V MAXIMUM CREDIBLE SYNTHETIC FUELS IMPLEMENTATION SCENARIO[6]

A. Purpose and Assumptions

As a device to uncover and elucidate the maximum impact situation, a scenario was prepared that attempts to depict the maximum rate at which a synthetic fuels industry could be deployed. Examination of the maximum impact situation was selected so that the adverse and beneficial consequences would stand out in boldest relief, and, as a result, decision makers might better perceive factors that might critically impair deployment of the industry.

The Maximum Credible Implementation (MCI) scenario assumes, for purposes of impact analysis, that all fuel conversion activities will occur close to the mines. While the nature of the oil shale resource requires this assumption (because the quantities of raw ore are so large they cannot conceivably be transported long distances economically), coal could be shipped long distances from the mine for conversion. However, to allow processing facilities to be distant from the resource would introduce a complex multitude of options that are beyond the scope of this study.*

A key underlying assumption, of course, is that there is an economic incentive for the industry to develop. This necessarily means that the fuels can be produced at a profit and yet be sold at prices

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*A subsequent study at SRI, funded by the Energy Research and Development Administration (ERDA), is addressing remote siting options for coal conversion facilities.

competitive with imported natural petroleum. It also is assumed that, once begun, there is a continuing incentive to deploy the technology. Since such a climate does not now exist, the scenario is <u>not</u> a prediction of the industry that will develop but is merely an outline of a plausible situation.

The rate of industrial deployment depicted in the MCI is determined mainly by presumed physical, economic, and business risk limitations rather than by adverse impacts. Of course, adverse impacts will exist. Their analysis constitutes much of this report's substance.

There are several very important aspects of the MCI that must be emphasized because they strongly affect the analysis that follows:

- The 10-million B/D (1.6 million m^3/D) of oil equivalent energy of the MCI cannot, alone, substitute for the 18-million-B/D (2.9 million m^3/D) imports projected under the HG3 scenario discussed previously (Figure 2).

- The MCI is heavily skewed towards the Rocky Mountain and Northern Great Plains regions of the country for two reasons: First, the coal and oil shale resources are most abundant there. Second, the nature of the deposits and the pattern of government ownership of western resources greatly facilitate acquisition of the reserves needed to guarantee a plant's lifetime operation.

- For coal-derived syncrude to be economically competitive with imported oil, the coal resources used must be low in cost and this greatly favors use of western coals amenable to strip or open-pit mining.

B. The Scenario

Table 1 (Section III) showed the building block sizes and their resource requirements for each technology. Table 7 depicts the MCI fuel production schedule, and Table 8 gives a schedule of the cumulative inputs (in 5-year intervals). Table 9 summarizes the synfuel output by regions of the United States and reflects several variables:

- Location of fossil reserves (Table 10)
- Current state or regional political sentiment towards mining and synfuel production (because these will affect the siting of plants in the next decade).
- Institutional barriers such as the ability to acquire enough coal resource to supply a plant for its lifetime.

Table 7

MCI SYNFUEL PRODUCTION SCHEDULE
(Million B/D)*

(Source: Table 6-1)

	Year				
	1980	1985	1990	1995	2000
Syncrude from oil shale	0.1	0.5	1.5	2.0	2.0
Methanol from coal†	0.05	0.3	1.0	2.5	4.0
Syncrude from coal	0	0.09	0.5	1.5	4.0
Total	0.15	0.89	3.0	6.0	10.0

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*10^6 B/D is about 1.6 × $10^5 m^3/D$.
†Oil equivalent energy.

Table 8

MCI CUMULATIVE RESOURCE INPUTS

(Sources: Tables 6-4, 6-5, 6-6)

	Year				
	1980	1985	1990	1995	2000
Construction	Cumulative Amount				
Capital (billions of 1973 $)	1.34	7.90	26.5	54.5	89.2
Labor (10^3 man-yrs)	12.9	38.1	257	593	973
Steel (10^6 tons)[*]	0.19	1.15	3.91	8.5	14.2
Site (10^3 acres)[†]	1.6	9.9	34.1	77	132
Operation	Annual Amount				
Coal (million tons/yr)[‡]	13	94	350	920	1760
Oil shale (million tons/yr)[‡]	54	270	810	1080	1080
Water (10^3 acre-ft/yr)[§]	31	196	685	1505	2680
Electric power (10^3 MW)	0.27	1.58	4.95	10.5	14.0
Labor (10^3 people)	2.6	17.9	50.5	100	162

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[*] 10^6 tons is about 907×10^6 kg.

[†] 10^3 acres is about $4.05 \times 10^6 m^2$.

[‡] 10^6 tons/yr is about 907×10^6 kg/yr.

[§] 10^3 acre-ft/yr is about $1.2 \times 10^6 m^3$/yr.

Table 9

MCI REGIONAL DISTRIBUTION OF SYNFUEL PRODUCTION
(10^6-B/D oil equivalent)*

(Source: Table 6-3)

	Year				
	1980	1985	1990	1995	2000
Coal					
Wyoming	0	0.06	0.39	0.99	1.95
Montana	0	0	0.08	0.58	1.6
North Dakota	0.025	0.125	0.275	0.650	1.05
New Mexico	0	0.05	0.15	0.20	0.20
Illinois	0	0.08	0.33	0.78	1.4
Kentucky	0.025	0.075	0.205	0.48	0.90
West Virginia	0	0	0.08	0.18	0.45
Ohio	0	0	0	0.15	0.45
Oil Shale					
Colorado	0.1	0.5	1.5	2.0	2.0
Total	0.15	0.89	3.0	6.0	10.0

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*10^6 B/D is about $1.6 \times 10^5 m^3/D$.

Table 10

STATES AND REGIONS WITH STRIPPABLE COAL RESERVES SUFFICIENT TO SUPPORT A LARGE SYNTHETIC FUELS INDUSTRY

(Source: Table 6-8)

States and Regions	Strippable Reserves (10^9 tons)*	Number of 100,000-B/D Plants Sustainable for 20 Years at 20 × 10^6 tons/year
Montana	43	110
Wyoming	24	60
North Dakota	16	40
Illinois/western Kentucky	16	40
West Virginia/ eastern Kentucky	8.7	22

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*10^9 tons is about 907 × 10^9 kg.

VI IMPLICATIONS OF THE MAXIMUM CREDIBLE IMPLEMENTATION SCENARIO

The MCI has many implications for U.S. society, institutions, and environments. The seven areas that the study team judged were most important because of their magnitude or the breadth of their impact are discussed individually below. Although the discussions that follow imply that these categories are independent, there are, in fact, many cross-links in the impacts. For example, in the arid West, the availability of water is linked with the socioeconomic effects on communities.

A. Impact Issues

1. Industrial Decision Making[9, 10]

Industrial decisions to deploy commercial-scale synthetic liquid fuel plants are obviously necessary to achieve the level of production hypothesized in the MCI scenario--unless the federal government decides to develop an enormous nationalized synthetic fuels industry. Since only the petroleum industry is well-positioned to develop and integrate synthetic liquid fuels into its business, the perceptions of the future held by major oil companies and their perceived available decision options become crucial to the future shape of the synthetic liquid fuels industry.

Several commonly held misconceptions about the oil industry are relevant to the future of synthetic liquid fuels. The first misconception is that there is a single "price" for crude oil in the world market determined by balancing supply and demand. Ever since the OPEC cartel set artificially high world prices for crude oil, the market place has not determined price. Moreover, even without OPEC, there would be a variation in the price asked for crude oils because of the variations in quality of oils. For example, because of air quality controls, the sulfur content of crude oils used for burning is a very important determinant of price. In addition, U.S. oil prices are regulated by the federal government.* Interventions by the federal government greatly complicate the process of corporate decision making because the stability of the regulations is uncertain. Similarly, the institutional stability of OPEC and its oil pricing policies is uncertain.

