
31	*	*			
WEEKLY :	44	27			
MONTHLY :	63	25			
* NO DATA					

TABLE I-B
MAXIMUM AND AVERAGE CONCENTRATION
(USING HOURLY INTEGRATED VALUES)
(MICROGRAMS PER CUBIC METER)

LA. GEOLOGICAL SURVEY, LSU PARCPERDUE TEST SIT			HYDROGEN SULFIDE JULY 01-31, 1980		
DAY OF MONTH	MAX 1-HR	AVG 24-HR	TIME OF DAY (STD)	DIR (N.AZ.)	SPEED (MPH)
1	*	*			
2	*	*			
3	*	*			
4	*	*			
5	*	*			
WEEKLY :	*	*			
6	*	*			
7	*	*			
8	*	*			
9	*	*			
10	*	*			
11	1	1	2000	210	6
12	*	*			
WEEKLY :	1	1			
13	12	4	600	280	2
14	18	7	1900	240	9
15	14	5	1200	290	7
16	5	1	2000	110	6
17	27	18	1400	60	6
18	3	1	1600	300	4
19	17	5	1800	150	8
WEEKLY :	27	6			
20	*	*			
21	*	*			
22	3	2	1600	150	2
23	12	5	1300	0	8
24	23	7	1300	50	8
25	42	17	2400	80	3
26	11	7	800	110	4
WEEKLY :	42	8			
27	11	6	1200	240	7
28	17	8	2400	40	1
29	22	12	1300	310	3
30	7	5	800	310	4
31	*	*			
WEEKLY :	22	8			
MONTHLY :	42	8			

* NO DATA

FIGURE 1

DAY OF MONTH VERSUS CONCENTRATION (MICROGRAMS/CUBIC METER)

COMPANY : LA. GEOLOGICAL SURVEY, LSU DATES OF SAMPLING : JULY 01-31, 1980

LOCATION : PARCERDUE TEST SITE

PARAMETER :

HYDROGEN SULFIDE

TABLE I-C

THIRTY HIGHEST
1-HOUR INTEGRATED CONCENTRATIONS
(MICROGRAMS/CUBIC METER)

COMPANY : LA. GEOLOGICAL SURVEY, LSU
LOCATION : PARCERDUE TEST SITE
DATE : JULY 01-31, 1980
PARAMETER : HYDROGEN SULFIDE

DAY OF MONTH	1-HOUR INTEG. CONC.	TIME OF DAY (STD)	WIND DIRECTION	WIND SPEED
25	42	2400	80	3
25	42	2300	70	3
25	38	2100	190	2
25	35	2000	140	3
25	33	2200	50	2
25	29	1900	190	5
17	27	1400	60	6
25	27	1800	180	10
17	26	1700	120	4
17	24	2300	0	1
17	23	1500	80	5
24	23	1300	50	8
29	22	1300	310	3
17	22	2400	90	1
17	22	1600	100	4
24	21	1100	50	8
24	21	1400	50	8
24	21	1000	40	7
17	20	2200	300	1
17	20	1200	350	4
17	19	700	60	2
14	18	1900	240	9
17	17	600	0	3
24	17	1200	50	8
19	17	1800	150	8
17	17	1800	120	4
19	17	1700	150	9
17	17	800	50	3
29	17	2300	250	4
17	17	1100	330	4

FIGURE 2

DAY OF MONTH VERSUS CONCENTRATION (MICROGRAMS/CUBIC METER)

COMPANY : LA. GEOLOGICAL SURVEY, LSU DATES OF SAMPLING : JULY 01-31, 1980

LOCATION : PARCERDUE TEST SITE

PARAMETER :

HYDROGEN SULFIDE

TABLE II

 TIME OF DAY VS AVG. CONCENTRATION
 (MICROGRAMS PER CUBIC METER)

COMPANY : LA. GEOLOGICAL SURVEY, LSU
 LOCATION : PARCPERDUE TEST SITE
 DATE : JULY 01-31, 1980
 PARAMETER : HYDROGEN SULFIDE

TIME OF DAY (STD HOURS)	AVERAGE CONCENTRATION	
	(PEAKS)	(INTEGRATED)
100	*	*
200	23.2	6.2
300	22.2	6.1
400	25.2	6.0
500	23.3	6.1
600	23.6	6.7
700	25.3	7.0
800	25.1	6.9
900	20.5	5.7
1000	26.2	7.6
1100	28.5	8.0
1200	29.3	8.9
1300	26.8	8.6
1400	26.9	7.9
1500	26.7	6.4
1600	24.4	6.1
1700	25.4	7.2
1800	26.8	9.0
1900	23.2	7.5
2000	25.9	8.0
2100	27.6	9.0
2200	21.7	7.6
2300	22.7	8.4
2400	23.0	8.6

* NO DATA

FIGURE 3

TIME OF DAY VERSUS CONCENTRATION
(MICROGRAMS/CUBIC METER)

COMPANY : LA. GEOLOGICAL SURVEY, LSU DATES OF SAMPLING : JULY 01-31, 1980

LOCATION : PARCERQUE TEST SITE

PARAMETER :

HYDROGEN SULFIDE

TABLE III

WIND DIRECTION VS AVERAGE CONCENTRATION
(MICROGRAMS PER CUBIC METER)

COMPANY : LA. GEOLOGICAL SURVEY, LSU
 LOCATION : PARCERDUE TEST SITE
 DATE : JULY 01-31, 1980
 PARAMETER : HYDROGEN SULFIDE

DIRECTION (DEGREES)	PERCENT OF WIND OCCURRENCES	AVG. CONCENTRATION (PEAKS)	(INTEGRATED)
CALM	2.2	35.0	14.1
10	2.4	21.8	4.9
20	2.7	25.3	6.5
30	3.2	19.8	4.6
40	2.4	19.9	5.5
50	4.3	27.8	11.9
60	2.7	22.3	7.1
70	1.4	37.5	21.1
80	3.2	23.0	8.0
90	1.9	28.0	10.1
100	1.6	29.5	8.8
110	2.7	23.6	5.4
120	.5	49.0	21.3
130	.5	27.0	4.9
140	1.4	28.3	11.8
150	4.3	26.6	9.0
160	1.1	23.5	5.7
170	1.4	25.8	5.9
180	2.7	23.3	6.6
190	3.2	30.3	10.5
200	3.2	20.1	4.1
210	3.0	18.9	3.8
220	1.9	22.8	4.3
230	3.2	16.9	3.4
240	6.2	29.6	9.0
250	4.1	22.0	4.4
260	2.2	27.2	7.6
270	5.4	24.1	5.5
280	3.5	20.4	5.1
290	4.6	26.7	6.2
300	5.1	24.5	7.9
310	3.8	22.8	6.1
320	2.4	23.7	6.6
330	1.9	22.9	7.0
340	1.1	29.7	11.0
350	1.9	26.6	9.5
360	.5	32.0	12.3

FIGURE 4

WIND DIRECTION VERSUS AVERAGE CONCENTRATION
(MICROGRAMS/CUBIC METER)
(PEAK VALUES)

COMPANY : LA. GEOLOGICAL SURVEY, LSU DATE OF SAMPLING : JULY 01-31, 1980
LOCATION : PARCPEQUE TEST SITE PARAMETER : HYDROGEN SULFIDE

FIGURE 5

WIND DIRECTION VERSUS AVERAGE CONCENTRATION
(MICROGRAMS/CUBIC METER)
(INTEGRATED VALUES)

COMPANY : LA. GEOLOGICAL SURVEY, LSU DATE OF SAMPLING : JULY 01-31, 1980

LOCATION : PARCPERDUE TEST SITE

PARAMETER :

HYDROGEN SULFIDE

TABLE IV

WIND SPEED VS AVERAGE CONCENTRATION
(MICROGRAMS PER CUBIC METER)

COMPANY : LA. GEOLOGICAL SURVEY, LSU
LOCATION : PARCPERDUE TEST SITE
DATE : JULY 01-31, 1980
PARAMETER : HYDROGEN SULFIDE

SPEED (MPH)	PERCENT OF WIND OCCURRENCES	AVG CONCENTRATION (PEAK)	(INTEGRATED)
0	.3	**	**
1	10.5	27.6	9.2
2	17.0	25.5	8.0
3	17.8	26.0	8.6
4	13.8	24.3	6.5
5	11.1	22.3	5.5
6	9.2	20.9	5.0
7	8.9	23.0	5.8
8	5.4	28.1	9.6
9	2.7	24.2	8.2
10	1.4	32.4	9.6
11	.5	19.0	3.9
12	.8	27.5	8.4
13	.5	37.0	8.6

** NO DATA

FIGURE 7

WIND ROSE

PERCENT OF TIME WIND WAS FROM A SPECIFIED DIRECTION

COMPANY : LA. GEOLOGICAL SURVEY, LSU DATE OF SAMPLING : JULY 01-31, 1980
 LOCATION : PARCPERDUE TEST SITE PARAMETER : HYDROGEN SULFIDE

FIGURE 6

WIND SPEED VERSUS AVERAGE CONCENTRATION
(MICROGRAMS/CUBIC METER)

COMPANY : LA. GEOLOGICAL SURVEY, LSU DATES OF SAMPLING : JULY 01-31, 1980

LOCATION : PARCERDUE TEST SITE

PARAMETER :

HYDROGEN SULFIDE

FIGURE 8

FREQUENCY DISTRIBUTION OF ONE-HOUR CONCENTRATIONS

COMPANY : LA. GEOLOGICAL SURVEY, LSU DATES OF SAMPLING : JULY 01-31, 1980

LOCATION : PARCERDUE TEST SITE

PARAMETER :

HYDROGEN SULFIDE

TABLE V

 FREQUENCY DISTRIBUTION
 (MICROGRAMS PER CUBIC METER)

COMPANY : LA. GEOLOGICAL SURVEY, LSU
 LOCATION : PARCERDUE TEST SITE
 DATE : JULY 01-31, 1980
 PARAMETER : HYDROGEN SULFIDE

RANGE OF CONCENTRATION	PERCENT (PEAKS)	PERCENT (INTEGRATED)
20	33.9	93.6
40	91.1	99.3
60	99.0	100.0
80	100.0	100.0

BASIC STATISTICS - (HOURLY BASIS)

ARITHMETIC MEAN (PEAK VALUES)	:	24.87
ARITHMETIC MEAN (INTEGRATED VALUES)	:	7.35
GEOMETRIC MEAN (PEAK VALUES)	:	21.02
GEOMETRIC MEAN (INTEGRATED VALUES)	:	4.06
STANDARD DEV (PEAK VALUES)	:	11.85
STANDARD DEV (INTEGRATED VALUES)	:	7.18
STANDARD GEOM DEV (PEAK VALUES)	:	2.01
STANDARD GEOM DEV (INTEGRATED VALUES)	:	3.79

KEMRON AEROMETRIC DATA BANK
KEMRON ENVIRONMENTAL SERVICES
16550 HIGHLAND ROAD
BATON ROUGE, LOUISIANA 70808
12/16/88 22:19:33

LA. GEOLOGICAL SURVEY, LSU
PARCERDUE TEST SITE
JULY 01-31, 1988

HYDROGEN SULFIDE CONCENTRATION IN PARTS PER MILLION

24-HOUR DATA LISTING CENTRAL STANDARD TIME

DAY	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	DAILY MEAN	NO.
1																									.000	8.
2																									.000	8.
3																									.000	8.
4																									.000	8.
5																									.000	8.
6																									.000	8.
7																									.000	8.
8																									.000	8.
9																									.000	8.
10																									.000	8.
11																									.000	8.
12																									.000	8.
13																									.000	8.
14																									.000	8.
15																									.000	8.
16																									.000	8.
17																									.000	8.
18																									.000	8.
19																									.000	8.
20																									.000	8.
21																									.000	8.
22																									.000	8.
23																									.000	8.
24																									.000	8.
25																									.000	8.
26																									.000	8.
27																									.000	8.
28																									.000	8.
29																									.000	8.
30																									.000	8.
31																									.000	8.

AVG.000 .004 .004 .004 .004 .005 .005 .005 .004 .005 .006 .006 .004 .006 .005 .004 .005 .006 .005 .006 .005 .006 .006 .005 .006 .006
NO. 8. 13. 13. 13. 13. 13. 13. 13. 14. 13. 13. 12. 13. 10. 12. 10. 10. 14. 15. 15. 13. 13. 13. 13.

SECTION VI

METEOROLOGY

WIND SPEED

KEMRON AEROMETRIC DATA BANK
KEMRON ENVIRONMENTAL SERVICES
16558 HIGHLAND ROAD
BATON ROUGE, LOUISIANA 70808
12/16/88 22:28:21

LA. GEOLOGICAL SURVEY, LSU
PARCERDUE TEST SITE
JULY 1-31, 1988

WIND SPEED (MPH)

61-HOUR DATA LISTING CENTRAL STANDARD TIME

DAY	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	DAILY
						AM													PM						
1																									
2																									
3																									
4																									
5																									
6																									
7																									
8																									
9																									
10																									
11																									
12																									
13	2.5	2.9	2.4	2.1	2.5	2.1	3.5	5.8	7.6	7.3	8.1	7.6	6.2	5.9	4.6	3.8	2.3	5.7	6.5	5.6	4.4	2.9	2.8	1.5	
14	1.5	1.3	1.3	1.2	1.5	1.5	5.9	3.5	6.4	7.5	8.4	5.8	5.8	5.3	4.7	3.9	3.8	5.6	5.6	5.7	3.5	3.5	3.5	2.3	
15	2.2	2.8	2.6	3.5	3.1	3.1	4.1	7.3	9.3	8.5	7.6	6.6	6.4	4.2	4.5	5.9	5.5	4.8	5.1	6.6	6.4	4.3	5.6	3.5	
16	3.3	3.1	5.5	4.8	5.4	3.5	5.3	10.6	8.8	6.5	7.1	7.2	5.8	5.7	3.4	4.5	5.1	3.6	13.3	6.5	4.9	1.8	3.5	2.2	
17	2.3	3.2	1.9	2.1	2.7	2.9	1.7	2.9	2.5	3.9	3.5	3.5	5.3	5.7	5.1	4.4	4.3	3.9	3.3	2.1	2.3	1.3	5.7	1.5	
18	1.1	1.5	1.7	1.5	1.5	1.1	1.6	4.4	7.7	7.9	2.7	2.6	3.2	6.8	4.8	4.9	7.6	4.7	4.5	5.1	5.3	5.5	5.3	3.3	
19	3.9	4.5	4.7	3.6	3.3	3.1	3.9	3.9	4.4	4.8	4.7	5.7	7.4	5.9	5.4	6.7	9.4	7.8	6.1	4.3	5.1				
20																									
21																									
22																									
23																									
24	3.2	2.2	2.3	3.7	3.6	2.9	5.2	5.3	6.5	7.4	8.3	7.7	7.5	7.6	5.8	5.5	4.8	4.3	3.1	1.9	2.5	2.4	2.1	1.5	
25	5.2	1.8	1.1	2.5	1.4	5.7	5.9	2.2	1.4	2.5	2.3	3.8	4.7	7.8	11.6	12.1	12.5	9.5	5.4	2.5	2.4	1.8	3.3	2.9	
26	2.3	2.7	3.4	1.8	1.9	2.6	2.8	4.1	4.1	3.2	7.2	9.5	9.5	9.7	9.9	10.3	9.3	10.7	9.2	5.4	2.5	3.5	2.9	3.5	
27	4.1	1.3	3.2	4.1	2.7	2.8	2.1	3.7	5.8	9.7	8.5	7.3	6.9	8.6	7.5	7.7	7.3	4.8	5.2	1.9	1.3	1.7	7.4	7.7	
28																									
29	1.5	5.7	1.5	1.1	1.8	1.6	1.3	1.8	2.1	3.5	3.3	2.4	2.9	2.3	2.8	3.3	3.4	2.8	2.4	2.6	2.7	3.2	3.9	3.7	
30	2.3	1.5	1.5	1.7	1.2	1.5	2.5	4.3	6.4	6.5	5.2	4.4		1.8	1.6	1.8	1.5	1.5	2.7	4.5	4.5	2.8	2.6	2.5	
31	1.6	1.3	1.1	1.4	1.4	1.7	1.5	4.5	3.8	3.5	3.2	2.1	3.5	6.5	12.4	6.5	6.6	4.6	3.1	3.7	3.2	1.1	1.9	2.3	
	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	

NO. 14. 14. 14. 14. 14. 14. 14. 15. 15. 15. 15. 15. 15. 17. 17. 18. 17. 17. 17. 17. 17. 17. 15. 15. 15.

