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ENVIRONMENTAL ASSESSMENT, GEOKINETICS, INC. OIL
SHALE RESEARCH PROJECT, UINTAH COUNTY, UTAH

December 1979

Laramie Energy Technology Center
Laramie, Wyoming

TECHNICAL INFORMATION CENTER
UNITED STATES DEPARTMENT OF ENERGY

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ENVIRONMENTAL ASSESSMENT

GEOKINETICS, INC. OIL SHALE RESEARCH PROJECT
Uintah County, Utah

December, 1979

U.S. DEPARTMENT OF ENERGY
ASSISTANT SECRETARY FOR FOSSIL ENERGY

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SUMMARY

Geokinetics, Inc. (GKI) proposes to complete the remaining experimental program to develop the LOFRECO modified horizontal in situ oil shale retorting process. This Environmental Assessment Report addresses the impacts of the project, located in a remote area of east-central Utah, about 70 miles south of both Vernal and Roosevelt.

The proposed project, a continuation of currently occurring activities, is scheduled to begin in January 1980 and to be completed in mid-1982. It is designed to optimize the LOFRECO process to establish its economic feasibility.

The LOFRECO process involves fragmentation of the shale in a specific section of an oil shale bed through the blasting of an array of boreholes. The fragmented zone constitutes an in situ retort. Blasting is such that the retort slopes to one end. Air injection holes are drilled at the high end of the retort. Off gas holes and production wells are drilled at the low end. The oil shale is ignited, and air is injected to move uniform combustion front through the retort. Oil, driven from the shale by the heat of combustion, drains to the bottom of the retort and flows to the low end where it is pumped to the surface by the production wells. Since 1975 GKI has blasted and burned a number of retorts of steadily increasing size to prove the technical feasibility of the process.

The remaining experimental program involves the blasting and burning of five retorts, each measuring 217 x 230 x 30 feet. It also includes the burning of four existing retorts.

To establish the economic feasibility of the LOFRECO process, the remainder of the experimental program is designed to: 1) minimize the cost of fragmentation; 2) optimize burning and oil lifting techniques to increase oil recovery, and 3) make effective use of the combustible retort off gas.

The activities in progress are being conducted by a field crew of 31 persons who live with their families in an on-site mining camp. Since the camp is currently at capacity, a 20-trailer expansion is planned for 1980 in order to accommodate a small increase in the work force and transient contractors. Other anticipated changes during the remaining experimental program include the drilling of a second well to obtain potable water; the installation of a fourth leach field for sanitary wastes and installation of a 500 KW diesel generator to supplement the existing capacity.

The economic effect of the total project involves \$1.5 to 2.0 million in annual wages and salaries.

The process entails clearing the ground surface over the retorts prior to drilling and blasting. The project, therefore, will result in a barren area in the vicinity of the retorts. This is considered a short-term biological impact, as the areas are to be revegetated after oil recovery.

The primary aesthetic impacts will be related to the clearing of vegetation and the development of a series of mounds, each about one acre in extent.

Impacts to the air quality will consist of gaseous emissions from the combustion of retort gases. No PSD increment or ambient air standard will be exceeded.

Noise associated with the project will be emitted from the 24-hour operation of the diesel generator and project-related vehicular movement. The retort blasting, an instantaneous, muffled sound, will occur infrequently. Sensitive receptors are limited to persons at the camp, all of whom are associated with the project.

Ground water contamination could occur through the migration of contaminant-bearing water from sanitary waste leach fields or an evaporation pond. There is also the possibility that ground water could be contaminated by seepage through burned retorts.

There are two known ground water zones below the site. One zone is very near the surface and is a perched zone, which exists in the fracture system of a relatively impermeable siltstone layer. A potable water aquifer exists 1,300 feet below the ground surface. The strata between the perched zone and this aquifer include one known aquitard, the Mahogany Zone, and a number of shale or siltstone layers which probably are aquitards.

Contamination of the perched water zone is considered unlikely, due to the horizontal and vertical immobility of the perched zone water. The probability of contaminating the aquifer is low because of the underlying distance below the Mahogany Zone and limited recharge from the surface.

No surface water impacts are anticipated.

Cultural resources are not expected to be impacted by the proposed action. One site of significance has been identified in the southwest corner of Section 2. It will not be affected by the remaining experimental program.

GKI has committed to environmental activities to determine:

- 1) site-specific air quality
- 2) site-specific meteorological characteristics
- 3) hydrogeologic and geohydrologic characteristics of the region and the project site
- 4) ground water quality
- 5) the effects of project activities on local vegetation (GKI, December 1979).

In addition, GKI will conduct a reclamation program to mitigate project-induced adverse impacts. The reclamation process will be optimized by utilization of site-specific data on soils, vegetation and climatology (GKI, December 1979).

CONTENTS

<u>Section</u>	<u>Page</u>
SUMMARY	
1.0 PURPOSE AND NEED FOR ACTION	1
2.0 PROPOSED ACTION AND ALTERNATIVES	2
2.1 General Process Description	2
2.2 Experimental Program	2
2.2.1 Blasting and Burning	6
2.2.2 Liquid Effluents	6
2.2.3 Oil Handling	8
2.2.4 Atmospheric Effluents	8
2.2.5 Personnel Requirements	9
2.3 Services Description	9
2.3.1 Kamp Kerogen	9
2.3.2 Solid Waste Disposal	11
2.3.3 Power Supply	11
2.3.4 Water Supply	11
2.3.5 Sanitary System	11
2.3.6 Communication	13
2.3.7 Transportation	13
2.3.8 Fuel Requirements	13
2.4 Alternatives	13
2.5 Alternatives Not Considered	14
3.0 AFFECTED ENVIRONMENT	15
3.1 Geology	15
3.1.1 Soils	15
3.1.2 Hydrogeology	15
3.2 Hydrology	15
3.2.1 Surface Water	15
3.2.2 Ground Water	18
3.2.2.1 Aquifer Description	18

3.2.2.2	Ground Water Testing	18
3.2.2.3	Water Use	21
3.2.3	Water Quality	21
3.3	Biology	21
3.3.1	Vegetation	21
3.3.2	Wildlife	23
3.4	Meteorology/Air Quality	23
3.4.1	Meteorological Characteristics	23
3.4.2	Ambient Air Quality	23
3.5	Noise	26
3.6	Socioeconomic Characteristics	26
3.6.1	Population	26
3.6.2	Local Economics	26
3.6.3	Services	28
3.6.4	Labor Availability	28
3.6.5	Transportation	28
3.6.6	Land Use	28
3.6.7	Land Use Plans	28
3.7	Aesthetics	28
3.8	Archaeology/Paleontology	29
4.0	ENVIRONMENTAL CONSEQUENCES	30
4.1	Geology	30
4.1.1	Soils	30
4.1.2	Erosion	30
4.2	Hydrological Impacts	30
4.2.1	Surface Water Impacts	30
4.2.2	Perched Water Impacts	30
4.2.3	Aquifer Impacts (Retorting)	33
4.2.4	Aquifer Impacts (Deep Well Injection)	33
4.3	Biological Impacts	34
4.3.1	Vegetation	34
4.3.2	Wildlife	34
4.4	Air Quality Impacts	34

4.4.1	Dust	34
4.4.2	Process Gases	34
4.4.3	Stack Gases	35
4.5	Noise	35
4.6	Socioeconomic Impacts	37
4.7	Aesthetics	37
4.8	Archaeological Impacts	38
4.9	Mitigation Measures	38
4.9.1	Air Quality	38
4.9.2	Wildlife	38
4.9.3	Archaeology/Paleontology	39
4.9.4	Reclamation	39
4.10	Energy Requirements	39
4.11	Irreversible or Irretrievable Commitments of Natural or Depletable Resources	39
4.12	Relationship Between Short-Term Uses of Man's Environment and the Maintenance and Enhancement of Long-Term Productivity	40
5.0	REFERENCES	41
APPENDICES		
A.	Soil Description	42
B.	Habitat Types	43
C.	Supplemental Tables	44
D.	Supplemental Figures	52
E.	Impact Analysis	57

LIST OF TABLES

<u>Table No.</u>		<u>Page</u>
1	Blasting and Burning Schedule	5
2	Meteorological Parameters to be Monitored	24
3	Ambient Air Quality Parameters to be Monitored	27
4	Water Quality Parameters to be Analyzed	32
5	Air Quality Parameters to be Monitored in the Process Gas Stream	36

LIST OF FIGURES

<u>Figure No.</u>		<u>Page</u>
1	Site Location	3
2	Schematic of LOFRECO Process	4
3	Site Layout	7
4	Kamp Kerogen Layout	10
5	Leach Field Locations	12
6	Soils Map	16
7	Columnar Section of Green River Formation	17
8	Section 2 Topography	19
9	Vegetation Map	22
10	Meteorological Monitoring Stations	25

LIST OF APPENDIX C TABLES

<u>Table No.</u>		<u>Page</u>
C-1	Statistical Characterization of Perched Water	45
C-2	List of Plant Species Occurring on Section 2	46
C-3	Rare, Endangered, Threatened, Restricted and Endemic Plant Species	48
C-4	Meteorological Station Description	49
C-5	Statistical Characterization of Retort Water	50
C-6	Retort #16 Gas Composition for September, 1978	51

LIST OF APPENDIX D FIGURES

<u>Figure No.</u>		<u>Page</u>
D-1	Series 1--Water Monitoring Well Locations	53
D-2	Series 2--Water Monitoring Well Locations	54
D-3	Supplemental Series Well Locations	55
D-4	Location of Study Plots and Ecologs on Section 2	56

LIST OF APPENDIX E FIGURES

<u>Figure No.</u>		<u>Page</u>
E-1	Burn Schedule 1980-1982	58
E-2	Maximum 1-Hour Average Concentrations at 1 KM For SO ₂	58
E-3	Comparison of 24-Hour Average Concentration For SO ₂ and NO ₂ With PSD Increment and National Ambient Air Quality Standards	59
E-4	Stack Gas Emissions	59

1.0 PURPOSE AND NEED FOR ACTION

The action under investigation is the completion of an experimental program begun in 1974 by Geokinetics, Inc. (GKI) to develop a modified, horizontal, in situ oil shale retorting process. This will be the final step in development of GKI's low front end cost (LOFRECO) process.

GKI began field programs at the present site in 1975. Through the blasting and burning of a series of retorts of increasing size, the technical feasibility of the LOFRECO process has been demonstrated. The purpose of the remainder of the experimental program is to optimize the LOFRECO process to make it economically feasible.

The LOFRECO process was designed to retort relatively thin oil shale beds under shallow overburden. However, the basic horizontal burn being developed can be applied to a number of other situations, such as a modified in situ process in thinner oil shale beds, or as a secondary recovery process to follow a room and pillar mining operation to recover oil from the mine pillars and from oil shales above and below the mine zone.

Upon completion of development, the LOFRECO process will provide a unique means of shale oil recovery. The beneficial characteristics of the process include:

- 1) low front end costs
- 2) enabling oil recovery in oil shale zones where such recovery would otherwise be economically infeasible.
- 3) increased oil recovery efficiency with classical mining techniques.

2.0 PROPOSED ACTION AND ALTERNATIVES

The proposed action is the continuation of GKI's experimental program to develop the LOFRECO process. The field program began in the spring of 1975, with two small retorts blasted in July 1975. The first retort was ignited in March 1976. Since that time, 24 retorts have been blasted and 12 have been burned, and the associated mining camp, Kamp Kerogen, has grown from three tents to a small village. The previous work used smaller retorts to develop the technical feasibility of the LOFRECO process. The remainder of the experimental program will use large retorts and is designed to optimize the process to establish economic feasibility of commercial operation.

The project is located in the northeast quadrant of Utah in Uintah County. It is approximately 70 miles southwest of Vernal and 72 miles southeast of Roosevelt. The project site is located in the northern half of Section 2, Township 14 South, Range 22 East. This section is located in the southern portion of the Uintah Basin. The Uintah Basin of east-central Utah consists primarily of Uintah and Duchesne counties, bordered on the south by the Book Cliff Mountains and on the north by the southern drainage of the Uinta Mountains. Figure 1 shows the general location of Section 2 and Figure 3 shows the general location of the site in the section.

