COLORADO OIL SHALE:
THE CURRENT STATUS

OFFICE of the EXECUTIVE DIRECTOR
DEPARTMENT of NATURAL RESOURCES
STATE of COLORADO

OFFICE of the REGIONAL REPRESENTATIVE
UNITED STATES DEPARTMENT of ENERGY
COLORADO

COLORADO OIL SHALE:
THE CURRENT STATUS

Prepared under
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OFFICE of the EXECUTIVE DIRECTOR
DEPARTMENT of NATURAL RESOURCES
STATE of COLORADO

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Oak Ridge # DOE/TIC-10251

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Project supervision was carried out by Dr. Walter Hecox, Executive Director's Office, and responsibility for the contents of this document rests solely with the Colorado Department of Natural Resources.

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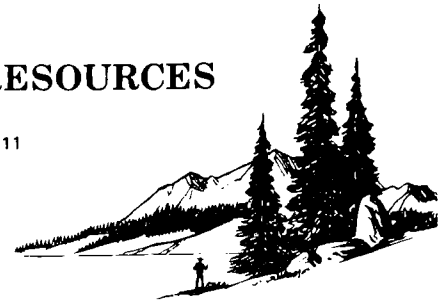
DEPARTMENT OF NATURAL RESOURCES

HARRIS D. SHERMAN, Executive Director
1313 Sherman St., Room 718, Denver, Colorado 80203 839-3311



Board of Land Commissioners
Division of Administration
Division of Mines
Division of Parks & Outdoor Recreati
Division of Water Resources
Division of Wildlife
Geological Survey
Oil and Gas Conservation Commissio
Soil Conservation Board
Water Conservation Board
Mined Land Reclamation

October 15, 1979

Oil shale presents Colorado with unique challenges and profound responsibilities. The state is rich in this energy resource and its development can contribute to the national goal of increased energy self-sufficiency. However, it is vital that oil shale be developed in a manner that will protect the economic, environmental, and social integrity of Colorado, as described by the attached testimony of Governor Lamm before the House Committee on Banking, Housing and Urban Affairs.

Colorado Supports a demonstration of differing oil shale technologies and the phased development of the industry. Colorado will look to a variety of important principles to guide oil shale, including:

- conservation of the oil shale resource to maximize recovery rates
- deliberate and orderly growth of communities to assure that community needs are available to existing and new residents
- protection and enhancement of environmental conditions
- promotion of stable, long term economic growth; and the healthy balancing of energy, agriculture, industry and commerce

Phased development properly applies to the demonstration of technologies which have not yet been commercially proven and to the rate of growth which may occur as technologies, proven in the demonstration stage, proceed to scale-up for commercial operation. An orderly rate of growth is essential if the necessary community facilities are to be available and the energy development is not to overwhelm county and regional services and environmental conditions.

The material in this briefing book provides a general background to oil shale and the potential impacts of its development. It is not meant as a technical discussion of all the issues and problems associated with the development of this energy resource. Rather, it is intended as an overview for those people not intimately knowledgeable concerning Colorado and its oil shale resource.

Colorado welcomes the chance to inform people throughout the nation about the current situation regarding oil shale. We have attempted to provide a comprehensive look at the complicated nature of this energy resource and the multiple impacts which will occur from its development. Projections of expected oil shale development and resulting impacts have been based solely on an analysis of industry plans; Colorado's position on an appropriate level of oil shale development remains that expressed in the Governor's July 28, 1979 testimony.

Harris D. Sherman

HARRIS D. SHERMAN

POSITION OF THE STATE OF COLORADO ON OIL SHALE DEVELOPMENT

Testimony of Richard D. Lamm, Governor of Colorado, before the Committee on Banking, Housing, and Urban Affairs, House of Representatives, Congress of the United States, on July 25, 1979.

INTRODUCTION

The State of Colorado recognizes the compelling national need to develop oil shale as a partial source of new domestic liquid petroleum. It is clear that Colorado will bear the major burden of this development since it contains 80 percent of the nation's high-grade oil shale reserves.

While the state is willing to accept that responsibility at this critical point in the nation's history, we have a duty to the citizens of Colorado who will be most affected by the rapid development of the state's natural resources.

The synthetic fuels proposals in front of Congress must be placed in a proper context with the nation's energy future. Under the most intense development scenario, little oil shale production will be realized within the next five years. In the interim period, our only response must be an intensive energy conservation program to meet the objectives of the President's goal for limiting petroleum imports. Clearly, bold new conservation efforts are required to cover the years before synthetic fuels can start meeting our energy needs, and, even after there is a synthetic fuels industry we cannot relax such conservation programs, since they will hold the key to meeting our long-term energy needs.

The conservation initiatives outlined by the President are steps in the right direction. However, we believe more needs to be done, particularly in those areas of the country heavily dependent on imported oil. We urge the President and the Congress to expeditiously implement a conservation program of a magnitude at least equal to the effort to develop synthetic fuels.

We urge this view because the necessary lead time for an operating synthetic fuels industry of significant size in the United States is a decade away. Even with full-

scale oil shale development, the probable realistic limit of production by 1990 is below 400,000 barrels per day. To reach such a level would unquestionably carry major environmental, social, and economic impacts. And since this level of production is only 2 to 3 percent of the nation's total petroleum consumption, oil from shale does not represent a "quick fix" solution to the nation's import problem.

However, within the next ten to twenty years, shale oil production can play an important supporting role in meeting the nation's petroleum needs. It is critical to launch this industry in a positive fashion that will insure its long-term viability. As the state has consistently proposed, this can best be done with a phased development as opposed to a crash program. Phased development will:

- Maximize the number of alternative technologies that may be developed;
- Reduce errors during scale-up which will ultimately lead to greater production levels;
- Control and spread population growth thus softening local boom town effects while maintaining local autonomy;
- Provide equal opportunity for smaller firms with innovative processes to compete technologically;
- Result in more efficient resource use through demonstrations of different technologies.

Colorado has a vital stake in the outcome of a major national synthetic fuels program which determines the manner and pace in which this development is conducted. The state's most basic concerns are in the areas of technology, social, and economic impacts, environment, and the respective roles played by the Federal Government, state government, and industry.

TECHNOLOGY

There appears to be a widespread perception, both among the public and the government, that extraction of crude oil from shale is a thoroughly tested, well-proven technology which only requires adequate financial support to become a full-scale commercial industry within a short period of time. This is not true.

Although many oil shale technologies are promising, to date, none has been proven commercially viable. They represent high risk in a crash synthetic fuels program. Extraction of crude oil from shale has been tested through

a variety of prototype plants (100 to 1,000 barrels per day), yet none of the surface or underground technologies has been demonstrated on a minimal commercial scale (5,000 to 12,000 barrels per day). The scale-up to full-size, above-ground, commercial-sized retorts will be ten to fifty times the size of existing prototypes. This scale-up will unquestionably lead to significant modifications and adjustments. There is an important learning curve ahead as we escalate to these commercial-sized retorts. We believe that the basic-sized units should first be constructed, tested, modified . . . and then we should proceed to add additional retorts in a deliberately-phased manner.

Attainment of full-scale commercial-sized plants will most likely be accomplished by adding commercial-sized retorts of about 5,000 to 12,000 barrels per day each, one-by-one and side-by-side, until production capacity of a single plant reaches 50,000 barrels per day.* In this fashion we will be able to minimize serious mistakes, develop technologies that maximize (rather than waste) valuable taxpayer dollars, better conserve the mineral resource, and minimize impacts on the environment.

The oil shale companies themselves are aware of these technological uncertainties and have generally supported a phased approach. As one company recently stated:

> "No one really knows what any of the available oil shale technologies will do or what they will cost in dollars per barrel to go commercial until modules are actually built and operated and we collect investment and operating cost data to make some good economic predictions. The numbers you have seen up until now are only preliminary projections.

* *Some mention should be given to the sheer size and volume of a commercial oil shale plant. A single 50,000 barrel per day surface retorting plant and associated background mine would be one of the largest mining operations in the United States and would, itself, be the largest industrial complex in the history of the State of Colorado. Yet, the President is proposing the construction of eight such large plants most of which would be located in Colorado with a total capacity of 400,000 barrels per day.*

> "By the phased approach we can actually get more production sooner with fewer mistakes. Some of the technologies currently being touted may not pass the module test from an environmental or economic standpoint. We could start construction of several commercial plants immediately and with confidence after a successful module demonstration."

A recent Rand Corporation report to the Department of Energy has added weight to the need for such an approach by suggesting the possibility of substantial cost overruns which might occur through a crash synthetic fuels program by committing "too much too early."

Perhaps our greatest concern is that in fact there are no commercially viable oil shale technologies ready to be taken "off the shelf." Everything we know about the process of large scale technological innovation points to the fact that a wide diversity of technological approaches in the early stages of a development program greatly increase the probability of success. A massive single-technology approach could "freeze" the technology at undesirably low levels. Many representatives of industry believe that the government should encourage a multiplicity of technological processes, since only a fraction of these will emerge as viable commercial operations. We share this view.

SOCIAL AND ECONOMIC IMPACTS ON COLORADO COMMUNITIES

Oil shale development will occur in a confined, very sparsely populated area of Colorado consisting of some eight communities with a total present population of only 14,500 people.

We anticipate enormous impacts during construction and operation of major energy facilities, and the resulting inability of communities to handle the impacts: Lack of front-end money to meet community needs before the tax base is in place; rapidly increasing demand for community services; immediate housing shortage as workers arrive to build the plants or mines; and increases in social problems associated with unplanned, explosive growth.

Social and economic impacts won't be limited to communities; farmers, ranchers and orchardists will also be affected. Energy development tends to dry up the agricultural labor supply, not just in the immediate area but halfway across the state. Additional people will put pressure on agricultural land and water above the direct needs

of the energy industry. We would like to see energy development unfold on the Western Slope in a way that does not destroy agriculture. Indeed, the economic and social stability that agriculture provides will be vital to developing a synfuels industry in the west. Maintaining the vitality of Western Slope agriculture is therefore in the national interest, and is another reason why a crash synfuels program should be avoided.

We anticipate that a 400,000 barrel per day oil shale industry, as proposed by the President, would add 70,000 to 75,000 people to the existing population base of 14,500. This five to six-fold population increase in the energy area, over a period of a decade, would cost over $400 million in community services alone, exclusive of housing needs.

Construction of highways in the oil shale counties would cost well in excess of $100 million to meet the needs associated with the President's goals.

While in national terms, this might not appear to be an excessively large amount of money, it must be viewed in a Colorado context. Like other small states, Colorado does not have the financial resources to meet such needs. Figures of $500 million for highways and community services would tax the state and local governments beyond their ability. I hasten to mention that no comprehensive programs exist at the federal, state or local level to equip us to deal with such rapid expansion.

The issue of explosive, unplanned growth not only affects the people living in the community, but the productivity of the industry itself. Chaotic community conditions will thwart an expeditious synthetic fuels program simply because companies will not be able to attract or keep quality workers. Eventually, communities will not look favorably on participating in synthetic fuel development.

Enough studies have been done to demonstrate that this productivity decline occurs during the construction as well as the operating phase, a situation that can also contribute to the large cost overruns mentioned earlier. We therefore believe that the costs of the development could escalate dramatically if the essential community planning and services are not in place. For example, in the construction of the Jim Bridger Power Generating Facility in Rock Springs, Wyoming, the company suffered greatly from productivity problems due to social disruption. Some observers have estimated that the impact of this

productivity decline nearly doubled the originally estimated cost of the plant.

A national synthetic fuels program cannot treat such compelling social issues as an afterthought. We must incorporate successful community and housing programs, pacing the development accordingly, if we are to make this national effort work.

ENVIRONMENT

An enormous amount of money, time and effort has gone into evaluating the environmental impacts of oil shale. The oil shale companies, university research centers, federal, state and local governments, and others have invested millions of dollars in such analyses. While the results generally appear promising (i.e., oil shale development can be undertaken within existing environmental regulations) many questions remain unanswered, particularly under a crash program.

A phased effort, starting with commercial-sized retorts which are then scaled-up to higher levels of capacity after adequate demonstration, appears to be the best way to minimize environmental damage. This is particularly the case in assessing potential water pollution, air pollution, and early reclamation programs where the jury is still out on how successful we will be in offsetting these impacts. Under a crash program, if substantial problems were to arise, the state would be left to correct very expensive in-place large-scale industrial plants, and to do it with limited financial resources.

Several very large plants (which is the kind of development which would be forced under a crash program) concentrate effluents and emissions which could rapidly saturate the water and air capacity of the regions beyond the borders of the area under actual resource development. This "preemption" of the environmental capacity of the region might relate to private lands as well as to lands owned by the Federal Government in the Naval Oil Shale Reserve and by the Bureau of Land Management. The possibility of this preempting by first-generation plants should be of great concern because it might prevent more innovative second-generation plants from being constructed.

WATER

Development of a large-scale oil shale industry in Colorado may also place a great burden on the scarce water resources of a semi-arid region. At a level of production

of about 500,000 barrels per day, we believe there is sufficient water available to accomodate the industry as well as other existing and projected consumptive use. Over 500,000 barrels per day, our studies indicate an increasingly tight situation which may cause shifts in historic allocations and priorities. Because water will be a major limiting factor in the ultimate level of production, serious considerations must be given to this issue.

The use and allocation of water will partly determine the economic diversity and balance that we seek to protect in Colorado. We want to protect, wherever possible, our agricultural economy which has occupied so important a place in our history. At the same time, if the Federal Government wants a major oil shale industry, it will need to work with Colorado to develop required water storage facilities for the industry. Based on past Carter Administration water policies, fundamental changes in federal water policy may be necessary.

FEDERAL-STATE-INDUSTRY ROLES

The only way an oil shale industry can be rationally developed, given the current state of its technology and associated questions, is through an intelligent and appropriate interaction of the Federal Government, the states and industry, each playing its own individual role.

Industry's main responsibility should remain the selection, design, construction, and operation of shale oil producing plants, using their own evaluation criteria as to economic rate of return; technology utilization and evaluation; development, formation and commitment of capital and operating dollars; risk and profit; and operating worker force training, productivity and technologic competence. In addition industry responsibility should include assistance to the state to meet needs such as housing and transportation and the provision of public services, and to work with the state to minimize in-migration patterns and to assure the employment of Colorado workers.

The Federal Government's role will be that of promoter, partial regulator, and often lessor of the lands to be developed. There is no question that the Federal Government will play a key role in determining the character, quantity, quality, and pacing of the development.

At the same time, the state will have a central role in such areas as regulating environmental impacts, mitigating impacts to affected communities, and conserving the resource. By necessity, there will be significant

interaction between the state and Federal Government. If the state is to exercise properly its responsibility, it must participate in major federal decisions as an equal partner and be able to clarify local conditions and areas of concern. Since states and local governments have always had the primary responsibility to regulate energy development, the environmental review and permitting processes must be carefully integrated into federal planning and funding programs.

Several recent proposals, including the President's Energy Mobilization Board, have raised important questions for the states. The states will insist on applying their laws and they will resist proposals which directly or indirectly call for federal preemption. At the same time, cutting of red tape and eliminating duplication in the environmental/regulatory process is a necessary component in any national synthetic fuels effort. We applaud that goal and believe there are constructive ways to accomplish it without threatening historic state/federal relationships.

For starters, the Federal Government should get its house in order. Most delays in the past have been associated with federal reviews as opposed to state or local government regulation.

A mutual goal for all levels of government should be to coordinate and integrate their reviews to the maximum possible extent. For example, Colorado has recently established a joint review process with our federal and local counterparts to eliminate unnecessary delays and to shorten the review time. We believe this can be accomplished without environmental shortcuts. This review process serves as a model of why federal preemption is unnecessary and unwarranted.

PROPOSED MODIFICATIONS TO PENDING SYNTHETIC FUELS LEGISLATION

Colorado wishes to present several concepts for incorporation into pending synthetic fuels proposals:

- Phased development
- Impact assistance legislation
- Environmental monitoring
- Adherence to state and local laws

Phased Development

Any program of federal incentives should be based upon a plan of phased development as opposed to a crash program. We are convinced that large-scale target levels of

production can be achieved through a graduated approach, since it will use the most effective technologies, while at the same time minimize costly mistakes, prevent waste of valuable taxpayer dollars, and reduce environmental and social impacts.

What is needed is time: Time for the communities of this region and its citizens to accommodate to this rapid rate of change, and time to learn from prior mistakes. A national crash program of oil shale development places a premium on time in order to meet level-of-production goals. We believe these two competing concepts can be harmonized by focusing on how fast as well as how far. We believe that controlling the rate of growth to reduce adverse human impacts can result in eventual levels of production at least equal to those proposed through crash development.

Therefore, we recommend that federal programs for oil shale development be designed in a manner requiring gradual, phased development in place of immediate large-scale development. The flow of federal dollars and programs should be conditioned on the phased approach.

Impact Assistance Legislation

The reasons set forth above demonstrate that any synthetic fuels legislation should be accompanied by specific assistance to energy-impacted communities. Colorado would recommend that Section 601 of the Power Plant and Industrial Fuels Use Act of 1978 be amended to:

- Include synthetic fuels;
- Allow for construction of facilities as well as development of necessary infrastructures;
- Provide energy impact assistance to agricultural producers through existing USDA channels;
- Provide for construction grants up to 100 percent of total cost;
- Authorize no less than $300 to $400 million during each of the first five years and $200 to $300 million for each of the last five years.

These recommended amendments would use existing statutes and agencies without requiring new hearings that in turn would likely delay action on this component of a synthetic fuels program.

We note that the above recommendations are consistent with amendments that Senator Gary Hart of Colorado intends to introduce within the immediate future.

Environmental Monitoring

Federal funds should be set aside to assist federal, state and local agencies to monitor and assess environmental impacts of the development. Only in this fashion can we avoid irreparable mistakes that could damage the state for years to come.

As part of this assessment, analysis must be directed toward the overall energy requirements of an oil shale industry. Of particular importance is the long-term electrical power needs to feed the oil shale development, including associated power plant and water development components.

Further evaluation will need to be given to the cumulative impacts between oil shale, coal and uranium development in this region of Colorado.

We recommend that sufficient budgetary allocations be made for the next ten years to accomplish this purpose.

Adherence to State and Local Laws

Any federal synthetic fuels program should include congressional language which clearly and unmistakably states that all synthetic fuels projects must comply with all state and local laws regardless of whether the facility is located on state, federal or private lands, and regardless of whether the facility is constructed by the private sector, the Federal Government, or some mixture of the two.

In particular, it should be recognized that the western states have historically controlled the allocation of water within and across their borders. This has been accomplished through a well-established network of interstate compacts which have been repeatedly and consistently upheld in state and federal courts. Level of energy production goals set by the Federal Government that preempt the role of the state in determining water allocations will face great difficulty from the outset.

In addition, sufficient funding should be made available to state, local and federal agencies to assist them in designing and implementing coordinated, streamlined programs that expedite permit reviews.

Under a coordinated joint review process, there is no need to preempt vital state and local requirements. Colorado is prepared to share, in detail, the model joint review process we have undertaken with our federal and local governmental counterparts.

Legislation to create an Energy Mobilization Board should focus on major state input into the selection of

priority energy projects, timetables for environmental and regulatory review, and creative, cooperative mechanisms to reduce unnecessary delays. The Board's mandate should minimize conflicts between state and Federal Governments and avoid federal preemption of important state and local roles.

These legislative additions to the synthetic fuels legislation are vital to the ability of Colorado to cope with the proposed energy developments. At the same time, they will help to direct synthetic fuel development in a fashion that insures its long-term role in the nation's energy future.

INTRODUCTION TO OIL SHALE

Oil shale is a very fine-grained sedimentary rock which contains enough organic matter (hydrocarbon) to produce crude oil when processed (retorted). The solid oil shale material containing hydrocarbon is called kerogen. In the United States alone, the oil shale resources probably exceed 2,000 billion barrels (42 U.S. gallons per barrel) of petroleum. For reference, the U.S. has consumed approximately 100-125 billion barrels of petroleum since 1859 and the current rate of consumption is approaching 7 billion barrels per year. Much of the oil shale resource is not economically recoverable. Indeed, only 25 to 30 percent of the resource is presently projected as being commercial.

Most shale rock of commercial grade varies from 20 to 50 gallons per ton, but some shales are as rich as 125 gallons per ton (although an insignificant amount), and much shale is in the range of 10 to 20 gallons per ton.

The most extensive high-grade deposits of oil shale in the U.S. are in the Rocky Mountain region, primarily Colorado, Utah, and Wyoming, under land which is mostly in the public domain. There are substantial private holdings among the rich deposits, and some of these holdings as well as the prime federal lease tracts are likely to be developed first. The largest deposits of high-grade oil shale are in the Piceance Basin (Garfield and Rio Blanco counties) of Northwest Colorado and in eastern Utah in the Uintah Basin.

There is a large-scale, oil shale resource in Wyoming (particularly the Green River Basin), but that deposit is generally of lower grade than deposits in Colorado and Utah. It is therefore not expected to play a role in any initial oil shale development during the 1980's.

For perspective, approximately 80 per cent of the U.S. high grade oil shale resource lies in the Rocky Mountain area, and 64 per cent of the U.S. total lies in the Piceance Basin area. Oil shale deposits in the eastern U.S. have not been as extensively explored as have deposits in the West.

"Processing" oil shale amounts to heating (retorting) it to a temperature of at least 900° F., at which point some of the organic material undergoes a chemical change and forms a vapor from which crude oil is then condensed. There are at least two basic ways to achieve this chemical change: (1) mine the shale rock, crush it, then feed it into a surface retort, using any of several different surface retort processes, to achieve the desired temperature; or (2) retort the shale in place (in situ) and condense the crude oil from the vapor while it is still in the ground. While the in situ process obviously sounds simpler, it is an unproven technology relative to surface retorting, and remains a subject of intense interest, research and speculation.

In fact, the entire oil shale industry is in its infancy even though oil shale as a source of petroleum has been of interest in this country since the 1920's. For the most part, oil shale technologies are not proven at a commercial level. Undoubtedly the technological direction of the industry will change in reaction to the experience accumulated from different processes achieving commercial

scale operations. Clearly, the oil shale industry is subject to rapid change, there is great uncertainty, and much is still unknown. This uncertainty characterizes the current surface technologies (Union B, TOSCO II, Paraho Direct, Superior, etc.), but it is even more descriptive of the in situ processes, of which there are two versions, pure in situ and modified in situ (MIS) technologies. Pure in situ processes involve recovery of the underground crude oil resource while operating exclusively from the surface. Modified in situ processes utilize an underground mining operation to aid in retorting the resource in place. Rapid advances in either of these technologies would dramatically change the pace, scale, and production levels of the oil shale industry.