Another misconception about the oil industry is that there is a single "cost" of producing crude oil with which the cost of syncrudes might be compared. In reality, domestic oils are produced at a wide range of costs that depend on such things as the difficulty of drilling, ease of extraction from the field (self-pressured or pumped), the rate of production, and rents or royalties. In general, the longer production continues in a field, the less favorable recovery becomes. Therefore, the operating costs of production generally increase with the age of a field. In the United States there are hundreds of thousands of

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*In an effort to hold down costs to the consumer, oil produced from wells in operation before 1972 is called "old" and subject to a price ceiling, while oil produced from wells not in operation in 1972 is considered "new" and can be sold at uncontrolled prices. Additionally, a program of "entitlements" designed to spread among refiners the effects of high cost imported oil is in effect. These definitions have been changed several times through legislation.

so-called stripper wells producing at a rate of less than 10 B/D ($1.6\ m^3/D$); many of these wells represent last efforts to recover oil from old fields by conventional means.

Compared with the small range in market prices for crude oil, the range in production costs is very large--from just tens of cents per barrel for Saudi Arabian oil to many dollars per barrel for most domestic oils. Of course, a company ceases production from any given well when its production costs equal the price it could bring on the open market because this would be a zero-profit situation. For a similar reason, because the oil industry believes that oil shale and coal syncrudes will cost more to produce than it would cost to purchase even high cost OPEC oil, they refrain from starting syncrude production.

To illustrate how oil companies compare syncrudes with their other options, Figure 5 shows the relationships among crude oil costs and prices and the expected syncrude costs in 1973 before the Arab embargo and Figure 6 shows the relationships after the Arab embargo, with syncrude costs still uncompetitive, but less so than previously. The cross-hatched area in Figure 6 represents possible conventional crude production activities that were previously unprofitable but which would now be profitable;* the dotted area represents the new conventional crude activities that should still prove more profitable than syncrude production if the world price of oil were to rise further.

Since decision makers in the oil industry see so many conventional crude oil options still available that are more attractive than syncrudes, it should come as no surprise that oil companies do not build syncrude plants. Moreover, the possibilities encompassed by the dotted

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*As long as OPEC kept its price up.

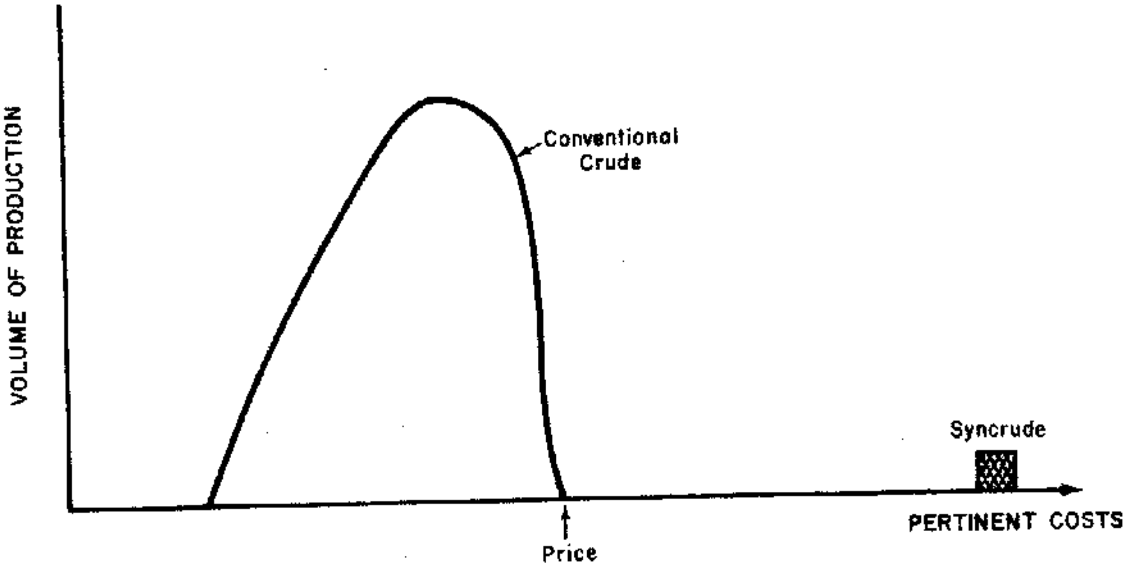

FIGURE 5. PRE-OPEC CRUDE OIL SITUATION

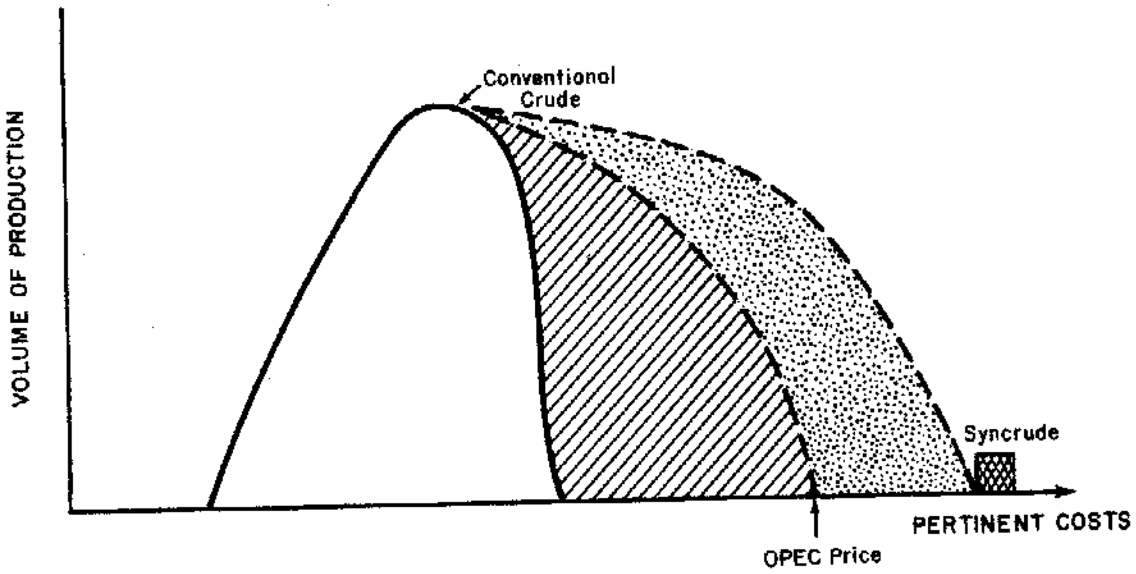

FIGURE 6. POST-OPEC CRUDE OIL SITUATION

and cross-hatched areas in Figure 6 are so large and so unknown (because their previous unprofitability had led to their neglect) that oil company decision makers must consider several major uncertainties:

- The actual amounts of oil that can be found and produced at costs less than syncrude (cross-hatched area of Figure 6).
- The rate at which world petroleum prices might rise compared with the time it takes to go from exploration to production of syncrude.
- The time when syncrudes might be less costly than OPEC oil.
- The possibility that OPEC might reduce prices, again rendering some of the new alternatives uneconomic.
- The question of whether U.S. energy policy will remain stable enough to accept the risk of producing high cost crude oils.

These sobering considerations appear to lead oil companies to continue to study synfuels but to refrain from starting construction on actual plants.