2.1 General Process Description

The LOFRECO process is designed specifically for areas where oil shale beds are relatively thin and close to the surface. In the process, a pattern of blastholes is drilled from the surface, through the overburden, and into the oil shale bed. The holes are loaded with explosives and fired, using a carefully planned blast system. The blast results in a well-fragmented mass of oil shale, with a high permeability. The void space in the fragmented zone occurs as a result of lifting the overburden, and producing a four-to five-foot uplift of the surface. The fragmented zone constitutes an in situ retort. The bottom of the retort is sloped to provide drainage for the oil to a sump where it is lifted to the surface by a number of oil production wells.

Air injection wells are drilled at one end of the retort, and off gas wells are drilled at the other end. The oil shale is ignited at the air injection wells, and air is injected to establish and maintain a burning front that occupies the full thickness of the fragmented zone. The front is moved in a horizontal direction through the fractured shale toward the off gas wells at the end of the retort. The burning front heats the oil shale ahead of it, driving out the oil, which drains to the bottom of the retort. From here it flows along the sloping bottom to the oil production wells. As the burn front moves from the air injection to the off gas wells, it burns the residual coke in the retorted shale as fuel. The process gases are recovered at the off gas wells. This gas is combustible. Progress of the burn front is monitored by thermocouples set in wells. The process is shown schematically in Figure 2.

2.2 Experimental Program

The remainder of the experimental program, which is expected to be complete in mid-1982, includes:

3

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SITE LOCATION

FIGURE 1

PLAN VIEW

SECTION A-A

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SCHEMATIC OF LOFRECO PROCESS

FIGURE 2

TABLE 1
BLASTING AND BURNING SCHEDULE

RETORT DIMENSIONS NO. W x L x OS x OB		18 — 108 x 156 x 18 x 26.5	19 — 126 x 182 x 30 x 50	23 — 50 x 125 x 35 x 36	24 — 217 x 230 x 30 x 45	25 — 217 x 230 x 30 x 45	26 — 217 x 230 x 30 x 55	27 — 217 x 230 x 30 x 30	28 — 217 x 230 x 30 x 45	29 — 217 x 230 x 30 x 60
1980	JANUARY	■■■■■								
	FEBRUARY		■■■■■			■■■■■				
	MARCH	■■■■■	■■■■■	■■■■■		■■■■■				
	APRIL		■■■■■	■■■■■		■■■■■				
	MAY		■■■■■	■■■■■						
	JUNE		■■■■■	■■■■■	■■■■■					
	JULY		■■■■■		■■■■■					
	AUGUST		■■■■■		■■■■■		■■■■■			
	SEPTEMBER				■■■■■		■■■■■			
	OCTOBER				■■■■■					
	NOVEMBER				■■■■■					
	DECEMBER				■■■■■					
1981	JANUARY							■■■■■		
	FEBRUARY							■■■■■		
	MARCH					■■■■■				
	APRIL					■■■■■			■■■■■	■■■■■
	MAY					■■■■■			■■■■■	■■■■■
	JUNE					■■■■■	■■■■■		■■■■■	■■■■■
	JULY					■■■■■	■■■■■			
	AUGUST					■■■■■	■■■■■			
	SEPTEMBER					■■■■■	■■■■■	■■■■■		
	OCTOBER						■■■■■	■■■■■	■■■■■	
	NOVEMBER						■■■■■	■■■■■	■■■■■	■■■■■
	DECEMBER						■■■■■	■■■■■	■■■■■	■■■■■
1982	JANUARY							■■■■■		
	FEBRUARY							■■■■■		
	MARCH							■■■■■		
	APRIL							■■■■■		
	MAY							■■■■■		
	JUNE							■■■■■		
	JULY							■■■■■		
	AUGUST							■■■■■		
	SEPTEMBER							■■■■■		
	OCTOBER							■■■■■		
	NOVEMBER							■■■■■		
	DECEMBER							■■■■■		

LEGEND:

W = Width
L = Length
OS = Oil shale thickness
OB = Overburden thickness

■■■■■ DRILL AND BLAST
■■■■■ BURN

- (1) Reducing the cost of rock fragmentation, the single most significant cost item in the process.
- (2) Improving the recovery of in-place oil. This involves improved blasting techniques to prepare the shale bed for retorting, optimized burning techniques to minimize burn-up and coking of oil in the retort, and better oil lifting techniques. The goal is consistent recovery of 50% or more of the in-place oil.
- (3) Making effective use of the combustible retort off gas to generate electrical power.

2.2.1 Blasting and Burning

There will be attempts to reduce the cost of rock fragmentation (i.e. blasting). This will involve variations in blasting patterns and in blasting charge. There is a potential that these variations in blasting technique may produce less overburden uplift than has occurred in the past.

Burns are ignited through the insertion of lighted charcoal at the air inlets and the subsequent cycling of air through the retort. Table 1 shows the expected duration of the burn at each retort. There will be attempts to optimize oil recovery by varying air flow through the retorts and by recycling gases through the retort; this has the potential of decreasing atmospheric emissions.

Table 1 shows the retort blasting and burning schedule for the remainder of the experimental program. The actual blasting of an individual retort is almost instantaneous. The "Drill and Blast" lines on Table 1 primarily reflect drilling time. Much of this drilling is exploratory, occurring after blasting to determine the success of the detonation activities. The location of the retorts is shown in Figure 3, Site Layout. The precise location of retort numbers 25 through 29 are not yet known; their probable location is indicated.

2.2.2 Liquid Effluents

As indicated in Section 2.1, retorted oil flows down the bottom slope of the retort and is pumped from the end of the retort at production wells. During the retorting process, water is released with the oil, and it is actually a water-oil emulsion which is pumped at these wells. The emulsion is pumped into a 200-barrel holding tank at the retort and eventually to a separation tank where it is allowed to stand until the oil and water separate. The effluent water is drawn off from the separation tank and pumped into a lined evaporation pond. The location of the evaporation pond is shown on Figure 3. The pond has a 9,000 barrel capacity and measures about 130 feet by 90 feet by 5 feet. The bottom and sides of this pond are lined with an impermeable membrane so that the effluent water will not seep into the soil. The membrane is an "R-type 85 black" liner supplied by Griffolyn Division of Reef Industries. It is a 3-ply, high density, rubber modified, nylong cord reinforced, polyethylene film. In November 1979, the pond contained about 2,000 barrels of water. Water addition to the pond averaged 17 barrels per day in 1979 and is expected to increase to 30 barrels per day in 1980. Considering the ambient evaporation rate of about 30 inches annually, the evaporation pond will contain about 7,300 barrels of water by the end of 1980.

SITE LAYOUT

FIGURE 3

Additional containment may be provided by construction of an additional pond on the site. The proposed pond would have a total surface area of 1-1/2 acres with a depth of four feet. The pond would be square with 256 foot sides and a capacity of 46,500 barrels. With the annual evaporation rate approximately 30 inches, this pond would supply all the necessary storage capacity required by the program.

A preferred alternative which is being considered for future operation is deep well disposal (injection) of water. This would eliminate both the potential of contaminating shallow ground water and of contamination spreading into the wildlife food chain if the current pond is expanded or the proposed pond is constructed. Preliminary indications from an ongoing feasibility study are that injection is possible at depths below 4,500 feet. Geophysical logs of exploratory oil wells in the region are being reviewed to identify an appropriate confined zone. Discussions are underway with the State of Utah Division of Oil, Gas and Mining regarding potential disposal zones and permit requirements.

2.2.3 Oil Handling

All oil recovered from the separation tank is pumped into storage tanks. The locations of three existing storage tanks and the separation tank are shown on Figure 3. The capacity of two of the tanks is 400 barrels; the capacity of the third tank is 3,000 barrels. The capacity of the separation tank is 400 barrels. Dikes have been built around two of the three storage tanks as a precaution against oil and effluent water spills. The berm for the 3,000 barrel tank is still under construction. Oil is transported through a completely enclosed system of piping and process equipment and stored in standard petroleum storage tanks. Oil is removed from the site by tank truck and transported to refineries for processing.

2.2.4 Atmospheric Effluents

Gas removed from the retort off gas wells, or process gas, is conducted into a system of filters and demisters which remove the bulk of the entrained oil mist and water vapor. After demisting, the oil and water are routed to the separation tank and the gas enters a gas incinerator to oxidize the burnable constituents of the process gas. The gases are then vented to the atmosphere via the gas incinerator stack.

A conservatively high estimate of SO₂ emissions is presented in Section 4.4.3. These estimates were derived, assuming the burning schedule presented in Table 1 and 50% recovery of oil in place. This estimate is high because some of the burning process alternatives to be tested will decrease atmospheric emissions. Precise estimates of decreases in emissions are not available.

In one of the process alternatives, retort off gas will enter an afterburner for combustion. A percentage of the combustion gases is cooled and recycled through the retort to control oxygen availability at the burn zone. The remaining gases are released to the atmosphere at a stack on the afterburner. This alternative may reduce overall atmospheric emissions. Also, atmospheric emissions may be reduced by reduction of air flow in retorts to optimize oil recovery.

In addition to these process variations, there will be other opportunities to decrease emissions during the remainder of the experimental program. EPA is conducting research in gas emissions control technologies, some of which could be tested at Kamp Kerogen. Research is also being conducted in the on-site use of process gases, and some of the alternatives available may be tested at the site. One of these uses could be the generation of electricity with a low Btu turbine.

In addition to the above stack emissions, some process gas may be lost to the atmosphere directly as fugitive emissions through fractures in retort overburden and around thermocouple wells.

Because of such uncertainties, precise quantities of atmospheric effluents are impossible to predict.

2.2.5 Personnel Requirements

Currently, a field staff of 31 is conducting the experimental program. This includes 21 wage-level personnel and 10 professionals. Responsibilities are as follows:

- 14 Roustabouts
- 4 Retort Engineers
- 3 General Labor
- 2 Lab Technicians
- 1 Carpenter
- 1 Electrician
- 1 Chemist
- 1 Environmental Engineer
- 1 Geologist
- 1 Meteorologist
- 1 Secretary
- 1 Manager

The Vernal office staff consists of two secretaries, one purchasing agent, and one draftsman. No significant change in the labor force is expected during the remainder of the experimental program.

2.3 Services Description

Because of the remoteness of the project site, some facilities must be provided for the labor force. Since the camp, referred to as Kamp Kerogen, causes an impact on the surrounding environment, and since GKI plans to expand it and continue its development, the camp is evaluated herein as part of the proposed action.

2.3.1 Kamp Kerogen

GKI maintains a mining camp of trailers with full utilities for its employees and their families. The camp is built to State of Utah mining camp standards (DOE, April 1979). The closest community is Vernal, approximately 70 miles, or two hours travel time from the camp. The last 40 miles of the road into Kamp Kerogen are unpaved and difficult to travel in winter and spring. Figures 1 and 3 show the location of the camp, and Figure 4 shows the camp layout.

RETORT BLASTED & BURNED
RETORT BLASTED

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KAMP KEROGEN LAYOUT

FIGURE 4

The camp population is presently 47 persons, including 10 wives and 7 children. The population will vary somewhat during the year as various contractors working at the site stay there.

GKI provides an indoor recreation facility at the project site. It is used as a camp meeting hall as well. Pool (billiards), T.V., board games and ping-pong are available activities. Company parties are sponsored periodically, as are other group activities (GKI, December 1979). Two shop and warehouse facilities are provided for maintenance of vehicles and equipment. As shown on Figure 3, one shop facility is somewhat removed from the main camp.

The camp is currently at capacity. A 20-trailer expansion is anticipated in 1980 to accommodate transient contractors and possibly a limited number of new project personnel. The location of this new facility has not yet been determined.