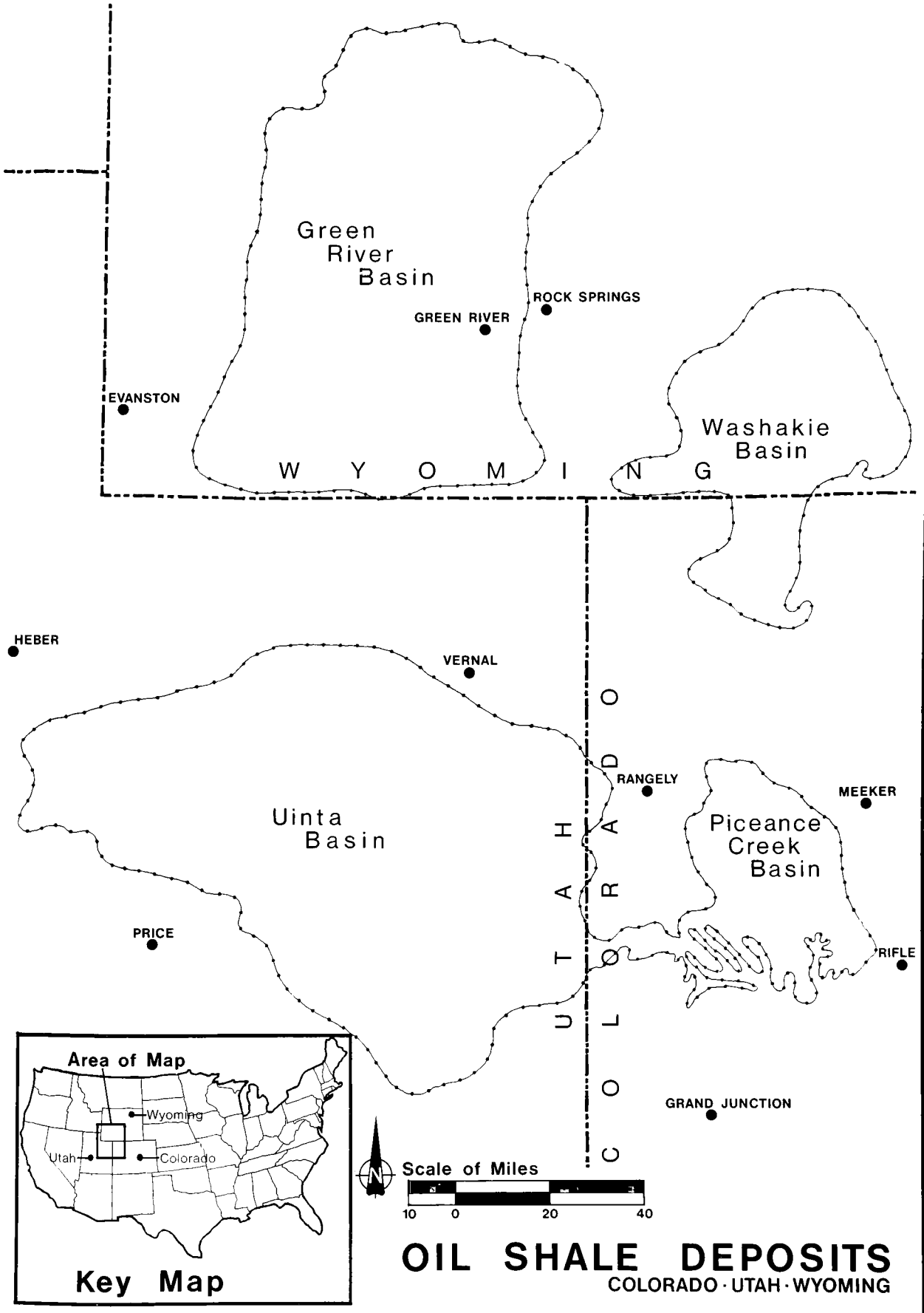
In the absence of such advances, production of crude oil from shale will mean reliance on surface retorting and underground mining operations of immense proportions. For example, at current levels of technology, a single surface plant operation, whose yield is 50,000 barrels of crude oil per day, would require a mining operation of 65,000 to 150,000 tons per day. For reference, the largest underground mining operation in the U.S. today is approximately 65,000 tons per day. In addition, the capital requirements for some oil shale plants might approach $2.0 billion, and the social-economic-environmental triad of problems associated with an expanding oil shale industry will be significant.

Oil shale development in Colorado will require intense analysis and monitoring on a continuing basis. The Colorado Energy Resources Development Plan Project in the Executive Director's Office, Department of Natural Resources, is a U.S. Department of Energy funded effort to

identify expected oil shale project impacts and plan for orderly growth of energy production in Colorado. Other State agencies are also focusing their attention on energy development in general and on oil shale development in particular; the common goal is to assure orderly growth of energy production in a manner compatible with the responsibilities of State government and the continued well-being of Coloradoans.

INFORMATION ON ACCOMPANYING MAP
TAKEN FROM:

USGS ENERGY RESOURCES MAP



OIL SHALE DEPOSITS

COLORADO · UTAH · WYOMING

FIGURE 1

COLORADO OIL SHALE: the current status, october, 1979
Department of Natural Resources
State of Colorado

OIL SHALE OWNERSHIP IN COLORADO & UTAH

Oil shale deposits in Colorado and Utah are widely dispersed, with ownership primarily in the hands of the federal government. However, existing leases on the federal lands and privately held lands are distributed over a large number of different companies. This diversity of ownership is significant in that the available technologies suitable for exploiting oil shale, as well as the economic potentials and problems connected with each tract, differ considerably. This means that different companies may choose to use different technologies to exploit their individual oil shale holdings due to site-specific criteria as well as the proprietary nature and ownership of different technologies.

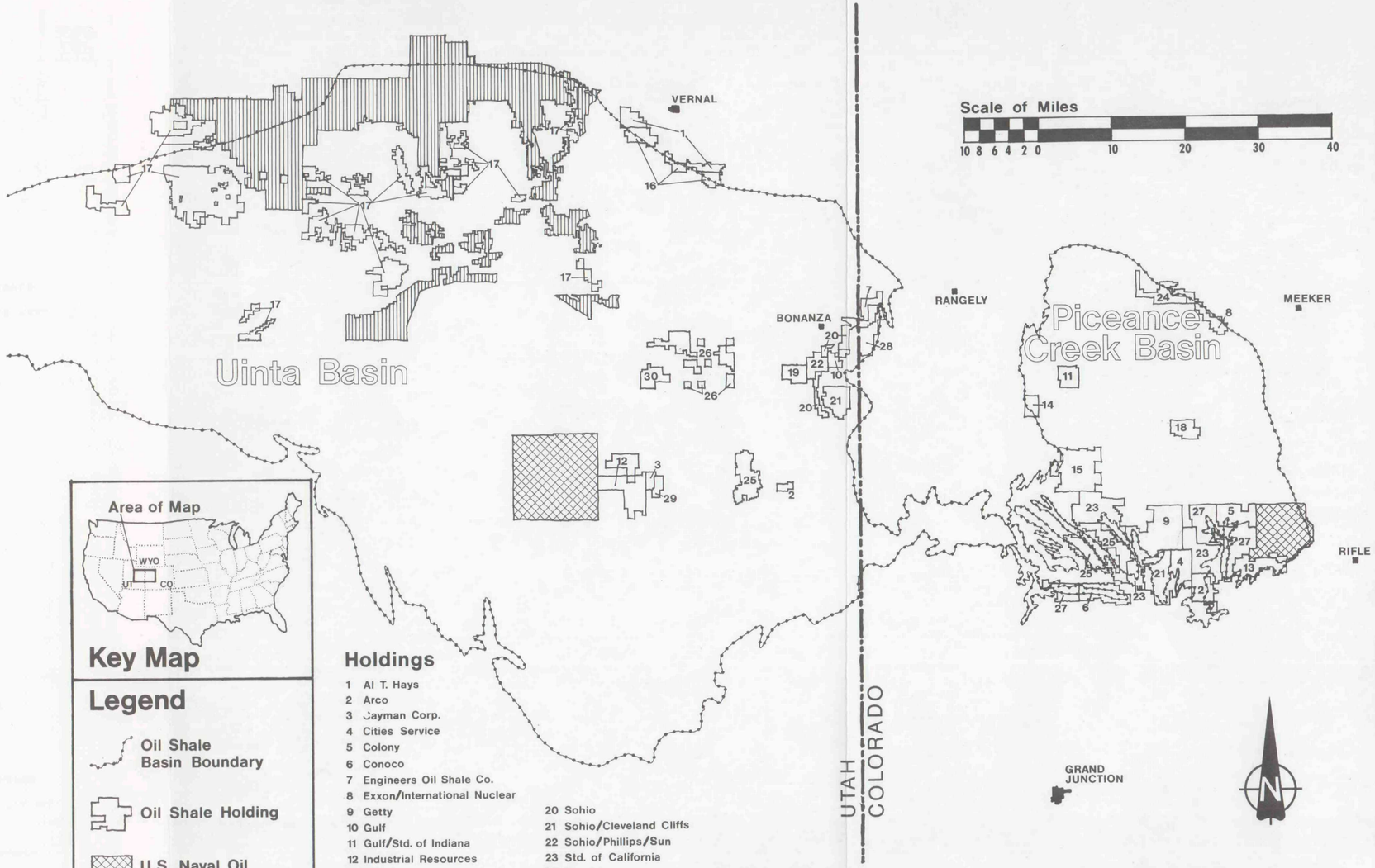
A few of these companies have already taken major steps towards commercial production on their holdings; others are moving in that direction; a significant number have not yet made any commitments.

The development of some of the individual sites in Colorado and Utah will affect not only the particular state in which it is located, but also adjacent states as well. Primary impacts which may cross state boundaries are likely to be air qulaity, water availability, transportation, community infrastructure, and population growth.

The pattern of high grade oil shale development in the West will be determined to a significant degree by the

types of technologies which prove feasible for commercial-scale production. If the in situ processes are successful, sites in both Colorado and Utah can be developed. If surface retorting is the only proven technology, then development will concentrate only on high-grade deposits accessible on the Piceance Basin edges; these deposits occur primarily on private lands in Colorado.

Because the federal government is the principal landowner in Northwest Colorado and eastern Utah and owns most of the mineral rights, it has a primary interest and will play an important role in determining the rate and manner by which oil shale is developed. Private holdings, which are in some cases the closest to commercial production, generally cannot be developed without federal cooperation. For example, electric power transmission lines, water collection and diversion systems, roads, railroads and shale oil pipelines must cross federal land and undergo federal environmental scrutiny. In addition, an extensive state and federal permitting process must be followed before construction and operation can proceed.



INFORMATION ON ACCOMPANYING MAP
PROVIDED BY:

CAMERON ENGINEERS, INC.

MAJOR OIL SHALE HOLDINGS COLORADO·UTAH

Map based on information from MAJOR OIL SHALE HOLDINGS, COLORADO·WYOMING·UTAH (map), by Cameron Engineers, Inc., Denver, CO, dated Jan., 1978

FIGURE 2

COLORADO: AN OVERVIEW

Colorado, on the backbone of the continent with more than fifty peaks rising at least 14,000 feet above sea level, is divided topographically into three parts:

- The high mountains, rich in timber and minerals, the location of the headwaters of four major drainage systems--the Colorado, the Arkansas, the Rio Grande, and the Platte Rivers, and the main attraction of the billion dollar tourist industry which benefits the entire state;
- The eastern prairies, a semi-arid area rich in minerals, a major grain and livestock producing part of American agriculture, and the western end of the great American prairie;
- The Colorado plateau, the high basin of the western part of the state, drained by streams tributary to the Colorado River, and the location of 64 per cent of the nation's rich reserves of oil shale.

Each of these three regions is characterized by different climate, terrain, cultural, and economic factors. Together they provide the state with unusual diversity.

For all the diversity in the state, a common denominator is weather. The elevations below 9,000 feet are

characterized by mostly sunny days and generally mild temperatures which can sometimes fluctuate by 60 degrees (F.) or more within a few hours. Thus natural resource development, except at the higher elevations, is manageable almost year round.

Colorado is a sparsely populated state and has an area of approximately 66 million acres, with nearly 24 million of them being federal lands. About 80 per cent of the State's 3 million citizens live along the front range where the Great Plains meet the Rockies. It has been necessary to divert western slope water through tunnels under the continental divide to front range cities and to the agricultural areas of the eastern prairie. All the members of Colorado's Congressional delegation come from front range communities, although two of the major districts extend to the Utah border. The majestic Rockies, with 13 million acres of national forests, world renowned ski slopes, and numerous national parks, constitute a political, cultural, and economic barrier between Colorado's eastern and western slopes.

Denver, the capital city, a metropolitan area of about 1.5 million persons, is the location of the nation's fifth busiest airport, a major truck terminal for the continent, and a railroad yard for east and west, north and south.

The city of Grand Junction, with a population of about 28,000, is the focal point of activity for western Colorado. On an established, stable agricultural base, the city has experienced a continuing expansion during the past decade as a result of energy resource exploration and development in Colorado, Utah, and southwest Wyoming. The drive from Denver to Grand Junction, although only 258 highway miles, takes the better part of a day on the State's only east-west

interstate, I-70. The mountain terrain, while spectacular, is often treacherous and I-70 is sometimes closed by snow in the winter.

The prospects for energy development over the next decade present Colorado with a substantial economic stimulus as well as a significant challenge. But there will be major changes: for example, there is the possibility that eastern slope interests will have to be more closely adjusted in the future to the stronger western slope presence in Colorado. Western Colorado faces the possibliity of rapid growth and financial prosperity, but also a number of environmental and social problems. Long a rural, agricultural economy with little political representation, this part of Colorado may be on the verge of a revolution in its customs and role in the State. The front range cities will likewise feel the impact of energy development; Denver is already becoming an energy capital for the West, with new jobs and residents, financial capital, and energy knowledge.

All regions of Colorado, however, will be affected by the pace and manner of energy development, therefore making it a common State interest to assure that this development proceeds in an orderly way and promotes the well-being of present and future Colorado citizens.

INFORMATION ON ACCOMPANYING MAP
PROVIDED BY:

COLORADO DEPARTMENT OF HIGHWAYS

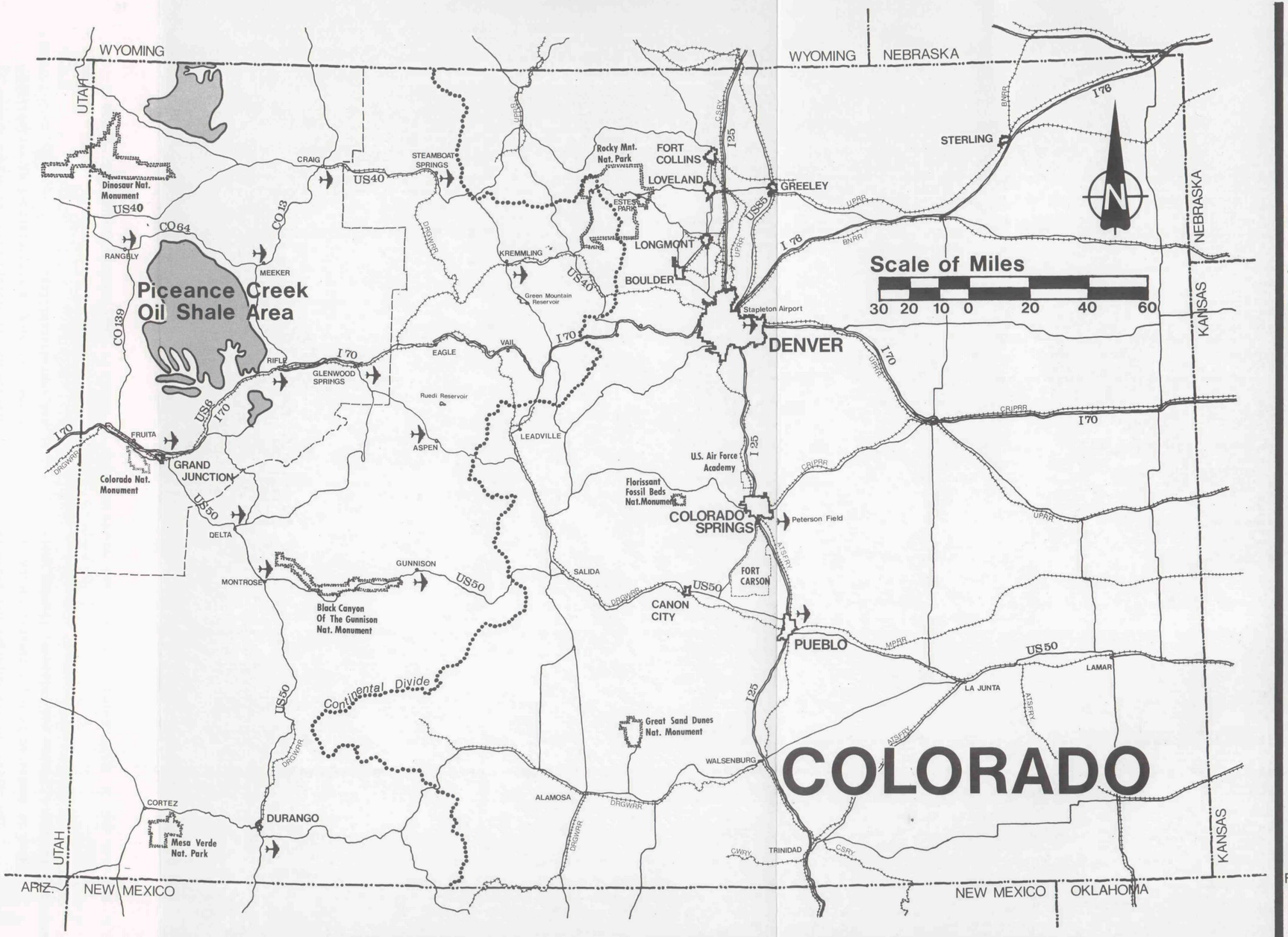


FIGURE 3

COLORADO OIL SHALE: the current status, october, 1979
Department of Natural Resources
State of Colorado

GEOGRAPHY & ARCHEOLOGY

Oil shale resources in Colorado lie in a unique and fragile region, one which must be managed carefully if this natural diversity and balance are not to be damaged. This natural condition of Northwest Colorado is itself a resource to Colorado, valued by agriculturalists, hunters, recreationists, tourists, and residents alike. If energy development is to occur in this area without permanent damage to its natural diversity, there must be a recognition of the importance of these natural features as well as a determination that steps will be taken to preserve the uniqueness of the region.

GEOGRAPHY

The terrain of the Colorado oil shale region is dominated by major rivers, including the White, Yampa, and Colorado, flowing westward out of the Rocky Mountains. The region is characterized by a rich and varied mosaic geography in which drainage, exposure, and local soil conditions all play a significant role in the ecosystem. The streams isolate a number of physiographic areas which constitute local drainage basins. In the Dinosaur National Monument area, the Yampa and Green Rivers have dissected the highland area and formed deep gorges. While the topography of the region contributes to highly varied microclimatic conditions, the oil shale region of Colorado can be described climatically as semiarid to arid. The only exceptions to this are the higher elevations on the Roan Plateau and the Flat Tops, where there is a considerably higher precipitation rate than in the neighboring lowlands. The land rises from the Colorado-Utah border toward the Continental Divide to the east, producing a pattern of increasing average annual precipitation at higher elevations. Climate is characterized by variability and unpredictability.

GEOLOGY

The geology of the region is complex. There are extensive flows of tertiary and quaternary volcanics on the eastern and southern borders of the region. These rocks cap Battlement Mesa and the Flat Tops. The Piceance Creek Basin and Roan Plateau are formed of the Eocene lacustrine sediments in which the richest oil shale deposits occur. The valleys in the Piceance Creek Basin are filled with recent alluvium eroded from the Green River and Uintah Formations. There are extensive exposures of deposits dating back to the upper Cretaceous age on all sides of the Piceance Creek Basin. North of the Yampa River, however, Eocene oil shale bearing deposits again appear, though they are not of the richness which characterizes the Piceance deposits. Finally, on the eastern boundary of the region and in the Dinosaur National Monument, the deposits range in age from Precambrian through Jurassic, with rocks of Pennsylvanian age.

ARCHAEOLOGY

The archaeological data suggest that sites occur in low density; known sites and current theory indicate 10 to 100 sites per square mile in zones of occurrence. Most of the sites are surface, but considerable potential exists for deeply buried sites in drainage areas of the region. The nature of these past cultures was one of a subsistence pattern with migration over a considerable area. In the prehistoric past, aboriginal groups were distributed along the rivers in sites which span the last two-thirds of human occupation in the New World. The ecosystems had generally limited but interesting human occupation in pre-history and are important in terms of the heritage of Colorado. At least one major cultural boundary, that of the Fremont culture, has been identified. Six potential subcultural areas have also been identified and their cultural resources evaluated. In only three cases, the Dinosaur-Blue Mountain-Brown's Park area, the Douglas Creek area, and the Piceance Creek Basin have

there been reasonably intensive studies conducted. Even in these areas caution must be exercised in interpretation and evaluation of the cultural resources.

In Northwest Colorado there are a number of known archaeological sites, with some included on the National Register. The major areas of interest are shown on the NATURAL FEATURES I Map. They are: Blue Mountain, Douglas Creek Drainage, Yellow Creek Drainage, Federal Oil Shale Tract C-a, Federal Oil Shale Tract C-b, Naval Oil Shale Reserve, Parachute Creek Drainage, and Battlement Mesa.

There are a number of cultural resource unknowns in the region and many questions related to pre-history that need to be answered. At the present time, specific development projects in the oil shale region are successfully meeting cultural resource management concerns under existing state and federal laws. Commercial oil shale development, however, may result in a substantial erosion of Colorado's natural heritage.

INFORMATION ON ACCOMPANYING MAP
TAKEN FROM:

COLORADO WEST TRANSPORTATION PLAN
(Draft) by:
TRANSPORTATION DEVELOPMENT
ASSOCIATES, INC.

INITIAL WILDERNESS INVENTORY MAP, 1979
BUREAU OF LAND MANAGEMENT U.S.
DEPARTMENT OF THE INTERIOR

INFORMATION PROVIDED BY:

INTERAGENCY ARCHEOLOGICAL SERVICES
CONSERVATION AND RECREATION SERVICES
U.S. DEPARTMENT OF THE INTERIOR

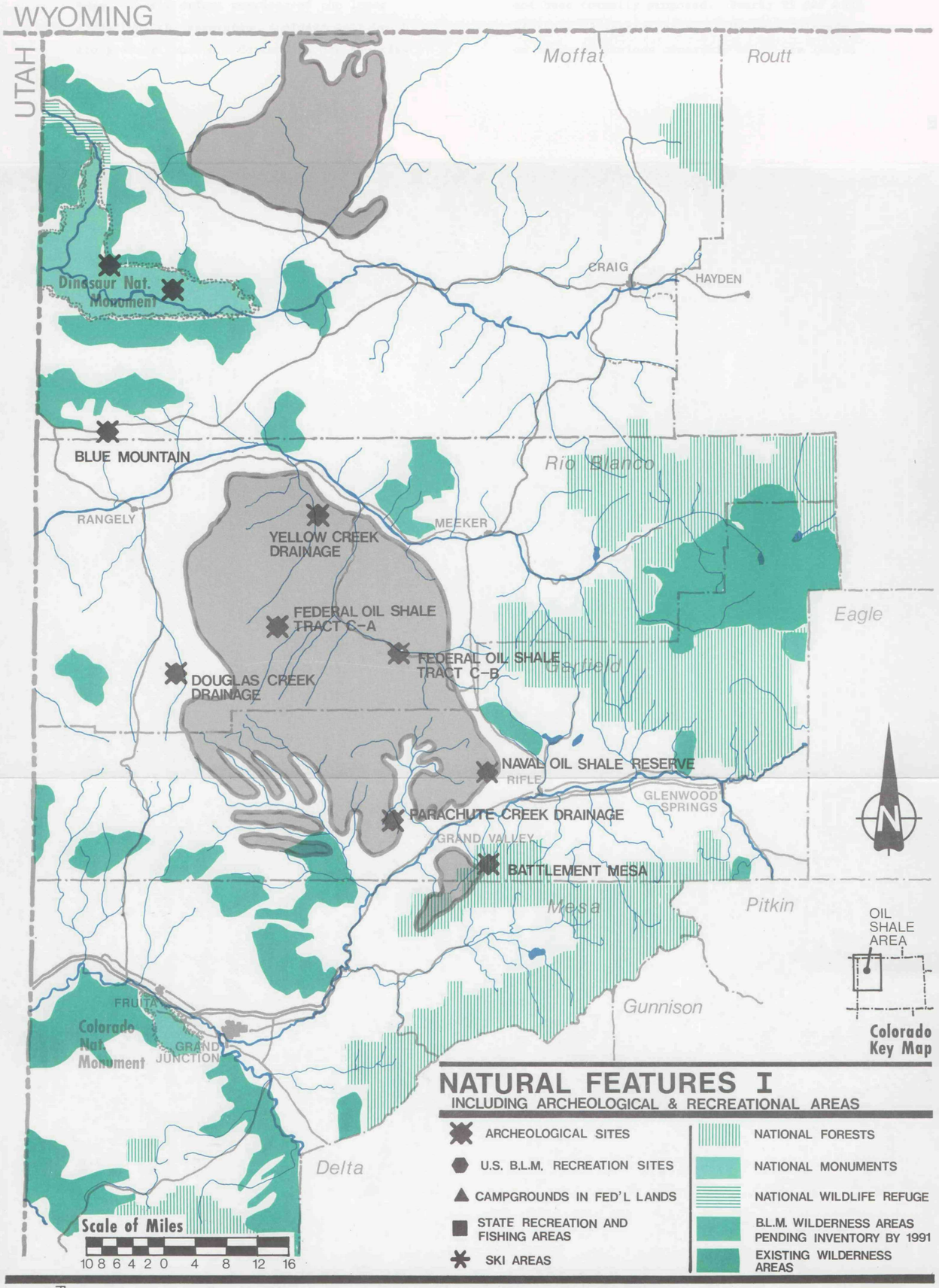


FIGURE 4 COLORADO OIL SHALE: the current status, october, 1979
Department of Natural Resources
State of Colorado

VEGETATION & WILDLIFE

Siting of oil shale developments in Colorado may be directly influenced by the presence of endangered and threatened plant and animal species. Federal laws require protection of certain species and these occur in significant numbers in Northwest Colorado. Prior knowledge of these important species and their location in the oil shale area, as well as proper regional and site development plans, can minimize the conflict between endangered and threatened species and energy development.

