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COMMITTEE PRINT

# SELECTED MATERIALS ON STRATEGIC ENERGY RESERVES

## SELECTED MATERIALS

PREPARED AT THE REQUEST OF

HENRY M. JACKSON, *Chairman*

## COMMITTEE ON INTERIOR AND INSULAR AFFAIRS
## UNITED STATES SENATE

PURSUANT TO

S. Res. 45

## THE NATIONAL FUELS AND ENERGY POLICY STUDY

**Serial No. 94–12 (92–102)**

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# SENATE RESOLUTION 45

## National Fuels and Energy Policy Study

This publication is printed for the use of Senators participating in the National Fuels and Energy Policy Study, authorized by Senate Resolution 45 of the 92d Congress.

Senate Resolution 45, introduced by Senators Jennings Randolph and Henry M. Jackson, was amended and agreed to by the Senate on May 3, 1971. The resolution authorized the Senate Committee on Interior and Insular Affairs and ex officio members of the Committees on Commerce and Public Works and the Joint Committee on Atomic Energy to make a comprehensive study of programs and policies required to meet national energy needs.

Subsequently, the Senate approved the addition of ex officio members from the Committees on Aeronautical and Space Sciences, on Finance, on Foreign Relations, on Government Operations, and on Labor and Public Welfare.

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# MEMORANDUM OF THE CHAIRMAN

*To Members and Ex Officio Members of the National Fuels and Energy Policy Study (S. Res. 45, 92d Congress), Committee on Interior and Insular Affairs:*

In 1975, almost 40 percent of domestic petroleum demand will be met by imports from abroad.

Our continuing reliance on oil imports, and the experience of the Arab embargo, have strengthened the case for establishing a system of strategic reserves. The very existence of such reserves could help to deter future embargos, as well as protect the U.S. economy from the impact of interruptions in vital energy supplies.

The 94th Congress must authorize the creation of a strategic reserve system. Hopefully, the development of additional reserve storage can begin this year.

The Armed Services and Interior Committees have already held joint hearings on strategic reserves issues. Both committees are giving priority to the development of legislation on this subject.

At my request, the Interior Committee staff has prepared this collection of materials on the subject of strategic reserves for the use of Senators participating in the National Fuels and Energy Policy Study.

HENRY M. JACKSON, *Chairman.*



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# INTRODUCTION

Realistically, there seems little doubt that the United States will be heavily dependent on oil imports for the next few years.

In 1973, 35.3 percent of total U.S. petroleum consumption was met through imports of crude oil and petroleum products. In 1974, we relied on imports for 37 percent of our requirements. Forecasts for 1975 suggest that imports will contribute over 40 percent of domestic consumption.

Obviously, the degree of reliance on imports will depend on the success of efforts to restrain demand through conservation programs and increased domestic production. But the lead times involved in securing pay-offs from either production or conservation programs assure substantial reliance on imports for the next decade.

The FEA has concluded, in its Project Independence study, that "oil imports will remain level or rise in the next few years, no matter what long-term action we take."

As long as substantial reliance on foreign oil is inevitable, some provision must be made to protect the Nation's economy against the impact of import interruption. The experience during the Arab embargo from mid-October 1973 to mid-March 1974 showed how serious that impact can be. During the first quarter of 1974, when the full effect of the embargo was felt, imports averaged 2.2 million barrels per day below earlier projections. The resulting cutback in petroleum consumption was accompanied by a 7-percent decrease in real GNP, rather than the increase forecast before the embargo.

Reporting on the effects of the embargo, the National Petroleum Council found that—

> While the primary effects on industry were held to a minimum, the secondary repercussions resulting from disruptions in world energy markets and from consumer reactions were significant. Gasoline shortages and rising fuel prices triggered a demand shift toward smaller cars, which slowed activity in domestic automotive and related industries. The tourist industry and vacation areas were hard hit. Repercussions in money markets contributed to slowdowns in the housing and construction trades.

The relatively short duration of the embargo, coupled with strong energy conservation efforts, kept the impact of the embargo within manageable limits, but a prolonged embargo could have far more serious effects. Obviously, the degree of vulnerability depends on the level of imports. The Project Independence report, asserting that vulnerability to import disruptions depend on world prices, concluded that—

> At $7 oil and no new domestic policy actions, imports will reach 12.3 M bbl/d in 1985, of which 6.2 M bbl/d are susceptible to disruption. A 1-year embargo could cost the economy $205 billion.
>
> At $11, imports will decline to 3.3 M bbl/d by 1985, and only 1.2 M bbl/d are susceptible to disruption, at a cost of $40 billion for a 1-year embargo.

Thus, the impact of a future embargo could be serious enough to justify comprehensive—albeit costly—measures to minimize such impacts.

The need for building stockpiles of petroleum has been increasingly discussed as the Nation's dependence on imports has grown. In 1970, the Cabinet Task Force on Oil Import Control recommended that—

> * * * further intensive study be given to the feasibility of developing safeguards for U.S. oil security by means other than import controls, with a view to possible legislative recommendations. Particular alternatives meriting continued study are underground and conventional storage, subsidization of shale oil or coal oil capacity, and the development of deliverable emergency productive capacity in Naval Petroleum Reserve No. 4.

In opening hearings on oil import issues in January 1973, Senator Jackson asked:

> If overseas imports are genuinely insecure—and I believe they are—how has it happened that we have no contingency reserve either in the form of storage or in the form of reserve producing capacity? How is it possible that there is no plan—and up to today at least, not even a public proposal to create such a strategic reserve?

The Department of the Interior, in a submittal for the hearings, agreed that a storage program "may be very desirable to help offset against short-term supply interruptions as to provide a cushion against longer-term interruptions in imports." But the Department deferred specific proposals pending the outcome of its own studies and a study by the National Petroleum Council.

The final report of the National Petroleum Council on this subject dated September 10, 1974, concluded that the United States should develop an emergency petroleum security storage system. The report asserted that a substantial volume of such storage was needed and that "efforts to implement such a program should begin immediately because of the long construction lead times involved." The report went on to state that—

> First consideration should be given to providing crude oil security storage to protect domestic refinery runs. This study indicates that 500 million barrels of crude storage in combination with normally available inventories will provide 90 to 180 days of supply for a large percentage range of crude imports presently foreseen. Crude storage can be efficiently located in one or more Gulf Coast salt dome projects and integrated with the crude transportation system that will serve Gulf Coast deep-water terminals. Specific circumstances and specific logistical problems could require storage of fuel oil at strategic locations on the East Coast.

Other recent energy studies have reached the same conclusion as the National Petroleum Council.

The preliminary report of the Ford Foundation's Energy Policy Project in mid-1974 concluded that if the Nation chooses to increase imports—

> It is incumbent on us to undertake a positive program for dealing with future cutoffs—a strategic storage program.

The report pointed out that it had been normal practice for industry to maintain inventories of 40 to 50 days supply to deal with seasonal demands and operating requirements. This normal inventory is not adequate in the event of a sudden interruption.

An economic evaluation of the concept of energy self-sufficiency by the MIT Energy Laboratory Policy Study Group, published this fall by the American Enterprise Institute for Public Policy Research,

found that security could be provided against import disruption by the introduction of radically new import policies, one important element of which would be oil stockpiles. The study found that the maintenance of a stockpile to guard against a 1-year cutoff of 2 million barrels per day of imports would cost about $990 million a year. If industry were required to provide such a stockpile, the cost of oil delivered to consumers would rise by no more than 25 cents a barrel, or two-thirds of a cent a gallon.

The Research and Policy Committee of the Committee for Economic Development released a statement on energy policy in December 1974, which endorsed the concept of strategic reserves.

The Agreement on an International Energy Program, signed by the United States and other major oil consuming nations in September 1974, requires each participating country to maintain "emergency reserves sufficient to sustain consumption for at least 60 days with no net oil imports."

The United States currently meets the requirements of the Agreement in this respect because the Agreement defines emergency reserves to include unavailable inventories such as petroleum in tank bottoms and pipelines.

At the Interior Committee's hearing on the International Energy Agreement on November 26, 1974, the administration witnesses made clear that compliance with the requirements for emergency reserves under the Agreement was no substitute for the establishment of a genuine strategic reserve.

President Ford's state of the Union message on January 15, 1975, approved a "strategic storage program of 1 billion barrels of oil for domestic needs and 300 million barrels for defense purposes." This was the first Presidential commitment to establishing a strategic reserve.

In opening hearings on strategic reserves legislation on March 11, 1975, Senator Jackson set forth three compelling arguments for creating such reserves—

First, possession of a sufficient reserve of petroleum reduces our vulnerability and minimizes the adverse impact on the Nation of any potential curtailment of oil imports; second, because a system of strategic reserves would reduce our vulnerability to import curtailments, the effectiveness of an embargo as a politico-economic weapon would be significantly reduced, thereby reducing the likelihood of its employment; lastly, when compared with a strategy of seeking total near-term energy self-sufficiency, one that combines enhancing energy self-sufficiency with the creation of a system of strategic reserves is significantly more cost-effective.

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# I. Excerpts From the Project Independence Report—Emergency Stockpiles

# Federal Energy Administration

# Project Independence Report



# Project Independence

November 1974

## Emergency Stockpiles

Existing Emergency Stockpiles: Today our only existing source of emergency supplies are current petroleum inventories. Normal inventory levels of crude oil and refined products in the United States are generally in the range of 800-1,000 million barrels. If total demand is in the range of six billion barrels per year, total inventories are on the order of 15 to 20 percent of annual demand or 60 days supply. Stocks of crude oil are generally a small fraction of consumption (4 percent) while stocks of finished products comprise the majority of the inventory. The current inventory level of approximately 450 million barrels over and above working and seasonal stocks would be sufficient to offset completely in total volume the effects of the 73-74 embargo. However, the mix of crude and products would be very badly matched to the cutoff quantities. Table VII-13 summarizes the current United States stock position and its potential for use in an emergency. Table VII-14 illustrates the problem of seasonality for several key products.

Table VII-13
Current "Emergency" Storage Capacity
(in millions of barrels)

| Product | 1972 Average Total Stocks[1/] | 1972 Average Consumption | Days Usable Storage |
|---|---|---|---|
| Crude Oil | 279.4 | 11.7[2/] | 23.9 |
| Gasoline | 216.0 | 6.4 | 33.8 |
| Distillate | 148.1 | 2.9 | 51.1 |
| Residual Fuel | 56.9 | 2.5 | 22.8 |
| TOTAL | | | |

1/ Stocks at primary storage locations only.
2/ Runs to stills used as consumption measure.

Table VII-14
Seasonal Variation in Product Storage Levels

| Product | Winter 1972[4] Average Stocks | Demand | No. Days | Summer 1972[5] Average Stocks | Demand | No. Days |
|---|---|---|---|---|---|---|
| Gasoline | 242.4 | 6.0 | 40.4 | 193.1 | 7.0 | 28.3 |
| Distillate | 128.0 | 3.8 | 33.7 | 153.0 | 2.0 | 76.5 |

4/ Jan. Feb. March
5/ June, July, Aug.

As the 1973-74 embargo demonstrated, however, it is highly unlikely that the Nation could, in fact, fully utilize its current inventories. Current stocks are not well distributed either among products or geographically; crude oil and residual stocks are relatively low, particularly on the East Coast. The use of these stocks would, in fact, result in localized shortages. Thus, perhaps less than one-half of the potential could be drawn down during an emergency. Whether it would be drawn is another matter. The United States and European experiences of last year have shown that available supplies are generally not drawn down due to the lack of knowledge of the duration of an emergency and the feeling that stocks should be saved for a possible worse situation.

Alternative types of additional emergency storage. The following discussion is an excerpt from the most recent summary report by the National Petroleum Council undertaken at the direction of the Secretary of the Department of the Interior

> "There are three basic alternatives for providing standby petroleum supplies to offset a sudden loss of imports. These are: (1) shut-in or reduction of production from domestic oil fields, (2) storage of crude after production from underground reservoirs and (3) storage of refined petroleum products. Several major factors must be considered in developing an optimum emergency standby system. First, standby supplies must be located so that facilities existing at the time of an emergency can transport such supplies to locations where needed at rates sufficient to replace imports that cannot be offset by other means. Second, the capability to construct associated facilities and obtain sufficient crude and/or product to fill programmed storage in the desired time frame must be assessed. Finally, the total cost to the Nation of available alternatives must be weighed against the degree of protection provided.
>
> The alternative of providing standby supplies by shutting-in or reducing production from domestic oil fields has major disadvantages. Such action would simultaneously reduce the supply of indigenous oil and gas to the United States economy. Reduced crude production would have to be offset by increased imports, if available; however, imported crude would probably have a high sulfur content and many United States refineries cannot process such crude. This would also make the United States even more dependent on imports and would adversely affect the United States' economy and balance of payments. Administration of such a program would be extremely complex. For example, provisions would have to be made to compensate owners of shut-in production for reduced current income and,

in many cases, reduced ultimate recovery. Establishment of fair compensation would be difficult and litigation on behalf of such owners would probably result. In addition, such action would cost the Nation from 5 to 10 times more per barrel of daily production capacity than security storage of crude or product.

Security storage of refined products or crude after production can be located above ground in steel tanks or underground in caverns leached in salt or mined in hard rock. The primary advantage of steel tank storage is locational flexibility and the ease with which supplies can be integrated into the existing petroleum logistical system. The major disadvantage of above ground tank storage is the high cost -- $3.80 to $7.00 per barrel, depending on location, type of storage and local conditions. The availability of steel for timely construction of very large scale tankage projects is also of concern.

In contrast, storage in salt domes can be provided for $0.60 to $0.85 per barrel if the volume to be stored exceeds 100 million barrels. Many salt domes on the Gulf Coast are capable of accommodating storage projects of several hundred million barrels. Extensive experience with such storage in the United States has proven its safety and reliability. Since crude or product is stored in large caverns, very high redelivery rates are possible. For example, a single 200 million barrel project might require only 20 to 40 wells and be capable of a redelivery rate of several million barrels per day during an emergency. Although other underground storage alternatives were also evaluated (mined caverns, salt beds, abandoned mines, depleted reservoirs), storage in salt domes has the lowest cost. Such storage is normally located 2,000 feet below the surface and is, therefore, more secure against natural disasters and sabotage than steel tank storage.

Crude oil storage in salt domes appears more practicable than refined product storage. The potential for weathering is reduced, and any quality problems that might occur with crude oil could be corrected during refining. Problems of quality control, questions of what grades, types and volumes of finished products to store and the seasonal nature of major product demands would exist for high-volume security storage of refined products over an extended period of time in a salt dome environment. Additionally, transportation of product from salt dome storage to terminals would be more difficult and expensive than for crude. Thus, if a product security storage program is implemented, storage aboveground in higher cost steel tankage is probably the best alternative. It is recognized that residual fuel oil imports present a special case because such imports are concentrated on the East Coast.

A security storage volume of about 500 million barrels in combination with other available supplies would provide protection commensurate with similar programs in effect in other consuming nations. Proposed new Gulf Coast deepwater terminal and pipeline facilities, which should be in service in 1978, will be capable of transporting imported crude to a

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large percentage of Midwest and Rocky Mountain refineries. Therefore, salt dome storage projects should be located near deepwater terminal tank farms to ensure easy distribution of security storage crude to refineries during an emergency.

Location of security storage crude for East Coast refineries in Gulf Coast salt domes will save $4 to $5 per barrel in storage cost. Gulf Coast deepwater terminals can be designed to permit loading of security storage crude for delivery to the East Coast during an emergency. However, use of foreign flag vessels to augment the United States' fleet may be required to ensure timely delivery during an emergency. Need for storage on the West Coast will depend on supply self-sufficiency there. Factors to be considered include the impending availability of North Slope crude and flexibility to ship crude from the Gulf Coast.

Leaching of several hundred million barrels of salt dome storage could be completed in about 6 years. Significant storage could be ready to fill about 1979, which is consistent with the anticipated startup of Gulf Coast deepwater terminals. Therefore, completion of a 500 million barrel crude storage program in the early 1980's appears feasible if crude can be made available for fill."

Crude and residual oil are the most attractive substances for emergency storage. They are the least covered by normal inventories in terms of the days of imported supply normally held. They are also fortunately the least costly form of petroleum to store. As long as there is sufficient refinery capacity available during the emergency, storage of crude also gives maximum flexibility to response to the cutoff.

The effectiveness of the storage options depends on the proximity of the appropriate types of crude to refineries, and where sufficient transport capacity will be available during the emergency. Specific further study of these considerations will be required for the development of these options.

The types and costs of emergency storage are summarized in Table VII-15.

## TABLE VII-15 1/

ALTERNATIVE MEANS OF PETROLEUM STORAGE
(COSTS AND OTHER CHARACTERISTICS)*

| Type | Construction Cost Range $/BBL | Annual Maintenance Cost, $/BBL | Geographical Limitations | Special Considerations |
|---|---|---|---|---|
| Above Ground | | | | |
| Steel Tanks | 3.00 - 5.00 | .06 - .10 | Essentially none. Several acrea required at each location. | Capacity of steel plate fabrication industry may significantly restrict construction rate. |
| Underground | | | | |
| Salt Domes (On-shore) | 0.50 - 0.75 | .002 - .005 | Gulf Coast locations only. | Costs assume a brine disposal pipeline to the Gulf. |
| Salt Domes (Off-shore) | 0.75 - 1.00 | .005 - .01 | Gulf Coast locations primarily. | Possible technical problems in drilling large diameter (24 to 36 inch) shafts from platforms. Multiple drilling locations required per salt dome. |
| Abandoned Mines | 0.20 - 1.50 | 0.5% of investment | Limited number of fixed locations, not necessarily near refining centers and/or distribution facilities. | Most are probably unsuitable for petroleum storage. |
| Mined Caverns | 5.00 - 10.00 | 0.5% of investment | Must be build in existing, hard-rock formations. | None. |

* Cost and advantages or disadvantages of shut-in production are discussed elsewhere. Sufficient cost data were unavailable for for inclusion of loating-roof pits.

1/ Source: Bass, Essley, and Webster, Emergency Energy Capacity: An Interim Report, U.S. Department of Treasury, Washington, D.C., October, 1973, generally consistent with National Petroleum Council study on Emergency Preparedness.

Costs and Benefits of Emergency Stockpiles. Two basic costs must be considered in deriving economically-efficient emergency petroleum stockpile levels. One cost is simply the direct investment costs of storage facilities, of acquiring a specified quantity (millions of barrels, MMB) of petroleum, and of maintaining those storage facilities over some stockpile program lifetime (years).

Estimates of these components of storage costs are as follows:

- Cost of Storage Facilities: this example assumes a $0.85 per barrel facilities purchase and development cost. This corresponds to the upper end of the salt dome facilities costs estimates.
- Cost of Oil to be Stored: this example assumes $10.50 per barrel investment. In fact, this is a parameter of the analysis, and will vary from case-to-case.
- Maintenance Cost--estimated at $.01 per barrel per year for salt dome storage.

Thus, the capital cost of oil storage is estimated to be $11.35 per barrel. Of this amount, only $0.85 is really a capital expenditure on a depreciable asset. The other $10.50 is an investment which would be recovered when the oil is withdrawn and used. In fact, the value of the oil in a time of shortage could be lower or higher than its original cost, resulting in a net return on the investment in that oil,* or lower resulting in a capital loss.

For the purposes of the analysis, the annual costs of storage were calculated as 15 percent of the capital outlay per year plus the maintenance costs, as follows:

| | | |
|---|---|---|
| $ 1.00/bbl | facilities purchase cost | |
| +10.50/bbl | oil purchased cost | |
| $11.50/bbl | total capital outlay per year | |
| X 15 | | |
| = | $1.57/bbl/yr | carrying cost of petroleum fill |
| | $ .15/bbl/yr | averaged annual amortized facilities (10 yrs) |
| | + .01/bbl/yr | maintenance costs |
| | $1.73/bbl/yr | total annual storage costs |

If stockpiles are to be publicly held, then the 15 percent rate is very conservative because it represents a relatively high opportunity rate for public sector investment. On the other hand, the 15 percent rate may be low if stockpiles are privately held.

*This may require controls on any resulting inventory profits if these stockpiles are privately owned.

The total cost of a stockpile program is equal to the product of this cost per barrel per year times the total level of stockpile in barrels times the design lifetime of the program in years.

The cost of energy supply disruption in the economy is the second cost involved. The potential GNP losses resulting from a shortfall will be incurred (but incurred each time) if a severe embargo (in comparison to emergency supply capacity) were actually experienced.

The total GNP costs of supply vulnerability are estimated by determining the amount which would be drawn out of the stockpile each day and the amount that can be saved by emergency supply and standby conservation measures (assumed equal to 1 MM B/D). These available savings are subtracted from the total level of supply cutoff, to determine the shortfall experienced in the economy. Finally, the estimated GNP impact of that shortfall is calculated at the rate of $33 billion annually per 1 MM B/D shortfall.

Table VII-16 demonstrates the effect of stockpiles in reducing the economic impact of a supply disruption in the absence of an IEP agreement. The costs shown for the disruption are those for a shortfall of 4.8 MM B/D resulting from an embargo against a United States import level of 9 MM B/D generated by insecure sources which maintain a 60 percent share of world import supply (refer to the previously specified embargo threat parameters). The period of interruption is assumed to be one year. The costs shown for the stockpile are for 10 years of storage based on the costs presented above.

Figure VII-7 shows the maximum GNP cost of supply vulnerability as a function of the stockpile level, the cost of the stockpile, and finally the total cost. The total cost is minimized in the neighborhood of 1400 million barrels of storage. This implies that if the United States import level is known (in this example, 9 MM B/D), and the stockpile is designed to minimize vulnerability, then the optimal size is about 1.5 billion barrels.

Table VII-16

Stockpile Costs and GNP Costs of
Residual Vulnerability for U.S. Imports of 6 MMB/D

| | Stockpile Level (MMB) | | |
|---|---|---|---|
| | 500 | 1000 | 1500 |
| Ten Year Costs of Stockpile ($ Billions) | 8.7 | 17.3 | 25.9 |
| GNP Cost of Supply Disruption with Stockpile ($ Billions) | 80 | 30 | 0 |
| Total Cost | 88.7 | 47.3 | 25.9 |

Figure VII-1

**COSTS OF VULNERABILITY AS A FUNCTION OF STOCKPILE SIZE**

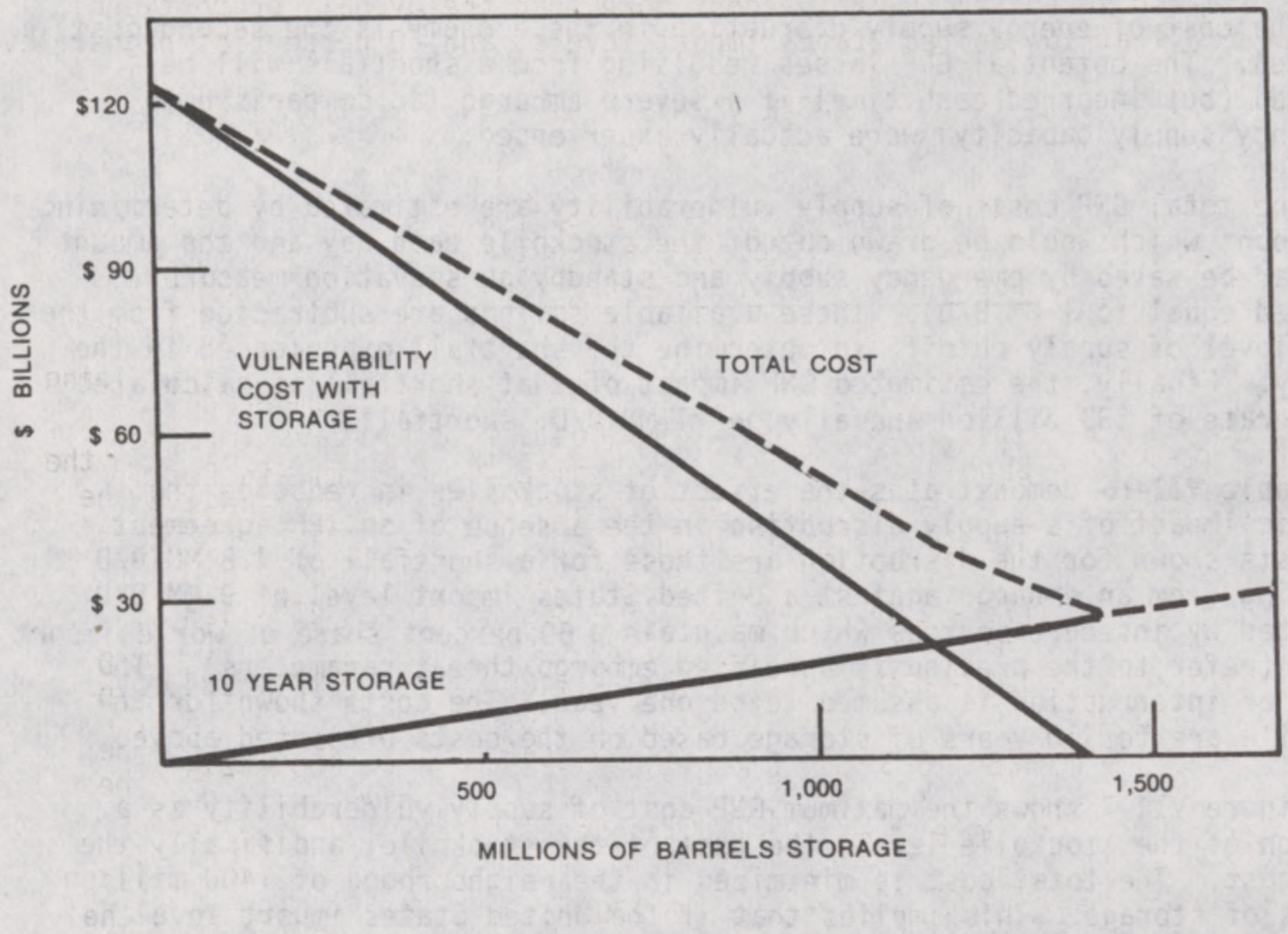


Table VII-17 contains the results of applying this analytical approach to the various levels of total United States imports. As before, the embargo group's market share is assumed to be 60 percent, and they are assumed to interrupt their supply. The disruption is assumed to be targeted on the United States, which is assumed to suffer 50-150 percent more than the overall proportional world shortfall at low United States import levels, and 50 percent at higher levels.

TABLE VII-17

Minimum Cost Stockpile Size
Based on Vulnerability Costs
for Various U.S. Import Levels

| Total U.S. Imports (MMB/D) | Insecure Supplies (MMB/D) | Min Cost Stockpile Size (MMB) 1/ | Numbered Days Imports in Min Cost Stockpile |
|---|---|---|---|
| 3 | 1.2 - 2.0 | 73 - 365 | 23 - 125 |
| 6 | 3.0 - 5.0 | 730 - 1460 | 117 - 234 |
| 9 | 4.8 - 5.3 | 1400 - 1925 | 156 - 214 |
| 12 | 6.6 | 2000 | 167 |
| 15 | 8.4 | 2700 | 180 |

1/ Assumes desirability of insuring against one occurrence - not an expected value.

Several major sources of uncertainty are not accommodated by this analysis. First, the United States import level cannot be known with certainty in advance; thus if there is a substantial chance that the United States import level could be higher, then the optimal stockpile size would also be higher. Moreover, interruptions of a more severe level and/or more protracted duration are possible. The high GNP costs associated with these possibilities will almost certainly increase the optimal stockpile size. Thus, the estimate of the optimal stockpile size based on vulnerability costs probably underestimates the optimal size.

Figure VII-8 can be used to estimate the marginal costs (per barrel of import) of providing supply security using a strategic stockpile. From this Figure, the expected costs of the postulated supply disruption in the Base Case is approximately $150 billion for United States imports of 10 MM B/D. Those costs are slightly less than $50 billion when the Base Case is moderated with a 1 billion barrel stockpile (including $10 billion of 10 year stockpile program costs).

In order to moderate the Base Case to an expected cost of approximately $50 billion, by an alternative program of import demand reduction, the assumed 10 MM B/D dependence would have to be reduced almost by a half, i.e., 5 MM B/D (refer to Figure VII-8). Given domestic energy supply/demand analyses and world oil prices postulated in the Base Case, there is a least cost combination of domestic supply stimulation and demand restraint required to reduce an import dependence level by 5 MM B/D, i.e., from 10 MM B/D to 5 MM B/D.

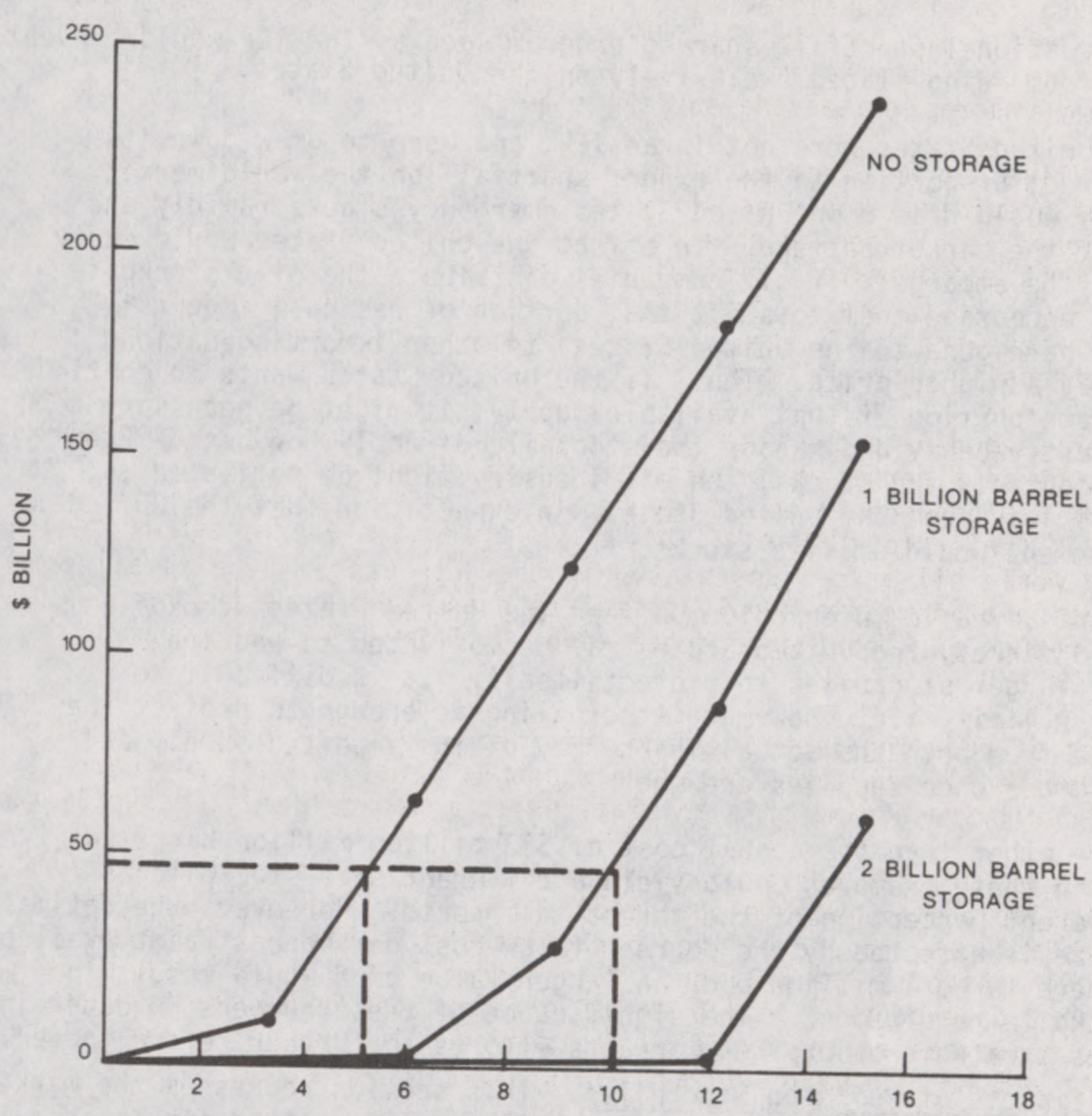
The cost of reducing import demand, divided by 1825 MM B (i.e., 5 MM B/D times 365 days/year), would be the average annual marginal cost per barrel of supply security resulting from initiatives to moderate domestic supply/demand.

In this example, the corresponding marginal cost per barrel of supply security, available through development of a 1 billion stockpile, can be calculated as follows: a one billion barrel stockpile has an estimated average annual cost of $1.73 billion. This stockpile would permit a 10 MM B/D level of import dependence (i.e., 5 MM B/D greater than under the previous case), without increasing the expected costs of supply insecurity over that incurred with a 5 MM B/D import level. This divides the annual stockpile security cost ($1.73 billion) by the additional 1825 MM B (5 MM B/D x 365) annual import consumption, yielding a marginal cost per barrel of $0.70.

Stockpiles and "Self-Targeting." Market forces apparently tended to distribute the total shortfall to some extent during the 1973-74 embargo; i.e., the United States did not bear the intended total impact. Market forces generally operate to send oil to those markets willing to pay the embargo-induced higher price. Once an export shortfall occurs, and the United States begins to draw down stockpiles, market forces might divert oil to other markets which could have gone to the United States if no drawdown occurred.

Figure VII-8

## VULNERABILITY COSTS AS A FUNCTION OF U.S. IMPORTS WITH NO STORAGE AND WITH 1 BILLION BARREL AND 2 BILLION BARREL STOCKPILES



If the United States were to draw down its stocks in direct proportion to the export shortfall on the world market, it would in effect replace the world shortage; i.e., the United States stockpile flow would simply replace the disrupted flow. Theoretically, no world oil price increase would result.

An international shortfall sharing program such as the IEP would prevent this burden from being placed exclusively on the United States.

If the United States were not in an IEP, and were to draw down its stocks in direct proportion to the export shortfall on the world market, such a policy would draw down United States emergency stocks rapidly and would distort the market pattern. In effect the United States would carry the brunt of the embargo. If oil companies distribute the oil, stockpile drawdown may encourage them to shift that portion of residual imports* (which would have gone to the United States) to other importing nations willing to pay a higher price. Thus, if the United States wants to continue to receive some portion of that available supply, it might be necessary to regulate industry behavior, manage the stockpile directly, or both. Even if the U.S. controls the stocks, the oil industry might be motivated to shift imports away from the United States, in expectation that the United States Government would utilize stocks.**

Given this dynamic interaction between the United States stockpile and the world market, the United States may be motivated to acquire increasingly larger stockpiles to protect itself. It is difficult to anticipate the limit, i.e., how much stockpiling is enough to protect the United States from both the actual insecurity of its imported supply and the market forces once supplies are short.

A figure other than the annual cost of $33 billion/million barrel/day figure used in these examples could yield a different size stockpile as would a different perception of the threat to imports. Moreover, the optimal stockpile size is affected by the degree of low cost demand restraint available, $\underline{K}$, assumed here to be 1 million b/d. A larger value of $\underline{K}$ would result in a lower stockpile requirement. The significance of these numbers in determing United States strategic stockpiles warrants efforts to further refine these values.

Market Impacts of Building Stockpiles. This section addresses the market impacts involved in building emergency stockpiles. Two related issues are of special importance:

1. The level of world market price fluctuations stimulated by short term increased petroleum demands during a buildup period; and
2. The extent to which emergency storage buildup programs may hold up world oil prices in an otherwise declining price market.

A world oil model has been used to study the short term market effects.*** Assumptions about the demand elasticities of primcipal oil importing countries are contained in a technical appendix. Two key assumptions should be kept in mind:

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* Post embargo available imports.
** IEP would largely eliminate this problem.
*** This is based on an adaptation of the Kennedy-Houthakker world oil model.

1. The supply for United States (and other consumer country) storage buildup levels treated below are assumed to be purchased from the world export market.
2. Producer countries are not assumed to cooperate by increasing export supply during the buildup.

Both of these assumptions are conservative in analyzing the potential market price effects of a storage buildup program. If the United States develops an alternative source of supply for storage buildup (e.g., Naval Petroleum Reserve #1), then substantial savings could be realized by avoiding the investment and carrying costs of purchasing the supply. In addition, it would avoid any transient increases in world oil prices and the increased costs of imported oil for oil importing countries during the buildup.

Furthermore, if oil supporting countries increase export supply during a storage buildup (especially if shut-in capacity were available), then no price effect need occur. On the negative side, this analysis underestimates the world price effects if other countries simultaneously attempt to build stocks.

Table VII-18 summarizes the market impact of several possible United States petroleum stockpile buildup programs. These are representative of the stockpiles analyzed above for the IEP and/or a supplemental storage development. Table VII-19 presents the estimated 10 year average cost per barrel imported associated with the impact on world oil prices of acquiring varying United States stockpile levels. For example, given the indicated world oil price assumed to hold through 1980, and the United States consumption and import levels, United States acquisition of a 144 million barrel stockpile (equal to 45 days of imports at 3.19 MM B/D) would result in increased United States import costs for all its imports of $542 million (or $.05/barrel of oil in storage over 10 years) due to the impact of increased world oil prices during the storage buildup. This would occur assuming a six-year buildup period beginning in 1975 and ending in 1980.

The calculations assume that only the United States builds up emergency storage during this period. If West Europe and Japan, for example, were to undertake simultaneous (with the United States) acquisition of 45 days or 90 days of stocks, given their respective import levels, over this same period, then the United States stockpile acquisition costs shown in Table VII-18 would be increased by approximately four times.

Similar cost analyses based on a projected decline in world oil prices from $9 to $6/bbl, and for higher and lower economic growth rates confirm that these costs are fairly representative over a wide range of such parameters.

The range of costs for the alternative storage buildup programs depicted in Table VII-18, while not insignificant, amounts to a security cost of 5-20 cents per barrel of import over a 10 year period.

TABLE VII-18

Medium Growth Projections for 1980:

A. Continuation of $9*/bbl (f.o.b. Persian Gulf)
US consumption 16.62 MM B/D
US imports 3.19 MM B/D

| Buildup** Program | Size (MMB) | Cost Due to Price Increase ($ Billions) | Ten Year *** Average Cost/bbl Imported |
|---|---|---|---|
| 45 Days Imports | 144 | 0.542 | 0.05 |
| 90 Days Imports | 288 | 1.074 | 0.09 |
| 5% **** Consumption | 303 | 1.140 | 0.10 |
| ***** 90 Days Imports and 5% Consumption | 591 | 2.224 | 0.19 |

*Constant 1972 dollars
**Buildup is assumed at a uniform rate over 1975-1980.
***Only the incremental costs due to increased price of U.S. Imports during stockpile oil acquisition program.
****5 percent of total U.S. consumption
*****Stockpiles equivalent to 90 days of imports (at 3.2 MMB/D), plus auxiliary stockpile equivalent to 5 percent of U.S. consumption.

Stockpile buildup programs have been analyzed for their impact on world oil prices under three world oil price trajectories over the 1974-1980 period assuming:

a. A continuation of $9/bbl (f.o.b. Persian Gulf, 1972 dollars);
b. A uniform decline in price from $9 to $6/bbl over the 6-year period;
c. A uniform decline in price from $9 to $3/bbl over the 6-year period.

In all cases and for various United States and other country stockpile buildup rates, the general effect on market price appears to be concentrated in a one-year transient increase in world oil price occurring in the first year of the buildup program. Thereafter, the market price substantially returns to within 10 to 20 cents of what it would have been in the absence of the increased stockpile demand.

Figure VII-9 presents the typical market impact of several storage buildup programs in a market in which prices are projected to decline from $9/bbl to $6/bbl. The costs of such impacts were considered in Table 19 above.

The effect of storage buildup programs on a declining market price are seen to be limited largely to the initial year of the program. The effect, moreover, could be even less pronounced since the decline in the market price is likely attendent to increasing export supplies. This would tend to make it difficult for oil exporters to control their production/price program so as to take advantage of the increased stockpile demand as distinguished from overall growth in demand.

This analysis gives a preliminary assessment of the effect of a stockpile buildup on the world oil price. Analysis is continuing to evaluate these effects fully.

# II. Excerpts From the National Petroleum Council's Report on Interruption of Petroleum Imports Into the United States: Available Alternatives

# . . . . . Emergency Preparedness for Interruption of Petroleum Imports into the United States. . September 1974

## A Report of the National Petroleum Council . . . . .

. . . . . Prepared by the National Petroleum Council's Committee on Emergency Preparedness . . . . Carrol M. Bennett, Chairman . . . . with the Assistance of the Coordinating Subcommittee . . . . James S. Cross, Chairman. . . . . .

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## AVAILABLE ALTERNATIVES FOR RESPONSE TO FUTURE IMPORT DENIAL

Among the steps the Committee considered for response to a future denial are:

- Conversion to alternate fuels,
- Emergency production,
- Reduction of consumption, and
- Emergency standby petroleum supplies.

### Conversion to Alternate Fuels

It has been previously assumed that, in a denial period, some relief could be obtained by converting industrial and utility boilers from oil or gas to coal. The opportunities are primarily in the electric utility sector but are quite limited. The medium case projection of fossil fuel use in electricity generation indicates a trend away from oil and gas to coal. Furthermore, the recently passed Energy Supply and Environmental Coordination Act of 1974 provides the authority to require oil and gas burning power plants to switch to coal. The law also permits the Federal Government to direct that new power plants use coal as the primary energy source. Since a high degree of the potential for conversion to coal will be realized over the next several years on a non-emergency basis, there will be little or no future emergency coal substitutability for oil and gas in industrial or utility plants.

### Emergency Production

As noted earlier, legal and economic problems involved in additional oil and gas production from private fields and Naval Petroleum Reserves precluded their use during the recent embargo. The potential from private fields will decline over time and this source can be counted on to provide only a small amount of the required volume of emergency supplies in the event of an imports curtailment.

### Reduction of Consumption

During a denial period, energy consumption can be reduced by voluntary or mandatory measures. The quantification of savings through voluntary steps is difficult because it requires an assumption of the level of compliance on the part of the public. Substantial potential reductions exist in every energy use sector, such as increased car-pooling in transportation, thermostat adjustments and reduced lighting in the residential and commercial sectors, and increased operating efficiencies in the industrial and utility sectors. In many cases, consumption can be voluntarily reduced promptly and with little or no capital investment. In other

instances, reductions effected by such measures as increased insulation and automotive design improvements require investments and time to produce results.

The voluntary actions which would be most effective in responding to an unanticipated interruption in energy supply would be those steps which the public would be willing to implement freely. The effectiveness or compliance level of these measures would relate directly to the cost to the individual or business. Therefore, it has been assumed that only those measures requiring little or no investment would be effective in a short-term emergency situation. A review of such activities in each of the major energy use sectors indicates potential consumption reductions of approximately 1.0 MMB/D and 1.1 MMB/D in 1980 and 1985, respectively.* Since the level of reductions achieved through voluntary curtailment is almost completely dependent upon public compliance, it is imperative that an extensive public information program be initiated at the time of any emergency to ensure favorable public response.

In the event that voluntary demand reductions are not sufficient to bring demand into balance with supply, mandatory actions such as allocation and rationing would be required.

## Emergency Standby Petroleum Supplies

There are three basic alternatives for providing standby petroleum supplies to offset a sudden loss of imports. These are: (1) shut-in or reduction of production from domestic oil fields, (2) storage of crude after production from underground reservoirs and (3) storage of refined petroleum products. Several major factors must be considered in developing an optimum emergency standby supply system. First, standby supplies must be located so that facilities existing at the time of an emergency can transport such supplies to locations where needed at rates sufficient to replace imports that cannot be offset by other means. Second, the capability to construct associated facilities and obtain sufficient crude and/or product to fill programmed storage in the desired time frame must be assessed. Finally, the total cost to the Nation of available alternatives must be weighed against the degree of protection provided.

The alternative of providing standby supplies by shutting in or reducing production from domestic oil fields has major disadvantages. Such action would simultaneously reduce the supply of indigenous oil and gas to the U.S. economy. Reduced crude production would have to be offset by increased imports, if available;

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* *Editor's Note:* These estimates include the savings from mandatory speed limit reductions and legislation similar to that passed in California to reduce electricity usage.

however, imported crude would probably have a high sulfur content and many U.S. refineries cannot process such crude. This would also make the United States even more dependent on imports and would adversely affect the U.S. economy and balance of payments. Administration of such a program would be extremely complex. For example, provisions would have to be made to compensate owners of shut-in production for reduced current income and, in many cases, reduced ultimate recovery. Establishment of fair compensation would be difficult and litigation on behalf of such owners would probably result. In addition, such action would cost the Nation from 5 to 10 times more per barrel of daily production capacity than security storage of crude or product.

Security storage of refined products or crude after production can be located aboveground in steel tanks or underground in caverns leached in salt or mined in hard rock. The primary advantage of steel tank storage is locational flexibility and the ease with which supplies can be integrated into the existing petroleum logistical system. The major disadvantage of aboveground tank storage is the high cost--$3.80 to $7.00 per barrel, depending on location, type of storage and local conditions. The availability of steel for timely construction of very large scale tankage projects is also of concern.

In contrast, storage in salt domes can be provided for $0.60 to $0.85 per barrel if the volume to be stored exceeds 100 MMB. Many salt domes on the Gulf Coast are capable of accommodating storage projects of several hundred million barrels. Extensive experience with such storage in the United States has proven its safety and reliability. Since crude or product is stored in large caverns, very high redelivery rates are possible. For example, a single 200 MMB project might require only 20 to 40 wells and be capable of a redelivery rate of several million barrels per day during an emergency. Although other underground storage alternatives were also evaluated (mined caverns, salt beds, abandoned mines, depleted reservoirs), storage in salt domes has the lowest cost. Such storage is normally located 2,000 feet below the surface and is, therefore, more secure against natural disasters and sabotage than steel tank storage.

Crude oil storage in salt domes appears more practicable than refined product storage. The potential for weathering is reduced, and any quality problems that might occur with crude oil could be corrected during refining. Problems of quality control, questions of what grades, types and volumes of finished products to store and the seasonal nature of major product demands would exist for high-volume security storage of refined products over an extended period of time in a salt dome environment. Additionally, transportation of product from salt dome storage to terminals would be more difficult and expensive than for crude. Thus, if a product security storage program is implemented, storage aboveground in higher cost steel tankage is probably the best alternative. It is recognized that residual fuel oil imports present a special case because such imports are concentrated on the East Coast.

Because of the apparent inability to protect against a substantial import interruption by any other means, it is concluded that a substantial volume of crude security storage is required. Such storage should be located in Gulf Coast salt domes. A security storage volume of about 500 MMB in combination with other available supplies would provide protection commensurate with similar programs in effect in other consuming nations. Proposed new Gulf Coast deepwater terminal and pipeline facilities, which should be in service by 1978, will be capable of transporting imported crude to a large percentage of Midwest and Rocky Mountain refineries. Therefore, salt dome storage projects should be located near deepwater terminal tank farms to ensure easy distribution of security storage crude to refineries during an emergency.

Location of security storage crude for East Coast refineries in Gulf Coast salt domes will save $4 to $5 per barrel in storage cost. Gulf Coast deepwater terminals can be designed to permit loading of security storage crude for delivery to the East Coast during an emergency. However, use of foreign flag vessels to augment the U.S. fleet may be required to ensure timely delivery during an emergency. Need for storage on the West Coast will depend on supply self-sufficiency there. Factors to be considered include the impending availability of North Slope crude and flexibility to ship crude from the Gulf Coast.

Leaching of several hundred million barrels of salt dome storage could be completed in about 6 years. Significant storage could be ready to fill about 1979, which is consistent with the anticipated startup of Gulf Coast deepwater terminals. Therefore, completion of a 500 MMB crude storage program in the early 1980's appears feasible if crude can be made available for fill.

Foreign crude could be utilized for fill; however, cost, timely availability, and high sulfur content are of concern. Production of certain domestic fields above MER to provide storage fill appears to be an unlikely possibility. Elk Hills (NPR-1) crude is low in sulfur content, and represents a reliable large volume, low cost source of supply. Another potential source of oil to fill security storage would be Federal Government royalty entitlements. An advantage of using this oil is that it would be clearly established that it would be available to meet either public (defense) or private needs under emergency conditions without introducing difficult problems of ownership, equity or compensation for inventory holding costs. It must be recognized, however, that commitment of royalty oil to security storage would increase oil import requirements in order to balance supplies with current consumption.

## RECOMMENDATIONS

In submitting its recommendations, the National Petroleum Council's Committee on Emergency Preparedness feels that the following points should be emphasized:

- *We will likely be more dependent on foreign oil in the future.* The extent of increased U.S. dependence on imported oil will largely be determined by our ability to conserve energy and increase domestic energy production. In the event of greater dependency on imports, a future embargo would have more severe and lasting effects on the U.S. economy if proper preparation has not been undertaken.

- *We cannot base plans on favorable weather conditions.* The winter of 1973-1974 was 8 percent warmer than normal in the United States and almost 5 percent warmer than the previous year. The resulting reduction in consumption of all heating fuels significantly reduced the severity of the oil shortage. This favorable circumstance cannot be assumed for future planning.

- *Emergency conservation potential will diminish over time.* Until the fall of 1973, energy in the United States was relatively inexpensive and many users were little concerned with energy conservation. Due to widespread public response to the need to conserve during the recent embargo and price increases following the embargo, major efforts are being made to conserve energy. Thus, there will be less potential for quick and easy conservation measures, and future supply shortages will more rapidly begin to impinge on critical energy requirements.

- *Public support of emergency measures must be secured through avoidance of misunderstanding as to the reality, the extent and the impact of an interruption.* Industry and government were ill-equipped to communicate the complex nature of the impact of the embargo on the economy and on the industry's complicated logistical system. As a result, the public became occupied with the question of whether an oil shortage even existed. Industry reporting procedures were not well enough developed to provide the kind of detail required to monitor the shortage effectively. In the event of a future embargo, the government, the communications media and industry need to be better equipped to appraise and communicate the problems to the American public resulting from an interruption in supply.

The Council realizes that years, perhaps decades, will be required to achieve the goal of energy self-sufficiency. In the interim, specific though flexible procedures must be developed to prevent any future interruption of energy supplies from exerting unacceptable pressures upon the U.S. economy.

In the interest of emergency preparedness, the National Petroleum Council submits the following recommendations:

*1. The United States must adopt and implement national energy policies designed to increase the Nation's self-sufficiency in energy.*

Sound and consistent government policies are required if energy conservation is to be encouraged and if the various energy suppliers to this country are to develop maximum domestic energy supplies and thereby minimize the need for and cost of emergency preparedness to protect against a sudden energy emergency. The key elements of such policies were outlined in the NPC's report, U.S. Energy Outlook, and are reaffirmed in this report:

- The United States must adopt broad national objectives for solving the energy problem.
- Healthy, viable and expanding energy industries should be encouraged by government.
- Import policies should not hinder the growth of domestic refining capacity.
- Field prices of natural gas should be allowed to reach competitive levels.
- A balance should be sought between environmental goals and energy requirements.
- Both the government and industry should continue to promote energy conservation and efficiency of energy use.
- Access to the Nation's energy resource potential underlying public lands should be accelerated.
- Energy research and development of technology should be accelerated.
- Tax policies should foster the discovery and development of domestic energy resources.
- The United States should support its nationals engaged in energy operations abroad.

*2. The United States should develop an operational definition of an energy emergency.*

At the outset of the recent embargo, the Nation found its emergency mechanisms inappropriate because emergency preparedness plans were based solely upon a military or defense-type emergency. An important lesson of the embargo is that the United States needs to define an "energy emergency," thus empowering its administration to take appropriate emergency actions in the event threatened or actual economic sanctions or boycotts are applied against this

country. The form of these powers should be such that a high degree of flexibility in administration is allowed. Such powers would serve the country both as a deterrent to external economic pressure and as an effective means of response should such pressure be applied.