There is one final and fundamental uncertainty. The opportunities for oil exploration and production raised in the cross-hatched and dotted area of Figure 6 are uncertain because no one knows the actual amount of resources that might be located and produced in that price range. By contrast, the production of the syncrudes is certain once a plant is built, but the major uncertainty lies in the actual cost of constructing and operating the plant for these commercially untried processes.

2. Capital Availability[8]

The MCI implicitly assumes that once the synthetic liquid fuel industry becomes profitable, deployment on a large scale could be financed. Industrial investment is normally financed either through retained earnings or in the national capital market through the instruments of stocks, bonds, and loans.

The assumption that the existing petroleum industry could raise the $89 billion (1973 dollars) cumulatively required to the year 2000 during a gradual transformation of itself into a synthetic liquid fuel industry requires scrutiny. The marshalling of such a large amount of capital must be appraised not only with respect to the industry's financing ability but also with respect to its implied share of total U.S. capital formation. Although financing the synthetic liquid fuels industry stood out as a potentially very critical obstacle, it appears that the nation could accomplish it readily.[*]

The proper analysis is in terms of the oil industry cash flow. It must be recognized that each profitable synthetic fuels plant would generate retainable earnings that could be used to finance more plants. In fact, because the future conventional petroleum industry will itself become increasingly capital intensive,[†] adding the financing requirements for the MCI to the future financing requirements for the conventional petroleum industry does not change the situation greatly. This finding is demonstrated in Figures 7 and 8 for an economy with a general annual rate of inflation of 5 percent. Figure 7 shows the expected cash flow situation for a future oil industry based on conventional petroleum alone, while Figure 8 shows the cash flow situation for an evolving combined conventional-plus-synthetic petroleum industry.[‡] In both figures, much of the growth shown arises from the inflation alone (at a 5-percent

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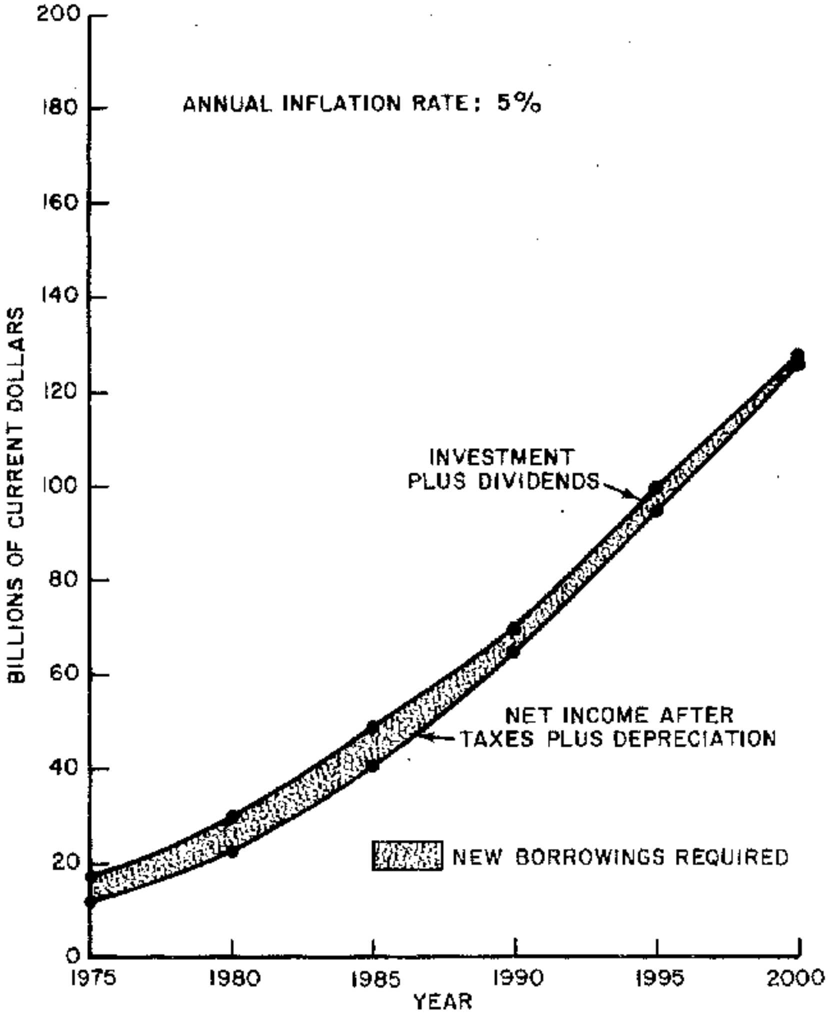
[*] Presuming that the industry can be made profitable; an unprofitable industry would be impossible to finance.[10]

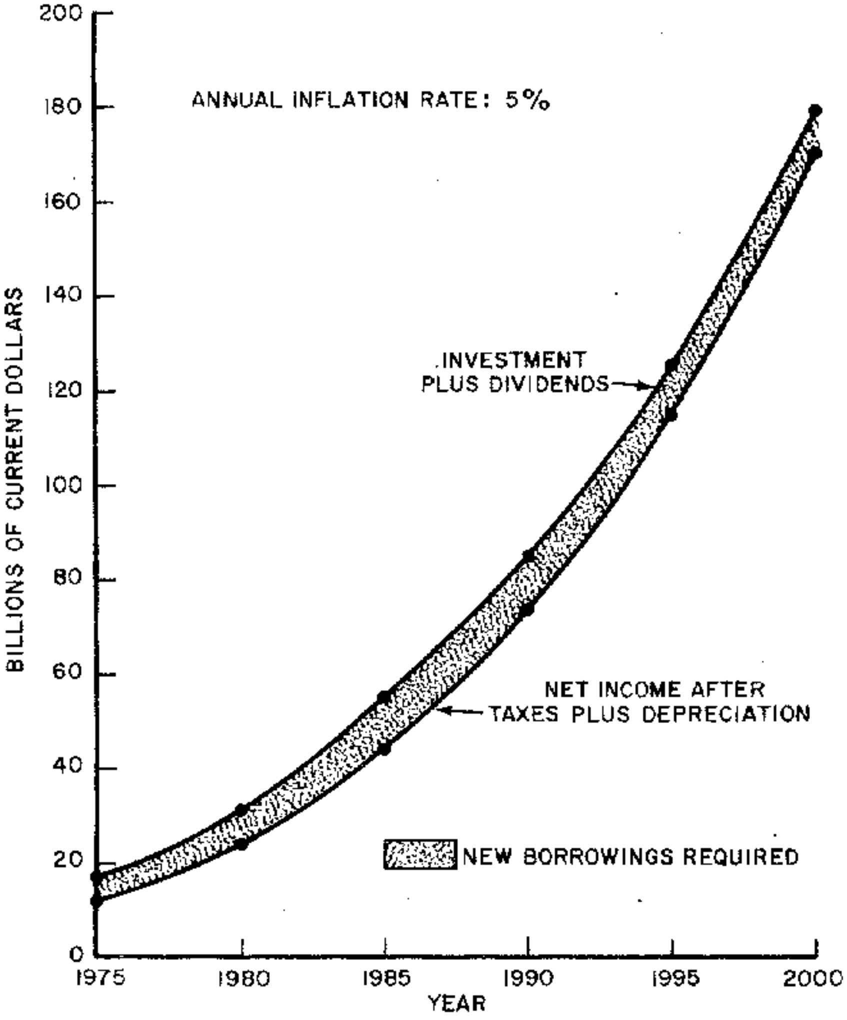
[†] Toward the end of the century domestic sources of petroleum will probably have capital investment requirements comparable to that of the synthetic liquids industry.[3]

[‡] The petroleum industry implied by HG1 plus the synfuels industry of the MCI scenario.