VEGETATION

Vegetation in the region varies with elevation and with proximity to the major drainages. In the driest portions of the lower elevation, the vegetation includes salt brush along water courses. Cottonwood and tamarisk grow along the permanent stream courses in the lower elevations, with tamarisk giving way to willows as one moves upward. At elevations above 5,500 ft. juniper and then pinyon appear. Much of the area at 6,000 and 8,000 ft. is covered with dense stands of pinyon-juniper woodland. The stands are usually found on ridges with well-drained soils. Mountain mahogany and service berry are common on the steeper slopes. At 8,000 ft. there are stands of Douglas fir, aspen, service berry, mountain mahogany and occasionally spruce-fir. These communities only appear where precipitation is in excess of 15 inches per year.

Of particular importance to the region is the presence of endangered/threatened plant species. Approximately 50 plant species in Colorado have been proposed as Endangered and Threatened; an additional 33 species are candidates for the Federal Register list but have not been formally proposed. Nearly 90 per cent of these 83 species occur in Western Colorado on lands of various ownership which are leased

for coal, oil, gas, or mineral exploration. The general locations of those most endangered plant species are noted on the NATURAL FEATURES II Map by corresponding numbers denoting the following:

1. locality of Astragalus wetherillii, a federally listed threatened plant species in Colorado. Along Colorado River between Una and Rifle. Locality of Sclerocactus glaucus, a federally endangered species of cactus, found along Colorado River near Grand Valley.

2. only known locality (Roan Cliffs) in the world of Festuca dasyclada, a federally endangered species. Only occurs on Green River Formation, on an Occidental Experiment Site on BLM land leased to Occidental Oil Company. High protection priority. The Roan Cliffs area is an identified Colorado Natural Area.

3. Cathedral Bluffs: This area, which is an identified Colorado Natural Area, harbors some endemic plant species of special biological concern to Colorado: Astragalus lutosus, Aquilegia barnebyi, and Crypantha breviflora.

   locality for Astragalus detritalis (debris milkvetch), a federally endangered plant (14 miles east of Rangely).

4. area southeast of Cathedral Bluffs, which harbors the 3 endemic species mentioned in #3, and is an identified potential natural area.

5. only known locality (Raven Ridge) in the world of Eriogonum ephedroides (wild buckwheat). Only 250 individuals were counted in 1978, summer. This is a federally endangered species.

   locality for Parthenium ligulatum (feverfew). This is a federally endangered species.

6. locality for Astragalus detritalis, a federally endangered species.

7. Dinosaur National Monument and lower Green River Canyon: Area of special botanical interest, harboring the following rare plant species: Parthenium ligulatum, Penstemon yampaensis, Penstemon pachyphyllus, Aster perelegans, Astragalus chamaeleuce.

   Excellent examples of riparian woodland of Northwest Colorado, unusual soil types resulting in considerable plant diversity.

locality for Eriogonum saurinum (dinosaur buckwheat), a federally threatened species.

locality for Eriogonum viridulum (wild buckwheat), a federally threatened species.

8. DeBeque area of the Grand Valley, Mesa County, locality for two federally endangered species: Phacelia submutica and Sclerocactus glaucus (also in 11).

9. localities for Crypantha elata (catseye, cliffdweller's candlestick), a federally threatened species.

10. one of a few remaining localities for Echinocereus triglochidiatus var. inermis, a federally endangered species.

11. locality for Astragalus linifolius (Grand Junction milkvetch), a federally endangered species.

12. locality for Parthenium ligulatum (feverfew), a federally endangered species (also occurs in 5).

13. locality for Eriogonum viridulum (wild buckwheat), a federally threatened species.

14. locality for Crypantha stricta (catseye), a federally threatened species.

15. locality for Oxytropis obnapiformis, a federally endangered species of locoweed.

WILDLIFE

Wildlife in the region is highly varied. Mule deer are the most common large native mammal in the region. The Piceance Basin is the winter range feeding ground for the largest migratory herd in the United States. There are also wapiti in the higher elevations and pronghorn in the lower grasslands and on the sage-covered hills along the Yampa River. Coyotes are the most common terrestrial predator and there are a few mountain lions and bobcats. Badgers and raccoons are also found in the region. The area abounds in avian predators with red tailed hawks the best represented large raptor. There is a full complement of rabbits, small rodents, reptiles, and amphibians in the region. Bald eagles are peripheral to the area.

Wildlife provides a bench mark against which to measure the quality of life, as species frequently are the first to disappear due to excessive adverse development and pollution. It is important to maintain a broad diversity of species of wild animals for the benefit of present and future generations. Of particular significance in the region are the endangered wildlife species which are protected under Federal and State Nongame and Endangered Species legislation. Not enough is known about some of these species to fully describe historic and occupied range. For the purposes of this overview, only general locations for the endangered species have been noted. See NATURAL FEATURES II Map. Of fourteen species listed as endangered in Northwest Colorado, only seven species have occupied ranges at this time. The species which have had historical ranges but have not been observed in this region in recent years are: the gray wolf, grizzly bear, black-footed ferret, wolverine, river otter, lynx and bonytail chub. The seven endangered species that occupy ranges in the region at this time are as follows:

Colorado River Cutthroat Trout occupies a small range of some five acres on the Colorado River. Trout need cold, clear, well oxygenated streams which are devoid of introduced trout. The occupied area is considered essential for the maintenance of existing populations.

Razorback Suckers are attuned to a river environment where there is enormous fluctuation in flows, water quality, and shifting substrates. The decline of the suckers stems from rapidly changing land and water uses. They currently occupy the Yampa River in Dinosaur National Monument, the Colorado River from DeBeque downstream to the Utah state line, and the Gunnison River from Whitewater downstream to the Colorado River confluence. All waters containing razorback suckers must be considered essential for maintaining existing populations.

Humpback Chub are found in swift, silty currents of large rivers. With the building of Flaming Gorge Dam, both

the humpback chub and the bonytail chub disappeared from the Green River. A few of the humpback chub have been collected from the Colorado River. Present populations are unknown.

Colorado Squawfish are adapted to a large river environment with fluctuating discharge, silt loads and fluctuating temperatures. The development and operation of Flaming Gorge Reservoir eliminated the squawfish in the Green River. A few have been found in the Gunnison River near the confluence. These habitats are considered essential for the maintenance of the species in Colorado.

American Peregrine Falcons require adequate nesting habitat and extensive hunting habitat. Nesting sites are located on precipitous cliffs with ledges, potholes or small caves. The decline of falcons has been continuous. They have had the greatest access to small prey laden with pesticides; the result has been reproductive failure. All occupied sites must be maintained and all historic sites which are still suitable for occupancy should receive the same protection (Roan Cliffs, Dinosaur National Monument, Colorado National Monument, and Cathedral Bluffs).

Whooping Cranes need extreme isolation for their nesting areas. The experimental birds raised at Gray's Lake, Idaho, with Greater Sandhill Cranes as foster parents, winter near the Bosque del Apache Refuge in southern New Mexico. They use the flyway through Northwest Colorado and make a major rest stop each spring and fall at the Monte Vista National Wildlife Refuge, Rio Grande County. In May, 1976, one of these migrant birds was sighted in the Piceance Basin. No area in Colorado should be considered essential at this time. Use of the flyway is sporadic and unpredictable.

Greater Sandhill Cranes nest mainly along the mountain meadow drainages in portions of Moffat County, southwest of Craig along the Yampa River in an area known as Big Bottom. This two-mile area should be considered essential for the species.

COLORADO NATURAL AREAS PROGRAM

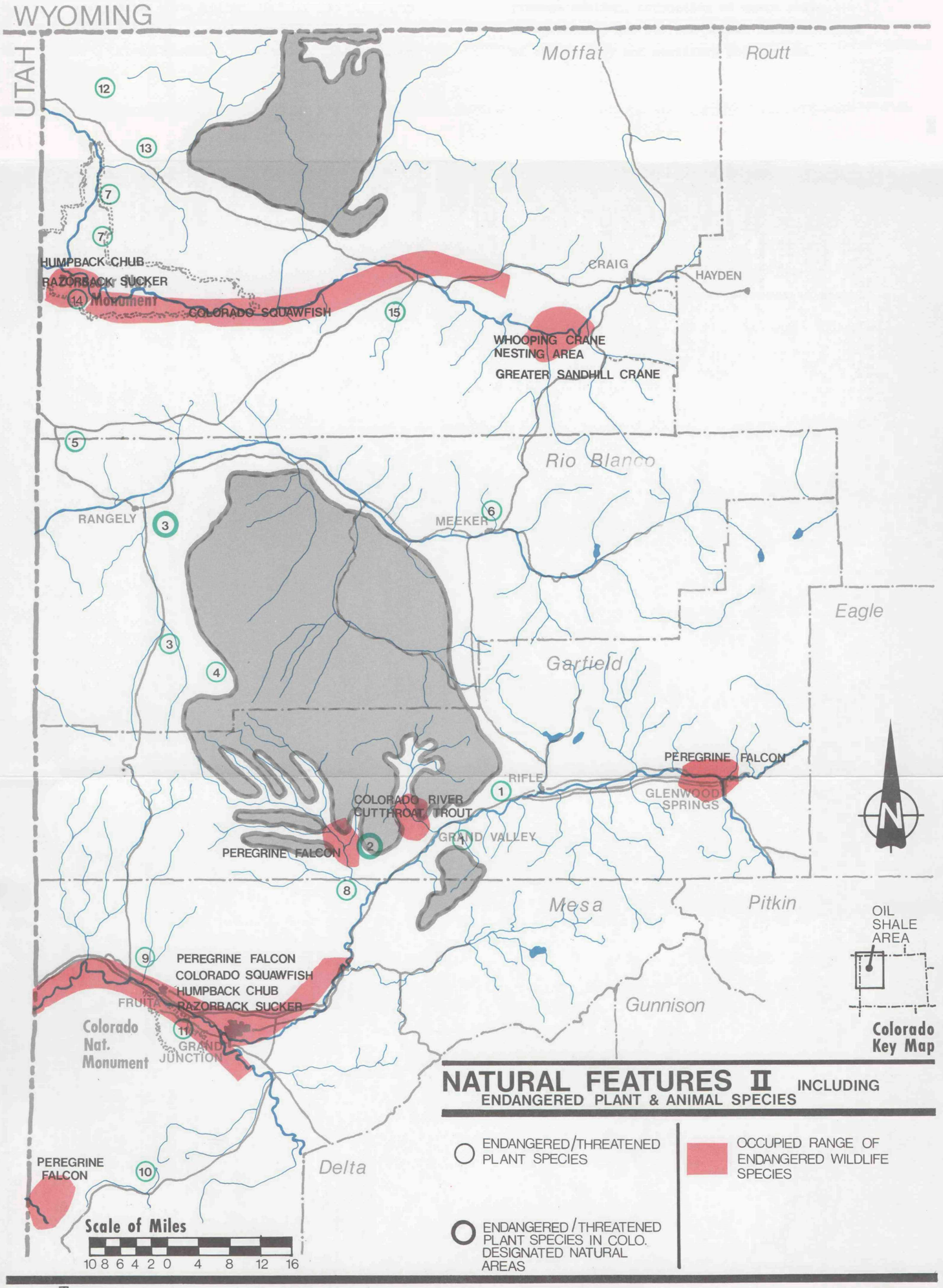
The Colorado Natural Areas Program, within the Colorado Department of Natural Resources, is mandated by the Natural Areas Act (signed July, 1977) to preserve, protect, perpetuate,

and enhance specific examples of Colorado's natural features and phenomena as an enduring resource, especially those threatened with irreversible change. The main responsibilities of the Program are: (1) to identify ecologically sensitive areas throughout the state; (2) to select from identified sites those containing rare or representative features worthy of protection; and (3) to protect, through the process of designation, selected sites, by negotiating legal arrangements with landowners. To identify priority areas for protection, the Program is currently implementing a natural heritage inventory to generate a comprehensive manual and automated data base containing all known information on native plant communities, geologic features and landforms, aquatic systems, soil types, and habitat for plant and animal species of endangered, threatened, or rare status.

INFORMATION ON ACCOMPANYING MAP
TAKEN FROM:

BLM: INITIAL WILDERNESS INVENTORY
FINAL 1979
BUREAU OF LAND MANAGEMENT
U.S. DEPARTMENT OF THE INTERIOR

INFORMATION ON PLANT SPECIES COMPILED BY:
COLORADO DEPARTMENT OF NATURAL RESOURCES



NATURAL FEATURES II INCLUDING ENDANGERED PLANT & ANIMAL SPECIES

- ENDANGERED/THREATENED PLANT SPECIES
- OCCUPIED RANGE OF ENDANGERED WILDLIFE SPECIES
- ENDANGERED/THREATENED PLANT SPECIES IN COLO. DESIGNATED NATURAL AREAS

FIGURE 5

COLORADO OIL SHALE: the current status, october, 1979
Department of Natural Resources
State of Colorado

WATER

The legal principle governing water rights in Colorado is the Doctrine of Prior Appropriation. According to this body of water law, two prerequisites are paramount in establishing a water right: (1) physical diversion from or storage of water on a natural watercourse, and (2) application of the water so captured to a beneficial use. When there is not enough water in a stream to satisfy all rights, those who acquired their rights most recently (i.e., junior rights) must cease diverting water. Thus, it is often said that the first in time is the first in right. A water right, subject to some limitations, may be transferred to a new use or a new place of use. In addition, water rights can be bought and sold as can any other interest in real property.

Recent studies by the Colorado Department of Natural Resources indicate that an oil shale industry of about 500,000 barrels per day could probably be established in Colorado without having to forego other projected consumptive uses of water. Present figures project approximately 6.000-8,000 acre feet per year of water use for each 50,000 BPD oil shale facility. Thus, ten such facilities could produce 500,000 BPD of oil from shale. It should be emphasized that uncertainty about hydrologic conditions and matters of river basin compact interpretation preclude the establishment of definitive water availability figures.

The amount of water actually used on a given oil shale site will be a function of (1) the generic type of recovery, either surface retort or in situ/modified in situ, and (2) the particular recovery process employed at that site. Surface retort facilities will consume water for mining operations, dust control, process cooling, compaction of waste shale, revegetation, and for the normal domestic needs of the primary and ancillary populations.

In the case of in situ or modified in situ processes, water would be consumed for similar purposes, except that it would not be needed for compaction and revegetation. However, the effect of in situ retorting processes on aquifers is not well understood and could possibly create significant water problems over broad areas.

While major oil shale companies have already appropriated or purchased a considerable number of water rights in the White and Colorado River basins (the accompanying map shows some of the potential water impoundment sites in the White River Basin), no data exist on the actual yield of these rights. In addition to the development or purchase of surface water rights, additional quantities of already impounded water may be available for sale from the U.S. Bureau of Reclamation. In particular, Green Mountain Reservoir, see Figure 3, may have 90,000 acre feet of water per year available for sale. Ruedi Reservoir, see Figure 3, does have 48,000 acre feet per year presently available. Once purchased, water could be released from the respective impoundment to flow along natural water courses to oil shale country, where it could then be diverted and pumped up to the site of oil shale facilities.

These conclusions about water supplies for energy development are adapted from the Upper Colorado River Basin 13 (a) Assessment, The Availability of Water for Oil Shale and Coal Gasification Development in the Upper Colorado River Basin, and from the Colorado Water Study, Directions for the Future. The research for both studies has been completed, and reports are being prepared by the Colorado Department of Natural Resources.

INFORMATION ON ACCOMPANYING MAP
PROVIDED BY:

WESTERN COLORADO PROJECTS OFFICE
U.S. BUREAU OF RECLAMATION,
UPPER COLORADO REGION

INFORMATION TAKEN FROM:

OIL SHALE DEVELOPMENT IN NORTHWEST COLORADO: WATER AND RELATED LAND IMPACTS

INSTITUTE FOR ENVIRONMENTAL STUDIES
UNIVERSITY OF WISCONSIN, MADISON
JULY, 1975

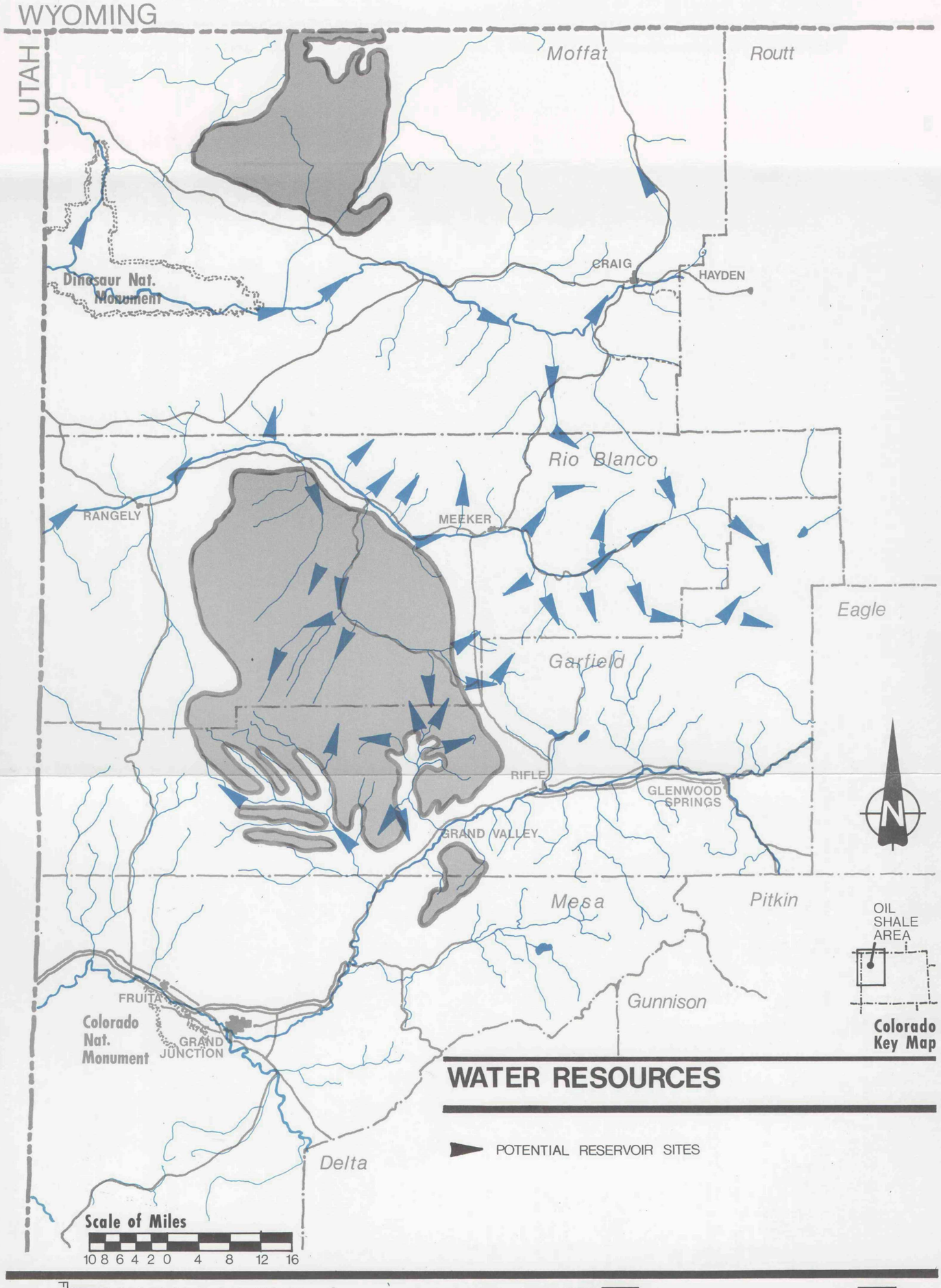


FIGURE 6

COLORADO OIL SHALE: the current status, october, 1979
Department of Natural Resources
State of Colorado

AIR QUALITY

Protection of air quality is a crucial consideration in the development of the oil shale resources of Northwest Colorado. Improperly handled, large-scale oil shale development could significantly impair the nearly pristine air quality in this corner of the state. Air quality can be protected if oil shale is responsibly developed.

The maintenance of high air quality conditions in the northwestern sector of Colorado is mandated by Federal and State laws that are intended to protect the public health and welfare (welfare includes aesthetic considerations, including clear visibility). At the present time, Northwest Colorado enjoys very good qir quality, with no known occurrences of sustained violations of air quality standards. The challenge will be to ensure that this high air quality is maintained, and that oil shale development does not introduce significant levels of air pollution into the area.

There are two principal threats to air quality from oil shale development. The most obvious is that of the direct oil shale mining and processing activities themselves. These activities will affect not only the air quality "on-site" at the facilities themselves, but may also affect air quality in areas many miles distant. The key factors in preventing such air pollution will be the types of oil shale mining and processing technologies employed, the overall scale of oil shale development, and the air pollution control techniques used. If available air pollution control methods are conscientiously employed, the direct effects of oil shale development on air quality should be minimal.

A source of air pollution more difficult to control will occur "off-site." Motor vehicle traffic engendered by large-scale oil

shale development and oil shale-related urbanization in Northwest Colorado will significantly worsen air quality, unless effective approaches to accommodating this growth are pursued. This will require an active partnership of the area's local governments, the State and Federal governments, and the private industry.

AIR QUALITY STANDARDS

The process of extracting crude oil from oil shale emits sulfur dioxide (SO_2), total suspended particulates (TSP), nitrogen dioxide (NO_2), hydrocarbons, and carbon monoxide (CO). In order to protect human health and welfare from these potential hazards, numerous air quality standards have been developed. These standards have been adopted by the EPA and the Colorado Air Quality Control Commission. The most critical set of standards applying to oil shale development are those associated with Class I and Class II PSD (Prevention of Significant Deterioration). PSD standards apply in certain designated geographic areas and allow ambient air quality increments above the baseline concentration. The designated areas are categorized according to the existing levels of air quality and the values that are being protected. Class I areas are clean, pristine regions which include all national parks and monuments, wilderness areas, and other designated protected areas. Class II areas are intended to allow moderate human activity and industrial development. Only SO_2 and TSP emission sources are regulated under PSD. The following table identifies the numeric standards that are the most critical for oil shale development in Northwest Colorado:

	Class I* (μ/m^3)	Class II* (μ/m^3)
Particulates (TSP)		
Annual	5	19
24 hour	10	37
Sulfur Dioxide (SO_2)		
Annual	2	20
24 hour	5	91
3 hour	25	521

*Increments above the baseline

EXISTING AIR QUALITY

A substantial amount of information has been collected concerning the existing air quality and meteorological conditions in Northwest Colorado. The AIR QUALITY Map, Fig. 7, indicates how the uniform baseline concentration has been monitored, and its levels of pollutant concentration will be used as a baseline for controlling all future activity that affects air quality. This baseline, in micrograms per cubic meters:

	Baseline Level (μ/m^3)
Particulates (TSP)	15-20
Sulfur Dioxide (SO_2)	25
Nitrogen Oxide (NO_x)	10
Carbon Monoxide (CO)	100
Ozone or Photochemical Oxidants (O_3)	70

The general wind direction and speed information are also illustrated in Figure 7. Weather conditions, i.e., the direction and speed of winds, temperature and precipitation occurrence, will strongly affect air quality in the oil shale region of Colorado.

AIR QUALITY CONSTRAINTS

The most critical air quality constraint to commercial oil shale development is compliance with the SO_2 Class I PSD standard for the Flat Tops Wilderness area. One-third of the PSD increment for the Class I area upwind of the Colorado oil shale region is already used up by permits awarded to Union and Colony oil shale operations. Those permits allow a production of about 70,000 barrels of oil per day. Some difficulties may also occur in meeting State and Federal requirements for ambient air concentrations for TSP in the urbanized cities of Northwest Colorado due to induced population growth.

STATE'S APPROACH

The State currently has the regulatory and statutory structure to attain and maintain air quality values in Northwest Colorado. A substantial amount of technical information is

available to make decisions. However, this regulatory structure is focused on a project (plant-by-plant) review without necessarily considering the regional perspective. Furthermore, State procedures are not totally consistent with Federal procedures and requirements. Additional resources will be needed to perform regional analyses and to consolidate State-Federal processes.