*3. Standby emergency preparedness plans should be developed to allow participation by industry personnel.*

Through the Emergency Petroleum and Gas Administration (EPGA), the United States has access to the knowledge and experience of experts and technicians within the petroleum industry. The expertise of these individuals is the cornerstone of the EPGA's effectiveness and organization in a declared national emergency.

It became clear in the initial stages of the recent embargo that because of the "conflict of interest" and antitrust statutes, personnel in industry would not be able to respond to the government's request to staff the Energy Allocation Planning Task Force (EAPTF) and the Office of Petroleum Allocation (OPA). It is apparent that this inability to serve on the part of industry personnel seriously affected the government's program. A future energy emergency is likely to produce the same result unless corrective action is taken.

To obviate this problem and to provide the government with the personnel necessary to deal effectively with such emergencies would require substantial amendments to the existing conflict of interest and antitrust statutes.

*4. The Federal Government should reassess the potential and use of the Naval Petroleum Reserves in a future emergency.*

Of the four Naval Petroleum Reserves, only NPR-1 (Elk Hills in California) has any near-term potential producing capacity for use in an emergency. In 1972, the Comptroller General estimated about $69 million would be required to develop NPR-1 to its maximum efficient rate of 267 MB/D. This rate might be achieved within 2 to 3 years. Regardless of the future dispositions of this reserve, the National Petroleum Council recommends that the requisite development be completed since it would greatly enhance the value of NPR-1 to the Nation.

Because of the uncertainties regarding the Nation's future energy position, the Council recommends that decisions on the ultimate disposition of whatever potential capacity is developed in Naval Petroleum Reserves be made after the reserves have been evaluated.

*5. The United States should develop standby emergency consumption reduction measures.*

The United States should have available emergency consumption reduction programs specifically designed for responding to an energy supply interruption and available for immediate use. While the FEO

rapidly implemented the provisions of the Emergency Mandatory Petroleum Allocation Act of 1973, this legislation was not totally appropriate for an embargo situation. In addition, calls for voluntary use curtailment were often hastily conceived, and the consumer, though willing, was often confused. Any standby energy demand reduction measures developed for use in future emergencies should be strongly oriented toward consumer education and cooperation. While a mandatory rationing system should be carefully developed, its use should be restricted until the effectiveness of other measures has been obtained. The gasoline retailing techniques (odd-even day sales, Sunday closings, minimum sale requirements, staggered and posted hours of services, etc.) used during the recent embargo suggest that substantial reductions in gasoline consumption can be managed without resorting to a coupon rationing system.

*6. In an emergency situation, options to increase domestic energy supplies through additional oil and gas production and additional use of coal should be utilized.*

The volume of temporary emergency oil production available from private fields is quite small compared to the potential size of an import interruption. This capacity above MER can be expected to decline to a negligible amount by the early 1980's. There are a number of legal and regulatory constraints to the effective utilization of such capacity. However, despite these problems such short-term emergency production could provide a degree of protection during the remainder of this decade and should be made available if practicable. This will require that state and federal regulatory agencies cooperate in developing acceptable procedures that will permit such emergency production.

Opportunities for converting utilities from oil or gas to coal will be limited since significant conversion is underway or planned. Since some small potential in dual-fired plants will remain through the end of the decade, conversion of these plants should be part of an emergency preparedness plan. In order to keep the Nation's future options as open as possible, it appears prudent to require such new oil or gas-fired power plants as may be approved to construct and maintain coal handling and burning facilities. Provisions for variances in environmental regulations during an emergency will assure the contribution of coal substitutability in an emergency.

*7. The United States should develop an emergency petroleum security storage system.*

The United States should create a petroleum security storage system that, in combination with other available measures, will provide adequate time to react positively to a substantial, sudden interruption in petroleum imports. Objectives concerning the ultimate size and structure of such a program will undoubtedly change with time because of the constantly changing world political and economic environment. However, it is clear that a substantial volume of petroleum security storage is needed within the United States and that efforts to implement such a program should begin immediately

because of the long construction lead times involved. Such a program must, of course, consider future U.S. obligations which may arise from international emergency energy sharing programs.

First consideration should be given to providing crude oil security storage to protect domestic refinery runs. This study indicates that 500 MMB of crude storage in combination with normally available inventories will provide 90 to 180 days of supply for a large percentage range of crude imports presently foreseen. Crude storage can be efficiently located in one or more Gulf Coast salt dome projects and integrated with the crude transportation system that will serve Gulf Coast deepwater terminals. Specific circumstances and specific logistical problems could require storage of fuel oil at strategic locations on the East Coast.

Among other important considerations to be resolved are the extent of government and/or industry financing and administration of the emergency storage and its fill. The Council feels that security storage should not be utilized until after (1) a proper declaration of an energy emergency by government and (2) appropriate voluntary and mandatory standby consumption reduction measures have been implemented.

## Chapter Four

## EMERGENCY STANDBY PETROLEUM SUPPLIES

There are three basic alternatives for providing standby petroleum supplies to offset a sudden loss of imports. One alternative is to shut in or reduce production from domestic oil and gas reservoirs to provide spare producing capacity that could be turned on during an emergency. Shut-in crude production would replace interrupted crude imports, while shut-in gas production might be utilized as a substitute for imported liquid fuels. The second alternative is to store crude oil after production from underground reservoirs and the third is to store refined petroleum products.

Storage of refined petroleum products or crude after production can be located aboveground in tanks or in underground caverns mined in rock or leached in salt. Very high redelivery rates are possible from such storage relative to production from natural petroleum reservoirs. To provide effective emergency producing capacity, shut-in reserves must be developed with adequate wells. Also, field facilities must be capable of handling produced fluids efficiently at emergency rates without waste or damage to the environment. In addition, transportation facilities existing at the time of an emergency must be capable of moving standby supplies to locations where needed at rates sufficient to replace those imports that are interrupted and cannot be fully offset by other measures (discussed in Chapter Three).

The alternative of shutting in or reducing production from domestic oil and gas fields has several disadvantages. The major disadvantage is that such action would simultaneously reduce the supply of indigenous oil and gas to the U.S. economy. This could be offset in two ways.

The first method is to increase crude imports to replace shut-in domestic crude production (gas produced with shut-in crude could not be replaced by imports). However, this may not be possible because of rapidly increasing competition for available crude supplies worldwide. Furthermore, most domestic crude has a low sulfur content whereas imported crude, if available, would quite likely be high in sulfur. Many U.S. refineries cannot process such crude without substantial capital investment and lead time for conversion. In addition, such action would make the United States even more dependent on imports, which would defeat the basic purpose for which standby supplies were created. It would also have a negative effect on the U.S. economy and balance of payments.

A second method to offset domestic production reductions (without increasing crude imports) is to reduce consumption and thus, offset reduced product availability resulting from running U.S. refineries spare. This alternative would probably require rationing and would create severe problems for industry, business and the consumer and would adversely affect the U.S. economy.

There are several other disadvantages to reducing domestic production:

- A nationwide prorationing or shut-in reserve program would require a massive and complex administrative system. Provisions would have to be made to compensate the owners of reduced production for loss of current income. There is a strong probability of litigation on behalf of such owners.

- If oil or gas reservoirs that have produced for a number of years were shut-in, there is a high probability that ultimate oil and gas recovery would be reduced because established reservoir pressure gradients would permit uncontrolled migration of oil, gas and water within such reservoirs.

- In addition, such uncontrolled migration could result in some properties not being returned to production after a long shut-in (e.g., leases located on the edge of a field having a natural water drive). This would affect equities, with some owners gaining and others losing reserves. Establishment of fair compensation for owners suffering reduced ultimate recovery would be extremely difficult.

- The cost of maintaining shut-in reserves in a state of operational readiness would be high, particularly in hostile environments such as offshore and the Arctic.

- A reduction in tax and other revenues to local governments, and decreased demand for services associated with field operation, would have a particularly negative effect on the economy of areas where shut-in fields were located.

- It is reasonable to expect a delay in bringing reserves that have been shut in for some time up to full production potential. For example, wells located offshore Louisiana often partially fill with sand and require remedial work to re-establish production after being shut-in for a significant period. The larger the amount of shut-in reserves, the more difficult it would be to mobilize the work force and equipment required to place such reserves on production, particularly if they were located in a remote area.

- Finally, such a course of action would cost the Nation from 5 to 10 times more per barrel of daily producing capacity than storage of crude or products in aboveground steel tanks or underground salt domes.*

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* Refer to Appendix D for a complete discussion of the cost of these alternatives.

## SECURITY STORAGE OF REFINED PRODUCTS OR CRUDE AFTER PRODUCTION

To be fully effective, a petroleum security storage program must meet two basic requirements:

- It must provide a sufficient volume of crude or product to satisfy the desired level of protection.
- Associated facilities must be capable of delivering such crude or product at the required daily rate. For example, if protection against an import interruption of 3 MMB/D for 180 days is to be provided by security storage, 540 MMB of crude and/or product is required. More importantly, capacity must be provided to deliver such crude or product to those locations where it is needed at a rate of 3 MMB/D.

### Aboveground Storage in Tanks

The primary advantage of aboveground storage in tanks is locational flexibility. Such storage can be easily integrated into the existing petroleum logistical system. Crude can be stored in tanks at individual refineries, and refined products can be stored at the optimum location for rapid supply to consumers, either at refineries or product terminals.

One disadvantage of tank storage is the cost per barrel of storage capacity. Such cost is a function of location, local construction requirements and tank size. An additional disadvantage is vulnerability to sabotage, natural disasters or acts of war.

Location plays an important role in tank cost. An obvious factor is location with respect to existing transportation facilities. A remote storage location requiring an expensive pipeline connection would add significantly to the unit cost. A second factor is the variation in material and construction cost at different locations in the United States. For example, it is estimated that a 5 MMB crude tankage project using simple foundations at an existing Gulf Coast refinery would cost about $3.80 per barrel, whereas a similar installation in the New York-Philadelphia area would cost about $5.20 per barrel.* If pilings must be driven to provide an adequate foundation, the cost per barrel could easily increase by 70 to 100 percent. It is recognized that actual estimates for a specific site may vary significantly from these values. However, the above comparison is believed to be representative of an average installation.

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* *Editor's Note:* While tanks can be constructed from various materials such as concrete, all cost comparisons in this report are based on steel tankage construction and mid-1974 dollars unadjusted for inflation. Because of rapidly rising costs, facilities constructed in the late 1970's will likely be much more expensive than indicated.

A third factor is the economy of scale provided by large tanks. Crude storage to protect the runs of a major refinery could utilize large tanks because the security storage requirement would probably be large (60 days of protection for a 200 MB/D refinery equals 12 MMB) and the number of crude segregations should be relatively small. On the other hand, product storage at terminals with relatively low throughput might require several small tanks because of the need to segregate a large number of individual products and grades or because sufficient land is not available to construct large tanks.

The cost of a typical 2 MMB East Coast clean product storage facility utilizing an average 180 MB tank would be about $5.70 per barrel. In contrast, a 500 MB storage facility utilizing an average 70 MB tank would cost about $7.00 per barrel. These costs would be even higher if heated tanks were required for viscous products.

In summary, the cost to construct steel tank storage at sites that can be tied into existing installations with minimum additional facilities should be in the general range of $3.80 to $7.00 per barrel. Higher costs would be anticipated for the following: locations near existing East Coast refineries *versus* Gulf Coast locations; product *versus* crude tankage; small *versus* large tanks; soil conditions requiring special foundations; and construction at locations that are a significant distance from existing terminal or refinery sites.

## Tankage Construction Limitations

If a large-scale security storage program utilizing steel tankage were undertaken, the capacity to construct such tankage as rapidly as desired could become a limiting factor. About 3,400 tons of steel are required to provide 1 MMB of tank storage capacity. If the United States is to achieve a high degree of energy independence by 1985, a staggering amount of drilling and construction of refineries and other energy related facilities will be required. For example, total tankage for the two proposed Gulf Coast deepwater terminal tank farms (LOOP and SEADOCK) will probably exceed 50 MMB. These projects and many other energy related facilities will be constructed during the next 5 years.

This will (1) place an enormous load on the construction and fabrication industries, (2) significantly increase the demand for steel and (3) lengthen the interval between the time that materials are ordered and construction is completed. Therefore, the availability of steel must be given careful consideration in planning the facilities required for timely implementation of an emergency preparedness plan.

## Underground Storage

Three proven methods of providing underground storage for petroleum are: (1) cavities leached in salt domes or salt beds, (2)

cavities mined in hard impermeable rock formations such as granite, shale or limestone, and (3) abandoned underground mines that have been specially adapted for storage.

A wide variety of hydrocarbon products and petrochemical feedstocks are stored underground. According to a Natural Gas Processors Association report of August 1973, about 255 MMB of light hydrocarbon underground storage capacity exists in the United States. About 95 percent of this capacity is located in cavities leached either in salt domes or salt beds, and only about 5 percent is in cavities mined in hard rock.*

## Salt Dome Storage

As illustrated by Figure 10, a salt dome is a massive column of rock salt, typically 0.5 or more miles wide, thrusting upward from many miles below the surface and topped by a thick caprock. The top of the salt may be near the surface, and in many cases, salt from such domes is mined for commercial use. Salt mining operations have resulted in creation of many millions of barrels of cavities which might be utilized for underground storage purposes. Also, there are more than 350 known salt domes within a 50,000 square mile area along the Gulf Coast (Figure 11).

Underground petroleum storage projects have an excellent record of safety and reliability based on more than 20 years of experience. Additionally, because salt caverns are generally located 2,000 or more feet below the surface, maximum protection against hazards such as fire, storm and sabotage is provided. Some 180 MMB of salt dome storage capacity are presently utilized. Individual storage well capacities commonly range from 0.5 MMB to 2 MMB, and a number of wells are designed to store up to 5 MMB. Even larger individual storage caverns are technically feasible.

Underground storage in leached salt dome cavities can be provided at a cost of $0.60 to $0.85 per barrel (1974 dollars), depending upon the cost of pipelines required to connect the storage facility to distribution facilities and the distance from a suitable brine disposal and water source area. This estimate does not include the cost of crude or product to fill such storage and is valid only for large volume projects (100 MMB or greater) consisting of wells having individual storage capacities of at least 3 MMB. These costs are based on a detailed analysis of several typical salt domes on the Texas and Louisiana Gulf Coast. Gulf Coast salt domes have an extremely large total storage potential. A few of these domes, such as Stratton Ridge, are large enough to provide 1 billion barrels of storage capacity, and many domes are large enough to provide a storage capacity of several hundred million barrels.

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* Natural Gas Processors Association, *L-P Gas Storage Survey--1973*, Tulsa, Oklahoma (August 1973).

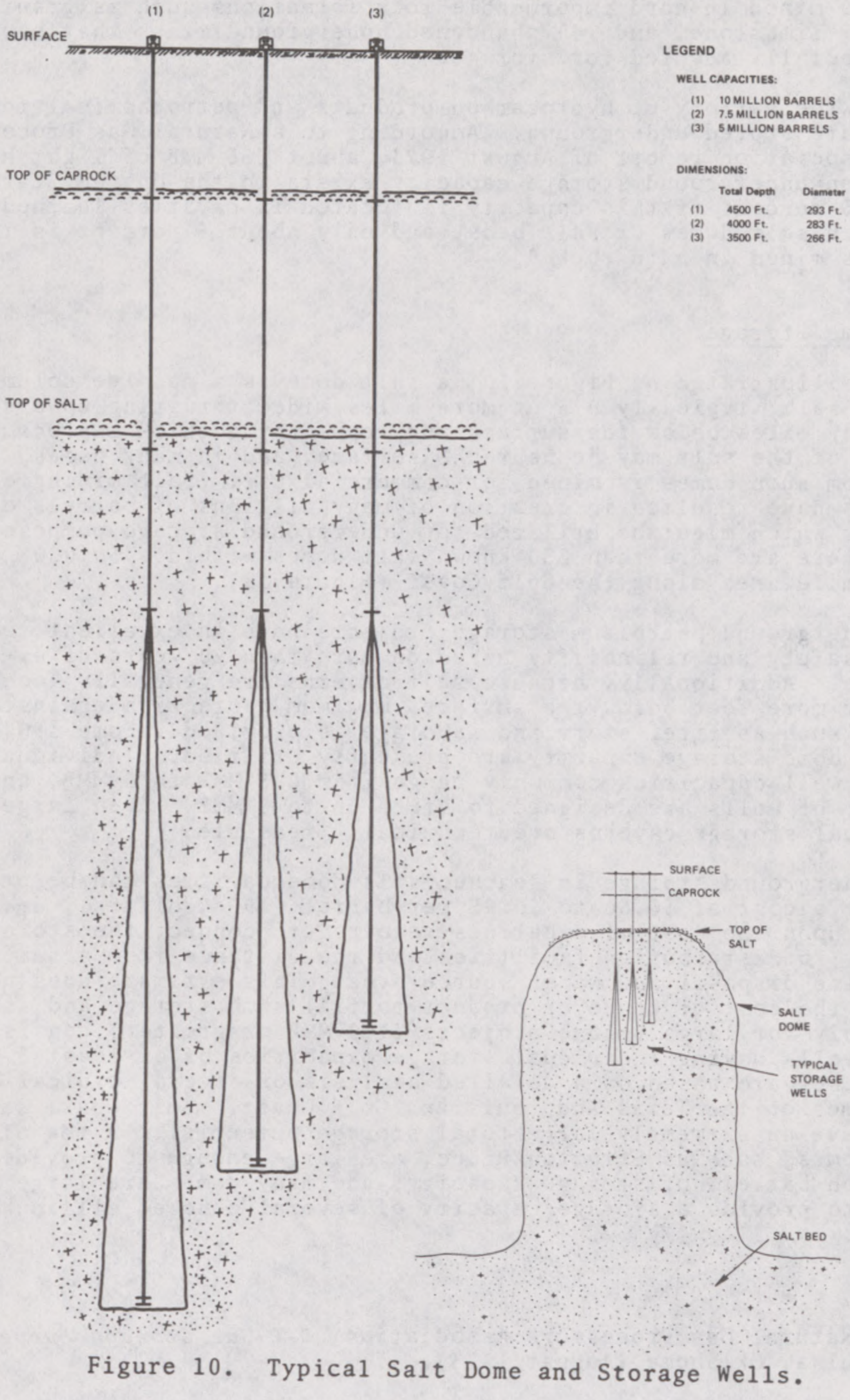
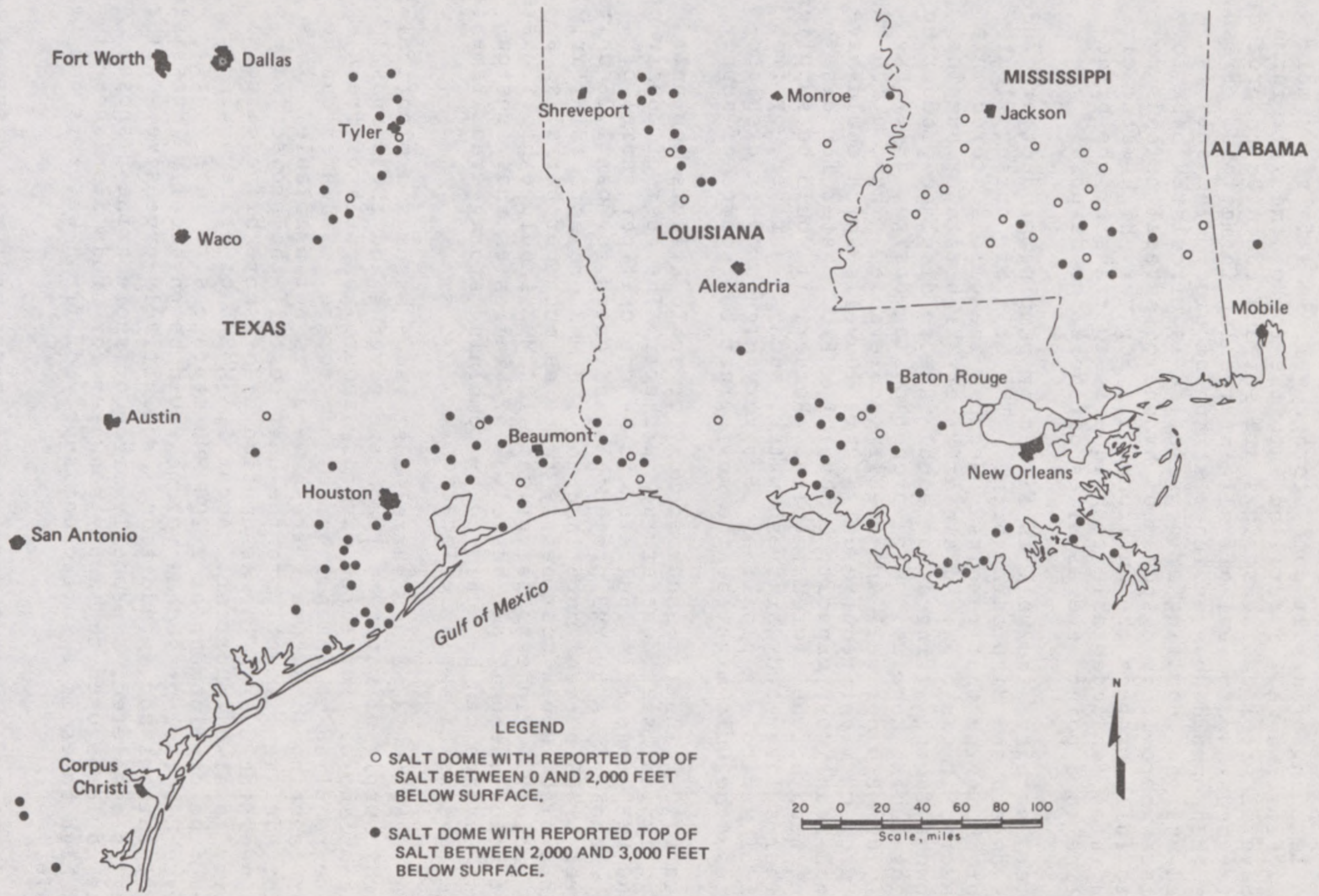



Figure 10. Typical Salt Dome and Storage Wells.

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*Source: U. S. Department of the Interior, Bureau of Mines, Information Circular 8313, (Washington, D. C.).*

Figure 11. Onshore Salt Domes That Offer Good Possibilities for Salt Extraction or Underground Storage Sites.

The leaching of a salt dome storage well is a fairly simple process. First, a well is drilled into the top of the salt formation. Several steel casing strings are set and cemented to protect freshwater beds and to seal off all intervening formations. Fresh water is then pumped down an inner string of pipe. The salt is dissolved and the resulting brine solution is circulated back to the surface where it is disposed of by one of several methods designed to fully protect the environment. For very high water circulation rates, an acceptable technique is to transfer the brine by pipeline to a point several miles offshore for disposal.

After leaching, the well is filled by pumping product or crude into the cavern and displacing brine. The oil, of course, floats on top of the brine that remains. Because the oil is stored in a large cavern, it can be withdrawn at a very high rate by pumping water down a tubing string at an equal rate to displace product up the casing-tubing annulus. With proper casing design, delivery rates of 200 MB/D per well are readily achievable. Thus, a 100 MMB storage project might require only 10 to 20 wells which could have a combined redelivery capacity of over 1 MMB/D. Water for displacement need not be stored in pits. Rather, it would be supplied from either a large body of fresh water, such as a river, or from the Gulf of Mexico via pipeline. For very high product displacement rates, the Gulf might be the most practical source of supply.

Figure 12 illustrates how economy of scale affects the unit cost of a typical salt dome storage project. The cost of constructing a 100 MMB project is indicated to be one unit per barrel of storage capacity. A 50 MMB project is indicated to cost 1.25 units per barrel or 25 percent more than the 100 MMB project. Similarly, a 20 MMB project would cost nearly twice as much per barrel as a 100 MMB project. Projects larger than 100 MMB should exhibit costs somewhat below one unit per barrel. This indicates that substantial cost savings can be achieved by combining storage requirements in large caverns at a single location.

The $0.60 to $0.85 per barrel cost range assumes a plentiful and nearby supply of water to leach the caverns and the disposal of brine offshore. For large caverns, about 7 barrels of fresh water are required to leach 1 barrel of storage. Seawater can be used for leaching if adequate fresh water is not available. This would not add significantly to the unit cost if the project were located near the Gulf. The assumption of offshore brine disposal capability is also important. About 1.3 MMB/D of brine would be produced from development of a 200 MMB storage site in 3 years. Subsurface disposal of such a volume would be physically impossible at most locations and in addition, prohibitively expensive. After leaching is completed, a properly sized offshore brine disposal pipeline could be used to supply seawater for crude displacement at very high rates if a sufficient supply of fresh water is not available.

It is recognized that water requirements and brine disposal considerations associated with large-volume salt dome storage projects raise questions concerning environmental protection. These

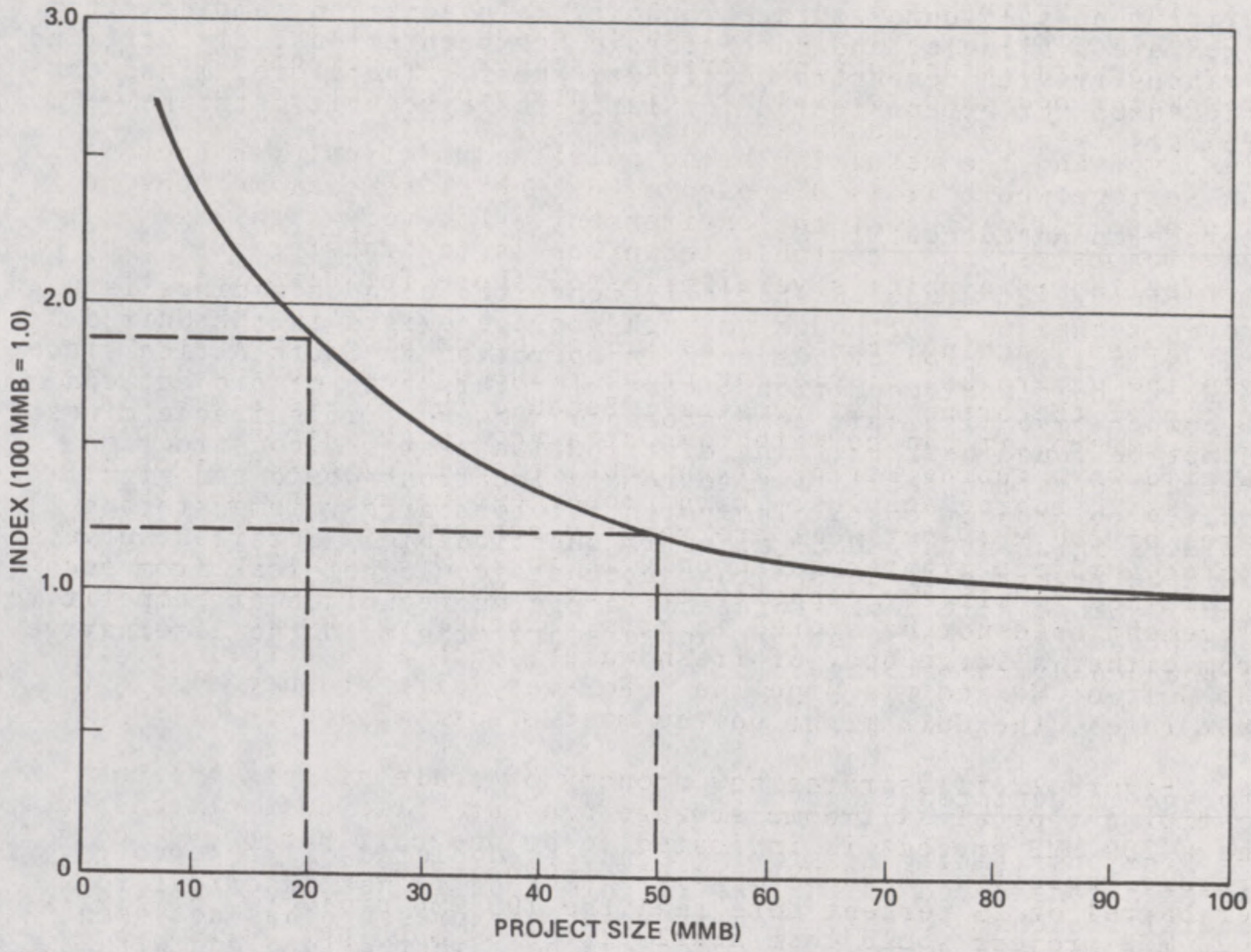



Figure 12. Salt Dome Storage--Economy of Scale Index of Relative Construction Cost per Barrel of Storage.

questions will of course be addressed in the planning, authorization and execution of specific projects. However, at most applicable Gulf Coast locations, it appears that sufficient water supplies can be obtained and that the environmental effects of disposing of essentially pure sodium chloride brine through a properly designed Gulf of Mexico disposal system will be small.

Storage cavities leached in salt beds are also a proven technique, although the potential utility of such beds for large volume security storage projects is limited. Most salt beds are located inland where freshwater costs are relatively high and where subsurface brine disposal would be required, thus making very large volume projects impractical.

Mined Cavern Storage

There are currently some 60 U.S. storage projects in mined caverns in hard rock. These generally vary in size up to about 800 MB and are usually used to store light hydrocarbons under pressure. Storage costs in mined caverns are substantially higher per

barrel than salt dome storage capacity. In addition, ample salt domes are available, and such storage has been extensively utilized by industry with demonstrated effectiveness. Therefore, mined cavities need not be considered for large-scale security storage projects.

## Storage in Abandoned Mines

Storage of crude in specially converted abandoned mines is a proven technique. Although no such storage exists in the United States, a large project has been in operation in South Africa since 1969. Under ideal conditions, costs for this type of project can be competitive with salt dome storage. However, if suitable mines cannot be found near existing distribution systems, construction of transportation facilities to remote locations would add significantly to project cost. The potential for large-volume storage projects in abandoned U.S. mines is questionable. Detailed surveys would be required to ensure that products could not leak from such mines. Since salt dome storage is a proven technique at competitive (and probably lower) cost, it appears preferable to the alternative of abandoned mine storage.

## Storage in Depleted Reservoirs

The possibility of storing crude in depleted oil reservoirs has been considered in the past. This type is not practical for several reasons. First, even if reservoir pressure has not been depleted, the rate at which crude can be injected into and withdrawn from porous reservoir rock is normally limited to the order of hundreds of barrels per day per well. This is severely restrictive compared to several hundred thousand barrels per day from a salt dome storage well. In addition, experience indicates that crude loss from such a system would be high.

## Gas Storage

Over 6 TCF of underground gas storage capacity currently exists in the United States. Such storage is drawn down to meet heating season demand in excess of producing and transportation capacity and refilled during the non-heating period. The cost to develop new working gas storage capacity is about $1,250/MMCF. This cost, which includes development and related facilities but excludes the cost of gas fill, is about 8 to 10 times as high as salt dome crude storage on a BTU equivalent basis. In addition, it is doubtful that a significant volume of gas over and above that necessary to satisfy normal requirements will be available for security storage fill.

On balance, salt dome storage appears to be by far the most viable and lowest cost method of underground storage. In addition, the per barrel cost of such storage is only 10 to 20 percent of the

cost of steel tank storage. Salt dome storage also provides maximum opportunity to reduce unit cost through economy of scale. In addition, material availability, particularly steel, appears to be less of a problem than with construction of very large amounts of steel tankage. Salt dome caverns can normally be filled and emptied many times without causing structural integrity problems, even when fresh water or seawater is utilized to displace stored crude or product. Since infrequent usage of security storage is anticipated, cavern enlargement during water displacement should not be a significant problem. Also, after leaching facilities are installed, salt dome storage can be expanded rapidly at a relatively low incremental cost per barrel.

## ASPECTS OF CRUDE *VERSUS* PRODUCT STORAGE

If salt dome cavern storage is accepted as the least expensive and generally most feasible storage technique in view of steel and appropriate land availability problems, the Texas/Louisiana Gulf Coast is indicated as the best location for emergency inventory.

### Location/Distribution

In deciding whether crude or products or a combination are to be stored, distribution facilities are of primary concern. If crude were stored, it would be possible and desirable to locate the caverns within convenient distance of crude distribution facilities such as the contemplated LOOP and SEADOCK projects, existing pipelines and marine terminals. If products were stored, the best location would be contiguous to existing marine (ship and barge) terminals and product pipelines such as Explorer and Colonial. Further analysis is required to determine whether, under the various likely circumstances of a crude and/or product import cutoff, sufficient capacity would exist in the available product distribution system from Gulf locations to make product storage logistically viable. Perhaps supplementary marine terminal facilities would be indicated in order to develop the necessary product distribution capacity and flexibility.

### Product Import Cutoff

Detailed studies should be made of the projected imports into the United States of crude and products and of projected domestic refinery capacity plus presumed available Caribbean refinery capacity. A range of product import cutoff cases, with and without crude cutoff, could be considered and tested against the logistical viability of various combinations of crude and/or product storage at Gulf Coast locations. Such studies may indicate that problems will exist if there is no product storage at all--for example, to meet the very large heavy fuel oil demand that is concentrated in the Northeastern states. Much of this fuel oil demand is normally supplied by imports largely from Caribbean refineries. It is possible that there will not be sufficient refinery yield

and distillate blending flexibility, conversion to alternate fuels, conserved consumption and running of domestic crude in possibly available Caribbean refineries to offset completely the effects of a fuel oil import cutoff.

If studies indicate a need for fuel oil storage to meet such Northeast demand, or that similar studies reveal a special need for product storage in other parts of the country, then further studies can determine if central storage of products in the Gulf area is a viable way to meet the problem. If not, product storage geographically proximate to the demand would be indicated.

### Quality Considerations

Deterioration, weathering or contamination problems should not be a concern for crude oil when stored for long periods, especially under pressure in salt dome caverns. In any case, the normal refining process would likely correct these problems without undue penalty. With respect to products, there is more of a possibility that long-term storage would affect product specifications, particularly if salt dome caverns were utilized. Studies of quality maintenance while in storage for each product should be undertaken, together with a determination of the treating and/or processing required to correct any problems uncovered, including the costs.

### Flexibility Considerations

Storage of crude will, of course, provide a full slate of products when refined and avoid the necessity, as in the case of products, of deciding the quantities of each grade, specification and type of product to store in order to meet projected future demand. Furthermore, there are far fewer segregations required for crude oil *versus* the full range of products. Accordingly, individual storage volumes in the case of salt dome caverns can be greater for crude, thus realizing the economies of size. Also, some products (e.g., heavier grades of resid) cannot be stored in salt dome caverns. If storage of these products were indicated, steel tankage would be necessary.

## FACILITIES FOR FILLING STORAGE AND MOVEMENT OF CRUDE FROM GULF COAST SALT DOMES TO OTHER LOCATIONS

Total U.S. security storage crude supplies could be located in Gulf Coast salt domes to take advantage of lower construction cost. However, in this event, transportation facilities must be capable of both filling such storage efficiently and transporting security storage crude to other areas of the Nation, particularly PAD District I, during an import interruption, with minimum delay.

Figure 13 shows the location of two proposed deepwater crude unloading terminals, LOOP and SEADOCK (neither project is designed

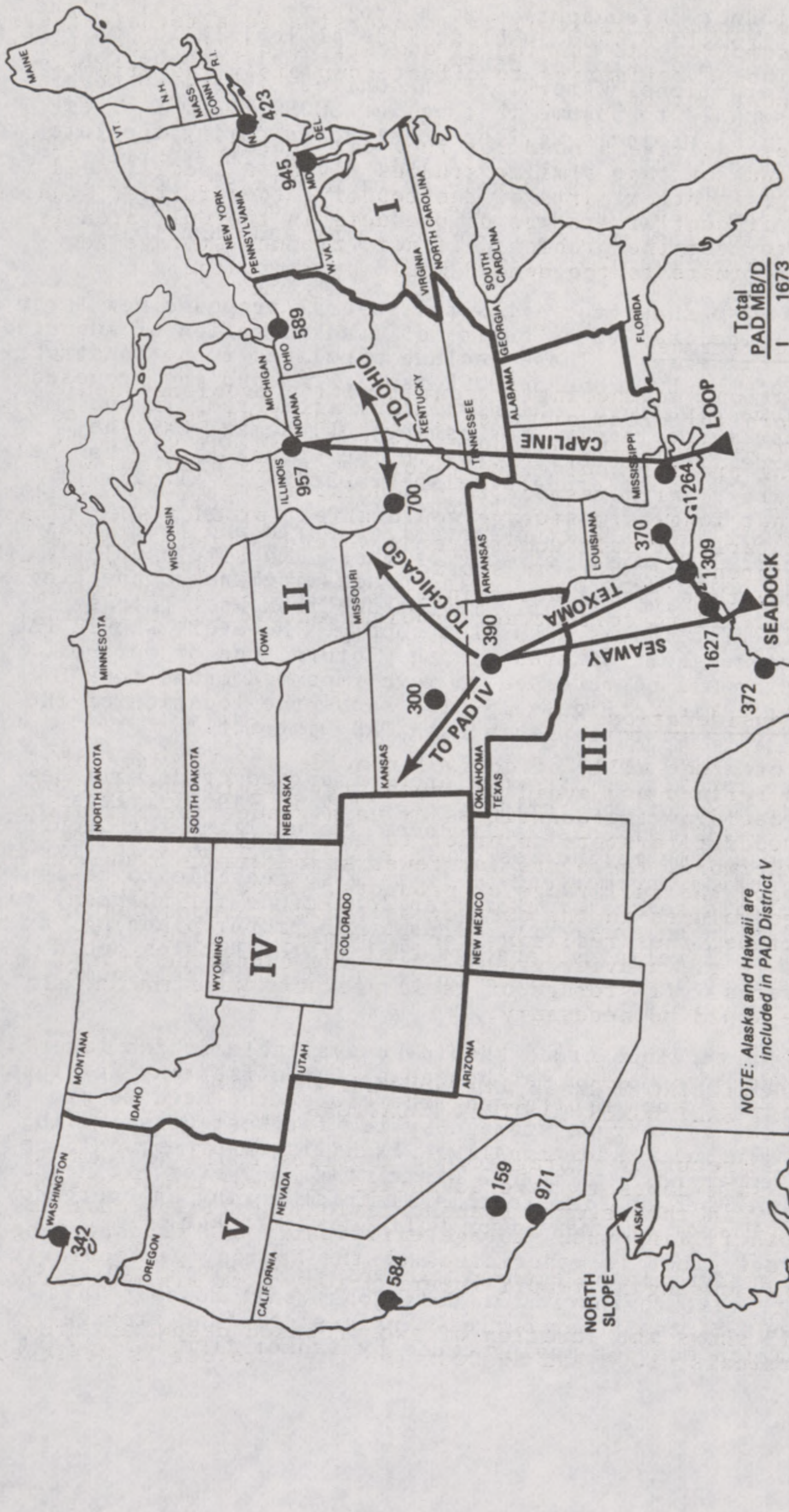



Figure 13. Major U.S. Refining Centers and Proposed Gulf Coast Deepwater Terminal Locations.

for finished product throughput). Both projects are still in the preliminary design stage, and enabling federal legislation must be enacted before these or similar deepwater terminals can be constructed in international waters off the United States. However, it appears reasonable to assume that either LOOP, SEADOCK or essentially identical projects will be constructed during the late 1970's. At both projects, deep-draft very large crude carriers (VLCC's) will tie up to buoys (single point moorings) located 20 to 30 miles offshore and unload crude. The crude will be pumped through buried pipelines to onshore tank farms and then to Gulf Coast and Midwest refineries.

Figure 13 also shows the sites for several proposed new large-diameter crude pipelines to be built for transportation of imported crude to U.S. refineries. These include pipelines to be constructed downstream of the LOOP and SEADOCK tank farms and the proposed Seaway and Texoma pipelines, which will run from Freeport and Beaumont, Texas, respectively, to Cushing, Oklahoma. Capline, which moves crude from the Gulf Coast to the Chicago area, can be expanded, and significant crude pipeline capacity is already in service between Cushing and the Chicago area. In addition, there is a large network of crude trunklines from North and West Texas to the Gulf Coast. Reversal of some of these lines to handle imported crude is being considered. The crude pipelines connecting PAD Districts II and IV presently move crude from west to east because PAD District IV has a surplus supply. However, should PAD District IV become short of crude in the future, one or more of these pipelines could be reversed to move imported crude to PAD District IV refineries. Figure 13 also shows the location of the major U.S. refining centers within each PAD District.

When these facilities are completed, imported crude will be able to flow to most of the refining capacity in PAD Districts II, III and IV. If Gulf Coast salt domes are utilized for security storage, these same refineries could easily receive security storage crude during an emergency. It is also feasible to design deepwater terminals so that tankers can load crude for shipment to other U.S. ports in an emergency. Thus, with proper planning, a large percentage of refining capacity east of the Rockies could effectively be supplied with crude out of Gulf Coast salt dome storage during an emergency.

By 1978, North Slope crude should be available to the lower 48 refineries. Such production may be capable of offsetting any loss in PAD District V crude imports and, therefore, the need to provide a formal security crude storage system for West Coast refineries appears minimal. Additionally, Elk Hills reserves would be available for emergency use in PAD District V. However, if necessary, crude could be supplied to this District during an emergency by exchange or direct shipment from Gulf Coast storage.

There is a significant economic incentive to store emergency crude for East Coast refineries in Gulf Coast salt domes. This would save about $4 to $5 per barrel *versus* steel tank storage. The transportation cost of moving crude by tanker from Gulf Coast

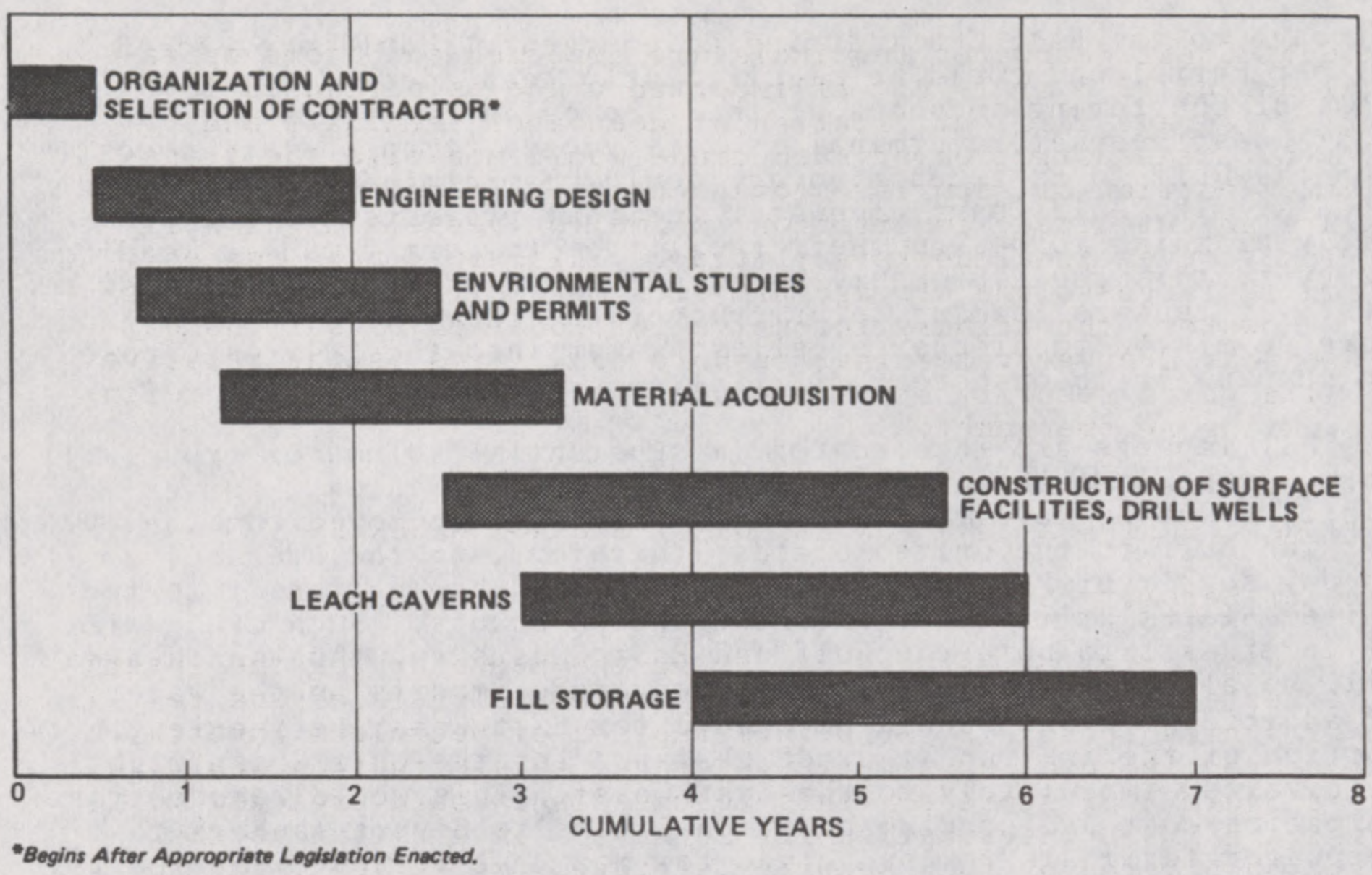
storage to the East Coast during an emergency should not exceed $1 per barrel and could be significantly less, depending on the cost of chartering in ships at the time of an emergency. If an East Coast deepwater terminal is constructed, transportation cost for the Gulf to East Coast voyage could be minimized to utilizing VLCC's. The Gulf Coast deepwater terminal projects are not presently planning to design their facilities to permit tanker loading. However, this could probably be accomplished at a relatively low cost, if tankers loading security storage crude during an emergency were permitted to discharge ballast water into the Gulf as opposed to pumping it to onshore facilities.

If imports are interrupted, a substantial volume of crude will normally be in transit by tanker to the United States. For example, about 30 days is required for a tanker to move from the Persian Gulf to the United States; therefore, on the average, a 30 day supply of Persian Gulf imports should be in transit to the United States at the time an interruption occurs. Such crude will be in transit to both the Gulf and East Coasts and thus, each area will be afforded some protection from crude imports on the water. If additional crude should be needed for East Coast refineries, a portion of the in-transit crude destined for the Gulf Coast might be diverted immediately to the East Coast. This would reduce transportation cost and provide additional time to divert tankers to deepwater terminals to load crude for movement to East Coast ports. If sufficient U.S. flag vessels are not available, utilization of foreign flag vessels should be allowed.

If a salt dome security storage program is implemented, consideration should be given to utilizing the approximately 100 MMB of existing cavities created from salt mining operations at the Stratton Ridge salt dome. Consideration should be given to construction of a second salt dome crude storage project in the vicinity of the pipeline between the LOOP onshore tank farm and the Capline terminal. This would enable direct connection of additional PAD Districts II and III refineries to a security storage crude supply. It would also increase total system redelivery capacity by connecting security storage crude to additional transportation facilities and would eliminate the need to move crude by tanker from Texas to Louisiana during an emergency. In the event Gulf Coast deepwater terminals are not completed by the time salt cavern storage is available, pipeline connections to existing crude distribution systems would be required. However, even in this case, salt dome storage on the Texas and Louisiana Gulf Coast still appears the most attractive means of providing security storage.

## Construction Timing

Figure 14 illustrates the time required to construct a large scale Gulf Coast salt dome crude storage project. From the time that a contractor is selected, it will take about 2.5 years to reach the stage where cavern leaching can begin. During this period, engineering design, environmental studies, material acquisi-




*Begins After Appropriate Legislation Enacted.

Figure 14. Salt Dome Crude Storage -- Project Construction Schedule.

tion, construction of service facilities and a portion of the well drilling would be completed. A key assumption is that long lead time materials will either be ordered in advance of obtaining necessary permits or that the time required to process permit applications will be reduced.

Leaching is a time-consuming process requiring the circulation of about 7 barrels of water for each barrel of storage capacity. Completion of 100 MMB of storage capacity per year would require a water circulation rate of about 1.9 MMB/D. While time to complete the ultimate storage capacity of a project is dependent on total size, location, degree of urgency and funding, it should be possible to leach a 100 to 200 MMB project in 3 years. If filling of the caverns could be completed in 3 years, the entire project from selection of a contractor to completion of fill would take about 6.5 years. This schedule suggests that completion of such a project by the early 1980's is possible. It also indicates that fill of newly constructed storage could probably not begin before 1979. Completion of two such projects simultaneously or one much larger project might require additional time depending upon the site(s) chosen, fresh water and drilling rig availability, etc. Since about 3 years is currently required to obtain materials and construct steel tankage, fill could not be initiated much, if any, earlier than if the aboveground storage alternative were selected.

Gulf Coast deepwater terminals are expected to become operational during 1978 or 1979. If imported crude is purchased for security storage fill, utilization of deepwater terminals and VLCC's for transportation of such crude would minimize the transportation portion of security storage costs. If deepwater terminals are not utilized, importation in smaller vessels might well over-load conventional dock facilities. This would make concentration in large-volume storage projects more difficult and expensive. However, the primary incentive for location of salt dome storage near deepwater terminal onshore tank farms is the relative ease with which security storage crude could be delivered to refineries during an emergency.

## ADDITIONAL CONSIDERATIONS FOR EMERGENCY STORAGE RESERVES

### Volume of Security Storage Required

In his letter of January 22, 1973, the Secretary of the Interior requested the NPC to analyze the possible effects of and responses available to a 3 MMB/D interruption of petroleum imports. If protected in total by security storage, this situation would require 540 MMB of storage. This volume alone would protect against a 6 MMB/D interruption for 90 days. In addition to the protection offered by such security storage, protection (time to implement emergency preparedness plans) would be provided by imported crude in transit at the time of an interruption and by usable U.S. working inventories.

According to the Bureau of Mines, U.S. crude inventories have fluctuated between a low of about 230 MMB and a high of about 290 MMB over the past few years.* The NPC Committee on Petroleum Storage Capacity has estimated that minimum crude inventories of 240 MMB are required for the system to remain fully operational. This minimum inventory includes line fill, unusable tank bottoms and working inventories required to maintain continuous operations. Therefore, if an interruption occurred when U.S. inventories were near the minimum, no usable inventory would be available, assuming operations were to continue at full capacity. To the extent that U.S. crude inventories are above this minimum level when an interruption occurred, that oil would be available for drawdown and use as an added cushion before security storage supplies would have to be utilized.

### Availability of Supplies for Security Storage Fill

Imports could be utilized for security storage fill. An input rate of 500 MB/D would be required to fill 500 MMB of storage in 3 years. However, it is possible that surplus foreign supplies may not be available for this purpose. Exporting nations have in-

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* U.S. Bureau of Mines, *Mineral Industries Survey*, Monthly Petroleum Statements.

dicated that expansion of producing capacity must be consistent with achievement of their national objectives. Politics as well as economics will play an important role in determining the upper limit of production that these producing nations will allow.

In addition, the cost of imported supplies would be high. Assuming world prices at the time security storage fill commences are at the current $10 to $12 per barrel level, the fill for a 540 MMB salt dome storage program utilizing imported crude would cost between $5.4 and $6.5 billion. Furthermore, any surplus imported crude available for storage fill would probably be high in sulfur content. Many U.S. refineries will not be able to process sour crude, and relaxation of environmental regulations would be required during an emergency to permit maximum utilization of sour crude in certain areas.

On balance, relying on foreign imports to fill crude storage by the early 1980's involves a risk that sufficient crude above normal demand may not be available to the United States. The probable high cost and relatively high sulfur content of imported crude is also of concern.

Another potential source of crude for security storage fill is domestic production. Except for the Naval Petroleum Reserves and certain proven reserves on Alaska's North Slope and in the Santa Barbara Channel, all U.S. oil fields are producing at maximum efficient rate as defined by federal and state conservation rules and regulations. While it is believed that certain fields could produce at higher rates for short periods during an emergency without reducing ultimate recovery, the capability of such fields to supply emergency crude will be reduced significantly through normal reservoir decline by 1979. Also, by 1979 it is felt that all existing reserves as well as future exploration discoveries will be producing at MER's consistent with the U.S. goal of moving rapidly toward energy self-sufficiency.