 

WIND DIRECTION

KEMRON AEROMETRIC DATA BANK
KEMRON ENVIRONMENTAL SERVICES
16555 HIGHLAND ROAD
BATON ROUGE, LOUISIANA 70809
12/16/88 22:20:21

LA. GEOLOGICAL SURVEY, LSU
PARCERDUE TEST SITE
JULY 1-31, 1988

WIND DIRECTION (DEG N. AZ.)

24-HOUR DATA LISTING CENTRAL STANDARD TIME

DAY	AM												PM												DAILY
	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	
1																									
2																									
3																									
4																									
5																									
6																									
7																									
8																									
9																									
10																									
11																									
12																		235.	285.	255.	285.	215.	255.		
13	255.	245.	285.	295.	295.	285.	325.	325.	305.	295.	285.	275.	275.	255.	255.	255.	245.	185.	175.	215.	225.	215.	255.	215.	
14	245.	255.	165.	285.	195.	195.	55.	285.	285.	295.	275.	275.	275.	275.	265.	265.	275.	265.	245.	245.	245.	245.	245.	235.	
15	245.	245.	275.	285.	295.	295.	315.	315.	305.	305.	305.	295.	315.	325.	275.	245.	265.	255.	235.	255.	255.	255.	265.	275.	
16	275.	275.	285.	295.	305.	315.	315.	315.	305.	275.	295.	315.	305.	325.	335.	235.	285.	325.	85.	115.	115.	45.	275.	115.	
17	355.	55.	325.	345.	25.	5.	65.	85.	5.	335.	335.	355.	65.	65.	85.	105.	125.	125.	155.	155.	245.	305.	275.	95.	
18	15.	35.	135.	195.	145.	335.	15.	65.	65.	85.	85.	205.	85.	155.	265.	305.	335.	335.	15.	25.	35.	35.	45.	45.	
19	65.	75.	85.	85.	85.	85.	35.	85.	95.	105.	115.	145.	85.	145.	155.	155.	155.	155.	155.	95.	95.				
20																									
21																									
22																									
23																									
24	75.	85.	35.	45.	25.	35.	25.	15.	15.	15.	25.	355.	5.	355.	15.	25.	25.	35.	45.	85.	55.	35.	45.	55.	
25	195.	335.	315.	345.	355.	5.	155.	15.	5.	115.	95.	105.	155.	165.	175.	195.	185.	195.	145.	195.	55.	75.	85.		
26	115.	115.	135.	185.	185.	35.	95.	115.	165.	155.	145.	155.	165.	185.	185.	175.	195.	195.	215.	235.	325.	35.	185.	185.	
27	175.	35.	185.	205.	195.	185.	205.	185.	205.	215.	215.	245.	245.	225.	225.	245.	235.	225.	195.	225.	205.	185.	345.	45.	
28																									
29	185.	365.	365.	305.	295.	325.	365.	315.	325.	295.	295.	295.	315.	275.	295.	295.	285.	305.	285.	245.	245.	245.	255.	275.	
30	245.	215.	265.	235.	235.	255.	295.	315.	305.	315.	315.	305.		275.	295.	255.	235.	235.	215.	215.	225.	245.	235.	235.	
31	235.	245.	265.	285.	345.	305.	265.	305.	325.	315.	285.	325.	305.	245.	215.	255.	75.	275.	15.	85.	115.	75.	95.	115.	
	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	

NO. 14. 14. 14. 14. 14. 14. 14. 15. 15. 15. 15. 15. 15. 17. 17. 18. 17. 17. 17. 17. 17. 17. 18. 15. 15.

TEMPERATURE

RAIN

APPENDIX C
Surface and Ground Water Quality Data
January - December, 1980
Parcperdue Test Site

SURFACE WATER QUALITY DATA: LEBLANC DITCH (NEAR VERMILION)

Date	Water Level	SC	pH	Temp.	Turb.	CaCO ₃	SO ₄	Na	Mg	Cl	C	Ca	K	Ba	Mn	O ₂	N	B	Pb	As	Cd	Hg
1-24-80	6"	72	6.5	10	211	25.6	5	6.25	1.67	7	13.6	7.39	6.37	.08	.14	9.9	1.60	ND	ND	.0043	ND	ND
2-20-80	2"	192	7.54	19	120	50.9	10	17.0	4.65	30	17.8	12.6	9.65	.17	.17	9.6	.63	ND	ND	.0038	ND	ND
3-21-80	1"	440	7.30	15	104	113.3	5	50.8	10.30	68.0	37	28.1	18.6	.19	.40	8.8	1.03	ND	ND	.0056	ND	ND
4-21-80	4"	180	6.90	18	1,370	72	6	16.9	6.17	29	35.6	18.0	5.29	.86	.91	5.2	.74	ND	ND	.0031	ND	ND
5-21-80	69"	81	6.14	25	710	28.8	5	6.0	2.54	9.5	24.9	7.1	5.23	.27	.36	3.8	1.70	.1	ND	.0019	ND	ND
6-23-80	10"	101	7.22	30	868	29.16	2	6.35	3.95	5.25	16.1	8.6	3.01	.44	.28	5.9	.42	.2	ND	.0022	ND	ND
7-22-80	4"	284	7.90	29	36	113.95	ND	19.35	9.03	7.50	4.9	30.5	2.07	.20	.34	7.1	1.29	.05	ND	.0056	ND	ND
8-21-80	5"	166	7.76	29	25	55.9	ND	13.8	5.08	18.0	5.2	13.7	4.12	.12	.41	5.4	1.24	.05	ND	.0105	ND	ND
9-22-80	8"	122	7.2	28	29	38.5	ND	8.0	3.30	12.7	5.2	9.9	7.40	.12	.11	6.6	.39	.07	ND	.0046	ND	ND
10-22-80	5"	159	6.6	16	8	48.7	ND	9.5	4.72	14.1	20.6	11.6	1.3	.16	.16	4.2	1.39	.25	ND	.0072	ND	ND
11-20-80	7"	629.8	7.80	8	24.1	108.8	ND	74.0	15.0	133.0	24.6	44	20.5	.40	5.05	8.7	4.11	.18	ND	.0052	ND	ND
12-17-80	4"	110	6.72	8	51	31.6	ND	8.0	2.82	13.0	11.1	7.9	6.4	.12	.16	8.6	1.11	.02	ND	.002	ND	ND
Average		211.4	7.13	19.58	296.34	65.76	2.75	19.66	5.77	28.92	18.05	16.62	7.50	.26	.71	6.98	1.30	.08	ND	.0047	ND	ND

Water level: feet below ground surface
Specific conductance (SC) in umhos/cm
pH in standard units
Temperature in centigrade
Turbidity in feet
All other values in mg/l

SURFACE WATER QUALITY DATA: LEBLANC DITCH (NEAR CHURCH)

Date	Water Level	SC	pH	Temp.	Turb.	CaCO ₃	SO ₄	Na	Mg	Cl	C	Ca	K	Ba	Mn	O ₂	N	B	Pb	As	Cd	Hg
1-24-80	4"	68	6.54	10	217	18.9	5	4.87	1.39	5	15.6	5.18	4.61	.06	.12	7.9	2.30	.1	ND	.0035	ND	ND
2-20-80	2"	142	6.98	17	144	43.4	9	13.0	4.0	20	21.0	10.5	1.90	.12	.40	7.8	.70	ND	ND	.0042	ND	ND
3-21-80	1"	229	7.35	17	222	68.8	4	25.0	4.95	89.0	25	18.4	5.24	.12	1.36	9.4	1.17	ND	ND	.0139	ND	ND
4-21-80	3"	168	6.35	19	3,200	68.1	ND	12.9	5.57	8	68.7	16.0	3.80	.78	2.89	4.1	1.93	ND	ND	.0043	ND	ND
5-21-80	5"	71	6.40	24	758	28.4	ND	4.5	2.66	4.7	22.9	6.5	3.70	.31	.66	4.7	1.70	.1	ND	.00023	ND	ND
6-23-80	4"	54	6.55	32.5	1,000	22.63	6.8	5.78	2.13	5.16	19.7	5.0	2.75	.62	.48	4.2	.59	.3	ND	.0023	ND	ND
7-22-80	2"	228	7.48	29	57	88.62	ND	15.61	8.01	5.0	6.8	21.5	2.45	.16	1.08	7.4	1.15	.09	ND	.013	ND	ND
8-21-80	1"	201	7.52	27	19	62.2	ND	28.7	7.65	32.5	9.7	24.0	2.60	.08	1.23	5.8	1.26	.08	ND	.0235	ND	ND
9-22-80	1"	210	6.91	27	11.5	53.4	ND	5.7	3.70	7.0	12.6	11.2	4.45	.30	5.58	6.5	1.26	.20	ND	.0035	ND	ND
10-22-80	4"	112	5.85	16	25	37.6	6.0	6.8	3.55	8.6	20.6	9.0	1.0	.13	.27	3.6	1.42	.10	ND	.075	ND	ND
11-20-80	0"	765.6	7.25	9	14	265.0	14	240.0	12.81	351.0	7.2	85.0	9.5	.26	.08	8.1	.91	.28	ND	.009	ND	ND
12-17-80	1"	79	5.75	9	50	32.2	ND	5.2	3.01	7.30	17.6	7.6	5.2	.08	.45	5.8	1.26	.02	ND	.001	ND	ND
Average		193.97	6.74	19.71	476.46	65.77	3.73	30.67	4.95	45.27	20.62	18.32	3.93	.25	1.22	6.28	1.30	.11	ND	.0128	ND	ND

Water level: feet below ground surface
 Specific conductance (SC) in umhos/cm
 pH in standard units
 Temperature in centigrade
 Turbidity in feet
 All other values in mg/l

SURFACE WATER QUALITY DATA: BAYOU PARCPERDUE

Date	Water Level	SC	pH	Temp.	Turb.	CaCO ₃	SO ₄	Na	Mg	Cl	C	Ca	K	Ba	Mn	O ₂	N	B	Pb	As	Cd	Hg
1-24-80	7"	83	6.24	9	280	25.4	4	6.62	1.69	6	12.6	7.27	5.25	.08	.16	8.6	1.36	ND	ND	.0037	ND	ND
2-20-80	10"	142	6.60	16	206	45.5	8	12.9	4.25	15	17.8	11.0	6.20	.14	.27	7.3	.56	ND	ND	.0046	ND	ND
3-21-80	4"	227	6.75	17	233	77.6	6	23.6	6.25	27.0	26	19.5	7.76	.22	1.73	4.5	.86	ND	ND	.0089	ND	ND
4-21-80	4"	112	6.40	19	2,650	60.8	ND	10.9	4.88	14	54.5	15.0	3.87	.53	1.79	2.6	1.06	ND	ND	.0033	ND	ND
5-21-80	7"	80	6.36	24	792.5	30.3	ND	5.2	2.60	5.4	24.6	7.5	4.13	.28	.48	5.6	1.43	.1	ND	.0024	ND	ND
6-23-80	4"	147	7.05	27	500	44.84	7.3	11.0	4.10	11.75	11.8	11.2	2.75	.31	.40	5.2	.43	.3	ND	.0018	ND	ND
7-22-80	13"	207	7.00	28	186	73.61	4	15.45	6.68	13.0	9.8	17.9	4.19	.18	.78	3.0	1.68	.15	ND	.0048	ND	ND
8-21-80	11"	230	7.16	28	19	102.6	ND	14.6	9.02	7.0	4.4	24.9	2.38	.19	1.84	1.6	.82	.05	ND	.0190	ND	ND
9-22-80	14"	133	6.50	29	40	40.8	ND	8.2	3.23	11.5	8.4	10.5	7.22	.38	.71	2.4	1.33	.09	ND	.0055	ND	ND
10-22-80	10"	148	6.18	16	24	52.6	2.0	6.7	4.48	7.6	19.6	13.1	1.1	.19	.80	2.4	1.39	.10	ND	.0045	ND	ND
11-20-80	4"	237.6	7.70	9	38	80.2	3	31.5	7.7	30.0	12.4	19.2	10.5	.18	.31	8.6	1.49	.05	ND	.0012	ND	ND
12-17-80	12"	124	6.65	10	94	43.3	ND	10.5	3.13	12.4	12.3	11.9	6.9	.17	.39	7.6	1.63	.02	ND	.001	ND	ND
Average		155.88	6.72	19.33	421.88	56.46	2.86	13.10	4.83	13.39	17.85	14.08	5.19	.24	.81	4.95	1.17	.072	ND	.0050	ND	ND

Water level: feet below ground surface
Specific conductance (SC) in umhos/cm
pH in standard units
Temperature in centigrade
Turbidity in feet
All other values in mg/l

GROUND WATER QUALITY DATA: MR. SWEETZ'S 50' WELL

Date	Water Level	SC	pH	Temp.	Turb.	CaCO ₃	SO ₄	Na	Mg	Cl	C	Ca	K	Ba	Mn	O ₂	N	B	Pb	As	Cd	Hg
1-24-80	NA	178	6.23	20	4	48.1	ND	22.7	4.87	8	5.5	11.1	1.81	.03	.17	.5	ND	ND	ND	.0008	ND	ND
2-20-80	NA	178	6.09	20	8	46.2	ND	22.4	4.50	7	5.1	11.0	1.75	.04	.13	.4	.45	ND	ND	.0011	ND	ND
3-21-80	NA	172	6.40	19	8	51.3	ND	23.4	4.80	7.6	4	12.5	1.91	.03	.17	2.0	.54	ND	ND	.0009	ND	ND
4-21-80	NA	188	6.48	18	12	49.3	ND	24.2	4.80	19	.8	11.7	1.75	.02	.17	.3	.40	ND	ND	.0009	ND	ND
5-21-80	NA	208	6.18	21	2	47.2	ND	23.6	4.48	7.6	2.1	11.4	1.76	.02	.15	.3	.48	.1	ND	.0008	ND	ND
6-23-80	NA	192	6.22	22.5	.38	49.1	ND	24.1	4.71	9.2	6.6	11.9	1.82	.03	.10	.5	.15	.4	ND	.0008	ND	ND
7-22-80	NA	193	6.4	22	.52	52.50	ND	24.9	5.04	5.5	.20	12.6	2.2	.01	.16	.7	.80	.08	ND	.0016	ND	ND
8-21-80	NA	192	5.65	22	.83	68.2	ND	19.5	6.62	5.25	.02	16.3	2.21	.02	.15	.6	.60	.05	ND	.0013	ND	ND
Average	NA	187.63	6.21	20.56	4.47	51.49	ND	23.1	4.98	8.64	3.04	12.31	1.90	.025	.15	.66	.43	.079	ND	.0010	ND	ND