INFORMATION ON ACCOMPANYING MAP
PROVIDED BY:

U.S. ENVIRONMENTAL PROTECTION AGENCY

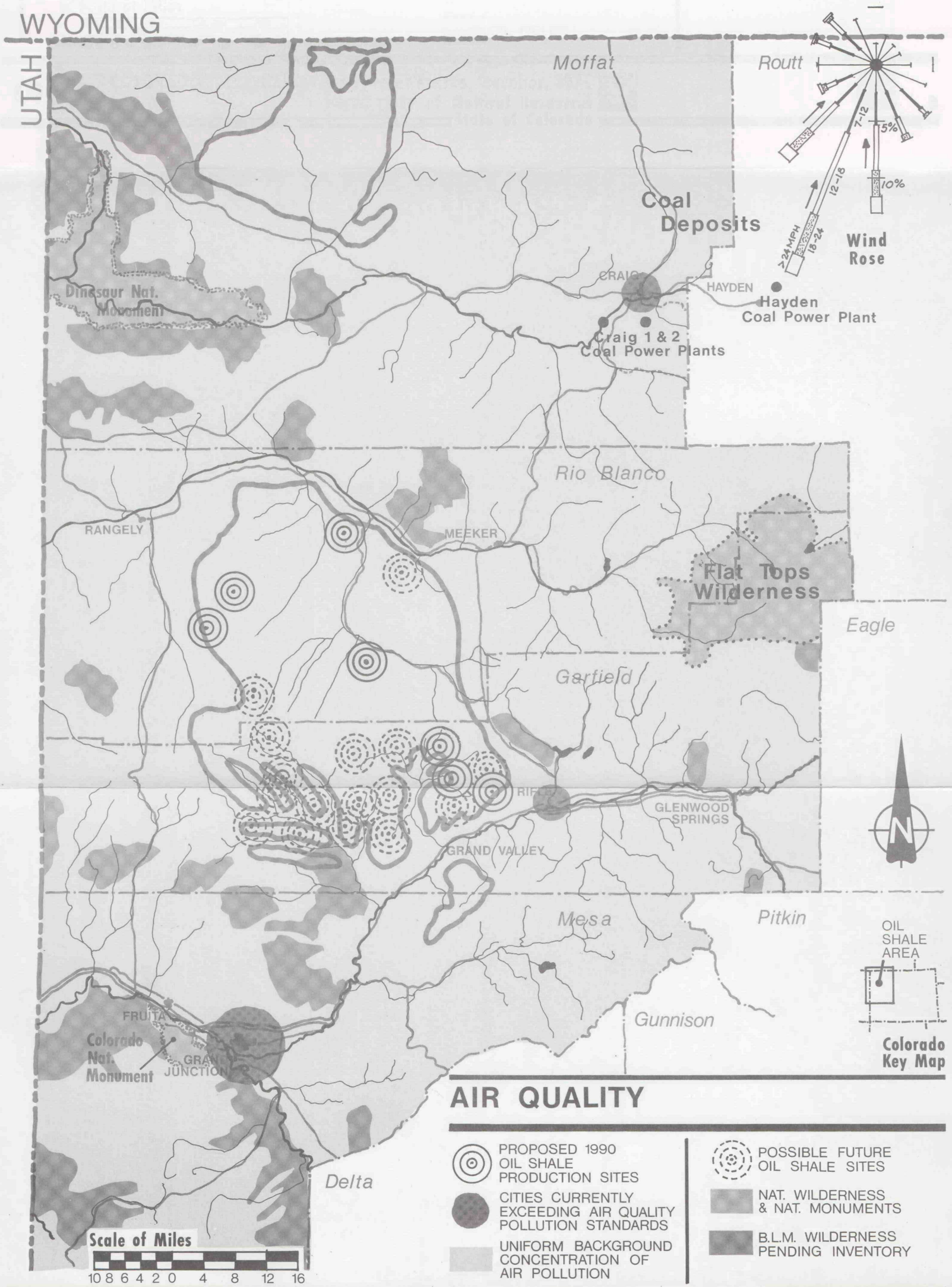


FIGURE 7

COLORADO OIL SHALE: the current status, october, 1979
Department of Natural Resources
State of Colorado

ENERGY RESOURCES

Oil shale development will exert a powerful impact on Northwest Colorado. However, that region also has a variety of other energy and mineral resource deposits. There is already considerable coal, uranium, and oil and gas activity there. In 1978 Northwest Colorado (State Planning Regions 10, 11, and 12) accounted for 13.3 million tons, or 94 per cent, of the State's total coal production. In addition, in 1978 Rio Blanco County alone produced 21.7 million barrels, or 59 per cent of Colorado's petroleum, and holds more than half of the State's oil reserves. In that same year, Rio Blanco produced 16 per cent of the State's natural gas total (30 billion cubic feet).

There is every indication that even higher levels of coal production are imminent. For 1990, projections are that 35.4 million tons to 58.4 million tons of coal will be produced in Northwest Colorado. In addition, significant reserves of natural gas are locked in deep, tight formations; these appear promising, but production will be difficult. Important deposits of uranium are also located just south of the Piceance Basin.

The map below presents an overview of Colorado's important energy resources which overlap oil shale deposits. Concurrent with the development of oil shale, demand for development of these other resources is expected to increase. The resultant total development and growth in Northwest Colorado will most likely bring about major problems with transportation, water availability, social infrastructure, and environmental quality.

INFORMATION ON ACCOMPANYING MAP
TAKEN FROM:

USGS ENERGY RESOURCES MAP

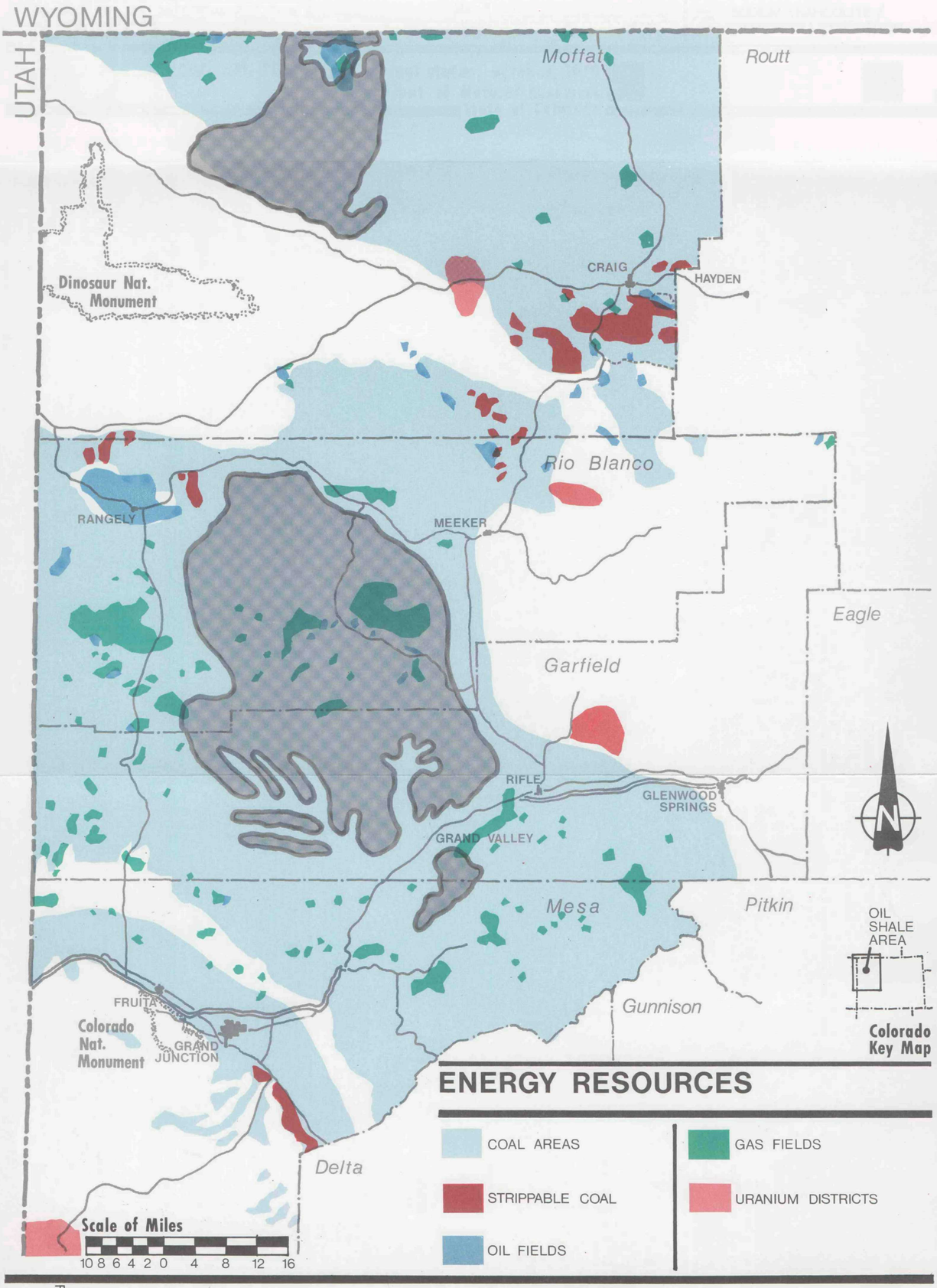


FIGURE 8 COLORADO OIL SHALE: the current status, october, 1979
Department of Natural Resources
State of Colorado

COAL & URANIUM ACTIVITY

While the focus of this document is on the current status of the oil shale industry in Colorado, there are other factors which might have a synergistic effect on development in Northwest Colorado, and projected expansion of production from coal and uranium resources in the area is one such factor.

Major coal mines and major new mining activity are shown in Figure 9. In the concerted push for synthetic fuels development, coal gasification/liquefaction is also attracting considerable interest. With the abundant coal resources in Northwest Colorado, Moffat County is a possible candidate for the State's first coal gasification plant, since existing gas distribution networks are nearby. Development would likely not occur before 1988, and at that time would require additional large quantities of coal as a feed stock.

Union Carbide has a uranium mill with capacity of about 1,300 tons per day just south of the Piceance Basin at Urivan, Colorado, and there are considerable uranium resources in the Colorado-Utah area of the Colorado Plateau. A new Pioneer-Urivan uranium processing mill with 1,000 tons per day capacity is projected for this area at Slickrock. There is a smaller, heap leaching uranium operation in Maybell and a small uranium-vanadium mill in Rifle, but this particular mill has processed only vanadium since 1972. Grand Junction is a recognized, regional hub for the uranium industry, and the U.S. Department of Energy has an important uranium office there.

INFORMATION ON ACCOMPANYING MAP
TAKEN FROM:

USGS ENERGY RESOURCES MAP

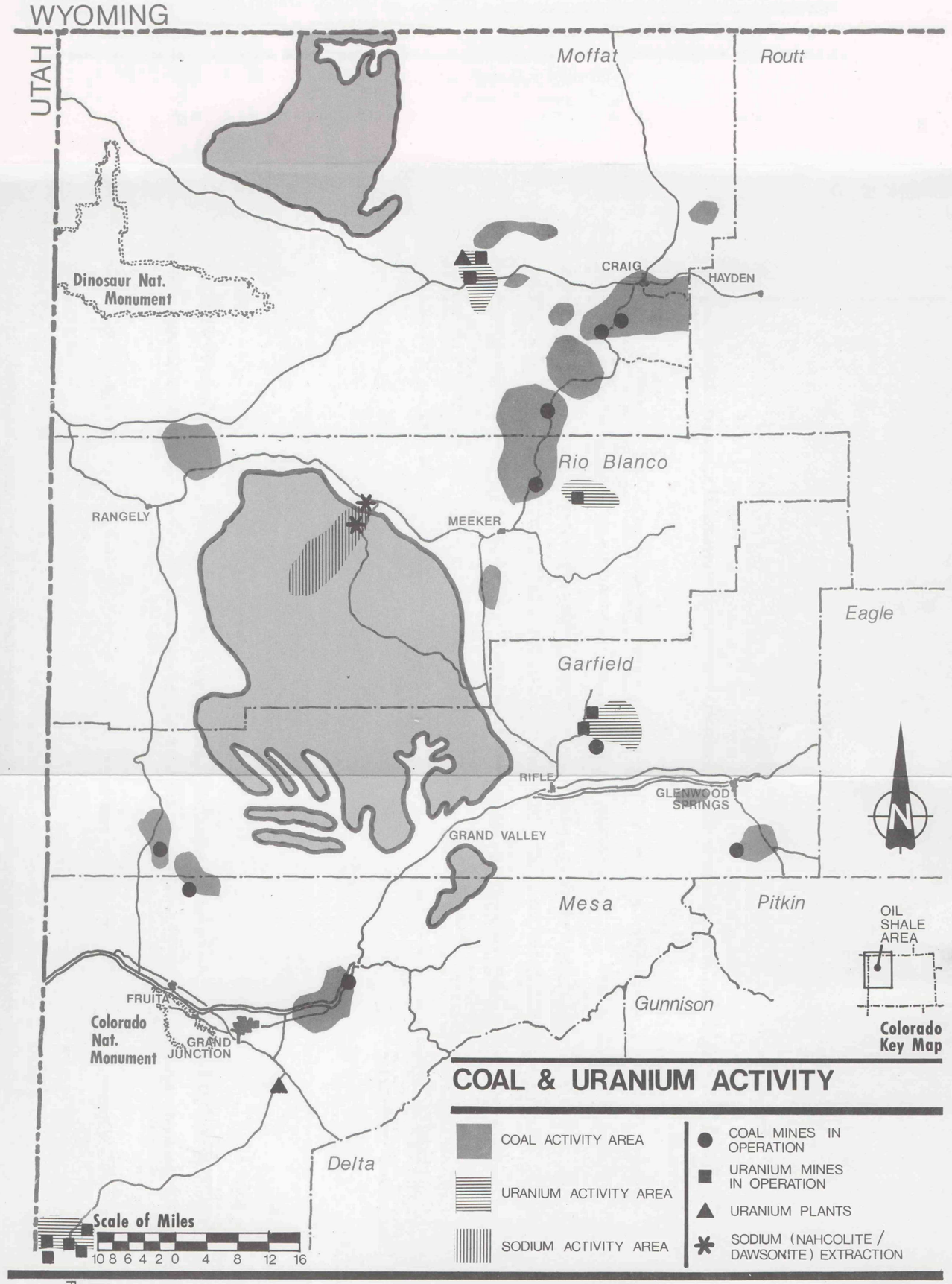


FIGURE 6 COLORADO OIL SHALE: the current status, october, 1979
Department of Natural Resources
State of Colorado

LAND USE

The emerging oil shale industry is destined to exert a powerful influence on the land use and customs of Northwest Colorado, an area that is primarily rural in nature. In this region the towns are small, the pace is slow, the population has deeply established roots, and people are generally comfortable with existing conditions. Agriculture and ranching, together with tourism--fostered by the natural, uncluttered landscape--are major sources of livelihood. Agricultural production in Northwest Colorado is a small proportion of the state total, but it is a significant contributor to the economic activity of the counties in this Northwest region.

While accommodation to change is difficult, the proposed oil shale development will likely create alterations that reach well beyond mere rearrangement of well established and traditional patterns of livelihood. These changes might be more indirect than direct, however, and have more to do with community stability, changing customs, and the availability of labor for traditional agriculture, than with the more easily measurable question of direct energy competition for land and water.

Present land use does not conflict directly with industry development plans for oil shale sites; it is unlikely that oil shale commercialization will directly displace significant tracts of fertile farm and grazing land. Much more subtle encroachments do appear likely, including labor displacement and changing land values which will lead to indirect land displacement.

The projected increase in energy activity will drive up wages, making it difficult for agricultural enterprises to compete for agricultural labor. The economics of farming

prohibit agriculturalists from matching the $8 to $10 per hour wage scale which is the current norm in the energy industry. An increase in total demand for labor in Garfield, Rio Blanco, and Moffat counties will compete with the already meager agricultural labor pool. Farm and ranch workers are valued by the energy industries as a source of labor because of their experience with machinery, willingness to work, and desire to remain as long-time residents in the energy impact areas.

To put the land use impact of expected energy development in perspective, it is essential to understand present land ownership patterns in Northwest Colorado. Historically, the early settlements occurred along the rivers in order to secure a reliable source of water. Consequently, private land ownership is currently concentrated along roads and rivers and is surrounded by publicly-owned lands. This will mean that some of the initial oil shale development will occur on privately owned lands presently held by energy companies. Of even more significance for land use patterns is energy-related urban expansion; as this occurs, it will encroach upon the available private, rather than unavailable public, lands adjacent to present communities. The resulting pressures will turn some prime agricultural land into shopping centers and subdivisions.

Agriculture cannot compete directly with energy companies for land, water, and labor, because of a number of economic factors that are national in nature and beyond the control of any single state. And yet, the preservation of agriculture is essential to maintaining the diversity, balance, stability, culture, and character of Northwest Colorado. Indeed, on a national scale, it would be foolish to systematically destroy agriculture at the expense of energy production, only to find in the future that food production has become a larger world problem than energy is now. Colorado is concerned about the impact of energy development on land uses and is committed to maintaining a

viable role for agriculture in the State's economy.

The Colorado Department of Agriculture's Resource Analysis Section has identified these likely impacts of energy development on agriculture as part of a two-year study of agricultural land conversion. One of the products of this study will be a published report: The Conversion of Agricultural Land in Colorado. This document describes trends of agricultural land conversion, analyzes causes and consequences, and discusses options for responding to this land conversion phenomenon.

INFORMATION ON ACCOMPANYING MAP
TAKEN FROM:

OIL SHALE AND THE FUTURE OF A REGION,
COLORADO WEST AREA COUNCIL OF GOVERNMENTS

WESTERN COLORADO COAL ENVIRONMENTAL IMPACT STATEMENT
BUREAU OF LAND MANAGEMENT
U.S. DEPARTMENT OF THE INTERIOR

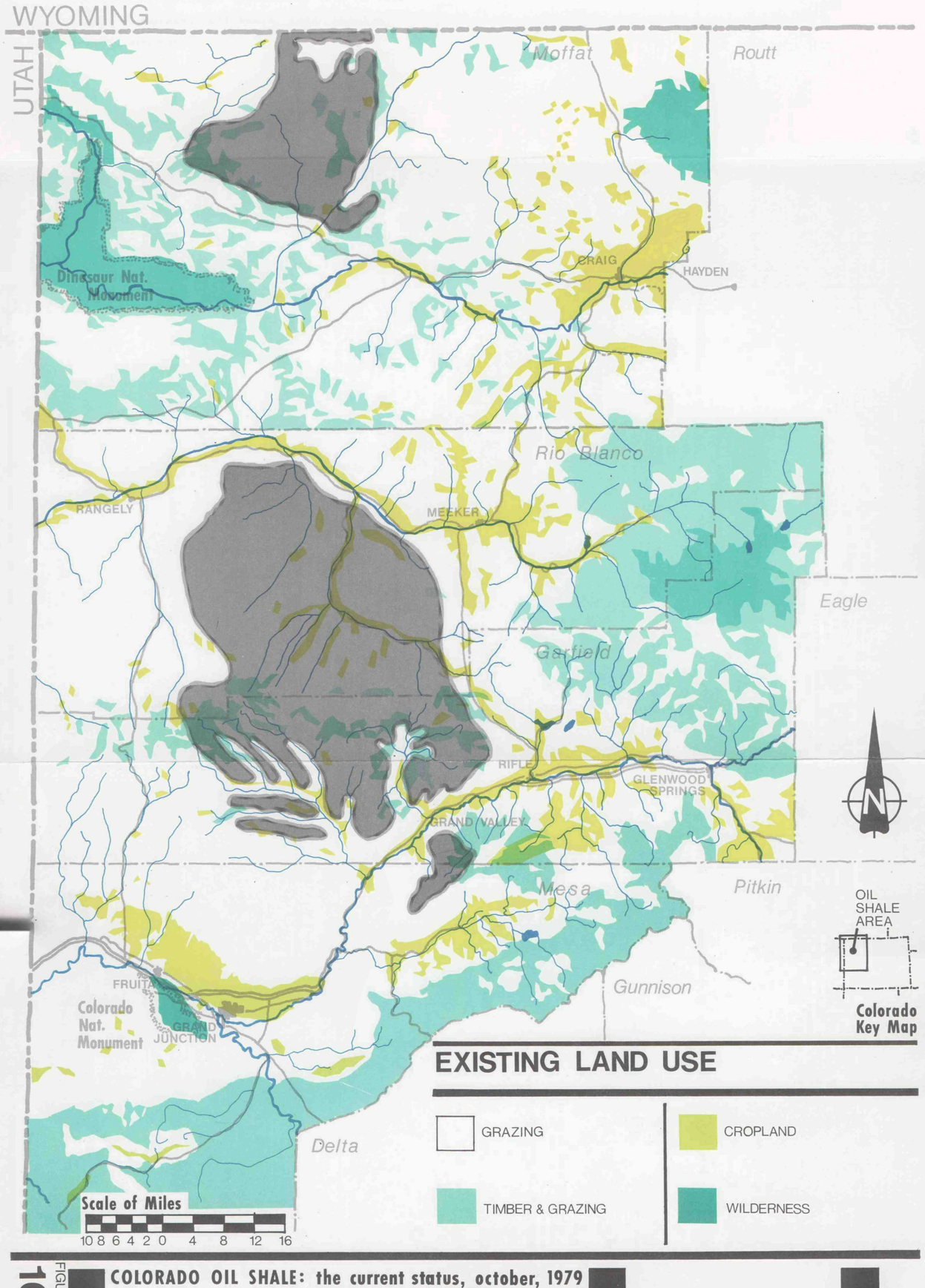


FIGURE 10 COLORADO OIL SHALE: the current status, october, 1979
Department of Natural Resources
State of Colorado

POPULATION & COMMUNITY INFRASTRUCTURE

Any future production of energy in Northwest Colorado will have important consequences for land-based and environmental characteristics and conditions. It will also result in increased population, which will have a series of secondary and off-site impacts. In order to measure the full impacts of the multi-resource energy development expected to occur in this area, the Impact Division within the Colorado Department of Local Affairs has developed a series of population projections based upon possible future energy production levels. The projections cover Colorado Planning and Management Regions 10, 11, and 12, which include 16 counties in Northwest Colorado as well as four energy resources: oil shale, coal, uranium, and oil and gas.

The construction and operation forces expected to be required for further levels of energy production have been adjusted to include the families who would accompany those workers. The resulting total new population has been allocated to the communities most likely to receive these additional energy workers. This influx of basic and non-basic new workers and their dependents has been added to the baseline population projections developed by the State Demographer for specific communities and counties. The population projections for Northwest Colorado for a high level of multi-resource energy production are as follows:

POPULATION LEVELS

(Population in Thousands of Persons)

	Actual 1974	Actual 1978	Projected for High Level of Energy Production 1985	1990
Region 10	47.5	53.6	65.7	77.0
Region 11	87.9	105.9	190.5	242.6
Region 12	19.3	24.0	44.1	60.1

One of the most profound impacts of high levels of energy production is the very rapid growth that will occur in individual communities in Northwest Colorado. The following table ranks communities by their per cent growth to 1990:

COMMUNITIES BY THEIR PER CENT GROWTH TO 1990

(Population in Hundreds of Persons)

		High Level Energy Production		
Community	Actual Population Level in 1978	Projected Population Level in 1985	1990	Projected Population in 1990 as Per Cent of 1978 Base
Rifle	23	373	347	1509%
Grand Valley	4	29	33	825
Silt	10	80	80	800
Meeker	19	103	141	742
Rangely	19	140	106	558

The implications of a high level of energy production in Northwest Colorado go beyond the actual levels of energy produced and the basic increases in population. A high level of energy production means that Northwest Colorado will, by 1990, be producing 58 million tons of coal per year where it currently produces 13 million tons per year; 3.3 million pounds of uranium where it currently produces 2.2 million pounds per year; and 360,000 barrels of crude oil per day where it currently produces none. This level of development will produce approximately 35,000 basic jobs and an additional number of non-basic or support jobs. The new population that will result from the employment influx will reach 150,000 and will double the existing population. All this will be layered upon an area that is already undergoing rapid growth for reasons other than energy development. This "non-energy growth" alone could account for an additional 60,000 new people arriving during the 1980's. It is this rapid growth and the effects that it will have upon Northwest Colorado which define the concept of impact.

More specifically, the energy-related employment and its attendant population will necessitate massive increases in virtually every support system currently in use in the affected area, as well as creation of certain new ones. Domestic water systems will require an additional 31,222,000 gallons per day of treatment and supply capability as well as 155,446,000 gallons of storage capacity for an estimated rough cost of $91,054,000 (in 1979 dollars). The Colorado Water Conservation Board estimates that the development costs of the water required to meet domestic demands will be approximately $210,500,000.

WATER TOTAL	$301,554,000

The proper disposal of domestic waste water will require an additional 14,836,600 gallons per day of treatment capacity.

SEWAGE TOTAL	$ 96,700,000

Education to serve the energy-related population requires the addition of 40 elementary schools and 16 high schools.

SCHOOLS TOTAL	$184,500,000

Police and fire protection require an additional 114 vehicles and 80,700 square feet of space.