Source: Figure 8-3

FIGURE 7. PROJECTED CASH FLOW FOR DOMESTIC OIL AND GAS INDUSTRY – NO SYNTHETIC LIQUID FUELS – AT A FIVE PERCENT ANNUAL RATE OF INFLATION



Source: Figure 8-4

FIGURE 8. PROJECTED CASH FLOW FOR DOMESTIC OIL AND GAS INDUSTRY — CONVENTIONAL ACTIVITIES PLUS SYNTHETIC LIQUID FUELS – AT A FIVE PERCENT ANNUAL RATE OF INFLATION

inflation rate, the general price level doubles roughly every 14 years). As Figures 7 and 8 show, the industry cannot finance itself from cash flow alone and new capital must be attracted each year. This continued need for new borrowing is caused by the inflation because depreciation credits accrue in dollars of diminished purchasing power that cannot actually finance plant replacement. In the year 2000, the combined industry requires about $9.2 billion in new borrowings compared to the conventional petroleum industry's requirement of $2.2 billion.

In the early 1970s, the petroleum industry constituted about 9 percent of total U.S. fixed business investment, but under the MCI, by 1995 the combined natural and synthetic oil industry percentage would double. Given the two decades to adjust, it seems likely that the U.S. economy could accommodate to this increased fraction of business investment being made by the fuels industry.

3. Resource Depletion[6]

Table 10 shows that if liquefaction and methanol synthesis were the sole uses of coal, the demonstrated strippable reserve base* could sustain about 270 synfuel plants, each producing 100,000 B/D (16,000 m^3/D) for their assumed 20-year long economic lifetimes. Since the coal derived fuel production of the MCI would require 80 such plants in operation in the year 2000, the industry could be sustained at that level for only about 70 years on strippable coal reserves. However, if the very substantial increases in coal consumption expected for coal gasification and electricity generation are also considered, then the strippable coal reserves of Table 9 would last only about 40 years. This implies that

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*Estimated in 1974 by the Bureau of Mines. This estimate is optimistic because it includes inferred but unproven resources.

a massive shift to the more expensive, more dangerous-to-mine underground reserves would be necessary early in the twenty-first century if the synthetic fuels industry were to continue.

4. Water Availability[19,20]

a. Legal Situation

In the states east of the Mississippi River identified as candidates for mine-mouth synthetic liquid fuel plants (Table 5), precipitation is high and fairly evenly distributed during the year. There are many streams and large rivers. In those states ample water appears to be available to supply the needs of the water-intensive synthetic liquid fuel conversion plants.[20]

The use of water in the water-rich eastern states is governed by riparian law (stemming from English common law). Under riparian water law, rights to water are attached to the lands through which or by which a stream flows. There are complex rules concerning the transferring of water (from legally entitled lands) to other uses (such as cities not situated on the streams). However, the abundance of water in the East has generally left administration of the law flexible and without even an enumeration of claimants and the basis of their rights.[20]

In contrast to the East, the states of the West considered in Table 9 are arid, and precipitation is highly seasonal. As a result, an entirely different approach to water rights has evolved in which use of water is governed by the appropriation system. Under this system, there are no riparian water rights; instead, the first claimant to water is entitled to it, although he is often required to demonstrate his claim by removing and using a certain amount of water in a stream. Because this system does not require the claimant to possess lands near the stream, the water is often conveyed long distances in water works before being used.[19]

While the appropriation system establishes the basis for a record-keeping procedure and a means to ascertain ownership of water rights, in actuality, the situation is not so simple. Besides problems of inadequate records, there is uncertainty about the relative rights to water held by the federal government, the states, and the Indian tribes who reside in the West.

In the aggregate, there is enough water physically present in the West for the MCI, but it is almost always in the wrong place and the rights to it are disputed. As a result, the understanding, untangling, and resolution of the institutional issue of water availability in the western states is a critical issue in the development of a synthetic liquid fuels industry.

Because about 50 percent of land in the affected western states is in the federal domain, much of the water flowing in western rivers originates on federal land. Potentially, the federal government can assert claim to this water because it was never transferred to the states when they were created out of the federal domain. Since federal law takes precedence over state law, this could render previous allocations under state law effectively invalid.

Indian water rights are also a central issue because there are two (still untested) theories of Indian water rights. The first is that the Indians possess native rights to the water by virtue of being the first inhabitants of the land. The second is that when the federal government created the Indian reservations by treaty, the Indians were also accorded water rights (but of uncertain quantity). Both theories give Indian rights priority over most other claimants because they are older than nearly all other claims.

Since Indian water rights, at worst, derive from a treaty with the federal government, they take precedence over state rights. Consequently, many existing and relatively recently acquired water rights may be rendered useless even though the claimants adhered to all the state's formal procedures for establishing claims.

Although, from the above discussion, the federal government and the Indians would seem to be dominant in the water picture of the western states, historically it is the states that have played the major role as disbursers of rights. The roles of the federal government and Indians are only now rising to the fore. Most states have permit systems for allocating water within their borders, but Colorado did not institute its permit system before the Colorado River was over-allocated. The discrepancy between physical and legal availability in the Colorado River has not yet become important generally only because many rights go unused or only partially used.

In addition to administering water within their borders, western states are parties to interstate compacts that divide the waters in major rivers among the states for further allocation to users within their borders.

b. Water Quantities[19]

Table 9 showed major development in three states of the upper Missouri River basin. As shown in Table 11 the water needed in these states to support the MCI in the year 2000 is about 1.39 million acre-ft per year for both mines and conversion plants. Other demands for water are also expected to grow, including a reservation for maintenance of in-stream values. These other demands are expected to total 2.89 million acre-ft per year as shown in Table 12.

Table 11

NORTHERN GREAT PLAINS SYNTHETIC LIQUID FUEL WATER DEMANDS IN THE YEAR 2000

(Sources: Tables 6-3 and 19-7)

State	Quantity (10^6 acre-ft/yr)*
Wyoming	0.584
Montana	0.479
North Dakota	0.326
Total†	1.390

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*10^6 acre-ft/yr is about $1.2 \times 10^9 m^3$/yr.
†Total does not add due to rounding.

Table 12

NORTHERN GREAT PLAINS* PROJECTED ANNUAL CONSUMPTIVE USE OF WATER IN THE YEAR 2000

(Source: Table 19-6)

Use	Quantity (10^6 acre-ft/yr)†
Coal gasification and electric power generation	0.620
Revegetation	0.031
Municipal	0.014
Agricultural	1.900
Fishery habitat and wildlife improvement	0.320
Total‡	2.890

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*Wyoming, Montana, North Dakota.
†10^6 acre-ft/yr is about $1.2 \times 10^9 m^3$/yr.
‡Total does not add due to rounding.

When compared to the 5.97 million acre-ft per year (7.4 billion m^3/yr) unallocated and available (measured at Sioux City, Iowa) in low water years, one can conclude that there is more than ample water to meet all future needs in the basin in the year 2000.

While there may be ample water on a multistate basis, the local occurrence of water does not match the distribution of coal and lignite in these states. As a result, on a local and regional level, if the MCI were to be implemented with mine-mouth plants, there would be severe water shortages and shortfalls unless new storage facilities and aqueducts were built to redistribute the water. Such redistribution could often involve existing federal water storage reservoirs constructed by the Bureau of Reclamation. However, nonagricultural use of water in these reservoirs is being challenged because the Bureau of Reclamation's enabling legislation specifies that its work should benefit agriculture.