Water level: feet below ground surface
 Specific conductance (SC) in umhos/cm
 pH in standard units
 Temperature in centigrade
 Turbidity in feet
 All other values in mg/l

GROUND WATER QUALITY DATA: MR. SWEETZ'S 100' WELL

Date	Water Level	SC	pH	Temp.	Turb.	CaCO ₃	SO ₄	Na	Mg	Cl	C	Ca	K	Ba	Mn	O ₂	N	B	Pb	As	Cd	Hg
1-24-80	NA	202	6.17	20	1	60	ND	19.1	6.62	4	5.6	13.1	2.09	.01	.16	.2	.36	ND	ND	.0008	ND	ND
2-20-80	NA	198	6.28	20	49	64.4	ND	20.4	6.35	5	2.5	15.2	1.90	.02	.16	.2	.53	ND	ND	.0010	ND	ND
3-21-80	NA	198	6.38	21	8	65.2	2	20.8	5.82	4.3	8	16.4	2.07	.02	.16	1.2	.58	ND	ND	.0008	ND	ND
4-21-80	NA	209	6.52	18	6	62.9	ND	21.5	6.60	11	1.6	14.2	2.95	.02	.17	1.3	.40	ND	ND	.0008	ND	ND
5-21-80	NA	209	6.25	21	2	63.6	ND	20.9	6.40	3.9	5.0	14.8	1.86	.02	.14	.5	.56	.1	ND	.0009	ND	ND
6-23-80	NA	226	6.55	22.5	.58	65.37	ND	22.4	6.65	4.9	5.2	15.3	1.91	.03	.10	.3	.15	.3	ND	.0007	ND	ND
7-22-80	NA	204	6.30	22	.40	61.65	ND	20.6	6.30	5.75	.20	14.2	2.22	.02	.14	.7	.70	.05	ND	.0016	ND	ND
8-21-80	NA	209	5.93	22	.55	57.6	ND	22.4	5.32	10.0	1.4	14.2	1.96	.01	.13	1	.30	.05	ND	.0013	ND	ND
9-22-80	NA	203	6.38	23	3.5	64	ND	18.3	6.12	6.2	.1	15.5	2.0	.08	.08	.8	ND	.10	ND	.0004	ND	ND
10-22-80	NA	200	5.75	20	9.2	49.5	ND	20.0	5.95	5.8	.1	9.9	2.0	.05	0.14	2.2	.25	.05	ND	.0006	ND	ND
11-20-80	NA	192.6	6.35	19	.4	64.2	ND	23.6	6.0	4.0	.1	15.7	2.1	.06	.14	.5	.50	.05	ND	.0008	ND	ND
12-17-80	NA	198	6.22	20	.4	63.6	ND	21.9	5.84	3.8	.1	15.7	20	.12	.21	.8	.58	.04	ND	.001	ND	ND
Average	NA	204.05	6.26	20.7	6.75	61.84	.166	20.99	6.16	5.72	2.49	14.52	3.59	.04	.14	.81	.41	.06	ND	.0009	ND	ND

Water level: feet below ground surface
Specific conductance (SC) in umhos/cm
pH in standard units
Temperature in centigrade
Turbidity in feet
All other values in mg/l

APPENDIX D**Elevation Data:****Parcperdue Test Site**

GROUND WATER QUALITY DATA: NEW 180' WELL

Date	Water Level	SC	pH	Temp.	Turb.	CaCO ₃	SO ₄	Na	Mg	Cl	C	Ca	K	Ba	Mn	O ₂	N	B	Pb	As	Cd	Hg
9-22-80	27.5'	326	7.51	--	2.9	166.3	2	27.9	6.26	71.2	9.4	56.2	1.61	.09	.11	6.8	.12	.25	ND	.0005	ND	ND
10-22-80	27.5'	296	7.2	18	2.0	101.7	ND	16.0	6.25	11.0	.1	30.0	1.4	.07	.57	9.2	.48	.08	ND	.0017	ND	ND
11-20-80	27.5'	258.5	6.65	20	2.1	98.2	ND	17.3	6.62	4.8	.1	38.2	1.5	.04	.47	9.0	.54	.08	ND	.0009	ND	ND
12-17-80	27.5'	278	6.80	19	20	127.2	ND	16.0	6.32	3.84	.1	40.0	1.0	.06	.70	9.6	.54	.03	ND	.001	ND	ND
Average	27.5'	289.6	7.04	19	6.75	123.35	.5	19.3	6.36	22.71	2.43	41.1	1.38	.07	.46	8.65	.42	.11	ND	.0010	ND	ND

Water level: feet below ground surface
 Specific conductance (SC) in umhos/cm
 pH in standard units
 Temperature in centigrade
 Turbidity in feet
 All other values in mg/l

ELEVATION DATA: PARCPERDUE TEST SITE

Meters

<u>BENCH MARKS</u>	<u>1968</u>	<u>1980</u>	<u>BENCH MARKS</u>	<u>1968</u>	<u>1980</u>
57V60	1.935		LSUP1		5.679
57V61	2.328		LSUP12		6.989
57V62	3.060		LSUP5		6.125
57V63	4.269		LSUP6		7.093
57V64	5.851		*28V25	6.838	6.804
28V24	5.576	5.539	LSUP11		6.436
LSUP10		5.395	*28V26	5.909	5.876
LSUP9		6.133	LSUP18		6.059
LSUP14		6.222	*28V28	6.038	6.012
LSUP7		5.671	*28V29	6.527	6.514
LSUP8		5.513	LSUP19		6.525
*57V66	6.117	6.102	*28V30	10.446	10.437
*57V65	5.481	5.467	*28V31	10.076	10.049
LSUP16		5.409	LSUP20		9.178
LSUP15		5.467	*28V32	9.740	9.649
LSUP17		6.091	LSUP21		10.424
LSUP14		6.244	*28V33	10.851	10.854
LSUP13		5.448	*28V34	7.751	7.752
LSUP7		5.671	LSUP22		9.725
LSUP4		6.341	LSUP23		10.135
LSUP3		5.730	*E3815A	9.214	9.200
LSUP2		6.400	E268		11.927

PARCPERDUE LEVELING DATA
(Normalized to Benchmark and Year)

Meters					
<u>BM</u>	<u>1968</u>	<u>1980</u>	<u>BM</u>	<u>1968</u>	<u>1980</u>
28V24		-0.041	28V25		-0.038
LSUP10			LSUP11		
LSUP9			28V26		-0.037
LSUP14			LSUP18		
LSUP7			28V28		-0.030
LSUP8			28V29		-0.017
57V66		-0.019	LSUP19		
57V65		-0.018	28V30		-0.013
LSUP16			28V31		-0.031
LSUP15			LSUP20		
LSUP17			28V32		-0.095
LSUP13			LSUP21		
LSUP4			28V33		-0.001
LSUP3			28V34		-0.003
LSUP2			LSUP22		
LSUP1			LSUP23		
LSUP12			E3815A		-0.018
LSUP5			E268		
LSUP6			P3	0.000	0.000

APPENDIX E**Reconnaissance Noise Survey****Parcperdue Test Site**

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1. INTRODUCTION
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3. DATA ANALYSIS
4. RESULTS OF THE NOISE SURVEY
5. CONCLUSIONS AND RECOMMENDATIONS
6. REFERENCE

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- 2 Photographs taken in the Parcperdue, Louisiana vicinity
- 3 Location of photograph and sensor sites
- 4 Amplitude response of the seismograph system
- 5 Spectral estimates of quiet (nighttime) background noise recorded at sensor site locations 5, 6 and 7
- 6 Spectral estimates of daytime background noise recorded at sensor site locations 5, 6 and 7
- 7 Spectral estimates of quiet (nighttime) background noise recorded at the five most northern sensor site locations
- 8 Spectral estimates of daytime background noise recorded at the five most northern sensor site locations
- 9 Proposed array configuration

1. INTRODUCTION

Louisiana State University under contract with the U. S. Department of Energy, and in cooperation with Dow Chemical USA, is sponsoring a project to drill and test a geopressured well in the vicinity of Parcperdue, Louisiana. The goals outlined by the test plan include a geologic and environmental assessment of the effects of a nine to ten month production of the geopressured well and subsurface disposal of the spent fluids.

Teledyne Geotech has been authorized by the University to conduct a microseismic monitoring program in the Parcperdue area prior to and during the well production. Microseismic data acquired before production will serve to establish a baseline representative of the natural seismic activity within the area. Therefore, at any time during the progression of the production test, a change in the microseismic activity level can be detected by comparison of the current data to the established baseline.

The monitoring network will consist of five remotely operated seismic sensors that will continuously record data. The sensors (Geotech Model S-13) will be installed in sealed containers at a depth of approximately four feet.

Microseismic events are generally characterized by high frequency content which attenuates rapidly over relatively short distances, especially in unconsolidated sediments such as exist in the gulf coast region. Since the anticipated seismicity is most likely to begin at very low levels, the detection of the weak signals requires that the seismic sensors be positioned in a low background-noise environment near the source of the activity.

A similar monitoring program is presently being conducted by Geotech in the coastal area of Brazoria County, Texas (Sorrells, 1980). An interesting result of this study has been the observation of microseismic activity associated with the well production and reinjection processes, clustering about the natural growth faults near the well. Generally, the activity has been confined within a radius of five kilometers distance from the well.

The first task associated with the Parcperdue monitoring program is the performance of a reconnaissance noise survey to identify seismically quiet locations for the installation of sensor sites. This task has been completed, and the results of the seismic noise survey are presented in this report.

2. DATA ACQUISITION

Figure 1 is a map of the vicinity of the proposed well test site showing the fault systems which bound the reservoir. The faults are mapped at an approximately depth of 14,000 feet. The circle drawn on the map describes a radius of an approximate 2-1/2 kilometer distance from the well.

Based upon results of the Brazoria monitoring program, seismic activity induced by the geopressured well tests is expected to occur along, and from extensions of these fault zones, within an approximate five kilometer radius of the well. Therefore, sites located near the 2-1/2 kilometer radius shown in figure 1 would be ideally situated to record the anticipated seismic activity. In preparation for the site selection, photographs of the local terrain were taken in the well test vicinity, as the area was checked for availability of electrical power and the willingness of local landowners to accommodate the seismographic equipment. These photographs, shown in figure 2, illustrate the general terrain of the area and the degree of isolation from sources of cultural noise.

The location of each photograph site is shown by the circled numbers in figure 3. The photograph view numbers are referenced by the circled numbers on the map. Eight locations were selected from within this general area, from which samples of natural microseismic background noise were collected. These locations are shown by the diamond shaped symbols on the map in figure 3.

At each location, the Geotech S-13, vertical motion sensor was left to record noise data for an adequate period of time to include both a sample of culturally quiet (nighttime) background noise and sample of high level (daytime) cultural activity. The seismograph system was calibrated at each site in order to determine data levels. The data was band pass filtered with corners at 5 and 25 Hz. Figure 4 illustrates the relative amplitude response of the system plotted on a frequency scale which can be directly compared to spectral data presented later in the report.

Figure 1. Location of the proposed well test site and local geological features

VIEW 1

VIEW 2

VIEW 3

VIEW 4

VIEW 5

VIEW 6

Figure 2. Photographs taken in the Parcpardue, Louisiana vicinity (sheet 1 of 3)

VIEW 7

VIEW 8

VIEW 9

VIEW 10

VIEW 11

VIEW 12

Figure 2. Photographs taken in the Parcpardue, Louisiana vicinity (sheet 2 of 3)

VIEW 13

Figure 2. Photographs taken in the Parcpardue, Louisiana vicinity (sheet 3 of 3)

Figure 3. Location of photograph and sensor sites

Figure 4. Amplitude response of the seismograph system

3. DATA ANALYSIS

A representative power spectrum was calculated and plotted for both a nighttime and daytime noise sample from each sensor site location. The spectral estimates were obtained from a Nicolet Scientific Corporation (NSC) analog spectrum analyzer (Model 440 Mini-Ubiquitous), by averaging the spectra of sixteen consecutive windows of 512 data points each. The data were sampled through the spectrum analyzer at the rate of 80 samples/second.

The analyzer is equipped with a plotter which automatically produces a plot of the power spectrum in units of volts^2/Hz in dB. A noise amplitude factor of 3 is equivalent to approximately 10 dB on this scale.

Actual data levels were determined from sine wave calibrations performed on site at each location, and then compared to system noise levels.

4. RESULTS

A preliminary analysis of the spectral curves representative of background noise from the eight sensor site locations, indicates a distinct difference in amplitude levels near 5 Hz at sites to the north of the proposed well test site as compared to the three most southern locations. Spectral samples from the sites in the northern part of the surveyed area, sites 1, 2, 3, 4, and 8, all contain prominent peaks near 5 to 6 Hz, which are diminished by as much as 20 dB in the spectra from sites 5, 6, and 7 which lie in the southern portion of the area. For purposes of comparison, the spectral samples have been separated according to this grouping, and are shown plotted in figures 5 through 8. Figures 5 and 6 show spectra from the south sites, 5, 6 and 7. Figure 5 contains spectra of the quiet (nighttime) noise samples, while figure 6 contains the noisy (daytime) samples. Figure 7 and 8 are similar spectral presentations of sites 1, 2, 3, 4 and 8.

Note from figures 5 and 6, that these sites, which will be termed the "quiet" sites, show very little difference in noise levels between night and day. The average difference appears to be on the order of 3 to 4 dB, a relative amplitude factor of about 1.5. Comparison of night to day samples within the data pass band of 5 to 20 Hz at noisy sites 1, 2, 3, 4 and 8 also indicate a rise in noise levels of about 3 to 4 dB during the daytime hours. Amplitude levels in the data pass band are also similar between the two groups of sites, that is, the quiet and noisy locations. It is apparent, therefore, that the significant difference between the two site groups is the noise amplitude levels around 5 Hz.

There are indications of possibly two peaks, perhaps resulting from different sources, one at 5 Hz, and another at 6 Hz. This, however, is not yet clear.

The system response curve shown in figure 4 has been overlaid on the spectral curves of figures 5, 6, 7 and 8, in order to be easily compared to the spectral samples.

By this comparison, it can be shown that frequencies less than 5 Hz and greater than 20 Hz are rapidly attenuated by the filter. System noise levels are indicated on each set of spectra.