POLICE & FIRE PROTECTION TOTAL	$ 25,102,000

Local Government Services, including traditional services such as public works and streets, will require 973,000 square feet of space and additional materials.

LOCAL GOVERNMENT SERVICES TOTAL	$276,000,000

Estimates from the Department of Health call for significant increases in health facilities, manpower and equipment.

MEDICAL SERVICES TOTAL	$ 50,000,000

Other human services will require 248,349 feet of space.

OTHER HUMAN SERVICES TOTAL	$ 82,500,000

Parks and recreation for the community infrastructure will require the purchase of equipment and 1,623 acres of land.

PARKS & RECREATION TOTAL	$ 49,200,000

The provision of housing may be one of the most important aspects of mitigating adverse impacts. This service usually falls within the purview of the private sector. Recent federal programs, however, offer some relief in the acquisition of sites for housing. Housing site costs are listed here for 58,546 housing units with attendant site development costs.

HOUSING TOTAL	$651,000,000

The operational expenses tied to the above capital improvements in the public sector exceed $158,000,000 per annum through 1990.

PUBLIC SERVICES TOTAL $1,057,000,000
(excluding housing and highway costs)

Aside from the quantifiable impacts addressed above, there are several intangible dimensions to growth which add to the impact picture. The mere spectre of change is sometimes difficult to accept. This is especially true in areas where the change process has not kept pace with the norm. In many of the areas projected to be affected by "boom" growth, population, values, and attitudes have undergone little change in the last two decades or more.

The economic aspects of growth are generally welcomed at face value and accommodations are made to take advantage of new-found wealth. However, the type of planning and attitude adjustment required to integrate change into the community over the long haul is more difficult. As new people arrive and settle in large numbers, the general state of community unpreparedness becomes more and more evident. This, in turn, foments dissatisfaction with the old order. When the population shifts from a majority of old to new, the old guard is relieved and new people begin to take over. Since the attitudes, values, and perceptions of the new people differ markedly from those of the old, the change is thrust upon the old residents. Many adapt and integrate back into the new community. Others, however, cannot make the shift; alienation, isolation and a variety of other phenomena are the results.

The identification and mitigation of impacts related to energy development are responsiblities of the Division of Energy and Mineral Impact Assistance, Colorado Department of Local Affairs. A Growth Monitoring, Evaluation, and Forecasting System is under development which will provide current information on employment patterns and allow projections of future employment. The establishment of impact development

standards will allow a comparison of community resources for growth against requirements for new facilities, resulting in more reliable information on impact assistance needs. A State Investment Program is also being developed which will provide for the implementation of development goals insofar as State resources will permit.

A set of ten Human Settlement Policies helps provide direction to the State of Colorado on how to accommodate population growth that is projected to occur. The Division of Planning, Colorado Department of Local Affairs, has published these in: Colorado's Human Settlement Policies. Basically, these policies are designed in response to such problems of growth as deteriorating air quality, energy scarcity, inflation, waning governmental resources, and changing economic bases. They are intended to provide a long-range framework for orderly growth, but are not expected to produce rapid or drastic changes since they are constrained by existing patterns of development and the limited role which State Government plays in the development of future events.

INFORMATION ON ACCOMPANYING MAP
PROVIDED BY:

DIVISION OF ENERGY AND MINERAL
IMPACT ASSISTANCE
COLORADO DEPARTMENT OF LOCAL AFFAIRS

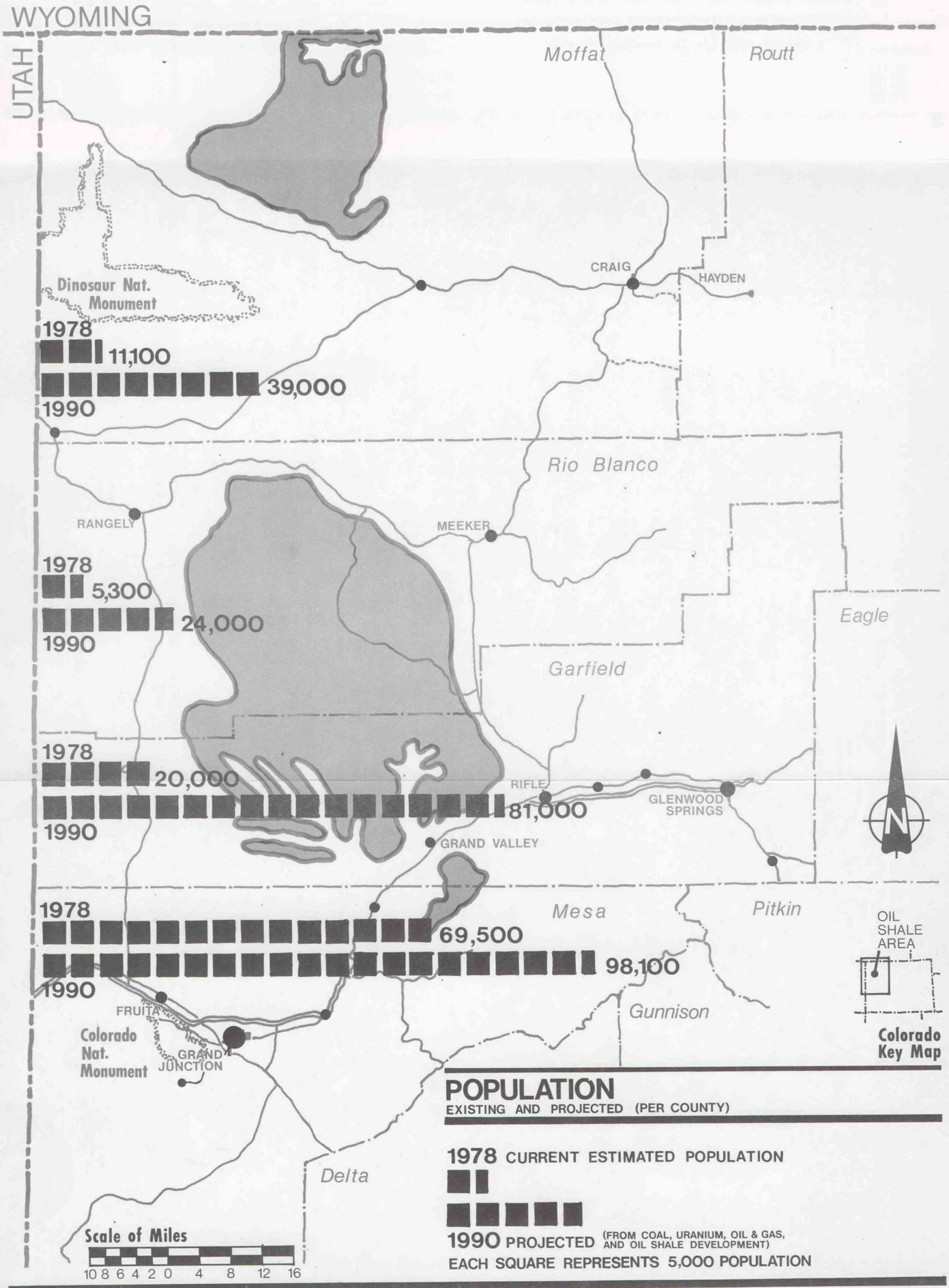


FIGURE 11 COLORADO OIL SHALE: the current status, october, 1979
Department of Natural Resources
State of Colorado

TRANSPORTATION

Energy development is currently having a significant impact on Northwest Colorado's transportation system. Any acceleration of the current rate of energy resource development in that area will exacerbate the present situation. To identify transportation requirements associated with a high level of multi-resource energy production, the Colorado Department of Highways has examined the potential impacts associated with: increased use of public roads for hauling coal to its point of use or shipment; increases in the number of coal train movements; and the impacts which can be expected on the regional highway system from expected growth of the oil shale industry. Figure 12 below shows existing roads, rail lines, and airfields.

This region is served by two U.S. numbered routes in the east/west direction: I-70 to the south and U.S. 40 to the north. Colorado Routes 13 and 82 are the main north/south routes. The existing rail system parallels I-70 along the Colorado River and closely follows U.S. 40 in the north. Coal is a major freight item for the railroads, and extension of the D&RGW spur line from Craig to the COLOWYO coal mine was completed in 1979. The D&RGW has recently replaced the Craig line with heavy rail, centralized traffic control, and additional sidings.

It should be noted that, while there are several airports which serve oil shale country, Grand Junction has the only airport, Walker Field, between Salt Lake City and Denver which can accommodate jet aircraft in the B-737 and B-727 family. Walker Field is also the only airport in the oil shale region with key facilities such as an airport traffic control tower, a precision instrument landing system, and an on-site flight service station.

The development of oil shale under a

high-level energy production scenario will have significant impact on Colorado transportation systems. Once individual oil shale plants reach a rate of production over 15,000 barrels per day, pipelines will probably be used to ship the product. However, until that production level is reached, trucks will be used to haul the product. Under the high scenario, in 1985 there will be 571 loaded trucks carrying oil extracted from shale to pipelines or railheads for shipment. This means that 1,142 truck trips per day (571 x 2) will take place on a few regional roadway facilities in Rio Blanco and Garfield counties. After 1990 the presence of pipelines is expected to reduce the number of truck trips to 352 per day. If for some reason the pipelines are not in place, there will be 5,142 truck trips per day in 1990. Such a situation would not only be uneconomical for the oil shale producers, but would also, in effect, close the highway system to all except truck traffic.

Extensive oil shale development is expected to increase average daily highway traffic counts in the area by approximately 50%. Increased traffic will create the need for a limited amount of widening, some climbing lanes, a significant amount of overlays, and other mitigation measures. The programmed road improvements shown in Figure 12 are those for which major decisions have been made and are being implemented. In this implementation category, State Highway projects through 1985 include completion of I-70 from Anvil Points, west of Rifle, to DeBeque Canyon, and widening or resurfacing segments of Colorado 13, 146, and 65. Construction also will be underway on I-70 in Glenwood Canyon. Rio Blanco County plans to complete the road from Rangely to lease tract site C-a, as the availability of outside funds allows.

In 1977, about $9 million was spent by cities and counties for streets and highways in the oil shale region, and State Highway

Department expenditures totaled about $3.5 million in the four-county area during that year. The Colorado West Area Council of Governments has recently released a draft Colorado West Transportation Plan which identified $40.8 million of needs on roads other than the region's portion of the Interstate Highway System through 1990. The Highway Commission has already committed $8.5 million of the $40.8 million as a part of its 1980-1984 5-Year Capital Improvement Plan, leaving $32.3 million worth of needs unfunded.

The Colorado Department of Highways has established an Office of Energy Programs to deal with the wide variety of energy-related activities influencing transportation in Colorado. There are three program categories where the work of this office will be focused: energy development impact mitigation, energy conservation, and energy assessment.

INFORMATION ON ACCOMPANYING MAP
TAKEN FROM:

COLORADO WEST TRANSPORTATION PLAN
(Draft) by:
TRANSPORTATION DEVELOPMENT
ASSOCIATES, INC.

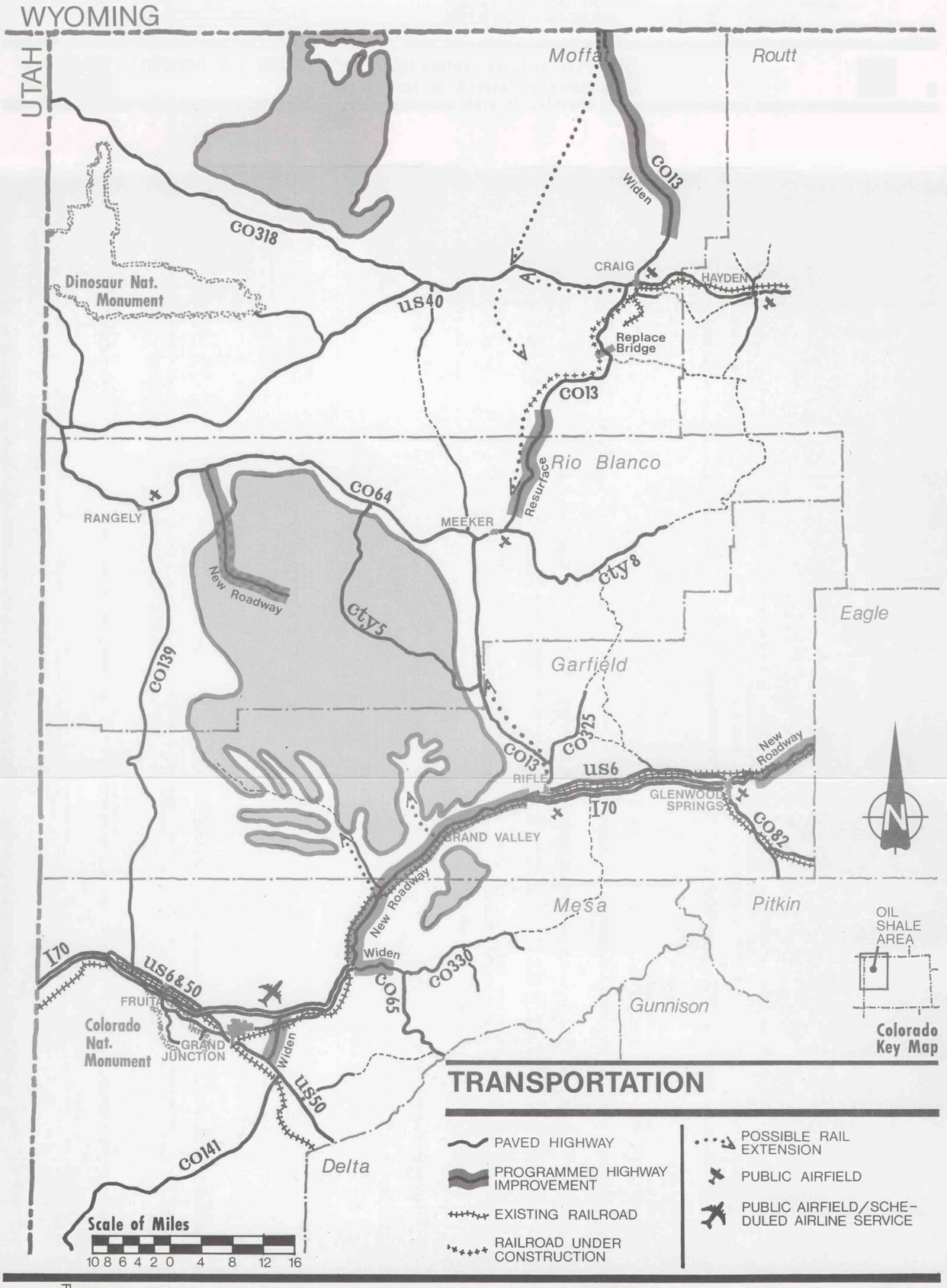


FIGURE 12 COLORADO OIL SHALE: the current status, october, 1979
Department of Natural Resources
State of Colorado

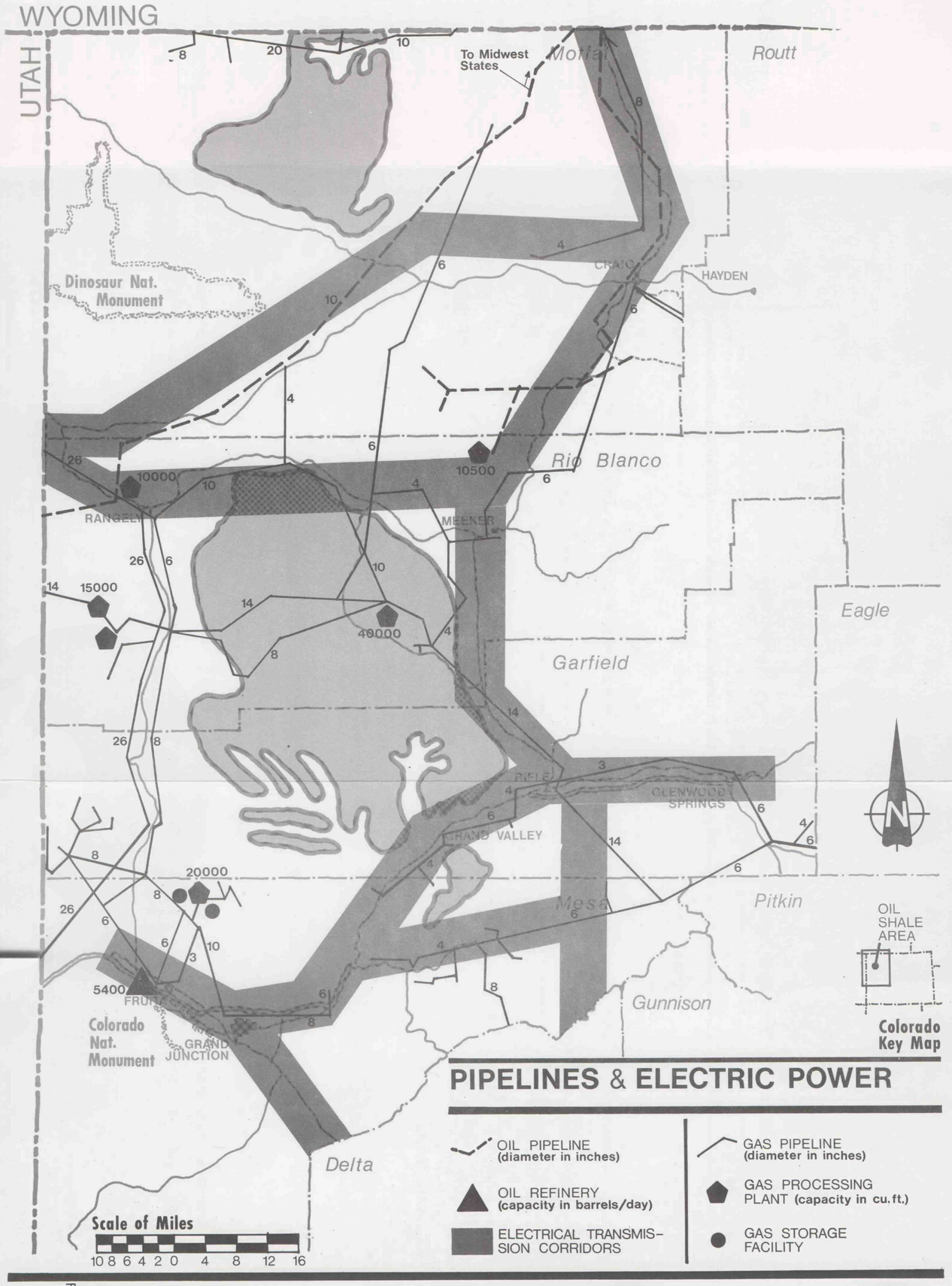
PIPELINES & ELECTRIC POWER

The oil shale region has an extensive set of natural gas pipelines and electric power transmission corridors. These can be extended to serve the needs of oil shale development, although concurrent development of the area's multi-energy resources and the ancillary growth may require additional generation capacity. Commercial oil shale operations may be able to use some low BTU by-product gas to generate enough electric power to meet most of their on-site needs and may even be able to add surplus electricity to the grid system.

The existing crude oil pipeline system is shown in Figure 13. Crude oil from shale might require a pre-refining step, and the only existing oil refinery in the area is at Fruita, northwest of Grand Junction. This refinery would need perhaps $50 million in upgrading to make it suitable for processing crude oil from shale, and there is no existing pipeline from the site areas to the Fruita refinery. Once refined, the oil could join a national distribution pipeline network by connecting with the 10-inch service line which passes just north of Rangely, subject to available capacity in that line. This routing would allow the delivery of the oil to midwest refineries and markets or to local markets in Colorado. There is no need to augment the deliveries of Alaskan crude to the West Coast. Deliveries to Gulf Coast refineries and petrochemical markets would require new connecting lines to the west towards Utah, then south to the San Juan Basin.

INFORMATION ON ACCOMPANYING MAP TAKEN FROM:

COLORADO WEST TRANSPORTATION PLAN (Draft) by:
TRANSPORTATION DEVELOPMENT ASSOCIATES, INC.



THE COLORADO JOINT REVIEW PROCESS

In anticipation of national pressure to develop Colorado's energy resources and in response to current energy and mineral resource development trends, Colorado independently recognized the need for improvement in government regulatory and review processes. In November of 1978, the Colorado Department of Natural Resources (supported by the U.S. Department of Energy) began a study to develop a rational, practical procedure that will coordinate federal, state and local decisionmaking processes associated with major energy and mineral resource development projects in the state. This effort is called the "Colorado Joint Review Process for Major Energy and Mineral Resource Development Projects." The product of this study will be a Joint Review Process Manual. It will detail coordination procedures and provide information on major federal, state and local permits. In conjunction with this program, the Department is participating in a joint venture with the U.S. Forest Service, Gunnison County and AMAX to coordinate the required governmental reviews associated with AMAX's proposed Mt. Emmons molybdenum mine near Crested Butte, Colorado. The AMAX "joint review" is serving as a case study during development of the generic "Joint Review Process."

DESCRIPTION OF THE JOINT REVIEW PROCESS

The Joint Review Process may be defined as:

> A voluntary, intergovernmental review procedure which coordinates existing regulatory reviews between the three levels of government, provides the public with additional opportunities to become involved in all phases of project planning and review, provides industry with additional opportunities to increase public awareness of project plans and promotes government by cooperation and compromise rather than "government by ambush."

Generally, the Joint Review Process is designed to address major energy or mineral resource development proposals. A broad definition of "major" has been developed for use in determining those projects that are "major" in character. A major project is one which will probably result in significant impacts, will involve regulatory decisions from two or more levels of government, and/or may be considered significant and controversial.

The Joint Review Process is a voluntary procedure. It offers industry an organized and systematic alternative to the existing fragmented and uncoordinated array of governmental reviews.

The process brings the three levels of government together in a common forum with the proponent on a regular basis to discuss governmental requirements, project plans and related issues and concerns.

It is designed to apply only to those projects that have recently completed the initial exploration phase and are about to commence design and feasibility studies.

The process is currently designed to address any of the following projects:

1. Coal mines
2. Uranium mines and/or mills
3. Oil shale development
4. Other metal mining developments

Finally, the process is designed to provide the public with additional opportunities to participate early, continuously and informally throughout the review of a major project.

OPERATION OF THE JOINT REVIEW PROCESS

There are three stages in the Joint Review Process. These stages will be described in detail in the Joint Review Process Manual scheduled for publication later this year.

Stage 1 commences when an industry proponent notifies the Department of Natural Resources that he is interested in considering the Joint Review Process alternative. The Department will ask the proponent to complete a general project description questionnaire. Based on that information, the Department will evaluate the project to determine if it qualifies as a major project and if the project is in an early stage of planning (i.e., completion of exploration or beginning of design/feasibility). The Executive Director of the Department will consult with principal agencies in state, local and federal government to determine if those agencies would be willing to participate in a joint review. The Director will formulate a recommendation and seek

concurrence from the Governor's Cabinet. If the Cabinet's decision is affirmative, the Governor will assign a state lead agency.

Stage 2 commences upon the Department's receipt of an affirmative answer from the Cabinet. During this six to seven month period numerous organizational activities will occur which include the following:

1. Through a process of negotiation, federal and local government coordinating agencies will be identified.

2. A Joint Review Team will be organized, which will be comprised of the three government lead agencies and the proponent. The team has no decisionmaking authority. Its function is to coordinate.

3. A cooperative agreement will be signed by the state, federal and local coordinating agencies and the project proponent.

4. A Statement of Responsibilities will be signed. This statement will list the responsibilities of all agencies at all three levels of government that have a regulatory or review responsibility associated with the project. The proponent will also list his responsibilities.

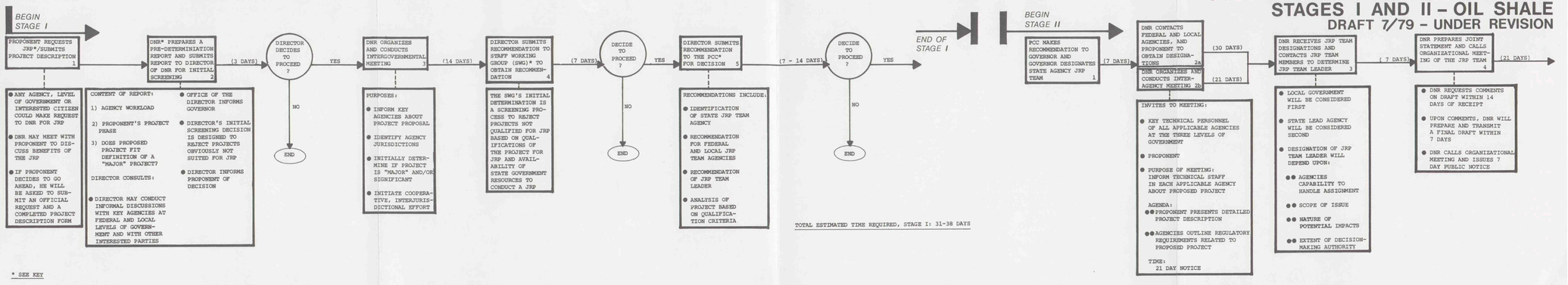
5. An inter-agency meeting will be conducted with all responsible agencies from the three levels of government and the proponent present.