2.3.2 Solid Waste Disposal

Solid wastes are disposed of at a sanitary landfill in accordance with the State of Utah Department of Social Services, Division of Health; Code of Solid Waste Disposal (DOE, April 1979). The waste consists of normal household trash, packing materials and waste lumber. As shown on Figure 3, the landfill is about one-quarter mile west of the house trailers.

2.3.3 Power Supply

Electrical power for both Kamp Kerogen and the retorting process is generated with diesel generators. There are presently four generators on-site with capacities of 75 KW, 100 KW, 150 KW, and 200 KW. The 200 KW diesel is operated routinely with the 150 KW diesel available as back-up. The other two are utilized infrequently.

It is expected that a 500 KW diesel generator will be installed in 1980 for routine operation and that the 200 KW diesel will then be maintained as a standby. The others will be available if needed.

2.3.4 Water Supply

Potable and service water are provided from a 1,300 foot deep well. Normal pumping at the well is about 150 barrels per day. An additional water well is planned for 1980.

2.3.5 Sanitary System

Sewage from Kamp Kerogen is collected in an underground collection system for delivery to a 6,000-gallon septic tank and then a leach field. It consists of a 150-foot by 75-foot grid of drainage tile. There are also two leach fields associated with the machine shop facility which is remote from the camp. There is a system for wash water which includes two oil and grease traps, two 1,000 gallon septic tanks in series, and a leach field which is a 60-foot by 120-foot grid of drainage tile. For sanitary wastes associated with the shop, there is a 3,000 gallon septic tank and a leach field which consists of a 100-foot, by 100-foot grid of drainage tile. Each leach field is buried to a depth of three feet in existing topsoil. The locations of the existing fields are shown on Figure 5.

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LEACH FIELD LOCATIONS

FIGURE 5

2.3.6 Communication

A three-channel radio telephone is provided for camp residents' use as well as for routine operation and emergencies. It is available 24 hours a day.

2.3.7 Transportation

Transportation to and from Vernal is provided frequently, normally as a part of operational requirements. Daily transportation is commonly available. Company vehicles are provided to crew family members for shopping in Vernal.

2.3.8 Fuel Requirements

Gasoline is provided for vehicles at the camp. Approximately 2,000 gallons are consumed per month. However, the greatest fuel requirement is for the diesel generators, which consume about 280 gallons of diesel fuel per day. Natural gas is utilized for heating and cooking at the camp. Monthly usage is expected to be about 500 cubic feet in milder months, and 1,000 cubic feet in the colder months.

2.4 Alternatives

Potential alternatives to the remaining experimental program include:

- (1) Cancelling the program
- (2) Alternative forms of mining and retorting
- (3) Conducting the program at another site
- (4) Modifying some of the steps in the program

Cancelling the program would stop development of a technically feasible oil-producing technology that shows indications of being cost- and energy-efficient. This alternative would eliminate potential impacts described in this document. The purpose of the research program is to advance the Geokinetics process toward commercialization by studying process, economics and environmental aspects of the process. Geokinetics is advancing fracturing and retorting technology. However, it will be some time before they will be able to commercialize their process. Retorting of large retorts has not been demonstrated. Water and gas treatment technology have not been developed or demonstrated for the Geokinetics process. Systems for utilization of off gases have not been tried. Pipelines to markets do not exist. Markets for shale oil do not exist. Few refiners in the region are able to hydro-treat shale oil for blending with conventional crude. While the proposed action provides process environment, and economic information which can eventually be used to design a total system, the DOE action will not provide the stimulus for construction and operation of a full-scale-shale oil-production project. The impacts associated with the proposed action, which is the remainder of the research program, are not significant enough to make the no action alternative desirable relative to the need for development of new sources of oil.

Alternative forms of mining, strip mining or underground (in areas of thicker overburden), with surface retorting, would be process alternatives to the proposed action. Benefits of these alternatives would include confinement of spent shale to management areas where systems could be engineered to prevent contamination of surface and ground water. Also fewer surface effects would

occur from underground mining, i.e., to vegetation, surface water, archaeology, aesthetics. Primary disadvantages of this alternative, however, would be its substantial costs and increased atmospheric effects.

Conducting the program at another site is not considered a realistic alternative because of the costs involved in relocating facilities and collecting data. Also, there would be difficulty in locating another site with the environmental characteristics of the currently utilized Section 2. These characteristics include:

- (1) Remoteness--there are few people to be affected by noise, atmospheric or liquid effluents, resource requirements of the operating personnel;
- (2) Topographic desirability--the site is located on a rise; consequently, there is little runoff and no potential for flooding at the site.
- (3) Minimal ground water contamination potential--there is substantial distance and a series of aquitards to impede contaminant migration. Also, there is limited recharge to promote ground water movement.
- (4) Lack of variability--the area is not unique and is sparse in vegetation, wildlife, and archaeological resources;
- (5) Good air quality and dispersion characteristics.

In light of the previously discussed characteristics of the various alternatives, and for the reasons listed below, the proposed action will be the subject of the remainder of this Environmental Analysis:

- (1) the low costs of the LOFRECO process;
- (2) the accessibility provided by the process to otherwise uneconomic shale beds;
- (3) the increased oil recovery when this process is used with classical mining methods;
- (4) the previous success in process development, and
- (5) the relatively minor environmental impacts presented in Section 4.0.

2.5 Alternatives Not Considered

Certain energy alternatives are not addressed herein, because the scope of this document is to consider alternative methods of processing oil shale. DOE's programmatic Environmental Impact Statement will address alternative energy sources such as geothermal, wind, solar and nuclear energy.

3.0 AFFECTED ENVIRONMENT

3.1 Geology

3.1.1 Soils

The soils are all relatively deep, well drained, and porous. Water has a tendency to soak into the soil rather than run off. Experience at the project site has indicated that erosion is not a problem. That which does occur is along roads and sites that have been compacted for retort activities (GKI, December 1979a). Figure 6 is a soils map of Section 2. General soil descriptions are provided in Appendix A.

3.1.2 Hydrogeology

The geology of Section 2 is dominated by two outcropping members of the Green River Formation; the Parachute Creek Member, and below it, the Douglas Creek Member. Figure 7 presents a general columnar section of the Green River Formation at the project site.

The Parachute Creek Member, which comprises the overburden of the Mahogany Zone, consists of sediments deposited in a lacustrine (low energy) environment. It is composed of marlstone, oil shale, silt-stone, and tuff, with some sandstone beds.

The Mahogany Zone is a relatively impermeable bed which is approximately 30 feet thick in the vicinity of Section 2. This bed is gray to very dark brown, has a relatively low specific gravity and is very resistant to weathering.

The Douglas Creek Member represents sediments deposited in a higher energy environment and is composed of sandstone, siltstone, and shale. The thickness and frequency of the sandstone beds increases downward in the section, with the principal aquifers probably in the lowest portion of the member.

A summary assessment of the stratigraphy and lithology of the project site, made from data obtained by coring, supported an assumption that any aquifer capable of yielding sufficient quantities of water suitable for human use or consumption would be located at such a depth that any communication from surface or near-surface water-bearing zones is improbable.

This assumption was supported by the drilling of a well to supply water to the field camp. The well was drilled to a depth of approximately 1,300 feet in March 1978. Coring also established that no significant water-bearing formations below the Mahogany Zone existed within 300 feet of the surface on or proximate to the project site (Hutchinson, May 1979).

3.2 Hydrology

3.2.1 Surface Water

From existing literature, those factors governing the hydrologic framework of the region are only generally known, but those which are known are typical of a high desert biome. Annual net evaporation is approximately 24 to 30 inches per year. Total annual precipitation is about 8 to 12 inches. The winters

SECTION 2. T14S, R22E, UTAH COUNTY, UTAH

- LR GRAVELLY LOAM
- JR LOAM ● TEST PIT
- HAVRE SILT LOAM
- LUHON LOAM
- ROCK OUTCROP

0 500' 1000'
SCALE

SOILS MAP

FIGURE 6

GENERALIZED COLUMNAR SECTION OF THE GREEN RIVER FORMATION IN NAVAL OIL-SHALE RESERVE NO. 2, UINTAH AND CARBON COUNTIES, UTAH

FIGURE 7

are dry and cold with some snow, the summers are hot and dry with intermittent thundershower activity, and the vegetation is predominantly pinyon pine, juniper and sagebrush (GKI, December 1979).

There are no streams or ponds on the project site. The potential for flooding is nil, given existing soil characteristics, precipitation pattern, and the site location along a topographic rise. Surface drainage is intermittent and present only as snowmelt or runoff from rainstorms (GKI, December 1979). Most snowmelt in the area has been observed to sink into the soil, with runoff observed only on compacted surfaces such as roads. The drainage of the site is to the southeast to an ephemeral stream in Indian Ridge Canyon which is shown on Figure 8 (DOE, April 1979). This canyon drains to the northeast and is tributary to Sweetwater Canyon, about four miles northeast of Kamp Kerogen. The stream in Sweetwater Canyon is the nearest perennial stream to the site.

3.2.2. Ground Water

3.2.2.1 Aquifer Description

Water is present in the Green River Formation immediately below the surface of the project site, but it has been found to be of poor quality. The water appears to be perched on the Mahogany Zone with some movement along fractures in the rock.

The deep aquifer at about 1,300 feet from the surface is noted throughout the entire region in the Wasatch formation which underlies the Green River Formation. The water is of good quality and contains the only potable water found to date on the research site (GKI, December 1979). The Wasatch Formation is composed of shales, tight siltstones, and lenticular sandstones.

The Mesaverde Formation is approximately 2800 feet below the surface and consists of alternating layers of sandstones and shales. The formation is non-productive of oil and gas in this area of the Uinta Basin. Estimated salinities of the formation fluids in the upper 1,950 feet increase downward from 2,000 ppm to approximately 12,000 ppm with a maximum of 23,000 ppm at 110°F. The weighted average of the salinities in the lower 1,500 feet of this formation is 12,500 ppm @110°F. Salinities vary greatly from one sandstone to the next, indicating isolation of individual formation fluids.

The Buck Tongue Member of the Mancos Formation underlies the Mesaverde Formation. The member is approximately 200 feet thick and consists of a black, dense marine shale. The Buck Tongue Member is highly consolidated and will act as a barrier to the injected water and prevent contact with lower formations.

A casing and cementing program has been designed to protect the entire Green River and Wasatch Formations and the upper 450 feet of the Mesaverde Formation from contamination by injected fluids. A dense and impermeable shale layer in the Mesaverde Formation will prevent any contact with the upper formations.

3.2.2.2 Ground Water Testing

Three well level studies were conducted during 1978 and 1979 to determine the following:

0 500' 1000' 2000'
SCALE

SECTION 2 TOPOGRAPHY

FIGURE 8

GEOKINETICS, INC.

KG

1. Amount and level of water above and below the Mahogany Zone.
2. Water movement above and below the Mahogany Zone.
3. Amount of hydraulic communication through the Mahogany Zone.

Thirty-three wells, comprising Series 1 of the hydrologic monitoring wells, were completed in January 1978. Thirteen Series 2 wells were established in June of that year. Water levels were monitored in Series 1 wells for about one year; Series 2 wells were monitored for about one-half year.

In addition to the well level monitoring of the Series 1 and Series 2 wells, a Supplemental Series of wells consisting of 14 previously drilled core holes scattered about the section were also monitored from June 17, 1978 until December 26, 1978.

The Series 1 wells were distributed among various in-situ retorts. All retorts had been blasted previously, and a few had already been developed and operated. Of the 33 wells, 20 were designed to monitor perched waters above the Mahogany Zone; 13 wells were intended to provide monitoring access to the waters below the Mahogany Zone.

Series 2 wells are all above the Mahogany Zone, and the supplemental series wells all extend below the Mahogany Zone. Figures D-1, D-2 and D-3 show the locations of the Series 1 wells, Series 2 wells, and Supplemental Series wells respectively.

The Series 1 shallow wells and the Series 2 wells show that there is significant contribution to some wells from spring runoff. Some wells showed absolutely no variability to seasonal influences. From a statistical standpoint, it was concluded that, although a few of the wells displayed significant variability to seasonal perturbations, the water table above the Mahogany Zone does not significantly change from one season to another.