Figure 5. Spectral estimates of quiet (nighttime) background noise recorded at sensor site locations 5, 6 and 7

Figure 6. Spectral estimates of daytime background noise recorded at sensor site locations 5, 6, 7

Figure 7. Spectral estimates of quiet (nighttime) background noise recorded at the five most northern sensor site locations G 11197

Figure 8. Spectral estimates of daytime background noise recorded at the five most northern sensor site locations.

5. CONCLUSIONS AND RECOMMENDATIONS

The source of the 5 to 6 Hz noise peak observed at sites 1, 2, 3, 4 and 8, cannot be identified by the single channel recordings at the trial sites. A comparison of the 5 Hz peak level to the 6 Hz level at each individual site location tends to indicate two separate noise sources. One source, associated with the 5 Hz peak, appears to be north of the well location, possibly from the direction of the Texas Gas Plant. The source of the 6 Hz peak, however, appears to be near the center of the surveyed area.

Assuming that the source (or sources) of the noise is cultural rather than resulting from movement along the growth faults of the area, then it is most certain that the high noise level of the northern part of the surveyed area will be detrimental to the detection of microseismic signals. The 5 to 6 Hz band is well within the frequency range of the anticipated microseismic activity, and may be very near the peak of the signal spectral amplitudes. On the other hand, as shown in the map of figure 1, to situate all sites toward the south of the proposed test well would result in an array "off center" from many of the zones of probable activity. This would result in loss of accuracy in locating the event hypocenters which occur outside the array.

Another consideration against moving all sites southward, is the possibility that the fault planes are refracting wavelengths associated with the 5 and 6 Hz peaks, and hindering their propagation toward the south. In this case, microseismic signals occurring in the well area might go undetected by an array positioned in the southern portion of the surveyed area. We recommend, therefore, that the initial monitoring array configuration consist of two sites in the northern part of the surveyed area, two sites situated in the southern portion of the area, and one site at the center of the array near the test well. Figure 9 is a schematic plan of the proposed array configuration. With data from this configuration, it should be possible to detect and identify the natural microseismic activity, and possibly to determine the source (or sources) of the 5 to 6 Hz noise. If data from this array indicates that the two northern sites should be moved to quieter noise environments in the southern portion of the surveyed area, then the sensors will be relocated.

Figure 9. Proposed array configuration

6. REFERENCE

Sorrells, G. G., 1980, Microseismicity at the Brazoria County Geopressured Reservoir, September 1978 - December 1979, Teledyne Geotech, TR 80-3

APPENDIX F
Environmental Monitoring Plan:
Sweet Lake Test Well No. 1

ENVIRONMENTAL MONITORING PLAN:

SWEET LAKE TEST WELL NO. 1

I. INTRODUCTION

Louisiana State University (LSU) will undertake management of environmental baseline and monitoring studies for geopressured test well activities in the vicinity of Sweet Lake, Louisiana. Magma Gulf Company, in cooperation with the U. S. Department of Energy (DOE), is currently planning to drill and test a geopressured well near Sweet Lake at the location given in Figure 1. A schedule for the planned drilling and testing program, which was initiated in January, 1980, is given in Table 1.

The drilling and testing operations associated with the Magma Gulf/DOE Sweet Lake geopressured well will be conducted within the scope of an Environmental Assessment prepared by Coastal Environments, Inc. under contract to Oak Ridge National Laboratory and identified as follows:

Environmental Assessment
Geothermal Energy, Geopressure Subprogram
Sweet Lake No. 1
January, 1980
U. S. Department of Energy

In this assessment, the implication of geopressured resource testing is evaluated for activities from well site preparation through site preparation through site restoration after testing is complete.

II. ENVIRONMENTAL BASELINE AND MONITORING STUDIES

The purpose of collecting environmental baseline data is to provide a description of selected physical, chemical, and biological conditions against which later environmental monitoring data can be compared. This comparison will provide a basis for determining the net environmental change attributable to test well operations at any subsequent time.

The following data shall be collected to establish the baseline of ambient conditions prior to fluid production:

Air Quality

- existing air quality conditions
- local meteorological characteristics

Water Quality (surface and subsurface)

- existing water quality conditions
- water resource usage
- hydrologic patterns, surface and ground water levels

Subsidence

- subsidence history
- leveling surveys

Seismicity

- microseismic surveys

Ecosystem Quality

- biological surveys

In order to avoid duplications, information presented in the DOE/Oak Ridge Environmental Assessment for the Sweet Lake well test shall be incorporated where possible in the LSU environmental baseline evaluation. For example, very little additional work may be required to establish existing ecosystem quality.

An environmental monitoring program designed to provide comparative data during drilling and production phases will include the studies listed below. The asterisk indicates the studies that are contingent upon the occurrence of environmental changes (e.g., changes in air quality and/or standards violation in the case of air quality) and are not considered in the base scope work.

Air Quality

- air quality monitoring
- pollutant dispersion modeling*
- continuous wind speed, wind direction, temperature and precipitation

Seismicity

- continuous microseismic surveys

Water Quality (surface and subsurface)

- water quality monitoring
- water level monitoring

Subsidence

- repeated leveling surveys

Ecosystem Quality

- biological surveys*
- bioassays*

Monitoring studies may be increased if environmental conditions, either natural or as a result of test well activities and geopressure fluid analysis require such adjustment. However, LSU will be obligated to demonstrate the inadequacy of the existing data collection program when seeking approval for additional studies.

The combined scope of environmental baseline and monitoring studies which are planned during the first year include the air quality, water quality, subsidence, seismic and ecological studies described below.

1. Air Quality. Air quality baseline studies will be performed to:

- (1) determine ambient air quality prior to possible disturbance from test well activities;
- (2) identify any substance potentially derived from the geopressured fluid that may have an adverse effect on the environment, and establish baseline concentrations for these substances;
- (3) collect locally available meteorological data necessary for understanding dispersion and conversion patterns; and
- (4) provide baseline data compatible with later measurements needed to assure compliance with state and federal air quality standards.

Air quality monitoring will be performed to determine changes in air quality which may be related to well testing activities.

Sampling and analysis for hazardous substances will be from a fixed automated monitoring unit located approximately 1 mile north of the test site (prevailing winds are from the South).

Analyses will include continuous measurement of sulfur dioxide hydrogen sulfide, total hydrocarbons and methane. Meteorological data from continuous recorders shall include wind speed, wind direction, temperature and precipitation. In the event of significant atmospheric pollutant emissions, dispersion characteristics will be determined.

Analytical procedures for air quality monitoring will be consistent with designated Reference or Equivalent Methods published by the U. S. Environmental Protection Agency, Monitoring and Research Laboratory, Research Triangle Park, North Carolina, November 3, 1978. Analyzer performance shall conform to specifications for automated methods as described in 40 CFR, Parts 50 and 53.

2. Water Quality Water quality baseline studies will be conducted to determine: (1) ambient water quality conditions in local bayous and canals and in shallow ground water prior to possible disturbance from test well activities; (2) baseline conditions for substances potentially present in the geopressured fluids; and (3) water resource usage and baseline concentrations for substances and physical properties for which state standards have been established.

Water quality monitoring studies will be performed so that changes in chemical and physical properties of surface and ground water can be determined. Surface water samples will be collected monthly; surface water levels will be recorded at the time of sample collection. Laboratory analyses to be conducted for each sample will include Na, K, NH_3 , SO_4 , Cd, Mn, Ca, Cl, Ba, Pb, As, B, Hg, total hardness (calculated), and total organic carbon. Field measurements shall

include pH, specific conductance, turbidity, temperature and dissolved oxygen.

Three observation wells will be drilled approximately 500 feet into the zone of fresh ground water. Ground-water samples will be collected each month. Field and laboratory analyses to be performed on ground-water samples will be the same as for surface waters. Water level in the observation wells will be reported monthly.

Ground and surface water sample collection, handling, preservation and analysis will be consistent with methods published by the U. S. Environmental Protection Agency, "Manual of Methods for Chemical Analyzers of Water and Wastes" (1974), and the U. S. Geological Survey, "Recommended Methods for Water Data Acquisition" (1977).

3. Subsidence. Subsidence baseline studies will include an initial leveling survey to establish relative surface elevations, and an examination of historic leveling data and topographic maps to determine subsidence history in the vicinity of the test well.

The initial leveling survey shall consist of approximately 20 miles of First-Order precise leveling. Leveling profiles will be tied to National Oceanic and Atmospheric Administration (NOAA) elevation benchmarks which are located beyond the area of potential subsidence impact. Procedures to be used in establishing benchmarks in the vicinity of the test well will be in accordance with guidelines provided in the NOAA publication, "Specifications to Support Classification, Standards of Accuracy, and General Specifications of Geodetic Control Surveys" (1978).

Subsidence monitoring will consist of first-order releveled surveys which will be conducted at 12-month intervals during production to document the occurrence of land-surface subsidence, if any, near the well site, or of differential surface movement along reactivated faults. First-order releveled is planned during the second year environmental monitoring program, and is not considered in the base scope of work for this proposal.

4. Seismicity. Microseismic surveys will be performed to (1) determine background microseismic activity prior to disturbance from fluid production, and (2) monitor microseismic activity during fluid production. Baseline microseismic studies will include an initial reconnaissance survey to determine sources and levels of background microseismic activity. Data from this survey will be used to identify locations for permanent monitoring installations which will be least influenced by natural and cultural background noise.

Continuous microseismic monitoring will be performed using seismometers emplaced in sealed boreholes at approximately 4 feet below ground surface. Microseismic monitoring studies will provide the origin time of local seismic events, their estimated locations, and their relative magnitudes. The microseismic monitoring net will be operative for approximately six months prior to fluid production.

5. Ecosystem Quality. Baseline ecological studies will rely on existing published and unpublished data to establish ranges and populations of plant and animal species in the vicinity of the test well. Additional biological surveys will be conducted in the event of significant impact to plant or animal life but are not considered part of the base scope of work.

III. ENVIRONMENTAL PROGRAM MANAGEMENT

The environmental monitoring program will be managed by Dr. Charles G. Groat, Director of the Louisiana Geological Survey and Professor of Geology, Louisiana State University. The management of environmental monitoring will include insuring that data collected is compiled, analyzed, and reported to the U.S. Department of Energy (DOE) on a quarterly basis, or more frequently, if necessary. LSU will provide for contractual arrangements with firms for performance or selected field and laboratory studies. Overall data interpretation and impact assessment will be performed by LSU investigators. LSU will also be responsible for determining if federal, state, and local environmental quality standards are being met, and will inform DOE in the event of non-compliance. LSU investigators will also inform DOE when an increase or decrease in baseline monitoring studies are required, justifying such changes in scope as they occur.

This Environmental Monitoring Plan outlines a one-year program of combined environmental monitoring and baseline studies. LSU will prepare quarterly status reports, including data summaries, and an annual report summarizing the results obtained during the first year. Based on analysis of the data, the development of the test well, and federal, state, and local regulations, LSU will propose a second year plan for continuing air quality, water quality, subsidence and micro-seismic monitoring studies. In preparing this plan, LSU will determine whether or not it can be accomplished at a reduced level in any of the monitoring programs (e.g., increasing the interval between water samples, reducing the number of ions analyzed, increased level of air quality monitoring, etc.)

Table 1. Sweet Lake drilling and testing schedule (from Magma Gulf Company).

	<u>By Days</u>	<u>By Months</u>	<u>By Quarters</u>
Production Well - drill and complete	1- 90	1 - 3	1st
Initial Disposal Well - drill and complete	100-130	4 - 5	2nd
Test Loop - develop, fabricate, install	1-180	1 - 6	1st & 2nd
- 60 -day test	181-240	7 - 8	3rd
Permanent Test Facilities - design, deliver, install	210-510	7 - 17	3rd - 6th
Second Disposal Well	400-430	14 - 15	5th
Permanent Test Facility - 240 day test	510-750	18 - 25	6th - 9th
Plug and Abandon	750-770	26	9th
or			
Place on commercial gas production and continue production indefinitely	Start At 570	Start At 20	Start At 6th

Figure 1. Sweet Lake Geopressured Prospect. Drill site location depicted with star. Magna Gulf leases are shown as follows: A - Amoco, S and L - Sweet Lake (from Magna Gulf Company).

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APPENDIX G
Air Quality Monitoring Data
July 1980
Sweet Lake Test Site

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**MONTHLY REPORT OF AN AMBIENT AIR SURVEY
FOR
LOUISIANA STATE UNIVERSITY
SWEETLAKE, LOUISIANA**

JULY 1980

FILE NUMBER CLI 802190/7-80

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INTRODUCTION

Core Laboratories, Inc., Lake Charles, Louisiana operates a single station ambient air quality sampling network in Sweetlake, Cameron Parish, Louisiana. Continuous pollutant information collected includes Sulfur Dioxide (SO_2), Hydrogen Sulfide (H_2S), Total Hydrocarbons and Non-Methane Hydrocarbons. Continuous meteorological information collected includes wind direction, wind speed, temperature and rainfall. This site has been established to monitor the air quality activities in the area of the geothermal/geopressure prospect in Sweetlake.

All air quality data is reported in $\mu\text{g}/\text{m}^3$. Conversion factors for changing parts per million gas to $\mu\text{g}/\text{m}^3$ are as follows:

Sulfur Dioxide	2620
Hydrogen Sulfide	1394
Hydrocarbons (as CH_4)	656

All continuous air monitoring equipment is operated in accordance with regulations established by the Environmental Protection Agency for PSD and SLAMS networks. The monitoring program at Sweetlake officially began July 1, 1980.

CLI 802190/7-80

II. EQUIPMENT AND ANALYTICAL PROCEDURES

A) Ambient Air Monitoring

Monitoring sulfur dioxide is accomplished with the use of the Meloy SA285E Sulfur Dioxide Analyzer, which has been designated as an "equivalent" method by EPA when equipped with a hydrogen sulfide scrubber. This analyzer utilizes the flame photometric technique. Hydrogen sulfide monitoring utilizes the same Meloy SA285E Sulfur Dioxide Analyzer equipped with a sulfur dioxide scrubber which allows a specific measurement of hydrogen sulfide. This method has been approved by the EPA.

All calibrations and precision checks on the sulfur analyzers are performed with the use of the Meloy CS10-2 calibration source. This is a permeation type precision instrument that supplies a National Bureau of Standards traceable standard gas. Integrity checks are performed on SO_2 and H_2S scrubbers monthly to insure maximum confidence.

Monitoring total hydrocarbons and non-methane hydrocarbons is accomplished with the use of the Meloy Model HC500-2C Hydrogen Analyzer, which is an approved method by the EPA. This analyzer

utilizes the established flame ionization detector (FID) as described in 40 CFR 50. The HC500-2C contains a high temperature oxidizer to oxidize non-methane hydrocarbons allowing only methane hydrocarbons to be monitored. The analyzer compares the methane hydrocarbons against the total hydrocarbons, thus determining non-methane hydrocarbons.

Calibrations and precision checks for the hydrocarbon analyzer are accomplished with the use of a gas dilution type instrument. Supplied with a standard gas source, highly accurate concentrations can be generated.

B) Meteorological Monitoring

All meteorological data (wind direction, wind speed, temperature and rainfall) is collected using Texas Electronics equipment. These sensors exceed all EPA specifications for PSD monitoring and have proven to be very reliable in past use in southern Louisiana.