6. Two public information meetings will be conducted (one in the project locality and one in Denver) at which time the proponent will be asked to present a description of his project and respond to questions raised by those in attendance.

7. Two public scoping meetings will also be conducted. At these meetings the public will have the opportunity to express concerns and raise issues about the proposed project.

8. The Joint Review Team will prepare a decision schedule which will coordinate the proponent's proposed timetable for planning and development activities; the major federal, state, and local regulatory processes; additional public participation activities; and joint review procedures. This decision schedule will be based on model schedules provided in the Joint Review Process Manual.

COLORADO JOINT REVIEW PROCESS
STAGES I AND II – OIL SHALE
DRAFT 7/79 – UNDER REVISION



Total Estimated Time Required - Stage II: about 210 days or 7 months

KEY:

JRP - JOINT REVIEW PROCESS

PCC - THE GOVERNOR'S POLICY PLANNING COORDINATING COUNCIL - DEPARTMENT DIRECTORS

ES - ENVIRONMENTAL STATEMENT

FR - FEDERAL REGISTER

DNR - DEPARTMENT OF NATURAL RESOURCES

SWG - THE PCC's STAFF WORKING GROUP - DEPUTY DIRECTORS OF ALL DEPARTMENTS

Stage 3 commences upon completion of the decision schedule prepared in Stage 2. It entails implementation of that schedule and will include such activities as preparation of an Environmental Statement (if one is required), completion of required regulatory reviews, completion of the proponent's design and feasibility studies, public participation and continuous Joint Review activities to ensure coordination. Major permit processes will be sequenced so that all final decisions will be complete prior to the time the proponent anticipates construction start-up.

The Joint Review Process Manual, due for completion later this year, will include model decision-schedules for the following four hypothetical energy and mineral resource development projects:

1. Commercial development of an existing federal oil shale lease tract in Rio Blanco County, Colorado;

2. Development of a commercial size strip coal mining operation on federal lands in Rio Blanco County, Colorado;

3. A uranium mine, mill, and tailings complex in Gunnison County, Colorado; and

4. A large metal mine and mill in Gunnison County, Colorado.

Included in this brief description of the JRP is a Draft Model decision schedule for a hypothetical oil shale development. It is important to note that this model decision schedule is intended for use only as a guideline. Timelines will change as various assumptions change. Further, note that the flow chart or bar chart describing the Stage 3 model shows individual sequences of regulatory and public participation events for each permit process. These are shown on a chart precisely according to their month and

day of occurrence, in order to indicate when particular events (e.g., public hearings, application preparation, application submittal, and other activities) would occur. It is recognized that the chart might be presented in a number of different configurations to show specific purposes (e.g., all decisions might be shown at the right-hand side of the chart in order that they might all be reached at approximately the same time, with staggered starting dates). Further refinements of Stage 3 of the Joint Review Process may address different and instructive configurations of the models.

Along with the permit sequences presented in the Stage 3 decision schedules, supplemental schedules were developed for JRP Team and proponent participation in Stage 3. Note that these parallel schedules are shown at the bottom of the Stage 3 decision schedule charts.

An additional public participation event (*PP*) is also suggested as a "required" event at the beginning of Stage 3 in the decision schedule for each activity. This public meeting would provide the proponent with an opportunity to respond to scoping issues raised at the two public scoping meetings near the end of Stage 2 of the Joint Review Process. This Proponent's Response Meeting would be held under the auspices of the JRP Team. The JRP Team would also continue to meet monthly to oversee implementation of the decision schedule. Additional written agreements might be developed during Stage 3 between the proponent and various government agencies, among agencies, or among other members of the Team, to assist in implementing the decision schedule.

Numerous assumptions were made about the proposed project and major permit processes. They include:

1. Only the major federal, state and local permit processes are shown in the schedule; those identified by industry and government officials as the "major" required actions.

2. The schedule is site-specific. That is, it is designed for a specific hypothetical oil shale development project.

3. The hypothetical project has the following characteristics:

   . it is a modified in situ oil shale development on an existing Federal Oil Shale Lease Tract

   . the project is proposing to scale-up to a commercial sized facility, thus requiring a new set of permits.

   . since an environmental impact statement was prepared by the Department of Interior in 1974 concerning the Prototype Federal Oil Shale Leasing Program, it was assumed that an additional environmental statement would not need to be prepared for the proposed commercial oil shale development. (The 1974 EIS did address both modular and commercial development of the federal oil shale lease tracts.)

   . the requirement for a U.S. Geological Survey Operating Plan on the proposed development has been satisfied through preparation of a Detailed Development Plan under the lease administered by the Bureau of Land Management. USGS oversees operations under the lease.

   . environmental baseline studies and monitoring activities have been undertaken in great detail during the modular development phase of the tract, and therefore would not be needed prior to commercial development.

4. The path from permit application to permit issuance will follow the most expeditious critical path through the flow diagram, but will include

4. (cont'd.)
   a path that incorporates a representative level of opportunity for public comment/ hearings/notice.

5. Where a time frame is mandated by statute or regulation (e.g., 30 days), that maximum time frame will be reflected, recognizing that the agency may complete required work prior to its expiration.

6. For procedures where no time frames or time limits are specified in statutes or regulations, best judgement estimates are made within the context of the agency estimates of total maximum time required for the permit process. These estimates were reviewed with applicable agencies.

7. An arbitrary 90-day pre-application meetings/ application preparation phase is estimated to be necessary before the time an application is submitted to the regulatory agency in each process. Of course, this application preparation phase will vary from process to process. Some coordination may be possible here, however.

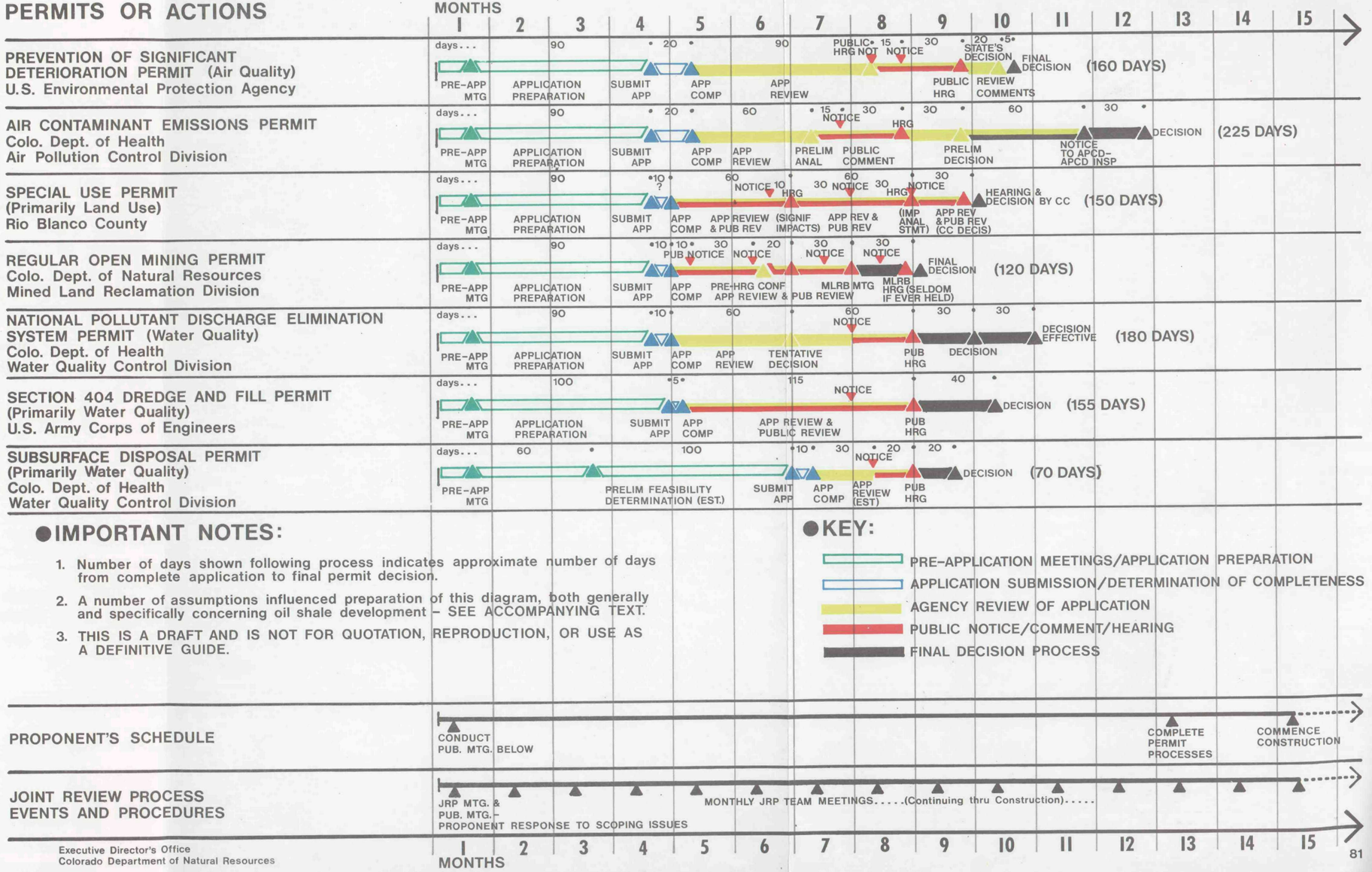
8. A "major" project is anticipated, and therefore the greatest level of administrative or regulatory detail (such as a more thorough application) will be required, unless already prepared in actual fact (for example, a pre-existing EIS may be available on the same topic or type of project).

9. Assumptions were made about each permit process which will not be detailed here. For example, the Environmental Protection Agency's Prevention of Significant Deterioration (PSD) program is shown in the model schedule to be completed within 160 days of receipt of a complete application. This time frame is based on a draft energy policy prepared by EPA Region VIII. In that policy, it was indicated that PSD permits would be processed within 6 months of receipt of an application. That policy is reflected in this schedule.

SUMMARY

The Joint Review Process Manual will be completed in late 1979. It will provide Colorado with a significant tool to coordinate governmental reviews and decision making on major energy and mineral resource development projects. It will also provide Colorado with the ability to quickly respond to an Energy Mobilization Board. It should provide Congress with a substantive example of how voluntary decision schedules for major energy projects might be developed. Colorado has prepared the administrative details for organization of an intergovernmental project review team and the regulatory details for coordination of specific permit and approval processes. The Colorado Joint Review Process should be thoroughly considered as Congress proceeds to examine regulatory reform programs.

COLORADO JOINT REVIEW PROCESS
STAGE III – PERMIT SEQUENCE – OIL SHALE
DRAFT 10/79 – UNDER REVISION



Executive Director's Office
Colorado Department of Natural Resources

INDUSTRY'S PLANS FOR DEVELOPMENT

Based on industry plans, production of crude oil from shale in Colorado and Utah is expected to range between 200,000 and 600,000 barrels per day by 1990. A variety of projections exist which characterize possible production totals for 1990 under different circumstances, and such projections include 400,000 barrels per day (President Carter, July, 1976), 500,000 barrels per day (some current industry estimates), and 600,000 barrels per day (Oil Shale 1980, Colorado Energy Research Institute).

There is ample explanation for the differences in existing projections: (1) current oil shale technology is untested at the necessary commercial scale; (2) market outlook for the future of oil shale is uncertain and is beyond the sole, direct control of domestic forces; (3) future policy directions of the U.S. Congress, the separate states, and the oil shale industry are unknown; and (4) actions of the OPEC cartel are unpredictable.

These factors, acting separately and in concert, cloud any picture of the future, so it is important to understand the assumptions used in the production projections in this report:

- The projections are an interpretation, and in some cases an extrapolation, of plans, permits, and EIS's which are published by the industry;

- Where plans were not available, other public documents, knowledge of the industry, and best engineering judgement were used to make projections so as to present a reasonable spectrum of possible oil shale technologies;
- Industry plans (Table 1) assume a $3 per barrel oil shale tax credit incentive by 1980;
- Maximum production levels (Table 2) were developed using similar assumptions.

The list below shows the 1990 expected totals by site:

Crude Oil Production from Shale by 1990
(Barrels per Day)

Site	Industry Plans	Maximum Possible
Union	30,000	33,000
Superior	24,000	26,400
Paraho	10,700	11,770
Dow	50,000	55,000
C-a	47,250	76,000
C-b	30,000	50,000
Ua & UB	0	12,100
Sand Wash	0	11,000
Geokinetics	0	2,000
Chevron	0	10,000
Mobil	0	10,000
Equity	1,000	2,000
TOTAL	192,950	299,270

A set of site specific maps were developed for these projections. These maps include information on surface facilities and disposal sites, along with narrative data

on tract size, process type, ore grade, water use, mining operations, amount of waste shale produced, employment, and amount of fines (that portion of the surface retort crushed oil shale feed stock too small in size to be treated in the primary retort). Some surface processes do not exclude fines, and others must retort fines in a separate process.

Surface retorts will be dependent upon mining operations of immense proportions, and the fabrication-construction of commercial sized surface retorts is unprecedented. Modified in situ (MIS) processes require bringing considerable amounts of the oil shale ore to the surface, in addition to the separate recovery of the resource in place. The ore brought to the surface in a MIS operation will likely be processed in a surface retort, and such projections are included in the "maximum possible" case.

Obviously, oil shale development patters different than those presented here are certainly possible. But if Colorado were asked to bear the brunt of significantly higher levels of production by 1990, the construction activity, water availability, mining operations, capital accumulation, existing community infrastructure, transportation systems, waste disposal, and environmental balance would impose natural constraints that might become physically restrictive. Such constraints may be encountered regardless of the commitment and desire to speed production of crude oil from shale.

INFORMATION ON ACCOMPANYING TABLE
PROVIDED BY:

ENERGY DEVELOPMENT CONSULTANTS, INC.

TABLE 1

PROJECTED DEVELOPMENT PLANS
OIL SHALE PRODUCTION
(BARRELS PER DAY)

Fig. No.	Tract (Ownership)	Process	1982	1983	1984	1985	1986	1987	1988	1989	1990
15	Long Ridge (Union Oil)	Union B/SGR		9,000	9,000	9,000	18,000	18,000	20,000	30,000	30,000
16	Anvil Points (Paraho Development Corp.)	Paraho Direct (Est)			4,700	4,700	9,400	9,400	9,400	10,700	10,700
17	Superior (Superior Oil Co.)	Circular Grate						12,000	12,000	12,000	24,000
18	Dow (Colony Development Co.)	TOSCO II					12,000	27,500	41,250	41,250	50,000
TOTAL SURFACE INDUCED				9,000	13,700	13,700	39,400	66,900	82,650	93,950	114,700
22	Tract C-a (Rio Blanco Oil Shale Co.)	MIS							37,500	47,250	47,250
23	Tract C-b (Occidental-Tenneco)	MIS					10,000	10,000	10,000	20,000	30,000
—	Equity	Pure/Steam						1,000	1,000	1,000	1,000
TOTAL IN SITU INDUCED							10,000	11,000	48,500	68,250	78,250
ALL PRODUCTION				9,000	13,700	13,700	49,400	77,900	131,150	162,200	192,950

TABLE 2

PROJECTED MAXIMUM DEVELOPMENT CAPACITY

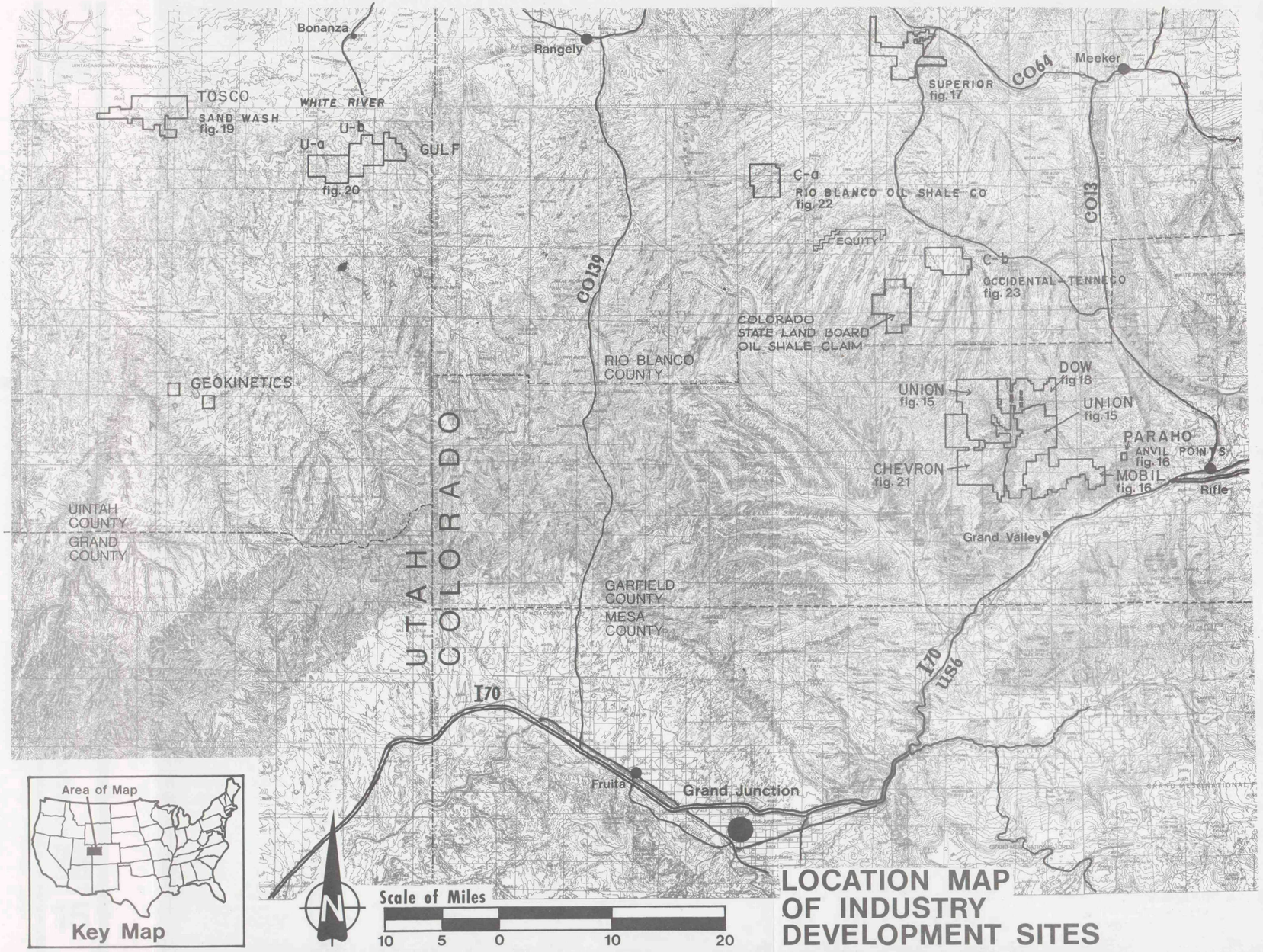
OIL SHALE PRODUCTION

(BARRELS PER DAY)

Fig. No.	Tract (Ownership)	Process	1982	1983	1984	1985	1986	1987	1988	1989	1990
15	Long Ridge (Union Oil Co.)	Union B/SGR	8,000	8,800	8,800	17,600	19,400	19,400	30,000	30,000	30,000
		TOSCO II (Fines)		880	1,760	1,760	1,940	1,940	3,000	3,000	3,000
16	Anvil Points (Paraho Development Corp.)	Paraho Direct		4,700	4,700	8,800	8,800	9,700	9,700	10,700	10,700
		Lurgi-Ruhrgas (Fines)			470	880	880	970	970	1,070	1,070
17	Superior (Superior Oil)	Circular Grate				12,000	12,000	13,200	13,200	24,000	24,000
		Lurgi-Ruhrgas (Fines)					1,200	1,320	1,320	2,400	2,400
18	Dow (Colony Development Co.)	TOSCO II				27,500	41,250	50,000	55,000	55,000	55,000
19	Sand Wash (Utah) (The TOSCO Corporation)	TOSCO II						10,000	10,000	11,000	11,000
20	Combined U-a, U-b (White River Project)	Paraho Indirect						10,000	10,000	11,000	11,000
		Lurgi-Ruhrgas (Fines)							1,000	1,100	1,100
21	So. Piceance Bsn. (Chevron)	Unknown A							10,000	10,000	10,000
16	So. Piceance Bsn. (Mobil)	Unknown B								10,000	10,000
TOTAL SURFACE INDUCED			8,000	14,380	15,730	68,540	85,470	116,530	144,190	169,270	169,270
22	Tract C-a (Rio Blanco Oil Shale Co.)	MIS						37,500	47,250	57,000	57,000
		Lurgi or TOSCO II						12,500	15,750	19,000	19,000
23	Tract C-b (Occidental-Tenneco)	MIS Surface Retort		10,000	20,000	30,000	50,000	50,000	50,000	50,000	50,000
—	Equity	Pure/Steam				1,000	1,000	1,000	2,000	2,000	2,000
—	SE Utah (Geokinetics)								2,000	2,000	2,000
TOTAL IN SITU INDUCED				10,000	20,000	31,000	51,000	101,000	117,000	130,000	130,000
ALL PRODUCTION			8,000	24,380	35,730	99,540	136,470	217,530	261,190	299,270	299,270

INFORMATION ON ACCOMPANYING TABLE
PROVIDED BY:

ENERGY DEVELOPMENT CONSULTANTS, INC.



INFORMATION ON FOLLOWING 10 MAPS
PROVIDED BY:

ENERGY DEVELOPMENT CONSULTANTS, INC.

LOCATION MAP OF INDUSTRY DEVELOPMENT SITES

FIGURE 14

SITE

Union Oil Company
Long Ridge, Parachute Creek, Colorado
2,660 acres

Of the current oil shale companies, Union is the oldest in terms of ownership of reserves and maturity of water rights. Its earliest processes date to the late 1950's. Union has completed the necessary state and federal permits to construct and operate a low-level commercial plant yielding approximately 10,000 barrels per day of crude oil from shale. This operation will likely produce the first commercial oil shale product from the State of Colorado. Union Oil Co. owns approximately 33,000 acres of oil shale property, making it the second largest private holder of the resource in Colorado.

MAXIMUM PRODUCTION 1990

30,000 barrels per day

WATER

Usage: 3000 acre ft. per yr.
Source: Wells, Colo. River

EMPLOYMENT

	Time	Workers
Const:	2-4 yrs.	700-800
Operation:		400-700
First Production:		1983

Basis for projections: 2 1/2 year construction phase for first 9,000 BPD facility; doubling that capacity within 3 years, achieving greater process efficiency by 1988; adding an additional increment of capacity by 1990. Projections listed in Table 2 assume separate surface retort for fines.