As discussed earlier, NPR-1 (Elk Hills) appears to be the only Naval Petroleum Reserve with sufficient proven reserves to support a substantial rate of production. With proven reserves of 1 to 1.4 billion barrels, NPR-1 is capable of providing a minimum of 500 MMB of security storage fill. If 500 MMB were produced from NPR-1 and placed in security storage, remaining NPR-1 reserves of several hundred million barrels would still support a substantial intrafield producing rate. Additional exploration on NPR-1 could add to reserves and, therefore, to producing capacity. This remaining producing capacity could be reserved for emergency production, used to provide additional security storage or maintained as a Naval Petroleum Reserve.

It should be noted, however, that there is a strong possibility that not all of the presently indicated recoverable reserves could be produced if production were suspended for a period of time after as much as 500 MMB had been produced. Losses in recovery from partially depleted reservoirs could occur during a prolonged shut-in. Accordingly, it should be recognized that once a sub-

stantial percentage of reserves is withdrawn, it may be necessary to continue production in order to maximize ultimate recovery. If Elk Hills crude were stored in Gulf Coast salt domes, such crude could be transferred to refineries at a rate of several million barrels per day. This is many times greater than the rate which could realistically be achieved from NPR-1 reservoir rock without adversely affecting ultimate recovery. Such action would therefore greatly enhance the national security protection capability provided by NPR-1 crude reserves.

In addition, Elk Hills crude is relatively low in sulfur content and could thus be utilized by a high percentage of U.S. refineries without adding to environmental problems. Also, utilization of Elk Hills crude for security storage fill would eliminate the need to purchase an equivalent amount of foreign crude, thus reducing the out-of-pocket cost of implementing the program by an estimated $5 to $6 billion.

Existing or new pipelines could be used to relocate 500 MMB of Elk Hills reserves in a Gulf Coast salt dome facility at a cost of about $1 per barrel (230 MB/D for 6 years). If tankers were used--either 50-55,000 deadweight tons (DWT) through the Panama Canal or VLCC's around South America--the transportation cost would be about $1.60 per barrel. While a combination of these methods could be used, tanker availability and cargo preference legislation may limit the latter alternative.

Another potential source of oil to fill security storage would be Federal Government royalty entitlements. An advantage of using this oil is that it would be clearly established that it would be available to meet either public (defense) or private needs under emergency conditions without introducing difficult problems of ownership, equity or compensation for inventory holding costs. It must be recognized, however, that commitment of royalty oil to security storage would increase oil import requirements in order to balance supplies with current consumption.

Among other important considerations to be resolved are the extent of government and/or industry financing and administration of emergency storage and its fill. The Council feels that security storage should not be utilized until after (1) a proper declaration of an energy emergency by government and (2) appropriate voluntary and mandatory standby consumption reduction measures have been implemented.

APPENDIX D

# ECONOMIC ANALYSIS OF THE COST OF MAINTAINING STANDBY EMERGENCY SUPPLIES

Given adequate planning and lead time, there are three basic alternatives for providing standby petroleum supplies to offset a sudden loss of imports. These are: (1) shut-in or reduction of production from domestic oil fields, (2) storage of crude after production from underground reservoirs, and (3) storage of refined petroleum products.

Alternatives for storage of emergency petroleum supplies include aboveground storage in steel tanks or underground storage in salt domes, mined caverns or abandoned mines. Restriction of production alternatives consists of nationwide prorationing (production of the majority of oil fields at less than MER) or shutting-in selected fields completely. This appendix discusses the feasibility, initial construction cost and relative economics of these standby supply options.

The alternatives which involve maintaining reserves in the ground by restricting production require a large total volume of reserves to provide the required daily producing capacity. This results from the basic mechanism of fluid flow in petroleum reservoirs. Extensive investigations have shown that the producing capacity of most domestic reservoirs will have begun to decline when the annual reserve-to-production ratio (R/P) drops below 8.0 (at an R/P of 8.0, one-eighth or 12.5 percent of the reserves are produced each year). Thus, to provide protection against a 6 month, 3 MMB/D interruption (540 MMB total), a minimum shut-in reserve of 8.8 billion barrels (3 MMB/D x 365 days x 8) would be required. Furthermore, if reserves at this stage of depletion were shut-in and produced during an emergency, producing capability would decline unless replacement shut-in reserves were provided.

Although some fields can and do produce at lower R/P's, it is doubtful if enough reserves of this type exist to provide an appreciable amount of shut-in protection. On the other hand, selection of fields with significantly higher R/P's would increase the amount of reserves dedicated to the program. For example, the Yates field is currently producing 50 MB/D and has a deliverable capacity to refineries of 110 MB/D (limited by trunkline capacity). Even at the higher producing rate, the field R/P would exceed 30, which is much greater than the average R/P of 8 assumed in this analysis.

In contrast, storage after production requires producing and transferring only the required volume of oil into storage where it can be delivered at very high rates when an emergency occurs. For example, in comparison to the requirement of 8.8 billion barrels mentioned earlier, only 540 MMB of security storage crude would be required to provide protection against a 6 month, 3 MMB/D crude import interruption.

PRESENT VALUE COST OF ALTERNATIVES*

To realistically compare the cost of maintaining emergency standby supplies, it is necessary to compare the costs on a unit of capacity basis. A per barrel cost comparison is not meaningful because it is the replacement of a given import interruption *rate* that is of importance. Such comparisons are logically based upon the total present value cost per barrel per day of emergency supply provided. The comparison in this study was based on a 3 MMB/D, 180 day interruption as specified by the Secretary of the Interior and assumes that the total denial would be offset by either security storage or restriction of domestic production.

The unit costs presented in Table 39 are based on large volume projects and are calculated in constant 1974 dollars. The cost associated with transporting emergency standby supplies to points of consumption such as refineries is not included. Depending on the type of interruption (crude or products) and the location of emergency preparedness facilities, logistical considerations could add significantly to cost. However, the unit cost at the field level provides a valid basis for ranking the cost of alternative emergency supply systems.

The results of the cost evaluations summarized on Table 39 indicate that storage in steel tanks or salt domes is a much less expensive method of providing emergency standby supplies than restricting production. The total present value costs of salt dome and steel tank storage are only 10 percent and 20 percent of the restricted production alternative, respectively. Also, salt dome storage costs only about one-half as much as steel tank storage. Present value costs listed on Table 39 are based on a discount rate of 10 percent. Various sensitivity cases were evaluated at higher discount rates, higher prices and more optimistic R/P's for the restricted production options. Although the absolute cost of the various alternatives changed in these cases, the ranking of the alternatives did not. Note also that the present value costs of a 10 year program are only about 25 to 30 percent less than the cost of a 20 year program.

COST ELEMENTS OF MAINTAINING EMERGENCY STANDBY SUPPLIES

The cost of maintaining any type of emergency standby supply is a combination of several factors. First is the initial cost of

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* *Editor's Note: The present value concept* simply recognizes that a dollar received today is worth more than a dollar received some years in the future by the amount of interest or return that dollar can be expected to earn. For example, if a dollar received today were invested in bonds, a savings plan or some other investment which earned interest at a rate of 10 percent, it would be worth $2.59 in 10 years. Conversely, a dollar of income received 10 years in the future is worth only $0.39 today, assuming a 10 percent interest rate. This is a common and well accepted method of comparing the present value of various future income streams.

TABLE 39

UNIT COST OF PROVIDING
STANDBY EMERGENCY SUPPLIES
(Dollars Per Barrel Per Day)

| | 20 Years | 10 Years |
|---|---|---|
| Salt Dome Storage | | |
| $0.75 Per Barrel Facility Cost | 930 | 620 |
| $1.00 Per Barrel Facility Cost | 970 | 660 |
| Steel Tank Storage | | |
| $5.00 Per Barrel Facility Cost | 1,790 | 1,370 |
| $7.00 Per Barrel Facility Cost | 2,200 | 1,750 |
| Production Restriction by Shutting-in Fields or by Prorationing | 10,300 | 7,400 |

Note: Based on present value cost per unit of supply. Assumptions are that:

- Emergency capacity initiates in 1975 and reserves are retained until 1985 or 1995 when they are sold.
- Cost is present value cost to operators, royalty owners and government (discounted at 10 percent) resulting from deferred producing income and/or receipt of direct tax payments.
- Unit costs are based on providing full protection for a 3 million barrel per day, 180 day interruption.
- All costs are calculated in constant 1974 dollars.
- Oil has a constant price of $8.00 per barrel of stored or shut-in crude.

establishing the emergency supply--for example, the cost of building steel tanks or salt dome storage facilities and of filling such storage with crude or products. Second is the cost of maintaining the standby supply. This includes the cost of direct labor and equipment maintenance required to maintain the capability to produce at full capacity during an emergency. An additional cost includes necessary expenditures to construct or replace pipeline, transportation and producing facilities.

Another major cost item is the loss in present value profit to the owners of shut-in production, government and the economy that would result from deferring the production and sale of standby supplies. For example, consider the case of shutting-in existing fields to provide emergency spare capacity. Under normal conditions, these fields would be produced to depletion over a period of years with resulting income accrued to operators and royalty owners from the sale of oil and gas. Income to local, state and federal governments in the form of production, sales and income taxes and, in some cases, royalty payments would similarily be deferred. There would also be substantial additional costs to the economy which have not been quantified in this analysis. It was assumed that emergency protection would be required for either 10 or 20 years, at which time alternative energy forms would be available and the security supplies could be produced and sold. Thus, if the fields were shut in to provide standby supplies for 20 years and then produced, income would be deferred for 20 years which would result in a substantial loss in present value to operators, royalty owners and government.

In the case of security storage, the sale of crude or products necessary to fill the storage would also be deferred. These products would also be sold after 20 years with a loss in present value. Although substantial, such loss would be far less than for the shut-in reserve case because of the smaller total volume involved.

Additional bases used in computing the costs shown on Table 39 are summarized below:

- Basis for Shut-In Reserve Cost

  --Operating expense saved as a result of shut-in equals 21 percent of revenue.

  --Annual maintenance cost of shut-in capacity equals $50 per barrel per day.

- Basis for Salt Dome Storage Cost

  --Large volume (at least 100 MMB) salt dome storage construction costs would range from $0.65 to $0.85 per barrel, depending on location with respect to suitable water source and brine disposal areas. Thus, using a cost of $0.75 per barrel, a 540 MMB storage program would have a total cost of $405 million excluding the cost of crude fill.

  --Construction costs are assumed to be spread over a 5 year period starting in 1975, and fill costs over a 3 year period beginning in 1978.

  --Maintenance cost of $0.01 per barrel of stored crude per year.

- Basis for Steel Tank Storage Cost

  --Steel tank storage costs for a large volume crude storage project are estimated at $4.00 to $6.00 per barrel. Using a cost of $5.00 per barrel results in a total cost of $2,700 million for a 540 MMB storage program excluding the cost of crude fill.

  --Timing of construction and fill costs are assumed to be the same as for salt dome storage.

  --Maintenance cost is 5 percent of capital investment per year.

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# III. Excerpts From the National Petroleum Council's Report on Petroleum Storage Capacity

# PETROLEUM STORAGE CAPACITY

A Report of the
National Petroleum Council's
Committee on Petroleum Storage Capacity
Chas. E. Spahr, Chairman

E. W. Unruh, Chairman
Technical Subcommittee

# INTRODUCTION AND SUMMARY

## INTRODUCTION

At the request of the Department of the Interior, the National Petroleum Council has periodically conducted surveys of the availability of petroleum inventories and storage capacity. Since 1948, these reports have provided assistance in evaluating our preparedness to withstand interruption in our normal oil supplies, whether by domestic dislocation or by foreign intervention.

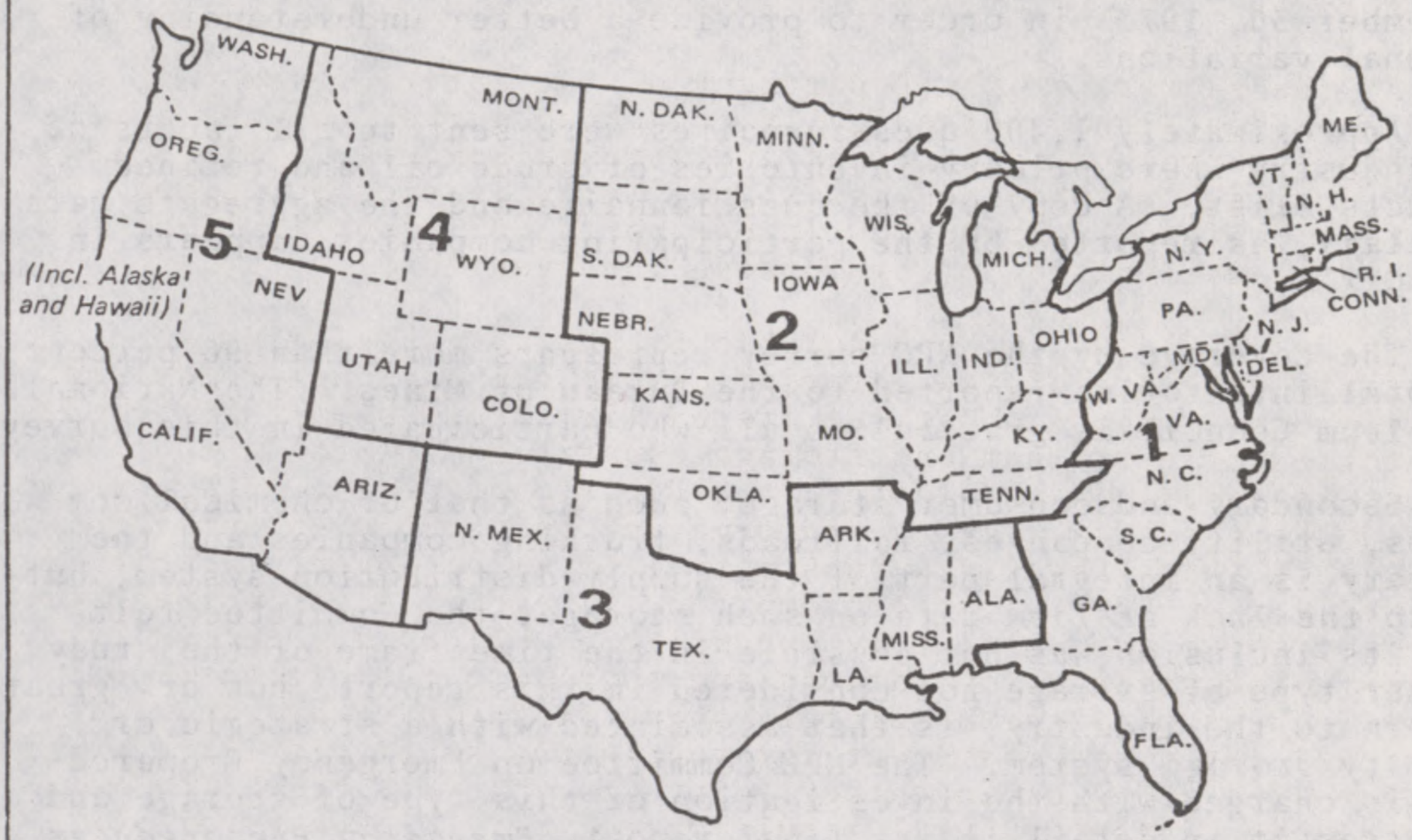
On July 12, 1973, the Honorable Stephen A. Wakefield, then Assistant Secretary of the Interior, wrote the National Petroleum Council requesting an update of its earlier studies on the Nation's inventories of petroleum and storage capacities. (See Appendix A for request letter.) In the letter, the Department of the Interior recognized the need for accurate information and a clear understanding of the fact that there is a substantial level of inventory which is absolutely *unavailable* for consumption. There is also an inventory increment above the absolutely *unavailable*, which is a necessity for uninterrupted refining operations and supply to the ultimate consumers. The sum of the absolutely *unavailable* inventory and this additional inventory increment for continuous supply is termed *minimum operating level* of inventory. Inventory levels below the *minimum operating* inventory will result in refinery slowdowns or shutdowns and product supply runouts. Only those supplies in inventory above this point can be considered available for consumption.

In response to this request, the National Petroleum Council established a Committee on Petroleum Storage Capacity under the Chairmanship of Mr. Chas. E. Spahr, Chairman of the Board, The Standard Oil Company (Ohio). The Committee was assisted by a Technical Subcommittee chaired by Mr. Earl W. Unruh, Vice President, Transportation Department, The Standard Oil Company (Ohio). (For a listing of the industry members of the Committee and its Subcommittee, see Appendix B.)

The Department of the Interior also asked for a survey of plans for the construction of new storage capacity. Although new storage is planned in conjunction with several offshore deepwater unloading ports and the Trans-Alaska Pipeline, all plans for new refineries, expanded capacities of existing refineries and new and expanded transportation systems are subject to frequent reassessment. The Committee therefore agreed that, at this time, a study of projected new storage capacity would not be meaningful.

This report provides national and regional information on the Nation's inventories and storage capacities as they are distributed throughout the country. The data are broken down by Petroleum Administration for Defense (PAD) Districts and by Bureau of Mines Refining Districts, as shown in Figure 1. The East and West Coast Refining Districts are further subdivided to provide more detailed information.

PETROLEUM ADMINISTRATION FOR DEFENSE – (PAD) DISTRICTS




BUREAU OF MINES REFINING DISTRICTS

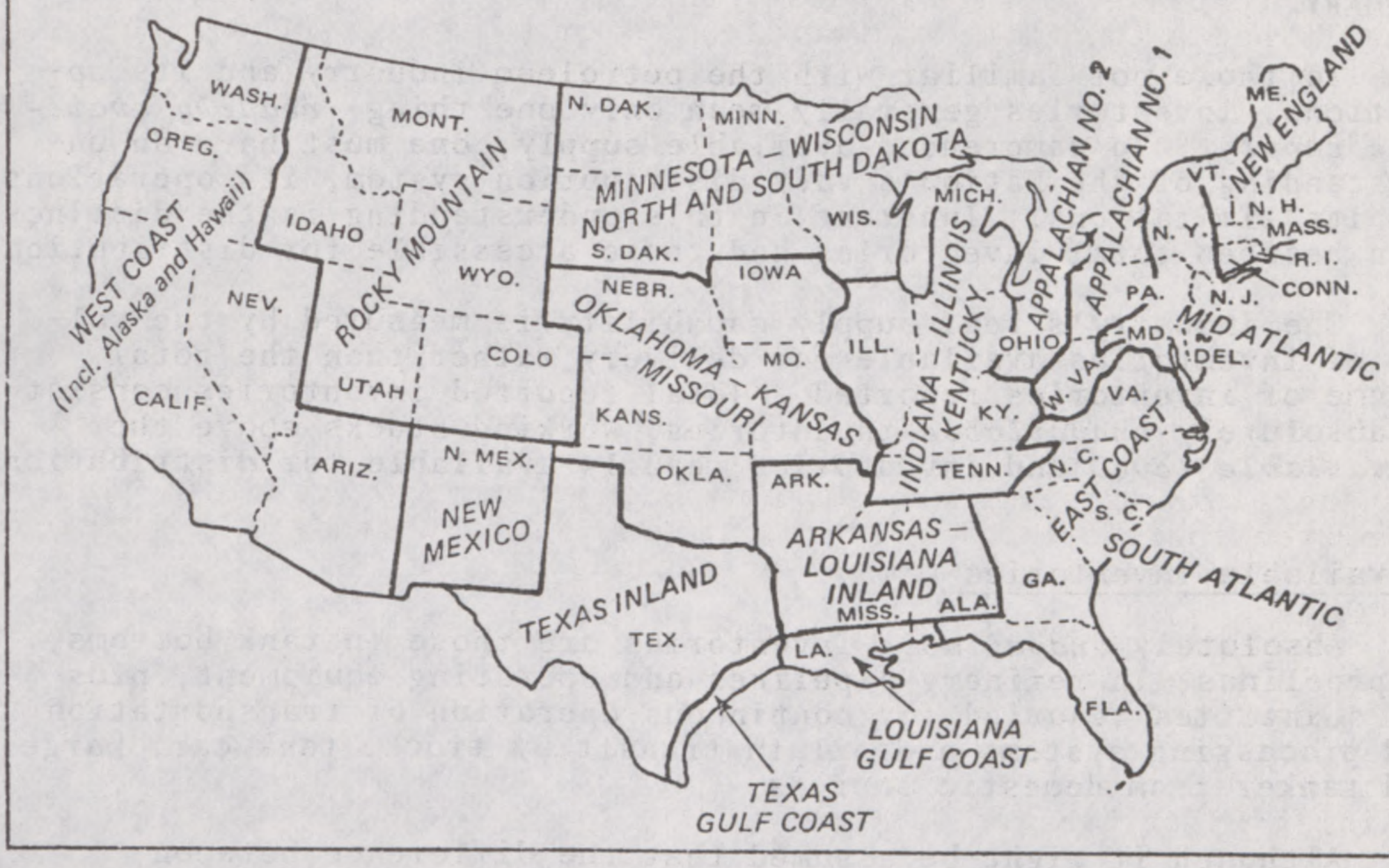



Figure 1.

This report includes inventory and storage data for the total United States, the Virgin Islands and Puerto Rico, and, for the first time, data are reported for two dates--March 31, 1973, and September 30, 1973--in order to provide a better understanding of seasonal variations.

Approximately 1,400 questionnaires were sent to all facets of the industry where primary inventories of crude oil and refined products exist. A copy of the questionnaire and the aggregate data in detail, as reported by the participating companies, appears in Appendix C.

The coverage by the NPC survey represents more than 96 percent of total inventories reported to the Bureau of Mines. The National Petroleum Council is grateful to all who participated in this survey.

Secondary and consumer storage, such as that of chemical companies, utility companies, railroads, trucking companies and the military is an integral part of the supply distribution system, but due to the lack of firm data on such storage, the Committee felt that its inclusion was not possible in the time frame of the study. Another type of storage not considered in this report, but of great concern to the industry, is that associated with a strategic or security storage system. The NPC Committee on Emergency Preparedness is charged with the investigation of this type of storage and discusses it in detail in its final report, *Emergency Preparedness for Interruption of Petroleum Imports into the United States.*

SUMMARY

To those not familiar with the petroleum industry and its operations, inventories generally mean only one thing--*readily available supply.* To comprehend available supply, one must have an understanding of the Nation's vast distribution system, its operations and its limitations. Inherent in this understanding is the distinction between total inventories and those accessible for distribution.

The industry's real supply capability is measured by the volume of inventories available for delivery rather than the total volume of inventories reported. Total reported inventories consist of absolutely *unavailable* inventories, working stocks above the *unavailable level* and inventories readily available for distribution.

Unavailable Inventories

Absolutely *unavailable* inventories are those in tank bottoms, in pipelines, in refinery pipelines and operating equipment, plus the quantities requried for continuous operation of transportation and processing systems and oil in transit by truck, tank car, barge and tanker from domestic sources.

Although it might be assumed that the difference between total and *unavailable* inventories would in fact be available for

distribution, experience has indicated that the U.S. oil logistics system simply would not operate if inventories were depleted to the absolutely *unavailable level*.

## Minimum Operating Inventories

To operate on a normal basis, an additional substantial increment of working inventory above the *unavailable level* is necessary for continuity of operations. Such working stocks must also be considered unavailable for consumption. The sum of total *unavailable* inventories and working stocks is termed the *minimum operating level*.

The industry's *minimum operating level* for a given petroleum product is difficult to measure because of the seasonal variations and the complex interdependency of fuels in the overall distribution system. The best available determination of the *minimum operating level* is obtained by comparing total industry inventory data with historical performance in supplying the needs of the consumer. In this report, the approach used is to obtain a consensus of *minimum operating levels* by careful study of industry inventory data during recent periods of tight supply and spot shortages (see Appendix D). Although this approach is somewhat judgmental, the experience of companies represented on the Committee has indicated that when national inventories fall below the *minimum operating levels* specified in this report, shortages and inefficiencies in the distribution system will develop, and run-outs caused by geographic dislocation of supply will occur.

The combination of tankage capacity, *minimum operating levels* and the *unavailable* portion of inventories provides a basis for analysis of the oil industry's storage operation within the frame work of the existing supply and distribution system. The significant conclusion to be drawn from this analysis is that *readily available* inventory represents only a small percentage of the total inventory reported.

The differences between *unavailable* and *minimum operating levels* relative to total inventories are illustrated by applying the results of this study to the data reported by the Bureau of Mines. For example, such an application shows that while 71.4 percent of the total crude oil inventories reported to the Bureau of Mines for September 30, 1973, could be considered *unavailable*, 99.5 percent of the total was felt to be representative of the *minimum operating level*. Out of the total clean products and residual fuel oil inventories reported for March 31, 1973, 32.2 percent could be classified as *unavailable*, while 97.8 percent was characterized as the *minimum operating level*. Similarly, of the total clean products and residual fuel oil inventories reported for September 30, 1973, 27.1 percent could be termed *unavailable*, while 97.2 percent represented the *minimum operating level*. The derivation of these percentages is presented in Table 1.

TABLE 1

UNAVAILABLE AND MINIMUM OPERATING LEVELS OF PRIMARY INVENTORIES

(Millions of Barrels)

| | Reported to Bureau of Mines | Calculated to be Unavailable | | Minimum Operating Level | |
|---|---|---|---|---|---|
| | Total (1) | Total* (2) | Percent (2)÷(1) (3) | Total (4) | Percent (4)÷(1) (5) |
| Crude Oil | | | | | |
| September 30, 1973† | 241.3 | 172.3 | 71.4 | 240.0 | 99.5 |
| Clean Products and Residual Fuel Oil | | | | | |
| March 31, 1973 | 422.4 | 136.0 | 32.2 | 413.0 | 97.8 |
| September 30, 1973 | 521.6 | 141.4 | 27.1 | 507.0 | 97.2 |

* Derived by multiplying column (1) by percent unavailable from the NPC survey.

† Thirteen million barrels of crude lease stocks are included, being considered completely unavailable.

Note: See Table 2 for details on individual products.

Storage Requirements

NPC surveys dating back to 1948 indicate that the industry is still finding it necessary to maintain a total storage capacity of at least two barrels for each barrel of actual inventory in the tanks, as shown in the following tabulation:

| Date of Survey | Ratio of Storage Capacity to Inventory in Tanks |
|---|---|
| March 31, 1948 | 2.4:1 |
| June 30, 1950 | 2.2:1 |
| March 31, 1952 | 2.2:1 |
| March 31, 1954 | 2.1:1 |
| March 31, 1957 | 2.2:1 |
| Sept. 30, 1962 | 2.0:1 |
| Sept. 30, 1969 | 1.9:1 |
| Sept. 30, 1973 | 2.1:1 |

This relationship is a prime requisite in maintaining operating flexibility and providing for seasonal variations in demand. In no sense can the difference between the actual inventories and the storage capacity figures shown herein be taken as an indication of available storage space for preparedness against extended interruption in supply.

In conjunction with an examination of petroleum inventory storage, there is significance in briefly reviewing the history of

its relationship to energy demand. From 1968 through 1973, domestic consumption of petroleum products increased by 28.4 percent. During this time, domestic transportation facilities and refineries were expanded, yet total inventories showed no increase, indicating that the distribution of products was handled through a much more efficient network. A growing dependence on foreign crude and products was also a contributing factor to this inventory plateau. Imported petroleum is not included in the Nation's inventory figures until it clears customs; therefore, inventories reported at refineries, in pipelines, etc., have not grown at anywhere near the same rate as has demand.

# PART ONE

# CONCEPTS OF PETROLEUM DISTRIBUTION AND STORAGE

## PETROLEUM DISTRIBUTION

It is necessary to understand the Nation's distribution system to understand the true meaning of inventories. This system can be divided into two basic categories--primary and secondary. Related detailed information is provided in a separate NPC report which deals with the Nation's transportation of petroleum and its products.*

### Primary Distribution Systems

The system of pipelines, tankers and barges that moves crude oil from producing areas to refining centers, and the similar facilities that move refined petroleum products in bulk to marketing areas, are generally categorized as the primary distribution system. An integral part of this distribution system includes the tank farms and terminals which provide tankage for storage at all levels in the system. In the transportation of crude oil, sizable tankage must be provided at all receiving terminals as well as at delivery points, primarily at refinery locations. Because the product distribution system is more widespread than the crude oil system, industry is required to maintain considerably more product tankage in order to maintain normal flexibility in the overall operation of the supply system.

#### Primary Crude Oil Systems

Primary crude oil systems or trunklines are comparable to the long lines systems in communications or to the main lines of railroads. They are served by gathering systems in producing areas and may pick up crude oil from a large number of gathering systems in numerous oilfields as well as from marine unloading terminals.

Due to the variation in quality among crude oils, the transportation systems generally segregate crude by type for movement and delivery. Segregation requirements are usually determined by quality characteristics such as sulfur content, specific gravity, asphalt content, lube oil considerations, etc., which might be dictated by the particular needs of a given refinery. Such segregations result in increased storage requirements.

Trunk pipelines generally are routed through focal points or "hubs," akin to the hubs of a wheel, where a number of pipelines may converge. These hubs are comparable to such locations as Chicago, St. Louis, Philadelphia, Houston, etc., on a railroad

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* NPC, *U.S. Petroleum and Gas Transportation Capacities* (1967)

freight interchange system. At such a point, exchanges of oil may be made or transfers to carriers destined elsewhere implemented. Examples of such locations are Midland and Crane, West Texas; Mexia and Longview, East Texas; Cushing, Oklahoma; Casper, Wyoming; and Patoka, Illinois. A large amount of storage capacity is required at these points not only to enable the oil to be brought into the area from numerous producing regions, but also to provide tankage for segregation, batching and inventoring necessary for continuous pipeline operation before the oil can be moved to refineries.

### Primary Products Distribution System

The primary products distribution system is made up of the trunk products pipelines which move products overland and the barges and tankers that provide for marine movements. While products are still in refinery tanks, there is usually a choice as to the direction in which the products may move, along with a choice of the mode of transportation. Once a product is on its way in an element of the primary distribution system, it is then committed to the geographical area which is serviced by the particular element. For example, the Colonial Pipeline extends from the Houston-Beaumont, Texas, area to the New York Harbor area, passing through Baton Rouge, Atlanta, Greensboro, Roanoke, Washington, Baltimore and Philadelphia areas en route. The product in this primary distribution system can be delivered or diverted to any delivery point along its geographical route. While the product is in the pipeline system, decisions can still be made regarding its destination along the line unless the product has already passed that point. When the product is delivered out of the pipeline into a bulk terminal tank along the route, it then leaves the primary system and enters the secondary system, and the ability to divert that product to a different geographical location becomes even more limited.

### Secondary Distribution Systems

The delivery of a shipment from a trunkline to a terminal point starts the secondary distribution movement. Shipment from the terminal is by truck, barge, railcar or pipeline to a limited area in the vicinity of the terminal; delivery points are consumers or small marketing bulk plants.

The final step in the distribution system begins at the small marketing bulk plants and is handled usually by trucks delivering directly to service stations, households or other end-users. Thus, the flexibility to divert decreases progressively as the product passes from the refinery into the primary and then secondary distribution systems.

## PETROLEUM STORAGE

The survey conducted to obtain the statistical data for this study dealt with primary stocks (inventories) and storage capacity.

Primary petroleum inventories in the United States, surveyed in this report, include:

- Crude oil, natural gas liquids and petroleum product inventories at refineries, including domestic oils in transit thereto by waterborne means

- Stocks in crude oil trunklines and their terminals (Producers' lease stocks were not surveyed; where used in this report, they are considered completely unavailable.)

- Stocks in product pipelines, including their terminals

- Product stocks in bulk terminals that receive product by tanker, barge or pipeline and all other bulk terminals with aggregate storage capacity of 50,000 barrels or more.

These inventory data are reported to the Bureau of Mines for publication in their monthly petroleum statements. The geographic coverage includes the 50 States, Puerto Rico and Virgin Islands (details are included in Appendix C); however, only data pertaining to the 50 States are included in the overall summaries to conform to the Bureau of Mines reporting procedure. Excluded from the survey were stocks held at such locations as consumer storage tanks, service stations, small marketing bulk plants and military installations. Stocks at these secondary locations are not regularly reported to the Bureau of Mines or any other source.

The survey data make it possible to ascertain the geographical location and to break down and delineate storage capacity and stocks that are classified as *unavailable*.

Also addressed is the equally important subject of *minimum operating* inventories. The minimum level of inventories required to maintain full operability of the refining and distribution system became of special national concern during the recent periods of tight supply and spot shortages. It is important to clearly understand the distinction between the *unavailable* inventory category as reported in the survey and the *minimum operating level*. The *unavailable* portion of gross inventories as reported herein represents only the material in storage in a static or inoperable distribution system. Significant additional inventory volume is required to sustain an ongoing nationwide refining and distribution system providing customary levels of service without interruptions of supply or without distribution inefficiencies. The *minimum operating level* is defined as the sum of the *unavailable* category, the working stocks required to maintain the system in a normal operating mode, and the seasonal inventory prestockage necessary to meet peak consumption periods.

Due to highly seasonal demands for some petroleum products, particularly distillate fuel oil, the petroleum industry must build-up above the *unavailable* and normal *minimum operating level*, sizable additional inventories in anticipation of peak demand. For the industry's two main products--motor gasoline and distillate fuel oil --the build-up to peak inventories usually occurs each year at the end of March and October, respectively. The capability of the refining industry to shift product yields is somewhat limited, and heavy seasonal drawdowns of inventories are required to meet peak demands. In addition, the capacity of the various segments of the distribution system is fixed and cannot be expanded to a point where product can be made available during peak consumption periods at rates adequate to meet demand during those periods. For example, enough heating oil must be transported and stored in the summer to offset the shortfall between refinery output, distribution system capabilities and consumer demands during the winter. Details of seasonal *minimum operating levels* for crude and products are arrayed on Table 2.

The Trans-Alaskan pipeline system, now under construction, shows the concept of tankage capacity, total stocks, *unavailable* stocks and *minimum operating* inventories. This system will include a single 48-inch pipeline, 800 miles long, with a line fill of 9 million barrels and a single receiving terminal at Valdez having approximately 10 million barrels of tank capacity. (For simplicity, the following discussion does not include gathering and other facilities in North Alaska.)

The tanks at the Valdez terminal will average approximately half full. The 5 million barrels of normal working stocks in the tanks allow the pipeline to continue full deliveries into storage whether or not tankers are loading oil. Likewise, these working stocks permit tankers to be loaded at a rate greater than the pipeline delivery rate. This working storage provides flexibility by having both *room in tanks* and *oil in tanks* for meshing two independent operations into a single efficient system.

As illustrated in Figure 2, provision has been made for maintaining *minimum operating* inventories below the normal drawdown levels. Should the pipeline operation be interrupted for any reason, tankers arriving on normal schedule could continue loading while the pipeline is being brought back into operation. Conversely, the reserve tank capacity above the normal working range would allow the pipeline to continue deliveries in the event of a severe storm in the Gulf of Alaska which might delay arrival of tankers.

Below the *minimum operating* inventories are tank bottoms which together with pipeline fill make up the *unavailable* stock which normally cannot be removed from the system. For the above example, the total inventory that would be reported to the Bureau of Mines would vary with the normal operating cycle and would range from 11.5 million to 16.5 million barrels or, on average, about 14 million barrels. Stocks typically reported as *unavailable* would be the pipeline fill and tank bottoms (9.5 million barrels) which would account for 68 percent of the total inventory. The additional 2

TABLE 2
CURRENT MINIMUM OPERATING INVENTORIES
(Millions of Barrels)

| | Total Inventory Reported to Bureau of Mines 9/30/73 (1) | Unavailable Inventory Reported to NPC 9/30/73 (2) | Minimum Operating Inventory (3) | Additional Inventory to Meet Seasonal Needs (4) (Percent of (3)) |
|---|---|---|---|---|
| Crude Oil* | | | | |
| Districts I-IV | 205 | 139 | 205 | Nil |
| District V | 36 | 16 | 35 | Nil |
| Total† | 241 | 155 | 240 | |
| Products | | | | |
| Gasolines (Including Avgas) | | | | |
| Districts I-IV | 189 | 68 | 180 | 10% |
| District V | 25 | 8 | 20 | 25% |
| Total† | 214 | 74 | 200 | |
| Kerosine/Kero Jet | | | | |
| Districts I-IV | 37 | 11 | 30 | 30% |
| District V | 6 | 2 | 5 | Nil |
| Total† | 43 | 13 | 35 | |
| Naphtha Jet Fuel | | | | |
| Districts I-IV | 3 | 1 | 4 | –‡ |
| District V | 2 | 1 | 1 | –‡ |
| Total† | 5 | 1 | 5 | –‡ |
| Distillate Fuel Oil | | | | |
| Districts I-IV | 186 | 34 | 90 | 120% |
| District V | 13 | 3 | 10 | Nil |
| Total† | 199 | 37 | 100 | |
| Residual Fuel Oil | | | | |
| Districts I-IV | 48 | 9 | 36 | Nil |
| District V | 13 | 3 | 14 | Nil |
| Total† | 62 | 11 | 50 | |

* Includes producers' lease stocks.

† Totals may not add due to rounding.

‡ Specific seasonal build-up levels are not shown for naphtha-type jet fuels. These are produced by blending certain components in the gasoline boiling range with components in the kerosine boiling range and seasonal fluctuations can be covered by inventories of these other products.

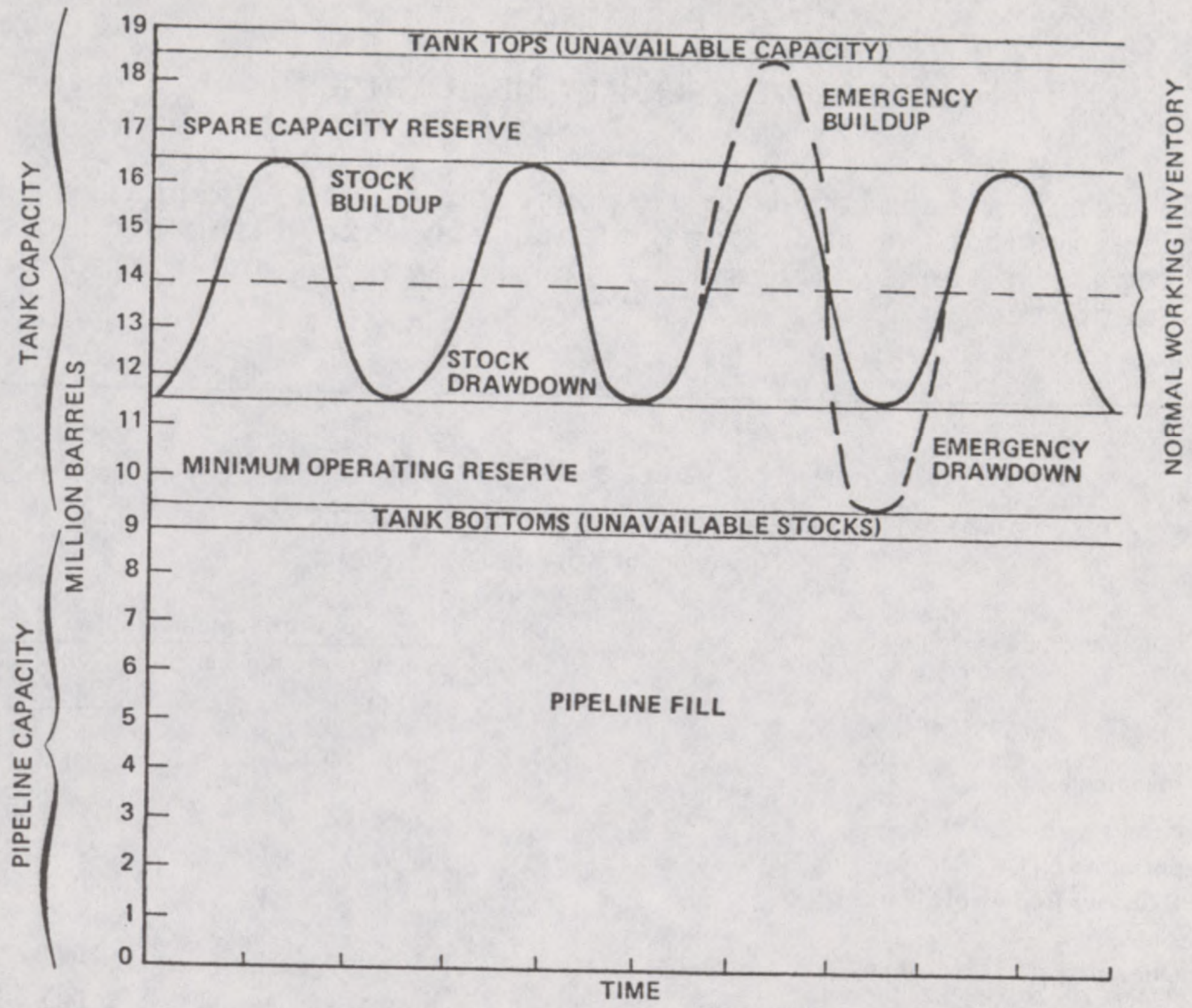



Figure 2. Illustrative Operating Conditions Trans-Alaska Pipeline.

million barrels for minimum working reserve would increase the total *minimum operating* inventories to about 82 percent of the total inventory.

The inventory components of the above example are existent in all of the Nation's distribution systems. Where multiple facilities are serving differing regional demands, each facility has a unique and independent operating cycle. While any single facility, or several facilities concentrated within a particular region, may periodically achieve a *minimum operating level*, all facilities in an overall system cannot in the course of normal operations reach a *minimum operating level* at the same time. The regional or spot shortages that have occurred in the past reflect conditions where inventories were depleted to or below this overall minimum. For the industry as a whole, with some facilities operating well above minimum levels and others at or near minimum, total inventory levels approach the mid-point of the normal working range. It is this averaging effect that lifts the *minimum operating level* for the industry far above the sum of the *minimum operating levels* of the individual facilities. Thus, the above example of an individual facility has a *minimum operating level* of only about 82 percent of the total inventory while the industry as a whole is calculated to have had a *minimum operating level* of about 99.5 percent of total crude oil inventories reported in September 30, 1973. The example illustrates how the use of total inventory data can create misconceptions relative to quantities of petroleum readily available foruse.

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# PART TWO

## CRUDE OIL--SUMMARY OF FINDINGS

The returns submitted in response to the questionnaire on crude oil inventories and storage capacity (excluding producer's lease stocks in tanks) are summarized in Table 3 and compared with results reported in 1969.

TABLE 3

SUMMARY OF INVENTORIES AND STORAGE CAPACITY*
(Thousands of Barrels)

| | As of September 30 | |
|---|---|---|
| | 1969 | 1973 |
| Total Inventories | | |
| Reported by Bureau of Mines | 245,912 | 228,280 |
| Reported to NPC | 240,341 | 221,859 |
| NPC Survey Represents (Percent) | 97.7 | 97.2 |
| Total Unavailable | 165,989 | 154,822 |
| As Percent of Inventories Reported to NPC | 69.1 | 69.8 |
| Working Stocks and Available Inventories | 74,352 | 67,037 |
| As Percent of Inventories Reported to NPC | 30.9 | 30.2 |
| Storage Capacity† | 370,326 | 386,713 |
| Amount in Tanks‡ | 174,526 | 161,642 |
| Percent Full | 47.1 | 41.8 |
| Inventories of Foreign Origin§ | | |
| In Bonded Storage | —¶ | — |
| In Transit | —¶ | 35,369 |

* For the purpose of this survey producers' lease stocks were excluded as they were considered as completely unavailable.

† Includes earthen and/or concrete reservoir storage capacity.

‡ Total crude oil inventories excluding producers' lease stock in transit and pipeline fill.

§ Inventories not reported to Bureau of Mines and not included in other categories listed.

¶ Not available; excluded from survey in 1969.

This is the eighth analysis of industry inventories conducted by the National Petroleum Council during the last 25 years. The data from this and the previous seven analyses are shown in Table 4. A comparison with previous results discloses several significant trends.

- Although refinery runs have increased greatly over this period, total crude inventories have not varied significantly. This indicates that refining and transportation functions have become more efficient over the years. Total crude oil inventories reported as of September 30, 1973, were 222 million barrels as contrasted with 240 million barrels as of September 30, 1969, and 218 million barrels as of September 30, 1962. This represents an 8-percent decrease in total inventories since 1969 and a 2-percent increase since 1962.

- *Unavailable* crude oil inventories since 1948 have expectedly increased as refinery capacity has increased; and unavailable pipeline fill has increased with the construction of new or expanded crude oil pipelines to supply refineries. The decrease in *unavailable* inventory in 1973 reflects no significant increase in crude oil trunklines and is possibly due to the retirement of some gathering systems as domestic crude oil production peaked.

- The *minimum operating* inventory for crude oil, as indicated in Table 2, is considered to be 240 million barrels without any need for seasonal build-up.

- For the first time in this survey, crude oil from foreign origins, which is still in transit or has not yet cleared customs, is reported as a separate item. This total, as of September 30, 1973, was 35 million barrels.

Table 5 shows responses from the questionnaire broken down by PAD districts.

TABLE 4

ANALYSIS OF CRUDE OIL INVENTORIES AS REPORTED TO NPC*

(Thousands of Barrels)

| | March 31 1948 | June 30 1950 | March 31 1952 | March 31 1954 | March 31 1957 | Sept. 30 1962 | Sept. 30 1969 | Sept. 30 1973 |
|---|---|---|---|---|---|---|---|---|
| Total Inventories Held by Reporting Companies | 213,224 | 224,948 | 238,413 | 243,692 | 225,516 | 217,626 | 240,341 | 221,859 |
| Unavailable Inventories | | | | | | | | |
| Tank Bottoms & Refineries Operating Requirements† | 34,067 | 38,031 | 39,364 | 41,423 | 41,277 | 41,431 | 44,701 | 43,595 |
| Pipeline Fill | 30,579 | 36,618 | 41,028 | 44,341 | 47,036 | 51,722 | 60,311 | 57,141 |
| Other Unavailable | 68,279 | 67,790 | 70,514 | 80,884 | 69,269 | 66,254 | 60,977 | 54,086 |
| **Total Unavailable Inventories** | **132,925** | **142,439** | **150,906** | **166,648** | **157,582** | **159,407** | **165,989** | **154,822** |
| Unavailable as Percent of Total Reported to NPC | 62.3 | 63.3 | 63.3 | 68.4 | 69.9 | 73.2 | 69.1 | 69.8 |
| **Working Stocks and Available Inventories** | **80,299** | **82,509** | **87,507** | **77,044** | **67,934** | **58,219** | **74,352** | **67,037** |

* Excluding producers' lease stocks and cargoes in transit from foreign countries.

† Contents of tank bottoms, in refinery pipelines and minimum quantity required to assure continuous processing, handling and blending various grades of crude oil.

TABLE 5

ANALYSIS OF CRUDE OIL INVENTORIES
AND STORAGE CAPACITY BY PAD DISTRICTS*
(Thousands of Barrels)

| | As of September 30, 1973 | | | | | |
|---|---|---|---|---|---|---|
| | PAD District I | PAD District II | PAD District III | PAD District IV | PAD District V | TOTAL U.S. |
| 1. Total Inventories Reported by Bureau of Mines† | | | | | | |
| (a) 1969 | 18,147 | 73,586 | 105,208 | 10,730 | 38,241 | 245,912 |
| (b) 1973 | 14,610 | 67,868 | 99,958 | 11,414 | 34,430 | 228,280 |
| 2. Total Inventories Reported to NPC† | | | | | | |
| (a) 1969 | 18,011 | 72,189 | 103,851 | 10,323 | 35,967 | 240,341 |
| (b) As percent of 1(a) | 99.3 | 98.1 | 98.7 | 96.2 | 94.1 | 97.7 |
| (c) 1973 | 13,485 | 65,042 | 99,297 | 11,581 | 32,454 | 221,859 |
| (d) As percent of 1(b) | 92.3 | 95.8 | 99.3 | 101.4 | 94.3 | 97.2 |
| 3. Unavailable Portion of Inventories Reported to NPC† | | | | | | |
| (a) 1969 | 13,823 | 51,111 | 74,101 | 7,711 | 19,243 | 165,989 |
| (b) As percent of 2(a) | 76.7 | 70.8 | 71.4 | 74.7 | 53.5 | 69.1 |
| (c) 1973 | 10,838 | 49,556 | 70,250 | 8,061 | 16,117 | 154,822 |
| (d) As percent of 2(c) | 80.4 | 76.2 | 70.7 | 69.6 | 49.7 | 69.8 |
| 4. Storage Capacity Reported to NPC | | | | | | |
| (a) 1969 | 24,906 | 96,414 | 159,772 | 20,281 | 68,953‡ | 370,326 |
| (b) 1973 | 28,317 | 102,048 | 176,643 | 19,765 | 59,940‡ | 386,713 |
| 5. Amount in Tanks § | | | | | | |
| (a) 1969 | 14,133 | 48,726 | 72,817 | 6,437 | 32,413 | 174,526 |
| (b) 1973 | 12,136 | 41,536 | 72,388 | 7,429 | 28,153 | 161,642 |
| 6. Percent of Tankage Filled | | | | | | |
| (a) 1969 | 56.7 | 50.5 | 45.6 | 31.7 | 47.0 | 47.1 |
| (b) 1973 | 42.9 | 40.7 | 41.0 | 37.6 | 47.0 | 41.8 |

* See map of PAD Districts (Figure 1).

† This includes inventories at refineries in pipeline and tank farms and in transit thereto.

‡ Includes earthen and/or concrete reservoir storage capacity.

§ Total crude stocks excluding producers' lease stocks in transit and pipeline fill.

IV. Emergency Energy Capacity: An Interim Report by the Department of the Treasury, Office of Energy and Natural Resources

# EMERGENCY ENERGY CAPACITY: AN INTERIM REPORT

BY

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## PREFACE

The recent transition of the U.S. from a position of energy self-sufficiency to the status of a major energy importer has created a concern for the security of oil imports from countries that have the political motivation and economic means to maintain a sustained curtailment of our oil supply. This study is an evaluation of our ability to deal with potential import disruptions, and of programs that could minimize the consequences of such disruptions. Our final report will be available in the spring of 1974. However, we feel that the findings and recommendations we have developed thus far are sufficiently substantive to warrant publication of this interim report. In most cases, we have omitted the analytical bases of quantitative findings from the interim report. Our analyses are essentially finished but complete documentation, which will appear in the final report, will take time to prepare. Consequently, the interim report should be considered only a presentation of results, rather than a completely self-contained analysis. We hope these results will provide a stimulus for fruitful discussion of this complex issue and for favorable consideration of our recommendations.

# CHAPTER I

## INTRODUCTION

Until 1967, the United States maintained a sufficient petroleum reserve, in the form of shut-in crude oil production capacity, to offset any potential loss of oil imports. At the present time, however, domestic production is declining, imports are soaring, and the U.S. is today without a major oil production reserve cushion to fall back on during an emergency. Figure 1 illustrates the disappearance of our shut-in reserve and the potential rapid increase in imports if past trends continue.1/

The bulk of our increasing oil imports must come from a few Persian Gulf, primarily Arab, producers. This situation has created the following problems, among others:

1. The concentration of oil reserves for meeting rising world demand in the hands of a few producers, notably Saudi Arabia, gives these producers, both as a group and as individuals, monopolistic control over price and availability of a major energy source.

2. This control creates political leverage over the U.S., and other importers, which in turn creates public pressure within the producing countries and peer pressure from other Arab nations to exercise that leverage to obtain a settlement of Arab-Israeli disputes.