In Colorado, the availability of water for the oil shale conversion component of the MCI is less favorable. Since it would be vastly too expensive to transport oil shale out of the basin for conversion and disposal, the conversion industry must either secure water from the Colorado River or develop the still largely unmeasured ground water sources. In the year 2000, oil shale conversion plants under the MCI scenario would use 0.321 million acre-ft per year (400 million m^3/yr) while other demands are expected to total 6.14 million acre-ft per year (7.6 billion m^3/yr) as summarized in Table 13. However, the Colorado River Compact* allots only 5.8 million acre-ft per year (7.2 billion m^3/yr) to the upper Colorado River Basin in which the oil shale lies.

Future withdrawals for any purpose will exacerbate the already high salinity of the lower Colorado because it will mean less

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*A compact among Wyoming, Colorado, Utah, New Mexico, Arizona, Nevada, and California.

flow to dilute salty return flows in the lower basin. Water delivered to Mexico is already too saline and desalting plants are planned to honor U.S. obligations to Mexico.

Table 13

PROJECTED NON-OIL SHALE WATER DEMAND IN THE UPPER COLORADO RIVER BASIN IN THE YEAR 2000

(Sources: Chapter 19 and Table 19-10)

Use	Quantity (10^6 acre-ft/yr)*
All existing	3.710
Future	
Coal gasification	0.140
Electric power generation	0.475
Mineral production	0.115
Municipal	0.750
Agricultural	0.800
Environmental protection (fish, wildlife, water quality)	0.150
Total	6.140

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*10^6 acre-ft/yr is about 1.2×10^9 m^3/yr.

The cost of water is only a very minor component of the total cost of producing syncrude from oil shale. As a result, the oil shale industry could easily afford to pay much more for water than could agricultural interests without there being a significant effect on the cost of their product. By contrast, most agriculture in the region, which is dependent on irrigation, requires low cost water to produce crops at competitive costs. Agricultural interests in the Upper Colorado Basin are concerned that enough political pressure will develop in favor of oil shale to force future allocations of water away from farming and ranching to the synfuel industry, partly on the basis of the willingness of the fuel industry to pay a high price. Water allocations governed by the willingness to pay for water would certainly result in the diversion of water from agriculture to the oil shale industry--at least for future allocations. It is not apparent, however, that existing agriculture would necessarily lose water because 4 million B/D of oil shale syncrude (twice the MCI) could be produced with 0.8 million acre-ft/year (1 billion m^3/yr) of water identified in Table 13 as needed for future growth in agriculture.

c. Transport of Coal to Save Water[19]

Unlike oil shale, coal can be shipped economically to water-rich areas for conversion. The two methods of coal shipment potentially most appropriate for western coal are unit trains and coal slurry pipelines.

A unit train is a train dedicated to a single use; it shuttles back and forth between the source of its cargo and end use locations. A unit train that carries coal from mine to processing point typically consists of 100 cars, each capable of carrying 100 tons (9.1×10^4 kg) of coal. Even though the train returns to the mine empty, such 10,000-ton (9.1×10^6 kg) unit trains are the cheapest method of moving coal by rail.

Coal slurry pipelines are relatively recent developments. The largest in the U.S. is a 273-mile (440 km), 5-million ton per year (4.5 billion kg/y) pipeline that links the Black Mesa mine in Arizona to the Mohave Power plant on the Colorado River in Nevada. In the formation of a slurry, finely crushed coal is mixed with water in about 50-50 proportions. The mixture can be pumped readily through a pipeline. At its destination, the coal is dewatered in centrifuges.

Slurry pipelines require only about one half as much water per ton of coal as a coal liquefaction plant. Thus, by exporting coal from a mine by slurry pipeline to the location of a coal liquefaction plant elsewhere, the water demand in the mining region is reduced by half. Railroads, of course, require almost no water in the mining region.

Both railroads and slurry pipelines have advantages and disadvantages. The advantages of railroads include the ability to phase in incrementally, flexibility of routes, and existing facilities. The disadvantages of railroads include the susceptibility to labor disputes, disruption to crossing auto traffic, and noise. The advantages of slurry pipelines include high reliability, small labor force, immunity to weather, ability to traverse more rugged terrain than can railroads, aesthetics of being placed underground, and the movement of coal for less money and energy cost than that entailed in rail transport. The disadvantages of slurry pipelines include fixed route, restriction to single product, and exports of water from water-poor regions.

Currently there is controversy about the relative desirability of slurry pipelines and railroads for coal transport. Railroads generally oppose slurry pipelines because they want the coal hauling business themselves. Since slurry pipelines would usually have to cross railroad rights of way, the railroads have been refusing to grant crossing rights. Congress is considering bills that would grant slurry pipelines powers of eminent domain to enable them to cross railroad rights of way.

Although, as presented here, the question of the use of slurry pipelines for coal shipment is centered on the issue of water availability, it is easy to see that the question quickly broadens to include the future viability of railroads and their value to society above and beyond hauling coal.

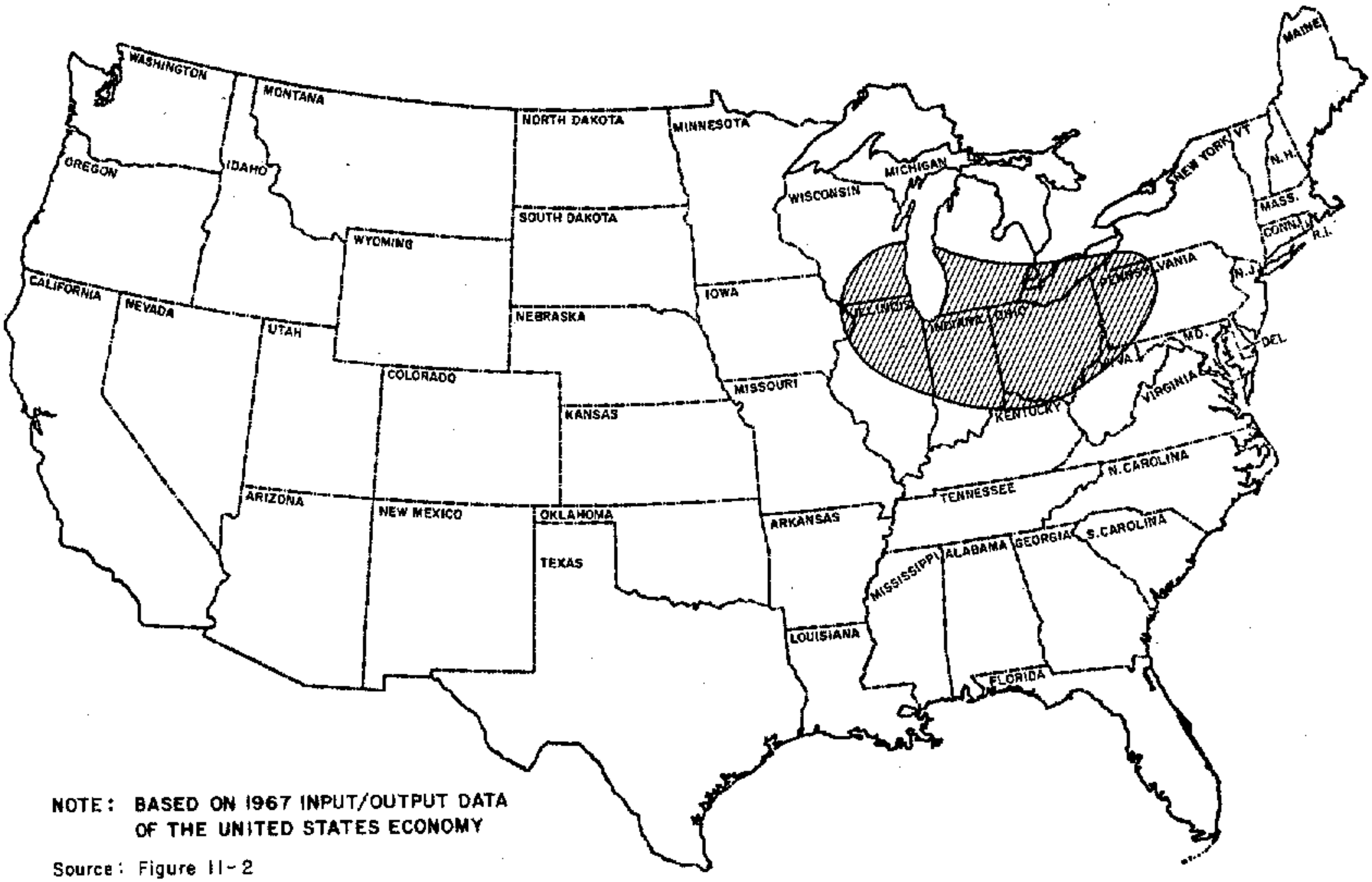
5. Economic Spin-Off Effects[11]