C) Data Collection

All data from the ambient air monitors and meteorological sensors are collected on strip chart recorders and hand digitized to yield hourly averages.

III. SULFUR DIOXIDE DATA SUMMARY

CLI 802190/ 7-80

MAXIMUM AND AVERAGE CONCENTRATION
Sulfur Dioxide
(Micrograms per Cubic Meter)

JULY 1980

<u>Day of Month</u>	<u>Maximum (1 hr)</u>	<u>Average (24 hr)</u>	<u>Time of Day (CST)</u>	<u>Direction (Degrees)</u>	<u>Speed (mph)</u>
1	0	0	-	-	-
2	0	0	-	-	-
3	13	1	0500	167.5	2
4	0	0	-	-	-
5	0	0	-	-	-
Weekly	13	0			
6	0	0	-	-	-
7	0	0	-	-	-
8	25	2	0900	360	7
9	49	9	0900-1000	360	3
10	0	0	-	-	-
11	43	4	1000	270	6
12	17	2	1000	270	7
Weekly	49	2			
13	17	3	1000-1600	270	8
14	6	0	1300	225	7
15	37	2	1100	270	10
16	13	2	0600-1300	270	2
17	29*	2*	0200	360	3
18	*	*	-	-	-
19	*	*	-	-	-
Weekly	37	2			
20	0*	0*	-	-	-
21	0	0	-	-	-
22	0	0	-	-	-
23	0	0	-	-	-
24	0	0	-	-	-
25	0	0	-	-	-
26	0	0	-	-	-
Weekly	0	0			
27	0	0	-	-	-
28	0	0	-	-	-
29	56	10	1200	360	4
30	0	0	-	-	-
31	0	0	-	-	-
Weekly	56	1			
Monthly	56	1			

* Data for day either totally or partially lost.

DAY OF MONTH VERSUS CONCENTRATION

Sulfur Dioxide
(Micrograms/Cubic Meter)
JULY 1980

LOUISIANA STATE UNIVERSITY
SWEETLAKE SITE

CLI 802190/7-80

THIRTY HIGHEST
3-HOUR AVERAGE CONCENTRATIONS
Sulfur Dioxide
(Micrograms per Cubic Meter)

JULY 1980

<u>Day of Month</u>	<u>3-hour Average Concentration</u>	<u>Time of Day (CST)</u>	<u>Wind Direction</u>	<u>Wind Speed</u>
29	49	1100	360	2
9	45	0900	315	3
29	43	1000	360	2
29	41	1200	360	3
9	41	0800	315	3
9	34	1000	360	3
29	28	1300	*	3
29	27	0900	360	3
9	24	0700	315	2
9	22	1100	360	2
11	18	0900	292.5	6
17	18	0800	-	0
29	18	1400	180	3
11	16	0800	292.5	5
11	16	1000	270	6
9	14	1200	360	3
8	13	0700	360	2
8	13	0800	360	2
13	12	1400	225	8
13	12	1500	225	8
15	12	0900	270	10
15	12	1000	270	10
15	12	1100	270	10
29	12	1500	180	2
11	11	1500	202.5	9
12	10	0900	270	7
12	10	1000	270	7
13	10	0800	270	9
13	10	0900	270	9

* No wind direction was recorded for this hour.

WIND DIRECTION -VS- AVERAGE CONCENTRATION
Sulfur Dioxide
(Micrograms Per Cubic Meter)

JULY 1980

<u>Direction (Degrees)</u>	<u>Percent Wind Occurance</u>	<u>Average Concentration</u>
Calm	10.0	0
22.5	4.3	0
45	8.7	0
67.5	2.0	0
90	4.6	0
112.5	5.3	0
135	3.1	1
157	5.0	0
180	10.0	0
202.5	12.7	1
225	8.7	1
247.5	3.0	0
270	7.6	3
292.5	2.1	2
315	1.0	11
337.5	0.03	0
360	9.0	5

WIND DIRECTION VERSUS AVERAGE CONCENTRATION
Sulfur Dioxide
(Micrograms/Cubic Meter)

Louisiana State University
Sweetlake Site

JULY 1980

- ① Lake Charles (15.2 miles)
- ② Industries (16.0 miles)
- ③ Hackberry (12.8 miles)

- ④ Cameron (21.6 miles)
- ⑤ Well Site (0.7 miles)

HOUR

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	13	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	25	49	49	37	17	13	13	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	6	43	6	0	0	0	6	13	13	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	6	17	6	6	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	13	17	0	0	0	6	13	17	6	0	0	0	0	0	0	0
D 14	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0
A 15	0	0	0	0	0	0	0	0	0	0	37	0	0	0	0	0	0	0	0	0	+++	0	0	0
Y 16	0	0	0	0	6	13	0	0	6	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	29	25	0	0	0	0	0	*	*	*	*	*	*	*	*	*
18	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
19	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
20	*	*	*	*	*	*	*	*	*	*	*	*	*	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+++	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	6	25	49	56	43	25	17	13	6	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

X Calibration
 * Equipment Malfunction
 +++ Precision Check

SULFUR DIOXIDE HOURLY AVERAGES ($\mu\text{g}/\text{m}^3$)
 JULY 1980

Sweetlake Monitoring Station
 Louisiana State Univeristy

CLI 802190/7-80

IV. HYDROGEN SULFIDE DATA SUMMARY

CLI 802190/7-80

MAXIMUM AND AVERAGE CONCENTRATION
Hydrogen Sulfide
(Micrograms per Cubic Meter)

307

JULY 1980

<u>Day of Month</u>	<u>Maximum (1 hr)</u>	<u>Average (24 hr)</u>	<u>Time of Day (CST)</u>	<u>Direction (Degrees)</u>	<u>Speed (mph)</u>
1	0	0	-	-	-
2	4	0	1900	180	2
3	0	0	-	-	-
4	0	0	-	-	-
5	0	0	-	-	-
Weekly	4	0			
6	0	0	-	-	-
7	0	0	-	-	-
8	0	0	-	-	-
9	0	0	-	-	-
10	0	0	-	-	-
11	0*	0*	-	-	-
12	0*	0*	-	-	-
Weekly	0	0			
13	0	0	-	-	-
14	0	0	-	-	-
15	0	0	-	-	-
16	0	0	-	-	-
17	0	0	-	-	-
18	4	0	2100	90	4
19	0	0	-	-	-
Weekly	4	0			
20	0	0	-	-	-
21	0	0	-	-	-
22	0	0	-	-	-
23	0	0	-	-	-
24	0	0	-	-	-
25	0	0	-	-	-
26	0	0	-	-	-
Weekly	0	0			
27	0	0	-	-	-
28	0	0	-	-	-
29	0	0	-	-	-
30	0	0	-	-	-
31	0	0	-	-	-
Weekly	0	0			
Monthly	4	0			

* Data for day either partially or totally lost.

DAY OF MONTH VERSUS CONCENTRATION

Hydrogen Sulfide

(Micrograms/Cubic Meter)

JULY 1980

LOUISIANA STATE UNIVERSITY
SWEETLAKE SITE

309

[illegible]

WIND DIRECTION -VS- AVERAGE CONCENTRATION
Hydrogen Sulfide
(Micrograms Per Cubic Meter)

JULY 1980

<u>Direction (Degrees)</u>	<u>Percent Wind Occurance</u>	<u>Average Concentration</u>
Calm	10.0	0
22.5	4.3	0
45	8.7	0
67.5	2.0	0
90	4.6	1
112.5	5.3	0
135	3.1	0
157	5.0	0
180	10.0	0
202.5	12.7	0
225	8.7	0
247.5	3.0	0
270	7.6	0
292.5	2.1	0
315	11.0	0
337.5	0.03	0
360	9.0	0

WIND DIRECTION VERSUS AVERAGE CONCENTRATION
Hydrogen Sulfide
(Micrograms/Cubic Meter)

311

Louisiana State University
Sweetlake Site

JULY 1980

① Lake Charles (15.2 miles)

④ Cameron (21.6 miles)

② Industries (16.0 miles)

⑤ Well Site (0.7 miles)

③ Hackberry (12.8 miles)

CLI 802190/7-80

	HOUR																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	*	*	*	*	*	*	*	*	*	*	*	0	0	0	0	0	0	*	*	*	*	*	*
12	*	*	*	*	*	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

* Equipment Malfunction

HYDROGEN SULFIDE HOURLY AVERAGES ($\mu\text{g}/\text{m}^3$)
JULY 1980Sweetlake Monitoring Station
Louisiana State University

CLI 802190/7-80

V. TOTAL HYDROCARBONS DATA SUMMARY

MAXIMUM AND AVERAGE CONCENTRATION

Total Hydrocarbons
(Micrograms per Cubic Meter)

JULY 1980

<u>Day of Month</u>	<u>Maximum (1 hr)</u>	<u>Average (24 hr)</u>	<u>Time of Day (CST)</u>	<u>Direction (Degrees)</u>	<u>Speed (mph)</u>
1	328*	178*	1100-1200	270.0	6
2	*	*	-	-	-
3	*	*	-	-	-
4	0*	0*	-	-	-
5	0	0	-	-	-
Weekly	328	47			
6	328	34	1800	157.5	10
7	0	0	-	-	-
8	0*	0*	-	-	-
9	0*	0*	-	-	-
10	492	82	2300-2400	-	0
11	328	27	0100-0200	-	0
12	0*	0*	-	-	-
Weekly	492	23			
13	164	14	2000-2200	202.5	5
14	164	7	0500	225.0	1
15	164	14	2000-2300	225.0	7
16	656	75	2400	45.0	3
17	984	157	2300	-	0
18	328	62	0200-1500	292.5	3
19	164	7	0300	45.0	3
Weekly	984	59			
20	328	62	2000	112.5	3
21	0	0	-	-	-
22	0	0	-	-	-
23	164	48	0600-2100	22.5	4
24	328	116	0500-2300	360.0	3
25	984	212	0400	45.0	3
26	656	142	0600	90.0	1
Weekly	984	82			
27	*	*	-	-	-
28	*	*	-	-	-
29	164*	14*	1200-1300	360.0	3
30	492	150	1500	202.5	3
31	656	170	0600	-	0
Weekly	656	130			
Monthly	984	64			

* Data for day either totally or partially lost.

Total Hydrocarbons
(Micrograms/Cubic Meter)
JULY 1980

LOUISIANA STATE UNIVERSITY
SWEETLAKE SITE

THIRTY HIGHEST
3-HOUR AVERAGE CONCENTRATIONS
Total Hydrocarbons
(Micrograms per Cubic Meter)

JULY 1980

<u>Day of Month</u>	<u>3-hour Average Concentration</u>	<u>Time of Day (CST)</u>	<u>Wind Direction</u>	<u>Wind Speed</u>
17	820	2100	292.5	1
25	765	0200	-	0
25	701	0300	45.0	1
25	701	0400	45.0	3
17	656	2200	-	0
17	601	2000	225.0	5
25	547	0100	-	0
26	547	0400	112.5	1
31	547	0500	225.0	1
16	492	2200	112.5	6
25	492	0500	45.0	1
26	492	0300	112.5	2
31	492	0600	-	0
10	437	2300	-	0
16	437	2300	45.0	4
17	437	2300	-	0
24	437	2400	-	0
26	437	0500	-	0
31	437	0400	225.0	1
31	437	0700	292.5	1
10	383	2400	-	0
25	383	0600	45.0	1
30	383	1300	247.5	5
30	383	1400	202.5	5
16	328	2100	180.0	5
24	328	0400	360.0	3
24	328	2300	-	0
26	328	0100	112.5	2
30	328	1000	270.0	8
30	328	1100	270.0	8

WIND DIRECTION -VS- AVERAGE CONCENTRATION
Total Hydrocarbons
(Micrograms Per Cubic Meter)

317

JULY 1980

<u>Direction (Degrees)</u>	<u>Percent Wind Occurance</u>	<u>Average Concentration</u>
Calm	10.0	101
22.5	4.3	44
45.0	8.7	35
67.5	2.0	12
90.0	4.6	13
112.5	5.3	75
135.0	3.1	8
157.0	5.0	14
180.0	10.0	35
202.5	12.7	31
225.0	8.7	32
247.5	3.0	78
270.0	7.6	53
292.5	2.1	88
315.0	1.0	0
337.5	0.03	246
360.0	9.0	39

WIND DIRECTION VERSUS AVERAGE CONCENTRATION
Total Hydrocarbons
(Micrograms/Cubic Meter)

Louisiana State University
Sweetlake Site

JULY 1980

HOUR

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	164	164	164	164	0	0	0	164	164	164	328	328	**	**	**	**	**	**	**	**	**	**	**	**
2	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**
3	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**
4	**	**	**	**	**	**	**	**	**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	164	164	0	0	0	0	0	0	0	0	0	0	0	0	164	328	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
9	*	*	*	*	*	*	*	*	*	*	0	0	0	0	0	0	0	0	0	+	+	0	0	0
10	0	0	0	0	0	164	0	0	0	0	0	0	0	0	0	0	0	0	0	328	328	164	492	492
11	328	328	*	*	*	*	*	*	*	*	0	0	0	0	0	0	0	0	0	0	*	*	*	*
12	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	164	0	164	0	0
D 14	0	0	0	0	164	0	0	0	0	0	0	*	*	*	*	*	*	*	*	*	*	*	*	*
A 15	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	164	+	+	164	0
Y 16	0	0	0	0	0	0	0	0	164	0	0	0	0	0	0	0	0	0	0	0	164	328	492	656
17	164	0	0	0	0	0	0	164	164	164	164	0	0	0	0	0	0	0	0	328	656	820	984	164
18	164	328	164	164	164	0	0	0	0	0	0	0	0	164	328	0	0	0	0	0	0	0	0	0
19	0	0	164	164	164	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	164	164	164	164	164	0	0	0	0	0	0	0	0	0	0	0	0	0	164	328	164	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	164	164	164	0	0	0	0	0	0	0	0	0	0	0	164	164	164	164	0	0
24	164	164	164	328	328	328	164	0	0	0	0	0	0	0	0	164	164	0	0	0	0	164	328	328
25	328	656	656	984	492	656	328	164	0	0	0	0	0	0	0	0	0	0	0	0	164	0	328	328
26	164	328	492	492	492	656	164	0	0	0	0	0	0	0	0	0	0	0	164	164	0	0	*	*
27	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
28	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
29	*	*	*	*	*	*	*	*	*	*	0	164	164	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	164	164	0	0	0	164	328	328	328	328	328	492	328	164	164	0	0	164	164	0	0
31	0	0	0	164	492	656	492	328	492	328	164	0	0	164	164	164	0	0	0	164	328	0	0	0

* Recorder Malfunction
 ** Equipment Malfunction
 + Precision Check

TOTAL HYDROCARBONS HOURLY AVERAGES ($\mu\text{g}/\text{m}^3$)
 JULY 1980

Sweetlake Monitoring Station
 Louisiana State University

CLI 802190/7-80

VI. NON-METHANE HYDROCARBONS DATA SUMMARY

CLI 802190/ 7-80

MAXIMUM AND AVERAGE CONCENTRATION
Non-Methane Hydrocarbons
(Micrograms per Cubic Meter)