The deep wells of Series 1 suggested that there is vertical communication through the Mahogany Zone underneath the retorts in the vicinity of Series 1. It has not yet been determined if this is due to blast related fracturing of the Mahogany Zone or if the communication was caused by malfunctioning casings and/or packings.

The Series 2 wells suggested that there is perched water above the Mahogany Zone, flowing in cracks and fissures, but not communicating freely either horizontally or vertically. Neither the Series 1 shallow wells nor the Series 2 wells provided an estimate as to how much ground water is perched above the Mahogany Zone or if the water flows at all. The investigation did not include any pump tests or recharge investigations.

The Supplemental Well Series suggested that there is very little horizontal communication of waters throughout the entire section below the Mahogany Zone because the heads of many of the wells are above surface elevations of other wells a relatively short distance away. This is reinforced by the amount of water found in the various wells and the lack of water outcropping on the surface at any one moment (Spradlin, June 1979).

GKI plans to continue work to develop an understanding of the geological structures underlying the test site. Items of particular interest will be

aquaculdes and wet and dry aquifers with respect to their porosities, water content, structure and relationships to each other. It is expected that core drilling, gamma logging, remote sensing, and field mapping will be the tools of choice. A second avenue of investigation will be to determine the hydrologic flow patterns on the project site prior to and after retorting. Well level monitoring plus chemical and isotopic tracing are the research tools most likely to provide the information needed (GKI, December 1979). The information obtained by this monitoring program will be used as a basis of continuing evaluation of the project's impacts, and, if necessary, mitigation of adverse impacts.

3.2.2.3 Water Use

The only known ground water use in the area is the Kamp Kerogen water supply well which extends to the deep aquifer at about 1,300 feet.

3.2.3 Water Quality

Eight water samples were taken from wells above the Mahogany Zone and sufficiently removed from any retort so as to be representative of natural conditions. Ground water samples were collected at irregular intervals in 1978 and 1979: one on January 24, 1978; another on May 3, 1978; two on July 31, 1978; and four on February 12, 1979. Three of the samples were taken from ERDA/DOE Core Hole #5, which was drilled to a depth of approximately 138 feet. The other five samples were taken from different wells of the GKI Series 2 hydrologic study wells discussed in Section 3.2.2.2.

Table C-1 shows the data collected and demonstrates the generally poor quality of the perched water, which has a total dissolved solids content of about 38,000 mg/l and a pH of 9.3. The mean concentration of chloride is 2,223 mg/l; sulfate, 11,143 mg/l; sodium, 10,455 mg/l; and COD, 6,090 mg/l.

3.3 Biology

3.3.1 Vegetation

Botanical studies made to date on Section 2 indicate that there are four major vegetation types on the site: 1) south-facing pinyon juniper, 2) north-facing pinyon-juniper, 3) sagebrush-slatbrush bottomland, and 4) sagebrush-grass upland (DOE, April 1979). Appendix B includes a description of habitat types observed on Section 2. A list of plant species occurring on Section 2 is on Table C-2, and a list of rare, endangered, threatened, restricted and endemic species which occur in habitats similar to the GKI site is shown on Table C-3. Figure 3 presents a vegetation map of Section 2. No rare, threatened, or endangered species have been found in the northern portion of Section 2 where the project is occurring.

None of the species listed on Table C-3 was observed during a field survey conducted by a professional biologist. One of the species on Table C3, Townsendia mensana, is possibly threatened. However, none has been observed in the northern portion of Section 2 which is affected by project activities. Because the species is more easily identified during spring flowering, a GKI employee will conduct a search for the plant during the spring of 1980.

Legend:

pinyon-juniper woodland (N-facing) (*Pinus edulis-Juniperus osteosperma*)

pinyon-juniper woodland (S-facing) (*Pinus edulis-Juniperus osteosperma*)

sagebrush-saltbush lowland (*Artemisia tridentata-Atriplex canescens*)

sagebrush-grass upland (*Artemisia tridentata-Bouteloua gracilis*)

CONTOUR INTERVAL: 5'

TOPOGRAPHIC BASE: BELL MAPPING CO., NOVEMBER 1976

DATE: February, 1978

FIGURE 9 VEGETATION MAP

ERIK R. OLGEIRSON, PhD ECOLOGIST CONIFER, COLORADO

A two-year baseline program on vegetation in Section 2 which began in 1978 is continuing (GKI, December 1979). This study will:

1. Determine the types, location and relative abundance of vegetation;
2. Develop an estimate of annual plant productivity on the project site;
3. Continue to monitor for the presence of any rare, endangered or threatened species of plants on the project site, and
4. Determine whether populations of important plant species are endangered by GKI activities at the project site.

Eight vegetation sites have been established to study herbaceous productivity in each vegetation type. These are shown on Figure D-4.

3.3.2 Wildlife

The local fauna include several species of birds, reptiles, small mammals and large game mammals. Songbirds, crows, hawks, sage grouse, doves, lizards, rattlesnakes, deer-mice, rabbits, moles, ground squirrels, bobcat, coyote, bear, mule deer and elk have been sighted in the area. None of the species sighted is on the threatened or endangered species list. The project site is in an area commonly used by big game for winter range. However, Section 2 itself is not an important component of this winter range (DOE, April 1979).

3.4 Meteorology/Air Quality

3.4.1 Meteorological Characteristics

The prevailing winds are predominantly from the southeast, with the average wind speed of seven miles per hour during the winter months. In contrast, the spring prevailing winds are predominantly from the southwest, with the average wind speed increasing to 17 miles per hour.

Annual precipitation is about 8 to 12 inches, and annual evaporation is 24 to 30 inches.

GKI has an ongoing site specific meteorological data collection program which began in 1978. The meteorological parameters listed in Table 2 will be monitored on a continuous basis during the remaining experimental program (GKI, December 1979). Figure 10 shows the locations of meteorological stations. A description of each station is provided in Table C-4.

3.4.2 Ambient Air Quality

The only ambient air quality monitoring to date has involved establishing a photographic record to determine baseline visibility characteristics. However, based on regional data, the air quality is good, with zero to 20 days of high pollution forecast annually (DOE, April 1979). The area is currently classified by the EPA and the State of Utah as a Class II air quality region, i.e. having air quality better than national standards for all pollutants. The project site is at 6,700 feet in elevation and, therefore, qualifies for

TABLE 2
METEOROLOGICAL PARAMETERS TO BE MONITORED

<u>Parameter</u>	<u>Units</u>
Air temperature at 100 feet	degrees Farenheit
Air temperature at 30 feet	degrees Farenheit
Air temperature at 10 feet	degrees Farenheit
Soil temperature at surface	degrees Farenheit
Relative humidity	percent
Barometric pressure	inches of mercury
Wind velocity at 30 feet	miles per hour
Wind velocity at 100 feet	miles per hour
Total wind travel	miles per day
Wind direction at 30 feet	degrees azimuth
Wind direction at 100 feet	degrees azimuth
Precipitation at surface	inches
Evaporation at surface	gallons per square foot
Solar radiation at 100 feet	calories per in ² per minute
Solar radiation at surface	calories per in ² per minute
Sunshine duration	hours per day

GECKINETICS INC.

8

METEOROLOGICAL MONITORING STATIONS

FIGURE 10

categorization as part of the Utah State Air Quality Area (AQA) number 3, mountains and valleys above 6,500 feet (DOE, April 1979).

Ambient air quality investigations will be undertaken in 1980. The baseline investigations will consist of periodic sampling of the air for constituent analysis and evaluating the ambient air scattering coefficient.

The monitoring program will initially consist of periodic sampling and analysis of ambient air which will become more frequent as the amounts of pollutants released approach the maximum yearly tonnages defined by federal and state air quality regulations. In general, the findings obtained from stack gas analyses will be used to determine the constituents to be monitored and the frequency of sampling for the ambient air monitoring program. The parameters which are presently envisioned for ambient air quality analysis are listed in Table 3.

3.5 Noise

The GKI project site is located in a remote area of the state and is infrequently visited by anyone not associated with the GKI oil shale project. In the absence of human activity, natural sound levels are very low, consisting primarily of wind, birds and other animals which traverse the area.

3.6 Socioeconomic Characteristics

Socioeconomic information has been collected on the Uintah Basin because GKI maintains an office in Vernal, and does most hiring and purchasing through Basin sources (Hutchinson, 1979).

3.6.1 Population

In 1978, the population of Uintah and Duchesne counties was nearly 30,000 (Hutchinson, June 1979). Vernal, in Uintah County, and Roosevelt, in Duchesne County, together represent about 12,000 people (DOE, April 1979).

The community nearest to the project site is Vernal, which is the county seat of Uintah County, and is located about 70 miles north of the project site. Vernal experienced a population increase in the 1960s, after which the population stabilized at about 3,000 to 4,000. The past two or three years has brought another population increase, largely due to petroleum development in the Uintah Basin. The region around the project site is sparsely populated by ranchers who own small tracts of land scattered throughout the area and who lease grazing rights on the surrounding public lands from the Bureau of Land Management and the Utah State Land Board. Petroleum development has caused a small influx of seasonal workers who usually maintain homes in Vernal or Roosevelt and who work on oil rigs throughout the region (DOE, April 1979).

3.6.2 Local Economics

1978 Gross Taxable Sales were estimated to \$167,192 million for the Uintah Basin (Hutchinson, June 1979).

TABLE 3

AMBIENT AIR QUALITY PARAMETERS TO BE MONITORED

Gross Particulates

Common Gases

Ammonia (NH_3)
Carbon Monoxide (CO)
Hydrogen Sulfide (H_2S)
Nitrogen Oxides (NO_x)
Sulfur Dioxide (SO_2)
Sulfur Trioxide (SO_3)

Hydrocarbons

C_1 through C_6

Oxidants (ozone)

3.6.3 Services

The closest retail and grocery stores, gasoline service stations, postal service, organized recreational facilities, schools, health and medical services and fire fighting aid are located in Vernal.

3.6.4 Labor Availability

The local labor market is capable of supplying skilled and unskilled laborers with an orientation toward skills needed in the oil industry and readily applicable to GKI's needs. The local labor pool is not capable of supplying professional personnel on anything but a sporadic basis.

3.6.5 Transportation

The project site is adjacent to a county road that runs south from Ouray. The last 40 miles to the camp are on unpaved road. Two airstrips (which are usable only during the summer) are available within five miles north and south of the site.

3.6.6 Land Use

Cattle grazing is the main land use in the area of the site. Primary uses in the region are agriculture (mainly grazing), oil and gas production, and recreation (mainly hunting) (DOE, April 1979). GKI leases mineral rights on Section 2 from the State of Utah. The land around the Section is controlled by the Bureau of Land Management.

3.6.7 Land Use Plans

The Uintah Basin Association of Governments (UBAG) is the principal planning agency concerned with growth in the Uintah Basin and has established an Energy Planning Office to assist in managing growth and mitigating adverse socio-economic impacts (Hutchinson, June 1979). There is, however, no planned development or specific use of the land in this region by city, state or federal governments (DOE, April 1979).

3.7 Aesthetics

The area in which the proposed project is located is a high desert biome characterized by rolling hills, bench land topography and predominantly low-lying and sparse vegetation. The result of these geologic and biologic characteristics is a landscape which provides expansive vistas in all directions. The area receives little use other than grazing, with evidence of human intrusion limited to a county road and the mining camp.

The camp itself consists of a scattering of retort mounds, trailers (or mobile homes), vehicles, equipment, and storage tanks. There is minimal vegetation, due both to natural conditions and the purposeful clearing of the retort areas for ease of access and drilling. The overall impression is that of a pocket of isolated human activity.

3.8 Archaeology/Paleontology

A historical, archaeological and paleontological resource study has been conducted on Section 2. Ten sites of interest were identified during the inventory. One site in the southern portion of the section was considered to be of sufficient significance that it be preserved or salvaged (Martin et al, January 1979).