The deployment of a synthetic liquid fuels industry will naturally affect many supporting industries and the labor market. The industrial sectors that will be most affected by the mining of the fossil resources, their transport, and the construction of conversion facilities are steel (raw and finished specialty goods), railroads, explosives and heavy equipment. Such industries are heavily concentrated in Illinois, Indiana, Ohio, Michigan, and Pennsylvania. Thus, although the development of a synthetic liquid fuels industry might be heavily concentrated in the resource-rich states of the West, substantial economic and employment spin-offs would result in the states with the heavy support industry. Figure 9 shows the geographical concentration of this economic spin-off.

Steel needed to support the MCI would result in the energy industry gradually increasing its share of the total steel produced in the United States from about the current 7 percent to about 11 percent.

While the gross figures for steel availability do not suggest problems, the availability of specialty steels, castings, forgings, and special equipment such as mining draglines, compressors, and pumps will quite likely present a bottleneck because lead times are already long in the fabrication industries and they cannot expand capacity rapidly. Currently, there are only one or two suppliers for some items. In addition, coal liquefaction, oil shale, and methanol facilities require large pressure vessels made of special steels and will have to compete for these vessels with the expanding coal gasification and nuclear power industries.

Although the MCI assumes conversion facilities near the mine, transportation of the coal to distant locations is sometimes considered. Railroads presently carry 78 percent of all coal to market, and this amounts to 20 percent of all rail traffic. If the MCI coal were all



NOTE: BASED ON 1967 INPUT/OUTPUT DATA
OF THE UNITED STATES ECONOMY

Source: Figure II-2

FIGURE 9 . PRIMARY CONCENTRATION OF MAJOR INDUSTRIAL SECTORS EXPECTED TO SUPPLY THE COAL AND OIL SHALE INDUSTRY

transported by rail for conversion far from the mine, over 300,000 more hopper cars would be required, and this exceeds the expected production capacity for such cars. These cars also require castings and forgings adding yet another strain on this component of the steel industry.

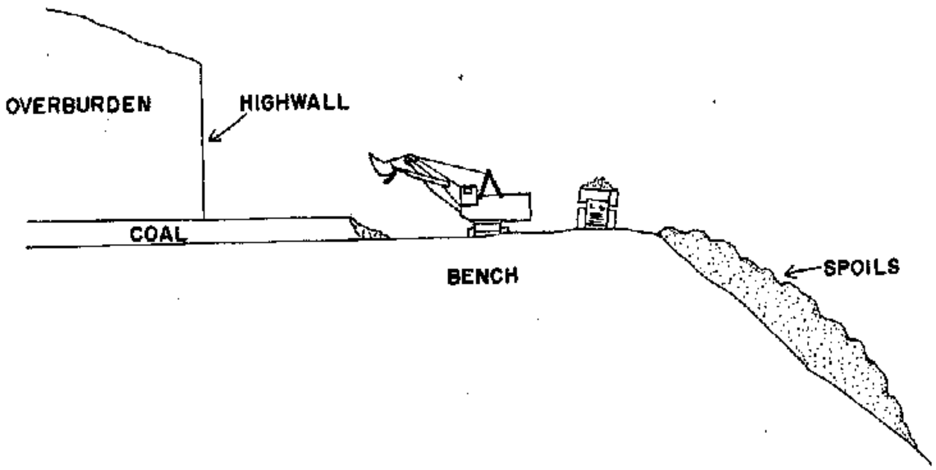
6. Environmental Effects

a. Reclamation of Coal Strip Mines[13,15]

Mining of both coal and oil shale presents severe environmental problems that cannot be alleviated simply. As noted earlier, the high production cost of synthetic liquid fuels from coal will necessitate the use of the cheapest possible coals--those obtainable by strip mining.

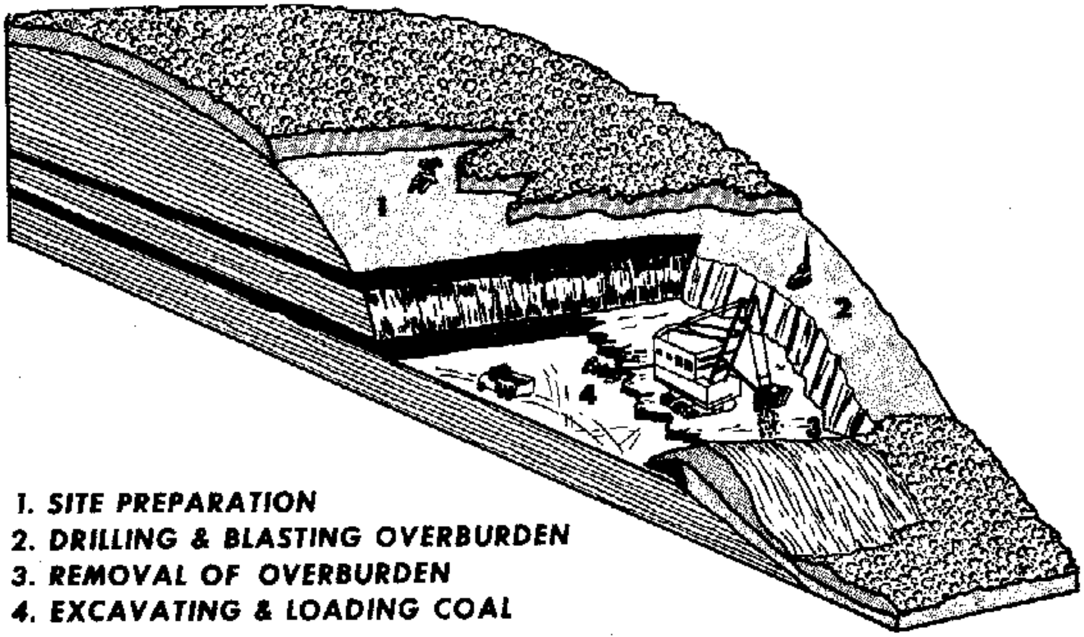
Strip mining for coal requires different equipment and procedures in different regions of the country because of the variation in the nature of the coal deposits. In Appalachia, strip mining takes place along hillsides where thin seams of coal outcrop. Extraction of such coal entails digging into the hillside until the thickness of the overburden becomes so great that its removal precludes economical recovery of the coal. For many years, after the overburden was removed it was merely pushed down the hillside away from the mining activity and abandoned. As a result, the many mined-out hillsides in Appalachia are badly scarred with the highwalls, benches, and downslopes spoil piles (see Figures 10 and 11) as well as a multitude of poorly built, abandoned mine access roads. These scars erode easily in the heavy rains and are slow to revegetate naturally .