3. The sudden transition to importing much of our incremental petroleum demand from undeveloped Arab countries with relatively small populations will cause a surge in our balance-of-payments deficit, and an accumulation of dollar reserves in countries that cannot absorb the dollars themselves and are not currently finding adequate investment outlets. These accumulating reserves:

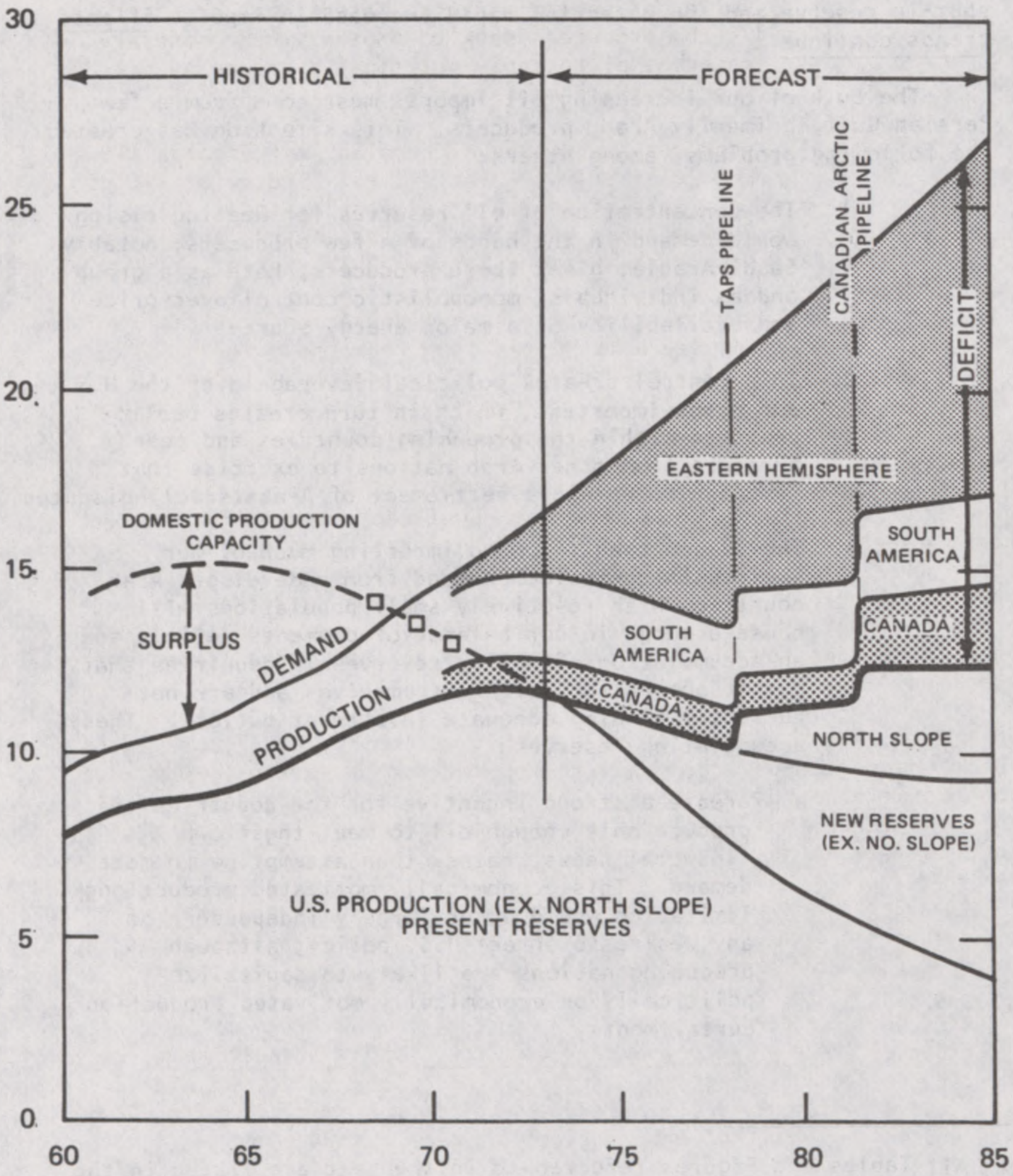
   a. create a strong incentive for the countries to produce only enough oil to meet their own financial needs, rather than attempting to meet demand. This economically motivated production limitation would occur largely independent of any desire to affect U.S. policy, although producing nations are likely to capitalize politically on economically motivated production curtailments;

---

1/ All Tables and Figures referred to in the text are listed in the Table of Contents.

**FIGURE 1**

**U.S. PETROLEUM LIQUIDS**
**SUPPLY AND DEMAND FORECAST**
**(CONTINUATION OF PRESENT TRENDS)**
**1973 - 1985**



b. enable some producers, without reducing spending, to forego oil production for a year or more, or to freeze production at current levels for as long as they wish, to create political pressure on the U.S.;

c. create the potential for major disruptions of dollar or equity markets, intentional or otherwise, as the producers seek to protect their monetary reserves or to apply political pressure by disrupting these markets.

4. The enormous quantities of Persian Gulf exports flow through relatively few facilities. These facilities present inviting sabotage targets for local liberation-front guerrillas or saboteurs, or military targets in a war among Persian Gulf states.

5. Finally, massive petroleum importation requires a long, vulnerable supply line from the Persian Gulf and Africa to the U.S. This implies a threat to supply continuity by overt military attack, sabotage, blackmail, or accidents of nature.

A severe supply disruption in the late 1970's or early 1980's could, if imports are similar to the magnitude shown on Figure 1, cause a major economic depression. Severe rationing would be required, and there would be shortages of fuel for industry, resulting in declining industrial output, increasing unemployment and a rapid decline in gross national product. Such economic disturbances would be likely to lead to demands for military intervention to obtain the needed energy supplies.

This threat to our future economic wellbeing, and future world peace, necessitates action now to prevent such a serious dependence upon foreign petroleum supplies, or to mitigate the consequences of any dependency that does develop. There are four classes of action that can be taken:

1. Actions to reduce demand for petroleum products, such as energy conservation measures, elimination of waste, or the substitution of plentiful domestic fuels such as coal.

2. Actions to increase domestic supply of petroleum, such as stimulating drilling, increasing use of improved oil recovery methods, or opening up new lands for exploration.

3. Actions to provide investment outlets for Arab income to encourage increased production and reduce their potential for bringing monetary pressure to bear on the U.S.

4. Actions to create a standby reserve, such as emergency storage capacity, or a shut-in production reserve, to serve as a buffer to minimize the effects of a major supply disruption.

This study is oriented primarily toward the last type of action.

The limitation of the scope of this study to emergency capacity does not by any means indicate a belief that other actions to reduce dependence on foreign supplies are less important than actions to create emergency capacity. Neither do we believe that the problems emergency capacity can deal with are by any means the most serious problems created by heavy reliance on oil imports. On the contrary, as the study has progressed, we have become increasingly convinced that the other actions are far more important, and that the U.S. would be unwise to rely upon a standby reserve or other emergency capacity as a major element in its energy and foreign policies. At best, standby reserves should be considered as a poor and expensive form of insurance that would allow us a brief time to make adjustments in an emergency. As a weapon to combat a wilful denial of oil for political or economic purposes, any attainable level of emergency capacity is pitifully inadequate.

Our projections, however, indicate that emergency capacity may be useful for certain kinds of import interruptions. Further, there have been a number of proposals in Congress that have suggested a security reserve program as a major element in a U.S. energy policy. Consequently, this study was undertaken to determine the costs of a standby security reserve program, the logistical problems that might result from such a program, and to evaluate existing emergency capacity, including emergency conservation, gasoline rationing, and excess working inventories. The questions we attempted to answer other than determining the cost of a standby reserve were quite simple. We wanted to know (1) where, (2) what kind, (3) how much, and (4) when standby security reserves should be built to deal with various possible supply cutoffs.

We hope that this study will clarify some of the complexities involved and provide sufficient information to allow policy-makers to make intelligent decisions concerning the cost and value of standby energy reserves.

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# CHAPTER II- PART 1

## FINDINGS

1. Potential Disruptions.

There are circumstances which could result in a denial of a portion of our oil imports from Mideast/North Africa producing countries for as long as a year. Some of these possibilities are as follows:

- An Arab-Israeli war (total cutoff of all Arab exports to the U.S. for an indefinite time, currently about 2 MM B/D. 1/).
- A decision by major Arab producers to limit or eliminate increases in production.
- A politically motivated cutoff or curtailment, not in a war situation.
- The destruction of producing, pipeline, or docking facilities during a war among Arab states.
- A price negotiation confrontation between OPEC countries and consuming countries.

2. Lack of Readiness.

Although the U.S. has considerable capacity to absorb near-term import disruptions, there is a glaring deficiency in planning, readiness, and legal authorization for emergency measures. To make best use of existing capacity, we need rapid implementation of emergency measures. Consequently, a high degree of readiness is quite important.

---

1/ This figure includes direct crude oil imports, imported products refined from Arab oil, and some Canadian imports that could be indirectly affected.

3. Existing Emergency Capacity.

Our existing emergency capacity to reduce the need for oil imports without severe economic damage is approximately as follows, in equivalent thousands of barrels per day (M B/D):

| | Equivalent oil savings, 1000 BBLS/DAY |
|---|---|
| Gasoline, diesel, and jet fuel Rationing [a] | 2500 |
| Emergency Conservation [b] excluding transportation fuels | 400 |
| Increased Oil [c] Production from existing fields | 300 |
| Electric Generating Plant [d] conversion to coal, and increased use of coal where currently used | 500 |
| Drawdown of existing [e] inventories | |
| 90 days | 2400 |
| 180 days | 1200 |
| 360 days | 600 |

---

a Strictly speaking, methods of reducing demand would not be considered as "capacity". In this report, we will consider all emergency measures which could be used to offset foreign supply disruptions as "emergency capacity," including procedures to reduce demand.

b Adjusted for expected compliance. This is a highly conservative estimate.

c Extensive physical and legal preparations are necessary.

d Environmental variance required for most plants.

e One half of existing stocks, excluding working stocks and seasonal stocks. This would result in sporadic local shortages and, unless excess refinery capacity is available, requires an extension of conservation and rationing beyond the end of the cutoff to allow restoration of normal inventory levels. Price controls are required to avoid withholding of inventories in anticipation of higher profits as prices rise due to shortages.

4. Future Emergency Capacity if No Storage is Developed.

Savings from the above emergency capacity measures will increase somewhat in the future. However, imports will increase much faster. The approximate relationship is shown in Figures 3 and 4.

5. Cost of New Storage Capacity.

Excluding the cost of standby transportation facilities, and of crude oil or refined products for storage, the estimated cost to construct facilities for emergency storage is:

| | Cost |
|---|---|
| Salt dome caverns | $.50 - 1.00 /BBL |
| Steel tanks | $3.00 - 5.00 /BBL 2/ |

Salt dome capacity is practically unlimited but is available only in the Gulf Coast area. Steel tanks are more expensive, take up much more land surface, but can be put almost anywhere. Oil for storage, if available, would probably cost at least $6 -$7/BBL. Assuming a mid-range projection for 1980 of imports of 10 million B/D, a 90-day storage reserve would cost about $6 billion initially, plus an additional $0.6 billion/year for more storage to account for import increases of perhaps 1 million B/D per year beyond 1980.

Construction of new storage capacity would be inflationary because such a program is a non-productive use of resources.

6. Other New Measures.

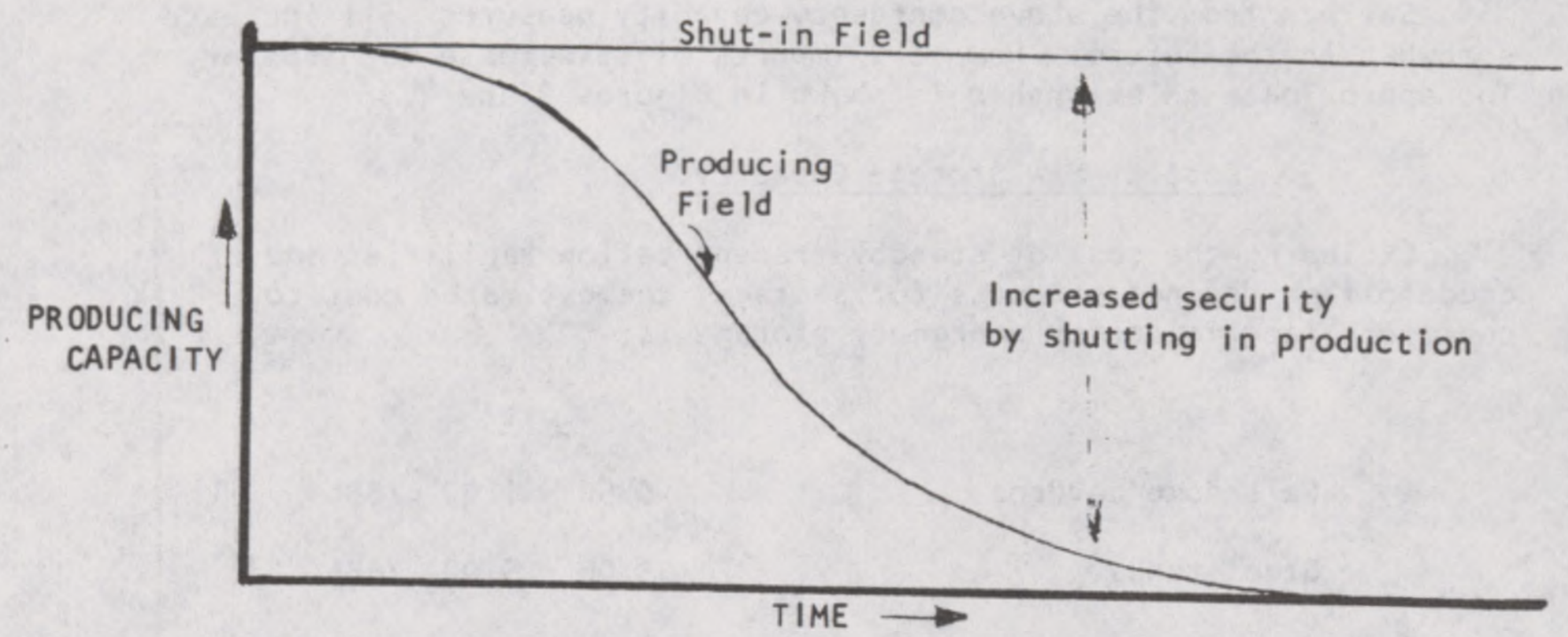
All alternatives to storage are either much more expensive or have highly limited potential. For example, standby emergency coal burning facilities in new oil-fired electric generating plants would be economically justifiable only if a cutoff of 1½ - 2 years or more is expected.

7. Shut-in Production Capacity.

Unless we are planning for a supply disruption of two years or more, ten or more years in the future, shut-in production capacity will be appreciably more expensive as an emergency reserve than crude oil storage. Since we are now deficient in crude oil, any production restriction will require increased imports to offset the shut-in production. Our net deficit will not change by shutting in production. However, the production capacity of shut-in fields will not decline, as it would if they were produced, unless the field is in waterflood or other secondary recovery (as are most U.S. fields). Hence there will be a delayed security benefit with time, as illustrated here.

---

2/ Based on present construction costs. A large scale program could well result in shortages of steel plate, labor, and construction equipment, perhaps materially increasing costs.




In addition to the delayed benefit, shut-in production costs are more on a barrel for barrel basis than a crude oil storage reserve, unless a two or three year supply is desired. Shutting in oil production will also reduce associated gas production, exacerbating the present gas shortage

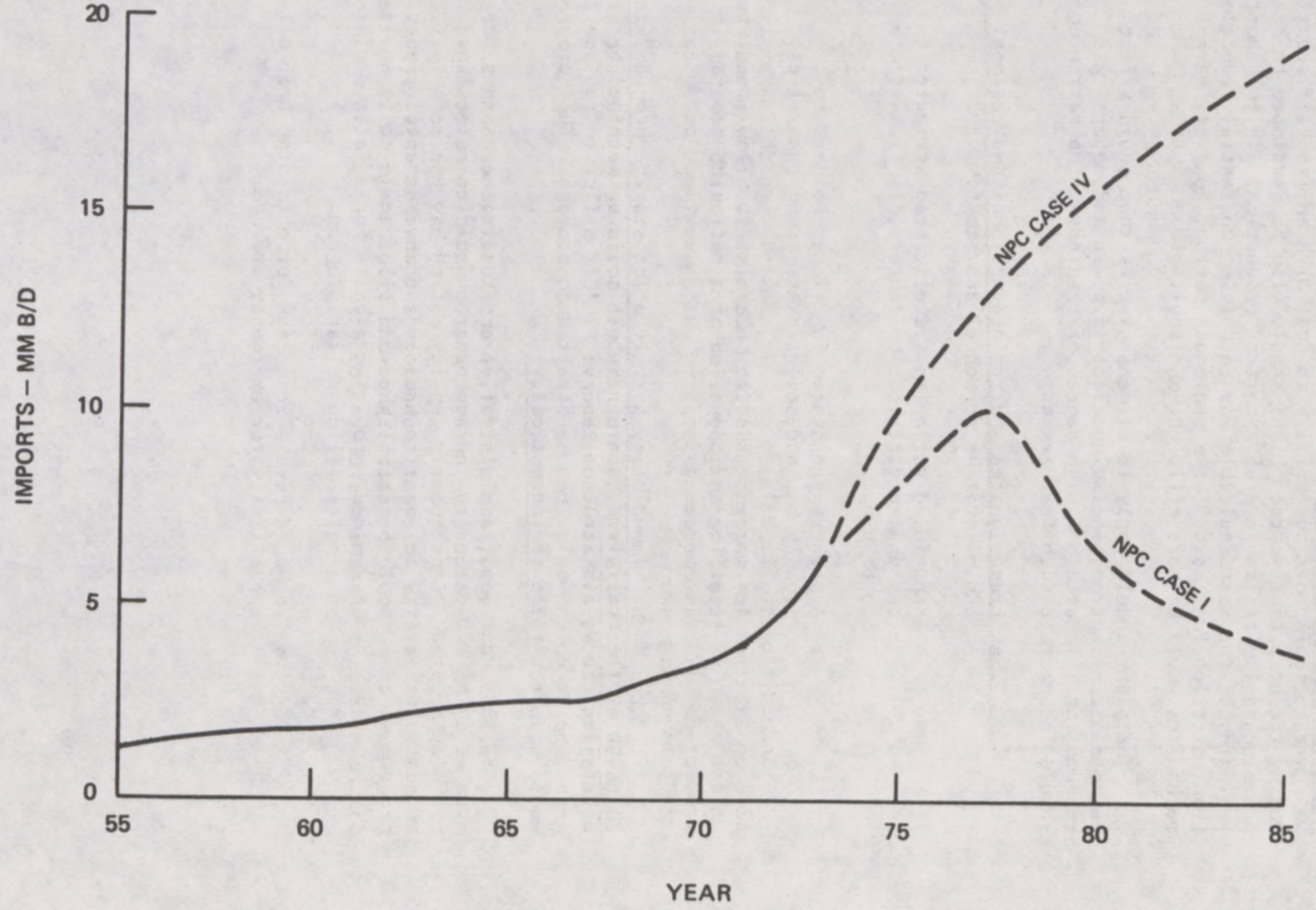
Due to the controversy surrounding this issue, we have prepared a detailed study, available on request.

8. Effect of Energy Policy.

By 1985, our imports could vary from as little as 4 MM B/D to as much as 20 MM B/D depending in large part on the federal energy policies adopted. Consequently, energy policy has far more influence on our vulnerability to import disruptions than does any storage program we could hope to establish beyond 1980. Figure 2 shows the possible range of future petroleum imports.

**FIGURE 2**

**U.S. PETROLEUM IMPORTS**



# CHAPTER II - PART 2

## RECOMMENDATIONS

1. Develop effective rationing and emergency conservation readiness programs designed for immediate implementation in the event of an oil import disruption. This is the single most effective action we can take to improve our ability to deal with an import disruption during the next five years. Plans should also be developed to deal with a prolonged limitation in Arab exporters' production. In the short run, rationing is the most equitable way to obtain substantial reductions in transportation fuel use. For a prolonged period, however, market mechanisms would be more efficient and equitable.

The plans should apply to all energy uses that could affect petroleum consumption, including electric power and natural gas consumption. To attain a high degree of readiness, the rationing plan should incorporate such features as:

- Predesignated and trained national and regional administrative personnel and staff.
- Preprinted rationing tickets, predistributed to designated distribution centers, if tickets are to be used.
- A prearranged system for ticket-holders to legally buy and sell tickets among themselves.
- An emergency funding mechanism to allow immediate staffing and operation of a rationing program in an emergency.

2. Begin immediately a small pilot storage program, say 20 to 50 million barrels. Much of the oil could be obtained by development of Naval Petroleum Reserve #1 (Elk Hills) to replace some Arab imports which would then be diverted to storage. This program would have the following advantages:

- Legal, administrative and funding mechanisms for a security storage program would be established.
- The relevant technology and environmental impact would be established and pilot-scale costs would be determined, providing a basis for a later decision on a multibillion dollar program.
- We would have a test case for obtaining Arab oil specifically for emergency storage.

- If Elk Hills were developed, we would have its production available for use in an emergency.

- A small storage reserve would provide some protection or deterrent against relatively small, short-term cutoffs. These might result from token actions by a smaller producer, small-scale sabotage, tanker accidents or natural disasters.

3. Establish now a unified emergency capacity organization to coordinate and administer the pilot emergency storage program and develop emergency plans for conservation, rationing, and use of emergency storage. None of the emergency measures will be fully utilized unless there is a balanced program with a prearranged strategy for using each measure. Emergency plans developed by this group should take into account the economic impact of each strategy, allowing for variations in different population segments and in geography.

A single organization (possibly a separate division or department in an existing agency, or a new agency) should be created to carry out the following functions:

- Start a pilot storage program, including creation of salt dome storage caverns, development of Elk Hills (Naval Petroleum Reserve #1), marketing of Elk Hills production, and purchase of Persian Gulf oil for storage.

- Develop time-staged, coordinated, emergency plans for drawdown and distribution of emergency storage, conservation, rationing, and other emergency measures. Plans must be designed to minimize adverse social and economic impacts and to be adjustable to various types of emergencies.

- Coordinate plans with any crude oil or petroleum product allocation programs that may exist, or develop such standby programs if necessary.

4. Begin immediately a long-term, intensive effort to reduce energy imports. This effort should at least include:

- A strong domestic demand reduction program through
  - rational energy pricing;
  - legal restrictions on inefficient energy use where market forces are ineffective in encouraging efficiency (big cars, commercial buildings, etc.);
  - strong conservation campaign to build consumer awareness.
- Maximum stimulation of domestic supply by
  - rational energy pricing;
  - modification of federal policies to accelerate domestic exploration and development of domestic fossil fuel resources to the maximum rate consistent with long-term environmental and coal mine health and safety policies (notably oil leasing and surface coal mining policies);
  - acceleration of research into alternate energy forms (nearly-commercial solar energy systems could be an important source by 1985), especially coal mining and coal use (mine health and safety technology, strip mine reclamation, coal gasification and liquefaction).

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# CHAPTER III

## SCOPE AND METHODOLOGY

The main purpose of our study is to determine our existing emergency capacity and to evaluate the costs and benefits of establishing additional emergency capacity. We have developed energy supply and demand projections, adapted from a National Petroleum Council (NPC) study 1/, for the years 1975, 1980, and 1985 to provide a framework for our analysis. We have used high (NPC Case IV), intermediate, and low (NPC Case I) demand projections to study emergency capacity over a range of future possibilities.

We first attempted to catalog the magnitude, duration and relative likelihood of the more worrisome potential petroleum import disruptions. Emergency capacity measures available to us today (including conservation, rationing, and excess working inventories) were then evaluated for potential emergency petroleum demand reduction. Problems associated with their use, and institutional and legal arrangements required to put them into effect were analyzed. The effectiveness of these measures was then analyzed in a computer model. The model determines the supply short-fall (or additional emergency capacity required) for various potential disruptions, for different regions of the U.S. Logistical problems and emergency refinery utilization were also examined with the model.

We have also evaluated the cost of storage and other potential measures for increasing emergency capacity. We have pointed out some of the problems in developing additional emergency capacity, and have evaluated some financing and administrative alternatives. Finally, we have made recommendations based on these analyses. This interim report, of necessity, treats some of these topics briefly. In particular, no model analyses are presented, as these are still in progress.

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1/ U.S. Energy Outlook, National Petroleum Council, December 1972

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# CHAPTER IV

## NATURE OF THE PROBLEM

### EMERGENCY CAPACITY IN THE CONTEXT OF OVERALL ENERGY POLICY

Decisions to use energy resources, made by private parties acting in what they view as their own best interests, are not always socially desirable. In such situations an active government role is justified to establish a legal framework ensuring that decisions to produce, allocate and use energy are made on a socially rational basis. Unfortunately, past federal energy policies have tended to encourage wasteful and excessive use of energy and to encourage the use of scarce energy resources at the expense of plentiful ones. Our future depencence upon foreign energy sources will depend to a great extent upon energy policies we adopt during the next few years. The possible range of oil imports over the next 10 to 15 years is illustrated in Figure 2. The upper curve (NPC Case IV) assumes a continuation of past policies and trends. The lower curve (NPC Case I) assumes price increases and other governmental policies to encourage increased domestic oil and gas production and use of plentiful coal.

Figures 3 and 4, discussed in detail later, give a rough picture of our existing emergency capacity in light of existing and potential total imports, and imports from oil-rich Arab countries. A vigorous and rational federal energy policy would go far toward alleviating the need for an emergency storage program, as well as providing many other benefits such as reduced balance-of-payments deficits. Conversely, a continuation of existing trends will soon result in massive imports with attendant severe problems. Under such circumstances, if we assume a requirement of, say, 90 days of emergency storage, our emergency storage needs would soon become quite large and cost billions of dollars. Such an emergency storage program would compete for scarce funds with other federal programs. However, with governmental policies that maximize domestic exploration and production, use of plentiful fuels, and conservation, our needs for emergency capacity become quite modest. The impact of overall federal energy policy on the need for emergency storage cannot be overemphasized.

An illuminating comparison can be made between the costs of establishing a 90-day emergency storage reserve in 1980 (buildup of a reserve could not be started before 1975)[1] for the two import demand cases shown in Figure 2, with and without assuming that our existing emergency capacity (discussed below) would be used to reduce the need for storage. Assuming $ .60/BBL to construct storage cavities and $6.00/BBL oil to fill them, (these costs are discussed later in detail), the costs of the four cases are shown in Table I. The costs range from zero to 9.5 billion dollars, or almost 2 $billion/year between 1975 and 1980, dramatically illustrating the potential effect of government energy policy on the need for, and cost of, emergency storage. Significantly, NPC Case I does <u>not</u> include the effect of long-term energy conservation measures which, if implemented now, could result in a demand reduction of two million B/D or more, by 1980.

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[1] This could be as late as 1977 because of the requirement for an environmenal impact statement.

TABLE 1

COSTS OF 90-DAYS OF STORAGE RESERVES IN 1980

| NPC Case | Imports, MB/D | Cost ($Billion) | |
|---|---|---|---|
| | | Use Existing Emergency Capacity | Do Not Use Existing Emergency Capacity |
| I | 7 | 0 | 4.2 |
| IV | 16 | 5.3 | 9.5 |

Clearly, we need a fundamental commitment to reduce our dependence on imported energy, especially:

1. Actions to reduce demand for petroleum products, such as energy conservation measures, elimination of waste, or the substitution of plentiful domestic coal.

2. Actions to increase domestic supply of petroleum, such as stimulating drilling, increased use of improved oil recovery methods, and opening up new lands for exploration.

We could list many specific recommendations for these and other measures. However, this is not the purpose of our study. Nevertheless, because the impact of these policies on the need for emergency capacity is so immense, we feel compelled to at least point to the need for such action.

## RISKS TO CONTINUITY OF SUPPLY OF IMPORTS

The following circumstances have combined to make oil importers vulnerable to actions by major Arab producers:

- A few producing nations, primarily Arab, control most of the existing and potential incremental world oil production, in an extremely tight market.

- These nations have relatively small populations and undeveloped economies. Consequently, their massive revenues from oil imports are piling up as monetary reserves. These reserves create a capability to launch political action, and a strong economic incentive to restrict production increases, independent of political motives.

- The near-term potential for alternative or substitute energy sources is severely limited for importers.

- The Arabs have a political objective, namely, settlement of territorial disputes with Israel, that they believe can be achieved through pressure by the oil importing nations.

All the above conditions apply to only a small number of countries (Saudi Arabia, Libya, Kuwait, Qatar,and the U. A. E.) on whom concern is focused. For most other producing countries, revenue from oil exports is too important to their economies for them to sustain substantial income reductions as a consequence of an intentional, politically motivated cutoff or production limitation.

Another possible cause of import disruptions is the destruction of petroleum facilities by politically motivated saboteurs, or in the course of local warfare among Mideast Nations, not necessarily involving Israel. In this case, all producers are subject to disruptions. A further danger here is that a producer might capitalize on sabotage of his facilities by intentionally delaying repairs.

A third possibility is the total cessation of Arab exports during an Arab-Israeli war. Otherwise, Israel has little effect on our oil import problems. The major Arab producers have powerful economic incentives to limit production increases. We believe that Arab threats to limit production increases unless the U.S. changes its Israeli policy are primarily an attempt to capitalize politically on restrictions on production increases that would be made in any event.

We shall examine potential temporary supply disruptions and their relative likelihoods so that we can evaluate the effectiveness of various emergency capacity programs. The prospect of an eventual permanent limit on foreign oil availability should be kept in mind, however. What is considered an emergency today will inevitably become a chronic condition in the not-too-distant future; exactly when depends on the producers' willingness to increase production capacity to its ultimate limit. Consequently, any discussion of emergency capacity must be limited to dealing with temporary supply dislocations in the next 15 years or so.

## Intentional Interruptions of Supply

The lack of supply alternatives in the near-term, and the rapidly accumulating monetary reserves of major Arab producers, suggest several scenarios that would have a major impact on our oil supply. Most of these fall into one of two generic classes; intentional cutoffs, and intentional restriction of production increases.

1. Intentional Cutoffs. Most of the major Arab producers now have monetary reserves sufficient to cover current expenditures for a year or more, with production totally shut off. There are no technical limitations on the ability of Mideast and North African producers to totally shut in fields. Shutting in production for a year or so would have no effect on their ultimate recovery.

- Multiple Producing Nations. A total cutoff of production by all major Arab producers would have a drastic impact on U.S., Japanese, and European supply, thus bringing extreme pressure to bear on oil importers.

  However, such an action could be considered an act of war by oil importing nations and might invite armed intervention by its very severity and stated intent. Additionally, internal economic activity in producing countries would be considerably disrupted for both domestic workers and foreign technologists, who must either be paid or go home. Current income would be foregone by producing countries, and current expenditures would have to be met from monetary reserves. Finally, the actual or implied threat of armed intervention would create increasing psychological pressure on the producing countreies to restore production as the importers' situation becomes more desperate.

  In spite of these disadvantages, a total or massive cutoff of supplies from Arab countries would be likely to accompany an Arab-Israeli war. A military stalemate might result in a sustained cutoff or curtailment to pressure importing nations into forcing a settlement on Israel. Such a cutoff could last as long as necessary to bring about a settlement.

- Single Producing Nations. For a single producing country, however, the risk of inviting armed intervention by a total, or partial, cutoff is much lower; the impact on world supply would be much less, and a military response by the affected importing nations would provide other producing countries with justification for cutting off oil from the military agressor. Hence, the incentive for action by a single producing country is higher than for group action. With the current extremely tight world crude market (which is likely to be kept tight by the major incremental producer, Saudi Arabia), the sudden loss of one or two million barrels per day of the world marked could create serious problems for importers. A determined smaller producer with adequate monetary reserves, such as Libya or Kuwait, could by itself bring considerable pressure to bear on importers without inviting armed intervention. For producing countries that have reached peak production, such as Libya and Kuwait, a cutoff now would affect a greater share of the world market than would a cutoff in the future.

2. Intentional Limitation of Production Increases. Mideast producers can freeze production at current levels indefinitely, or arbitrarily limit the production growth rate. This would actually increase their income, because world price would then go up due to a relatively fixed world supply in the face of rapidly growing demand. This would cause mild shortages within months, and severe shortages within one to two years in most importing countries, based on current demand projections. It would not affect ultimate recovery.

On grounds of resource conservation and economic rationality alone, some producing countries have a great incentive to restrict production increases or even to cut back production somewhat. Kuwait has already frozen production and Libya has cut back production for these reasons. These freezes or cutbacks could be implemented by producing countries, which meanwhile might hint that perhaps they could be convinced to "waste" some oil (produce more oil than they need for income to meet current expenditures) if only the U.S. would modify its Israeli policy. However, a return to a rapid production growth is highly unlikely once producing nations have tasted the economic fruits of restricted growth. Growth limitation can hardly be considered an act of war, and is not likely to provoke armed intervention. Although this would not create an immediate supply deficit in the U.S., considerable pressure would develop in a year or two years from a freeze by all producers, or by Saudi Arabia alone, due to relatively limited supply alternatives in the face of rapidly rising demand. Far from sacrificing revenue, net income to producers would actually rise as prices rose with a tightening market. Thus, any producer with a balanced or surplus budget (i.e., most major Arab producers) would not need to draw from his monetary reserves. Further, this action might produce pressure upon the U.S. almost as great as would a cutoff.

3. Ability of Producers to Act Individually. Of course, Arab producing countries cannot be treated as a homogeneous entity. They have many problems and disputes with one another and cannot be guaranteed to act in concert. The threat to security of supply is no less for this, however, because:

- World supply will be so tight for the next five to ten years, at least, that the loss or severe curtailment of production from almost any Mideast or North African producing country would cause serious supply problems for oil importers,

- Saudi Arabia and, to a much lesser extent, a few other individual producing countries can themselves create shortages by freezing production at current levels.

The impact of restricting production increases would be greater if done now than in the future. There are almost no disadvantages to producing countries of freezing production indefinitely at current levels, although this is an effective option primarily for Saudi Arabia. We reemphasize that the economic incentives of higher prices and resource conservation are by themselves sufficient to encourage a freeze of production by producing nations as a group, or by Saudi Arabia alone. Hence, even if a freeze is effected with strong hints by the producing nations that "normal" production increases would be resumed if the U.S. performs certain actions, a resumption of "normal" growth is unlikely once the producing countries have tasted the economic fruits of restricted production. Consequently, we should exert maximum effort to prevent a freeze, since, once done, it will probably never be completely undone.

4. Internal Political Pressure. All major Arab producing nations are governed by ruling families. As their people become wealthier and better educated (many in Western universities), they naturally desire more control over their government. Additionally, as awareness grows within these countries of the ability of these governments to pressure the U.S. into forcing a settlement on Israel, there is increasing public pressure (stimulated by Palestinian and popular liberation-front groups) on the ruling families to use their leverage on U.S. policy. The

ruling families are acutely aware of these pressures and feel increasingly compelled to take actions to maintain their credibility with their public in order to avoid a coup or popular revolution. Any action we can take to publicize our existing emergency capacity, or to extend emergency capacity with additional storage, would reduce that pressure, to the extent it reduces the Arabs' perception of their leverage against us. Quantification and publication of our existing emergency capacity, which is considerable, may in itself constitute a partial deterrent to a politically-motivated cutoff.

Other Causes of Supply Interruptions.

In addition to intentional supply curtailments by producing nations, there are a number of other potential causes of import disruptions. These include sabotage or wartime destruction of production, pipeline, or docking facilities, mechanical accidents (including tankers), and natural disasters. As far as we can determine, these potential disruptions either would have negligible effects on the world market or would have effects similar to some of the potential disruptions discussed previously. Because we are primarily concerned with planning for disruptions of a given magnitude and duration, not with the motives or causes of these disruptions, we shall not further discuss these possibilities.

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# CHAPTER V

## EXISTING EMERGENCY CAPACITY

We have evaluated existing emergency capacity, both to aid in assessing the need for emergency storage and to determine our current ability to cope with an import disruption. Emergency capacity consists primarily of:

- flexibility in production and use of energy;
- use curtailment by emergency conservation and rationing;
- emergency withdrawals of petroleum from storage;
- emergency increase of domestic energy production.

Because a round trip tanker voyage from the U.S. Gulf Coast to the Persian Gulf requires 63 days, there would be roughly a 30 day interval from the time a cut off was implemented until thefull impact was felt in the United States, thereby giving us 30 days to put our emergency measures into effect.

## FLEXIBILITY

Flexibility allows us to make maximum use of whatever energy is available during a disruption. Gasoline rationing is more effective if a refinery can shift some output from gasoline to heating oil. If a power plant can convert temporarily from oil or gas to coal, shortages of oil elsewhere can be partially alleviated, and gas can replace scarce oil for some users who can burn either. Both refiners' flexibility to vary product mix and users' ability to switch fuels are considered in our analyses. We have assumed that flexibility is used to the extent necessary to take the greatest possible advantage of use curtailment and of stocks of fuel available for drawdown in an emergency.

### Fuel Convertibility

One form of flexibility is to substitute domestic coal for imported petroleum. The degree of substitution which can be achieved will be limited by our ability to switch to coal from oil or gas and by our ability to mine and transport additional coal. As a practical matter, our ability to substitute coal for oil and gas during an emergency is essentially limited to the electric utility industry.

A number of electric generating plants have converted from coal to oil or gas in recent years. Many of them retained the capability of switching back to coal, or can regain that capability within a few months. The Federal Power Commission recently completed a survey of power plant convertibility (FPC Form 36). Table 2 summarizes the results of this survey.

TABLE 2

OIL AND GAS SAVINGS DUE TO ELECTRIC
GENERATING PLANT CONVERSION TO COAL, PLUS
INCREASING CAPACITY FACTOR ON COAL-FIRED PLANTS

| PAD District | Savings from Conversion: Oil to Coal MB/D | Savings from Conversion: Gas to Coal MMCF/D | Savings from Conversion: Gas to Coal Equivalent MB/D | Savings from Increased Capacity Factor: MB/D Equivalent | Total, MB/D Equivalent |
|---|---|---|---|---|---|
| I | 505 | 265 | 44 | 54 | 603 |
| II | 37 | 818 | 137 | 37 | 211 |
| III | 0 | 8 | 1 | 0 | 1 |
| IV | 2 | 172 | 29 | 0 | 31 |
| V | 0 | 0 | 0 | 0 | 0 |
| TOTAL | 544 | 1,263 | 211 | 91 | 846 |

NOTES

1. Environmental variances from state emission standards are required because most reconvertible plants must burn high sulfur coal.

2. Achievable oil savings depends on excess coal mine and rail capacity. We have assumed 500,000 MB/D is attainable.

3. Except for PAD I, conversion is 85-100 percent complete in one month. For PAD I conversion is about 60 percent complete in one month and over 80 percent complete in two months.

4. Gas savings are primarily from interruptible gas burned in the summer. Hence, the savings rate for gas would be approximately twice that indicated above in the second and third quarters, and approximately zero in the first and fourth quarters.

5. All conversion data are from a recently completed Federal Power Commission survey (FPC Form 36).

The survey data do not reflect the ability of the coal mining and rail industries to meet a sudden surge in demand that would result from conversion. The best available opinion is that most of the required mining and rail capacity would probably be available. The FPC survey data also do not account for potential equipment shortages if a number of utilities attempt to restore missing coal transportation, loading, storage and handling equipment simultaneously. This could cause the conversion time to be greater than estimated by many companies.

In addition, most of the reconverted plants would have to burn a high-sulfur coal, and an environmental variance would be required. To allow environmental variances during an emergency, however, would require modification of the Clean Air Act by Congress and emergency variances to state emission regulations.

Because of the above factors, the actual conversion is likely to be less than reported to the FPC. For a long-term supply disruption, substitution approaching that reported to the FPC might be possible.

There are many counterbalancing factors affecting future convertibility. We feel that, on balance, future convertibility will not differ materially from the present potential.

Increased Capacity Factors.

Another way for electric utilities to reduce gas and oil consumption is to increase the amount of power generated by coal-fired plants, and back down on generation from oil and gas fired plants. Some coal plants are not now run at maximum output because doing so is either uneconomic, or they are old plants that use high sulfur coal, or they are so located on a power system that the extra output cannot be used. Hence, increasing the capacity factor of coal fired plants in an emergency would require a normally uneconomic mode of operation, or the use of high sulfur coal, or (mostly) both. An estimate of the potential for oil savings is shown in Table 2.

## CONSERVATION AND RATIONING

We feel that there is significant potential for short-term energy use curtailment, without severe damage to the economy, or danger to the health and safety of the public. We certainly do not wish to deemphasize the discomfort, inconvenience, and impact on normal activities accompanying most curtailment measures. However, curtailment does represent about half of our existing capacity. Potential discomfort and inconvenience must be evaluated in light of alternatives discussed later.

Conservation.

The principal conservation measures and amounts of specific curtailments are shown in Table 3. Use of curtailment measures are either voluntary or mandatory (some measures could be either). Our original calculations were based on projections for 1980 and subsequently adjusted for other years examined in the study. The measures shown in Table 3 are categorized as voluntary or mandatory. The voluntary measures are assumed to be either high (35% of target) or low (10% of target) compliance. In our analyses, the figures for the voluntary measures have been adjusted for effects of seasonality, start-up delays, and expected level of compliance. In practice, compliance would certainly depend on the political climate during the emergency. Mandatory measures have been adjusted for start-up delays, exceptions, and other problems. All these factors are taken into account in using these measures in our analyses.The annual average potential savings is currently about 400 M B/D, excluding transportation measures.

Rationing.

Although rationing requires a large, complex, bureaucratic administration, it is the only way to obtain a sudden large reduction in petroleum consumption without creating social chaos. Using a stiff tax, or allowing market prices to rise to allow for shortages would not assure an equitable distribution of limited supply. The equitable and efficient allocation normally associated with a freemarket results only when prices move gradually over time. This allows both suppliers and users time to adjust operations and equipment purchases to changes in price and availability. Such adjustments cannot be made in the limited time available in an emergency. However, if a sustained cutback is anticipated, market prices should gradually be allowed to supplant an initial rationing program as an allocation mechanism.

The figures on gasoline rationing*, which may seem large, were derived from a study done for the Department of Transportation and from independent estimates. We are reasonably confident that this level of rationing is achievable, if somewhat uncomfortable. A major factor is that nearly one-third of gasoline consumption is in recreation and pleasure driving, which should be reducible for short periods.

Our rationing estimates are only for transportation fuels. Other fuels could be rationed. A savings estimate for heating oil would be similar to the savings, shown in Table 3-I, for adjusting thermostates. Undoubtedly, by far the greatest potential is in transportation fuels. We estimate a current potential savings of about 2,500 M B/D.

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* Table 4.

TABLE 3

EMERGENCY CONSERVATION MEASURES
1973 SAVINGS POTENTIAL

NOTE: Potential savings indicated are the theoretical maximum annual average assuming full cooperation for all voluntary measures. The actual savings achieved would probably be 10 to 20 percent of the potential savings.

3-1.Residential

| MEASURE | POTENTIAL ANNUAL AVERAGE SAVINGS, EQUIV. B/D | SEASON WHEN MOST SAVINGS OCCUR | PROBABLE MEANS OF IMPLEMENTATION | PROBABLE DEGREE OF COMPLIANCE |
|---|---|---|---|---|
| A. REDUCE SPACE HEATING | | | | |
| 1. Reset Thermostats 3°, summer and winter, 24 hrs. per day | 550,000 | Winter | Voluntary | Low |
| 2. Insulate Attics of all Existing Homes Lacking Adequate Insulation | 180,000 | Winter | Voluntary | Low |
| 3. Install Plastic Sheet Storm Windows | 60,000 | Winter | Voluntary | Low |
| 4. Service Oil Burning Furnaces | 30,000 | Winter | Mandatory | High |
| 5. Shut Off Furnace Pilots in Summer | 15,000 | Summer | Voluntary | Low |
| B. REDUCE ENERGY USED FOR LIGHTING | | | | |
| 1. Reduce Electricity Used for Lighting (By a variety of measures) | 50,000 | All | Voluntary | Low |
| 2. Shut off Gas Lights | 20,000 | All | Voluntary | Low |
| C. REDUCE ENERGY USED BY APPLIANCES | | | | |
| 1. Stop hot water use in clothes washing | 180,000 | All | Voluntary | Low |
| 2. Stop use of clothes dryers | 100,000 | All | Voluntary | Low |
| 3. Shut off range pilot lights | 40,000 | All | Voluntary | Low |

3-I. Residential (Continued)

| MEASURE | POTENTIAL ANNUAL AVERAGE SAVINGS, EQUIV. B/D | SEASON WHEN MOST SAVINGS OCCUR | PROBABLE MEANS OF IMPLEMENTATION | PROBABLE DEGREE OF COMPLIANCE |
|---|---|---|---|---|
| C. REDUCE ENERGY USED BY APPLIANCES | | | | |
| 4. Wash dishes by hand instead of by dish-washers | 20,000 | All | Voluntary | Low |
| 5. Shut off oven pilots | 20,000 | All | Voluntary | Low |
| **3-II. Commercial** | | | | |
| REDUCE ENERGY CONSUMPTION OF COMMERCIAL BUILDINGS BY 10% | 400,000 | All | Voluntary | High |
| **3-III. Transportation** | | | | |
| A. REDUCE ENERGY CONSUMED IN AUTOMOTIVE USE | | | | |
| 1. Increase by 1 the number of passengers in every commuting auto | 780,000 | All | ** | |
| 2. Check auto tune-ups every 6 months | 140,000 | All | ** | |
| 3. Reduce highway speed of autos, trucks and buses to 50 mph | 250,000 | All | ** | |
| B. INCREASE PASSENGER LOAD FACTOR ON AIRCRAFT TO 65% FROM 50% | 120,000 | All | Mandatory | High |
| **3-IV. Industrial** | | | | |
| REDUCE ENERGY CONSUMPTION 10% IN INDUSTRIAL SECTOR BY A VARIETY OF MEASURES | 1,400,000 | All | Voluntary | Low |

** Mandatory implementation may be possible, but the effects of these measures would probably be attained indirectly by gasoline rationing. See Table 4.

TABLE 4

REDUCTIONS IN TRANSPORTATION PETROLEUM CONSUMPTION OBTAINABLE BY RATIONING

| Measure | Reduction in Trans. Demand (%) for: Gasoline | Jet Fuel | Diesel Fuel |
|---|---|---|---|
| (1) Increase in Load Factors and Modal Shifts to Reduce Fuel Intensiveness | 11.8 | 30.1 | 5.9 |
| (2) Cutback in Recreational and Pleasure Driving of 50% | 19.0 | 0 | 0 |
| (3) Cutback in Personal Driving of 25% | 3.7 | 0 | 0 |
| TOTAL % | 34.5 | 30.1 | 5.9 |
| 1973 | | | |
| Demand, MB/D | 6,800 | 1,100 | 830 |
| Savings, MB/D | 2,350[1/] | 330[2/] | 50 |

1/ Some additional savings could possibly be obtained from mandatory tuneups and reduced speed limits. Because the above estimate is already so large, however, we have chosen not to add on these savings.

2/ Because modal shifts (air freight and air passengers to ground transportation would take time to accomplish, we have used only the savings from increased load factors (120,000 B/D, Table 3-III).

Total Savings From Flexibility And Use Curtailment.

For electric generation plant conversion, conservation and rationing taken together, we feel there is a potential for emergency curtailment on the order of 3 million B/D, today. This is about 9% of energy demand and 18% of petroleum demand. However, careful planning and a high level of readiness are necessary for maximum use of this potential.

## EMERGENCY DRAWDOWN OF EXISTING INVENTORIES

Total Stock Levels.

U.S. stock levels, as reported by the Bureau of Mines, have not varied appreciably for the last 5 years, in spite of increasing demand. During this period, inventory levels have generally been within the following ranges:

| | MM BBLS |
|---|---|
| Crude oil and condensate | 230-280 |
| Refined products | 500-600 |
| Unfinished oils | 90-105 |
| Liquefied gases | 50-105 |

Based on 1972 levels of consumption, the above storage levels represent approximately 20-24 days of crude supply and 40-50 days of refined product supply (including unfinished oils). However, any expression of stock levels in terms of storage volume is misleading because large portions of the crude oil and products in storage cannot be withdrawn and are necessary to make the refining and distribution system work.

The stock levels listed above include pipeline fill, volumes within refinery vessels, refinery storage, and storage at pipeline, marine, and bulk terminals. Stocks held by marketing companies in local distribution terminals, in service stations, and by large industrial users are not included in the statistics.

Maintaining crude oil or product stocks is expensive and ties up capital that could be employed elsewhere. Consequently, it seems reasonable to assume that most companies maintain stocks at minimum levels. If so, how can we assume that we can obtain some supply during an emergency by drawing down stocks?

Need for Stocks.

Stocks maintained by the oil companies can be grouped into three general categories:

- working stocks;
- seasonal stocks;
- buffer stocks.

Working stocks are those required to make the distribution system work. Pipelines must be full at all times. Refinery vessels must always contain some crude oil or products. When a pipeline is used to move more than one product or different crude oils by batching, separate storage at least equal to batch size must be available at each end of the pipeline, for each product transported. For the system to operate efficiently the storage must be approximately half full at all times. For most efficient refinery operation, refiners usually blend crude oils to obtain a uniform feedstock mix. This requires crude oil storage at refineries for various crudes from which a proper mix is blended. In addition, large stocks of unfinished oils are normally kept at refineries for blending and to obtain efficient operation of downstream processing units. Tanks are usually tapped on the side of the tank rather than at the bottom to allow for settling of impurities and sediment. Thus, a portion of the oil in any tank cannot be recovered.

Working stocks, such as those described above, are necessary for efficient operation of the distribution system. Consequently, there is some working level below which stock levels could not be lowered without the distribution system malfunctioning.

A second use of stocks is to meet seasonal, or cyclic, variations in demand. Demand for certain products, such as heating oil, is highly seasonal. It is economically more efficient to run refineries at uniform rates, and store excess products produced during periods of low demand for use during periods of high demand, than it is to build sufficient refinery capacity to meet peak-use demand by refinery runs. Distillate stocks generally vary from a low of about 90-100 million barrels at the end of the heating season to a high of about 180-230 million barrels at the beginning of the heating season. Gasoline stocks usually vary from a low of about 190 million barrels in the fall to a high of 260 million barrels in the spring. Residual fuel oil stocks generally vary from 40 million barrels to about 65 million barrels. However, since a large portion of our residual fuel oil supply is obtained from the Caribbean area, additional volumes of residual fuel oil stocks are undoubtedly maintained in that area that are not reported by the Bureau of Mines.

If the distribution system were perfect, supply and refinery runs were constant, and demand followed a regular cyclic pattern, additional stocks above working level requirements and seasonal storage would not be required. However, our system is imperfect, the weather is unpredictable, and our planning ability is far from perfect. Consequently, large buffer stocks are maintained to allow meeting unusual demands, or to offset imperfections and irregularities in supply and distribution patterns.

As the oil industry's knowledge of its distribution system, and of supply and demand patterns, has increased, buffer stocks have decreased as a percent of demand. Offsetting a reduction in buffer stocks due to increased efficiency, however, will be changing supply-demand relationships and logistic patterns, which may increase the need for additional buffer stocks in the future. For instance, rapidly increasing natural gas curtailments (due to the gas shortage) are causing a number of industrial customers previously supplied by natural gas to switch to #2 fuel or propane during curtailments. This has created a large demand for #2 fuel and propane in certain areas that exceeds the ability of the distribution system and storage facilities in those areas to meet such requirements. This combination of rapidly increasing demand (due to unusual weather conditions and gas curtailments) and inadequate distribution facilities resulted in spot shortages of distillate and propane last winter. It has led to a rapid expansion of storage facilities in certain areas, and to a backlog in storage construction. Unless the gas shortage is solved, we can expect an increasing need for buffer stocks and seasonal stocks of propane, distillate fuel, and residual fuel oil.