4.0 ENVIRONMENTAL CONSEQUENCES

4.1 Geology

4.1.1 Soils

As discussed later in Section 4.2.2, there is a potential for change in soil chemistry due to hydrological effects. Tests conducted to date indicate that these effects are insignificant.

4.1.2 Erosion

There is no substantial runoff across the site. The bulk of precipitation is snow which has a tendency to soak into the soils when it melts. Some erosion is expected on roads and other areas where soil is compacted.

As indicated in Section 4.9.4, GKI has a reclamation plan and has received professional site-specific guidance for erosion control (E. R. Olgeirson Associates, 1978).

4.2 Hydrological Impacts

4.2.1 Surface Water Impacts

As indicated in Section 3.2.1, there are no perennial surface water bodies near the site, and there is no substantial surface runoff. Therefore, no significant surface water effects would be expected except possibly through communication with ground water which is discussed in the following sections.

GKI will periodically review changes in drainage patterns due to the project and will continue to pursue potential surface water effects.

4.2.2 Perched Water Impacts

Contamination is possible due to:

- (1) seepage from leach fields
- (2) leakage from the evaporation pond
- (3) ground water seepage through burned retorts

As indicated in Section 2.3.5, the three leach fields are buried in the fairly porous topsoil layer (described in Section 3.1.1) which overlies the siltstone and marlstone over the Mahogany Zone. It is expected that much of the water from the leach fields will be confined to the topsoil by the much less permeable siltstone and marlstone below and eventually be removed through evapotranspiration. Some water might work its way to the perched water through the fracture system. However, the significance of this is not great in light of the static nature of the perched water.

In theory, the evaporation pond could leak. The fate of such a leak would probably be the same as the leach field water. The likelihood of a liner leak is low, however, due to the protected location of the evaporation pond and the fact that it is relatively new (1978). There is a level gauge in the evaporation pond and an evaporation pan nearby. These are monitored by GKI personnel.

Ground water has been experienced in retorts prior to burning, which indicates that ground water can be expected in burned retorts. This water might leach soluble contaminants from the burned materials. The nature of this potential contamination is under study. The significance of this contamination to the overall perched water system is expected to be limited in light of the static nature of the perched water.

Impacts of further contamination of the perched water under the site would be minimal. The water is not used and, as indicated by Section 3.2.3, is of naturally poor quality. Undesirable impacts would result if further contaminated perched water were to migrate to another aquifer or to surface water which is used. As indicated in Section 3.2.2.2, there is evidence to suggest that the perched water simply collects in the fracture system of the zone and that little horizontal communication occurs within the siltstone and marlstone layer over the Mahogany Zone.

However, the Series 1 well monitoring tests discussed in Section 3.2.2.2 showed that retort rubblelization improves horizontal communication. The extent to which this provides for horizontal water movement is uncertain. Because the zone of fracturing appears to be limited to a radius of about 100 yards or less from retort boundaries (DOE, April 1979), horizontal perched water movement should not be significant on a regional basis.

The impact of the upward movement of this potential contamination on vegetation is also a consideration. There is a possibility that contaminated water could be transported upward into the root zone of the vegetal community through thermal effects or capillary action. This could endanger vegetation or introduce undesirable constituents into the food web.

In a study to determine the significance of such an effect, GKI concluded that natural perched water may be more toxic than retort water for some constituents (Hutchison, March 1979). In general, both waters are of poor quality. There are variations in some of the constituents. However, any upward movement of contaminated perched water should not have a substantially different effect than present water. A chemical analysis of soils over the retorts has shown no change in the chemical constituents following the burning of the retorts (Olgeirson, September 1979). The statistical characterizations of perched and retort water are presented in Tables C-1 and C-5, respectively.

During the remaining experimental program, investigations will be conducted to determine the geohydrologic flow patterns on the project site prior to and after retorting. Well level monitoring plus chemical and isotropic tracing are the research tools most likely to provide the information needed.

Perched water and the various retort water process streams will be analyzed to determine their dissolved and suspended constituents. Initially, all samples will be analyzed for an extensive suite of parameters which have been identified as potential trace constituents in retort process water or are basic indicators of water quality. Table 4 lists the parameters which have been considered to be of initial interest.

TABLE 4
WATER QUALITY PARAMETERS
TO BE ANALYZED

<u>Regular or Routine</u>	<u>Quarterly</u>
Alkalinity as CaCO_3	(In addition to all routine parameters examined)
Harness, total	
pH	
Specific conductance	Hydroxide as OH
Temperature	Barium as Ba
Turbidity	Chloride as Cl
	Copper as Cu
Chemical oxygen demand	Iron as Fe
	Manganese as Mn
Carbon, total organic	Nickel as Ni
Dissolved solids, total	
Suspended solids, total	Cyanide as CN
	Phosphate, total, as $\text{PO}_4\text{-P}$
Dissolved solids, volatile	Orthophosphate, as $\text{PO}_4\text{-P}$
Suspended solids, volatile	
	Coliform, total
Ammonia as $\text{NH}_3\text{-N}$	Coliform, fecal
Bicarbonate as HCO_3	
Carbonate as CO_3	Sulfur as S
Nitrate as $\text{NO}_3\text{-N}$	Zinc as Zn
Nitrite as $\text{NO}_2\text{-N}$	
Sulfate as SO_4	Oil and grease
	Phenols
Calcium as Ca	Surfactants
Potassium as K	Carbon, dissolved organic
Silica as SiO_2	
Sodium as Na	Gross alpha
	Gross beta
Arsenic as As	BOD, 5-day
Boron as B	Trace elements
Fluorine as F	
Magnesium as Mg	
Mercury as Hg	
Molybdenum as Mo	
Selenium as Se	

4.2.3 Aquifer Impacts (Retorting)

As indicated in Section 3.2.2.1, the Mahogany Zone is a relatively impermeable barrier. It is expected that this zone provides the boundary for the perched water. It is possible that fracturing of the retorts may establish communication through the Mahogany Zone and allow perched water movement into the Douglas Creek Member. As indicated in Section 3.2.2.2, there is some evidence that this may be the case. However, as Figure 7 shows, the Mahogany Zone is probably underlain by a marlstone which would be relatively impermeable.

The consequences of vertical communication are not clear. Figure 7 shows the Douglas Creek Formation is underlain by alternating series of sandstone and siltstone. The sandstone could contain water or provide an avenue for water transport. In the only deep well prepared by GKI, fresh water was not encountered until 1,300 foot depth.

Because of the relatively small number of retorts to be prepared in the remaining experiments program, and limited recharge to the perched zone, no significant effect on usable water supplies is expected. The information obtained in the monitoring program described in Section 3.2.2.2 will be used by GKI as a continuing evaluation method of the project's impact, if necessary, mitigation of adverse impacts. The potable water supplies are analyzed quarterly for all the contaminants encountered in retort water.

4.2.4 Aquifer Impacts (Deep Well Injection)

An electric log from a well near the location of the proposed injection well shows the average porosity of the sands with an injection zone in the Mesaverde Formation to be approximately 15 percent. The total thickness of the injection sandstone would be about 400 feet. This leads to a calculated value that the migration front of injected effluent water would be 650 feet from the well bore after 20 years of injecting 2,000 barrels per day. Similarly, the migration front would be 1,020 feet from the well bore after 20 years of injecting 5,000 barrels per day. The extent in either case would be small and would not affect existing natural springs in the area or seep from the outcrop in the future. The outcrop of the Mesaverde Formation is updip and approximately 20 miles south of the proposed injection well location.

The average salinity of Mesaverde Formation waters in the injection well interval is well above EPA standards for potable water. No contamination of usable potable formation waters will result. No detrimental effect on known petroleum producing horizons will occur.

Pretreatment of effluent water may be necessary prior to injection to inhibit scale formation, corrosion, and clogging due to bacterial growth. The water will be treated with emulsion breaking chemicals to help remove oil and grease. Formation waters will be sampled prior to injection to determine compatibility with the effluent waters. If necessary, effluent waters will be treated to enhance the compatibility.

4.3 Biological Impacts

4.3.1 Vegetation

Extent of vegetation clearing can be seen on Figure 9. The vegetation loss is not significant in light of the extensiveness of the vegetation types in the region. As indicated in Section 4.9.4, testing is underway to optimize revegetation of cleared areas. An additional two acres of vegetation may be cleared if a new effluent pond is constructed.

4.3.2 Wildlife

Effect on wildlife is not considered significant. Some habitat will be lost; there may be some road kills, and there may be disturbances from people and industrial processes. Dr. Robert E. Stoeker, who conducted wildlife studies for the site, commented that even severe impacts to wildlife and wildlife habitat in all of Section 2 would probably be considered insignificant in a regional context.

4.4 Air Quality Impacts

Ambient air quality concentrations for the major pollutants emitted by the process have been determined and are presented in Appendix E. These concentrations are based on existing and predicted levels and compared with National Ambient Air Quality Standards and Prevention of Significant Deterioration requirements. The potential air quality impacts on the environment are minimal. No Class I or potential Class I area will be affected.

4.4.1 Dust

Only during summer and fall is the local climate sufficiently dry to enable normal project operations to generate dust in significant quantities. It is virtually impossible to generate dust during winter and spring due to the normal snow cover and to the high soil moisture. The major sources of dust on the project site are roads and construction sites due to vehicular and aeolian generation if the surface is not stabilized. Two other sources of dust on a sporadic and transitory basis are retort drilling and retort blasting. The retort set up, burn and shut-in operations generate little dust due to the very light vehicle traffic on retorts during these phases and due to the soil compaction in the course of operations (DOE, April 1979).

Periodic monitoring of fugitive dust and aerosols will be performed using integrating nephelometers and photographic visibility studies. Fugitive dust emissions will be controlled.

4.4.2 Process Gases

Process gas emissions directly to the atmosphere are fugitive losses through fractures in retort overburden or from faulty equipment. Any substantial leaks which occur are readily detectable because of visible condensation of vapors in the atmosphere. Such leaks can be corrected by grouting. Leaks also become evident because of the distinct odor of the gases. The probability of leaks is minimized because a negative pressure is maintained in the retort. Fans at the air-out end of the retort operate at a greater rate than the fans of the air-in end.

Chromatographic analysis of the process gas have been conducted. The constituents occurring in greatest concentration are CO, CO₂, CH₄, N₂, O₂ and H₂. Table C-6 provides the relative concentrations of these constituents. A comprehensive study of fugitive emissions was conducted by Monsanto Research Corporation on Retort 17 for a two-week period during the summer of 1979. These data are not yet available. A slight odor in the vicinity of the retorts indicates that some fugitive emissions may be occurring.

GKI will continue process gas analysis. Routine semimonthly analysis will evaluate the parameters listed in Table 5 and the analysis for nitrosamines and polynuclear aromatics will be conducted by an independent laboratory. Carbon monoxide samples are collected daily, using a hand-held CO detector to monitor for positive emissions. Sampling is done with the sample tube held about three feet above the ground surface.

4.4.3 Stack Gases

Emission rates to date for any one pollutant have neither approached nor exceeded 100 tons per year. The pollutants with significant concentrations appear to be sulfur dioxide, nitrogen oxides, carbon monoxide and hydrocarbons (GKI, December 1979a). Table C-7 presents cumulative emissions information for three quarters of 1979. SO₂ and NO_x emissions are calculated estimates based on assumed total combustion of H₂S_x and NH₃ in the stack eliminator. CO and HC are measured directly.

Preliminary calculations indicate that the SO₂ emissions for the scheduled research activities noted in Table I will exceed 100 tons for 1980. Detailed calculations of these emissions are being prepared. PSD permit applications are being prepared to be submitted to EPA and the State of Utah. Modeling has not yet occurred to predict the impacts on the ambient air quality. The retorting schedule will depend upon receipt of necessary permits and the facility will be operated in conformance with federal and State of Utah regulations. The nearest Class I area is Dinosaur National Monument, about 70 miles to the northeast. Since prevailing winds are out of the southeast during winter months, no impact on the Class I area is expected.