Today, most strip mining in Appalachia employs improved materials handling procedures designed to eliminate much of the downslope disturbance by returning overburden to the bench and breaking down the highwall after the coal has been removed. Provided that toxic spoils



Source : Figure 13-5

FIGURE 10. DIAGRAM OF A CONTOUR MINE



Source: Figure 13-6

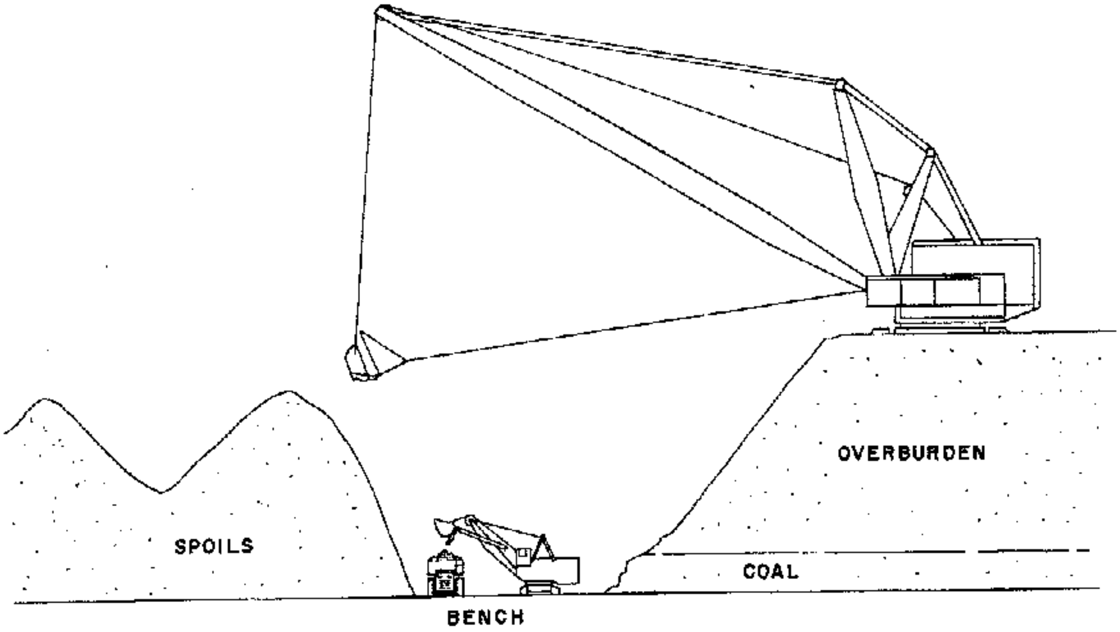
FIGURE 11. CONTOUR STRIP MINING

are buried deep and the best soils are replaced on the top, the disburbed land can be revegetated. The ample moisture in Appalachia would make revegetation and reclamation reasonably successful if the hillsides were not steep. The steep hillsides and large amount of land disturbed per unit of coal produced makes reclamation in Appalachia costly to achieve and protect against erosion until revegetation has stabilized the surface.

In the Midwest, the Northern Great Plains, and parts of the West, where coal lies near enough to the surface to allow strip mining, extraction of the coal is much more straightforward. The overburden is removed from a large area, coal is removed, and then the spoils are replaced in the hole. Since the coal underlies relatively flat terrain in large sheets that are also generally thicker than in Appalachia, far less area is disturbed per unit of coal removed. Indeed, in parts of the Northern Great Plains coal, seams are 30 to 100-ft (9 to 30 m) thick and mining can assume the form of an open-pit operation that resembles quarrying (see Figures 12 and 13).

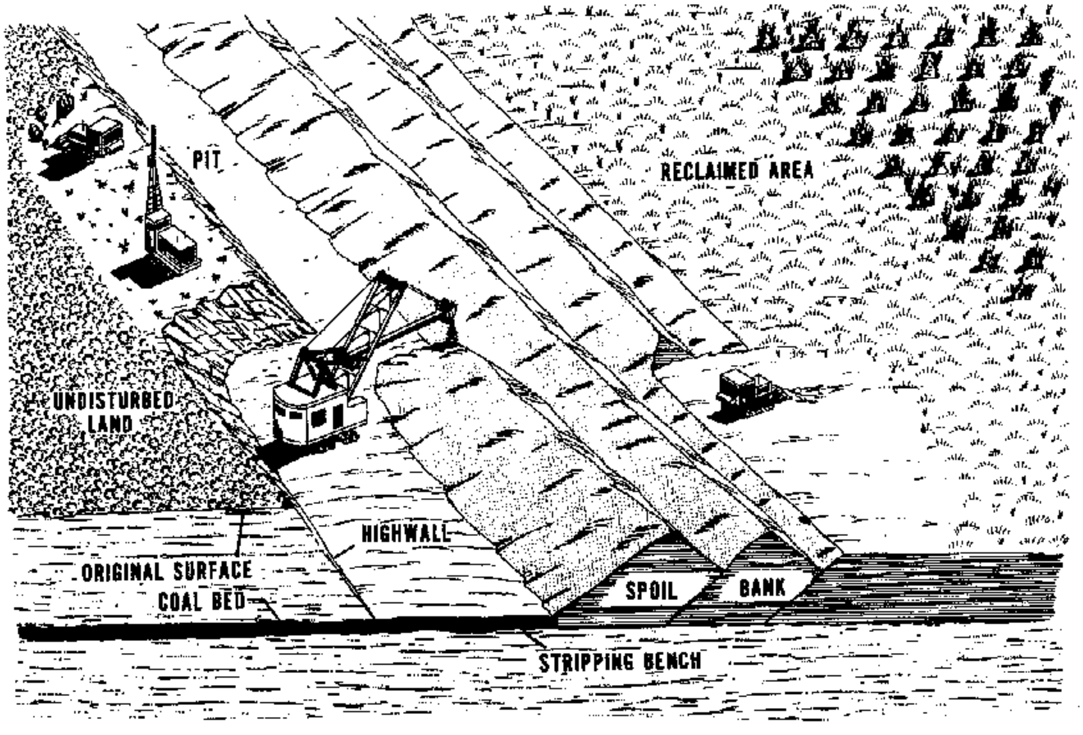
In the Midwest, the deep soils, ample rainfall, and relatively level terrain make reclamation fairly successful whenever it is planned as an integral component of the mining plan. Were it not for the arid conditions in the West and Northern Great Plains, reclamation there would be similarly successful. However, the low and very seasonal pattern of rainfall in these regions makes it difficult to reestablish self-sustaining vegetation. Although some success has been demonstrated, there has not been time enough to insure that the new vegetation can survive without continued human care.

Restoration of mined lands is an issue that has stirred the national consciousness and has resulted in repeated attempts to pass strict federal and state strip-mine reclamation laws. Because of this and the likely focus of future strip mining activities in the arid West, reclamation of mined lands is a critical factor in the deployment of any



Source: Figure 13-8

FIGURE 12. DIAGRAM OF AN AREA MINE



Source: Figure 13-9

FIGURE 13. AREA STRIP MINING WITH CONCURRENT RECLAMATION

significant synthetic liquid fuels industry--even one much smaller than the MCI.