At the request of the Department of the Interior, the National Petroleum Council (NPC) has periodically estimated the minimum stock levels required to operate our distribution system. The last such survey was in September 1969. Presently, the NPC is preparing a new survey but the new results are unlikely to be available until late 1973.

Based on minimum stock levels reported in previous NPC surveys the following are probably reasonable estimates of present minimum-stock levels of several products:

| | MM BBLS | | |
|---|---|---|---|
| | July 20, 1973 Inventory | Est. Minimum Working Stocks | Available Stocks (Difference) |
| Crude oil | 245 | 175 | 70 |
| Gasoline | 208 | 75 | 133 |
| Kerosene | 41 | 15 | 26 |
| Distillate | 150 | 40 | 110 |
| Residual fuel | 51 | 15 | 36 |

Comparison of these estimated minimum level with existing levels indicates that the U.S. has appreciables quantities of crude oil and products in storage that might be drawn down during an emergency. In the past, increases in minimum working stock levels have been offset by decreases in buffer stocks, such that total stock levels have not changed appreciably. Rapidly changing logistic patterns will be likely to create a need for increased buffer stocks. If so, we can reasonably expect future increases in both total stocks and the stocks that would be available for drawdown during an emergency. However, in the immediate future, shortages may prevent a stock buildup and further reduce the volume of available stocks.

The difference between stock levels and minimum requirements represents cyclic and buffer stocks in the system. One can logically question whether such stocks will be available for actual use during a foreign supply disruption. A number of individuals have stated the belief that stocks will not be available since cyclic stocks are required for normal seasonal variations and buffer stocks are required to allow for irregularities in supply and demand.

However, during an emergency supply disruption we can assume that demand will be reduced, through conservation or rationing, reducing the need for a large portion of the cyclic stocks normally used to meet peak demands. Also, with a reduced demand, there should be less need for buffer stocks. Consequently, we can assume that a large portion of the indicated available stocks could be utilized. However, we undoubtedly would start experiencing local spot shortages as we began utilizing buffer stocks, increasing to nationwide shortages as we reduced stocks to minimum working levels.

Price Controls.

Emergency draw down of working inventories would not be automatic. At the outset of an emergency, the prospect of steeply rising prices, caused by shortages, would cause suppliers to withhold inventories initially in anticipation of higher profits later on. Price controls and inventory reporting, as required in the recently announced Propane Allocation Program, would be required to offset this problem. Control of petroleum prices is a highly complex problem, as we are currently discovering, requiring seasonal and other adjustments to achieve a balanced mix of products in a limited supply situation.

Restoration of Stock Levels.

To the extent that buffer and cyclic stocks are drawn down during an emergency, they must be built up again after the emergency is over, unless demand is reduced permanently. In other words, one effect of using these stocks during an emergency would be to cause shortages to last beyond the actual cutoff of imports. Stock drawdown, therefore,

does not actually prevent a shortage but causes the shortage to be spread over a longer period. By alleviating the severity of a shortage at any one time, however, stock drawdowns can be useful. The purpose of cyclic and buffer stocks is to smooth out irregularities in supply and demand. When used during a supply disruption, they have the effect of smoothing out the supply shortfall.

U.S. Stocks Related to Imports.

Present situation. Since we are primarily concerned with the adequacy of our stocks during an interruption of foreign supplies, it is more meaningful to relate our stock levels to imports, rather than to total consumption. However, this becomes meaningless when applied to individual products. For instance, gasoline, with large stocks and relatively small imports, has an extremely large stock availability/ import ratio, whereas residual fuel, which is largely supplied from imports, would have a low stock availablily/import ratio.

The most meaningful comparison is to compare total stocks available for emergency drawdown with total imports. Based on NPC data and our own estimates of working level stocks for items not reported by the NPC, we estimate total U.S. working stock requirements to be about 400 million barrels. Thus, in July 1973, with total stocks around 900 million barrels (estimated from API data on major products) the U.S. had about 500 million barrels of seasonal and buffer stocks that could be drawn down during an emergency. Based on an estimated 1973 import level of about 6,100,000 B/D, this would indicate available stocks of about 82 days of imports. Of the 500 million barrels of seasonal and buffer stocks, about 75 million represent seasonal stocks. If it is assumed that these stocks should be retained to meet peak demand periods later, then approximately 425 million barrels, or about 70 days imports, would have been available in an emergency.

Effect of emergency conservation measures. During a major foreign supply disruption we can assume that the U.S. would introduce emergency conservation measures and would maximize substitution of other energy forms for oil and petroleum products. An 18% savings in petroleum usage does not seen unreasonable[1/] (this corresponds roughly to a 9% reduction in total energy usage). With an 18% reduction in petroleum usage,, our available stocks would suffice to meet a complete cessation of current (1973) imports for about 140 days.[2/]

If we further assume that Canadian imports would not be affected, than our available stocks would be sufficient for about 280 days.

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1/ See Findings, and section on existing capacity.

2/ There may be regional problems or problems with specific products. Notably, east coast electric generating plants maintain about 25 days of residual fuel oil inventory. However, emergency needs can be met if refinery operations are modified to increase fuel oil output, and if electricity use is curtailed.

Future situation. With the large volumes of buffer stocks that could be drawn down, and with the potential savings from emergency conservation measures, the U.S. could presently withstand all but a prolonged, major reduction in imports without major consequences. Unfortunately, as import levels increase, the relative benefits from emergency conservation measures decline significantly. For instance, with overseas imports equal to 30 percent of demand, and a 20 percent demand reduction, only 10 percent of normal demand would need to be met by stock drawdowns. However, if overseas imports rise to 60 percent of demand, as some projections indicate, then even with a 20 percent demand reduction during a supply disruption,40 percent of normal demand would have to be supplied from stock reductions. Thus, it appears that while our buffer stocks are adequate for our present needs, they may be woefully inadequate in the 1980's if our import levels continue to increase. It is this future possible inadequacy of our buffer stocks to serve our needs during an emergency that has led many to suggest that the U.S. initiate a system of security reserves as protection against a disruption of foreign supplies.

Achievable Drawdown of Stocks.

Many problems would be caused by drawing down cyclic and buffer stocks. We should therefore not assume that every last drop of the theoretical potential is available for emergency use. For present purposes, we have assumed that roughly one-half of the above calculated potential could actually be drawn down in an emergency.

## EMERGENCY INCREASES IN EXISTING OIL AND GAS PRODUCTION

The recently completed interim report of the National Petroleum Council, "Emergency Preparedness For Interruption of Petroleum Imports Into the United States", develops in considerable depth an analysis of our domestic producing industry capability to increase production for short periods of time during an emergency. Their conclusion is that this capability is very limited. In summary, they found that:

- The U.S. is already producing almost all existing fields at capacity, where capacity is defined as the Maximum Efficient Rate (MER)--the highest rate of production which can be sustained over a long period of time without reservoir damage and loss of ultimate oil and gas recovery.

- There are a limited number of fields in the United States which can exceed the MER for short periods of time without reservoir damage.

- In 1974, the average increase possible from these fields over a 180-day period would be about 570,000 barrels per day. However, the deliverable capacity through existing pipelines over the same 180-day period would only be about 331,000 barrels per day. This means that only about 60% of what could be produced in an emergency (in excess of existing production rates) could actually be delivered to refineries.

- By 1978, with a pre-investment of $120 million for standby facilities and pipelines, an emergency excess capacity of 622,000 barrels per day (all of which could be delivered to refineries) could be available.

- Actual attainment of these capacities would require the removal of numerous legal and administrative obstacles. However, with considerable planning and the establishment of emergency preparedness plans, many of these obstacles could be overcome.

- In the absence of careful planning, very little emergency capacity could actually be made available.

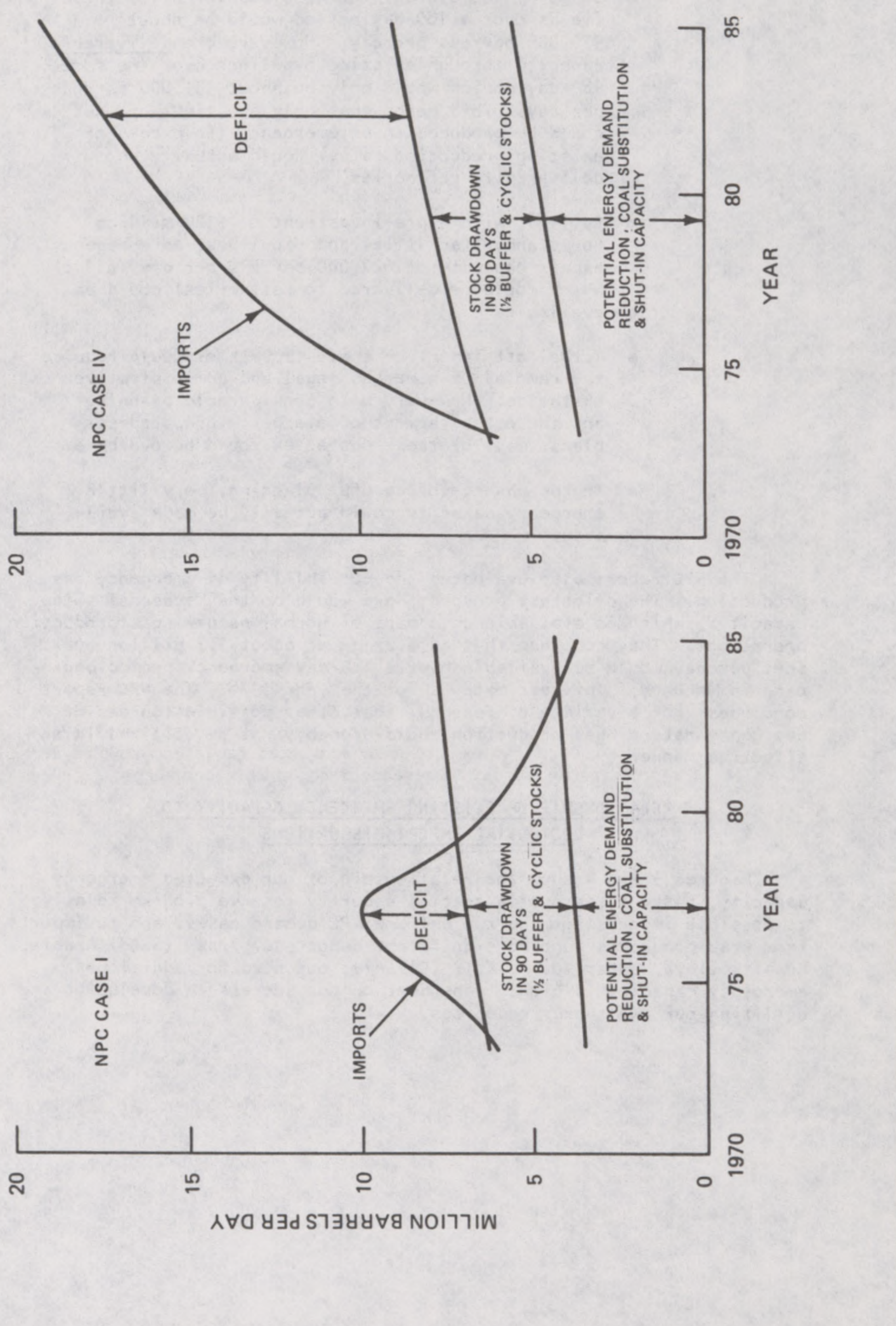
The NPC report also evaluates the possiblility of emergency gas production. The brightest prospect here would be the "seasonal swing capacity", which is available as a part of normal natural gas production operations. They conclude that an average of about 1.7 billion cubic feet per day would be available over a 180-day emergency period beginning in January. This estimate is for the year 1974. The NPC report concludes, for a variety of reasons, that other possible sources of emergency natural gas production could probably not be utilized in an effective manner.

## RELATIONSHIP OF EXISTING EMERGENCY CAPACITY TO POTENTIAL IMPORT DISRUPTIONS

Figures 3 and 4 show the relationship of our expected emergency capacity, in the absence of a special security reserve program, relative to possible imports for the two extreme NPC demand cases, and to imports from Arab producers running significant budget surpluses (Saudi Arabia, Kuwait, Libya, Qatar, U. A. E.). Clearly, our need for additional emergency capacity is highly dependent on our success in developing and utilizing our own energy resources.

FIGURE 3

ESTIMATED TOTAL PETROLEUM IMPORTS AND EXISTING EMERGENCY CAPACITY



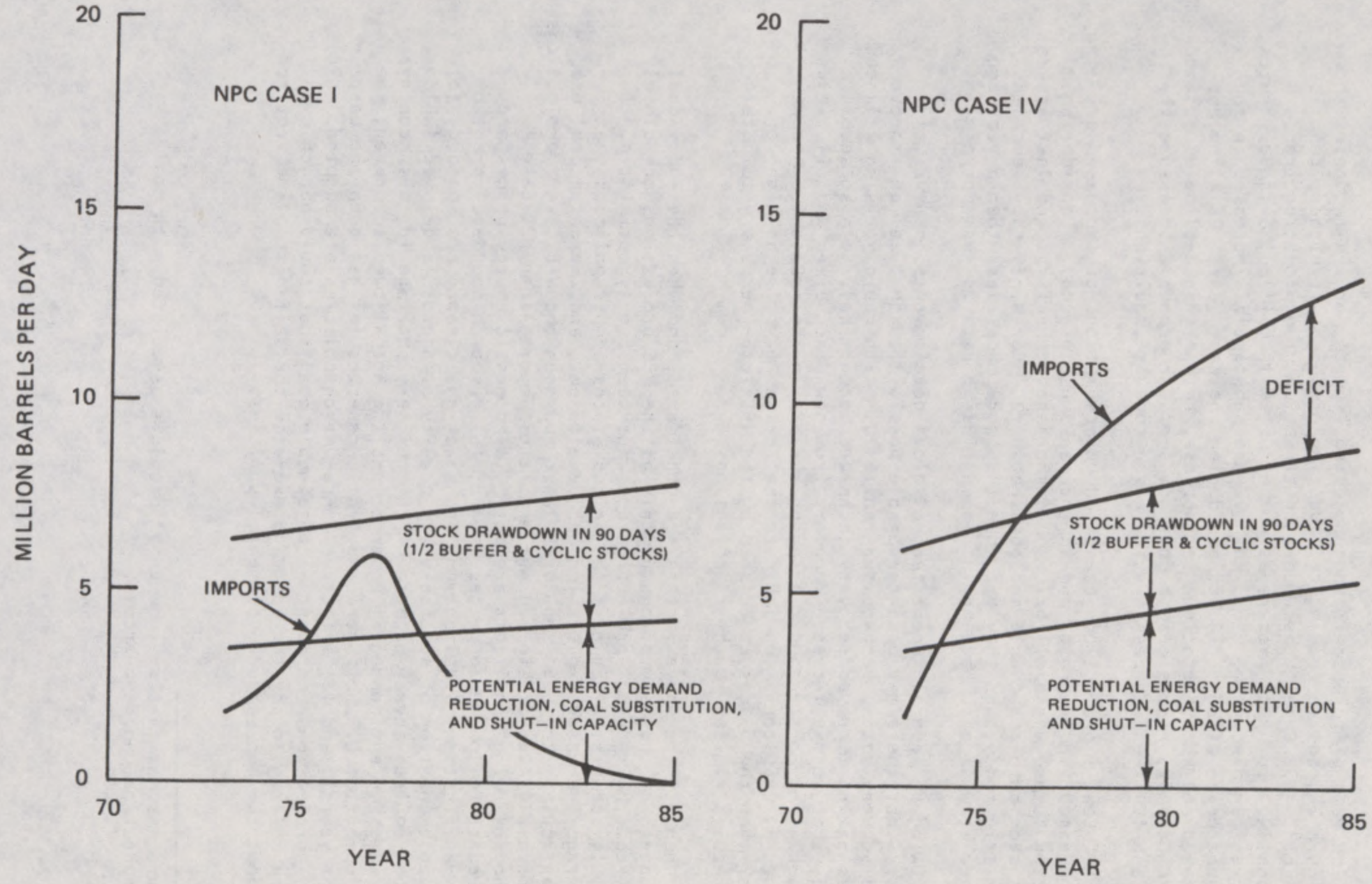
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**FIGURE 4**

**ESTIMATED IMPORTS FROM ARAB COUNTRIES AND EXISTING EMERGENCY CAPACITY**



The vast difference in the projected imports for the two cases shown in Figure 2 leads to the logical question of which, if either, case is realistic. NPC Case IV assumed a continuation of exploration trends through 1971 for such factors as number of wells drilled, discovery rates, reserves per discovery, etc. We have had substantial increases in the wellhead price of both oil and gas during the past year. Drilling has increased and should continue to increase, rather than decline as assumed in NPC Case IV. Therefore it does not seem unreasonable to assume that NPC Case IV is unduly pessimistic, given today's conditions.

NPC Case I projections are based on assumptions of increased drilling, an increased finding rate, and an increased use of coal. Considering expected future world oil prices and shortages, the first and last assumptions seem both reasonable and obtainable. 3/ Certainly they seem less optimistic today than they did when they were made, less than a year ago. Whether we will also have an increased finding rate is less certain.

Owing to several recent technological developments, however, it appears that there may be a reasonable possibility that we can improve our discovery rates, perhaps substantially. With rapidly rising wellhead prices making improved recovery techniques economical, it also seems likely that we may increase recovery from new discoveries and oil fields as much as or more than projected by the NPC in their Case I. Recent actions by OPEC countries indicate that prices may rise as high, or higher than the prices calculated by the NPC to be necessary to obtain the results similar to their projections.

When all the above factors are considered, and when the individual components of the assumptions underlying the NPC projections are closely analyzed, their Case I projection does not seem overly optimistic. In fact, it seems attainable if the United States adopts policies that encourage increased exploration and development, and increased coal use. In particular, the U.S. should at least approach the NPC Case I projections and possibly even attain a lower amount of imports than NPC Case I if the following conditions are met: (a) domestic energy prices are allowed to follow world prices upward; (b) research and development of coal gasification, liquifaction, and stack-gas cleanup are speeded; (c) the implementation of secondary air quality standards is delayed (which may be required anyway because of the refinery shortage in this country); (d) excessive environmental restrictions are not allowed to prevent the development of U.S. offshore and Arctic reserves (as has been the case in recent years); and (e) effective conservation policies are adopted. NPC Case I projections represent an obtainable goal that could be achieved if we are willing to pay the cost and exercise the self-discipline required to adopt the necessary governmental policies.

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3/ This assumes that environmental problems associated with coal production can be overcome.

There is another reason why the NPC Case I projections appear attainable. These were made assuming no future demand growth reductions due to conservation efforts. Thus, even if our discovery rate is not as successful as projected, or we fall short in other areas, such shortfalls may be offset by reduced demand. Conservation will move us away from NPC Case IV towards NPC Case I. Additionally, energy demand should be somewhat dampened by recent energy price increases. How much depends on the increase of real energy prices, and on the true sensitivity of energy demand to real energy prices and to other non-price factors.

On the other hand, political realities and considerations tend to indicate that the policies required to achieve Case I projections may not be forthcoming. Having tasted the fruits of victory, environmentalists will be reluctant to back down, even partially or temporarily, on adoption of our current environmental program. Consumer advocates will press for price controls to keep U.S. energy prices below world prices,artificially stimulating demand and dampening exploration activities. Opponents of big business will likely persist in their efforts to break up major U.S. oil companies. If environmental restrictions prevent increased use of coal, if energy prices are rolled back or contained at low levels (causing investment money to flow elsewhere), and if the major U.S. companies are crippled by court action, then NPC Case I projections would appear to be highly optimistic. In fact, under such conditions,their Case IV projections might come about in spite of the recent price increases and improved drilling rate.

In short, either NPC Case I or Case IV could be realistic, depending upon future governmental policies and what happens overseas with regard to oil prices and development of new areas. We feel that imports will actually fall in between the two projected cases. If the Arabs continue to abrogate existing contracts and force prices up, and increase their threats to disrupt supplies to bring pressure on our Israeli policies (and this seems likely),this should push the U.S. towards energy self-sufficiency.

To summarize, our potential for reducing imports to volumes similar to those projected in NPC Case I should not be overlooked. During the past year, we have seen numerous projections and heard comments that imply that large import levels are inevitable. They are not. It would be a mistake to assume that they are. They represent what could happen if we don't change some of our energy policies. However, such dire projections do not necessarily represent what is likely to happen. We still have an opportunity to control our own energy destiny.

# CHAPTER VI

## COST AND AVAILABILITY OF NEW EMERGENCY CAPACITY

The most practical form of new emergency capacity in any significant quantity is storage of crude oil in salt domes in the Gulf Coast states, located near planned superports. There are over 350 known salt domes along the Gulf Coast. A salt dome is a massive column of rock salt from 0.5 to 6.0 miles across, thrusting up from depths of about 30,000 feet. The top of the salt may vary from depths of 10,000 to a few hundred feet. Over 100 million barrels of underground storage has been established in salt domes during the past 20 years. Steel tank storage might be of limited use to provide some geographic diversity, but is considerably more expensive, and uses more land than salt domes. Shutting in production,* or prorationing, either in currently producing or undeveloped fields, is extremely costly, disruptive to current normal operations, and would provide little protection for many years. Similarly, building standby coal facilities at new oil-burning power plants is more expensive than oil storage, unless a cut-off in excess of two years is expected.

Storage of refined products is expensive, reduces flexibility in an emergency, and would require the use of refining capacity (which is now in short supply) above normal production to create products for storage. Conservation and rationing would probably be required to reduce demand so that a portion of refining capacity could be made available to produce products for storage.

The unit costs of various storage options, excluding the cost of distribution facilities and oil, are given in Table 5. Assuming the oil were available for storage, salt dome storage could probably be developed at a rate of 100-200 MM BBL/year.

The cost of storage depends upon (1) the type of storage selected, (2) the location of the storage, (3) the type of product stored, (4) special facilities, such as transportation, needed in conjunction with the storage, and (5) the size of the facilities.

## THE TYPE OF PRODUCT STORED

Volatile product storage requires more expensive vapor control facilities than non-volatile product storage. Consequently, when stored above ground we can expect gasoline storage to be more expensive than distillate storage or crude oil storage. Residual fuel oil in storage requires heating to obtain adequate viscosity for handling. Consequently, residual fuel oil storage should be more expensive than crude oil storage.

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* A detailed report on shut-in production is available on request.

TABLE 5

STORAGE SUMMARY*

| Type | Construction Cost Range, $/BBL | Annual Maintenance Cost, $/BBL | Geographical Limitations | Special Considerations |
|---|---|---|---|---|
| Above ground | | | | |
| Steel Tanks | 3.00-5.00 | .06-.10 | Essentially none. Several acres required at each location. | Capacity of steel plate fabrication industry may significantly restrict construction rate. |
| Underground | | | | |
| Salt Domes (On-shore) | 0.50-0.75 | .002-.005 | Gulf Coast locations only. | Costs assume a brine disposal pipeline to the Gulf. |
| Salt Domes (Off-Shore) | 0.75-1.00 | .005-.01 | Gulf Coast locations only. | Possible technical problems in drilling large diameter (24 to 36 inch) shafts from platforms. Multiple drilling locations required per salt dome. |
| Abandoned Mines | 0.20-1.50 | 0.5% of investment | Limited number of fixed locations, not necessarily near refining centers and/or distribution facilities. | Most are probably unsuitable for petroleum storage. |
| Mined Caverns | 5.00-10.00 | 0.5% of investment | Must be built in existing, hard-rock formations. | None. |

* Costs and advantages or disadvantages of shut-in production and depleted porous reservoirs are discussed in detail elsewhere. Sufficient cost data were unavailable for inclusion of floating-roof pits.

## TYPE OF STORAGE

Broadly, the various types of storage available may be classified as follows:

1. Above-Ground
   - a) Steel tanks -- floating or fixed roofs
   - b) Reinforced concrete tanks -- floating roofs
2. Ground level -- lined pits -- floating roofs
3. Underground
   - a) Excavated caverns
     - Abandoned mines
     - Conventional mining
     - Solution mining in salt formations
   - b) Porous formations (for crude oil storage)
     - Depleted oil or gas reservoirs
     - Original reservoir (shut-in production)

The cheapest containers are abandoned mines, or depleted oil or gas reservoirs. Unfortunately, neither are likely to be ideally located and would require expensive standby pipeline facilities to move the stored product to the point of need during a supply disruption. The added transportation cost will eliminate most abandoned mines and depleted reservoirs from consideration. Additionally, porous formations are not desirable as storage reservoirs for both technical and legal reasons. The purpose of security storage is to provide replacement supplies for a period of time during a foreign supply disruption. However, fluids can be withdrawn from porous reservoirs only at a relatively slow rate (as a fraction of the fluid stored). Five to eight barrels of crude oil would have to be stored for each barrel recovered during the first year of withdrawal. The need for such large investment for extra crude oil* would make storage in abandoned reservoirs prohibitively expensive unless we are planning for a long-term (3-5 year) disruption of supplies.

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* To meet an emergency demand of 5 MM B/D for 100 days would require a minimum of $500 \text{ MM} \times \frac{365}{100} \times 5$, or 9.125 billion barrels stored in abandoned reservoirs.

Shut-in production is also an expensive way to store oil for an emergency and presents a number of other problems. It provides no immediate protection since our demand now far exceeds domestic supply. Imports would increase immediately by the amount of domestic production shut-in, and our net deficit during a foreign supply disruption would remain the same (however, because of a decline in production if a field is produced, there would be a net gain over time from shutting in production) Shut-in production would also create a refinery problem since high sulfur imports would have to replace shut-in (low sulfur) domestic production. Technically, there are a number of reasons why many U.S. fields cannot be shut-in or have production rates significantly reduced without experiencing a loss of ultimate recovery. There are also legal reasons why many fields cannot be shut-in. When all factors are considered, shut-in production is found to provide minimum security at relatively high cost. Except for very special situations, it should not be considered for a possible security reserve.

Storage at ground level in lined pits with floating roofs could represent relatively low-cost storage for a crude oil "topped" to reduce vapor pressure. However, these pits require large land areas and are highly vulnerable to sabotage.

The least expensive storage (in large volumes) would likely be in caverns excavated in salt domes by solution mining. Rock salt can be removed by solution mining at a relatively low cost when the salt domes are located close enough to the ocean to allow inexpensive disposal of the saturated brine. Large cavities are possible and, with the large number of salt domes along the Gulf Coast, essentially unlimited capacity could be obtained at costs of approximately one-third to one-tenth of the cost of above-ground storage. Further, a number of the salt domes appear to be located ideally with respect to our petroleum transportation network. Recovery from salt dome storage would be approximately 95% of the oil stored. Thus, for every barrel of emergency capacity desired, roughly 1.05 barrels must be stored.

## LOCATION OF STORAGE FACILITIES

The most logical locations for crude oil storage are at future superports (major points of entry of overseas crude oil into the U.S.), at transshipping points in the Caribbean, or at refineries. The most logical locations for product storage are at refineries, along product pipelines, or near markets. Storage at such locations would allow utilization of existing transportation systems to move crude oil to refineries or products to market. Storage at other locations would require construction of standby transportation facilities, at high cost.

Besides onshore salt domes, underground crude oil storage in offshore salt domes near superports located in water with depths exceeding 90 feet is also attractive. Supertankers could unload directly into storage and during a supply disruption, smaller tankers could load directly from storage for delivery to Gulf Coast or East Coast refineries. Presumably, during a supply disruption, the Jones Act* could be waived temporarily if adequate U.S. flag tankers were not available (during a disruption many foreign flag tankers could be idle). Offshore salt dome storage development might be slightly more expensive than storage in on-shore salt domes due to increased well costs. However, savings in transportation facilities and in brine disposal would largely offset the increased well costs.

## ESTIMATED COST OF STORAGE

The cost estimates in Table 5 include the cost of tanks, land and related facilities, but exclude transportation costs and cost of the material to be stored. Higher land and labor costs will make above-ground storage in the East more expensive than along the Gulf Coast.

Salt dome storage compared to other forms provides advantages in lower initial costs, greater physical security and lower yearly operating costs. Further, crude oil or products stored in above-ground tanks will require cycling periodically to avoid deterioration. Crude oil (or products) stored under pressure in salt domes will not undergo evaporation and shrinkage and can be stored essentially indefinitely without cycling. Yearly savings in operating costs of 5¢-10¢ per barrel in salt dome storage appear possible compared to above-ground storage in tanks.

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* The Jones Act requires U.S. intracoastal tanker shipments to be carried in U.S. flag tankers.

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# CHAPTER VII

## COST OF A 90-DAY PROGRAM

We feel it is instructive to consider the cost of a possible storage program. We shall evaluate a program, similar to the European program, of storing 90 days of total imports in 1980. However, the reader should bear in mind that several of the more likely disruptions could last far beyond 90 days, although they would probably not involve a total cut-off of imports.

A mid-range estimate of 1980 imports is 10 MM B/D. In addition to the construction of storage facilities, oil must be purchased. Such purchases would probably be made from the same producers we are protecting against and, once the purpose is known, these producers would undoubtedly charge a premium price, conservatively estimated at $6/BBL. Assuming a 60¢/BBL salt dome construction cost, the total cost* of 900 MM BBL of storage is 5.94 billion dollars. Once the facility is built it must be expanded to allow for increasing imports. An intermediate projection for the annual rate of increase of imports is 1 MM B/D. This would add 90 MM BBL/year to the storage at $0.594 billion/year, say through 1985. The "present value" of this program in 1975, excluding operating costs, is in excess of 8 billion dollars, equivalent in cost to about 20 new 200-M B/D refineries (or about the same number of new 1000-MW electric generating plants), as much domestic refining capacity as could be expected to be added between now and 1980. Eight billion dollars also exceeds 4 years of current federal expenditures on energy research and, viewed as defense spending, means a two percent increase in annual expenditures through 1980.

To fill this storage (filling could not start before 1975 at the very earliest) would require, between 1975 and 1980, an average of about 500,000 barrels a day. This would be a 5% increase in imports at a cost of over 1 billion dollars per year, with a corresponding adverse impact on the U.S. balance of payments. Since a round trip by tanker from the Persian Gulf takes about 63 days, fifteen to twenty 300,000 dwt supertankers would be occupied full time carrying oil to fill this storage. Clearly, the impact of a storage program on world oil movements and U.S. imports between 1975 and 1980 would be significant.

An important point is that relying on existing emergency capacity (conservation, rationing, etc.) costs almost nothing unless it is actually used in an emergency. On the contrary, new emergency storage causes considerable expense while being established.

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* The cost is actually about 5% higher due to a true recovery rate from salt dome storage of about 95%.

# CHAPTER VIII

## AUTHORIZATION, FUNDING, PLANNING, AND ADMINISTRATION OF AN EMERGENCY CAPACITY PROGRAM

Existing emergency capacity, potentially extremely important, is of little value without:

- legal authority for implementation;
- emergency plans and procedures (such as preprinted rationing tickets distributed to regional operations centers) ready to be used instantly;
- funding for planning and emergency operations;
- administrative machinery for planning and emergency operations.

Although these same features are necessary to use new emergency capacity, such as emergency storage, they would probably be provided in enabling legislation. However, the planning and use of existing and new capacity should be highly coordinated, rather than separate operations.

## LEGAL AUTHORITY

Since many emergency capacity measures are voluntary, no legal authorization is required for them.

The major regulatory measures are rationing and reconversion of electric generating plants to coal.

For most regulatory measures, existing legal authority derives from the Defense Production Act and the Economic Stabilization Act.

Section 203 (a)(3) of the Economic Stabilization Act of 1970, as amended, gives unquestionable authority to control the allocation of petroleum and products at the refiner and wholesaler level. In view of the legislative history of the statute, it may reasonably be considered that the authority extends to the rationing of petroleum and products to consumers. Authority for allocation and rationing also exists under the Defense Production Act of 1950, but only if the material is found by the President to be critical for the national defense. As to coal, apparently the sole authority would be in the Defense Production Act. However, authority under both Acts expires in mid-1974.

It appears that the substitution of coal for oil and gas by large-scale users could be effected if there were authority to allocate oil and gas. That is, the existence of such authority would permit the Administration to simply decrease the amount of oil and gas available

to utilities and industrial users, thus obliging them to turn to some other fuel or source of energy. On a short-term basis, coal would apparently be the only feasible substitute.

We have determined that most of the reconvertible electric generating plants must use a high sulfur coal, which would require modification of standards administered under the Clean Air Act. However, the Act contains no provision for emergency exceptions. Any long, continued use of quantities of coal with a substantial sulfur content would be difficult to justify under the Act. Thus, if any legislation to deal with a cut-off of overseas oil supplies is to be considered, attention should probably be given to an appropriate amendment of the Clean Air Act. No such amendment is proposed in the possible legislation annexed to the Petroleum Contingency Plan,* which instead would rely on the concept that non-enforcement of the standards during a brief emergency would be appropriate. This approach has potential difficulties, including the question of citizen litigation. In many cases, emergency variances would also be required for state emission regulations.

Comprehensive legislation providing a longer-term authority specifically for dealing with non-wartime petroleum or energy emergencies is clearly needed.

## PLANNING AND ADMINISTRATION

There are currently no funding or personnel dedicated to planning for a disruption of oil imports. Neither are there any plans or administrative machinery in readiness, or funded, to quickly implement conservation campaigns and rationing measures in an emergency. To the extent that they exist, planning and administration functions are vested in the Office of Oil and Gas, Department of the Interior, and the Office of Preparedness, General Services Administration (formerly the OEP). The President's Joint Board on Fuel Supply and Fuel Transport has drafted a Petroleum Contingency Plan that provides a good start on this highly complex problem. A much higher degree of readiness is required, however, in funding, designated personnel and procedures if these emergency measures are to be of any use. Otherwise, the inevitable confusion and start-up delays would render these programs ineffective for several months. Neither the Office of Preparedness nor the Petroleum Allocation Program (which would undoubtedly bear the brunt of administering these measures) is adequately funded or staffed to cope properly with the initial planning, preparedness, and emergency operation requirements. In the event a security storage program is developed, there will be an additional requirement for coordinating the use of that storage with other emergency measures. This would help to ensure effective, rational, and equitable use of emergency measures and would be essential to avoid chaos, and conflicting actions by separate agencies. Clearly,

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* This plan was prepared recently by the President's Joint Board on Fuel Supply and Fuel Transport.

the responsibility for planning and operations should be housed under one roof. The magnitude and nature of the emergency program we have recommended is roughly equivalent to managing a large corporation.

A single organization (possibly a separate division or department in an existing agency, or a new agency) should be created to carry out the following functions:

- Start a pilot storage program, including creation of salt dome storage caverns, development of Elk Hills (Naval Petroleum Reserve #1), marketing of Elk Hills production, and purchase of Persian Gulf oil for storage.

- Develop time-staged, coordinated emergency plans for drawdown and distribution of emergency storage, conservation, rationing, and other emergency measures. Plans must be designed to minimize adverse social and economic impacts, and to be adjustable to various types of emergencies.

- Coordinate plans with any crude oil or petroleum product allocation programs that may exist, or develop such standby programs if necessary.

## FINANCING AN EXPANDED STORAGE PROGRAM

Any of the following methods, or a combination, could be utilized to finance a security storage program:

1. Industry controlled storage.

   a) Require a specified storage volume as a right to import (costs passed on to customers).

   b) Tax incentives.

   c) Direct government subsidy payments.

2. Government-controlled storage (stockpile program).

Revenue for subsidies, or for purchasing oil and constructing storage facilities under a government stockpile program, could be obtained from general tax revenues or could be obtained by a special tax on gasoline (or perhaps other fuels). Depending upon the landed cost of foreign crude oil that is put into storage, each 1¢/gallon tax increase on gasoline should yield sufficient revenue over a 1-year period to construct storage and store 150-200 million barrels of crude oil in salt domes, or around 100 million barrels of products in steel tanks.

The type of financing and the administrative control arrangements will depend to a great extent upon the type of products stored and the type of storage. Products stored above ground in steel or concrete tanks would gradually deteriorate due to vapor losses. To keep products of a usable quality will require cycling the stored product (i.e., selling the stored product periodically and replacing it with new product). To accomplish such recycling at a reasonable cost will require a tie-in with normal distribution facilities. Such recycling could best be accomplished by the various oil companies. Consequently, there would appear to be operating advantages to having industry control any product storage.

A simple tax credit against income taxes for the cost of maintaining excess storage capacity would create no inducements to a refiner to build storage unless the credits exceeded 100 percent of the cost (which is a roundabout way of spending government money).

If tax or other incentives are eliminated as a financing method for industry-controlled storage, the government must either make direct payments to the oil companies or allow them to pass costs directly through to the consumer. Since it would be difficult in practice to require all marketers, both major and independent, to maintain similar storage levels,* it would appear to be more equitable to make direct government payments for:

- The cost of the increased storage;
- The cost of the products or crude oil in storage;
- Yearly maintenance, cycling, and overhead costs.

Government costs could be recovered, for example, by a special tax on gasoline.

If a storage program is undertaken, the significantly lower cost for crude oil storage in salt domes indicates that we should maximize crude oil storage in salt domes to the extent possible. Since considerable savings are possible in large storage projects, and periodic cycling is not required, government ownership and control appears to offer advantages for crude oil storage. Salt dome storage could be constructed and storage maintained by a government organization that would also be responsible for related emergency conservation and rationing planning.

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* Major oil companies or Gulf Coast importers could have cost advantages over small independent oil companies or East Coast importers by using large, cheap Gulf Coast salt dome storage.

# V. Excerpts From the Senate Interior Committee Hearing on Strategic Petroleum Reserves Proposal

# STRATEGIC PETROLEUM RESERVES

## HEARINGS

BEFORE THE

## COMMITTEE ON INTERIOR AND INSULAR AFFAIRS UNITED STATES SENATE

**Pursuant to S. Res. 45**

**A National Fuels and Energy Policy Study**

NINETY-THIRD CONGRESS

FIRST SESSION

ON

## S. 1586

A BILL TO CREATE A SYSTEM OF STRATEGIC PETROLEUM RESERVES IN THE DEPARTMENT OF THE INTERIOR; TO LIMIT IMPORTS OF OIL AND NATURAL GAS TO LEVELS, SOURCES, AND FORMS THAT ARE CONSISTENT WITH NATIONAL SECURITY, PUBLIC SAFETY, AND WELFARE; AND FOR OTHER PURPOSES

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MAY 30 AND JULY 26, 1973

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**Serial No. 93–11 (92–46)**

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Testimony by Walter J. Mead, Senior Economist
The Energy Policy Project (Sponsored by the Ford Foundation),
presented before the U.S. Senate, Committee on Interior and
Insular Affairs, May 30, 1973

Senator Jackson's letter to me dated May 23, 1973 raises a series of questions related to the general subject of strategic petroleum reserves and I will respond to each of them directly. Before doing so I want to note that the views I am expressing here are my own and not necessarily those of The Energy Policy Project.

The first question raised by Senator Jackson is--should a system of strategic petroleum reserves be established? In my view, this nation has reached a condition in which petroleum reserves must be expanded as quickly as possible. The following reasons support this view: (A) The U.S. crude oil reserve production capability has declined to approximately zero. In 1963, the state of Texas as the leading crude oil producing state, permitted oil wells in the state to operate at only 27% of the maximum efficient rate of production and Louisiana permitted a 32% production rate. Similarly, in other market-demand prorationing states, production has been curtailed, creating an idle production capacity available tc meet an emergency need. The purpose of market-demand prorationing was not to provide an emergency production capability, but prorationing had this side effect. From 1963 to 1972, this idle capacity was steadily reduced so that by early 1972, Texas permitted production at 100% of the maximum efficient rate. Louisiana similarly eliminated all idle capacity in 1972. Today, the U.S. oil industry is producing at approximately full capacity and, except for the Naval Petroleum Reserves, we have no emergency production capability.

At the same time that production from some oil fields was being expanded, other fields were declining, with the result that U.S. crude oil production leveled off, then declined slightly in 1972. But U.S. crude oil consumption continued to increase at a 4 1/4% annual growth rate. The facts that the U.S. is the world's largest crude oil producer (19% of the total), but consumes about 32% of world consumption, while having only 5.5% of the world's crude oil reserves, is convincing evidence that we are going to become even more dependent on foreign crude sources. Dependence is an increasingly apparent fact of life. As we move into the decade of the 1980's getting about half of our crude oil from abroad, we must provide a reserve supply of crude oil to meet possible interruptions in normal foreign supplies.

Interruptions may occur periodically, due not to any diabolical intent on the part of OPEC nations, but due only to a stalemate in negotiations between buyers and sellers on price matters. Such stalemates are more likely to occur if consumer nations form a buyer cartel to bargain with the OPEC cartel. Economist call this situation a "bilateral monopoly" and it normally produces occasional supply interruptions. Other military and political supply interruptions have been analyzed by the Cabinet Task Force on Oil Import Control.[1/]

In the past, our approach to the supply security problem has been tax subsidies and import quotas to provide incentives leading to domestic production. However, crude oil is not wheat and corn which can be reproduced year after year. Oil is a non-renewable resource which can only

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1/ See pages 125-132, The Oil Import Question, 1970.

be produced once. Our past policy of stimulating domestic production in fact has contributed to our present and growing level of dependence on foreign sources. We are reaching the end of the domestic oil self-sufficiency road. The events and facts described above have forced the President to abolish import quotas on oil. In the future, security of supply must be provided by reserve supplies instead of domestic production and our annual crude oil needs will be supplied from countries that have large remaining reserves of crude oil.

A second question raised by Senator Jackson is--what alternative forms of strategic petroleum reserves are available? The following are the principal reserve forms:

1. Fully developed but shut-in petroleum reserves (in-situ reserves). Naval Petroleum Reserve No.1 (Elk Hills) located near Bakersfield, California is a partially developed example of an in-situ reserve.

2. Salt cavern storage. Salt caverns are currently being used for natural gas and petroleum product storage in the U.S. and Canada. These caverns may be created in salt domes or strata located onshore or offshore.

3. Tank storage. Steel or prestressed concrete tanks of million barrel capacity could be constructed for this purpose.

4. Abandoned underground mines may be converted into oil storage facilities.

5. Storage caverns may be created deep underground by explosion of a nuclear device.

Third, what are the costs of each alternative storage form?

1. Fully developed, shut-in reserve costs may be estimated with considerable accuracy from the Elk Hills record.[1/] Accordingly, we will use Elk Hills as a case study.

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1/ For a more detailed description of the Elk Hills Naval Petroleum Reserve along with three other Naval Petroleum Reserves, see W. J. Mead and P. E. Sorensen, "A National Defense Petroleum Reserve Alternative to Oil Import Quotas," Land Economics, Aug. 1971. pp. 211-224. A copy is attached as Appendix B.

To the extent that other existing fields that are candidates for in-situ storage have conditions similar to Elk Hills, the results may be generalized to represent in-situ storage costs. The cost of shutting-in a productive oil reservoir are as follows: (A) interest cost on the net value that would be received annually from oil (and gas) production if the reservoir was liquidated under a normal commercial liquidation plan, (B) maintenance and management costs of maintaining the field in a ready-reserve status capable of emergency production on a 60-day notice basis, and (C) interest, depreciation, and maintenance cost on oil and gas pipelines connecting the reserve to other pipelines or refineries that would be idle in the event that foreign supplies were cut-off.

(A) In order to estimate the interest cost on a shut-in oil field, we need an estimate of the market value of the oil in-place acknowledging that, under commercial operation, the field would be liquidated over a period of decades. Therefore, the appropriate method of analysis is to determine the discounted present value of a future net income flow. This discounted present value would represent what a willing buyer would pay to purchase Elk Hills, or a willing seller would demand for a field similar to Elk Hills that might be purchased by the Government.

To estimate the discounted present value of Elk Hills, we need an estimate of future oil production from Elk Hills. The remaining crude oil reserves are officially estimated at 1,022 million barrels. However, there is a widespread history of conservative reserve estimation in the petroleum industry. Under-estimation of the physical reserves would result in an under-estimation of the value of this field.[1/] The Navy has provided a higher estimate of probable production based on the inclusion of "Possible Reserves" from "limited oil bearing strata differentiated from those in the massive, main body oil bearing strata", and increased in oil recovery due to technological changes since the mid-1960's when the reserve estimates were made.[2/] Thus, a more realistic estimate of probable future oil production from Elk Hills is 1,363,435,000 barrels, plus 1,858 billion cubic feet of gas.

A commercial liquidation of the Elk Hills field is shown in Appendix A. An additional $100 million investment is required for field development. As this investment is committed, field production would remain constant for five years, then a ten percent decline rate would result in a total 43 year liquidation period. The value of oil and associated

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1/ Buyers of oil fields apparently compensate for (1) under-estimates of true reserves and (2) possible increases in the deflated future price of oil and gas by using low discount rates. Instead of normal discount rates for future net(before-tax) income of about 18%, oil field net income appears to be discounted at about 10% (before tax) and some cases of 6% discount rates have been reported

2/ See letter dated April 11, 1973 from J. P. Trunz, Jr., Director, Naval Petroleum and Oil Shale Reserve, to W. C. Truppner, Office of Emergency Planning. Appendix C.

gas production is calculated by years in Appendix A, Column 3. Lifting costs are low initially, and rise to a shut-down level in the 43rd year. Net revenues by year are shown in Column 7.

The present value of Elk Hills is estimated using a 10% discount rate applied to before-tax income. Normal business judgement would require a higher discount rate, perhaps 18% on a before-tax basis. The 10% rate is used to acknowledge arguments made by oil industry representatives that oil properties, in fact, are discounted at uncommonly low rates, which have the effect of increasing the purchase price of future oil income. Use of the 18% rate would yield a present value for Elk Hills of $2,013,788,700, whereas a 10% rate yields a $2,813,716,600 present value.

Using the 10% discount rate, the present value of oil and associated gas to be produced over a 43 year liquidation period is $2.06 per barrel of oil, compared to $3.98 per barrel at current market prices. Thus, discounting at 10% reduces the current value of future oil by 48%.

The significance of this present value estimate is that the social cost of oil reserves in-situ, is only about half the cost of oil purchased in the current market and then stored in tanks or re-committed to underground storage. This advantage for in-situ reserves is the counterpart of the point that, in an emergency, oil cannot be as quickly withdrawn from in-situ storage as it can from tank or cavern storage. This latter point requires that, for short-run needs, more in-situ oil storage than tank or cavern storage is needed to meet any given short term requirements.

Having estimated the present value of the Elk Hills field as a case study, we must convert the present value estimate into annual costs. Using a 6% long-term social time preference rate to make this conversion, we obtain annual social costs of $168,823,000.

Annual maintenance costs on idle production facilities and management expenses necessary to maintain a shut-in field in a state of perpetual readiness are estimated on the basis of current Elk Hills costs, $4,000,000 per year.

Standby pipeline capacity to deliver oil from Elk Hills to Los Angeles, a distance of about 100 miles, would require a 36 inch pipeline having a capital cost of about $50 million. Pumping stations and other facilities would cost an additional $10 million.

The pipeline capital costs have been converted to annual costs using a 6% social time preference rate [1/] and a 30 year amortization period.

Oil production also results in production of associated gas, requiring standby gas pipeline facilities. A 100 mile natural gas pipeline, with all the required facilities, is assumed to cost $13 million.

The sum of annual interest costs on shut-in petroleum , field maintenance and management, and idle pipeline facilities is shown in total and on a per barrel of reserve basis in Table I. The cost is $178,376,000 annually (social cost) for about 1.4 billion barrels of oil and 1.9 trillion cubic feet of gas. This amounts to $0.13 per barrel of oil.

1/ In Mead and Sorensen, an 18% before tax rate of return on the oil pipeline was allowed on the grounds that the existing pipeline was privately owned. In order to permit comparisons between storage alternatives, a 6% social time preference rate is calculated here on all pipeline and storage systems

TABLE 1 -- COST ESTIMATES FOR ALTERNATIVE STORAGE SYSTEMS

| | CAPITAL INVESTMENT | | | | | ANNUAL COSTS | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 7 | 8 | | 9 | 10 |
| Type storage | Facility | Pipeline | Petroleum | Land | TOTAL | Interest & depreceation on cols. 1&2 @ 6% | Interest only on cols. 3&4 @ 6% | Maintenance & Management | TOTAL | Cost per barrel of oil reserve |
| 1. In-situ (Elk Hills case study 1,363,435 Mbbls oil & 1,858,362 Mlcf. gas) | a/ | $ 73,000,000 | $ 2,813,716,600 | a/ | $ 2,886,716,600 | 5,303,000 | $168,323,000 | $4,250,000 b/ | $178,376,000 | $ 0.13 |
| 2. Salt cavern-PAD III on shore | | | | | | | | | | |
| 1 MM bbls. | $ 4,4000,000 c/ | 2,000,000 | 4,000,000 | 100,000 | 10,500,000 | 465,000 | 246,000 | 10,000 | 721,000 | 0.72 |
| 2 MM bbls. | 4,960,000 c/ | 3,000,000 | 8,000,000 | 150,000 | 16,110,000 | 578,000 | 489,000 | 12,000 | 1,079,300 | 0.54 |
| 10 MM bbls | 8,300,000 c/ | 4,000,000 | 40,000,000 | 500,000 | 52,800,000 | 893,000 | 2,430,000 | 15,000 | 3,338,600 | 0.33 |
| 3. Tank storage-PAD-I 1 MM bbls | 4,140,000 c/ | -0- | 4,000,000 | 200,000 | 8,340,000 | 300,800 | 252,000 | 190,000 | 742,800 | 0.74 |
| 4. Abandoned mine 10 MM bbls | 5,400,000 c/ | 4,000,000 | 40,000,000 | 500,000 d/ | 49,900,000 | 682,900 | 2,430,000 | 30,000 | 3,142,900 | 0.31 |
| 5. Nuclear Cavity 1 MM bbls | | | | | | | | | | |
| High estimate | 4,140,000 | 2,000,000 | 4,000,000 | 200,000 | 10,340,000 | 446,000 | 252,000 | 20,000 | 718,000 | 0.72 |
| Low estimate | 2,070,000 | 2,000,000 | 4,000,000 | 200,000 | 8,270,000 | 296,000 | 252,000 | 20,000 | 568,000 | 0.57 |

a/ In the Elk Hills case, the value of the gas, oil and land includes the value of the facility.

b/ Includes field and pipeline maintenance.

c/ Estimates developed by the American Petroleum Institute, Division of Statistics and Economics.

d/ Cost of purchasing an abandoned mine are dependent on the relative bargaining strength of the parties. A nominal cost is shown. The social cost depends on the next best alternative. This may be zero, or it may be the value in reopening the mine at some future date when mineral prices increase or technological changes occur in mining or mineral [illegible]

But the costs per barrel of oil reserve shown in Table I, charges all costs against oil, neglecting the fact that gas is produced as a joint product of oil production. The gas-oil production ratio is 1.363 Mcf of gas per barrel of oil. Elk Hills contains an estimated 1,858,362,000 Mcf of recoverable natural gas. In terms of wellhead values, 85% of all in-situ value is in oil, and 15% is in gas. If we allocate costs in these percentages, costs per barrel are as shown in Table 2.

Table 2 also shows the annual cost of a fully developed Elk Hills shut-in reserve in terms of annual emergency production of oil and gas. Assuming that emergency production is established on a commercial liquidation basis, following a 60-day notice, 127,750,000 barrels of oil and 174,123 million cubic feet of gas could be produced in a one year period. The annual cost of holding this emergency reserve production capability is shown to be $1.24/bbl. of oil, and $0.16/Mcf of gas. If we think in terms of two years of emergency production, the annual holding cost falls to $0.62 per barrel of oil, and $0.08 per Mcf of gas. Costs are also shown for 3,4, and 5 year time periods.