321

JULY 1980

<u>Day of Month</u>	<u>Maximum (1 hr)</u>	<u>Average (24 hr)</u>	<u>Time of Day (CST)</u>	<u>Direction (Degrees)</u>	<u>Speed (mph)</u>
1	164	14	1100-1200	247.5	5
2	0	0	-	-	-
3	0	0	-	-	-
4	0	0	-	-	-
5	0	0	-	-	-
Weekly	164	6			
6	0	0	-	-	-
7	0	0	-	-	-
8	0	0	-	-	-
9	0	0	-	-	-
10	0	0	-	-	-
11	328	48	2300-2400	202.5	2
12	0	0	-	-	-
Weekly	328	8			
13	0	0	-	-	-
14	0	0	-	-	-
15	0	0	-	-	-
16	0	0	-	-	-
17	164	14	2100-2200	292.5	1
18	0	0	-	-	-
19	0	0	-	-	-
Weekly	164	2			
20	0	0	-	-	-
21	0	0	-	-	-
22	0	0	-	-	-
23	0	0	-	-	-
24	0	0	-	-	-
25	0	0	-	-	-
26	0	0	-	-	-
Weekly	0	0			
27	0	0	-	-	-
28	0	0	-	-	-
29	0	0	-	-	-
30	0	0	-	-	-
31	0	0	-	-	-
Weekly	0	0			
Monthly	328	3			

DAY OF MONTH VERSUS CONCENTRATION

Non-Methane Hydrocarbon

(Micrograms/Cubic Meter)

JULY 1980

LOUISIANA STATE UNIVERSITY
SWEETLAKE SITE

<u>Day of Month</u>	<u>3-hour Average Concentration</u>	<u>Time of Day (CST)</u>	<u>Wind Direction</u>	<u>Wind Speed</u>
11	273	2200	202.5	2
11	218	2300	202.5	1
11	164	2100	202.5	4
1	109	1000	270.0	6
1	109	1100	270.0	6
11	109	2000	202.5	6
11	109	2400	202.5	1
17	109	2000	225.0	5
17	109	2100	292.5	1
1	55	0900	270.0	10
1	55	1200	202.5	8
11	55	0600	270.0	1
11	55	0700	315.0	2
11	55	0800	292.5	5
11	55	1800	202.5	8
11	55	1900	202.5	7
17	55	1900	180.0	5
17	55	2200	-	0
-	0	-	-	-
-	0	-	-	-
-	0	-	-	-
-	0	-	-	-
-	0	-	-	-
-	0	-	-	-
-	0	-	-	-
-	0	-	-	-
-	0	-	-	-
-	0	-	-	-
-	0	-	-	-
-	0	-	-	-

WIND DIRECTION -VS- AVERAGE CONCENTRATION
Non-Methane Hydrocarbons
(Micrograms Per Cubic Meter)

JULY 1980

<u>Direction (Degrees)</u>	<u>Percent Wind Occurance</u>	<u>Average Concentration</u>
Calm	10.0	2
22.5	4.3	0
45.0	8.7	0
67.5	2.0	0
90.0	4.6	0
112.5	5.3	0
135.0	3.1	0
157.0	5.0	0
180.0	10.0	0
202.5	12.7	11
225.0	8.7	0
247.5	3.0	0
270.0	7.6	3
292.5	2.1	22
315.0	1.0	0
337.5	0.03	0
360.0	9.0	0

WIND DIRECTION VERSUS AVERAGE CONCENTRATION
Non-Methane Hydrocarbons
(Micrograms/Cubic Meter)

325

Louisiana State University
Sweetlake Site

JULY 1980

- ① Lake Charles (15.2 miles)
- ② Industries (16.0 miles)
- ③ Hackberry (12.8 miles)

- ④ Cameron (21.6 miles)
- ⑤ Well Site (0.7 miles)

CLI 802190/7-80

	HOUR																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
D A Y	1	0	0	0	0	0	0	0	0	0	164	164	**	**	**	**	**	**	**	**	**	**	**	**
	2	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**
	3	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**
	4	**	**	**	**	**	**	**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	8	0	0	0	0	0	0	0	0	0	0	*	*	*	*	*	*	*	*	*	*	*	*	*
	9	*	*	*	*	*	*	*	*	*	*	0	0	0	0	0	0	0	0	+	+	0	0	0
	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	11	0	0	0	0	0	0	164	T	T	T	0	0	0	0	0	0	0	0	0	0	0	0	0
	12	T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	164	T	164	328	328
	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	T	T	0	0
	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	+	0	0
	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	164	164	T	T
	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	T	T	0	0	0

* Recorder Malfunction
 ** Instrument Malfunction
 + Precision Check
 T Trace

NON-METHANE HYDROCARBONS HOURLY AVERAGES ($\mu\text{g}/\text{m}^3$)
 JULY 1980

Sweetlake Monitoring Station
 Louisiana State University

CLI 802190/7-80

VII. WIND ROSE

CLI 802190/7-80

WIND ROSE

Percent Of Time Wind Was From
A Specified Direction

JULY 1980

Louisiana State University
Sweetlake Site

VIII. METEOROLOGICAL DATA

CLI 802190/7-80

HOUR

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	270	270	270	270	270	270	270	270	270	270	270	225	225	225	225	225	225	225	225	225	225	225	225	225
2	270	270	270	270	270	270	270	315	315	360	360	180	180	180	225	225	225	225	315	360	135	180	0	180
3	135	0	135	135	135	90	90	90	90	90	90	90	90	90	90	90	135	135	135	135	135	90	90	0
4	0	270	0	0	0	0	0	270	225	270	225	180	180	180	180	180	180	180	180	180	180	180	180	0
5	0	0	0	0	0	0	360	360	360	360	360	135	360	270	360	180	180	180	180	180	180	0	180	0
6	45	135	0	0	45	45	45	45	45	45	90	90	90	135	135	135	180	180	180	180	180	180	180	180
7	180	180	180	0	0	0	45	225	225	225	225	225	225	225	225	225	225	225	225	225	180	225	225	90
8	45	225	225	90	45	90	360	360	360	360	360	360	360	360	360	180	180	180	225	225	225	270	270	0
9	0	0	0	0	0	315	315	315	315	360	360	360	360	360	180	180	180	180	180	180	180	180	0	0
10	0	45	270	45	0	45	45	360	360	360	360	360	360	360	180	180	180	180	180	180	180	180	0	0
11	0	0	0	0	0	360	315	270	270	270	270	225	225	225	225	225	225	225	180	180	225	225	225	225
12	225	225	225	270	270	315	315	270	270	270	270	225	225	225	225	225	225	225	225	225	225	225	225	225
13	225	225	225	270	0	0	270	270	270	270	270	270	270	225	225	180	180	180	180	225	225	225	225	225
14	225	225	225	225	270	270	270	270	270	270	270	270	270	225	225	225	225	225	225	225	225	225	225	225
15	225	270	270	270	270	270	270	270	270	270	270	270	270	225	225	225	225	225	225	225	225	225	270	270
16	270	270	270	270	270	315	270	270	270	270	270	270	270	270	270	225	225	225	180	180	135	135	45	45
17	45	45	45	0	0	0	0	0	360	360	360	360	360	360	90	180	180	180	180	315	270	0	0	0
18	360	360	360	45	0	0	0	360	360	360	360	180	180	225	225	45	45	360	360	90	90	90	45	45
19	45	45	45	360	45	45	90	90	90	90	90	90	90	90	90	135	135	135	135	135	135	90	90	90
20	90	90	90	90	90	90	180	180	180	180	180	180	180	135	135	180	135	135	135	135	135	135	135	135
21	360	45	45	45	90	135	270	270	270	360	135	135	135	180	180	180	135	135	135	135	135	0	0	45
22	45	45	0	0	0	0	360	360	360	360	45	90	90	135	135	90	90	90	45	45	45	45	45	45
23	45	45	90	45	45	180	45	45	45	45	45	45	45	45	45	45	45	45	45	45	360	45	45	45
24	360	360	360	360	360	360	45	45	45	45	45	45	45	45	45	45	45	45	90	180	135	135	0	0
25	0	0	45	45	45	45	45	45	45	45	90	90	90	135	135	180	180	180	180	180	135	90	90	135
26	135	135	135	135	0	45	45	90	180	180	180	180	90	225	90	180	180	180	180	225	270	*	*	*
27	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
28	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
29	*	*	*	*	*	*	*	*	*	*	*	360	360	225	225	225	225	225	225	225	225	225	225	225
30	0	225	225	225	225	315	270	270	270	270	270	270	225	225	225	225	0	180	180	180	180	225	225	225
31	225	225	270	270	270	0	270	270	270	270	180	180	225	225	225	225	180	180	180	180	180	180	180	180

* Equipment Malfunction

WIND DIRECTION (°)
JULY 1980

Degrees reported reflect origin of wind.

Sweetlake Monitoring Station
Louisiana State University

CLI 802190/7-80

		HOUR																								
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
D A Y	1	8	8	8	8	7	2	5	9	10	6	6	5	6	8	8	8	8	8	8	7	6	5	4	5	
	2	3	5	4	1	0	2	6	6	4	3	2	4	5	6	9	10	7	2	2	3	4	1	0	1	
	3	1	0	1	1	2	4	4	4	4	8	9	10	9	10	10	10	10	6	3	3	2	2	1	0	
	4	0	1	0	0	0	0	5	8	9	8	6	6	6	6	6	8	8	7	6	4	2	1	1	0	
	5	0	0	0	0	0	0	2	2	4	5	3	3	3	5	3	5	6	7	5	3	2	0	1	0	
	6	1	1	0	0	1	0	2	7	7	6	5	5	6	6	6	6	9	9	10	10	7	6	6	7	6
	7	5	4	1	0	0	0	1	2	4	4	5	7	8	7	7	8	9	9	9	9	7	4	3	1	1
	8	6	9	4	3	3	2	1	3	7	7	7	6	6	5	6	4	6	5	5	2	2	3	2	0	
	9	0	0	0	0	0	1	1	3	3	3	2	4	4	5	12	10	8	8	6	2	1	1	0	0	
	10	0	1	1	1	0	1	2	2	5	4	4	3	3	5	9	10	8	8	6	4	2	1	0	0	
	11	0	0	0	0	0	1	2	5	6	6	6	8	7	7	9	9	9	8	7	6	4	2	1	1	
	12	1	1	1	1	1	1	1	4	8	7	5	7	6	5	7	8	9	9	7	4	1	2	3	1	
	13	1	2	2	1	0	0	2	6	9	10	9	10	11	10	8	8	8	8	8	6	4	4	3	3	
	14	2	1	3	3	1	2	2	5	7	8	8	7	7	8	10	10	10	10	10	10	8	6	5	5	4
	15	2	2	1	1	2	3	5	10	8	11	10	10	8	8	11	11	12	12	9	8	4	6	6	7	
	16	4	5	5	2	2	2	5	9	10	9	8	5	5	4	4	6	8	10	8	5	5	6	4	3	
	17	3	2	1	0	0	0	0	0	3	4	3	4	6	6	6	9	11	8	5	5	1	0	0	0	
	18	1	1	1	1	0	0	0	1	2	4	6	10	4	6	6	5	10	14	10	6	4	6	5	2	
	19	3	3	3	5	7	7	6	6	8	10	11	10	10	10	10	11	10	6	5	3	3	3	4	3	
	20	3	3	4	5	6	6	7	7	7	7	8	8	8	7	5	2	2	2	3	3	3	2	3	3	
	21	1	1	2	1	1	2	3	2	1	2	9	5	5	6	6	4	2	1	1	3	4	0	0	4	
	22	3	1	0	0	0	0	1	5	5	5	6	11	6	5	4	2	1	1	1	1	2	2	4	3	
	23	1	2	2	2	3	3	5	5	8	10	11	11	11	11	11	11	9	7	5	3	5	2	2	2	
	24	3	2	3	3	3	3	5	6	7	9	10	11	11	10	9	9	9	7	5	4	2	1	0	0	
	25	0	0	1	3	1	1	3	6	7	7	7	8	9	10	11	12	12	11	7	2	1	1	1	2	
	26	2	1	2	1	0	1	1	1	2	2	4	3	6	7	15	3	6	8	11	11	0	1	2	4	
	27	2	2	4	2	3	2	5	6	7	6	8	8	8	10	13	12	12	8	6	3	6	9	7	4	
	28	3	3	2	1	1	1	15	9	8	6	8	7	7	8	6	3	3	3	0	0	1	0	0	1	
	29	0	0	0	0	0	0	2	1	3	3	2	4	3	3	3	3	1	1	3	3	4	4	4	2	
	30	0	2	1	2	2	1	3	6	8	8	6	5	5	5	3	1	0	2	2	3	2	2	2	2	
	31	2	2	2	1	1	0	1	1	3	5	4	5	4	5	6	6	6	6	5	5	2	1	1	1	

WIND SPEED (mph)
JULY 1980

Sweetlake Monitoring Station
Louisiana State University

CLI 802190/7-80

	HOUR																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
D A Y	1	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	2	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	3	*	*	*	*	*	*	*	*	*	*	*	89	89	90	91	89	86	83	83	82	82	82	81
	4	81	81	81	81	81	86	89	90	89	91	92	93	94	94	93	92	91	89	84	84	84	83	82
	5	82	82	82	81	81	85	88	90	92	92	93	93	85	89	94	92	90	89	87	85	84	84	83
	6	83	83	83	82	82	85	86	89	90	91	93	95	96	95	95	94	91	89	86	84	84	84	84
	7	84	84	82	81	81	85	91	91	92	93	93	94	95	96	94	93	92	89	86	84	84	83	82
	8	81	80	82	80	80	81	88	89	91	92	93	94	95	95	96	95	94	90	87	84	84	84	83
	9	83	82	82	82	81	84	88	91	93	92	96	96	96	89	92	92	91	89	85	84	83	83	82
	10	82	81	82	82	82	84	87	91	93	91	95	94	96	91	92	92	91	89	86	85	84	84	83
	11	83	82	82	82	82	84	87	89	91	92	93	94	95	95	93	93	92	90	86	85	84	83	83
	12	83	83	83	82	81	85	87	89	91	91	93	94	95	95	94	93	92	89	85	83	84	84	83
	13	83	83	83	82	81	84	87	88	90	91	92	94	95	95	94	93	91	89	86	85	84	84	84
	14	83	84	83	83	83	86	89	89	91	92	93	94	94	94	93	93	91	91	87	86	85	85	84
	15	83	83	83	83	83	86	87	89	89	92	93	94	96	94	93	93	91	89	86	85	85	84	84
	16	84	83	81	81	89	82	85	87	89	91	94	95	97	98	97	95	91	89	86	86	85	83	82
	17	80	80	80	79	79	83	85	89	91	93	94	96	98	100	99	94	91	89	87	85	85	83	82
	18	81	81	81	80	81	84	87	90	92	93	90	82	88	91	92	82	79	77	80	78	78	77	76
	19	76	77	77	79	81	86	88	90	91	92	92	93	93	93	90	88	84	82	82	81	81	81	80
	20	80	80	79	80	83	85	85	88	88	89	90	82	81	81	85	83	82	81	81	80	80	80	80
	21	80	80	80	80	81	80	83	85	87	80	76	81	81	84	83	82	82	81	79	79	80	80	80
	22	80	80	80	80	82	82	84	87	89	89	83	80	82	84	84	84	84	83	82	82	79	79	78
	23	78	78	78	78	78	78	79	81	84	86	87	89	90	91	91	91	90	88	84	84	83	82	80
	24	80	79	78	78	78	80	82	84	85	87	88	89	90	90	91	91	90	88	85	84	84	83	82
	25	82	81	80	80	80	81	85	88	89	89	91	92	92	90	89	87	86	84	83	82	82	81	80
	26	80	80	80	80	80	83	87	90	90	91	92	85	*	*	*	*	*	*	83	82	81	80	80
	27	82	82	84	84	84	84	87	90	85	82	82	80	81	86	88	90	90	88	85	85	84	81	78
	28	78	78	79	79	80	80	80	79	76	75	75	76	76	77	79	81	82	83	82	80	80	79	78
	29	78	78	78	78	78	78	78	82	86	88	89	90	91	92	92	92	92	91	87	83	82	82	82
	30	82	82	82	82	82	82	83	85	87	88	89	90	91	92	92	93	94	92	88	86	85	84	84
	31	84	84	83	83	83	81	83	87	88	88	90	90	90	91	92	92	91	90	88	86	84	83	82