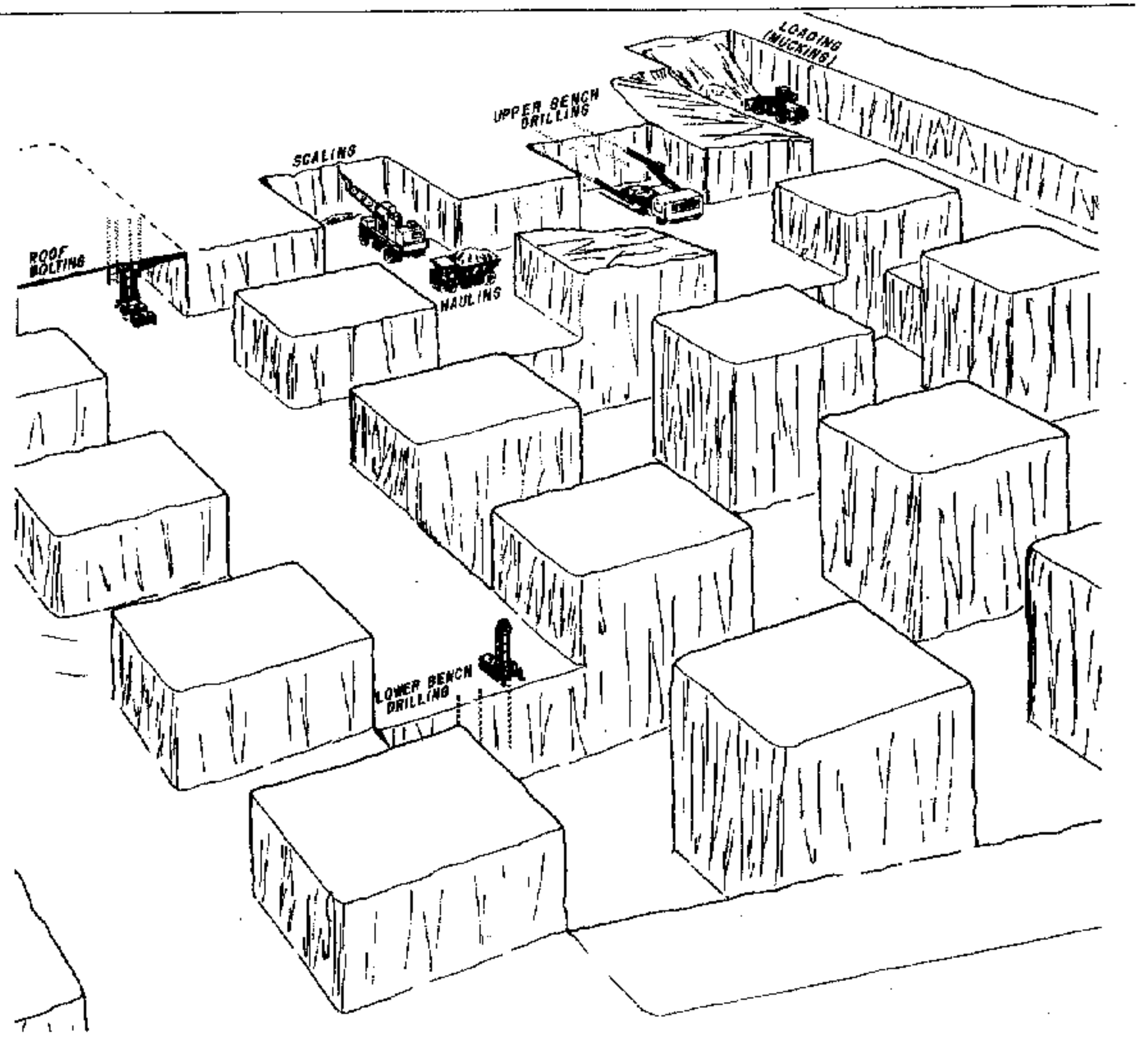
b. Reclamation of Mined Oil Shale Lands[14,15]

The mining and restoration of oil shale lands is a considerably different matter. The volume of oil shale that must be handled to produce a given quantity of synthetic crude is about three times the volume of coal that would be handled for the H-coal process (see Table 4). Not only is the volume of material extracted and processed larger, but the volume of waste material requiring disposal is also vastly larger because the volume of spent shale exceeds the volume of raw shale.

Oil shale usually occurs in deposits so thick that the mining of it underground resembles quarrying (except under a roof) as shown in Figure 14. Open-pit surface quarrying would often also be suitable. In either case, in principle, spent shale could be returned to the mines once mining activities had ceased. In practice, however, disposal somewhere else would be required during early stages of the industry. Some additional disposal sites would be required to accommodate the excess volume of spent (compared to raw) shale. Since oil shale country is heavily cut with canyons, the general expectation is to fill canyons with spent shale. Revegetation of this spent shale has not been successfully demonstrated on a large scale and over a long enough period to be certain that it can survive after human attention wanes. Disposal and reclamation of spent oil shale is a critical environmental factor.

c. Air Quality[16]

By any measure, the synthetic liquid fuels plants being considered here are large, heavy industrial plants and are potential sources of air pollutants.



Source: Figure 14-1

FIGURE 14. UNDERGROUND OIL SHALE MINING BY THE ROOM AND PILLAR METHOD

Three classes of nondegradation standards have been defined by the Environmental Protection Agency for regions presently possessing air quality equal to or better than federal secondary standards:

- Class I--only slight degradation of air quality*
- Class II--allows modest decline in air quality, compatible with light industry or carefully controlled heavy industry.
- Class III--essentially equivalent to the federal secondary standards.

Emissions from each of the three processes selected for this study have been examined under the assumption that the best available emission control technology would be applied and that the most relevant ambient standards are the federal Class II "nondegradation" standards.

The best available controls appear to be inadequate for a single oil shale conversion plant (with the emission levels available to this study)† to meet Class II standards. Particulates and sulfur dioxide emissions require 85 and 72 percent more control, respectively.

A single coal liquefaction plant could successfully meet Class II standards without additional control of emissions. However, dispersion modeling of the air quality impact of a complex of four liquefaction plants in Wyoming's Powder River Basin under worst-case

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*Class I standards are so strict that they, in effect, preclude industrial activity, and therefore essentially contradict the assumption that the conversion plants exist.

†Revised emissions for the TOSCO II process have recently been released in the draft Environmental Impact Statement for the "Proposed Development of Oil Shale Resources by the Colony Development Operation in Colorado" (December 1975).

wind conditions shows that although a single plant could meet Class II standards, additional control of particulates would be required to enable a complex of plants to meet the standards. Since the MCI hypothesizes about 18 plants in Wyoming in the year 2000, probably with 5 to 10 in the Powder River Basin area, it is apparent that development and use of improved air quality controls technology will be essential to meet plausible ambient air quality standards.

Although it appears that a complex of well-controlled plants would not result in air quality as bad as that found in many major cities, there would be major deterioration below present levels. Since holding air quality deterioration to the level of Class II standards requires controls beyond the best available today, air quality control represents a very important critical factor in deployment of a synthetic liquid fuels industry. If states do not select their ambient air quality standards uniformly, then the industry will tend to locate in the areas with the least stringent standards.

d. Urbanization[17]

Rapid rates of population growth in areas now sparsely populated leads to the creation of boom towns in which environmental quality protection measures are usually inadequate. Sewerage, storm run-off, solid waste disposal, and other environmental protection facilities usually cannot keep pace with the population influx and, as a result, environmental quality can be seriously impaired at the local level. In addition, new population increases demands for outdoor recreation--demands that often result in excessive hunting, fishing, use of off-road vehicles, and vandalism of archeological or scenic resources. (Social effects of boom towns are described later.)