The Elk Hills field alone is of sufficient size so that if it was developed on a commercial level as indicated in Appendix A, then shut-in and maintained fully producible on a 60-day notice basis, it would be capable of replacing 86% of the 1972 non-Canadian crude oil imports into the entire West Coast (PAD-V).[1/] Appendix A shows that production

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1/ Total 1972 imports of crude oil into PAD-V were 242,711,000 barrels, of which 94,436,000 came from Canada. U.S. Dept. of the Interior, "Mineral Industry Surveys" December, 1972, p.17. Thus, non-Canadian oil imports into PAD-V were 148,275,000 in 1972. This level of imports will probably increase in the next three or four years, then decline as Prudhoe Bay oil becomes available on the West Coast.

TABLE 2--Cost per unit of oil and gas reserve, and per unit of production over several time periods.

| | OIL | GAS |
|---|---|---|
| Total annual cost | $151,620,000 | $26,756,000 |
| Reserve | 1,363,435,000 bbls. | 1,858,362,000 Mcf. |
| Annual cost per unit or reserve | $0.11/barrel | $0.014/Mcf |
| Annual cost per unit of production under commercial liquidation schedule in the following time periods: | | |
| 1 year<br>127,750,000 bbls oil and<br>174,123,000 Mcf gas. | 1.18/bbl | 0.15/Mcf |
| 2 years<br>255,500,000 bbls oil and<br>348,246,000 Mcf. gas | 0.59/bbl | 0.08/Mcf |
| 3 years<br>383,250,000 bbls oil and<br>522,370,000 | 0.40/bbl | 0.05/Mcf |
| 4 years<br>511,000,000 bbls oil and<br>696,493,000 Mcf. gas | 0.30/bbl | 0.04/Mcf |
| 5 years<br>638,750,000 bbls oil and<br>870,616,000 Mcf gas | 0.24/bbls | 0.03/Mcf |

could be sustained at 127,750,000 barrels per year for five years before a 10% decline rate would begin operating. If 100% protection for PAD-V is desired, then a higher level of investment in field development would be necessary. Elk Hills might be extensively developed (beyond a commercial liquidation level) to yield 435 million barrels of crude oil in one year.[1/]

2. Salt cavern storage may be developed wherever a suitable salt dome or strata is available. The process employed requires conventional drilling into a salt bed, pumping fresh water into the formation and withdrawing and disposing of brine. This process is repeated until a cavern of the desired size is developed. When crude oil is placed in the cavern, further enlargement of the cavern comes to an end.

Most of the onshore known salt domes are located in Texas, Louisiana and Mississippi. Other salt occurances are in the Great Lakes region and scattered through the Rocky Mountain states and east as far as Kansas. Some of these formations might be suitable for oil storage development.

The capital cost (not including oil) of developing 1 million barrels of crude storage capacity in salt domes located in the southern states onshore has been estimated by the American Petroleum Institute at $4,400,000 or $4.40 per barrel. Imported or domestic oil to be placed in a salt cavern would cost an additional $4 million or $4 per barrel at current prices. Thus capital costs including oil would be $8,400,000 or $8.40 per barrel.

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1/ See letter from Trunz to Truppner in Appendix C.

Land and subsurface rights must be purchased. Some means of brine storage and disposal is needed. A $100,000 land cost is added, although actual cost might vary widely from this figure.

Annual maintenance on salt dome storage would be minimal or negligible. Only occasional checking would be necessary. Maintenance is estimated at $10,000 per year.

The oil storage cavern must be accessible to a pipeline system that would have some idle capacity in the event that foreign supplies were interrupted. We will assume that 10 miles of standby pipeline would be necessary to tie into such a system. This pipeline and pumping facility is estimated to cost $2 million.

The capital cost, annual cost, and cost per barrel of oil in reserve by 1, 2 and 10 million barrel salt dome storage caverns is calculated and shown in Table I. Great economies of scale are shown. Costs per barrel decline from $0.72 for 1 million barrel storage, to $0.33 for 10 million barrels.

3. Tank storage is a highly versatile storage form.[1/] Whereas in-situ and salt cavern storage locations are limited by nature, tanks can be constructed wherever needed. They would probably be constructed at a refinery location where they can be managed in conjunction with a refinery. Also, placing tanks near a refinery or major pipeline obviates the need of connecting pipelines.

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1/ Costs have been estimated for steel tank storage. However, pre-stressed concrete tank storage might also be used. Studies by the API, Division of Statistics and Economics indicate that the capital cost of a concrete facility might be less than steel. All other storage costs should be the same. Relatively less is known about concrete tank storage reliability.

The cost of 1 million barrel tank storage is estimated at $4,140,000 for the complete storage facility, or $4.14 per barrel. The optimum size is believed to be about 1 million barrels.

Each 1 million barrel storage unit requires about 4 acres of land for the tank, associated facilities and open space. Land near refineries is assumed to be relatively expensive and a land charge of $200,000 is shown for each tank.

Maintenance and management charges for tank storage are relatively high, estimated at $190,000 per year. Since storage is above ground, there is an obvious security problem. Our cost estimates provide for maintenance and management by two men around-the-clock, at an annual cost of $130,000. Repainting every two years is an annualized cost of $10,000. Supplies and miscellaneous expenses are added amounting to $50,000 annually. The total annual cost for tank storage is shown in Table I to be $742,800 for 1 million barrel storage, or $0.74 per barrel.

4. Abandoned mine storage may be the cheapest form of short-term storage, but depends on the availability of suitable abandoned mines. Suitability requires that the mine (1) be structionally stable, (2) have formations surrounding the mine that are free of fractures and relatively impermeable, (3) contain material either chemically inert or not reactive to oil, (4) be free of water flows that may carry contaminants, and (5) have a groundwater level high enough above the mine to provide sufficient hydrostatic pressure to prevent loss of oil into formations outside the mine.[1/] Based on South African experience, Brandt claimed that abandoned

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1/ H.W. Brandt, "Abandoned coal mine converted into man-made oil field," Oil and Gas Journal, December 25, 1972, p.76.

mine storage (the facility only) could be developed for only about 15% of the cost of steel tanks facilities. Since the tank facility accounts for only 40% of the total tank storage cost (Table I), the reduction in total annual cost would be about 35%. The case on which Brandt bases his estimate provided 17 million barrels of storage and the land cost was minimal.

An estimate of the development cost only for abandoned mine storage has been constructed by the API. This estimate, based on 10 million barrels capacity, shows very low cost; $0.54 capital cost per barrel of reserve. When other expenses are added and computed on an annual basis, Table I shows a relatively low cost; $0.31 per barrel.

5. A nuclear cavity might be created deep underground for crude oil storage.

There currently is no experience with this type of storage system. There has been a series of nuclear explosions to stimulate gas production in the United States, and in Russia there have been two explosions to stimulate oil production. A possibility of a nuclear cavity for oil storage is limited to non-populated regions. in order to avoid surface damage. A twenty-five kilo-ton device might be exploded at least two thousand feet below the surface and would yield approximately one million barrels of storage capacity. The storage chamber would be approximately 150 feet in diameter and about 250 feet high. The contaminants would be flushed out before oil is pumped in. Oil might be pumped in approximately six months after the explosion. Some experts who work in this area argue that radioactive contamination is not a problem, even in the case of gas stimulation where gas is recovered shortly after an explosion. The radiation danger in the gas stimulation case is limited to about one per cent of the natural background exposure. In the case of oil storage the

danger would be less, simply because the function would be storage rather than production. The stored oil might, in fact, remain in the ground for decades. The fissile material becomes incorporated in the molten rock (glass) which accumulates in a "puddle" at thc bottom of the cavity. Evidence accumulated in the last fifteen years of underground explosions (about four hundred explosions ranging from a few tons up to five mega-tons) indicates there are no long-term seismic effects.

Very little cost data are available. The limited data suggest that a nuclear cavity might vary in cost from a low of about half that of a steel tank facilities, up to a high about equal the tank cost. High and low cost estimates are shown in Table I, indicating that the annual cost per barrel of storage might vary from a low of $0.57 to a high of $0.72.

In a preliminary sense, use of the nuclear approach is sufficiently attractive to warrant further investigation for areas where salt formations and in-situ possibilities are not available.

A fourth question raised by Senator Jackson's letter is--what are the advantages and disadvantages of different storage forms?

1. From a cost point of view, comparison between in-situ and all other storage forms involves the "apples and oranges" problem; reserves in-situ are a different product. On a cost per barrel of reserve basis, Table I shows that in-situ reserves are the lowest cost form, $0.13 per barrel of oil (of if some costs are allocated to gas, $0.11 per barrel of oil, see Table 2). In contrast, other forms range from $0.31 per barrel of reserve stored in abandoned mines, to $0.74 for tank storage. But, in-situ is long-term storage. A normal commercial liquidation schedule

permits recovery of only 9.4% of the recoverable reserves in the first year of an emergency. This means that in-situ storage cost for one year recovery is relatively high--$1.18 per barrel of oil and $0.15 per Mcf of gas. In contrast, oil can be recovered quickly from the alternative storage systems. However, when oil is fully recovered from the quick-recovery systems, all reserves have been exhausted whereas in long-term storage by the in-situ system, a like amount of emergency production is available for a second, third, fourth and fifth year. As a long-term storage system, five years of steady reserve production of both oil and gas have a relatively low cost of $0.24 per barrel of oil and $0.03 per Mcf of gas. Reserves are available beyond 5 years at a 10% decline rate.

Elk Hills (Naval Petroleum Reserve No.1) is already in public ownership, as are Naval Petroleum Reserves No.2 (Buena Vista adjoining Elk Hills), No.3 (Teapot Dome in Wyoming) and No.4 (23,680,000 acres on Alaska's North Slope due west of Prudhoe Bay). NPR No.4 is estimated to contain from 4 to 25 billion barrels of oil.[1/] However, exploration in this area has been inadequate thus far. The process of developing NPR No.4 would begin with a thorough exploration effort. NPR No.4 may not be suitable as a candidate for in-situ reserves because of the high cost of maintaining production and transportation facilities in a fully developed but shut-in basis. NPR No.4 might be developed for current production, using the net income to the government to finance acquisition and development of new in-situ reserves in more suitable locations.

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1/ Cabinet Task Force on Oil Import Control, p. 306.

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2. From a safety point of view, in-situ reserves rank high, next to salt cavern storage, abandoned mine, nuclear caverns, and with tank storage having the highest risk factor. Leakage is possible from salt, mine and nuclear cavity storage. Average recovery from salt dome storage has been above 90 percent. However, only 57% of the stored oil was recovered from an Arcadia, Louisiana salt dome. If an entire reservoir is under in-situ control, then loss is zero. Oil remains where it has accumulated over the centuries.

Nuclear cavities have incompletely evaluated safety problems from possible contamination. Ground water contamination is possible, as well as possible contamination of stored oil.

There are potentially severe safety problems in tank storage. Sabotage or military operations may cause tank ruptures with consequent fires or massive oil spills. This is not a problem for underground storage.

3. From a locational flexibility point of view, tank storage ranks high. Storage tanks can be constructed where needed, assuming they can pass environmental quality and public relations requirements. Salt cavern storage can be established only where suitable salt domes are available, and most locations are in the Gulf of Mexico area, either onshore or offshore. A Bureau of Mines study reported that "there are 130 onshore salt domes in the Gulf coastal area that offer good possibilities for storage sites. Many of these domes are near existing transportation facilities." 1/ However, salt dome storage is not available in the populous

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1/ Bureau of Mines, "Salt Domes in Texas, Louisiana, Mississippi, Alabama and Offshore Tidelands: A Survey." 1966, (IC 8313)

East Coast region. Hence, storage there may require tank facilities. Nuclear underground explosions disturb the surface by their earthquake effects and therefore are not suitable for populated areas.

Fifth, my views were requested concerning S-1586. I offer the following:

(1) At least 90 days of petroleum reserve storage is clearly a necessity as we move into an era where by necessity, we become increasingly dependent on foreign crude oil supplies. However, a reserve system of more than 90 days would seem advisable in the long-run.

(2) In my opinion, it would be inadvisable to re-establish the now defunct oil import quota system. Import restrictions by a system of license requirements as proposed raises a question concerning who is to be given the right to import. I see nothing in the history of oil import quota administration in the past that would lead one to believe that the national interest will be served by import restrictions. Administration will surely conform to the economic interests of the dominant interest group--probably oil companies. The national interest in secure petroleum supplies can be served with an adequate reserve system.

License or quota administration is extremely complex and requires a large bureaucracy. Corruption of public officials becomes a strong possibility because valuable rights are dispensed by such officials. The complexity of market interference requires that a host of problems be pre-answered in legislation and administration. This leads to over-control and excessive administrative interference. The proposed Title III Oil and Gas Import Regulation seems to reflect these problems.

(3) The proposed budget to "conduct a program of exploration for oil and gas on the naval petroleum reserves" is obviously needed. This is particularly appropriate for NPR No.4

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Policy Conclusions

(1) The analysis presented here clearly leads to the conclusion that exclusive reliance on any one reserve storage system would be unwise.

(2) Rather, a mixed package reserve system is a necessity due to regional differences. Long term in-situ reserves offer clear advantages in PAD-V where Elk Hills, if developed on a commercial production schedule, is capable of providing a high degree supply security for the entire west coast for at least five years of emergency production.

(3) The advantages of in-situ reserves (cost and safety) are sufficient to warrant a study of other large reservoirs to determine their suitability. Potential existing fields would include the East Texas, Willmington, Yates, and the "Main Pass Block" No.112 offshore from Louisiana. New fields to be discovered in the future might be included for study. Current output from any productive field that is set aside in a petroleum reserve system must be replaced by additional imports from abroad. But this is true of any storage system. Oil for storage is in addition to present domestic and foreign supplies.

(4) Abandoned mine storage is most attractive from a short-term cost point of view and is relatively safe. These considerations should lead to use of this storage from wherever suitable locations are available.

(5) Salt dome storage is suitable particularly in the Gulf coast area. Large scale salt dome storage is low cost for short-term storage and is relatively safe. Research should be conducted which would identify any long-term effects of the salt environment on crude oil.

(6) Tank storage is least attractive from both a cost and safety point of view. However, it may be utilized where other storage forms are not available to fill out any remaining reserve capacity needs.

(7) While a system of crude oil storage is now a necessity, S-1586 also proposes renewed oil (and gas) import regulations. The President has abolished the Oil Import Quota System because it failed to serve the national interest. I see no net benefits that would follow from re-establishing an import control system.

Appendix I -- Estimated Net Before-Tax Income, Discounted to Obtain a Present Value for the Elk Hills Naval Petroleum Reserve

| Year | Production (thousand barrels of oil) | Value @$3.40/bbl. for oil, plus gas @58¢/bbl of oil=$3.98[a] | Lifting cost per barrel | Total lifting cost | Additional capital cost (Mill. $) | Before-tax net income (value less costs) | Present value at 18% discount | Present value at 10% discount |
|---|---|---|---|---|---|---|---|---|
| 1. | 127,750 | $508,445,000 | $0.25 | $31,937,500 | $20 | $476,507,500 | $403,819,600 | $433,188,20 |
| 2. | 127,750 | 508,445,000 | .25 | 31,937,500 | 20 | 476,507,500 | 342,220,100 | 393,807,70 |
| 3. | 127,750 | 508,445,000 | .25 | 31,937,500 | 20 | 476,507,500 | 290,016,800 | 358,006,80 |
| 4. | 127,750 | 508,445,000 | .25 | 31,937,500 | 20 | 476,507,500 | 245,776,900 | 325,460,90 |
| 5. | 127,750 | 508,445,000 | .25 | 31,937,500 | 20 | 476,507,500 | 208,285,700 | 295,873,50 |
| 6. | 177,205 | 446,475,900 | .27 | 31,645,350 | | 414,830,550 | 153,660,100 | 234,160,60 |
| 7. | 98,277 | 391,142,460 | .29 | 28,500,330 | | 362,642,130 | 113,842,400 | 186,092,70 |
| 8. | 88,405 | 351,851,900 | .31 | 27,405,550 | | 324,446,350 | 86,315,000 | 151,356,50 |
| 9. | 69,096 | 275,002,080 | .34 | 23,492,640 | | 251,509,440 | 48,054,400 | 106,664,40 |
| 10. | 57,937 | 230,589,260 | .36 | 20,857,320 | | 209,731,940 | 33,959,600 | 80,860,70 |
| 11. | 48,581 | 193,352,000 | .39 | 18,946,590 | | 174,405,410 | 23,931,700 | 61,127,90 |
| 12. | 40,735 | 162,125,300 | .42 | 17,108,700 | | 145,016,600 | 16,863,500 | 46,206,60 |
| 13. | 34,156 | 135,940,880 | .45 | 15,370,200 | | 120,570,680 | 14,020,800 | 34,925,00 |
| 14. | 28,640 | 113,987,200 | .48 | 13,747,200 | | 100,240,000 | 9,878,400 | 26,396,30 |
| 15. | 24,015 | 95,579,700 | .52 | 12,487,800 | | 83,091,900 | 6,939,500 | 19,891,50 |
| 16. | 20,136 | 80,141,280 | .56 | 11,276,160 | | 68,865,120 | 4,874,000 | 14,947,90 |
| 17. | 16,884 | 67,198,320 | .60 | 10,130,400 | | 57,067,920 | 3,422,900 | 11,290,50 |
| 18. | 14,157 | 56,344,860 | .65 | 9,202,050 | | 47,142,810 | 2,396,300 | 8,479,00 |
| 19. | 11,870 | 47,242,600 | .70 | 8,309,000 | | 38,933,600 | 1,677,100 | 6,365,90 |
| 20. | 9,953 | 39,612,940 | .75 | 7,464,750 | | 32,148,190 | 1,173,600 | 4,778,60 |
| 21. | 8,346 | 33,217,080 | .81 | 6,760,260 | | 26,456,820 | 818,500 | 3,575,10 |
| 22. | 6,998 | 27,852,040 | .87 | 6,088,260 | | 21,763,780 | 570,600 | 2,673,60 |
| 23. | 5,868 | 23,354,640 | .93 | 5,457,240 | | 17,897,400 | 397,600 | 1,998,70 |
| 24. | 4,920 | 19,581,600 | 1.00 | 4,920,000 | | 14,661,600 | 276,100 | 1,488,50 |
| 25. | 4,126 | 16,421,480 | 1.08 | 4,456,080 | | 11,965,400 | 190,900 | 1,104,30 |
| 26. | 3,459 | 13,766,820 | 1.16 | 4,011,440 | | 9,754,380 | 131,900 | 818,40 |
| 27. | 2,901 | 11,545,980 | 1.25 | 3,626,250 | | 7,919,730 | 90,800 | 604,00 |
| 28. | 2,432 | 9,679,360 | 1.35 | 3,283,200 | | 6,396,160 | 62,000 | 441,30 |
| 29. | 2,039 | 8,115,220 | 1.45 | 2,956,550 | | 5,158,670 | 41,300 | 325,00 |
| 30. | 1,710 | 6,805,800 | 1.55 | 2,650,500 | | 4,155,300 | 25,000 | 236,80 |
| 31. | 1,434 | 5,707,320 | 1.66 | 2,380,440 | | 3,326,880 | 19,600 | 173,00 |
| 32. | 1,202 | 4,783,960 | 1.79 | 2,151,580 | | 2,632,380 | 13,200 | 123,70 |

Continued on next page.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 33. | 1,008 | 4,011,840 | 1.93 | 1,945,440 | | 2,066,400 | 8,300 | 88,800 |
| 34. | 845 | 3,363,100 | 2.08 | 1,757,600 | | 1,605,500 | 5,800 | 62,600 |
| 35. | 709 | 2,821,820 | 2.31 | 1,637,790 | | 1,184,030 | 3,600 | 41,400 |
| 36. | 594 | 2,364,120 | 2.40 | 1,425,600 | | 938,520 | 2,400 | 30,000 |
| 37. | 498 | 1,982,040 | 2.58 | 1,284,840 | | 697,200 | 1,400 | 20,200 |
| 38. | 418 | 1,663,640 | 2.78 | 1,162,040 | | 501,600 | 600 | 13,000 |
| 39. | 350 | 1,393,000 | 2.98 | 1,043,000 | | 350,000 | 350 | 8,400 |
| 40. | 294 | 1,170,120 | 3.20 | 940,800 | | 229,320 | 200 | 5,000 |
| 41. | 246 | 979,080 | 3.45 | 848,700 | | 130,380 | 100 | 2,600 |
| 42. | 207 | 823,860 | 3.70 | 765,900 | | 57,960 | 50 | 1,000 |
| 43. | 34 | 135,320 | 3.98 | 135,320 | | -0- | -0- | -0- |
| Total | 1,363,435 | $5,430,350,920 | | $477,321,370 | $100 | $4,953,029,550 | $2,013,788,700 | $2,813,716,60 |

[a]Gas is valued at 38.79¢/MCF at Elk Hills, The reserve estimates indicate that there are 1,363 cu. ft. of recoverable gas per barrel of oil. Thus, the value of the associated gas is 53¢/barrel of oil. Oil and gas values are as of May 23, 1973.

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF EMERGENCY PREPAREDNESS
WASHINGTON, D.C. 20504

MAR - 9 1973

LCDR Kirby E. Brant
Acting Director
Naval Petroleum and Oil Shale Reserves
Department of the Navy
Washington, D.C. 20360

Re: Maximum Production Rate -- Naval Petroleum Reserve #1.

Dear Commander Brant:

The OEP and the National Research Council are jointly conducting a study of the costs and feasibility of various methods to obtain emergency energy capacity. One concept we are investigating is the concept of a "National Defense Petroleum Reserve" as proposed by Professors Mead and Sorensen in an August 1971 article in Land Economics, and as recently proposed in HR 422 submitted by Representative Conte on January 3, 1973.

In their article, Professors Mead and Sorensen state with regard to Naval Petroleum Reserve #1 that "The Navy estimates that with an additional investment of $278 million, initial year emergency production amounting to 453 million barrels may be attained." The $278 million investment mentioned above is in addition to a $100 million investment to increase capacity from the present capacity to 127.75 million barrels per year. The combined investment of $378 million does not include costs to expand the transportation system to move production from the field.

The Comptroller General of the U.S., in a report to Congress dated October 5, 1972, concerning the "Capability of the Naval Petroleum and Oil Shale Reserves to Meet Emergency Oil Needs" listed remaining reserves in NPR #1 as 1,022 million barrels. A first year production rate of 453 million barrels would result in a first year depletion of 44% of the indicated reserves. Such a depletion rate is appreciably higher than normal. Also, increases of potential production from 36 million barrels/year (present potential) to 453 million barrels for an investment of only $378 million ($0.905/barrel of production the first year) appears appreciably lower than normal oil field development costs.

To assist our study we would appreciate the Navy confirming the production rate and investment data quoted by Professors Mead and Sorensen. We would also appreciate the following information:

1. The number of wells required in both the Shallow Oil Zone and Stevens Oil Zone to obtain a shut-in capacity sufficient to produce 453 million barrels during the first year of an emergency.

2. The spacing that the above number of wells represents.

3. The cost of drilling and completing each Shallow Oil Zone and Stevens Oil Zone well.

4. The cost of surface equipment (excluding pipeline facilities from the field) to handle 453 million barrels production the first year.

5. The initial rate at the beginning of emergency production and the production rate at the end of the first year to obtain 453 million barrels during the year.

6. The decline rate during the first year plus the Navy's estimate of production during the second year following an initial year's production of 453 million barrels.

7. The Navy's estimate of the loss of ultimate recovery, if any, that might result from producing NPR #1 at such high rates.

8. The manpower requirements and operating costs to produce NPR #1 at the above rates.

9. The manpower requirements and yearly maintenance and operating costs to maintain NPR #1 on a standby basis capable of producing 453 million barrels during the first year of any emergency. (This assumes that the field will have been fully developed prior to being put on a standby basis.) Include in the cost estimate any ad valorem taxes that would be levied by the County or State Governments against the value of wells and equipment. If none are levied, please so state. Also, we would appreciate a breakdown of standby costs into categories such as corrosion and maintenance, engineering and testing, standby labor.

10. Any additional investments, such as modification of power distribution networks, that might be required to allow production at the high initial rate.

11. The time required to bring the field to a state of readiness to produce 453 million barrels the first year following appropriation of the necessary funds.

In the event that you do not believe that an initial rate of 453 million barrels per year is possible, please indicate either the maximum feasible rate, or the rate which the Navy would recommend developing the field as a standby reserve. In this event, we would appreciate your estimate of the investment required to develop the field to produce at the recommended or estimated maximum rate, plus answers to the above questions at the reduced rate of standby capacity.

Sincerely,

W C Truppner

W. C. Truppner
Assistant Director for
Resource Analysis

EPB:sli

RC/4850
Serial: 1[illegible]

11 APR 1973

Mr. W. C. Truppner
Assistant Director for
Resource Analysis
Executive Office of the President
Office of Emergency Preparedness
Washington, D.C. 20504

Re: Maximum Production Rate —
Naval Petroleum Reserve No. 1

Dear Mr. Truppner:

Thank you for your letter of March 9, 1973 relating to the oil deliverability of Naval Petroleum Reserve No. 1 (Elk Hills).

In the third paragraph of your above mentioned letter, the remaining reserves in Naval Petroleum Reserve No. 1 are quoted as 1,022 million barrels. This value is the oil reserves in Naval Petroleum Reserve No. 1 including Asphalto as of December 31, 1970. The oil reserves quoted in the Mead and Sorenson paper "A National Defense Petroleum Reserve Alternative to Oil Import Quotas" are 1,363,435,000 barrels as of December 31, 1969. This larger reserve value is due to:

a. The inclusion of "Possible Reserves" in the Elk Hills reserve estimate. These are estimated recoverable reserves in limited oil bearing strata as differentiated from those in the massive, main body, oil bearing strata.

b. An increase in oil recovery from an estimated 40% to 50% due to improvements in technology since the Mid-1950's when the Elk Hills Engineering Committee estimates were made. This larger reserve value results in a first year depletion of 33% as compared to the 44% shown in paragraph 3 of your letter.

Also, in the third paragraph, 36 million barrels/year (present production) is mentioned. This is equivalent to 98,630 barrels/day. The current production from Naval Petroleum Reserve No. 1 is about 3,300 barrels/day. The source of the number 36 million barrels/year is not known here.

The following is offered in reply to Question No. 1 of your letter:

| | Shallow Zone | Stevens Zone |
|---|---|---|
| Number Operable Wells | 510 | 236 |
| Number Locations (estimated) initial rate) | 2,540 (150 b/d/w) | 823 (1,000 b/d/w) |
| Number Wells not Operable - (high GOR, etc.) | 200± | |
| Total Wells & Locations | 3,050 | 1,059 |

The grand total wells plus locations for the Stevens and Shallow Zones is 4,109 plus 6 for Carneros and Dry Gas Zones making a field total of 4,115.

In reply to Question No. 2, the spacing for the Stevens Zone would be ten acres/well and for the Shallow Zone five acres/well.

In reply to Question No. 3, the cost of drilling and completing each Shallow Oil Zone well is $50,000 and is $113,000 for each Stevens Zone well.

In reply to Question No. 4, the cost of surface equipment to handle 453 million barrels production the first year is $158,069,000.

In reply to Question No. 5, the initial rate at the beginning of the emergency production is 1,505,000 barrels/day and at the end of the first year is 999,000 barrels/day

In reply to Question No. 6, the decline rate during the first year is 33.6% (loss ratio) and the second year production is 302 million barrels

In reply to Question No. 7, no loss of ultimate recovery is anticipated since the closer well spacing required will tend to cause new reserves to be developed due to the discovery of additional fault blocks and sand lenses and due to better drainage because of less bypassing in the presently developed areas because of reservoir heterogeniety.

In reply to Question No. 8, the manpower requirements and operating costs under the above rate conditions can be estimated by scaling up similar estimates from the 230,000 barrels/day Contingency Plan. The estimates are as follows:

$$\frac{445 \text{ People}}{230 \text{ M b/d}} \times 1241 \text{ M b/d} = 2,400 \text{ People}$$

$$\frac{\$18,160,000}{230 \text{ M b/d}} \times 1241 \text{ M b/d} = \$95,000,000 \text{ in the first year}$$

In reply to Question No. 9, the manpower requirements to maintain Naval Petroleum Reserve No. 1 on a standby basis would be 90 Unit Operator employees and 24 Navy employees (20% more than at present) and assuming the current philosophy of contracting work will continue. The maintenance and operating costs for standby operations can be estimated on the basis of current costs as follows:

$$\frac{\$3,500,000/\text{Year}}{1,022 \text{ Wells}} \times 4,000 \text{ Wells} = \$15,000,000/\text{Year}$$

This office estimates the operation and maintenance costs to range from $8,000,000 to $15,000,000/year. Information is not readily available which would permit subdividing these costs by categories. The Government interest is not taxed by the State or County Governments. However, the 20% interest in Naval Petroleum Reserve No. 1 owned by Standard Oil Company of California, is taxed at the rate of $1,600,000/year by the County. Idle standby labor is not contemplated since most work will be done by contract.

In reply to Question No. 10, no additional investments such as modification of power distribution networks are contemplated except for pipelines and for gas compression for crude and gas transport from the field.

In reply to Question No. 11, the time required to bring the field to the required state of readiness is eight to ten years.

In reply to the last paragraph of your letter, the Navy at this time does not recommend an initial rate of 453 million barrels per year although that rate is possible. The maximum rate that the Navy would recommend at this time is 755,000 barrels/day and details of the plan for this rate will be forwarded to you as soon as it is available.

Sincerely yours,

J. P. TRUNZ, JR.
Commander, CEC, USN
Director

# LAND ECONOMICS

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## A National Defense Petroleum Reserve Alternative to Oil Import Quotas†

*By* WALTER J. MEAD* and PHILIP E. SORENSEN**

THE NET SOCIAL COST to the nation of the oil import quota system is estimated to be between one and four billion dollars annually. Quotas were originally instituted and now wholly justified on national security grounds. But an alternative program is available which offers both a known present degree of national security at lower cost and a higher degree of long-run national security. This paper presents the case for that alternative program.

### *Oil Import Quotas*

During World War II the United States shifted from a net oil-exporting status to a net-importer status. In the postwar periods, imports expanded rapidly such that in 1957 crude oil imports amounted to 11.6 per cent of domestic demand. Faced with increasing foreign competition, the domestic oil industry, joined by the coal industry, persuaded the federal government to institute a program of voluntary restrictions on crude oil imports in 1957. The voluntary program proved to be ineffective and on March 10, 1959, President Eisenhower, by proclamation, ordered mandatory import quotas.

The President stated that "the basis of the new program, like that for the voluntary program, is the certified requirements of our national security which make it necessary that we preserve to the greatest extent possible a vigorous, healthy petroleum industry in the United States." The Trade Agreements Extension Act of 1955 provided that "whenever the Director of the Office of Defense Mobilization (hereinafter referred to as ODM) has reason to believe that any article is being imported into the United States in such quantities as to threaten to impair the national security, he shall so advise the President," and that the President "shall take such action as

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† The authors wish to thank the John Randolph Haynes and Dora Haynes Foundation and the Sea Grant Program of the National Science Foundation for financial support of their research. While retaining complete responsibility for the analysis, we also want to express our appreciation for criticism and comments to M. A. Adelman, S. David Freeman, Richard L. Gordon, Stephen L. McDonald, and George J. Stigler.

* Professor of Economics, University of California, Santa Barbara.

** Associate Professor of Economics, Florida State University, Tallahassee.

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he deems necessary to adjust the imports of such article to a level that will not threaten to impair the national security." On April 23, 1957 and again on February 27, 1959, directors of ODM certified to the President that "crude oil and the principal crude oil derivatives and products were being imported in such quantities and under such circumstances as to threaten to impair the national security." Neither the certifications nor any studies submitted prior to the certifications provided an economic analysis of the oil-import national-security relationship. There was no estimate of the economic cost of oil import restriction and there was no estimate of alternative means of satisfying a national security requirement.

A major motive of the oil industry in pressing for import quotas, as for any industry asking for a restriction in competition, was to obtain a higher price for its domestic product. The import quota system limits imports into Petroleum Administration Districts I to IV (the area east of the Rocky Mountains) to 12.2 per cent of estimated domestic production in these districts. Imports into District V (the area west of the Rocky Mountains including Hawaii and Alaska) are limited to the difference between (1), the sum of District V domestic production, shipments from Districts I-IV into District V, and overland imports from Canada and Mexico; and (2), total demand (at the desired price) in that District as estimated by the Bureau of Mines. Given this limitation on foreign supply, the price of crude oil in the United States has increased and the gap between United States crude prices and world prices of crude oil has widened up to 1970. The Cabinet Task Force on Oil Import Control concluded that Middle Eastern crude oil could be imported into the United States at a free trade cost of $2.14 per barrel. Adding the existing tariff of 10½ cents per barrel the delivered price in the absence of quotas would be about $2.25 per barrel. The East Coast delivered price of domestic crude was estimated at $3.89 per barrel. Thus the East Coast premium due to oil import quotas was about $1.65 per barrel.[1] Market place support for this conclusion is offered in the fact that import quota tickets distributed free of charge to domestic refiners in 1969 traded at about $1.50 per barrel.[2]

The import quota system fails in several respects as a solution to the national security problem. Given import restrictions, domestic prices of crude oil and finished petroleum products rise above their free market levels. Thus an economic efficiency problem is created: (a) High domestic crude oil prices lead producers to develop submarginal fields and continue to produce from inefficient wells. Resources are misallocated and in the process the nation's security is damaged. (b) Restrictions on imports force the United States to accelerate the rate at which it depletes its domestic reserves. Since oil is a non-renewable resource, future security is sacrificed in order to obtain present security. (c) Industries such as the petrochemical industry which use oil as a feed stock in producing products sold on world markets are placed in a noncompetitive position. These industries thus have an incentive to establish plants abroad. (d) The question of distributive equity arises. Consumers must

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[1] Cabinet Task Force on Oil Import Control *The Oil Import Question* (Washington, D.C., February 1970), p. 19.

[2] *Ibid.*, p. 260. The 1970 curtailment of Libyan oil production and the closure of the Trans-Arabian Pipeline (reopened in 1971) caused a shortage of oil available in the Mediterranean. Compensatory shipments have been made from the Persian Gulf around South Africa, as well as from other distant shipping points. As a result of the increased demand for tankers, shipping rates have increased sharply, temporarily eliminating the value of import tickets.

pay higher prices for refined products while owners of crude oil resources receive windfall gains. The cost of whatever degree of national security we purchase through quotas is in no sense equally shared. (e) Finally, important quotas are not an effective method for securing a specific level of national security since there is no necessary relationship between the quota, on one hand, and the volume of reserve productive capacity on the other. In view of these problems we should inquire—is there a better way to meet our national security requirements?

### *The National Defense Petroleum Reserve Proposal*

The most attractive alternative method of providing a reliable future petroleum supply for security purposes appears to be a shut-in domestic petroleum reserve. McDonald has suggested that the federal government "purchase wholly or partially developed petroleum reservoirs and set them aside as a reserve to be drawn upon in the event of emergency."[3] This "explicit national defense reserve" would utilize the lowest cost method of oil storage, its in-situ natural state. Where entire reservoirs are dedicated to a national defense reserve and properly maintained, there is no loss through oil migration, evaporation, or deterioration. That quantity of petroleum estimated to be needed for future emergency supply may be provided by reservoir acquisition. If the need for reserves increases, additional reservoir purchases can be made. Geographical needs for reserve capacity may be provided by appropriately located acquisitions and by pipeline construction. The present import quota system, in contrast, is haphazard. In various ways, both domestic and foreign exploration and production are heavily subsidized but no provision is made for an explicit reserve capacity. If excess capacity is equal to national defense needs, it is purely a chance event.

*The Record of Naval Petroleum Reserves.* There is a little known but highly significant history of military petroleum reserves in the United States. In 1909, President Taft, by executive order, temporarily withdrew from the public domain 38,073 acres of potential oil land located in the Elk Hills field southwest of Bakersfield, California, an area later designated as Naval Petroleum Reserve No. 1. Subsequent additions to this Reserve have increased the total acreage to 46,095 acres, of which 81 per cent (79 per cent of the known oil) is owned by the federal government. The remaining 19 per cent is owned by Standard Oil Company of California.[4] In June 1944, the Federal Government entered into a "Unit Plan Contract" with Standard which gave to the Navy "full and absolute power to determine from time to time the rate of prospecting and development on, and the quantity and rate of production from, the Reserve," including the right to "shut in wells on the Reserve if it so desires."[5]

Estimates provided by the Navy indicate that the Elk Hills Petroleum Reserve as presently developed contains

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[3] Stephen L. McDonald, "Conservation Policies and National Security," *Quarterly of the Colorado School of Mines*, October 1969, p. 154.

[4] Department of the Navy, "History of Naval Petroleum and Oil Shale Reserves," mimeographed (June 30, 1969), p. 25.

[5] "Unit Plan Contract between Navy Department and Standard Oil Company of California Relating to Naval Petroleum Reserve No. 1 (Elk Hills)," Contract No. NOd-4219, June 19, 1944. As a consideration for entering into the Unit Plan Contract, Standard received the right to recovery of 25,000,000 barrels of oil from its share of the Reserve, together with associated hydrocarbons, or ⅛ of Standard's share of the estimated recoverable oil in the shallow oil zone "whichever of said events shall first occur." *Ibid.*, pp. 10-11.

1,363,435,000 barrels of recoverable oil (utilizing known primary recovery methods), plus 1.8 trillion cubic feet of gas. This oil reserve amounts to approximately one-third of the current annual United States crude oil consumption. The current rated efficient productive capacity of the Elk Hills Reserve is 160,000 barrels per day (58.4 million barrels per year) available on a 60-day notice basis. The Navy has also estimated that, with an additional $100 million for capital investments, the 60-day emergency productivity of this Reserve could be efficiently increased to 350,000 barrels per day (127.75 million barrels per year) which would approximately equal current foreign imports into the West Coast, not counting imports from Canada. Initial output levels may be increased further with additional development investments.

Reserves in the Elk Hills field are currently known to be in three different zones. The largest is the Stevens zone, estimated by the Navy to contain 854.15 million barrels or nearly two-thirds of the presently known Elk Hills Reserve.[6] This zone is partially developed by 236 wells. All but one of these is in complete shut-in status but fully producible on a 60-day notice. The single exception is producing from a different Stevens zone field *inside* the Elk Hills Unit and is operating only to protect the Reserve from an adjacent well operated by Atlantic-Richfield Company. This single well is currently producing at a rate of only 20 barrels per day. In addition, *outside* of the Elk Hills Unit several operators are producing on private land from Stevens zone oil. This has forced the Navy to produce approximately one million barrels per year from adjacent Reserve lands.

The Shallow zone in the Elk Hills Reserve had its static equilibrium disturbed by early and wartime production and is subject to water encroachment and possible migration to privately-owned properties outside of the Reserve unit. In order to protect its reserve the Navy is producing approximately one million barrels of oil per year from this zone to evaluate equipment, monitor reservoir performance and prevent water encroachment. This amounts to 0.3 per cent of the estimated reserves in this zone. Finally, some production is taking place from the least developed and the smallest of the three zones, the Carneros. Annual production currently amounts to about 0.4 per cent of its estimated reserve.

In addition to the Elk Hills Reserve, there are three other designated naval petroleum reserves. In 1910 oil was discovered in the Buena Vista Hills area, immediately south of the Elk Hills Reserve. In 1912, President Taft set aside 30,181 acres as Naval Petroleum Reserve No. 2. However, 63 per cent of this acreage was already subject to private claims and thus only 37 per cent of NPR No. 2 is in government ownership. Unlike Elk Hills, this Reserve is not covered by a unit-operating agreement. Consequently, private owners are producing oil from this field on a commercial basis and the Navy, in order to protect the public interest in the Reserve, has been forced to lease its mineral interests for commercial production. Thus, NPR No. 2 is not a true national defense petroleum reserve but is, rather, in the same defense status as an existing productive oil field in private ownership. As of January 1, 1969, NPR No. 2 had estimated reserves (Navy owned) amounting to

[6] Department of the Navy. "Navy Report as of and to December 31, 1969, Elk Hills Field, Naval Petroleum Reserve No. 1," January 12, 1970, p. 4.

23,054,200 barrels of oil and its current annual production, 2.6 million barrels, is approximately 11 per cent of its remaining reserves. It has no additional standby capacity.

Naval Petroleum Reserve No. 3 is more renowned for its scandalous history than as a petroleum reserve. By executive order, President Wilson designated the Teapot Dome area in Wyoming as a naval petroleum reserve in 1915. In 1921 President Harding transferred administration of the petroleum reserves from the Navy to the Secretary of the Interior. In 1922 the Teapot Dome Reserve was leased to the Mammoth Oil Company formed by Harry F. Sinclair, while Elk Hills reserves were leased to the Pan-American Petroleum and Transport Company, owned by Edward L. Doheny. The U.S. Supreme Court determined that the lease arrangements were products of "conspiracy, corruption and fraud" and ordered the lands to be returned to the Navy in 1927. Following the Supreme Court judgment, the Teapot Dome Reserve was shut in until 1952. In 1949 and 1950, oil was discovered on private lands adjacent to the Reserve and the Navy was subsequently forced to withdraw oil from the Reserve in order to avoid a drainage loss. In 1968 production from NPR No. 3 amounted to 313,000 barrels. Estimated reserves are a relatively modest 50 million barrels. Thus, protective production is running at a rate of 0.6 per cent per year.

Since oil is a migratory common property resource, commercial production from adjacent private lands drawing on the same oil reservoir has forced the Navy to engage in matching commercial production from the above three Reserves in order to protect the public ownership. This production is contrary to national defense reserve objectives. The obvious solution is for the federal government to purchase adjoining private interests that tap reservoirs which are part of the Reserves. To date, funds have not been made available for this purpose.

Naval Petroleum Reserve No. 4 was established in Alaska by President Harding by an Executive Order signed in 1923. This Reserve encompasses 23,680,000 acres which is more than 500 times as large as Elk Hills in terms of geographical area. It is located on the North Slope of Alaska directly west of the major Prudhoe Bay discoveries. Although three oil fields have been discovered and gas is currently being produced, the total Reserve has not been adequately evaluated. A drilling program carried on between 1944 and 1953 was limited to the relatively shallow Cretaceous zones, while the deeper zones in which Prudhoe Bay oil has been found have not yet been explored. Estimates concerning the recoverable reserves from NPR No. 4 have varied from 4 to 25 billion barrels.[7]

For NPR No. 4 to qualify as a ready reserve, standby delivery capacity must be made available. The Cabinet Task Force on Oil Import Control estimated that a 3-million-barrel-per-day standby capacity would require a pipeline from the North Slope to Valdez, Alaska having an initial cost of $1.9 billion. Furthermore, in order for this reserve capacity to be of maximum military use, oil should be delivered by pipeline to the Chicago area. This involves an additional, but not estimated, cost. Annual maintenance cost for the pipeline only is assumed by the Task Force to amount to $20 million per year. The high cost of idle capacity under Arctic conditions

[7] The Cabinet Task Force on Oil Import Control, *op. cit.*, p. 306.

TABLE I—ESTIMATED NET BEFORE-TAX INCOME, DISCOUNTED TO OBTAIN A PRESENT VALUE FOR THE ELK HILLS NAVAL PETROLEUM RESERVE

| Year | Production (thousand barrels of oil) | Value@$3.00/bbl. for oil, plus gas @41¢/bbl. of oil = $3.41[a] | Lifting cost per barrel | Total lifting cost | Additional capital cost (Mill. $) | Before-tax net income (value less costs) | Present value at 18% discount |
|---|---|---|---|---|---|---|---|
| 1. | 127,750 | $435,627,500 | $0.25 | $31,937,500 | $20 | $383,690,000 | $325,158,090 |
| 2. | 127,750 | 435,627,500 | .25 | 31,937,500 | 20 | 383,690,000 | 275,558,484 |
| 3. | 127,750 | 435,627,500 | .25 | 31,937,500 | 20 | 383,690,000 | 233,525,245 |
| 4. | 127,750 | 435,627,500 | .25 | 31,937,500 | 20 | 383,690,000 | 197,899,628 |
| 5. | 127,750 | 435,627,500 | .25 | 31,937,500 | 20 | 383,690,000 | 167,710,899 |
| 6. | 117,205 | 399,699,050 | .27 | 31,645,350 | | 368,023,700 | 136,327,019 |
| 7. | 98,277 | 335,124,570 | .29 | 28,500,330 | | 306,624,240 | 96,255,481 |
| 8. | 88,405 | 301,461,050 | .31 | 27,405,550 | | 274,055,500 | 72,906,980 |
| 9. | 69,096 | 235,617,360 | .33 | 22,801,680 | | 212,815,680 | 47,979,295 |
| 10. | 57,937 | 197,565,170 | .35 | 20,277,950 | | 177,287,220 | 33,872,496 |
| 11. | 48,581 | 165,661,210 | .38 | 18,460,780 | | 147,200,430 | 23,833,222 |
| 12. | 40,735 | 138,906,350 | .41 | 16,701,350 | | 122,205,000 | 16,768,000 |
| 13. | 34,156 | 116,471,960 | .44 | 15,028,640 | | 101,443,320 | 11,795,829 |
| 14. | 28,640 | 97,662,400 | .47 | 13,460,800 | | 84,201,600 | 8,297,226 |
| 15. | 24,015 | 81,891,150 | .50 | 12,007,500 | | 69,883,650 | 5,835,984 |
| 16. | 20,136 | 68,663,760 | .53 | 10,672,080 | | 57,991,680 | 4,104,071 |
| 17. | 16,884 | 57,574,440 | .57 | 9,623,880 | | 47,950,560 | 2,875,595 |
| 18. | 14,157 | 48,275,370 | .61 | 8,635,770 | | 39,639,600 | 2,014,881 |
| 19. | 11,870 | 40,476,700 | .65 | 7,715,500 | | 32,761,200 | 1,411,025 |
| 20. | 9,953 | 33,939,730 | .70 | 6,967,100 | | 26,972,630 | 984,501 |
| 21. | 8,346 | 28,459,860 | .75 | 6,259,500 | | 22,200,360 | 686,657 |
| 22. | 6,998 | 23,863,180 | .81 | 5,668,380 | | 18,194,800 | 476,886 |
| 23. | 5,868 | 20,009,880 | .86 | 5,046,480 | | 14,963,400 | 332,337 |
| 24. | 4,920 | 16,777,200 | .92 | 4,526,400 | | 12,250,800 | 230,560 |
| 25. | 4,126 | 14,069,660 | .99 | 4,084,740 | | 9,984,920 | 159,259 |
| 26. | 3,459 | 11,795,190 | 1.06 | 3,666,540 | | 8,128,650 | 109,899 |
| 27. | 2,901 | 9,892,410 | 1.14 | 3,307,140 | | 6,585,270 | 75,467 |
| 28. | 2,432 | 8,293,120 | 1.22 | 2,967,040 | | 5,326,080 | 51,716 |
| 29. | 2,039 | 6,952,990 | 1.30 | 2,650,700 | | 4,302,290 | 35,408 |
| 30. | 1,710 | 5,831,100 | 1.40 | 2,394,000 | | 3,437,100 | 23,956 |
| 31. | 1,434 | 4,889,940 | 1.50 | 2,151,000 | | 2,738,940 | 16,187 |
| 32. | 1,202 | 4,098,820 | 1.60 | 1,923,200 | | 2,175,620 | 10,878 |
| 33. | 1,008 | 3,437,280 | 1.71 | 1,723,680 | | 1,713,600 | 7,266 |
| 34. | 845 | 2,881,450 | 1.83 | 1,546,350 | | 1,335,100 | 4,793 |
| 35. | 709 | 2,417,690 | 1.96 | 1,389,640 | | 1,028,050 | 3,125 |
| 36. | 594 | 2,025,540 | 2.11 | 1,253,340 | | 772,200 | 1,992 |
| 37. | 498 | 1,698,180 | 2.26 | 1,125,480 | | 572,700 | 1,248 |
| 38. | 418 | 1,425,380 | 2.40 | 1,003,200 | | 422,180 | 781 |
| 39. | 350 | 1,193,500 | 2.60 | 910,000 | | 283,500 | 445 |
| 40. | 294 | 1,002,540 | 2.78 | 817,320 | | 185,220 | 250 |
| 41. | 246 | 838,860 | 2.98 | 733,080 | | 105,780 | 120 |
| 32. | 207 | 705,870 | 3.10 | 641,700 | | 64,170 | 61 |
| 43. | 34 | 115,940 | 3.41 | 115,940 | | -0- | -0- |
| | 1,369,435 | $4,669,773,350 | | $465,496,610 | $100 | $4,104,276,740 | $1,667,343,242 |

[a] Gas is valued at 31¢/MCF at Elk Hills. The reserve estimates indicate that there are 1,363 cu. ft. of recoverable gas per barrel of oil. Thus, the value of the associated gas is 41¢/barrel of oil.

may be offset by some potential advantages in terms of reserve size and absence of private claims within the Reserve.

*The Opportunity Cost of a Petroleum Reserve.* The merits of the explicit National Defense Petroleum Reserve proposal must be judged, first, on the basis of its net social cost relative to alternative methods and second, by comparison of the physical effectiveness of the proposed and alternative methods of supplying oil in emergencies.

The social cost of the proposed alternative is the cost of foregone opportunities, plus the cost of standby equipment maintenance and of standby pipeline capacity. By holding otherwise productive reserves idle, we forego the right to produce oil on an economic liquidation basis. The foregone opportunity involves an interest cost on the immobilized capital. This cost will be estimated by calculating the market price for a developed petroleum reservoir such as Elk Hills, and then imputing an interest cost to the immobilized capital in order to obtain an annual capital cost. We will then add the estimated cost of continuing maintenance for a shut-in reserve held in standby status. We must identify the annual cost of maintaining all of the necessary equipment for an operating oil field even though the field in fact is shut in. Finally, we will add the estimated annual capital and maintenance cost for standby pipeline capacity which must be available to connect the reserve field with a pipeline grid.

In order to estimate the costs outlined above, we will use the Elk Hills Petroleum Reserve as a case study. Elk Hills is currently the most fully shut in of the nation's developed oil fields. Further, there is an adequate cost history of shut-in field management at Elk Hills that may be drawn upon. In order to estimate the important capital costs we will determine the price that a willing buyer would pay to a willing seller to acquire an entire oil field such as Elk Hills. We assume that this figure will be representative of the per-unit capital cost of meeting any defined level of national security needs by means of reserve expansion.

The present value of a delineated petroleum reserve is its future wellhead value, minus both the additional capital costs necessary to recover the oil and the lifting costs, all discounted to the present. The Elk Hills Reserve is estimated to contain 1,363,435,000 barrels of oil. Assuming an orderly rate of commercial production at a stable daily output for five years, followed by a logarithmic declining output thereafter for a total 43-year depletion period, the initial level of production amounts to 127,750,000 barrels per year. The annual output based on this production schedule is shown in Table I. Using early 1970 oil prices the wellhead value of Elk Hills oil was $3.00 per barrel.[8] The cost of lifting the oil

[8] While our analysis uses a 1970 (Spring) market price for oil it overstates the social value of oil since both import quotas and market demand prorationing reduce the supply of oil and thereby create an artificially high price. On the other hand, the depletion allowance and other tax favors reduce the after-tax cost of production and thereby provide a slight stimulant to exploration and production which in turn artificially lowers the price. An Interior Department study in 1969 concluded that, in the absence of import quotas restricting imports into District V, the price of West Coast crude petroleum would decline about 75 cents per barrel. (Letter from Cordell Moore, Assistant Secretary of the Interior, to Senator William Proxmire, January 16, 1969). After the Interior Department study was completed, the price of domestic crude was increased approximately 25 cents per barrel without a corresponding change in the world oil price. Therefore, we may estimate that if artificial impediments to trade were removed, the price of West Coast crude petroleum under conditions prevailing at the time of the study would decline approximately one dollar per barrel. We would therefore be justified in using, not $3.00 per barrel wellhead price, but $2.00 per barrel. The latter would more accurately reflect the social value of oil on the West Coast. Nevertheless, we have used the 1970 crude market price. We expect that additional petroleum reserves would be acquired before import quotas would be removed. Thus, present owners of any acquired reserves would not suffer a capital loss due to the United States price of crude oil falling to a competitive world level.

would be low during the early period of production and would rise steadily thereafter as field pressure is reduced. We have accepted Navy estimates that the initial lifting cost would amount to 25 cents per barrel and would increase logarithmically thereafter until the 43rd year when the lifting cost would equal the value of the oil. At this point production would cease.