MINING OPERATION

Type: Underground, room and pillar
Tons per day: 35,000
Grade: 30-40 gallons per ton
Recovery: 70-75%
Fines: 3500 tons per day

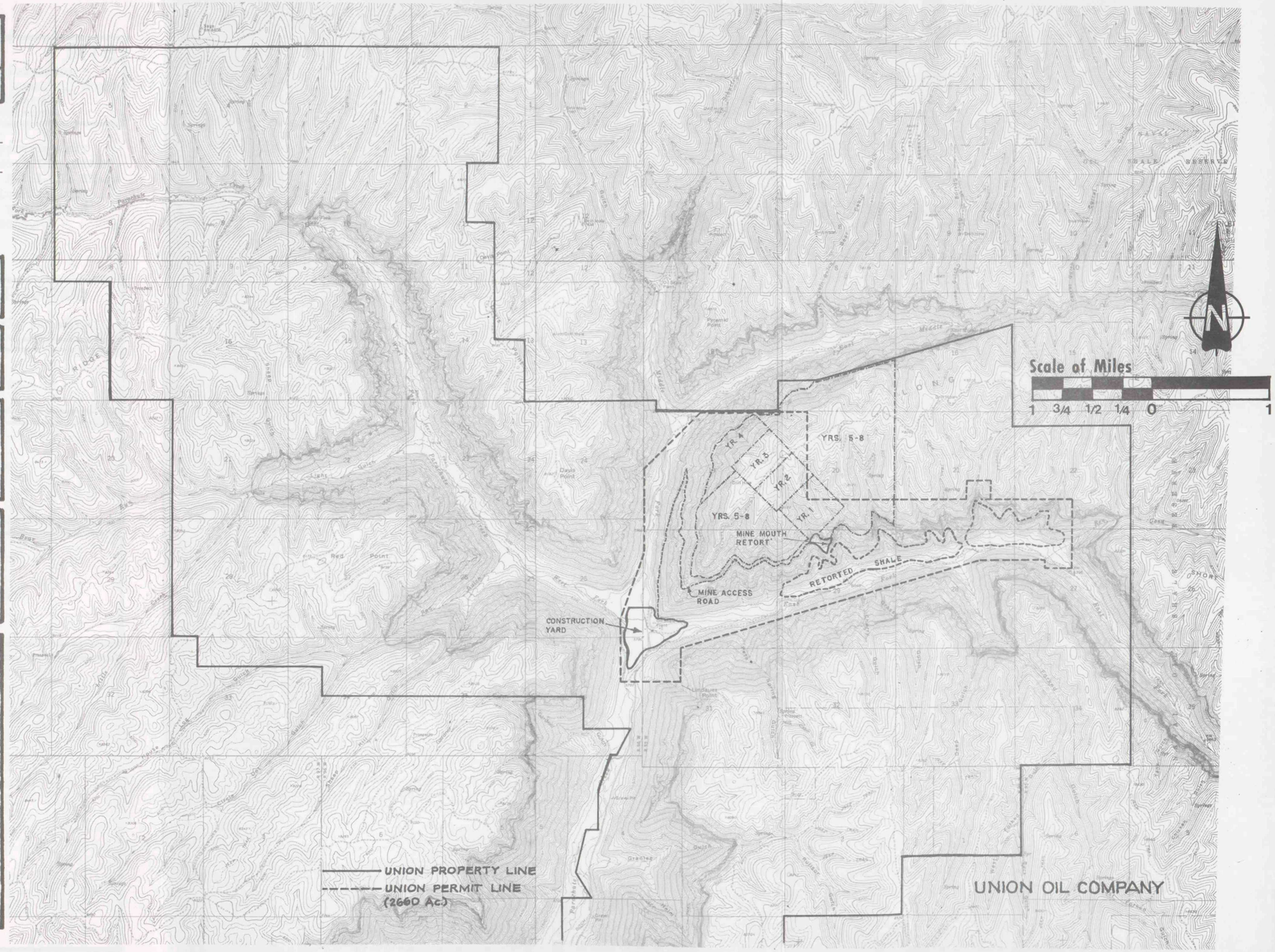
PROCESS

Type: Surface, rock pump, vertical retort
Retorted shale: 25,200 tons per day (waste)
Oil Yield: 100% of Fischer Assay

WORK FORCE REQUIREMENTS & EXPECTED RESIDENCY

	1980	'81	'82	'83	'84	'85	'86	'87	'88	'89	'90
Construction	300	800	700	200	800	700	200	0	0	0	0
Operation	100	250	400	400	400	400	550	700	700	700	700

It is estimated that 60% of the work force will reside in Rifle, 10% each in Silt and Grand Valley, and the remaining 20% in rural Mesa County.



COLORADO OIL SHALE: the current status, october, 1979
Department of Natural Resources
State of Colorado

FIGURE 15

SITE

Mobil Oil Corporation
Adjacent to Naval Oil Shale Reserve, Colorado
Approx. 8,500 acres

Mobil Oil Corporation owns total or part interest in approximately 22,500 acres of oil shale deposits in Northwest Colorado. The particular tract near the Union Oil Company holding and the Naval Oil Shale Reserve and between Parachute Creek and the Colorado River is well-situated, has good potential, and will likely be among the "second wave" of oil shale development expected in the late 1980's.

MAXIMUM PRODUCTION 1990

10,000 barrels per day

WATER

UNKNOWN

Basis for projections: Several different tracts in the South Piceance Basin area are likely to be developed in the late 1980's-early 1990's, and this tract is included as an example of that expected production.

EMPLOYMENT

UNKNOWN

MINING OPERATION

UNKNOWN

Grade: 30 gallons per ton

PROCESS

UNKNOWN

WORK FORCE REQUIREMENTS & EXPECTED RESIDENCY

UNKNOWN

SITE

Paraho Development Corp.
Anvil Points, Colorado
365 acres

Paraho has operated a demonstration plant since the mid 1970's and has longer continuous runs of a demonstration project than does any other oil shale process. Paraho has produced approximately 100,000 barrels of oil in total for testing by the Department of Defense and by industry. The project is located on the Naval Oil Shale Reserve at Anvil Points, Colorado. Of the current surface processes, the Paraho process is mechanically the least complicated, resulting in lower relative requirements for operational force and capital.

MAXIMUM PRODUCTION 1990

10,700 barrels per day

WATER

Usage: 237 acre ft. per yr.
Source: Natural springs and diversion from Colo. River

Basis for projections: Future agreement with federal government will be reached and will allow continued, then expanded, production on Naval Oil Shale Reserve. Paraho has a large amount of experience and is significant among possible processes.

EMPLOYMENT

	Time	Workers
Const.:	2-3 yrs.	500
Operation:		300-500
First Production:		1984

MINING OPERATION

Type: Underground, room and pillar
Tons per day: 17,000
Grade: 25-30 gallons per ton
Recovery: 70% - 75%
Fines: 1700 tons per day

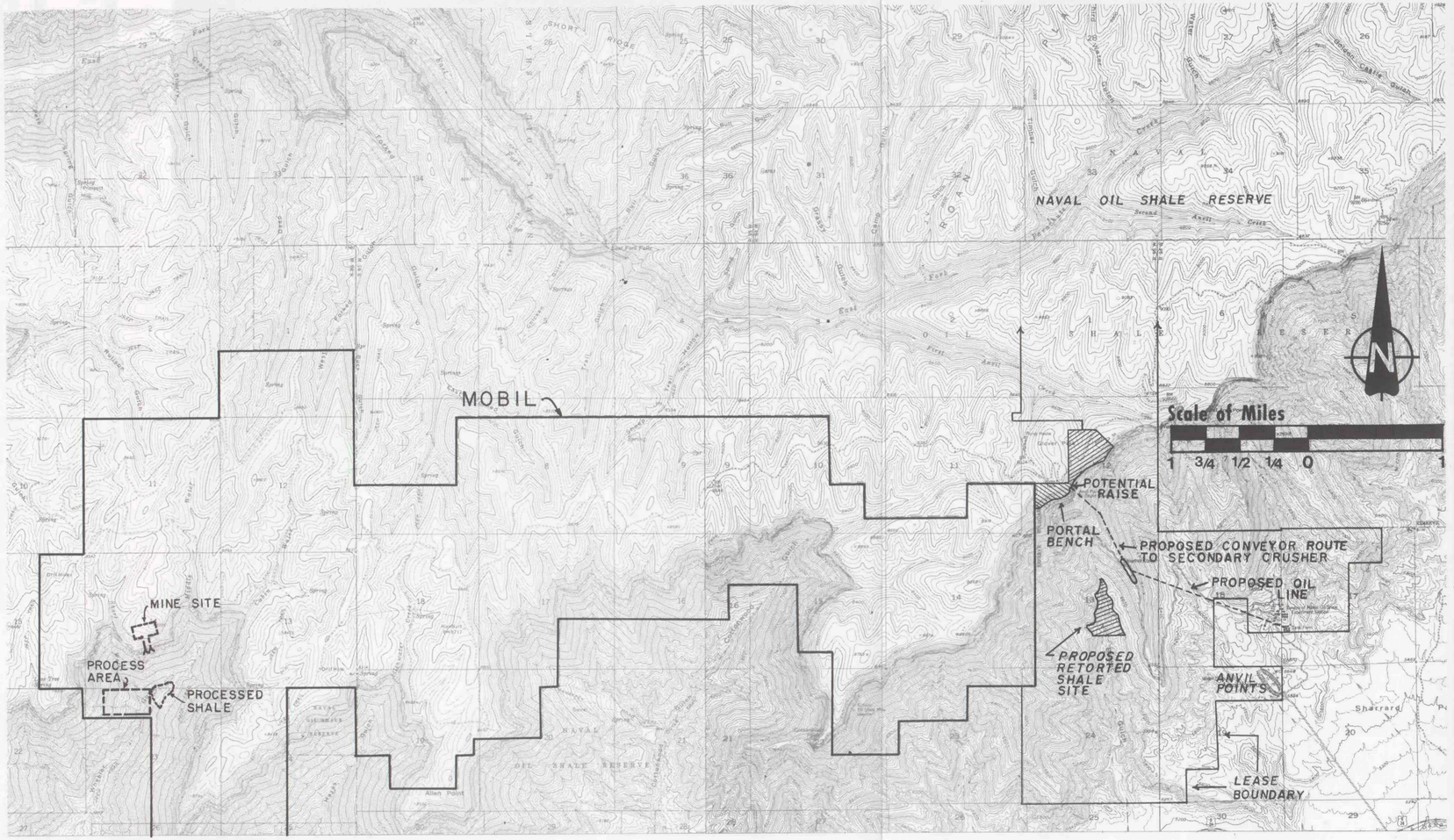
PROCESS

Type: Surface, gravity feed vertical retort
Retorted shale: 12,500 tons per day (waste)
Oil yield: 90% of Fischer Assay

WORK FORCE REQUIREMENTS & EXPECTED RESIDENCY

	1980	'81	'82	'83	'84	'85	'86	'87	'88	'89	'90
Construction	0	300	500	200	250	400	200	100	0	0	0
Operation	80	200	300	300	300	300	300	450	450	550	550

It is estimated that 60% of the work force will reside in Rifle, 20% in Silt, and 10% each in Grand Valley and rural Garfield County.



MOBIL & PARAHO

FIGURE 16

SITE

Superior Oil Company
Meeker, Colorado area
Approx. 6500 acres

Superior is a pioneer in the recovery of multi-mineral products. Its tract is naturally rich in alumina, soda ash, and kerogen. Superior's circular grate process is a derivation from iron ore processing technology with a correspondingly longer and more nearly proven background relative to some other oil shale retorting technologies. This process has more definitive retort temperature control, allowing greater thermal efficiency and improved yields. The commercial success of this operation is dependent upon the acquisition of sufficient contiguous land; negotiations to trade for federal land are now in progress.

MAXIMUM PRODUCTION 1990

24,000 barrels per day

WATER

Usage: 100 acre ft. per yr.
Source: Diversion from Piceance Creek, White River

Basis for projections: Superior will operate initially at its projected capacity of 12,000 BPD; if successful, maximum development by 1990 would result in a doubling of production.

EMPLOYMENT

	Time	Workers
Const:	3-5 yrs.	800-1000
Operation:		900-1200
First production:		1987

MINING OPERATION

Type: Underground, room and pillar
Tons per day: 55,000
Grade: 25 gallons per ton
Recovery: 65% - 75%
Fines: 2000 tons per day

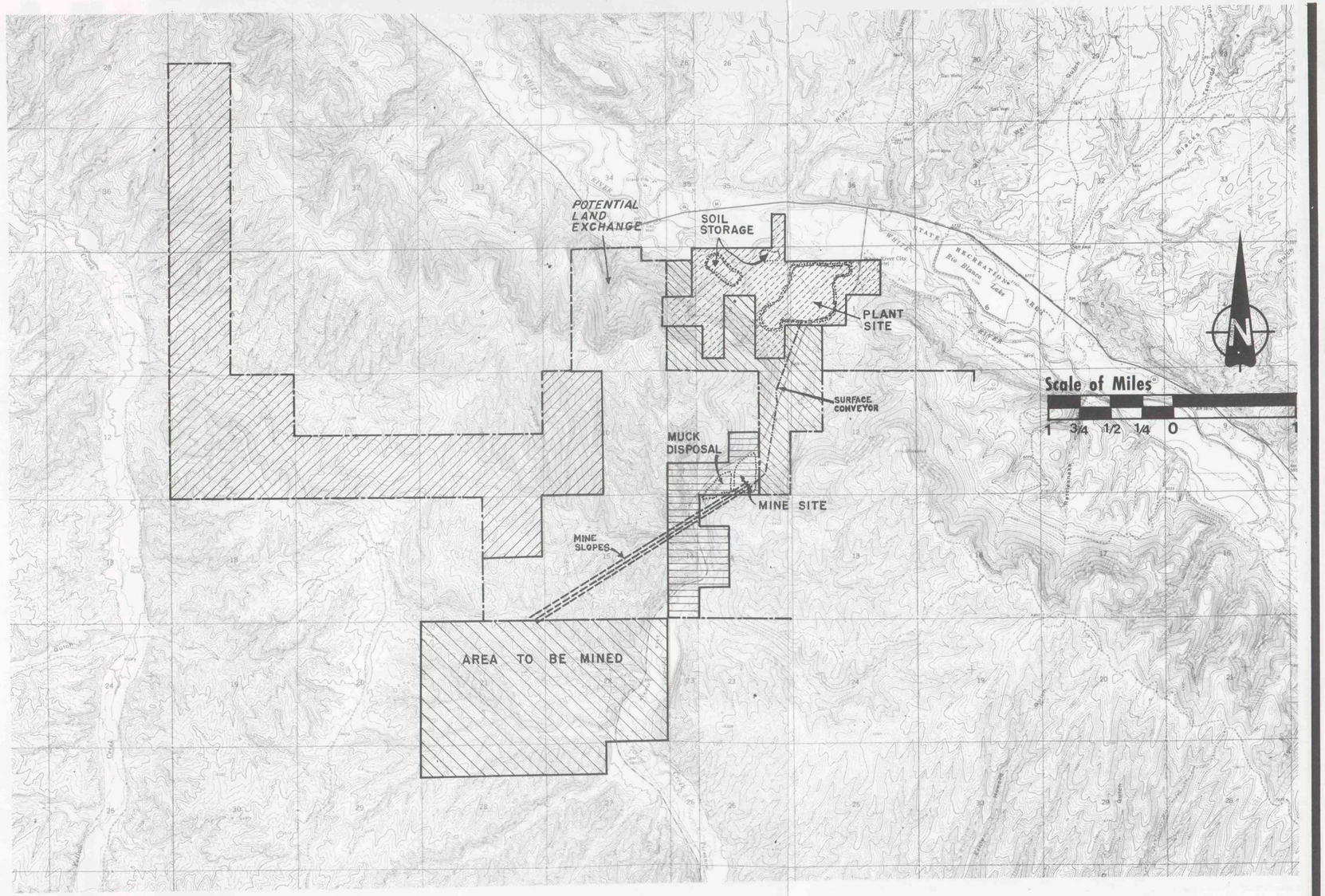
PROCESS

Type: Surface, circular grate
Retorted shale: 29,400 tons per day (waste)
Oil yield: 98% of Fischer Assay

WORK FORCE REQUIREMENTS & EXPECTED RESIDENCY

	1980	'81	'82	'83	'84	'85	'86	'87	'88	'89	'90
Construction	0	0	150	275	450	800	710	100	400	600	100
Operation	20	50	110	185	405	540	600	920	920	1200	1200

It is estimated that 35% of the work force will reside in Rangely and Meeker each, 20% in Rifle, and the remaining 10% in rural Garfield County.



SUPERIOR OIL COMPANY

FIGURE 17

SITE

Colony Development Operation
Dow West, Parachute Creek, Colorado
4,400 acres

Colony is a joint venture of Atlantic Richfield (60%) and the TOSCO Corporation (40%)--one a petroleum company and the other a technology company--and experiments date back to the mid-1960's. Colony probably has conducted more environmental and socio-economic studies than any other potential oil shale producer. To accommodate their projected maximum production level, Colony has discussed plans for a new, self-contained community at Battlement Mesa, which is close to their development area. Technologically, the TOSCO II oil shale process has a high yield, and the feedstock fines are handled in the same process, rather than separately as required by some other processes.

MAXIMUM PRODUCTION 1990

50,000 barrels per day

WATER

Usage: 7200 acre ft. per yr
Source: Colorado River

EMPLOYMENT

	Time	Workers
Const:	4-5 yrs.	1500-2000
Operation:		1500-2000
First production:		1986

Basis for projections: Colony detailed development plan; phased operation.

MINING OPERATION

Type: Underground, room and pillar
Tons per day: 66,000
Grade: 35 gallons per ton
Recovery: 70% - 75%
Fines: None

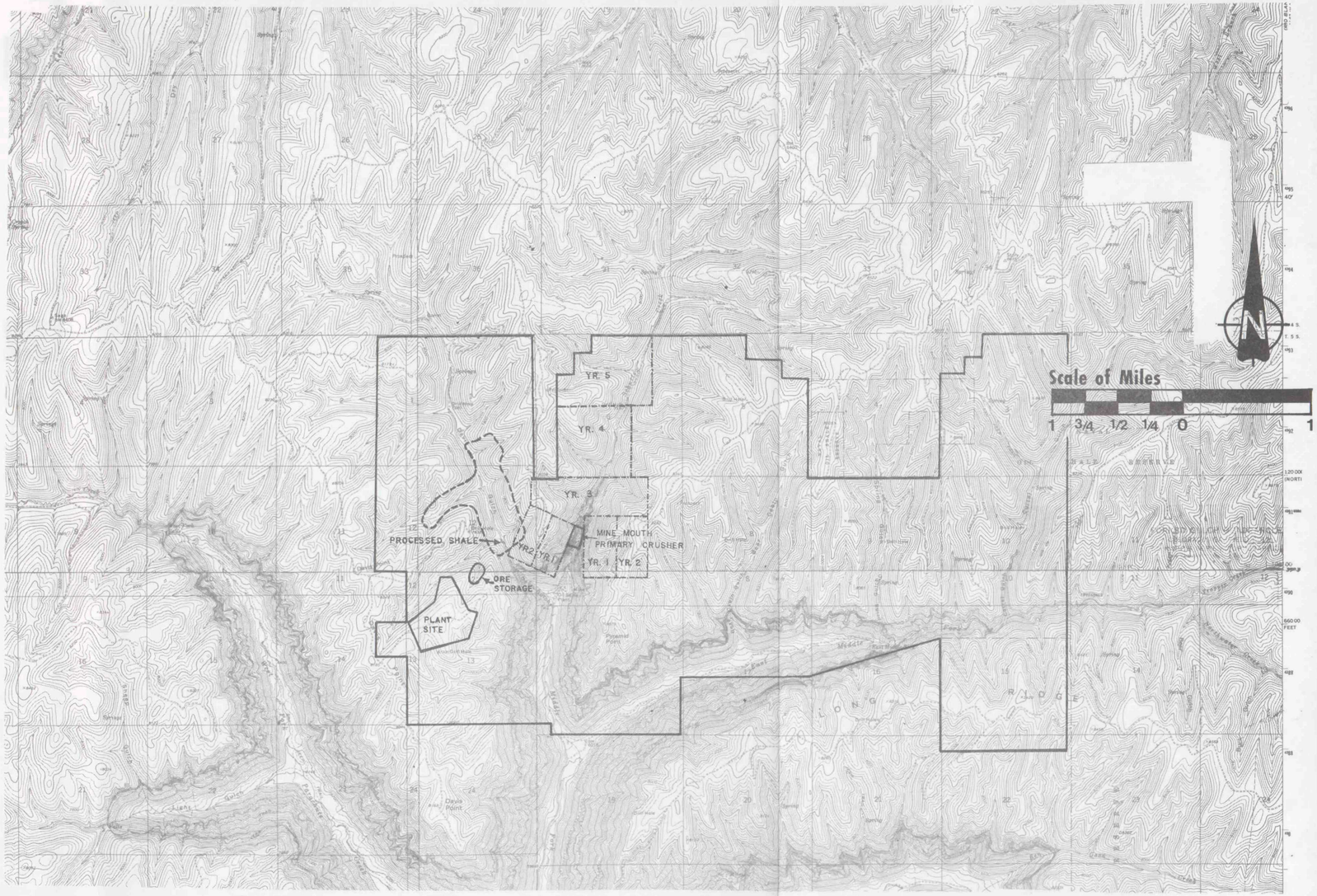
PROCESS

Type: Surface, horizontal retort, TOSCO II
Retorted shale: 53,200 tons per day (waste)
Oil yield: 100% of Fischer Assay

WORK FORCE REQUIREMENTS & EXPECTED RESIDENCY

	1980	'81	'82	'83	'84	'85	'86	'87	'88	'89	'90
Construction	400	600	1000	1500	2000	2000	2000	2000	2000	1500	1000
Operation	150	300	500	800	800	800	800	1200	1500	1800	2000

In the absence of Battlement Mesa project, it is estimated that 50% of the work force would reside in Rifle, 10% in Silt, 30% in rural Mesa County, and 5% each in rural Grand County and rural Garfield County.



DOW
COLONY DEVELOPMENT OPERATION

COLORADO OIL SHALE: the current status, october, 1979
Department of Natural Resources
State of Colorado

FIGURE 18

SITE

The TOSCO Corporation
Sand Wash Project
Uintah County, Utah
14,688 acres

The Sand Wash Project was formed by the first unitization agreement approved for oil shale. In December, 1975, twenty-nine separate oil shale leases in Utah were combined to form the Sand Wash Unit, scattered over an area eight miles wide and twelve miles long. The twenty-five gallon per ton shale varies in thickness from 50-80 feet, and the overburden averages 2,000 feet.

MAXIMUM PRODUCTION
1990
11,000 barrels per day

WATER
UNKNOWN

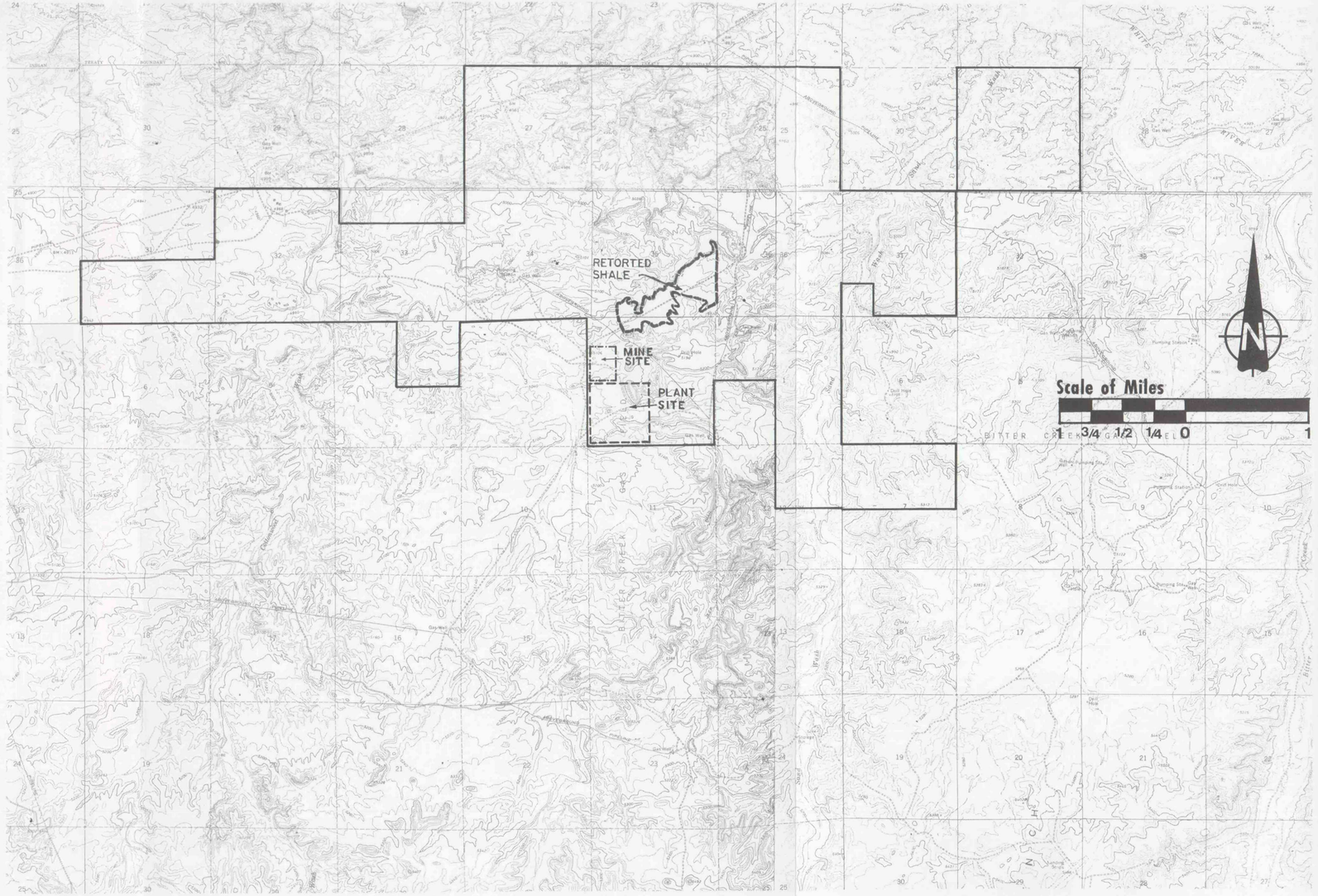
EMPLOYMENT
UNKNOWN

Basis for projections: This tract is a likely second generation operation since the TOSCO Corporation has a 40% interest in the Colony Development Operation on the Dow Tract in Colorado.