4.5 Noise

The major source of noise at the site is the diesel generators which operate on a 24-hour basis. There are other small equipment and vehicular noises which are considered insignificant. The increased noise levels resulting from project activities are not significant in light of the remoteness of the area and the general low density of wildlife.

Retort blasting will occur twice in 1980 and three times in 1981. Noise produced by this blasting produces an instantaneous, muffled sound. The muffling effect of overburden makes this an insignificant impact.

The ERP indicates that ambient background sound levels will be monitored if necessary. Occasional verification of sound levels will be taken with a precision sound level meter with industry-standard A-weighting and slow ballistic features.

TABLE 5

AIR QUALITY PARAMETERS TO BE MONITORED
IN THE PROCESS GAS STREAM

Temperature

Common Gases

Ammonia (NH_3)
Carbon Dioxide (CO_2)
Carbon Monoxide (CO)
Hydrogen Sulfide (H_2S)
Nitrogen Oxides (NO_x)
Sulfur Dioxide (SO_2)^x

Mercaptans

Elemental Gases

Hydrogen (H_2)
Nitrogen (N_2)
Oxygen (O_2)²

Hydrocarbons

C_1 through C_6

Carbonyl Sulfide (COS)

Organometallics

Trace Elements

4.6 Socioeconomic Impacts

Potential impacts on socioeconomic conditions in the Uintah Basin are limited by the scope of GKI operations. Approximately 30 persons were employed by GKI in 1978, and gross expenditures were less than \$1.5 million. Comparing these figures with Basin population and gross taxable sales figures can give an idea of the relative importance of GKI activities.

In 1978, the population of Uintah and Duchesne Counties was nearly 30,000. GKI employees represented 0.1% of the Basin population. 1978 Gross Taxable Sales were estimated to be \$167,192 million for the Uintah Basin. GKI expenditures were less than 1% of gross taxable sales, even if it is assumed that all expenditures went to Basin businesses.

The proposed project will result in some increase in GKI employment and expenditures, but these increases will have insignificant socioeconomic impacts on local communities. New employees will, as in the past, be hired locally whenever possible and reside at Kamp Kerogen, so that no significant increases in the Basin population will result from GKI experimental activities.

Some employees already own and others will seek to purchase homes in the area. In addition, other taxable property, as well as groceries, personal and household items, will be purchased from local merchants, primarily in Vernal and Roosevelt. The resultant economic impacts will be beneficial.

Several years ago, Utah State University researchers developed a document entitled "Anticipated Socioeconomic Impacts in the Uintah Basin of Utah Resulting from Oil Shale Development in the Area" which provides estimates of population changes and impacts associated with employment growth in Uintah County. Their report indicated that a project increasing basic employment by 400 persons would have minor impacts, but would increase the tax base of the county. Increases in basic employment of up to 3,000 persons would have substantial impact and warrant careful advance planning, but should not present unsolvable problems to the area. Other socioeconomic impact studies have reported favorably on Uintah Basin growth resulting from oil shale development (Hutchinson, June 1979).

It is concluded that GKI operations will have minimal adverse impact upon the Uintah Basin and in fact will probably have a net beneficial impact on the Basin.

4.7 Aesthetic Impacts

Impacts to the aesthetic environment will largely be localized as activities will continue to occur in the vicinity of the established camp. There will be some expansion of camp facilities, with the addition of about 20 trailers and other facilities to accommodate the increased work force. In addition, the proposed five additional retorts will occupy about five acres of land, plus roads and access areas. This land will be cleared of existing vegetation for the duration of the project. Within the site, the land will be altered in configuration by the blasting and will become one-acre mounds rising about five feet above the surface. The producing retorts are significantly warmer than the surrounding ground, so they do not support snow cover. When the camp and surrounding countryside are blanketed in snow, the retorts remain brown and barren.

There will be some impacts outside Kamp Kerogen, due to the increased opportunity for access by persons living and working there. These impacts are likely to include disruption of vegetation and small game habitat due to off-road pedestrian and vehicle use, plus some hunting pressure. In addition, increased traffic between the camp and population centers to the north will somewhat decrease the isolated nature of the camp and its residents.

4.8 Archaeological Impacts

Archeological impacts will be minimal. The one significant find discussed in Section 3.8 will not be affected by the remaining program. Any additional findings will be reported, identified, and if valuable, preserved or protected. GKI will instruct its employees to report such finds to their supervisors. Significant finds will be promptly reported to the parties that conducted the original survey and to the Division of State History. Appropriate measures will be taken to preserve or protect such resources until they can be evaluated by competent authorities.

4.9 Mitigation Measures

4.9.1 Air Quality

Sections 4.4.2 and 4.4.3 describe the fugitive emissions and stack gas monitoring that will be conducted to assure that atmospheric emissions are within established standards during the remaining experimental program.

GKI will investigate process gas leakage daily using carbon monoxide, sulfur dioxide or other appropriate gases as indicators. The investigation will initially consist of monitoring for excessively high concentrations of carbon monoxide as defined by OSHA on and about reports and processing equipment. Carbon monoxide comprised 2% to 10% of the retort off gas and is also the greatest amount of toxic substance per unit volume of gas. It is currently assumed that carbon monoxide will be a limiting indicator of the presence of toxic contaminants. If ongoing analyses show the presence of some of the exotic contaminants, in toxic concentrations, indicator contaminants to be used in routine monitoring will be changed.

It is not yet possible to clearly define the mitigation measures to be taken in light of atmospheric emissions. Research is now underway to develop control equipment for airborne contaminants of concern to the shale oil industry. GKI may experiment with some of these. Also, opportunities may exist to try some on-site uses of off gas. This might include utilization of a gas turbine to produce electricity from the off gas.

4.9.2 Wildlife

The evaporation pond is fenced to prevent wildlife access. Some small species may pass through the fence and contact the effluent water. Waterfowl and other flying species may also access the pond from the air. The proposed new effluent evaporation pond would also be fenced. The impact on wildlife is expected to be minimal.

4.9.3 Archaeology/Paleontology

Appropriate authorities will be informed if project activities uncover possible resources.

4.9.4 Reclamation

GKI has committed to restore the productivity of the project area. As a part of this, there are commitments to additional study of soils, vegetation and climate to enhance the success of revegetation.

The post-operational goal is to return the land to its original level of productivity as soon as possible. This necessitates that roads and construction sites be policed of debris, returned to their original contours and revegetated. After burnout, each retort will be stripped of process equipment and pipes, all holes and vents will be sealed and the surface will be stabilized until temperature monitoring indicates that reseeding may begin. Prior to seeding, the retort slopes will be terraced or built up to 2:1 grades to promote seed retention and minimize erosion (DOE, April 1979).

Guidelines for minimizing environmental surface degradation and achieving rehabilitation of land affected by project operations have been prepared (E. R. Olgeirson Associates 1978). This plan made recommendations for minimizing erosion and other landscape degradation during development. The testing of recommended revegetation procedures began in late 1979 with the planting of two test areas: 1 1/4-acre test area on and around Retort 9 and a 1/2-acre test area on and around Retorts 14 and 15. These test areas will be evaluated in 1980 and thereafter.

If structures are no longer required at the end of the experimental program, GKI will remove all trailers and structures from the site, close the dump, obliterate the evaporation pond and terminate the employment of all employees. All foundations will be broken up and buried. The evaporation pond will be allowed to dry up and the evaporate will be sold as chemical feedstock or disposed of in an environmentally acceptable manner. Most professional employees will be terminated immediately upon completion of the experimental operations, and non-professional employees will be terminated on a gradual basis as environmental reconstitution nears completion.

4.10 Energy Requirements

The annual energy requirements of the proposed project are estimated to be:

2,000 cubic feet of natural gas
24,000 gallons of gasoline
110,000 gallons of diesel fuel

4.11 Irreversible or Irretrievable Commitments of Natural or Depletable Resources

The only irreversible commitment of the proposed project is the energy requirements described above and the oil removed from the Mahogany Zone during experimentation.

4.12 Relationship Between Short Term Use of Man's Environment
and the Maintenance and Enhancement of Long Term Productivity

With successful reclamation, the short term use of Section 2 for development of the LOFRECO process will not impact the long term productivity of the Section as wildlife habitat and grazing land.

5.0 REFERENCES

Geokinetics, Inc. (GKI)

- 1979a Environmental summary report, November 1977-November 1979.
Contained in GKI Environmental Research Plan (December).

1979b Environmental Research Plan for the Geokinetics, Inc. An investigation of the horizontal in situ oil shale retorting process (December).

Hutchinson, David L.

- 1979a GKI water quality studies progress report, in Investigation of the Geokinetics Horizontal In Situ Oil Shale Retorting Process. Quarterly Report, January-February-March 1979 (March).

1979b Socioeconomic impacts of GKI activity, in Investigation of the Geokinetics Horizontal In Situ Oil Shale Retorting Process. Quarterly Report, April-May-June 1979 (June).

Martin, Russell B.

- 1979 LOFRECO 2, Uintah County, Utah Environmental Report. Sociocultural, investigations, historical resource studies, archaeological, paleontological and historical resources inventory (January 9).

E. R. Olgeirson Associated

- 1978 Landscape and Erosion Control Plan.

1979 Soil studies, physical and chemical analysis, native and retort soils (November).

Spradlin, Hilding, K. L.

- 1979a Well level monitoring investigation: in Investigation of the Geokinetics Horizontal In Situ Oil Shale Retorting Process. Quarterly Report, July-August-September 1979 (June).

1979b Meteorological and climatological investigation: review of January-June 1979 investigative period: in Investigation of the Geokinetics Horizontal In Situ Oil Shale Retorting Process. Quarterly Report, July-August-September 1979 (September).

Stoecker, Robert E.

- 1979 Wildlife studies for the Hollberg Oil Shale site, Uintah County, Utah (May).

U.S. Department of Energy

- 1979 Environmental Assessment, Geokinetics, Inc. Oil Shale Research Project, Uintah County, Utah (April).

APPENDIX A

SOIL DESCRIPTIONS

LR Gravelley Loam - This soils series consists of shallow, well-drained soils that formed in residuum from Green River shale. The LR Series occurs on south- and west-facing side slopes and ridges. Normal depth is 10-50 inches.

JR Loam - This mapping unit consists of moderately deep, well-drained soils that formed in residuum on colluvium from Green River shale. The JR series is located on north- and east-facing ridges. The underlying subsoil layer consists of weathered angular shale fragments and is about 40 percent of the soil by volume. This layer is about 12 inches thick. The lowest subsoil layer consists of about 95 percent slightly-weathered, angular shale fragments with some silt loam and is about 24 inches thick. Below this lowest subsoil horizon is hard, unweathered and fractured shale.

Havre Silt Loam - This mapping unit consists of deep, well-drained soils that formed in mixed alluvium. The Havre series occupies nearly level to moderate-sloping stream terraces and flood plains. In a typical profile, the surface layer is grayish brown, strongly calcareous silt loam, about 8 inches thick. The surface layer is typically covered by a layer of sage duff about 1 inch thick. The underlying material is light brownish-gray, strongly calcareous loam to a depth of 60 inches or more.

Luhon Loam - This mapping unit consists of deep, well-drained soils that formed from mixed alluvium and in residuum from Green River shale. Luhon soils occur on gently sloping to gently rolling fans and valley side slopes. In a typical profile, the surface layer is a pale brown, silty clay loam about 9 inches thick. The substratum consists of about 7 inches of very strongly calcareous loam underlain by gravelly loam. (The gravelly loam is about 90 percent soft, weathered shale fragments; about 60 percent of these shale fragments slake when soaked in water.)

Source: Olgeirson, 1979

APPENDIX B

HABITAT TYPES

1) South-facing Pinyon-Juniper Woodlands. Pinyon pine is the predominant tree in these stands, as in all woodland stands sampled. Cover by trees averages 29% of the ground area of this vegetation type in Section 2. Utah juniper makes up a somewhat greater portion of the cover values, even though its densities are less than that of pinyon pine. This factor is accounted for by the tendency of juniper to form multi-boled trunks.