* Equipment Malfunction

TEMPERATURE (°F)

JULY 1980

Sweetlake Monitoring Station
Louisiana State University

CLI 802190/7-80

HOUR

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
D 14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A 15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Y 16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.10	.02	0.00	0.00	0.00	0.00	.04	.01	.01	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	.03	0.00	0.00	0.00	0.00	0.00	.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.15	.06	.02
21	0.00	0.00	0.00	0.00	.01	.19	0.00	0.00	0.00	.49	.92	0.00	.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.66	.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.06	.06	.22	.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.04	0.00	.13
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.06	.52	1.22	.30	.34	.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*	*	*	*	*	*	*	*	*	*	*	*	*
30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

* Equipment Malfunction

RAINFALL (H₂O)
JULY 1980

Sweetlake Monitoring Station
Louisiana State University

CLI 802190/7-80

APPENDIX H
Surface and Ground Water Quality Data
May - December 1980
Sweet Lake Test Site

SURFACE WATER QUALITY: BRIDGE

Date	Water Level	SC	pH	Temp.	Turb.	CaCO ₃	SO ₄	Na	Mg	Cl	C	Ca	K	Ba	Mn	O ₂	N	B	Pb	As	Cd	Hg
5-06-80	107"	530	7.7	27	38	127	3.2	62	5.9	49	12.1	35	2.1	.3	.9	4.1	.12	1.1	.05	.008	.002	.0007
6-03-80	75½"	424	7.1	29	24	60	4.5	18.4	.84	20	21	3.2	1.7	.03	.32	4.0	.30	1.6	.26	.002	.003	.0002
7-08-80	93½"	462	7.2	30	14	58	5.8	61	5.0	94	16	14.0	1.2	.16	.03	2.6	.1	.82	.05	.032	.002	.0017
8-12-80	86"	720	7.2	30	10	74	17.9	133	8.83	175	14.5	14.5	3.01	.2	.05	3.2	.06	.3	.05	.005	.002	.0123
9-16-80	84½"	695	7.6	33	7	82	3.7	115	6.7	26	37	21	56	.2	.17	3.6	.22	1.4	.05	.006	.002	.002
10-15-80	98"	606	7.6	23	30	63	4.9	86	8.14	50	24	1.6	5.84	.1	.26	4.8	.24	1.4	.05	.069	.002	.0104
11-12-80	100"	1,046	8.0	19	14	99	9.8	203	93	210	13	19.58	9.51	2.4	.18	8.8	.1	.7	.05	.038	.002	.0129
12-16-80	95"	500	8.0	26	110	98	195	62	10	90	89	41	14.9	105	.51	1.8	.23	2.2	.1	.016	.002	.0039
Average		622.88	7.55	27.13	30.88	82.63	30.60	92.55	17.30	89.25	28.33	18.74	11.78	13.54	.30	4.11	.17	1.19	.08	.022	.002	.0055

Water level: feet below ground surface
Specific conductance (SC) in umhos/cm
pH in standard units
Temperature in centigrade
Turbidity in feet
All other values in mg/l

SURFACE WATER QUALITY: SQUARE LAKE

Date	Water Level	SC	pH	Temp.	Turb.	CaCO ₃	SO ₄	Na	Mg	Cl	C	Ca	K	Ba	Mn	O ₂	N	B	Pb	As	Cd	Hg
5-06-80	24"	350	7.2	26	105	37	7.1	33	5.9	62	16.6	10.5	4.3	0.1	0.03	8.2	0.1	0.50	0.05	0.004	.002	.0014
6-03-80	48½"	410	6.8	29	35	16.5	3.2	15.4	0.44	28	7.6	.55	1.8	.1	.03	6.9	.1	1.9	.05	.002	.002	.0002
7-08-80	18½"	679	6.7	31	23	35	5.4	98	5.3	205	11	4.9	1.51	.03	.04	6.8	.1	1.15	.05	.004	.002	.0013
8-12-80	52"	906	6.9	32	7.5	78	38	155	12.07	225	14.5	10.0	4.35	.2	.04	5.8	.11	.3	.05	.031	.002	.0045
9-16-80	48½"	2,336	6.2	33	3.4	177	87	253	32	285	13	22	16	.5	.06	4.6	.1	2.0	.05	.009	.004	.0043
10-15-80	22½"	5,075	6.7	25	1.0	474	282	323	91	1,500	10	5.1	26	.2	.13	4.0	.1	4.6	.05	.169	.006	.0127
11-12-80	23"	7,630	7.3	19	1.0	760	414	1,533	1,600	2,260	5.9	47	55	.4	.22	8.0	.1	3.3	.05	.039	.002	.0031
12-16-80	49"	4,396	7.1	27	65	480	123	549	82	1,339	10.6	49	26	2.6	.11	8.6	.15	5.3	.05	.015	.002	.0027
Average		2,722.75	6.86	27.75	30.11	257.19	119.96	369.93	228.59	738	11.15	18.63	16.87	.52	.08	6.61	.11	2.38	.05	.034	.003	.0038

Water level: feet below ground surface
 Specific conductance (SC) in umhos/cm
 pH in standard units
 Temperature in centigrade
 Turbidity in feet
 All other values in mg/l

SURFACE WATER QUALITY: SWEET LAKE

Date	Water Level	SC	pH	Temp.	Turb.	CaCO ₃	SO ₄	Na	Mg	Cl	C	Ca	K	Ba	Mn	O ₂	N	B	Pb	As	Cd	Hg
5-06-80	81"	330	7.2	26	88	36	1.0	36	10.0	57	15.6	8.6	4.3	.1	.03	6.7	.1	.50	.05	.019	.002	.0008
6-03-80	89"	524	6.8	29	44	20	2.7	18.7	.45	36	7.8	.90	2.1	.03	.02	6.0	.16	1.3	.05	.002	.002	.0002
7-08-80	101"	598	6.1	33	24	28	5.8	109	5.0	202	10	2.1	1.46	.20	.11	6.4	.1	1.23	.06	.004	.002	.0013
8-12-80	85"	1,813	6.4	32	6.0	161	92	255	28.57	555	10	13.7	8.30	.4	.16	6.2	.11	1.5	.05	.008	.002	.0094
9-16-80	80"	3,346	6.5	32	6	272	165	345	46	400	11	25	10.68	.3	.03	7.8	.1	2.2	.05	.006	.003	.0021
10-15-80	81"	6,921	6.2	24	.9	739	395	739	356	2,250	6	14.2	39	.4	.78	7.7	.1	7.2	.05	.046	.002	.0059
11-12-80	79"	7,350	7.2	19	1.0	770	410	1,678	1,737	2,260	5.4	40	44	.3	.22	8.6	.1	3.8	.05	.024	.002	.003
12-16-80	83"	4,082	6.8	28	.5	420	415	564	76	1,179	10.2	45	24	.5	.04	9.4	.1	4.8	.05	.01	.002	.0035
Average		3,120.5	6.65	27.88	21.30	305.75	185.81	468.09	282.38	867.38	9.5	18.69	16.73	.28	.17	7.35	.11	2.82	.05	.015	.002	.0033

Water level: feet below ground surface
Specific conductance (SC) in umhos/cm
pH in standard units
Temperature in centigrade
Turbidity in feet
All other values in mg/l

GROUND WATER QUALITY: WELL #1

Date	Water Level	SC	pH	Temp.	Turb.	CaCO ₃	SO ₄	Na	Mg	Cl	C	Ca	K	Ba	Mn	O ₂	N	B	Pb	As	Cd	Hg
10-24-80	NA	589	7.58	18	3.5	115	3.6	99	8.73	60	20	39	1.50	.1	.1	4.2	.1	1.1	.05	.002	.002	.0084
11-12-80	NA	388	6.9	21	.46	116	2	71	102	50	5	15.32	2.04	.1	.13	5.8	.1	.8	.05	.023	.002	.0142
12-19-80	NA	628	7.6	22	.05	103	2.7	83	8.9	91	3.1	37	1.49	.3	.09	4.8	.1	1	.05	.006	.002	.0029
Average	NA	338.67	7.36	20.33	1.34	111.33	2.77	84.33	39.88	67	9.37	30.44	1.68	.17	.11	4.93	.1	.97	.05	.010	.002	.0085

Water level: feet below ground surface
 Specific conductance (SC) in umhos/cm
 pH in standard units
 Temperature in centigrade
 Turbidity in feet
 All other values in mg/l

GROUND WATER QUALITY: WELL #2

Date	Water Level	SC	pH	Temp.	Turb.	CaCO ₃	SO ₄	Na	Mg	Cl	C	Ca	K	Ba	Mn	O ₂	N	B	Pb	As	Cd	Hg
10-24-80	NA	665	7.74	19	3.0	149	4.0	99	7.67	85	36	49	2.86	.2	.03	6.5	.1	1.1	.1	.003	.002	.0052
11-12-80	NA	693	6.9	21	.92	122	4.0	143	82	56	9	45	3.8	.3	.08	4.1	.1	.9	.05	.021	.003	.0255
12-19-80	NA	602	7.6	22	.05	106	3.9	84	9.8	97	1.5	13	2.04	.3	.1	4.9	.1	1.2	.05	.005	.002	.0032
Average	NA	653.33	7.41	20.67	1.32	125.67	3.97	108.67	33.16	79.33	15.5	35.67	2.9	.27	.07	5.17	.1	1.07	.07	.010	.002	.0113

Water level: feet below ground surface
 Specific conductance (SC) in umhos/cm
 pH in standard units
 Temperature in centigrade
 Turbidity in feet
 All other values in mg/l

GROUND WATER QUALITY: WELL #3

Date	Water Level	SC	pH	Temp.	Turb.	CaCO ₃	SO ₄	Na	Mg	Cl	C	Ca	K	Ba	Mn	O ₂	N	B	Pb	As	Cd	Hg
10-24-80	NA	665	7.62	17	12	128	11.5	87	6.67	65	25	42	2.36	.1	.03	8.4	.1	1.9	.1	.002	.002	.0106
11-12-80	NA	776	6.9	21	4.0	143	2.5	94	79	85	5	51	2.86	.03	.11	8.1	.1	.9	.05	.022	.002	.0133
12-19-80	NA	706	7.6	22	.20	122	4.0	89	8.6	118	1.0	44	2.27	.3	.04	5.7	.1	1.0	.05	.008	.002	.0039
Average	NA	715.67	7.37	20	5.4	131	6	90	31.42	89.33	10.33	45.66	2.5	.14	.06	7.4	.1	1.27	.07	.011	.002	.0093

Water level: feet below ground surface
 Specific conductance (SC) in umhos/cm
 pH in standard units
 Temperature in centigrade
 Turbidity in feet
 All other values in mg/l

APPENDIX I
Elevation Data
Sweet Lake Test Site

Table I-1. Sweet Lake leveling data (not normalized).

BENCH MARKS	1918	1938	1955	1965	1969	1972	BENCH MARKS	1918	1938	1955	1965	1969	1972
X	6.185	6.289	6.274	6.194		6.124	D1	3.136		3.169	3.085		3.014
Y	6.033	6.124	6.099			5.946	T161			2.645			
4122			4.892			4.734	E1	6.140		6.179	6.075		5.977
W100		5.336	5.367				G1	5.915		5.948	5.848		5.745
Stiner2		6.001	5.965				H1	5.889		5.929	5.835		5.737
Stine		5.769	5.826				Q210					4.255	4.186
W29		5.101	5.103				BM2			4.085	3.998		
P161			5.468	5.391		5.318	BM1			2.511			
Z	4.346	4.454	4.471				BM4			2.950	2.863		
Q161			5.319	5.235			D4161			2.928			
U161			4.630	4.508	4.475	4.381	TT29B			3.900	3.808		
2B			4.480	4.369	4.336	4.249	D4151			6.395	6.279		
TT169LS			5.324	5.189	5.146	5.048	D4153			4.654			
R161			4.608	4.479	4.427	4.323	TT167			4.551			
S161			4.009	3.910	3.888	3.800	4152			3.566	3.470		
N210					5.534	5.454	C162			3.952	3.881		
B1	3.973		3.971				E162			1.672	1.596		
C1	4.263		4.241	4.165	4.165	4.091	BM4(u)			2.810	2.706		
I1	3.461		3.453				BM3			3.960	3.875		
4107			4.790	4.698	4.792	4.619	BM1			1.071	1.002		

Table I-1. (cont'd)

BENCH MARKS	1918	1938	1955	1965	1969	1972	BENCH MARKS	1918	1938	1955	1965	1969	1972
V108			4.474				B162			5.808			5.658
W108			3.858			3.506	A162			5.597			5.475
R210					4.134	4.082	A4171			6.052			5.958
X108			2.610	2.542	2.525	2.488	A4172			6.216			6.137
Y108			3.185	3.098	3.088	3.033	01	7.847		7.507			7.735
A109			3.580 ^R	3.498	3.490	3.434	A4174			7.275			7.177
V161			3.680			3.810	A4175			7.517			
F162			3.622	3.542		3.479	P1	9.199		9.292			
Z108			3.778 ^R	3.700		3.640	14			9.299			
W161			4.092	4.027		3.957	D164			0.136			
K1	4.399		4.501	4.422		4.370	H17			10.335			
X161			3.702			3.564	E164			8.501			
A4145			4.763	4.680		4.627	F164			8.933			
A4144			4.016	3.935		3.873	E2214			7.239			
Y161			4.716	4.637		4.595	13			9.651			
A4142X			4.808	4.725		4.671	H162			9.508			
Z161			4.520	4.449		4.405	A4177			8.441			
A4141			5.270	5.191		5.119	A4178			7.683			
A4140			5.807	5.710	5.615	5.621	A4179			6.770			
A4139			5.084	5.011	5.442 ^R	4.952	A4180			6.220			
MJ	5.493		5.584				A4181			6.364		6.342	

Table I-1. (cont'd)