As noted earlier, the Navy has estimated that an additional $100 million of investment is necessary for full field development of the two currently known major reservoirs of the Elk Hills Reserve. We have assumed an additional $20 million capital investment for each of the first five years of production.

Table I shows estimated net income from commercial operation of the Elk Hills Petroleum Reserve, by year, through the productive life of the field. In order to compute the present value of expected future net income we need a discount rate which a representative oil company would use to capitalize income from an oil field. The present value thus obtained would approximate the price a willing buyer would pay to a willing seller for an oil property such as Elk Hills.

We have used an 18-per-cent rate to discount *before-tax* net income. Given the existence of the depletion allowance and other tax arrangements favorable to oil production, oil industry taxes are minimal. In 1968 the twenty-one largest United States oil companies had an average effective federal income tax rate of 7.7 per cent.[9] From 1962 through 1968 this average tax rate varied from a low of 4.0 per cent to a high of 8.3 per cent. Accordingly, an 18-per cent before-tax rate of return in the oil industry is equivalent to approximately 16.6 per cent *after taxes*. Given the degree of risk involved in estimating oil reserves, together with uncertain future events (including tax legislation), an 18-per-cent discount rate for *before-tax* income appears reasonable.[10]

We conclude that the present value of the Elk Hills Reserve is $1,667 million. The social cost of this immobilized capital is the annual interest cost. Utilizing a six-per-cent social time preference rate, the annual interest cost is $100.2 million or (dividing by 1,363,435,000 barrels of reserve) 7.3 cents per barrel of reserve per year.[11]

In addition, annual maintenance costs on the idle production facilities and management expenses must be estimated. To fulfill its objectives, a National Defense Petroleum Reserve must be maintained in a perpetual state of readiness. The equipment must be replaced when it deteriorates or becomes obsolete. These costs are avoidable by liquidating the Reserve and are therefore chargeable to it. In fiscal year 1969, total management costs (including administrative expenses) for the entire Elk Hills Reserve were $3,876,036. A four-million-dollar annual expenditure for maintenance and management is believed to be adequate. This amounts

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[9] U.S. Senate, *Congressional Record*, July 14, 1969, p. 8029.

[10] In a 1956-57 study, Lanzillotti found that large firms used an average 14-per-cent, after-tax target rate of return in pricing products, and individual firms varied between 10 and 20 per cent. Robert F. Lanzillotti, "Pricing Objectives in Large Companies," *American Economic Review*, December 1958, p. 923.

[11] By way of comparison, if we assume a 10-per-cent discount rate for both the private oil company and for society, the present value of the Elk Hills Reserve is $2,315 million and the annual interest cost is $231.5 million or 17¢ per barrel of reserve per year. There is no reason for assuming that private and social rates of discount would be (or should be) equal in this situation. Cf., M. S. Feldstein, "The Social Time Preference Discount Rate in Cost-Benefit Analysis," *Economic Journal*, June 1964, pp. 360-79. Our analysis has not taken any credit for the possibility that crude oil prices in the future might continue to increase as they have in the past. A six percent annual gain would eliminate the holding cost on oil reserves.

to 0.3 cents per barrel of reserve per year.

Finally, standby pipeline capacity must be available to transport oil to its major markets, or to connecting pipelines. Oil production from private lands surrounding the Elk Hills Reserve has been declining and idle pipeline capacity happens to exist at the moment. However, owners of these pipelines will expect to be compensated for providing continuing standby capacity. Furthermore, we are interested in generalizing our findings to other similar fields which might be purchased and added to the nation's petroleum reserves. Accordingly, we must estimate the social cost of standby pipeline capacity consisting of interest on and amortization of invested capital, plus maintenance costs. A 36-inch pipeline, 100 miles long, running from Elk Hills to Los Angeles involves a capital cost of about $50 million. Pumping stations and other facilities add another $10 million. Annual maintenance charges would amount to about $250,000. Assuming a 30-year pipeline life and that the pipeline company requires an 18 per cent before-tax yield on its invested capital, the annual interest and amortization cost amounts to $10.9 million.[12] Adding the $250,000 annual maintenance cost this totals 0.8 cents per barrel of reserve per year.

The sum of all estimated annual social costs for a petroleum reserve similar to the Elk Hills Reserve is $115,350,000. This amounts to 8.5 cents per barrel of reserve per year.[13] Reserves can be made available indefinitely at approximately this cost by purchase of additional oil fields for inclusion in the Reserve system. Fields located far from a pipeline grid or in an environment involving high maintenance costs will involve slightly higher annual expenditures.

If a higher level of emergency production is desired, closer well spacing, additional field production facilities, larger pipeline capacity, and greater pumping capacity would be necessary, requiring additional investment commitments. Initial emergency production would be higher than provided in the commercial production schedule shown in Table I. The Navy estimates that with an additional investment of $278 million, initial year emergency production amounting to 453 million barrels may be attained (instead of 127.75 million barrels).[14]

Again using a 6-per-cent social time preference rate, the annual cost (interest and amortization) of an additional $278 million investment is $20.2 million. Standby maintenance costs would increase annual charges by another $10 million. Adding this to the $115,250,000 estimated above, we arrive at an annual social cost of $145.5 million. Thus, the annual cost of holding 1,363,499,000 barrels of oil in reserve indefinitely at a higher rate of initial emergency production becomes 10.7 cents per barrel of reserve.

Alternatively, the social cost of an in-situ reserve may be expressed as a cost per barrel of additional emergency oil

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[12] Pipeline companies do not have the same tax advantages that oil companies enjoy. They are subject to rate regulation. An 18-per-cent before-tax rate of return would produce approximately nine per cent after taxes.

[13] Alternatively, assuming a uniform 10-per-cent discount rate for private oil companies, pipeline companies and society, the sum of all estimated costs is 17.8¢ per barrel of reserves per year.

[14] Instead of a constant rate of production for each of the first five years, followed by a declining rate of production for a total of 43 years, the added investment would permit the following liquidation schedule:

| Year | Production (mill. bbls.) | Year | Production (mill. bbls.) |
|---|---|---|---|
| 1 | 452.7 | 10 | 13.2 |
| 2 | 301.7 | 11 | 9.2 |
| 3 | 200.3 | 12 | 5.7 |
| 4 | 133.2 | 13 | 3.7 |
| 5 | 89.1 | 14 | 2.9 |
| 6 | 61.3 | 15 | 1.4 |
| 7 | 40.6 | 16 | 1.0 |
| 8 | 27.0 | 17 | 0.7 |
| 9 | 19.1 | 18 | 0.5 |

supplies in some time period, say one year. Thus, the initial 453 million barrels of reserve production capacity is available at a carrying cost of $145.5 million, or 32 cents per barrel, for the initial year.

*Comparison: Import Quota and the Petroleum Reserve Alternatives*

The social cost of the existing system of import quotas has been estimated by both the Charles River Associates and by the United States Department of the Interior. The CRA Study concluded that the annual social cost amounted to $3.9 billion.[15] The Department of the Interior estimated lower costs of the present system for two years, 1975 and 1980, under minimum and maximum assumptions about domestic production in these years.

Prorationing is assumed to continue under the quota system.[16] Resolving this difference of opinion and assumptions in favor of the quota system, we will use the United States Department of Interior estimates of import quota costs, assuming a low level of domestic production in the absence of quotas.[17]

According to the analysis of the Interior Department, the import quota system will stimulate an increase in domestic crude oil production (in 1975) by 2.17 billion barrels at a social cost of $2.26 billion. This amounts to $1.04 per barrel of additional domestic production. Thus, utilizing the most favorable estimate of quota system costs, we find that the cost of providing petroleum for national defense emergencies is clearly less expensive under the National Defense Petroleum Reserve proposal (32 cents per barrel of initial year production) than under the quota system ($1.04 per barrel of annual production). Whereas shut-in petroleum reserves can be maintained indefinitely at the relatively low cost of 8.5 cents per barrel of reserves, high level domestic production of a non-renewable resource as provided by the quota system cannot be perpetual. Further, the already high cost of domestic production stimulated by the quota system will increase persistently as we continue to exhaust the lowest cost domestic reserves.

The Interior Department has also studied and published estimates on sev-

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[15] James C. Burrows and Thomas A. Domencich, *An Analysis of the United States Oil Import Quota*, A Charles River Associates Research Study (Lexington, Massachusetts: 1970), p. 158. This analysis is based on 1968 data and assumes that prorationing would be impossible in the absence of import restrictions. Elasticity of demand is assumed to be −.05.

[16] United States Department of the Interior, Bureau of Mines, "The Cost of the Oil Import Quota Program: A Reconciliation of the Adelman, Blair, Charles River Associates, and United States Dept. of the Interior Estimates," mimeographed, Sept. 1969, Table 4. Like the CRA study, the USDI analysis assumes that prorationing would end with the termination of quotas. Demand is assumed to be highly inelastic, −0.02. *Ibid.*, p. 13.

[17] The social costs of the import quota system (net of income redistribution) consist of three elements. First, society bears the cost of inefficient production which is stimulated when the domestic price of oil is increased from the $2.14 competitive price to a $3.89 per barrel noncompetitive price created by the restriction of foreign competition. Second, American buyers suffer a loss of consumer's surplus through foregoing additional quantities of oil which might be purchased at lower competitive world prices. Third, society bears the additional cost of inefficiencies arising from state prorationing systems. Market-demand prorationing is possible only in a market insulated from competition. If import quotas were removed, continuation of the state market-demand prorationing system would be impossible. The estimate of the social cost of import quotas should be distinguished from the cost to consumers. The latter includes in addition the cost of transfer payments from consumers to the oil industry. The cost to consumers has been estimated in several studies. Adelman wrote that "the annual cost for this whole system of organized waste, including the import controls needed to insulate it from foreign competition . . . is just over $4 billion." M. A. Adelman, "Efficiency in Resource Use in Crude Petroleum," *Southern Economic Journal*, October 1964, p. 105. Adelman's estimates for 1962 data were updated by John Blair for 1968 conditions. Blair's estimate indicated a consumer cost of $7.2 billion. United States Congress, Senate, *Hearings* before the Subcommittee on Antitrust and Monopoly of the Committee on the Judiciary, 91st Cong., 1st Sess., Part 1, March 11, 1969, p. 40. The Charles River Associates report estimated consumer costs to be $6.2 billion for 1968, *op. cit.*, p. 7-17. The Cabinet Task Force estimated that the import quota system cost consumers $6.04 billion in 1969 and that this cost will increase to $9.69 billion by 1985, *op. cit.*, p. 262. The Interior Department estimates vary from $7.13 billion for 1975 to $8.15 billion for 1980, *op. cit.*, p. 8.

eral alternatives to import quotas, not including a shut-in petroleum reserve alternative. (See Table II) According to the Interior Department analysis, salt dome storage at $0.39 per barrel per year is the least cost alternative studied.[18] While this alternative is considerably cheaper than import quotas, it is more expensive than shut-in petroleum reserves for the following reasons: (1) Oil for storage must be purchased in the current market rather than at a discounted present value from some future production date. (2) It must bear a lifting cost. (3) The purchased oil must be transported to the site of the salt dome. (4) Finally, it must bear the cost of pumping back into the ground for storage. Recovery and storage involve high capital costs on which interest must be computed. Finally, salt dome storage involves a net loss of some of the oil placed in storage.[19]

With respect to reserve reliability, there are additional doubts regarding the merits of restricting the importation of oil as a means of promoting United States national security. The Cabinet Task Force commented as follows. "The fixed quota limitations . . . bear no reasonable relation to current requirements for protection either of the national economy or of essential oil consumption. The level of restriction is arbitrary and the treatment of secure foreign sources internally inconsistent."[20] The economic rationalization behind import restrictions is that higher crude oil prices are needed in order to induce operators to explore for and develop new petroleum reserves. While the theory in general is valid for a limited time horizon, there is no specific relationship between the limitation of imports, on one hand, and the particular level of desired spare productive capacity, on the other. In fact, the reserve-to-production ratio in the United States has been declining persistently, until the Prudhoe Bay discoveries in Alaska. In 1960 the ratio of proved reserves to annual crude oil production was 12.8. By 1969 this ratio had declined

TABLE II—Cost of Strategic Oil Reserve Alternatives

*(dollars per barrel per year of additional reserves)*

| Program | 1975 | 1980 |
|---|---|---|
| 1. Salt Dome Storage | .39 | .39 |
| 2. Oil Shale Case II[1] | 1.45[2] | .51[2] |
| 3. Present Program (modified to exclude prorationing) | .67 | .68 |
| 4. Oil Shale-Case I[1] | 1.45[2] | .68[2] |
| 5. Steel Tank Storage | .98 | .98 |
| 6. Present Program—with continued prorationing) | 1.04 | 1.04 |
| 7. Subsidize Oil Exploration Case I[3] | 1.12[4] | 1.17[4] |
| 8. Oil from Coal | 1.35[5] | 1.35[5] |
| 9. Subsidize Oil Exploration Case II[3] | 1.56[4] | 1.64[4] |

[1] Oil Shale Case II assumes that an "improved technology" is introduced early enough to affect 1980 costs whereas Case I assumes delayed technological innovation.

[2] 105,000 barrels per day available in 1975.
1,000,000 barrels per day available in 1980.

[3] Subsidy Case I assumes a "straight subsidy" whereas Case II assumes this subsidy plus a "large field" incentive.

[4] 3,500,000 barrels per day available in 1978.
5,000,000 barrels per day available in 1981.
6,000,000 barrels per day available in 1983 @$1.21 per barrel for Case I; $1.69 per barrel for Case II.

[5] 100,000 barrels per day available in 1975.
1,000,000 barrels per day available in 1980.

*Source:* Letter from Mr. John Licca, Deputy Director, Office of Oil and Gas, U.S. Department of the Interior, to Mr. Phillip Areeda, Executive Director, Cabinet Task Force on Oil Import Control, Sept. 19, 1969. Table 1.

[18] The reader should be warned of cost comparability problems due to the use of estimates from diverse studies.

[19] Stigler suggested in private correspondence that "an unregulated system of oil production would also hold reserves for emergencies. If the price of oil were not fixed in an emergency (a huge if), is there even a case for reserves?" If the government would guarantee, and if private owners of oil resources were willing to accept a guarantee, that oil prices would not be controlled or subjected to "jawboning" in any future emergency period involving a shortage of oil, then private owners would indeed have an incentive to provide for probable future shortages.

[20] Cabinet Task Force, *op. cit.*, p. 128. For a similar point of view, see McDonald, *op. cit.*, p. 153.

to 9.3. This decline in the reserve-to-production ratio should in fact be expected. Petroleum is a non-renewable resource. While higher prices will initially bring forth both expanded exploration and new discoveries, the best prospects will be exploited first. Having had favorable tax treatment for oil in the form of depletion allowances since 1926, and having had mandatory import restrictions since 1959, both exploration and production have been stimulated for an extended time period. The best prospects have been exploited, leaving the worst prospects for the present and future. This indeed is the major shortcoming of an oil import restriction program. It sacrifices future national security in order to obtain a higher degree of current self-sufficiency.

The Petroleum Reserve proposal, in contrast, would permit any desired level of strategic reserve. If reserve needs increase, reserves may be expanded through additional purchases. Having guaranteed whatever level of national security is desired, the nation would then be free to import low-cost foreign crude oil for current needs.

Whereas the Petroleum Reserve proposal provides for an increase in oil supplies from secure domestic reserves, the import quota system stimulates domestic exploration and development and thereby increases annual domestic supplies. The Quota system provides no reserve production capacity which may be drawn upon for additional oil supplies in the event of an emergency.

National security objectives are served when a nation allocates its scarce resources in an efficient manner. Whereas the present system of import quotas leads to high cost production and permits well-known prorationing inefficiencies, the Petroleum Reserve proposals in the absence of quotas and prorationing, would permit the free market to allocate resources in a relatively more efficient manner.

McDonald has warned that there are some administrative problems arising out of both acquisition of a Petroleum Reserve system and its management.[21] Selection and valuation of reservoirs pose difficult problems since some of the most important variables are not subject to precise measurement. Multiple ownership interests raise equity problems. Favoritism charges might be heard frequently. Community pressure for various objectives might be mounted against the federal government. Once a large reserve has been established, producers might object that it would be used to exert governmental pressure on crude oil prices. Rules would be needed governing the start-up and close-down conditions. These, and perhaps other problems, must be compared with the lower cost and greater effectiveness of the proposed Petroleum Reserve system. And it should be noted that the present import quota system has its own serious set of administrative problems.

### *Conclusions and Public Policy Implications*

A shut-in National Defense Petroleum Reserve is found to be the lowest cost available means of providing an emergency petroleum supply capacity as an alternative to the present oil import quota system. The social cost of this in-situ storage system is limited to the interest cost on the immobilized investment, the incremental maintenance and management expenditure, and the cost of standby pipeline facilities. The total social cost of this form of national defense reserve is estimated at 8.5 cents per barrel of reserves per year or 32 cents per

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[21] McDonald, *op. cit.*, pp. 155-6.

barrel of additional emergency oil supplies for one year. This is significantly lower than the social cost of the present system of import quotas estimated at $1.04 per barrel per year, calculated on the basis of additional costs to society of incremental domestic production induced by the quota system. The second most attractive reserve alternative is oil storage in salt domes, estimated at 39¢ per barrel per year.

It is reasonable that in-situ storage should be the lowest cost possible storage form. Like any storage arrangement, society foregoes immediate consumption and must therefore bear the interest cost of an immobilized resource. In addition, any storage form will involve costs for equipment and standby pipeline capacity. However, unlike both salt dome storage and steel tank storage, there is no need to first recover the oil, transport it to a storage location and then replace it in storage. Furthermore, where an oil field is 100-per cent owned by the Reserve, there is no cost of seepage, evaporation, or deterioration in field storage. Unlike the present oil import quota system, the shut-in storage proposal involves no interference with the market mechanism and there is no consequent misallocation of resources due to artificially high domestic prices of oil and production from inefficient wells. Since the shut-in reserve proposal does not involve subsidized current production, it does not require a cash subsidy from consumers to owners of oil resources. The reserve proposal provides for an emergency increase in domestic oil supplies not provided by the present system. Finally, since the proposal does not subsidize current production from dwindling United States petroleum reserves, it does not require that future national security be sacrificed in favor of immediate security.

Three public policy implications follow from this analysis. First, on June 11, 1970, President Nixon sent to Congress a draft of a bill to terminate twenty oil leases on federal lands in the Santa Barbara Channel and to compensate the lessees by producing and selling oil from the Elk Hills Naval Petroleum Reserve. The bill provided that: "the Secretary of the Navy is authorized and directed to produce, by whatever means he deems necessary, sufficient oil from Naval Petroleum Reserve Number One to fulfill the requirements" for reimbursement of the lessees. The amount of the reimbursement is to be determined by legal action in the United States District Court. According to one estimate, the ultimate compensation may be in the area of $300 million.[22] If the payment required is near this amount, approximately 100 million barrels (about 7 per cent of the total Reserve) will have to be withdrawn from Elk Hills. While repurchase of the twenty oil leases in the Santa Barbara Channel may be appropriate—given the environmental problems—there is no necessity to compensate the lessees with petroleum from a national defense reserve. Instead, compensation for lease cancellation should pass through the normal Congressional appropriation procedures. This proposal failed in the 91st Congress and has been expanded and resubmitted to the 92nd Congress. The new bill expands from 20 to 35 the number of leases to be repurchased. It further provides for exploration of Petroleum Reserve Number Four, for compensating both the Interior Department and the Justice Department for administrative costs arising out of the repurchase program, and for reimbursing the Treasury Department for rental income lost due to the lease cancellation,

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[22] *Oil and Gas Journal*, June 29, 1970, p. 1.

all to be financed by production and sale of Elk Hills oil.

Second, instead of Elk Hills reserves being reduced, their low cost and their high reliability characteristics suggest that they should be expanded. When the Elk Hills Petroleum Reserve is fully developed it will be sufficient to replace all non-Canadian imports into the United States west of the Rocky Mountains. Given the likelihood that Alaskan production will be available within a few years to further supply national security needs of this region, no large-scale expansion of petroleum reserves is needed in District V. However, privately-owned land in and adjacent to Elk Hills should be acquired to remove the threat of further drainage from the Reserve. Large-scale expansion of petroleum reserves east of the Rocky Mountains is in order. Consideration should be given to acquiring privately-owned oil resources adjacent to the Teapot Dome Naval Petroleum Reserve in Wyoming. Acquisition of these private lands would eliminate the necessity for offsetting production by the Navy and would expand the Reserve itself. Reserves should then be acquired in the important Gulf Coast producing area. For example, the recently discovered "Main Pass Block" No. 112 offshore from Louisiana, reported to be one of the largest United States oil fields, might be purchased in its entirety and placed in ready-reserve shut-in status.[23] Other fields in Texas, Louisiana and Oklahoma, as needed, would then be acquired to complete the reserve system. In all cases, present owners would be fully compensated for the discounted present value of their holdings.

Third, oil import quotas are a costly, inequitable and unreliable method for assuring future strategic energy capacity. The rationale for oil import quotas rests entirely on national security considerations. A National Defense Petroleum Reserve would provide greater long-run security for the nation at a fraction of the cost imposed by the system of quotas. Quotas should be progressively eliminated and a National Defense Petroleum Reserve program should be established at the earliest possible date.

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[23] *Oil and Gas Journal*, June 1, 1970, *68*, p. 30.

## STATEMENT OF JOHN H. LICHTBLAU, EXECUTIVE DIRECTOR, PETROLEUM INDUSTRY RESEARCH FOUNDATION

Dr. LICHTBLAU. I appreciate the committee's invitation to testify at today's hearings on the subject of strategic petroleum reserves, as outlined in title 2 of Senate bill 1586. Strategic reserves as I would define it for this purpose are oil supplies located in this country over and above normal market and inventory requirements and reserved for use only when foreign oil is physically unavailable in sufficient quantities.

The need for such reserves under existing conditions has become so obvious that it is no longer a controversial issue. Unfortunately, that does not mean anything is actually being done about it. There is often a world of difference between recognizing the desirability of a course of action and specific measures to implement it.

Thus, the President in his energy message acknowledged the need for a strategic oil reserve but, so far, the administration has not offered a program to implement it. Neither has the industry, although it should be pointed out that the National Petroleum Council is currently working on a comprehensive study on the subject of emergency preparedness which will include a detailed discussion of strategic reserves.

One of the merits of Senate bill 1586 is that it is calling public attention to the need for specific, early action regarding the establishment of strategic oil reserves in this country. Perhaps, the principal reason why so little has been done on this vital subject up to now is that, like so much else in the U.S. oil industry, the need for it is quite new.

Until 3 years ago our domestic excess crude oil producing capacity was consistently larger than our total waterborne crude oil imports from overseas sources. In 1970, our refineries depended for only 9 percent of their crude oil requirements on such imports and total U.S. reliance on waterborne oil imports, crude and refined products, did not exceed 18 percent.

This year both these percentages will be nearly twice as high and our sustainable excess crude oil producing capacity amounts probably to no more than 400,000 barrels per day, equal to one-fifth our total crude oil imports from overseas. And this is just the beginning. By 1980 our dependency on overseas oil supplies is likely to reach 45 percent of our requirements.

Under these conditions the creation of strategic reserves for security purposes becomes absolutely essential if the United States is not to be subject to the political, military, or accidental vagaries of international oil supplies. Western Europe and Japan have long recognized the need for such reserves and have currently an active policy to increase total oil stocks from their existing level of 65 days of consumption to 90 days over the next 3 to 4 years.

Of course, these countries rely for 90 percent and more of their oil supplies on overseas imports, while the United States even by 1980 will still be about 55 percent self-sufficient, including overland im-

ports from Canada. We need no strategic reserves for our domestic and other North American oil supplies.

But for our growing overseas supplies we probably need a higher ratio of security reserves to demand than Europe's and Japan's new target. As one of the world's two superpowers we may become more subject, and be more sensitive to the threats and pressures of a cutoff in the flow of oil imports than other importing countries.

A large, visible and readily available security storage may well act as a deterrent to any politically motivated cutoff of U.S. oil imports because the exporting or transit country considering such action is much less likely to engage in it if it knows in advance that the United States would not begin to feel the impact for many months.

If adequate security stocks of the various qualities of foreign oil required here were currently available, U.S. refineries would not have to run some 320,000 to 350,000 barrels daily below desired operating levels because of inability to obtain the right type of foreign crude oil.

This would be enough to stave off the threatening gasoline and/or distillate heating oil shortage for this year. Similarly, if security storage had been available in the second half of 1970 when the combination of a substantial Government-decreed reduction in Libyan oil exports and the sabotage of the trans-Arabian pipeline caused a worldwide tanker shortage, there would have been no impact on the United States and perhaps the release of supplies from our security storage would have eased the tanker shortage sufficiently to have affected Libya's exceptional bargaining posture.

Another reason is that our relations with consuming countries require that we adopt security storage. Until we do this the whole talk about a consuming country organization will not be taken very seriously by some of the other consuming countries, because at the moment whenever there is the slightest supply shortage we have to frantically search the world for oil supplies. This is an undesirable situation. It is difficult to create an international cooperation under these conditions.

The first question that must be answered if we are to proceed from the discussion stage to the action stage is who will pay for the cost of strategic reserves. This is of great importance for the cost is quite large. During the 5 years it would take to develop a level of emergency crude oil stocks sufficient to cope with a major foreign supply interruption the total annual cost may well approach $1 billion.

For the petroleum industry which will need all obtainable capital for the construction and expansion of domestic refining capacity and the search for oil and gas in our offshore areas, the expenditure of such an amount would probably require the curtailment of some of these projects.

Given the shortage in both domestic refining capacity and oil and gas supplies, such a shift in funds would hardly make a net contribution to the security of U.S. oil supplies. Since the sole justification for emergency storage is national security, it should be financed in some form by the Government. The logical means of raising the necessary funds would be the security fee which the Government has recently imposed on imported oil.

If this fee were earmarked for this purpose and set at a level designed to cover the cost, it would cease to be an arbitrary figure,

subject to political and bureaucractic challenges and pressures in both directions. Instead, it would represent the true national security cost differential between oil from overseas and from domestic and Canadian sources. This would give the public and its representative finally a visible and logical reason for the cost of the oil import control program. A fee on the importation of a natural resource which is in increasingly short supply domestically may be difficult to justify in the long run. But the need to pay for the cost of storing such a resource so as to have it available in an emergency is bound to make sense to most people.

The security storage facilities financed by the security fee could be managed or controlled by the Federal Government through a Government agency established for the purpose of administering the storage program, similar to the strategic materials stockpiling program carried on by the Government for many years.

Alternately, it could be handled by a nonprofit public corporation functioning under whatever Government regulations are established and whose owners would be the crude oil importers. A third alternative might be a joint industry-Government venture.

Any of these approaches would result in a uniform centralized storage system with exactly equal unit cost, that is cost per barrel, for all participants. This would be superior to a system whereby the crude oil refiner-importers would be individually responsible for maintaining the required security storage.

Under this latter system the unit cost for storage would vary widely, depending on the type of storage facility required, salt domes versus steel tanks, the cost and availability of storage sites, as well as differences in local zoning regulations.

Furthermore, a centralized storage system would be less costly than a private system, since it could make optimum use of salt dome facilities and Government land and could build each storage facility of sufficient size to justify connections to existing pipelines, barge terminals and deep water ports for redelivery of the stored oil.

The size of the security storage depends on the amount of the security fee charged on what kind of interruption we foresee and how much security we wish to buy to guard against this potential interruption. Obviously, the answers to all of these questions are essentially matters of judgment.

For working purposes. however, we would suggest a goal of 4 months of security storage so that each three barrels of crude oil imported from overseas would be backed by one barrel of security storage.

In the very extreme case of the complete and simultaneous unavailability of crude oil from all overseas sources, we would, therefore, be totally unaffected for the first 4 months. By imposing a modest form of compulsory rationing—about 7 or 8 percent of total demand—during this period and by drawing down our normal commercial stocks of crude oil and refined products which together amount to about 60 days of consumption, we would probably be able to avoid at least for the first 6 months a major impact in our economy and security.

Whether this would be enough to settle or alleviate the crisis and whether a 6 months' protection would be a strong enough deterrent

against a showdown export embargo is of course a matter of speculation. It is obvious, however, that a 6 months' protection is far superior to what we have now.

Certainly, our existing stock levels must be considered inadequate to cope with any major future oil supply crisis. The cost of providing 4 months of crude oil security stocks depends principally on three factors—the volume of imports required for this purpose, the cost of imported crude oil, and the type of storage facilities used.

According to a recent National Petroleum Council study, the United States will require approximately 9 million barrels daily of total overseas oil imports by 1980. If we assume, not unreasonably, that half of this volume will consist of crude oil, we will need about 550 million barrels of security storage by 1980 to meet our 4 months requirement.

The Interior Department estimated in a 1966 study the capacity of unused onshore salt domes in the gulf coast area suitable for petroleum storage at 650 million barrels, more than our total requirement. It may be assumed that some of these salt domes are no longer available and that for this and other reasons one-third of the security storage will have to be placed in aboveground steel tanks.

The Cabinet Task Force on Oil Import Control estimated in its 1970 report the annual cost of crude oil storage, assuming a 20-year amortization and an 8-percent discount rate, at 28 cents per barrel for salt domes and 55 cents per barrel for steel tanks.

This figure included land cost—for steel tanks—maintenance and $2 per barrel for delivered overseas crude oil. If we assume the average cost of delivered foreign crude oil over the next 5 years at $4 per barrel and if we increase the other costs in the task force estimate by 25 percent for inflationary factors, the total annual per barrel storage cost over a 20-year period would be, at 8-percent discount, about 55 cents in salt domes and about 90 cents in steel tanks.

I believe the 55 cents compares with Dr. Mead's 32 cents.

Dr. MEAD. It depends on the size of the storage.

Mr. LICHTBLAU. I think the minimum was 32.

Dr. MEAD. Thirty-three for 10 billion barrels.

Mr. LICHTBLAU. So it is a midfigure between 33 cents and 73 cents that Dr. Mead suggested. The 90 cents compares to 74 cents that Dr. Mead suggested.

At our assumed ratio of two-thirds salt domes and one-third steel tanks, the composite annual cost could be about 66 cents per barrel. Thus, for our 4-month security storage we would have to put a security fee of approximately 22 cents per barrel on each barrel of imported crude oil from overseas.

Admittedly, this is a very rough calculation. It excludes the cost of a redelivery system for the stored crude oil which could well amount to several cents per barrel.

Obviously, the 21 cents per barrel current security fee on crude oil would not fully cover the cost as calculated above, not only because the fee itself is too small, but also because for the next several years a substantial part of our imports will come in without fee under the current oil import program.

The same applies for the security fee on finished products. It would therefore be necessary either to adjust the existing fees upward or to

levy an additional fee on all oil imports to cover the balance of the emergency storage cost.

Some of the other provisions would be:

*Canada.*—The security fee should be removed from pipeline imports of Canadian crude oil. The security of this oil has been officially recognized by the U.S. Government as superior to that from any overseas destination.

Our oil import policy should reflect this fact which would act as an incentive for Canadian oil exploration and, thus, to our potential benefit.

*Rationing.*—Another requirement is the establishment of a standby compulsory oil rationing plan. Most European countries have such a standby plan because they realize that it cannot be properly designed and prepared for implementation in the face of an actual emergency.

*Timing of imports.*—Finally, consideration should be given to the time frame within which to build up the emergency storage to its desired level. Given the existing tightness in world oil supplies, it is important to bring in the necessary volumes at low enough import rates not to affect prices and freight rates significantly. For our suggested 4 months emergency storage a 5-year buildup would mean an annual 7-percent increase in U.S. crude oil imports over and above what would otherwise be imported.

I would like to say a word about production reserves as opposed to storage. It is sugegsted in S. 1586 that, in addition to storing imported oil, an emergency reserve can also be acquired by setting aside a percentage of existing or potential commercial domestic oil production as a reserve.

In areas where the drilling and connection of wells is relatively expensive, such as our offshore areas, the cost may be disproportionate when compared with underground storage. But more important than comparative costs are several conceptional drawbacks of shutting in productive reserves for emergency use. I am talking about commercially productive reserves.

For one thing, underlying each barrel of productive capacity is a multiple number of barrels of proved reserves. For operating purposes, the required national average reserve-production ratio at MER without gas flaring may be estimated at 1:8.5, that is for each barrel of production we must have 8½ barrels of approved reserve in the ground.

Thus, if we wanted to shut in a million barrels per day of production we would have to set aside 3.1 billion of proved reserves. On the other hand, if we wanted to have emergency storage for 1 million barrels per day, we would only have to import a total of 365 million barrels and build a redelivery system of the desired capacity.

The difference in these two methods of emergency storage could have a considerable impact on our balance of payments. Using the above example, if we wanted to shut in a million barrels per day of productive capacity, we would have to import a corresponding volume of oil year after year as long as it is available. That is, as long as we have no emergency. The storing of imported oil, by contrast, would only require the importation of this volume for 1 year, if we felt a

1-year security cushion was enough to cope with any realistically conceivable international oil emergency.

Thus, by and large, our optimum course of action should be to maximize domestic oil production in order to minimize our current overseas dependency. At the same time we should import oil above our current needs whenever it is economically available, in order to develop a reliable emergency storage of whatever capacity we deem desirable.

I have not mentioned oil products in my prepared statement. However, I would like to call attention to the fact that the U.S. east coast is almost entirely dependent on imports for its residual fuel oil needs. Utilities at the U.S. east coast are now relying on 70 percent of their generating fuel on residual fuel oil, and virtually all of this residual fuel oil comes from overseas destinations. These utilities have storage equal to about 22 to 26 days of consumption. Additional residual fuel oil storage at the east coast is equivalent to 10 or 12 days of demand for all purposes.

So the total storage facilities for residual fuel oil on the east coast are relatively low. Less than a month, generally. Thus, if this imported oil became unavailable for just 1 month, our large electric utilities on the east coast may have to shut down for lack of generating fuel, since we produce very little residual fuel oil domestically.

So I think in addition to what I've said earlier about crude oil, we should consider emergency storage of residual fuel oil used by electric power plants, where these plants rely primarily on this particular fuel.

This ends my statement.

[The prepared statement of Mr. Lichtblau follows:]

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STRATEGIC PETROLEUM RESERVES

A Statement by

John H. Lichtblau, Exec. Director

Petroleum Industry Research Foundation, Inc.

Before the Senate Committee

on Interior and Insular Affairs

Washington, D.C.

Wed. May 30, 1973, 9:30 a.m.

## Introduction

My name is John H. Lichtblau. I am executive director of the Petroleum Industry Research Foundation, Inc. in New York City.

I appreciate the Senate Interior Committee's invitation to testify at today's hearing on the subject of strategic petroleum reserves, as outlined in Title II of Senate Bill 1586.

Strategic reserves are oil supplies located in this country over and above normal market and inventory requirements and reserved for use only when foreign oil is physically unavailable in sufficient quantities.

The need for such reserves under existing conditions has become so obvious that it is no longer a controversial issue. Unfortunately, that does not mean anything is actually being done about it. There is often a world of difference between recognizing the desirability of a course of action and specific measures to implement it. Thus, the President in his energy message acknowledged the need for a strategic oil reserve, but, so far, the Administration has not offered a program to implement it. Neither has the industry, although it should be pointed out that the National Petroleum Council is currently working on a

comprehensive study on the subject of Energency Preparedness which will include a detailed discussion of strategic reserves. One of the merits of Senate Bill 1586 is that it is calling public attention to the need for specific, early action regarding the establishment of strategic oil reserves in this country.

Our New Dependency on Foreign Oil

Perhaps, the principal reason why so little has been done on this vital subject up to now is that, like so much else in the U.S. oil industry, the need for it is quite new. Until three years ago our domestic excess crude oil producing capacity was consistently larger than our total waterborn crude oil imports from overseas sources. In 1970, our refineries depended for only 9% of their crude oil requirements on such imports and total U.S. reliance on waterborn oil imports -- crude and refined products -- did not exceed 18%. This year both these percentages will be nearly twice as high and our sustainable excess crude oil producing capacity amounts probably to no more than 400,000 bld, equal to one fifth our total crude oil imports from overseas. And this is just the beginning. By 1980 our dependency on overseas oil supplies is likely to reach 45% of our requirements.

## The Need for Strategic Reserves

Under these conditions the creation of strategic reserves for security purposes becomes absolutely essential if the U.S. is not to be subject to the political, military or accidental vagaries of international oil supplies. Western Europe and Japan have long recognized the need for such reserves and have currently an active policy to increase total oil stocks from their existing level of 65 days of consumption to 90 days over the next 3 to 4 years.

Of course, these countries rely for 90% and more of their oil supplies on overseas imports, while the U.S. even by 1980 will be about 55% self-sufficient, including overland imports from Canada. We need no strategic reserves for our domestic and other North American oil supplies. But for our growing overseas supplies we probably need a higher ratio of security reserves to demand than Europe's and Japan's new target.

As one of the world's two super powers we may become more subject, and be more sensitive, to the threats and pressures of a

cutoff in the flow of oil imports than other importing countries. A large, visible and readily available security storage may well act as a deterrent to any politically motivated cutoff of U.S. oil imports because the exporting or transit country considering such action is much less likely to engage in it if it knows in advance that the U.S. would not begin to feel the impact for many months.

If adequate security stocks of the various qualities of foreign oil required here were currently available, U.S. refineries would not have to run some 320,000-350,000 barrels daily below desired operating levels because of inability to obtain the right type of foreign crude oil. This would be enough to stave off the threatening gasoline and/or distillate heating oil shortage for this year.

Similarly, if security storage had been available in the second half of 1970 when the combination of a substantial government-decreed reduction in Libyan oil exports and the sabotage of the Trans-Arabian Pipeline caused a worldwide tanker shortage, there would have been no impact on the U.S. and perhaps the release of supplies from our security storage would have eased the tanker shortage sufficiently to have affected Libya's exceptional bargaining posture.

## Paying for Emergency Reserves

The first question that must be answered if we are to proceed from the discussion stage to the action stage is who will pay for the cost of strategic reserves. This is of great importance for the cost is quite large. During the five years it would take to develop a level of emergency crude oil stocks sufficient to cope with a major foreign supply interruption the total annual cost may well approach $1 billion. For the petroleum industry which will need all obtainable capital for the construction and expansion of domestic refining capacity and the search for oil and gas in our offshore areas, the expenditure of such an amount would probably require the curtailment of some of these projects. Given the shortage in both domestic refining capacity and oil and gas supplies, such a shift in funds would hardly make a net contribution to the security of U.S. oil supplies.

Since the sole justification for emergency storage is national security, it should be financed by the government. The logical means of raising the necessary funds would be the Security Fee which the government has recently imposed on imported oil. If this fee were earmarked for this purpose and set at a level designed to cover the cost, it would cease to

be an arbitrary figure, subject to political and bureaucratic challenges and pressures in both directions.

Instead it would represent the true national security cost differential between oil from overseas and from domestic and Canadian sources. This would give the public and its representatives finally a visible and logical reason for the cost of the oil import control program. A fee on the importation of a natural resource which is in increasingly short supply domestically may be difficult to justify in the long run. But the need to pay for the cost of storing such a resource so as to have it available in an emergency is bound to make sense to most people.

The security storage facilities financed by the security fee could be managed or controlled by the Federal government through a government agency established for the purpose of administering the storage program, similar to the strategic materials stock piling program carried on by the government for many years. Alternately, it could be handled by a non-profit public corporation functioning under whatever government regulations are established and whose owners would be the crude oil importers. A third alternative might be a joint industry-government venture.

Any of these approaches would result in a uniform centralized storage system with exactly equal unit cost for all participants. This would be superior to a system whereby the crude oil refiner-importers would be individually responsible for maintaining the required security storage. Under this latter system the unit cost for storage would vary widely, depending on the type of storage facility required (salt domes vs. steel tanks), the cost and availability of storage sites as well as differences in local zoning regulations.

Furthermore, a centralized storage system would be less costly than a private system, since it could make optimum use of salt dome facilities and government land and could build each storage facility of sufficient size to justify connections to existing pipelines, barge terminals and deep water ports for redelivery of the stored oil.

Size and Cost of Emergency Storage

The size of the security storage depends on the amount of the security fee, on what kind of interruption we foresee and how much security we wish to buy to guard against this potential interruption.

Obviously, the answers to all of these questions are essentially matters of judgment. For working purposes,

however, we would suggest goal of four months of security storage so that each 3 barrels of crude oil imported from overseas would be backed by 1 barrel of security storage. In the very extreme case of the complete and simultaneous unavailability of crude oil from all overseas sources, we would therefore be totally unaffected for the first four months. By imposing a modest form of compulsory rationing - about 7-8% of total demand - during this period and by drawing down our normal commercial stocks of crude oil and refined products which together amount to about 60 days consumption, we would probably be able to avoid at least for the first six months a major impact on our economy and security. Whether this would be enough to settle or alleviate the crisis and whether a six months protection would be a strong enough deterrent against a show-down export embargo is of course a matter of speculation. It is obvious, however, that a six months protection is far superior to what we have now. Certainly, our existing stock levels must be considered inadequate to cope with any major future oil supply crisis.

The cost of providing four months of crude oil security stocks depends principally on three factors: The volume of imports required for this purpose, the cost of imported crude oil and the type of storage facilities used.

According to a recent National Petroleum Council study, the U.S. will require approximately 9 million barrels daily of total overseas oil imports by 1980. If we assume, not unreasonably, that half of this volume will consist of crude oil, we will need about 550 million barrels of security storage by 1980 to meet our four-months requirement.

The Interior Department estimated in a 1966 study the capacity of unused on-shore salt domes in the Gulf Coast area suitable for petroleum storage at 650 million barrels, more than our total requirement. It may be assumed that some of these salt domes are no longer available and that for this and other reasons one-third of the security storage will have to be placed in above-ground steel tanks.

The Cabinet Task Force on Oil Import Control estimated in its 1970 report the annual cost of crude oil storage, assuming a twenty-year amortization and an 8% discount rate, at 28¢/bbl for salt domes and 55¢/bbl for steel tanks. This figure included land cost (for steel tanks), maintenance and $2.00/bbl for delivered overseas crude oil. If we assume the average cost of delivered foreign crude oil over the next five years at $4.00/bbl and if we increase the other costs in the Task Force estimate by 25% for inflationary factors, the total

annual per barrel storage cost over a twenty-year period would be about 55¢ in salt domes and about $0.90 in steel tanks. At our assumed ratio of 2/3 salt domes and 1/3 steel tanks, the composite annual cost would be about 66¢/bbl.

Thus, for our 4-month security storage we would have to put a security fee of approximately 22¢/bbl on each barrel of imported crude oil.

Admittedly, this is a very rough calculation; it excludes the cost of a redelivery system for the stored crude oil which could well amount to several cents per barrel. Obviously, the 21¢/bbl current security fee on crude oil would not fully cover the cost as calculated above, not only because the fee itself is too small but also because for the next several years a substantial part of our imports will come in without fee under the new program. The same applies for the security fee on finished products. It would therefore be necessary either to adjust the existing fees upward or to levy an additional fee on all oil imports to cover the balance of the emergency storage cost.

## Other Provisions

Canada:

The security fee should be removed from pipeline imports of Canadian crude oil. The security of this oil has been officially recognized by the U.S. Government as superior to that from any overseas destination. Our oil import policy should reflect this fact which would act as an incentive for Canadian oil exploration and, thus, to our potential benefit.

Rationing:

Another requirement is the establishment of a stand-by compulsory oil rationing plan. Most European countries have such a stand-by plan because they realize that it cannot be properly designed and prepared for implementation in the face of an actual major emergency.

Timing of Imports:

Finally, consideration should be given to the time frame within which to build up the emergency storage to its desired level. Given the existing tightness in world

oil supplies, it is important to bring in the necessary volumes at low enough import rates not to affect prices and freight rates significantly. For our suggested four-months emergency storage a five-year build-up would mean an annual 7% increase in U.S. crude oil imports over and above what would otherwise be imported.

## Production Reserves

It is suggested in § 1586 that, in addition to storing imported oil, an emergency reserve can also be acquired by setting aside a percentage of existing or potential commercial domestic oil production as a reserve. In areas where the drilling and connection of wells is relatively expensive such as our offshore areas, the cost may be disproportionate when compared with underground storage. But more important than comparative costs are several conceptional drawbacks of shutting in productive reserves for emergency use. For one thing, underlying each barrel of productive capacity are a multiple number of barrels of proved reserves. The required national average reserve/production ratio at MER, without gas flaring, may be estimated at 1:8.5. Thus, if we wanted to shut-in a

million b/d of production we would have to set aside 3.1 billion of proved reserves. On the other hand, if we wanted to have emergency storage for a million b/d, we would only have to import a total of 365 million bbls and build a redelivery system of the desired capacity.

## Impact on the Balance of Payments

The difference in these two methods of emergency storage could have a considerable impact on our balance of payments. Using the above example, if we wanted to shut-in a million b/d of productive capacity, we would have to import a corresponding volume of oil year after year as long as it is available. The storing of imported oil, by contrast, would only require the importation of this volume for one year, if we felt a one-year security cushion was enough to cope with any realistically conceivable international oil emergency.

## Summary

Thus, by and large, our optimum course of action should be to maximize domestic oil production in order to minimize our current overseas dependency. At the same time

we should import oil above our current needs whenever it is economically available, in order to develop a reliable emergency storage of whatever capacity we deem desirable.

# VI. "Oil and National Security," Naval War College Review, May–June 1974



49-868 O - 75 - 14

[From the Naval War College Review, May–June 1974]

# Oil and National Security

*Recent experience has shown that even a limited and poorly maintained Middle Eastern oil embargo can strongly affect the economic and temperamental well-being of the United States. "The potential for a future cutoff, due either to peace-time political and economic policy or wartime interdiction, remains a worrisome contingency for American strategists. A viable counter to future threats on our foreign oil supply is oil stockpiling, an expensive and complicated procedure, but one that cannot be ignored."*

(By Barry M. Biechman and Arnold M. Kuzmack)

The October 1973 war in the Middle East finally witnessed the long threatened use of the Arab "oil weapon." The major Arab oil producers—Saudi Arabia, Kuwait, Iraq, the Sheikhdoms on the Persian Gulf, Algeria, and Libya—all embargoed shipments of their oil to the United States. The embargo was designed to curtail U.S. military, economic, and diplomatic support for Israel and to cause this Nation to force Israel to return to the pre-1967 cease-fire lines. Additionally, the Arab oil producing states announced progressive cutbacks in total oil production. Beginning in October, crude oil output was to be reduced 5 percent per month from the level obtained in September 1973. This step would mainly affect Europe and Japan—the major consumers of Arab oil—which, it was expected:

made it certain that those nations would not provide any support for Israel;

made it more difficult for the United States to receive Arab oil indirectly; and

put pressure on the United States from these important sources to accede to the Arabs' demands.

The production cutback was a short-lived policy. The December reduction was canceled and output has since risen, although it seems unlikely to return to prewar levels for some time. Also, the production cutback was never a unified policy maneuver. Iraq, for one, flatly declined to go along. The embargo was sustained longer and more uniformly and continued in effect until March 1974. However, neither of these actions have attained their stated ends. The United States continues to provide Israel with necessary military equipment and diplomatic backing. And, while Israeli forces have withdrawn from the Suez Canal, a return to the pre-1967 cease-fire lines appears in the cards only for the distant future, if ever. More importantly, despite sharp increases in the price of petroleum products in the United States, a threatened shortage of fuel oil, and long lines at gasoline stations, public support for Israel in the United States remains as high, or higher, than it was before the war.

In part, the failure of the oil weapon may be attributed to the administration's longstanding policy of standing up to political coercion, but a more significant factor is the United States present oil import situation. The United States now imports only about 6 percent of its petroleum requirements directly from the Middle East, and it obtains only 10 percent of its needs from the Arabs even when products which are imported from refineries in third nations are included. Unfortunately, this situation is likely to change in the future. Before the war, reasonable projections indicated that the United States would import about 50 percent of its oil during the 1980 to 1985 period and that at least half of this total would have to originate in the Middle East. While these projections may now be somewhat high—both because the sharp rise in petroleum prices will likely result in a more moderate growth in demand and because it will spur greater efforts to develop alternative domestic energy sources—there seems little doubt that the United States will be significantly more dependent on foreign sources for its petroleum supplies in the 1980's than it is today.

Increasing dependence on imported oil is undesirable for a number of reasons. It gives foreign nations greater influence in determining the price of oil; it contributes to our unfavorable balance of payments; and it greatly increases the leverage wielded by the producing nations in the international monetary system. It can, potentially, undermine the vitality of the domestic oil industry.

The most disquieting potential consequences of increased dependence on foreign oil are the implications for national security. These consequences, a source of concern for all oil importing nations, are considered more vital for the United States as its political, economic, and military power provides the basis for the Western security system. Disrupting the flow of petroleum could be an effective way of waging war against this country as well as a potent political lever to influence the foreign policy decisions of the United States in peacetime.

It is the intent of this paper to give substance to vaguely felt concerns over the national security implications of the energy crisis. We aim to determine the degree and the manner to which these concerns are real and to examine alternative ways of coping with such potential problems. We begin by exploring contingencies, in war and in peace, in which supply interruptions might occur, with three questions in mind:

What conditions are necessary for oil cutoffs to occur?

How serious would they be?

And what policies could be instituted to deal with them, should they occur?

We will not be judging the absolute likelihood of any of these scenarios; in fact, some would appear so implausible as to not warrant serious reflection. But this the reader will ultimately have to judge for himself. Moreover, he will have to decide if the alternative policies warrant the cost of implementing them.

## THE INTERRUPTION OF PETROLEUM SUPPLIES IN WARTIME

From the beginning of the Second World War through 1943, the United States encountered considerable difficulties in supplying petroleum products for the war effort. This came about for two reasons.

First, there was a sharp increase in the Armed Forces' demand for petroleum. Between 1940 and 1945 military demand for petroleum increased from 1 to 33 percent of U.S. production,[1] and these figures take no account of demand increases due to the needs of war-related industrial production. Second, German submarines had considerable success during the early part of the war in interdicting the movement of petroleum from producing to consuming areas, particularly from the Caribbean and the U.S. gulf coast to the eastern seaboard.

Much of the concern over future increased U.S. dependence on oil imports seems to stem from this experience. Many observers fear that, given the increasing rate of demand, the United States in future wars would not be able to meet its normal requirements, far less the increased demands generated by wartime needs. In a wartime environment, an adversary with sizable and sophisticated military forces could attempt to interdict the movement of petroleum between producing areas and the United States, Japan, and Western Europe in a number of ways. Our objectives here are to outline the tactics available to an opponent and the counteractions likely to be taken by the West, to describe the forces which each side could bring to bear, and to highlight certain critical determinants of the outcome of the engagement.

In a conventional war between NATO and the Warsaw Pact—the most demanding scenario with regard to petroleum requirements—choices facing the Soviet Union involve: first, the points in the oil distribution system at which to apply pressure; and secondly, the types of weapons to employ.