The shrub layer of the south-facing woodlands is dominated by big sagebrush. Other important shrub layer species include saltbush and saplings of pinyon and juniper. The half-shrub snakeweed, also attains high density values in some stands. The shrub understory in both woodland types is poorly developed.

The herb layer of the south-facing stands is better developed than that occurring in the north-facing stands. Neither type has a well developed herbaceous layer, however. The predominant herb is gramma grass, a perennial grass that is well rooted and can evade drought extinction through its perennial habit. Western wheat grass also occurs on these sites, but at low frequencies. The majority of the remaining portions of the herb layer are occupied by annual forbs, such as baby blue eyes and wild parsley.

2) North-Facing Pinyon-Juniper Woodlands. The average tree cover is approximately 34% of this vegetation type in Section 2. The greater portion of the total density is accounted for by pinyon pine, which characteristically predominates in open woodland sites in areas of adequate winter precipitation.

As in the south-facing stands, gramma grass is a common herb. The importance of gramma grass in the north-facing stands is overshadowed, however, by a species of sedge (Carex sp.). The herb layer is little-developed in the north-facing stands, even in comparison with south-facing sites.

3) Sagebrush-Saltbush Bottomlands. Big sagebrush is the dominant shrub in these stands. Total shrub cover in these stands averages approximately 67%.

Although no tree layer is present in the bottomland sagebrush stands, there is a secondary layering effect produced by the shrub species. The tall shrub layer is formed by big sagebrush, rubber rabbitbrush, and saltbush. The low shrub layer is composed of winter fat, pasture sage, and snake weed. The herb layer in these stands is composed chiefly of annual forbs, ragweed, baby blue eyes, tansy mustard, and wild carrot.

4) Sagebrush-Grass Uplands. As in the bottomland sites, the major shrub species in the sagebrush-grass uplands is big sagebrush which accounts for approximately 21% of the density in upland sites.

Source: DOE, 1979

APPENDIX C

TABLE C-1

STATISTICAL CHARACTERIZATION OF PERCHED WATER

BASED ON $n = 11$ UNLESS OTHERWISE NOTED

ALL CONCENTRATIONS EXPRESSED AS mg/l, UNLESS OTHERWISE NOTED

n-Size	Parameter	Mean	Standard Deviation	Variance	High	Low
	Alkalinity as CaCO_3	25,217.5	7,607.81	50,643,943	37,460	16,000
	Hardness as CaCO_3	39.28	10.32	93.17	50	21.8
	pH units	9.33	0.20	0.04	9.67	8.99
	Conductivity $\mu\text{mhos. cm}^{-1}$	36,323.75	6,884.55	41,472,448	44,900	22,400
	COD	6,090.75	5,497.07	26,440,597	16,434	2,016
	Ammonia as $\text{NH}_3\text{-N}$	24.54	13.71	164.36	42.6	3.5
	Bicarbonate as HCO_3	25,961.88	8,968.82	70,384,749	38,180	11,468
	Carbonate as CO_3	2,383.25	2,050.76	3,679,928	4,060	0
	Chloride as Cl	2,223.13	1,450.33	1,840,518	4,800	20
	Cyanide as CN	0.11	0.09	0.008	0.29	0
	Nitrate as $\text{NO}_3\text{-N}$	6.21	6.69	39.17	14.4	0
	Nitrite as $\text{NO}_2\text{-N}$	0.39	0.57	0.29	1.6	0
	Phenol	0.193	0.203	0.036	0.43	0
	Phosphate-total	5.02	3.36	9.91	11.32	1.88
	Phosphate-ortho	2.17	1.52	2.02	4.265	0.05
	Sulfate as SO_4	11,143.88	11,368.43	113,086,058	23,413	92
	Sulfide as S	16.95	21.98	422.87	57.6	1.18
6	Oil & Grease	3.33	2.34	4.56	6.2	0
4	Surfactants as MBAS	4.31	2.93	6.45	6.4	0
	Total Dissolved Solids	37,648.13	16,846.26	248,321,965	64,068	21,200
4	Gross Alpha $\pm 3.5\text{pCi.l}^{-1}$	6.18	1.31	1.29	8.0	5.0
4	Gross Beta $\pm 5.0\text{pCi.l}^{-1}$	17.75	5.68	24.19	24.0	12.0
6	Antimony as Sb	0.24	0.221	0.041	0.6	0.007
	Arsenic as As	0.46	0.40	0.140	0.8	0.040
	Barium as Ba	0.71	0.528	0.244	1.96	0.36
6	Beryllium as Be	0.009	0.005	0.00002	0.014	0
6	Bismuth as Bi	0.30	0.31	0.078	0.7	0.008
4	Bromide as Br	0.152	0.103	0.008	0.25	0.016
4	Boron as B	87.85	174.77	22,907.60	350	0.24
	Cadmium as Cd	0.14	0.36	0.11	1.02	0
	Calcium as Ca	7.11	5.99	31.42	20.0	0
6	Chromium as Cr	0.10	0.12	0.01	0.28	0.02
	Cobalt as Co	0.28	0.35	0.107	1.12	0.01
	Copper as Cu	0.20	0.13	0.015	0.52	0.11
4	Fluoride as F	93.3	19.93	298.01	123	80.8
4	Germanium as Ge	0.009	0.011	0.00008	0.022	0
	Iron as Fe	13.18	19.88	345.98	56	0.73
	Lead as Pb	0.17	0.107	0.01	0.349	0.04
	Lithium as Li	0.24	0.076	0.005	0.35	0.136
	Magnesium as Mg	12.79	14.18	175.91	40	2.05
4	Manganese as Mn	0.383	0.513	0.197	1.15	0.086
4	Mercury as $\text{Hg } \mu\text{g.l}^{-1}$	0.7	1.4	1.47	2.8	0
	Molybdenum as Mo	0.41	0.221	0.041	0.68	0.14
	Nickel as Ni	0.43	0.509	0.227	1.62	0.05
	Potassium as K	53.80	24.63	530.60	88	19.91
	Selenium as Se	0.97	1.38	1.66	4.22	0
4	Silica as SiO_2	28.6	16.58	206.16	46.5	14
4	Silver as Ag	0.041	0.031	0.0007	0.078	0.012
	Sodium as Na	10,455.38	2,877.39	7,294,884	13,803	4,380
4	Strontium as Sr	0.035	0.024	0.0004	0.05	0
4	Tin as Sn	0	0	0	0	0
4	Vanadium as V	0.31	0.1	0.008	0.42	0.18
	Zinc as Zn	0.15	0.133	0.015	0.456	0.043

TABLE C-2

LIST OF PLANT SPECIES OCCURRING ON SECTION 2

SCIENTIFIC NAME	COMMON NAME
<u>Grasses and Forbs</u>	
<u>Agropyron smithii</u>	western wheatgrass
<u>Allium geeyeri</u>	wild onion
<u>Ambrosia artemisifolia</u>	ragweed
<u>Antennaria parvifolia</u>	pussytoes
<u>Arabis divaricarpa</u>	rock-cress
<u>Astaragalus ceramicus</u>	milkvetch
<u>A. kentrophyta</u>	skeleton milkvetch
<u>Bouteloua gracilis</u>	gramma grass
<u>Bromus tectorum</u>	cheatgrass
<u>Carex sp.</u>	sedge
<u>Castilleja chromosa</u>	Indian paintbrush
<u>Chaenactis douglasii</u>	pincushion; false yarrow
<u>Chenopodium album</u>	goosefoot
<u>Collinsia parviflora</u>	baby blue-eyes; blue-eyed Mary
<u>Crepis acuminata</u>	hawks beard
<u>Cryptantha nana</u>	cryptantha
<u>Delphinium nelsonii</u>	larkspur
<u>Descurainia pinnata</u>	tansy mustard
<u>Draba brachycarpa</u>	whitlow wort
<u>Erigeron argentatus</u>	fleabane daisy
<u>Erigeron utahensis</u>	fleabane daisy
<u>Eriogonum caespitosum</u>	eriogonum
<u>Erysimum capitatum</u>	wallflower
<u>Euphorbia robusta</u>	spurge
<u>Haplopappus acaulis</u>	dwarf goldenweed
<u>Hymenoxys acaulis</u>	actinea
<u>Iva xanthifolia</u>	marsh elder
<u>Linum lewisii</u>	false-flax
<u>Lithospermum ruderale</u>	pucoon
<u>Lomatium dissectum</u>	wild carrot
<u>L. grayii</u>	wild parsley
<u>Oenothera caespitosa</u>	evening primrose
<u>Oryzopsis hymenoides</u>	Indian ricegrass
<u>Penstemon sp.</u>	penstemon
<u>Phlox longifolia</u>	long-leaved phlox
<u>Physaria floribunda</u>	bladder-pod
<u>Poa arida</u>	bluegrass
<u>Senecio multilobatus</u>	golden ragwort
<u>salsola iberica</u>	Russian thistle
<u>Sisymbrium altissimum</u>	thimble mustard
<u>Sphaeralcea coccinea</u>	copper mallow
<u>Stipa comata</u>	needle-and-thread grass
<u>Taraxacum officinale</u>	dandelion
<u>Townsendia mensana</u>	easter daisy
<u>Verbascum thapsus</u>	mullien

TABLE C-2 (continued)

SCIENTIFIC NAME	COMMON NAME
<u>Trees, Shrubs, Half-Shrubs, and Succulents</u>	
<u>Artemisia cana</u>	silvery wormwood
<u>Artemisia frigida</u>	pasture sage
<u>Artemisia tridentata</u>	big sagebrush
<u>Atriplex canescens</u>	four-angled saltbrush
<u>Ceratoides lanata</u>	winter fat
<u>Cercocarpus montanus</u>	mountain mahogany
<u>Coryphantha vivipara</u>	mountain ball cactus
<u>Chrysothamnus nauseosus</u>	rubber rabbitbrush
<u>Chrysothamnus viscidiflorus</u>	little rabbitbrush
<u>Ephedra viridis</u>	Mormon tea
<u>Gutierrezia sarothrae</u>	snakeweed
<u>Juniperus osteosperma</u>	Utah juniper
<u>Leptodactylon pungens</u>	prickly gilia
<u>Opuntia polyacantha</u>	prickly pear cactus
<u>Pinus edulis</u>	pinyon pine
<u>Purshia tridentata</u>	antelope bitterbrush
<u>Symphoricarpos oreophilus</u>	snowberry
<u>Yucca sp.</u>	yucca

TABLE C-3

RARE, ENDANGERED, THREATENED, RESTRICTED AND ENDEMIC
PLANT SPECIES KNOWN TO OCCUR IN UINTAH COUNTY, UTAH
IN HABITATS LIKE THOSE ON OR NEAR THE GEOKINETICS SITE

Enceliopsis nutans (COMPOSITAE) -- rare and restricted

Cryptantha barnebyi (BORAGINACEAE) -- rare, endemic, threatened

C. rollinsii -- endemic

Glaucocarpum suffrutescens (CRUCIFERAE) -- endemic, rare, endangered

Astragalus detrialis (LEGUMINOSAE) -- endemic

A. hamiltonii -- endemic, rare, threatened

A. lutosus -- endemic, restricted, endangered

Hermidium alipes (NYCTAGINACEAE) -- endemic, rare, endangered

Gilia Mcvickerae (POLEMONIACEAE) -- endemic, rare, endangered

G. stenothryrsa -- endemic

Phlox grahamii (POLEMONIACEAE) -- endemic, rare, threatened

Erigonium ephedroides (POLYGONACEAE) -- endemic, rare, restricted,
endangered

E. saurinum -- restricted, threatened

Penstemon grahamii (SCHROPHULARIACEAE) -- endemic, rare, restricted
threatened

TABLE C-4
METEOROLOGICAL STATION DESCRIPTION

<u>Station and Parameter</u>	
A-01	Barometric pressure Maximum temperature Minimum temperature
A-02	Evaporation Wind travel, total
A-03	Solar radiation
A-04a	Temperature (100 ft.) Temperature (30 ft.) Temperature (10 ft.) Temperature (0 ft.) Wind speed (30 ft.) Wind direction (30 ft.) Precipitation
A-04b	Relative humidity Temperature Maximum temperature Minimum temperature
A-05	Mercury barometer Microbarograph Psychrometer Maximum temperature Minimum temperature
A-06	Direct sunshine duration
A-07	Wind speed (30 ft.) Wind direction (30 ft.) Temperature (30 ft.)