<u>BENCH MARKS</u>	<u>1918</u>	<u>1938</u>	<u>1955</u>	<u>1965</u>	<u>1969</u>	<u>1972</u>	<u>BENCH MARKS</u>	<u>1918</u>	<u>1938</u>	<u>1955</u>	<u>1965</u>	<u>1969</u>	<u>1972</u>
2173			5.878		5.835		2114			6.816			
Q1	6.242		6.452 ^R				WelshR1			6.019			
Lacassine			6.131		6.296		WelshR2			6.124			
2126			6.569				2113			7.078			
2124			5.825		5.819		TT5B			7.602			
G162			5.740		5.700		W1	5.804		5.755			
TT3B			6.578		6.545		2112			7.233			
R1	6.162		6.234		6.173		2111			6.462			
2121			7.170		7.170		2110			8.428			
S1	6.451		6.543		6.508		X1	8.309		8.424			
2120			5.419				N162			8.006			
2119			6.759				TT7H			7.242			
2118			5.336		5.316		P162			6.650			
T1	7.572		7.704				Q162			7.102			
J162			5.791				R162			7.649			
K162			5.651				2109			6.448			
L162			5.604				TT9B			5.999			
U1	7.688		7.818				Y1	6.383		6.501			
V1	7.518		7.638				2108			5.840			
Welsh Grav			4.508		4.510		2107			4.980			
M162			6.249				2106			4.653			

Table I-1. (cont'd)

<u>BENCH MARKS</u>	<u>1918</u>	<u>1938</u>	<u>1955</u>	<u>1965</u>	<u>1969</u>	<u>1972</u>	<u>BENCH MARKS</u>	<u>1918</u>	<u>1938</u>	<u>1955</u>	<u>1965</u>	<u>1969</u>	<u>1972</u>
Z105			4.158				B2224			5.076			
V162			8.596				62	4.718		4.820			
2103			7.933				B2226			5.045			
A2111			8.114				B2227			4.875			
S162			7.870				B2228			4.531			
T162			7.814				T2			4.021			
U162			7.597				B2230			3.530			
2102			7.668				B2232			2.990			
2101			7.671				B2233			4.461			
Jennings			8.264				B2234			3.849			
JenningsR2			8.425				B2235			4.234			
C2	10.312		10.445				462			3.878			
D2	9.807		9.933				TT17B			3.873			
B2	9.832		9.956				K2	4.662		4.772			
A406			7.374				461			4.808			
A405			6.260				L2	5.330		5.450			
V162			4.384				X162			5.574			
F2	5.547		5.662				TTS14B			5.791			
W162			4.903				Z162			5.143			
B2208			5.016				AT63			5.023			
P163			4.063				B163			4.681			

Table I-1. (cont'd)

<u>BENCH MARKS</u>	<u>1918</u>	<u>1938</u>	<u>1955</u>	<u>1965</u>	<u>1969</u>	<u>1972</u>	<u>BENCH MARKS</u>	<u>1918</u>	<u>1938</u>	<u>1955</u>	<u>1965</u>	<u>1969</u>	<u>1972</u>
C163			4.584										
Y60			3.964										
G164			4.902										
A4303			4.389										
Z60			3.988										
456			4.687										
N2	4.628		4.750										

Table I-2. Sweet Lake leveling data (normalized to benchmark only).

<u>BENCH MARKS</u>	<u>1918</u>	<u>1938</u>	<u>1955</u>	<u>1965</u>	<u>1969</u>	<u>1972</u>	<u>BENCH MARKS</u>	<u>1918</u>	<u>1938</u>	<u>1955</u>	<u>1965</u>	<u>1969</u>	<u>1972</u>
X	6.124	6.124	6.124	6.124		6.124	T161			2.495			
Y	5.972	5.959	5.949			5.946	E1	6.079		6.029	5.925		5.977
4122			4.742				G1	5.854		5.798	5.778		5.745
W100		5.171	5.217				H1	5.828		5.779	5.765		5.737
Stine R2		5.836	5.815				Q210					4.190	4.186
Stine		5.604	5.676				BM2			3.935	3.928		
W29		4.936	4.953				BM1			2.361			
P161			5.318	5.321		5.318	BM4			2.800	2.793		
Z	4.246	4.289	4.321				D4161			2.778			
Q161			5.169	5.165			TT298			3.750	3.738		
U161			4.480	4.438	4.410	4.381	D4151			6.245	6.209		
2B			4.330	4.299	4.271	4.249	D4153			4.504			
TT169LS			5.174	5.119	5.081	5.048	TT167			4.401			
R161			4.458	4.409	4.362	4.323	4152			3.416	3.400		
S161			3.859	3.840	3.823	3.800	C162			3.802	3.811		
N210					5.389	5.454	E162			1.522	1.526		
B1	3.912		3.821				BM4(u)			2.660	2.636		
C1	4.202		4.091	4.095	4.100	4.091	BM3			3.810	3.805		
I1	3.400		3.303				BM1			0.921	0.932		
4107			4.640	4.628	4.727	4.619	V108			4.324			
D1	3.075		3.019	3.015		3.014	W108			3.708			3.506

Table I-2. (cont'd)

<u>BENCH MARKS</u>	<u>1918</u>	<u>1938</u>	<u>1955</u>	<u>1965</u>	<u>1969</u>	<u>1972</u>	<u>BENCH MARKS</u>	<u>1918</u>	<u>1938</u>	<u>1955</u>	<u>1965</u>	<u>1969</u>	<u>1972</u>
R210					4.069	4.082	A4171			5.902			5.958
X108			2.460	2.472	2.460	2.488	A4172			6.066			6.137
Y108			3.035	3.028	3.023	3.033	01	7.786		7.357			7.735
A109			3.430	3.428	3.425	3.434	A4174			7.125			7.177
V161			3.530			3.810	A4175			7.417			
F162			3.472	3.472		3.479	P1	9.138		9.142			
Z108			3.628	3.630		3.640	14			9.149			
W161			3.942	3.957		3.957	D164			-0.014			
K1	4.388		4.351	4.352		4.370	H17			10.185			
X161			3.552			3.564	E164			8.351			
A4145			4.613	4.610		4.627	F164			8.783			
A4144			3.866	3.865		3.873	E2214			7.089			
Y161			4.566	4.567		4.595	13			9.501			
A4142X			4.658	4.655		4.671	H162			9.358			
Z161			4.370	4.379		4.405	A4177			8.291			
A4141			5.120	5.121		5.119	A4178			7.533			
A4140			5.657	5.737		5.621	A4179			6.550			
A4139			4.934	4.941		4.952	A4180			6.070			
M1	5.432		5.434				A4181			3.214			6.364
B162			5.658			5.658	2173			5.728		5.770	
A162			5.447			5.475	Q1	6.181		6.302			

Table I-2. (cont'd)

<u>BENCH MARKS</u>	<u>1918</u>	<u>1938</u>	<u>1955</u>	<u>1965</u>	<u>1969</u>	<u>1972</u>	<u>BENCH MARKS</u>	<u>1918</u>	<u>1938</u>	<u>1955</u>	<u>1965</u>	<u>1969</u>	<u>1972</u>
Laccassine			5.981		6.296		Welsh R2			5.974			
2126			6.419				2113			6.928			
2124			5.675		5.754		TT5B			7.452			
G162			5.590		5.635		W1	5.743		5.605			
TT3B			6.428		6.480		2112			7.083			
R1	6.101		6.084		6.108		2111			6.312			
2121			7.020		7.105		2110			8.278			
S1	6.390		6.393		6.443		X1	8.248		8.274			
2120			5.269				N162			7.856			
2119			6.609				TT7H			7.092			
2118			5.186		5.251		P162			6.500			
T1	7.511		7.554				Q162			6.952			
J162			5.641				R162			7.499			
K162			5.501				2109			6.298			
L162			5.454				TT9B			5.849			
U1	7.627		7.668				Y1	6.322		6.351			
V1	7.457		7.488				2108			5.690			
Welsh Grav			4.358		4.445		2107			4.830			
M162			6.099				2106			4.503			
2114			6.666				2105			4.008			
Welsh R1			5.869				Y162			8.446			

Table I-2. (cont'd)

<u>BENCH MARKS</u>	<u>1918</u>	<u>1938</u>	<u>1955</u>	<u>1965</u>	<u>1969</u>	<u>1972</u>	<u>BENCH MARKS</u>	<u>1918</u>	<u>1938</u>	<u>1955</u>	<u>1965</u>	<u>1969</u>	<u>1972</u>
2103			7.783				B2226			4.895			
A2111			7.964				B2227			4.725			
S162			7.720				B2228			4.381			
T162			7.664				T2			3.871			
U162			7.447				B2230			3.380			
2102			7.518				B2232			2.840			
2101			7.521				B2233			4.311			
Jennings			8.114				B2234			3.699			
Jennings R2			8.275				B2235			4.084			
C2	10.251		10.295				462			3.728			
D2	9.746		9.783				TT17B			3.723			
B2	9.771		9.806				K2	4.601		4.572			
A406			7.224				461			4.658			
A405			6.110				L2	5.269		5.300			
V162			4.234				X162			5.424			
F2	5.486		5.511				TT514B			5.641			
W162			4.753				Z162			4.993			
B2208			4.866				A163			4.873			
P163			3.913				B163			4.531			
B2224			4.926				C163			4.435			
62			5.670				Y60			3.814			

Table I-3. Sweet Lake leveling data (normalized to benchmark and year).

BENCH MARKS	1918	1938	1955 BASELINE	1965	1969	1972	BENCH MARKS	1918	1938	1955	1965	1969	1972
X	0.000	0.000	0.000	0.000		0.000	4107				-0.012	+0.008	-0.021
Y	+0.023	+0.010				-0.003	D1	+0.056			-0.004		-0.005
4122						-0.008	E1	+0.050			-0.024		-0.052
W100		-0.046					G1	+0.056			-0.020		-0.053
StineR2		+0.021					H1	+0.049			+0.014		-0.042
Stine		-0.072					BM2				-0.007		
W29		-0.017					BM4				-0.007		
P161				+0.003		0.000	TT29B				-0.012		
Z	+0.054	-0.032					D4151				-0.036		
Q161				-0.004			4152				-0.016		
U161				-0.042	-0.059	-0.099	C162				+0.009		
2B				-0.031	-0.048	-0.081	E162				+0.004		
TT169LS				-0.055	-0.082	-0.126	BM4(u)				-0.024		
R161				-0.049	-0.085	-0.135	BM3(u)				-0.005		
S161				-0.019	-0.025	-0.059	BM1(u)				+0.011		
N210							W108						-0.202
B1	+0.091						X108				+0.012	+0.011	+0.028
C1	+0.111			+0.004	+0.020	0.000	Y108				-0.007	-0.001	-0.002
I1	+0.097						A109				-0.002	+0.006	+0.004

Table I-3. (cont'd)

<u>BENCH MARKS</u>	<u>1918</u>	<u>1938</u>	<u>1955 BASELINE</u>	<u>1965</u>	<u>1969</u>	<u>1972</u>	<u>BENCH MARKS</u>	<u>1918</u>	<u>1938</u>	<u>1955</u>	<u>1965</u>	<u>1969</u>	<u>1972</u>
V161						+0.280	2173					+0.103	
F162				0.000		+0.007	Q1	-0.121 ^R					
Z108				+0.002		+0.012	Lacassine					+0.261	
W161				+0.015		+0.015	2124					+0.090	
K1	-0.013			+0.001		+0.019	G162					+0.056	
X161						+0.012	TT3B					+0.063	
A4145				-0.003		+0.014	R1	+0.017				+0.035	
A4144				-0.001		+0.007	2121					+0.096	
Y161				+0.001		+0.029	S1	-0.003				+0.061	
A4142X				-0.003		+0.013	2118					+0.076	
Z161				+0.009		+0.035	T1	-0.043					
A4141				+0.001		-0.001	U1	-0.041					
A4140				-0.017	-0.096	-0.036	V1	-0.031					
A4139				+0.007	Reset	+0.018	Welsh Grav					+0.098	
B162						0.000	X1	-0.026					
A162						+0.028	Y1	-0.029					
A4171						+0.056	C2	-0.044					
A4172						+0.071	D2	-0.037					
O1						+0.378	B2	-0.035					
A4174						+0.052	F2	-0.026					
A4181					+0.074		G2	-0.013					

Table I-3. (cont'd)

<u>BENCH</u> <u>MARKS</u>	<u>1918</u>	<u>1938</u>	<u>1955</u> BASELINE	<u>1965</u>	<u>1969</u>	<u>1972</u>	<u>BENCH</u> <u>MARKS</u>	<u>1918</u>	<u>1938</u>	<u>1955</u>	<u>1965</u>	<u>1969</u>	<u>1972</u>
K2	-0.021												
L2	-0.031												
N2	-0.033												
W1	+0.138												

Table I-4. Sweet Lake leveling data (not normalized).

<u>BENCH MARKS</u>	<u>1965</u>	<u>1968</u>	<u>1980</u>	<u>BENCH MARKS</u>	<u>1965</u>	<u>1968</u>	<u>1980</u>	<u>BENCH MARKS</u>	<u>1965</u>	<u>1968</u>	<u>1980</u>
D214	6.479	6.464		U214	1.238		1.275	12V6		2.753	2.765
E214	5.109	5.090		V214	1.549		1.588 ^R	S7			3.409
F214	5.705			W214	1.178			S8			1.854
TT137	7.416			Y214	1.327			S2			2.490
G214	5.623			Draw Bridge	2.433			S1			2.390
H214	5.939			X214	0.998			S3			3.016
J214	4.398			Z214	1.131			S4			2.534
K214	4.538			F215	1.078			12V7		2.825	2.800
L214	5.733			E215	1.086			S5			2.700
BM11	3.196			D215	1.103			S6			2.313
TT161	2.916			TIP	0.893			12V8		4.081	
B4135	2.398			C215	1.007			12V9		3.797	
M214	2.118		2.107	B215	0.978			12V10		3.911	
N214	2.348		2.334	A215	1.272			12V11		2.597	
P214	2.940		2.934	D213	1.278			12V12		0.980	
Q214	4.300		4.286	S12			2.325	12V13		2.230	
R214	3.406		3.411	S11			1.760	12V14		1.358	
S214	2.852	2.841	2.871	12V4		2.209	2.234	12V15		0.716	
B4142	2.540	2.528	2.554	12V5		2.963	2.984	12V16		2.772	
TT159	2.611	2.606	2.630	S9			2.023	Grand Lake		3.385	
T214	1.856		1.886	S10			1.801	Grand Lake R1		3.211	
B4169		0.739						Grand Lake R4		3.717	
J226		1.035									
12V19		2.253	2.247								

Table I-5. Sweet Lake leveling data (normalized to benchmark and year).

<u>BENCH MARKS</u>	<u>1965</u>	<u>1968</u>	<u>1980</u>
	<u>BASELINE</u>		
D214	0.000	0.000	
E214		-0.004	
M214			-0.010
N214			-0.013
P214			-0.005
Q214			-0.013
R214			+0.006
S214		+0.004	+0.020
B4142		+0.003	+0.015
TT159		+0.010	+0.020
T214			+0.031
U214			+0.038
V214			+0.040
	<u>BASELINE</u>		
12V4	0.000		0.000
12V5			-0.004
12V6			-0.013
12V7			-0.050
12V19			-0.031