MINING OPERATION
Type: Underground, room and pillar
Grade: 25 gallons per ton

PROCESS
Type: Surface, horizontal retort, TOSCO II (possible second generation TOSCO II)

WORK FORCE REQUIREMENTS & EXPECTED RESIDENCY
UNKNOWN



THE TOSCO CORPORATION
SAND WASH UTAH

FIGURE 19

SITE

White River Shale Oil Corp.
Tracts U-a and U-b, Utah
10,240 acres (5,120 acres in each tract)

The White River Shale Project is a proposed joint development of federal lease tracts U-a and U-b in the Uintah Basin near Bonanza, Utah. The bonus bid for Tract U-a was $76.6 million by Sun Oil Co. and Phillips Petroleum Co., and the bid for Tract U-b was $45.1 million by White River Shale Oil Corp., jointly owned by Sun, Phillips, and Sohio Petroleum Co. Both of these leases were issued June 1, 1974. The State of Utah has challenged in federal court the U.S. Government's title to both of these Utah tracts. The Utah claim to Tracts U-a and U-b is on the basis of "in lieu lands." The lower federal court and the U.S. Court of Appeals have ruled in favor of the State of Utah, and this case is presently pending. In the meantime, the terms of the lease have been suspended.

Basis for projections: Ownership of White River lands is currently clouded by litigation involving "in lieu lands" in Utah. This problem will eventually be resolved, but will delay production. Projections in Table 2 include separate retorting of surface fines.

MAXIMUM PRODUCTION 1990

12,100 barrels per day

WATER

UNKNOWN

EMPLOYMENT

UNKNOWN

MINING OPERATION

Type: Underground; room and pillar

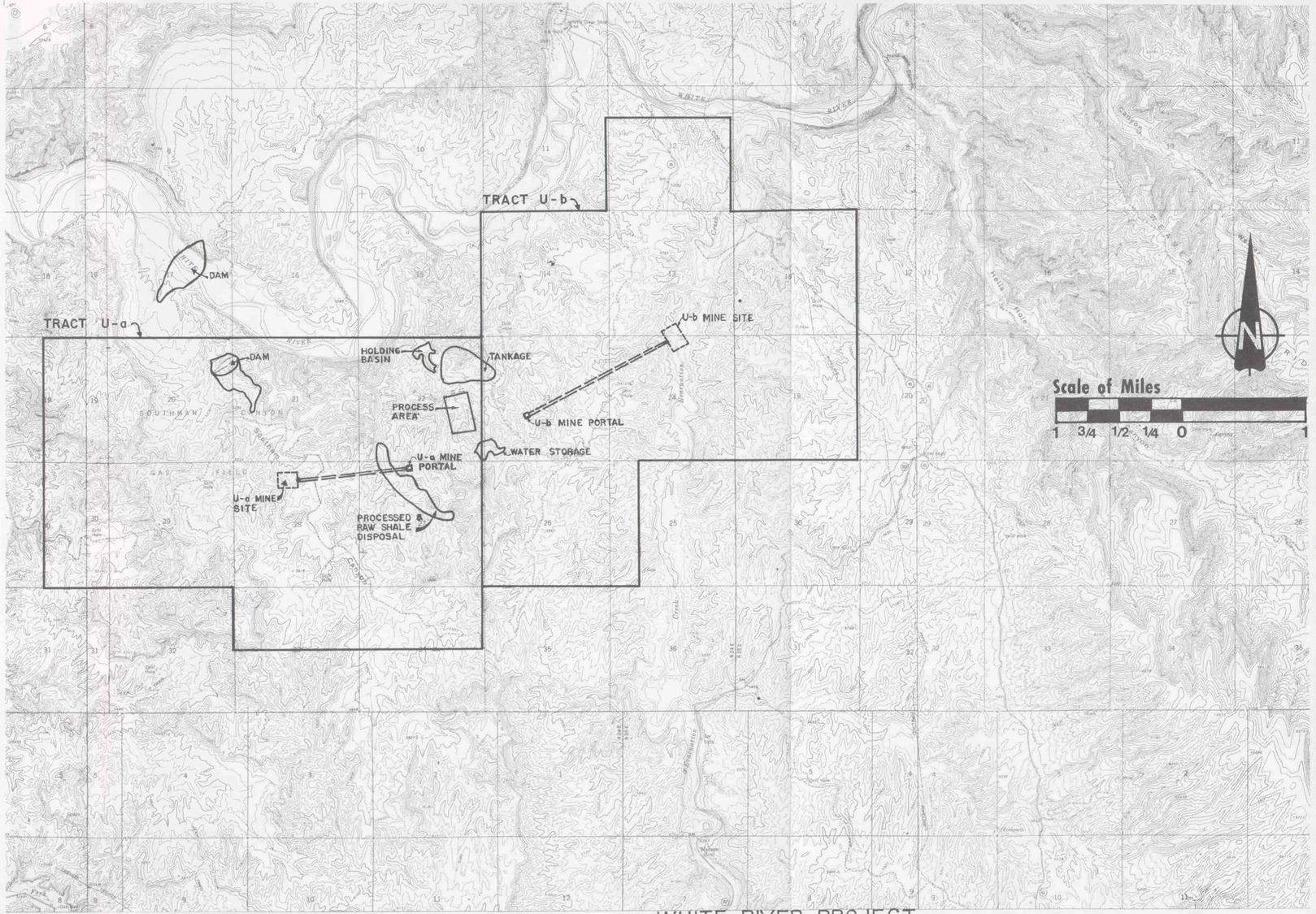
Grade: 25-30 gallons per ton

PROCESS

Surface (Paraho and TOSCO II or LURGI)

WORK FORCE REQUIREMENTS & EXPECTED RESIDENCY

UNKNOWN



WHITE RIVER PROJECT
OIL SHALE TRACTS U-a, U-b

COLORADO OIL SHALE: the current status, october, 1979
Department of Natural Resources
State of Colorado

FIGURE 20

SITE

Chevron Shale Oil Company
Parachute Creek, Colorado
Approx. 11,500 acres

Chevron Shale Oil Company is a 100 per cent subsidiary of Standard Oil Company of California and owns approximately 40,500 acres of oil shale property, making it the largest single private holder of this resource in Colorado. The property shown here is expected to be part of an expanded oil shale industry development program in the late 1980's, utilizing the accumulated experience from the pioneering efforts of commercial scale operations.

MAXIMUM PRODUCTION 1990

10,000 barrels per day

WATER

UNKNOWN

Basis for projections: Several different tracts in the South Piceance Basin area likely will be developed in the late 1980's-early 1990's, and this tract is included as an example of that expected production.

EMPLOYMENT

UNKNOWN

MINING OPERATION

UNKNOWN

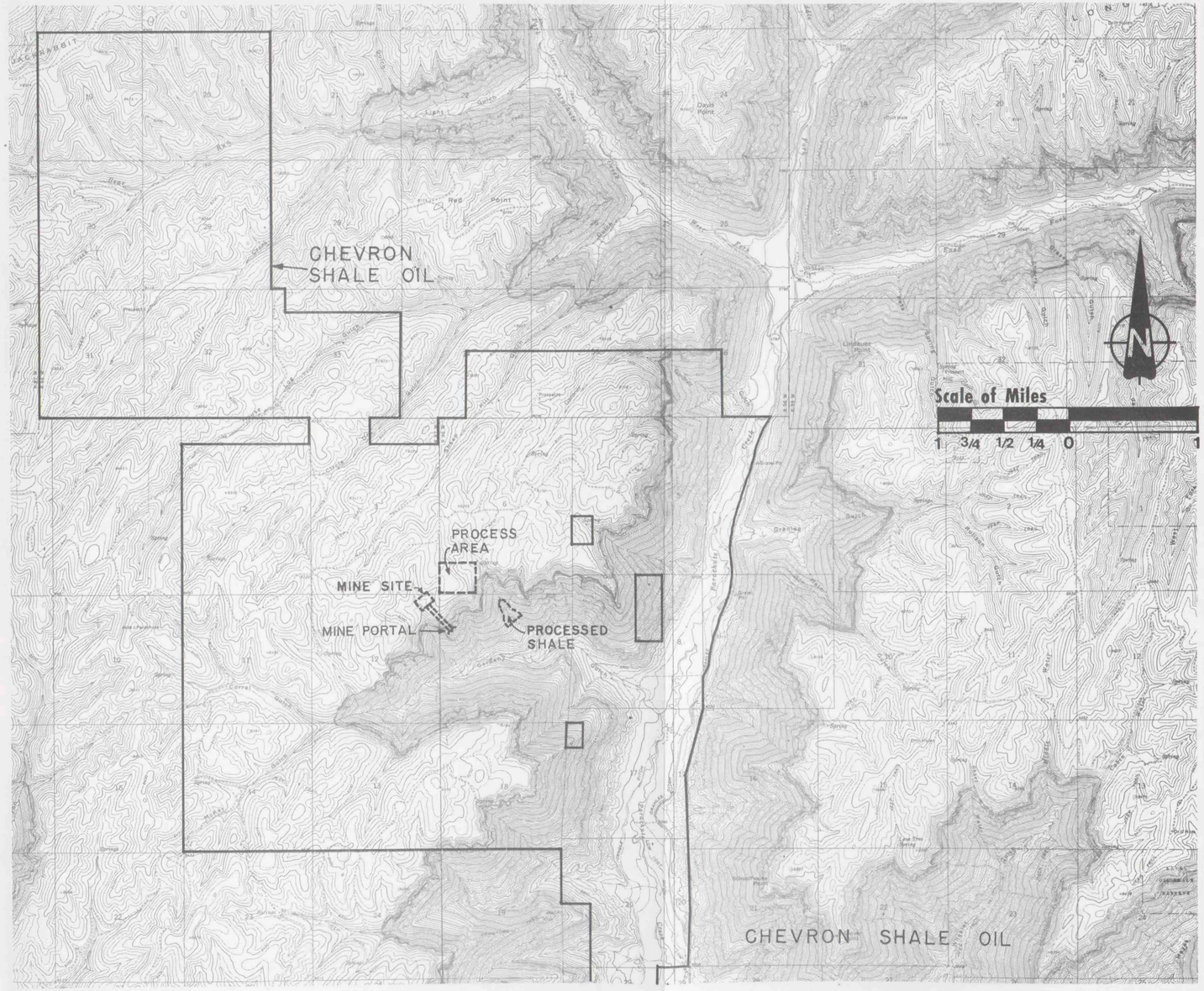
Grade: 25-30 gallons per ton

PROCESS

UNKNOWN

WORK FORCE REQUIREMENTS & EXPECTED RESIDENCY

UNKNOWN



COLORADO OIL SHALE: the current status, october, 1979
Department of Natural Resources
State of Colorado

FIGURE 21

SITE

Rio Blanco Oil Shale Co.
Tract C-a, Colorado
5,090 acres

Rio Blanco is a general partnership of Standard Oil (Indiana) and Gulf Oil Corporation. Lease tract C-a brought the highest bonus bid ($210 million) from the original federal sale of oil shale tracts. The original intent was to strip mine and then surface retort the shale on this tract, since the overburden ranges from 0 to 400 feet. Because of problems with the disposal of spent shale, the current focus of Rio Blanco is a variation of the early modified in situ (MIS) technologies. The start of a demonstration project is projected for early 1980, and is scheduled to continue for several years. If the MIS technologies do not prove themselves to be commercially viable, the surface process might be revived at this site.

MAXIMUM PRODUCTION 1990

47,250 barrels per day

WATER

Usage: Unknown
Source: Aquifer plus surface

EMPLOYMENT

	Time	Workers
Const.	6-7 yrs.	1000-1500
Operation:		1000-1500
First production:		1988

Basis for projections: Rio Blanco detailed development plan; projections listed in Table 2 assume surface retorting of shale mined in MIS process.

MINING OPERATION

Type: Underground, removal of shafts and drifts
Tons per day: 60,000
Grade: 25 gallons per ton
Recovery: 100%
Fines: 7200 tons per day

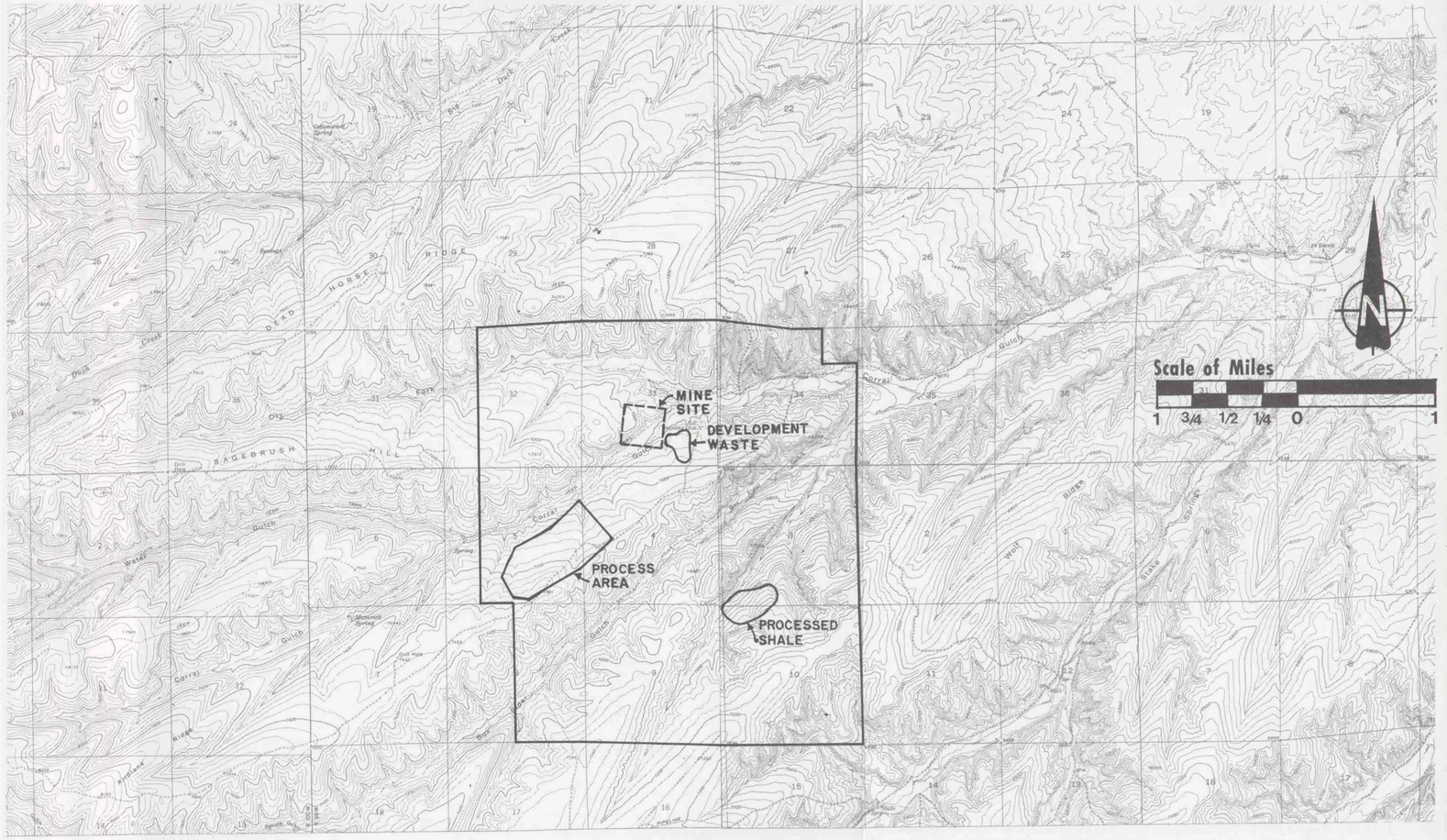
PROCESS

Type: Modified in situ
Retorted shale: 48,950 tons per day (waste)
Oil yield: 50% of Fischer Assay

WORK FORCE REQUIREMENTS & EXPECTED RESIDENCY

	1980	'81	'82	'83	'84	'85	'86	'87	'88	'89	'90
Construction	0	0	0	100	300	300	500	1000	1500	800	500
Operation	0	250	350	300	300	300	300	600	1000	1200	1500

It is estimated that 50% of the work force will reside in Rifle, 20% in Meeker, 10% in Silt, 6% in Rangely, and 7% each in rural Mesa County and rural Garfield County.



RIO BLANCO OIL SHALE PROJECT
TRACT C-a

FIGURE 22

SITE

Occidental/Tenneco
Tract C-b, Colorado
5,094 acres

This tract is to be developed as an equal joint venture between Occidental Petroleum and Tenneco and will use Occidental's modified in situ process. Occidental has conducted continuous demonstration experiments at Logan Wash for 5-10 years. There is a unique element of risk associated with Tract C-b. The overburden is approximately 1500 feet thick, and such depths preclude the possibility of economical underground mining operations, since the underground support systems would be too extensive for sufficient resource recovery. Unless some modified in situ process emerges as commercially attractive, there is no apparent option for recovery of the resource.

Basis for projections: Modified in situ is an unproven but potentially attractive recovery process.

MAXIMUM PRODUCTION

1990 30,000 barrels per day crude oil shale

WATER

Usage: Unknown
Source: Aquifer plus surface

EMPLOYMENT

	Time	Workers
Const.	5-6 yrs.	800-1200
Operation:		800-1200
First production:		1986

MINING OPERATION

Type: Underground, removal of shafts and drifts
Tons per day: 38,000
Grade: 25 gallons per ton
Recovery: 100%
Fines: 4000 tons per day

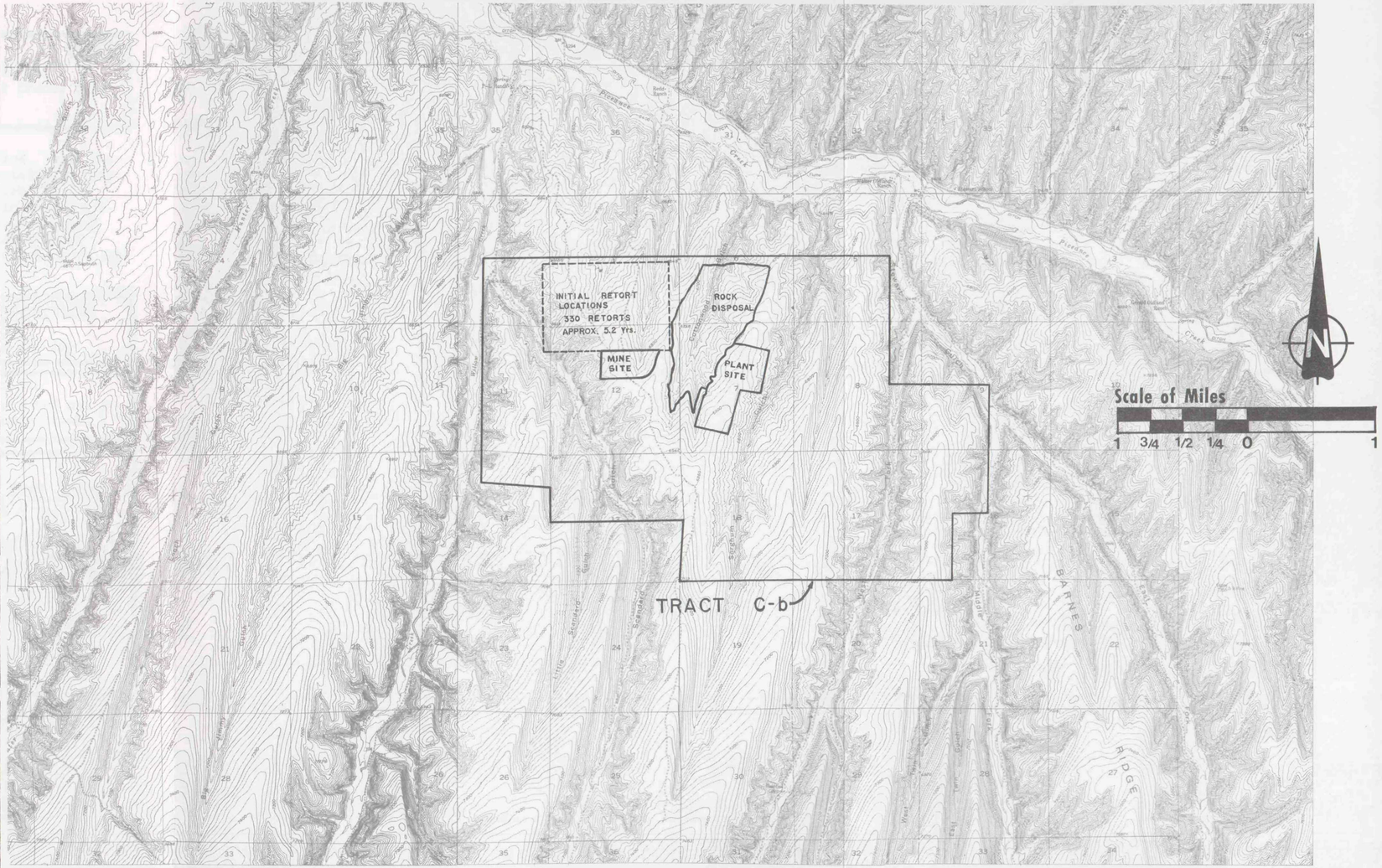
PROCESS

Type: Modified in situ
Retorted shale: 31,000 tons per day (waste)
Oil yield: 50% of Fischer Assay

WORK FORCE REQUIREMENTS & EXPECTED RESIDENCY

	1980	'81	'82	'83	'84	'85	'86	'87	'88	'89	'90
Construction	0	0	0	100	300	300	500	1000	1500	800	500
Operation	0	250	350	300	300	300	300	600	1000	1200	1500

It is estimated that 50% of the work force will reside in Rifle, 20% in Meeker, 10% in Silt, 6% in Rangely, and 7% each in rural Mesa County and rural Garfield County.



OIL SHALE TRACT C-b

FIGURE 23

SITE

Equity Oil Company
Black Sulphur Creek, Colo.
10 acres

Equity is included in these projections as a special case. This process is presently experimental: Super heated steam is injected into the subsurface shale deposit through injection wells with the intention of "communicating" with separate producing wells from which crude oil is recovered. The Equity process requires a special oil shale deposit with high permeability to allow connection between injection and recovery wells. This process is one of the pure in situ projects, and if this technology proves to be successful, an appropriate oil shale resource must be secured before commercialization can proceed.

MAXIMUM PRODUCTION 1990

1,000 barrels per day

WATER

Usage: 70 acre ft. per yr.
Source: Piceance Creek

EMPLOYMENT

	Time	Workers
Const. phase:	1 yr.	100
Operation:		300
First production:	1987	

Basis for projections: Equity is included to indicate the diversity of process methods.

MINING OPERATION

NONE

PROCESS

Type: Pure in situ
Retorted shale: Unknown
Oil yield: Unknown

WORK FORCE REQUIREMENTS & EXPECTED RESIDENCY

	1980	'81	'82	'83	'84	'85	'86	'87	'88	'89	'90
Construction	UNKNOWN										
Operation											

SITE

Geokinetics , Inc.
Near Willow Creek, Utah
Approx. 1280 acres

Geokinetics has been conducting field tests to develop horizontal in situ retorting since 1973. The porosity required for this process is established directly in the shale formation by raising a relatively shallow overburden during explosive fracturing of the formation. Geokinetics, Inc., is an oil shale technology company, and in order to engage in commercial scale production of crude oil from shale, it would need to join with a company which holds the appropriate type of oil shale resource or otherwise acquire such a resource.

MAXIMUM PRODUCTION 1990

2,000 barrels per day

WATER

UNKNOWN

EMPLOYMENT

UNKNOWN

Basis for projections: Geokinetics is included to indicate the diversity of process methods.

MINING OPERATION

UNKNOWN

PROCESS

Type: pure in situ
Oil Yield: up to 70% of Fischer Assay

WORK FORCE REQUIREMENTS & EXPECTED RESIDENCY

UNKNOWN