TABLE C-5

STATISTICAL CHARACTERIZATION OF RETORT WATER

BASED ON n = 11 UNLESS OTHERWISE NOTED

ALL CONCENTRATIONS EXPRESSED AS mg/l, UNLESS OTHERWISE NOTED

n-Size	Parameter	Mean	Standard Deviation	Variance	High	Low
	Alkalinity as CaCO ₃	17,836.36	4,373.39	17,387,768	30,300	15,000
	Hardness as CaCO ₃	153.72	85.75	6,684.20	303	28
	pH units	8.56	0.34	0.10	9.08	8.14
	Conductivity μ mhos. cm^{-1}	34,035.91	10,968.05	109,362,003	64,800	24,600
	COD	3,682.36	650.57	384,764	4,420	2,000
	Ammonia as NH ₃ -N	1,270.68	779.52	552,415	2,400	65.2
	Bicarbonate as HCO ₃	17,174.91	7,152.98	46,513,803	36,996	11,346
	Carbonate as CO ₃	2,825.45	1,567.70	2,234,261	4,560	0
	Chloride as Cl	3,016.36	4,292.25	16,748,550	15,000	800
	Cyanide as CN	13.31	9.55	82.89	25.3	0.94
	Nitrate as NO ₃ -N	34.16	28.15	720.25	76	2.5
	Nitrite as NO ₂ -N	1.33	1.13	1.17	3.6	0.18
	Phenol	11.56	11.84	127.50	26.48	0.10
	Phosphate-total	2.1	1.22	1.34	3.82	0.50
	Phosphate-ortho	1.07	0.80	0.58	2.26	0.02
	Sulfate as SO ₄	609.09	361.71	118,942	1,020	184
	Sulfide as S	447.36	280.72	71,641.55	816	34.8
	Oil & Grease	103	202.00	37,095.68	697.8	7.9
	Surfactants as MBAS	23.20	34.39	1,075.35	110	0
	Total Dissolved Solids	22,144.64	7,133.03	46,254,620	23,500	16,052
	Gross Alpha $\pm 3.5\text{pCi.l}^{-1}$	8.29	4.21	16.13	14	3.8
	Gross Beta $\pm 5.0\text{pCi.l}^{-1}$	26.45	6.74	41.34	38	21
5	Antimony as Sb	0.011	0.003	0.000006	0.015	0.008
	Arsenic as As	2.55	3.92	13.96	13.485	0.21
	Barium as Ba	0.54	0.18	0.03	0.82	0.30
5	Beryllium as Be	0.009	0.006	0.00003	0.016	0
5	Bismuth as Bi	0.059	0.017	0.0002	0.088	0.046
	Bromide as Br	0.18	0.10	0.01	0.4	0.1
	Boron as B	60.55	67.63	4,157.52	175	0.51
	Cadmium as Cd	0.084	0.088	0.007	0.2	0.001
	Calcium as Ca	32.58	33.25	1,005.19	101.7	0.12
5	Chromium as Cr	0.078	0.039	0.001	0.144	0.046
	Cobalt as Co	0.56	0.30	0.08	1.272	0.246
	Copper as Cu	0.209	0.167	0.025	0.504	0.026
	Fluoride as F	35.15	6.47	38.10	44.3	25.0
	Germanium as Ge	0.044	0.096	0.008	0.28	0
	Iron as Fe	13.99	25.46	589.10	88.20	1.54
	Lead as Pb	0.642	0.924	0.776	2.24	0.015
	Lithium as Li	0.179	0.117	0.012	0.378	0.070
	Magnesium as Mg	17.49	7.75	54.56	26.4	6.86
	Manganese as Mn	0.937	1.876	3.20	4.74	0.038
	Mercury as Hg $\mu\text{g.l}^{-1}$	3.78	11.35	117.18	38	0
	Molybdenum as Mo	11.91	8.74	69.49	24.4	2.05
	Nickel as Ni	1.62	2.06	3.85	5.21	0.067
	Potassium as K	121.43	21.16	407.10	147.8	99.2
	Selenium as Se	0.215	0.470	0.20	1.238	0
	Silica as SiO ₂	17.95	4.15	15.65	25	13.5
	Silver as Ag	0.135	0.123	0.014	0.316	0.004
	Sodium as Na	9,392	2,951.0	7,916,720	17,800	7,281
	Strontium as Sr	0.002	0.003	0.000008	0.007	0
	Tin as Sn	0.168	0.454	0.187	1.5	0
	Vanadium as V	0.43	0.25	0.056	0.82	0.12
	Zinc as Zn	0.095	0.067	0.004	0.242	0.03

TABLE C-6

RETORT #16 GAS COMPOSITION FOR SEPTEMBER, 1978

The following table shows the major constituents (1% of the retort off gas from retort #16. The figures are derived from chromatographic analysis of retort gas samples taken from September 1, 1978 to September 30, 1978. This period was selected as typical of a normal retort burn after ignition and prior to burn-out and shut-down.

Gas	High Mole %	Low Mole %	Mean Mole %
Hydrogen	6.023	1.481	4.347
Oxygen	11.158	2.647	5.120
Nitrogen	70.470	61.870	62.129
Methane	3.733	1.674	2.466
Carbon Monoxide	6.240	2.575	4.840
Carbon Dioxide	20.948	11.202	15.949

The following gases are also commonly found in the process gas in quantities of less than 1% of total off gas: Propane, propylene, isobutane, n-butane, 1-butane, isobutylene, trans-2-butane, 1:3 butadioene, isopentane, n-pentane, ethylene, ethane, 1-pentene and 2-methylbutene. The few wet chemical analyses done on the gas to date indicate that hydrogen sulfide constitutes about 0.2% of the process gas.

Source: DOE, April 1979

SECTION 2, T14S, R22E, UINTAH COUNTY, UTAH

GEOKINETICS, INC.

LOCATION OF STUDY PLOTS AND ECOLOGS ON SECTION 2

FIGURE D-1

KG

FIGURE D-2

SECTION 2, T14S, R22E, UINTAH COUNTY, UTAH

• HYDROLOGICAL STUDY
WELL

GEOKINETICS, INC.

KG

SERIES 2 WELL LOCATIONS

FIGURE D-3

0 500' 1000'
SCALE

SUPPLEMENT SERIES WELL LOCATIONS

FIGURE D-4

GEOKINETICS INC.

KG

APPENDIX E

IMPACT ANALYSIS

E.1 Air Quality Impacts

The air quality impacts were determined using the PTMTP model with the following input parameters:

Emissions Strengths: $\text{SO}_2 = 37.53 \text{ g/sec.}$

$\text{NO}_2 = 12.51 \text{ g/sec.}$

Stack Height: 9.15 m

Stack Gas Exit Temperature: 970°K

Wind Speed = 2.7 m/sec.

Wind Direction = 120° - 130° Atmospheric Stability = A, D and F

Receptor Location = 1 km from the point source

Mixing Height = 200 m

Radius of Stack = 1.68 m

Velocity = 1.33 m/sec.

As can be seen in Table E-1, emissions will occur concurrently from stacks at a number of different retorts. In utilizing PTMTP, it was assumed that all emissions will take place from a single stack. Since the stacks will actually be dispersed, this results in a conservatively high impact estimate.

The maximum 1-hour average concentrations at 1 km are presented in Table E-2. The maximum 24-hour average concentration for SO_2 resulting from project operations at 1 km is about $6 \mu\text{g}/\text{m}^3$ which is below the PSD increment of $91 \mu\text{g}/\text{m}^3$ first Class II areas. Since the background 24-hour average concentration for SO_2 is about $15 \mu\text{g}/\text{m}^3$ (measured at federal tracts U-a and U-b), the combined maximum 24-hour average concentration of SO_2 at 1 km would be $21 \mu\text{g}/\text{m}^3$. This is well below the primary Ambient Air Quality Standard of $365 \mu\text{g}/\text{m}^3$.

The maximum 24-hour average concentration for NO_2 due to project operations at 1 km is about $2 \mu\text{g}/\text{m}^3$. Assuming that the annual average concentrations are 25 percent of the 24-hour value, the maximum project related concentrations for NO_2 would be less than $1 \mu\text{g}/\text{m}^3$ which is well below the NO_2 National Ambient Air Quality Annual Average Standard of $100 \mu\text{g}/\text{m}^3$. The background 24-hour average concentration for NO_2 is about $24 \mu\text{g}/\text{m}^3$, (measured at federal tracts U-a and U-b). Therefore, the maximum combined 24-hour average concentration at 1 km would be $26 \mu\text{g}/\text{m}^3$. This is also well below the annual average $100 \mu\text{g}/\text{m}^3$ standard.

The comparison of SO_2 and NO_2 concentrations with applicable standards is shown in Table E-3. Assumptions and calculations are presented in Table E-4.

E.2 Visibility Impacts

The visibility effects of air pollutants depend upon the concentrations of gaseous and particulate pollutants, the size distribution of the particulate matter, the meteorological conditions and the lighting conditions. According

to a draft report, "Atmospheric Visibility in the United States" (Energy and Environmental Analysis, Inc. 1978), visual range is primarily affected by the conversion of SO_2 to submicronic sulfate particulate matter in the atmosphere, while the effects of primary particulate emission and the presence of nitrogen dioxide do not have a significant effect. For example, information in this report showed that a source emitting 276 tons per day of SO_2 would be expected to cause a maximum reduction of 10% in the visual range. The proposed project is estimated to emit at the worst case 0.1% of this amount of SO_2 , and thus the impact on visibility is expected to be negligible.

TABLE E-1

BURN SCHEDULE 1980-1982

Retort 18 - January 1, 1980 - May 15, 1980 (135 days)

Note: Retort 18 burned for 49 days in 1979.

Retort 24 -- October 1, 1980 - June 1, 1981 (245 days)

Retort 22* -- January 15, 1981 - April 15, 1981 (90 days)

Retort 25 - March 1, 1981 - November 1, 1981 (245 days)

Retort 26 -- January 15, 1982 -- September 15, 1982 (245 days)

Retort 27 -- April 1, 1982 - December 1, 1982 (245 days)

*Retort 22 has been tentatively scheduled during 1981, but most likely will never be burned.

TABLE E-2

MAXIMUM 1-HOUR AVERAGE CONCENTRATIONS AT 1 KM FOR SO_2
AND NO_2 ($\mu\text{g}/\text{m}^3$)

	Wind Speed <u>m/sec.</u>	Stability Class <u>A</u>
SO_2	2.7	44
NO_2	2.7	133

TABLE E-3

COMPARISON OF 24-HOUR AVERAGE CONCENTRATION
FOR SO_2 and NO_2 WITH PSD INCREMENT AND
NATIONAL AMBIENT AIR QUALITY STANDARDS

	24-hour Average Concentration ($\mu\text{g}/\text{m}^3$)	Background Concentration ($\mu\text{g}/\text{m}^3$)	Total PSD		NAAQS ($\mu\text{g}/\text{m}^3$)
			Concentration ($\mu\text{g}/\text{m}^3$)*	Increment ($\mu\text{g}/\text{m}^3$)	
SO_2	6	15	21	91	365 24-hr. average
NO_2	2	24	26		100 annual average

*Measured at Federal Tracts U-a and U-b.

TABLE E-4

STACK GAS EMISSIONS

Source: Geokinetics data.

Assumptions

- (a) 0.27 lb. of SO_2 per 1,000 ft^3 of retort off gas
- (b) 0.09 lb. of NO_x (as NO_2) per 1,000 ft^3 of retort off gas
- (c) Standard Gas Volume (SGV) = 1 CFM per unit cross sectional area