One possibility would be to deny the oilfields themselves to the West, either by destroying the fields in air raids or by physically seizing the oil producing areas. To the extent that either tactic would be practical, the fields along the Persian Gulf, because of their proximity to the U.S.S.R. and their great output, would seem to be the most likely target.

There are, however, implicit difficulties in the airstrike option. Oilfields are not particularly vulnerable to air raids with conventional munitions as they are comprised of many individual targets, each relatively "hard" and individually of low intrinsic value. A somewhat more fruitful approach might be to attack the tanker loading terminals. There are only a few such facilities—Kharg Island, Ras Tanura, Bahrein, and Abadan—and these will handle a large portion of the Gulf's output in the 1980's. These targets would be relatively easy to repair, however, and would have to be attacked repeatedly. An additional problem derives from deficiencies in Soviet airpower. Most oilfields in the Gulf area (even those in Iran) are beyond the combat range of Soviet fighter aircraft based in the U.S.S.R. Thus, the primary vehicles for such strikes—the 700 medium-range bombers assigned to the U.S.S.R.'s long-range aviation, less those used in other missions or held in reserve to deter China from initiating hostile action—would have to carry out the bombing without fighter escorts. In such a situation they would be very vulnerable to interceptor aircraft. Even if no U.S. forces were deployed to the region, the Iranian

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[1] Cabinet Task Force on Oil Import Control, *The Oil Import Question: a Report on the Relationship of Oil Imports to the National Security*, February 1970, p. 233. Cited hereafter as Cabinet Task Force Report.

Air Force, presently composed of only eight tactical fighter squadrons but in the process of being expanded and equipped with advanced fighter aircraft, would be capable of inflicting heavy Soviet losses.

The second means of denying the oilfields to the West—occupying them—would seem to be a better choice. The U.S.S.R. probably would not attempt such an exercise by amphibious invasion, as the forces it maintains for such operations are quite limited. In addition, what forces could be mustered would be vulnerable to attack by Western naval forces during the long transit between Soviet ports and the Persian Gulf. Nor would the U.S.S.R. be likely to attempt an airborne invasion, even though Soviet capabilities in this area are more impressive, because of limited fighter escort range and because of restrictions on the amount of armor and other heavy equipment that could be quickly delivered to the combat theater. The probable course of action would be an overland invasion of Iran from the Caucasus region and then, assuming such a foray were successful and Iranian bases became available for Soviet use, expanding to the other producing regions on the gulf one by one.

In peacetime the U.S.S.R. maintains 21 divisions in the Caucasus and West Turkestan regions, sufficient forces to occupy Iran—which maintains 7-plus divisions at present—within several weeks. This swift and decisive victory might be compromised, however, by several factors: the fortunes of Soviet troops in Europe, American intervention, and the performance of the Iranian Armed Forces, for example. Conceivably, the U.S.S.R. might gain the support of Iraq in such a contingency by playing on the deep-seated ethnic and political rivalries among the states at the head of the gulf.

A third possibility for the Soviet Union would be to cripple the West's refining capability, a tactic used with considerable success by the Allies during World War II. Attacks on the Ploesti refineries beginning in May 1944, using only 12,000 tons of bombs, are said to have caused a more than 70 percent decrease in Rumanian oil exports to Germany by June and a total shutoff by July.[2]

This success is unlikely to be repeated in Soviet attacks against NATO refineries. For one thing, NATO refining capacity is not as concentrated as was Germany's in World War II. Whereas there were fewer than 100 refinery targets at that time, there are already more than 700 contributing to Western oil supplies, and this number will increase in the future. Moreover, more than 40 percent of the West's refining capacity is located in the Western Hemisphere, beyond the range of all but a handful of Soviet aircraft.[3] Of course, refineries in Europe would be important targets, but it would not be of a strategic significance comparable to the destruction of German refineries in World War II.

A fourth set of options available to the U.S.S.R. would involve the interdiction of oil tankers, both those moving crude oil to storage areas and refineries and those transporting finished products to consumers. In the early years of World War II, Germany adopted this tactic against the movement of oil from the Caribbean and the gulf coast to the Northeast United States. Within 4 months of the beginning of this interdiction campaign (February 1942), tanker shipments were cut to only 18 percent of the rate in December 1941. Shipments

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[2] U.S. Strategic Bombing Survey, *The Effects of Strategic Bombing on the German War Economy* (n.p., 1945), pp. 78–81.

[3] "Worldwide Oil at a Glance," Oil and Gas Journal, Dec. 25, 1972, pp. 82–83.

continued to decline for another year, reaching a low point of 6 percent of the December 1941 rate in May of 1943. Tanker shipments did not return to previous levels until late 1944.[4]

The number of Soviet submarines and aircraft committed to an oil interdiction campaign would depend, again, on the U.S.S.R.'s perception of other requirements for these forces, their assessment of the chances of successfully interdicting oil flows, and their reading of the strategic consequences of such a campaign should it be successful. In such a campaign the Soviet Union could choose among several potential chokepoints on the oil routes. Three possibilities come to mind.

One is the offloading facilities, both in Europe and the United States. Between 1960 and 1970, the average size of ships in the world tanker fleet, as expressed in deadweight tons, doubled (from 20,000 to 40,000 dwt), and their size will rise more sharply in the present decade. At the end of 1970, the average size of tankers under construction in the West was more than 100,000 dwt. The reason for this increase is the introduction of very large crude oil carriers (VLCC's), ships ranging between 175,000 and 600,000 dwt. With the increase in overall tanker size has come a sharp rise in the draft of these vessels. A tanker of 100,000 dwt is likely to have a draft of about 50 feet, while a tanker of 500,000 dwt will have close to a 100-foot draft. In the 1980's, there may well be tankers of 1,000,000 dwt, with correspondingly deeper drafts.[5]

These giant vessels require special deepwater offloading facilities where they can disgorge their cargoes into pipelines or storage tanks or transfer them for final delivery by smaller ships. There are about 10 such facilities in operation in Europe at present, perhaps 10 more are planned. The United States has none, but the ever more obvious need for such facilities has led to several proposals under active Federal consideration. By 1985 there are likely to be 10 deepwater facilities in North America. These locations would be tempting targets for Soviet bombers, as well as points of reference from which submarines might locate incoming tanker shipments.[6]

Another possibility, probably the most vulnerable point in the oil flow network, is the entrance to the Persian Gulf—the Strait of Hormuz.[7] This waterway is only 25 nautical miles wide (outside the 20-fathom line), and the channel used by deep-draft oil tankers is far less—about 2 nautical miles. Either Soviet submarines could deploy to the Indian Ocean and torpedo tankers as they left the gulf, or the Soviets could attempt to close the channel with sea mines. Assuming that Soviet sea mines have a lethal sweepwidth of 200 feet relative to a typical VLCC, say of 250,000 deadweight tons, and further assuming that Soviet naval doctrine calls for minefields with a 25-percent kill probability per passage, then only 200 mines would be required to close the 25-mile strait. Another 50 mines might be added to this requirement to hedge against technical failures, misplaced drops,

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[4] John W. Frey and H. Chandler Ide, eds., "A History of the Petroleum Administration for War: 1941–45" (Washington, U.S. Government Printing Office, 1946), pp. 87–88.

[5] Data from U.S. Congress, Senate, Committee on Interior and Insular Affairs, *Deep Water Port Policy Issues: Hearings*, 92d Cong., 2d sess., 1972.

[6] See Bernard Frankel, "Offshore Tanker Terminals: Study in Depth," *United States Naval Institute Proceedings*, March 1973, pp. 56–64; also, several studies reproduced in Senate Committee on Interior and Insular Affairs.

[7] This point was highlighted by Adm. Elmo R. Zumwalt, Jr., the Chief of Naval Operations, " * * * the channels are relatively easy to mine or block. Sinking just a handful of supertankers in critical passages could effectively block shipments from the Gulf for a long time * * * there is little the U.S. could now do militarily to forestall this possibility." Source: Statement of the Chief of Naval Operations Before the [Senate] Committee on Interior and Insular Affairs (Processed January 1973), pp. 11–12.

and similar errors. If the minefields were laid by submarine, only six to eight submarine loads would be required.[8] The U.S.S.R. also could employ airdropped mines to close the gulf. Medium-range "Badger" aircraft can probably carry around 20 mines apiece (if they are not also equipped with air-to-surface missiles),[9] and only 12 plane loads would be required.

Clearly, if unopposed, the Soviet Union would have more than ample resources to close the Persian Gulf, but unless they were predep oyed before the initiation of hostilities, submarines would have to pass through barriers established by the NATO navies between Soviet naval bases and the submarines' expected operating areas. These barriers might be in the various straits between the Pacific and Indian Oceans or the area between Greenland, Iceland, and the United Kingdom. Moreover, NATO and Iranian ASW forces could patrol in the Arabian Sea near the mouth of the gulf. If aircraft were used to mine the channel, they would face problems similar to those discussed in attempts to bomb the oilfields or loading terminals at the head of the gulf. In fact, aircraft on minelaying missions would face greater difficulties in that they would have to penetrate further south. On the other hand, aircraft on minelaying missions might avoid a large portion of Western defensive interceptors by overflying India, or perhaps Afghanistan and Pakistan, before heading for the Straits of Hormuz. This tactic could be partially countered by the use of an aircraft carrier in the Arabian Sea, but carrier-based air defenses would be relatively inefficient if the attacking aircraft remained largely over land.

Obviously, some Soviet submarines and aircraft would be destroyed but others would succeed in depositing their mines, and since the number of successful missions required is quite low (6 to 8 for submarines, 12 for aircraft), it should be expected that the U.S.S.R. would be relatively successful. Also, planners should not be too optimistic in the effectiveness that mine countermeasure forces (minesweeper ships and specially equipped helicopters) would have in clearing the area. Modern sophisticated mines are extremely difficult to sweep,[10] and the U.S. Navy has been reducing its mine countermeasure forces (perhaps because of their limited effectiveness). Besides, other priorities will most likely make it necessary to hold back a large portion of these forces for mine clearance operations in the United States and Western Europe.

Another tactic available to the Soviets would be to attack tankers on the high seas. During a war in the 1980's, roughly 25 to 28 million barrels of oil per day would have to be delivered to the United States and Western Europe.[11] Assuming that tankers averaged 250,000 dwt at that time, 13–15 deliveries would have to be made each day. If the

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[8] Present day Soviet nuclear submarines can carry up to 64 mines apiece but would want to use some of this capacity for torpedoes for self-defense or targets of opportunity. See Robert D. Wells, "The Soviet Submarine Force," United States Naval Institute Proceedings, August 1971, pp. 63–79.

[9] "Badgers" without ASM's are reported to carry 9 tons of ordnance internally; see John W.R. Taylor and Gordon Swanborough, Military Aircraft of the World (New York: Scribner, 1971), p. 133.

[10] Bryon F. Calame, "Deadly and Sophisticated, Navy's Mines Can Do Everything but Smell," Wall Street Journal, May 10, 1972, p. 1.

[11] This calculation is founded on the National Petroleum Council's projections of peacetime oil consumption and production in 1985 and on the authors' own estimates of incremental demands posed by a major war in Europe. The latter was based on U.S. Army planning factors (as specified in Field Manual 101–10–1), experience during the Vietnam war (based on data supplied by the Office of the Assistant Secretary of Defense for Installations and Logistics), and force levels as presently envisioned. Table 1 shows a brakedown of incremental demand and required deliveries to Europe, by source.

average trip from producing to consuming area were 23 days, then at any one time there would likely be some 600–700 potential targets on the high seas.

In World War II, shipping was protected by sailing in convoys, each convoy escorted by destroyers. There might be some difficulty adopting this tactic for VLCC's, however, in that the immense size of these vessels makes them difficult to maneuver and, therefore, risky to sail close to one another. More likely, the defensive tactic adopted would be to clear the general area through which the oil routes passed. This would be accomplished by attriting the Soviet submarines force as it passed through the barriers mentioned earlier and by searching the oil routes with antisubmarine aircraft, based at sea or on land. The Soviets probably would not use all their submarines for the oil interdiction mission. Even so, a force of 50 to 100 nuclear attack submarines could be expected to sink a considerable number of tankers before being destroyed by Western antisubmarine warfare forces.

In summary, the most potent threat to Western oil supplies posed by the U.S.S.R. in a major NATO-Warsaw Pact conflict would be mining the entrance to the Persian Gulf. Of the 25 to 28 million barrels of oil which would constitute the daily United States and other NATO import requirement in such a contingency in the 1980's, 11 to 14 million barrels per day (MMB/D) would originate in the Persian Gulf (table 1).[12]

TABLE I.—PETROLEUM INCREMENTAL DEMAND AND DELIVERIES IN THE EVENT OF A MAJOR WAR IN EUROPE IN 1985

[In thousands of barrels per day]

| | Incremental demand | Required deliveries to Europe |
|---|---|---|
| U.S. military forces: | | |
| Ground combat forces [1] | 167 | 200 |
| Tactical air forces [2] | 175 | 350 |
| Naval forces [3] | 86 | ---------- |
| Subtotal | 428 | 550 |
| U.S. industry | 250 | 0 |
| Other NATO military forces [4] | 0 | 1,080 |
| Subtotal | 678 | 1,630 |
| Other NATO civilian demand [5] | 0 | 12,000–16,000 |
| Total | 678 | 13,630–17,630 |

[1] 17 divisions and nondivisional elements; a total of 1,200,000 men.
[2] 80 Air Force squadrons, 6 carrier air groups, and 1 Marine air wing; a total of 2,100 aircraft (UE).
[3] 600 ships.
[4] Assumes 2,500,000 men in ground forces; 2,500 tactical aircraft; and 800 naval ships. These forces represent roughly a 10-percent decrease from the present force levels (including reserves) of Belgium, Denmark, France, West Germany, Italy, Netherlands, and Norway.
[5] In 1985 the states listed in note (4) will consume roughly 25,000,000 barrels of petroleum per day, one-fifth of which will originate from domestic sources (mainly the North Sea). The degree to which this consumption could be reduced—either by physical destruction of industrial facilities or by government imposed rationing—is unclear. The lower figure in the table corresponds to a total cutoff of German consumption (such as would occur as far as the United States were concerned if West Germany was overrun by Soviet troops) and a 20-percent reduction in the import requirements of the other states. The higher figure assumes strictly a 20-percent drop in import needs. This could come about through a combination of increased domestic production (perhaps with synthetics as Germany did in World War II), rationing, and war-related damage.

[12] This assumes that 6 MMB/D originate in the Western Hemisphere outside the United States, 5 MMB/D would come from the Mediterranean (including pipeline output), and 3 MMB/D would originate in West Africa. Asian production is assumed to go strictly to Japan.

What would be the consequences of the denial of this oil, which constitutes 20 to 30 percent of the military and civilian demand projected for the war? During World War II, both Germany and Japan had considerable difficulty securing adequate supplies of petroleum. Oil shortages played a significant role in weakening the German and Japanese war efforts in the form of cutbacks in pilot training, reduced war-related industrial production and transportation, and, ultimately, restrictions on the mobility, flexibility, and overall effectiveness of combatant forces.

However, the interruption of German and Japanese oil supplies toward the later part of the war was proportionally far greater than the United States and NATO supplies that would be affected by blockage of the Persian Gulf. In January 1945 German production and imports of petroleum products had been slashed to less than one-fourth the monthly average in 1943.[13] Similarly, in the spring of 1945, Japanese production and imports of all petroleum products totaled less than one-fourth the prewar rate.[14] As noted, a cutoff of imports from the Persian Gulf would amount, at most, to one-fourth of U.S. and NATO demand. Moreover, despite the sharp increase in the dependence of modern-day military forces on petroleum, total military demand is small relative to civilian demand. Consequently, a one-forth cutoff is unlikely to affect the consumption of the Armed Forces themselves, which would, of course, receive first priority in wartime. The reduction would, however, bite strongly into civilian consumption. The degree to which such a reduction would be debilitating to the war-related industrial effort would depend upon several factors, including the scope and effectiveness of any compensatory measures which were undertaken.

## SUPPLY INTERRUPTIONS IN PEACETIME

Since a major conventional war involving the United States appears highly unlikely, most concern over the national security implications of increasing oil imports focuses on supply interruptions in peacetime. Growing dependence on imports is said to provide a ready means for other nations to coerce the United States into making foreign policy choices, particularly in connection with the Middle East, that it might not otherwise make.

*Arab Oil Supply Cutoffs.*

In this range of contingencies, the major Arab oil producers would use their oil exports as a weapon against U.S. support of Israel. This might be done as means of influencing the outcome of diplomatic negotiations regarding the resolution of the Arab-Israel conflict, during a crisis, or during an actual Arab-Israel conflict.

The producers that would most probably be involved are Saudi Arabia, Iraq, Kuwait, Algeria, and Libya, of which Saudi Arabia is by far the most important. It is important to remember that Iran—the second largest producer of petroleum in the Middle East—is not an Arab country, that it has amicable relations with both the United States and Israel, that it is a rival of several of the Arab countries

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[13] U.S. Strategic Bombing Survey, Oil Division Final Report (n.p., 1947), fig. 16.
[14] U.S. Strategic Bombing Survey, The Effects of Strategic Bombing on Japan's War Economy (n.p. 1946), p. 134.

just mentioned; therefore, it would have no incentive to participate in such a supply interruption. In fact, Iran's interests would lie in helping in defeat the petroleum interruption. It also should be noted that many of the Arab nations just listed are ideologically, and sometimes politically at odds (e.q., Iraq-Kuwait and Libya-Saudi Arabia).

There are a number of different ways the Arab countries could implement the interruption in oil flow, each with very different implications for the United States, Western Europe, and the oil picture generally. In the first case we consider, the Arab countries decide to halt all shipments to the United States but otherwise follow their economic self-interest. They would therefore be willing to increase shipments of oil to customers other than the United States in hopes of regaining the revenues lost by not shipping to the United States. However, this policy would greatly reduce the effectiveness of the cutoff as a means of coercing the United States, since the world oil market could act to neutralize the effect of the cutoff. Importing countries other than the United States could increase their imports of Arab oil, thus freeing non-Arab sources, including Iran, to meet U.S. needs. Alternatively, swaps could be made among consuming nations, or the international oil companies could perform the same function.

Obviously, the Arab States would be aware that an interruption of this sort would be likely to have only marginal effects on the United States. They would view it as a symbolic step—a means of indicating displeasure to the United States and, at the same time, helping to still pressures originating in the Arab world for more consequential (and costly) measures.

In the second scenario, the Arab countries would stop shipments to the United States and continue shipments to other Western countries but would be unwilling to increase those shipments. Thus, they would not attempt to pressure or punish Western Europe as well as the United States, but neither would they be willing to permit the sort of swaps described above which would vitiate the effectiveness of the cutoff.

If this contingency occurred in 1985, when the United States is likely to be importing 53 percent of its oil, according to the National Petroleum Council,* we estimate that the amount of oil affected would be about 5 to 7 million barrels per day, or about 25 percent of U.S. consumption. Let us now consider how the world oil system would respond to the cutoff hypothesized here. The market would work to supply the unsatisfied demand. With some time delay, existing excess capacity in non-Arab countries would be brought into production.

While additional capacity is brought into production, the oil industry could operate from reduced stocks. Drawing down commercial and pipeline stocks in the United States could meet the shortfall for perhaps 30 days but, of course, such drawdowns lead to inefficiencies and spot shortages in some areas for particular products.

To the extent that existing stocks and excess capacity would not be adequate, higher prices and specific Government policies designed to conserve energy would reduce demand. Further, high U.S. prices would draw supplies away from other countries, resulting in higher

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*The NPC projections were made late in 1972. They do not, therefore, reflect the consequences of the October war or subsequent events. One would expect the embargo and resultant shortages to temper the rise in U.S. demand and to spur greater output from alternative energy sources.

prices and reduced demand there and spreading the shortfall throughout the oil consuming countries. The OECD oil sharing agreement could provide a government-to-government mechanism for facilitating the dispersion process. Since, in this case, the shortfall would be only a small fraction (6 to 8 percent) of total non-Communist world demand and since projected excess production capacity is comparable in magnitude to the shortfall, there would seem to be little question that the world oil system could handle the situation without severe interruptions in meeting petroleum needs, but that increased prices and somewhat reduced consumption also would be likely.

The third case of Arab oil supply interruptions is one in which the participating Arab States cut off production destined for both the United States and Western Europe. Such an action is substantially less likely than those previously considered because of the great economic cost to the Arabs themselves and because the Western European countries have clearly disassociated themselves from U.S. support for Israel. Nevertheless, the close association between Western Europe and the United States in many other areas and, more importantly, the likelihood that an Arab oil cutoff would fail unless Western Europe were included make it prudent to consider this wider cutoff.

We estimate that, in 1985, Western European imports of oil from Arab countries would be 12 to 15 million barrels per day. Adding to this figure the 5 to 7 million barrels per day of U.S. imports from these countries, total U.S. and Western European imports from the Arab countries in 1985 are likely to be in the range of 17 to 22 million barrels per day or about 35 to 45 percent of combined U.S. and Western European consumption. Thus, the amount of oil cutoff under this contingency is 3 to 4 times as much as would be involved in a cutoff aimed at the United States alone.

A cutoff of this magnitude would be too large to be handled completely by the sort of automatic mechanism discussed above. Probably less than 5 million barrels per day of excess capacity would be available for reallocation, and some of this might be quite difficult to bring into production. As the demand for petroleum is relatively price inelastic, it would be difficult to greatly reduce demand through price increases alone; stringent Government rationing would be necessary. It is likely that the impact on day-to-day life would be as great as occurred in World War II, and the impact on industry would be much greater, since industry probably would not be a preferred user as was the case with war-related industries in World War II.

On the other hand, this sort of cutoff also would have the most severe impact on the revenues of the producing nations. Foregoing oil revenues is not a decision these governments will take lightly. While growing currency reserves provide a cushion, particularly so for Saudi Arabia, the expectations of lost income will provide considerable incentive against implementation of such a broadly targeted oil supply cutoff.

Thus, the third case—a cutoff of Arab exports to both the United States and West Europe—is both the one case likely to bring about severe economic and social deprivations in the United States and the one least likely to occur.

*An OPEC Oil Supply Interruption*

This scenario envisions a cutoff involving more than the Arab producers. The world's major petroleum-exporting countries could threaten to interrupt shipments to the major importing countries (the United States, Western Europe, and Japan) in order to force up the price of oil and to increase their own oil revenues. If such a threat were carried out, the results could be extremely serious, since OPEC members produced 63 percent of the non-Communist world's oil in 1972, a fraction which is unlikely to decrease in the foreseeable future.

*Physical Disruption of Oil Flows in Peacetime*

In the peacetime contingencies considered so far, the cutoff of oil was due to a conscious decision of the governments involved. It is also possible, however, that U.S. oil supplies could be disrupted by physical damage. One such scenario envisions the sabotage of oil facilities in Iran in conjunction with domestic turmoil. Another possibility would be inadvertent damage resulting from a war among the states at the head of the Persian Gulf—Iran, Kuwait, and Iraq—but these threats are most credible if taken in the context of another Arab-Israeli war. In such a conflict there would be four relatively independent actors; the United States, Israel, the Arab governments, and Palestinian irregular forces. Of these, only the latter would have any incentive to physically damage oil production facilities. The United States obviously would not want to damage facilities upon which it depends for important supplies. Nor would Israel wish to take actions that would make U.S. support more difficult. The Arab governments could accomplish the same thing, at less ultimate cost, through administrative fiat. The Palestinians, on the other hand, could see an attack on oil facilities as useful either as a means of exerting pressure on the Arab governments for greater support (although the possibility of counterreactions would be quite high) or as a direct means of influencing the United States.

It is unlikely that such an attack could disrupt oil supplies sufficiently to present significant problems to the United States. The oil facilities are relatively isolated and distant from the primary focus of the Arab-Israeli conflict, and there are few single targets whose destruction would have grossly disproportional effects. These factors would make such an effort by the Palestinians difficult and, furthermore, would suggest that the oil facilities are unlikely to be an accidental victim of military conflict in the area. The one exception to this statement are the pipelines leading to the Mediterranean, but their importance is on the decline in the oil transport system. Thus, while a determined Palestinian effort undoubtedly would do considerable damage in dollar terms, its consequence for U.S. oil supplies is unlikely to be major.

## ALTERNATIVE STRATEGIES AND POLICIES

*Contingency Planning*

One way to reduce the impact of an oil cutoff is to minimize both the amount of time necessary to take compensatory action and the degree of attendant inefficiencies in the supply distribution. In order

to do this, plans have to be made well in advance for short-term conservation mechanisms, production increases, rationing, or other supply and demand allocation mechanisms, and the like. The more realistic, flexible, and current the contingency planning is, the more it is possible to cushion the effect of any oil cutoff. Consideration also should be given to improving and strengthening government-to-government mechanisms for dealing with oil supply interruptions and for allocating available supplies.

Measures of contingency planning have two common characteristics: they are cheap and they do not go very far toward solving the problem. By themselves, they would be unable to handle the more severe contingencies discussed, but they are essential to the success of any strategy for dealing with oil cutoffs and should, therefore, be pursued.

*Oil Stockpiles and Similar Measures*

Another way to limit the effects of oil supply interruptions is to hold stocks of oil, sufficient to outlast the interruption, in reserve. Such a strategy would by definition be successful, but it is also expensive and presents several practical problems.

A policy of stockpiling oil would be most effective if the U.S. allies in Western Europe and Japan undertook similar measures. As was noted in the discussion of supply interruption scenarios, the oil supply situations of Western Europe and the United States would be closely linked both in peacetime and in wartime. Actually, the allies are ahead of the United States in the provision of oil stockpiles. Under present EEC policy, the West European countries maintain stocks equal to 65 days of consumption, and efforts are underway to increase this amount to 90 days by 1975. Britain is reported already to have 120 days of oil stocks, and Japan has instituted a policy to build up to 60 days of stocks by 1975.[15]

The major advantage of oil stockpiling or similar strategies is that they would be effective against all the contingencies. Depending on the duration of the cutoff and the amount of oil affected, a stockpiling strategy would reduce the impact of price-motivated cutoffs, politically motivated cutoffs, and those which occur in wartime.

Oil stockpiles could take several forms: storage in steel tanks, storage in natural formations such as salt domes or coal mines, shut-in production capacity, maintaining part of the stockpile in the form of coal, and maintaining part of the stockpile in the form of refined products rather than crude oil. Each of these variants involves particular advantages and disadvantages which would have to be weighed in designing a stockpile. Space barely permits a listing of some of these. There is one set of difficulties which they all must confront—financing and the institutional context in which the stockpiles would be maintained. Should the U.S. Government own the stockpile? If so, how would it be managed? If not, should it be separate from commercially maintained stocks? How would the Government regulate it? With respect to financing, how much of the cost should be borne by the Federal Government, and how much by the oil companies who would, in turn, pass the cost on to the consumer? We have no

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[15] Sam H. Schurr and Paul T. Homan, Middle Eastern Oil and the Western World" (New York American Elsevier, 1971), p. 80; "Japan Envisages Holding of 60 Day Oil Stock by March 1976," Japan Petroleum Weekly (Tokyo), July 24, 1972, p. 1; "Directive du Conseil du 20 decembre 1968 faisant obligations aux Etets membres de la C.E.E. de maintenir un niveau minimum de stocks de petrole brut etiou de produits petrollers," (68/414/CEE), Journal officiel des Communautés européannes, Dec. 23, 1968, No. L308, pp. 14–16.

answers to these and similar questions, but they must be answered if a stockpile strategy is to be considered seriously.

*Steel Tank Storage.*—Crude oil storage in steel tanks is the simplest form of oil stockpile, the form most feasible, and the form that presents the fewest problems of transition from the normal system to one which depends on stockpiles.

Even so, there are a number of difficulties with the steel tank storage approach. The size and cost of the stockpile is directly proportional to the length of time it is designed to insure against import cutoffs. Since there is no way to be sure how long a peacetime supply interruption or a war would last, the stockpile would clearly have finite limits determined ultimately as a matter of judgment.

Other potentially serious problems involve the availability of land for tank farms, the possible need for reserve transportation capability, and, for the European allies, vulnerability in wartime.

A cost estimate is impossible without specifying where the stockpile will be set up, its design and potential uses, and such a study is far beyond our resources. We can, however, provide some extremely rough estimates, mainly so that the reader can decide whether the costs are of an order of magnitude that justifies further consideration.

Table 2 presents these calculations. They are based on a very simple formula: total cost is equal to the product of the cost per barrel of oil storage—including the cost of obtaining the oil, the number of barrels per day that must be replaced, and the number of days for which protection is desired. As this formula ignores many complicating factors, the range of uncertainty associated with the figures shown in the table is likely to be on the order of plus or minus 50 percent.

TABLE 2.—TOTAL COST OF OIL STOCKPILE (STEEL TANKS) TO REPLACE 1985 IMPORTS FROM ARAB COUNTRIES

[In billions of dollars]

| Period covered (days) | No conservation measures | 10 percent conservation measures |
|---|---|---|
| 90 | (40) $6.2 | (29) $3.6 |
| 180 | (80) 12.4 | (57) 7.2 |
| 360 | (160) 24.8 | (115) 14.5 |

Source: Authors' estimate. Assumes 1985 consumption of 25,000,000 barrels per day (MMB/D) and imports of 13.5 MMB/D, of which 6 MMB/D are from Arab countries. Cost is taken as $7.50/bbl for oil and $4.00/bbl for 10-yr cost of storage, broken down as follows:

| | |
|---|---|
| Steel tanks | $2.50 |
| Land | .25 |
| 10-yr operating costs | 1.25 |
| Total | 4.00 |

Storage costs are derived from Cabinet Task Force Report, App. J.

Note: Figures in parenthesis shows number of days for which a stockpile would replace all U.S. imports.

The table does illustrate the factors that are involved in determining the most desirable size of the stockpile. First, which imports is the stockpile required to replace? The case shown in the table assumes replacement of 1985 imports from Arab countries, the case of interest when considering politically motivated supply interruptions. However, the table also shows (in parentheses following the cost figures) the number of days for which a given stockpile alternative would replace all required imports. Second, how effective should we assume oil conservation (demand reduction) measures to be? The table shows

two out of a large number of possibilities: no reduction and an average 10-percent reduction. Third, how long should the hypothetical supply interruption be assumed to last? This is completely a matter of judgment; table 2 shows three alternatives. With respect to peacetime supply interruptions, the major question is how long the boycotting governments would be willing or able to do without oil revenues. With respect to a major conventional war, the issue is how long the war would be likely to last. Finally, it should be kept in mind that the costs shown in table 2 represent the total investment plus 10 years of operating costs (such as management, repair, maintenance, and evaporation loss) for the stockpile. Annual costs would be much less, averaging perhaps a tenth of those shown in the table; although there may be large costs in the near future caused by initial outlays to set up the stockpile.

The table indicates that for a cost of $14.5 billion (or about $1½ billion per year), the United States could create a stockpile which would enable it to replace Arab imports for about a year in 1985, if demand reduction measures were taken as well. Under similar conditions the same stockpile would last for about 7 months with no conservation measures undertaken. It would last about 120 days if, in wartime, no net demand reductions could be achieved but one-quarter of peacetime imports could be obtained. As a matter of judgment, such a stockpile would appear to be more than enough for a major war in Europe and probably adequate for peacetime supply interruptions as well. While the cost is substantial, it is small when compared, for example, to the cumulative cost of the oil import quota program undertaken between 1958 and 1973 for essentially the same reasons.

*Crude Oil Storage in Natural Formations.*—It is also technically possible to store large amounts of oil in natural formations, such as salt domes and coal mines. The main advantage of such schemes is the very low cost when compared to steel tank storage, but natural formations are unlikely to be located just where they are needed. Thus, added costs must be assumed for a reserve transportation system.

*Shut-In Production Capacity.*—Under this scheme, the Government would obtain control of certain oilfields in the United States and would restrict their production for use in a crisis. For example, the Government could buy existing oilfields from their present owners or could lease the wells and order the owners not to produce. Alternatively, the Government could drill for oil on the Continental Shelf, build pipelines to refineries, and hold the wells in reserve. Yet another possibility would be to supplement steel tank or natural formation storage lasting 6 months to a year with a reserve oilfield that is fully proved but not drilled.

The primary advantage of a shut-in stockpile is that it obviates the necessity of deciding how long a supply interruption to hedge against and reduces the cost of erring in this judgment. Also, shut-in capacity would have the ability to produce at a given level at least for several years, much longer than any supply interruption is likely to last. Thus, if it is felt that a very long (more than 1 year) supply interruption is a contingency worth hedging against, maintenance of a stockpile in this form becomes more attractive. However, there are considerable uncertainties involved in the feasibility of shut-in capacity schemes. For

example, how much would it cost to maintain the production equipment (including secondary recovery equipment, perhaps)? What would be the expense in providing for a skilled labor force in reserve but ready to operate on short notice? Uncertainties also exist concerning maintenance of a transportation system in reserve.

*Coal Stockpiles.*—Another possible hedge against an interrupted oil supply could come in the form either of a coal stockpile or of shut-in production capacity for coal. Maintenance of the latter entails the same sorts of problems as were mentioned above in connection with oil. It is possible, however, that it would be cheaper to maintain stockpiles of coal near users such as electric generating plants and large factories who could switch quickly between different fossil fuels.

*Stockpile of Refined Products.*—A final possibility would be to maintain a portion of the stockpile in the form of refined products. This obviously would be the most expensive alternative, but it might reduce the uncertainties inherent in those alternatives which require a reserve transportation system or excess capacity in the transportation system.

*Summary.*—A strategy of stockpiling oil appears to be feasible, but there are many problems of how to design the system. Some of these involve determination of the optimal form of the stockpile, while others consider the technical problems of maintaining the stockpile and transition from the normal to the reserve system in case of emergency. Other problems are on a policy level and require judgments as to the length of supply interruptions against which it is desired to hedge, the amount of oil which would be cut off, and the extent to which demand reduction measures could be relied on in case of emergency. While a rigorous cost estimate is impossible without answers to some of these problems, it is possible to project some useful cost data. The bill will be high but not prohibitive: an annual cost of about $1½ billion appears to be in the ball park. The stockpiling strategy has the advantage that it would work in a multitude of contingencies, only a few of which we have discussed: price-motivated supply interruptions, politically motivated supply interruptions, and wartime interruptions.

*Options Involving Military Forces*

In wartime, military forces would be used, of course, to defend the flow of petroleum by protecting the oil production facilities, loading and unloading facilities, tankers, and ground based transportation systems from enemy attack. We have discussed the strategies and weapons an adversary could use to attack the oil import system vital to the defense of the West.

To fall back on an old adage, the oil importation system is only as strong as its weakest links, and while all parts of the system are vulnerable—for example, the loading facilities in the gulf and the offloading facilities in Europe or the oilfields themselves to ground attack—it is the entrance to the Persian Gulf, the Strait if Hormuz, which provides the weakest link in the system. Since, for technical reasons, there is little the United States could do to counter a Soviet mine blockade in the strait once the mines are laid and since the number of mines required to block the channel is small and their successful emplacement virtually impossible to prevent, it appears that Western Europe and the United States should expect disruptions in the flow of oil from the Persian Gulf in the event of a major war with the Soviet

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Union. Consequently, if tankers cannot safely pass through the Strait of Hormuz, it makes little sense to spend substantial sums of money to strengthen other parts of the system from the Gulf to the United States. For example, a program to build destroyer escort ships to convoy tankers from the gulf to the United States would not appear to be an efficient allocation of resources. Escort forces still have great value in transport systems from the other oil producing regions of the world, say, from Latin America, although the question of whether these needs impose incremental requirements on U.S. naval force levels can only be answered after a more detailed and comprehensive study of a United States-Soviet conflict. It should be noted, additionally, that the kinds of military forces used only in a combat role, as they would be to deal with wartime import interruptions, are totally ineffective in protecting the United States from price or politically motivated peacetime supply interruptions.

Military force can, however, be an effective political weapon in the event of peacetime supply interruptions, despite the recent trend to downgrade the utility of military force as means for superpowers to secure their objectives vis-a-vis the smaller nations. A military intervention to terminate an oil boycott could well appear to be a viable option if the boycotting states controlled a sufficient portion of world production and were willing to maintain the boycott long enough to seriously impair the functioning of the United States and West European economies. In fact, some have argued that a peacetime interruption in oil supplies, if politically motivated, would be an intolerable form of coercion and would constitute, in the traditional international legal sense, casus beili.

There are, however, two factors which could make the intervention a failure, even if only viewed from a short-run perspective. First, while occupation of the oilfields may be relatively easy, maintenance of their production levels could be more difficult in the face of sabotage or other opposition. Second, although unlikely, one cannot rule out the possibility of Soviet involvement to deter or to counter a U.S. effort to seize the oilfields. Finally, assuming the other drawbacks were negligible, the long-run costs of the intervention could still overwhelm the tactical advantages of ending the oil boycott.

Yet, even acknowledging the risk, a U.S. administration faced with an oil related economic slump as well as consumer (that is, electorate) pressure to "do something" might well feel compelled to exercise this option. Moreover the option would always be available to U.S. decisionmakers as it requires little new expenditures and the existing U.S. general-purpose forces would be more than ample to complete the exercise.

In fact, this is the primary advantage of an armed intervention strategy to counter peacetime politically motivated oil boycotts. Given the low probability that such a boycott would be maintained long on a scale that would seriously impair the economy, more expensive strategies—such as stockpiles—tend to be looked upon unfavorably. Moreover, the potential threat of armed intervention, always present, could be a significant deterrent against attempts at an oil boycott. For this reason alone, it would not be wise for an administration to deny the possible use of military force for such contingencies, in extremis.

## CONCLUSIONS

An important conclusion stands out from the above analysis. The only strategy that promises to be effective against both peacetime and wartime supply interruptions is oil stockpiling. However, before implementing such a strategy, there are important technical and institutional problems to be solved and important policy judgments to be made, particularly as to the assumed length of time that an oil cutoff would be likely to last. More strikingly, given that the price tag associated with a stockpile may be on the order of $15 billion over 10 years, the Nation must decide if the policy is worth its cost.

The cost can be placed in perspective by comparing it with the costs of other measures with similar objectives. For example, the cost of the oil import quota program has been estimated at $5 billion for the year 1969 alone; this program was undertaken ostensibly for the same purpose. Or consider another comparison: if the United States were to attempt a military defense of the flow of oil imports, it might add, say, two carrier task forces and 75 escort ships to the Navy. Such a force would have a 10-year cost of more than $15 billion. Yet, because of the vulnerability of the entrance to the Persian Gulf and other problems, it might still not be adequate to the task. Thus, the cost of a stockpiling strategy does not appear excessively large when compared with either what the United States has spent for secure oil supplies in the past or what it might consider spending in the future.

Looking at the price tag another way, if the cost of an oil stockpile were borne fully by consumers, it would initially increase the price of petroleum products an average of one-half cent per gallon, hardly noticeable in light of today's fuel price increases. But neither this observation nor the previous ones tell us whether a supply interruption is likely enough to justify spending what is, in absolute terms, at least, still a large sum of money. As is typical in national security discussions, some of the contingencies we have considered are unlikely but potentially disastrous. Weighing costs and risks in such cases is necessarily a subjective process.

In making such judgments, another set of factors should be kept in mind. In addition to the threat of an actual oil supply cutoff, a more subtle long-term risk to national security exists in the possibility that the threat of a cutoff will influence the foreign policy decisions of the United States, the oil exporters, and other interested parties. Even if the impact of these threats is small in each individual decision, the cumulative impact could be harmful to U.S. interests. For example, oil producers could be more insistent that the United States tailor individual foreign policy decisions to their desires, e.g., not to license the export of a certain computer to Israel. Moreover, fear that certain actions could lead the Arab oil producers to contemplate or to threaten a boycott could lead U.S. decisionmakers to modify certain policies even without an overt maneuver on the part of the oil producers.

Thus, the existence of an oil stockpile not only would serve to assure U.S. oil supplies in the event of major war with the Soviet Union or an oil boycott by exporting states, but it would have other more salient, if perhaps more subtle, effects. Knowledge of the stockpile and of the

fact that any oil cutoff would have to remain effective for longer than the number of days of U.S. imports held in reserve, could help deter oil producing states from attempting to coerce the United States in this manner. It would also bolster the flexibility of U.S. policymakers in that they would feel more confident in reaching decisions which may be opposed by the oil producers. In addition, the stockpile also would strengthen the hand of the United States in negotiations over the price of oil.

Similar effects can be obtained by maintaining a viable option of military intervention in the event of a prolonged oil cutoff motivated by political objectives. Although an actual decision to force the end of a boycott by seizure of the production facilities would depend upon the specifics of the situation at the time—the setting of the boycott, the participants, their reasons, the degree of economic hardship which the boycott was causing the United States, and many other factors—acknowledgment of the possible use of U.S. military forces could be a valuable deterrent not only against oil embargoes but, as in the case of stockpiles, against the more subtle and individually less consequential forms of coercion which the implicit threat of a boycott could help bring about.

## Biographic Summary

Barry M. Blechman received his Ph. D. in political science from Georgetown University and is serving as a senior fellow and a member of the defense analysis program at the Brookings Institution. Before joining the Brookings staff in 1971, Blechman was affiliated with the Center for Naval Analyses for nearly 6 years. During that time, he participated in studies of U.S. antisubmarine warfare forces and strategic policies and directed a study of U.S. military options in the Indian Ocean. He is one of the coauthors, this year, of Brookings' annual review of the Federal budget, "Setting National Priorities": he contributed to the 1973 and 1972 editions as well. His other writings published by Brookings include: "Strategic Forces: Issues for the Midseventies" and "The Changing Soviet Navy." He is also the author of several articles on issues in U.S. defense policy published in various newspapers and journals.

## Biographic Summary

Arnold M. Kuzmack recived an A.B. degree in physics from Harvard University and a Ph. D. in mathematics from M.I.T. From 1966 to 1970 he was a staff member of the Naval Forces Division, Office of the Assistant Secretary of Defense (Systems Analysis), and was appointed deputy director of the Naval Forces Division in 1969. From 1970 to 1973 he was a member of the defense analysis staff of the Brookings Institution. In 1973 he became an operations research analyst in the Office of Planning and Evaluation, U.S. Environmental Protection Agency. He has written a number of articles and monographs on defense planning and on general purpose naval forces.

This article was written by Dr. Kuzmack in his private capacity. No official support or endorsement by the Environmental Protection Agency or any other agency of the Federal Government is intended or should be inferred.

# VII. Alternatives For Petroleum Storage

# storage cavities leached from salt

This technique saw rapid development in the U.S.A. in the 1950 s for the storage of LPG but has now been used successfully for large underground stores of crude oil and petroleum products. The storage cavities are created in rock salt by controlled leaching with fresh water or sea water. The product to be stored then replaces the brine and the product is removed by reinjecting brine or displacing with fresh water.

The location for such a storage facility must be carefully chosen taking into account the distance to production or importing centres, areas of consumption, or proximity to a pipe-line network. As well as the need for a suitable salt deposit, the location must be within reach of a water supply (fresh or sea water) and a suitable outlet for the waste brine (sea, salt pans, or porous strata already impregnated with salt water). The brine might also be saleable to the chemical industry.

## *use of storage cavities leached in salt*

Many applications are possible for this type of storage due to the natural impermeability of the cavities created and the fact that salt is chemically inert with respect to a large number of products (in particular to hydrocarbons).

***Storage of liquid products,***

especially crude oil, diesel oil and fuel oil

***Storage of liquified gas,***

butane and propane

***Storage of gases,***

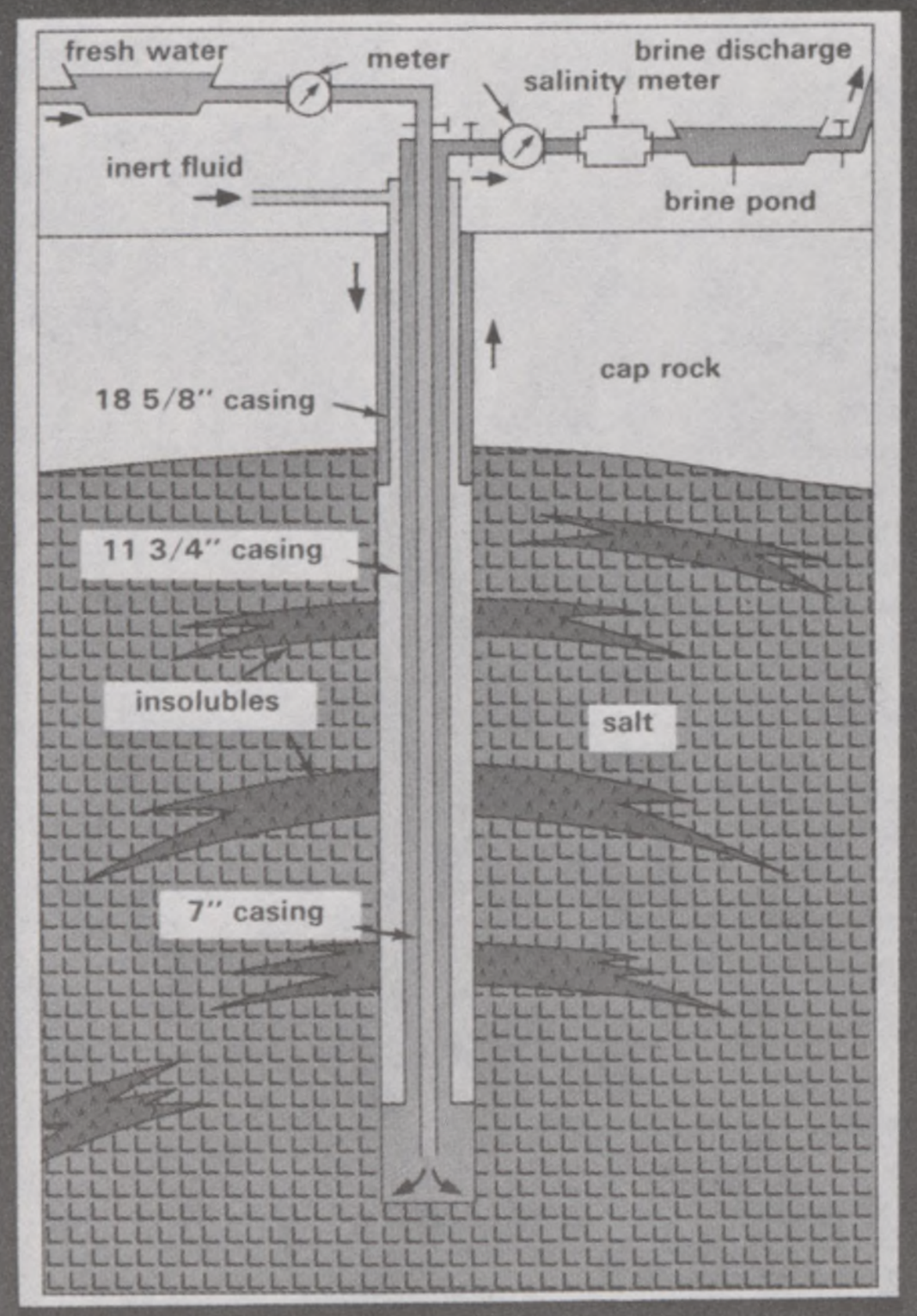
natural gas, ethylene, town gas, air, inert gases, etc.

***Disposal of wastes,***

radioactive waste products, chemicals, petroleum waste. Eventual chemical reaction by long term contact with salt must be carefully studied, even when the waste is not to be recovered.

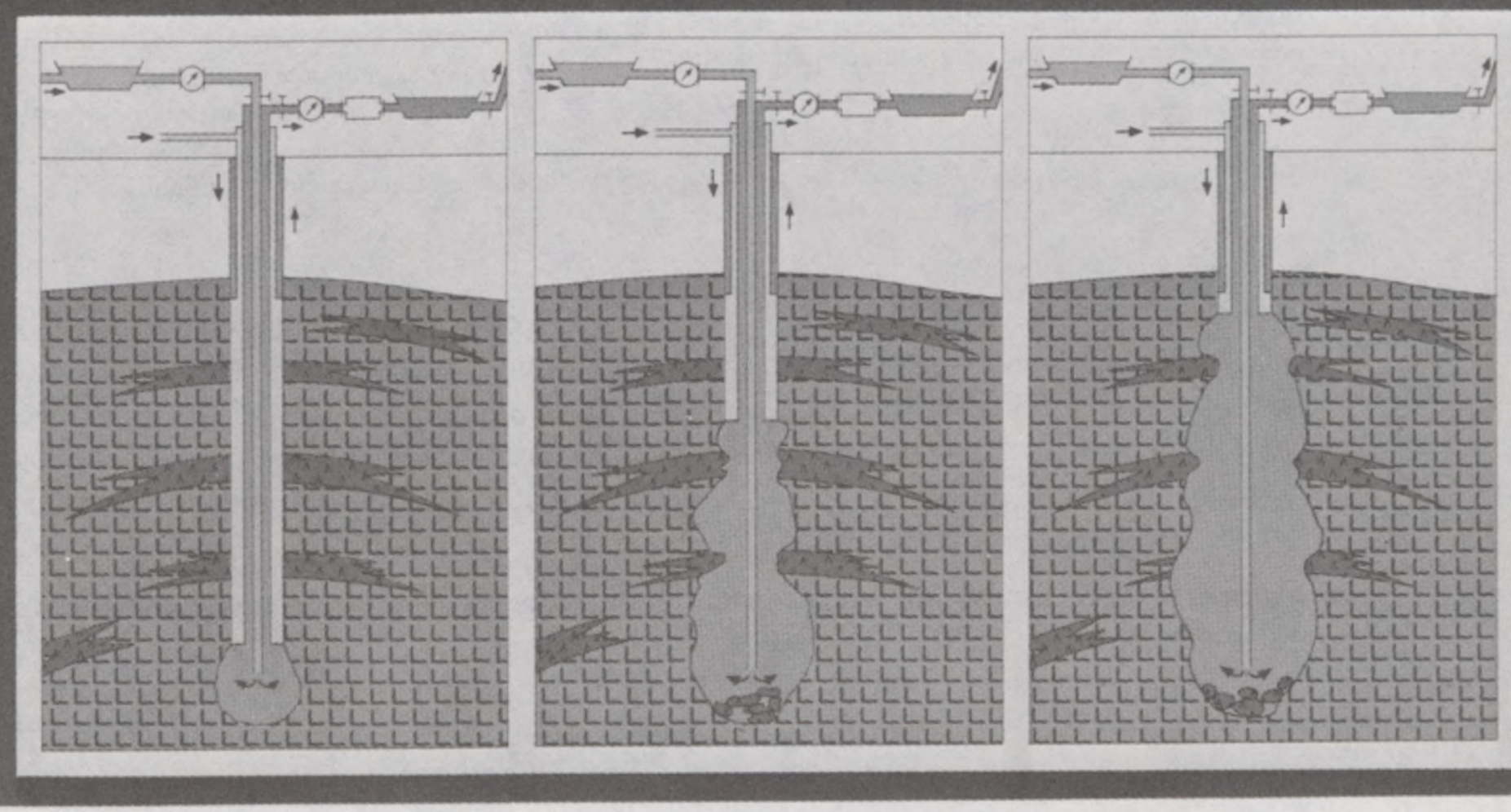
**geostock**

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*télex auropari 61094 géo*




## *leaching*

The optimum size to which cavities should be leached is a function of a number of parameters including depth and the petrophysical characteristics of the salt deposit. The method of use of the cavity must also be taken into account.



## *cavity construction*

Once a suitable salt bed has been located through normal exploration procedures, a hole is drilled to a depth corresponding to the bottom of the future cavity. The hole is then cased and cemented from surface to the required depth in the salt (top of cavity) and two vertically adjustable concentric tubings are installed. Fresh water injected through the central tubing dissolves the salt producing brine which flows to surface via the annular space where it is disposed of or utilized. When the cavity has reached the desired size, the center tubing in removed and the remaining tubing is lowered to the bottom of the cavity.

## *operation*

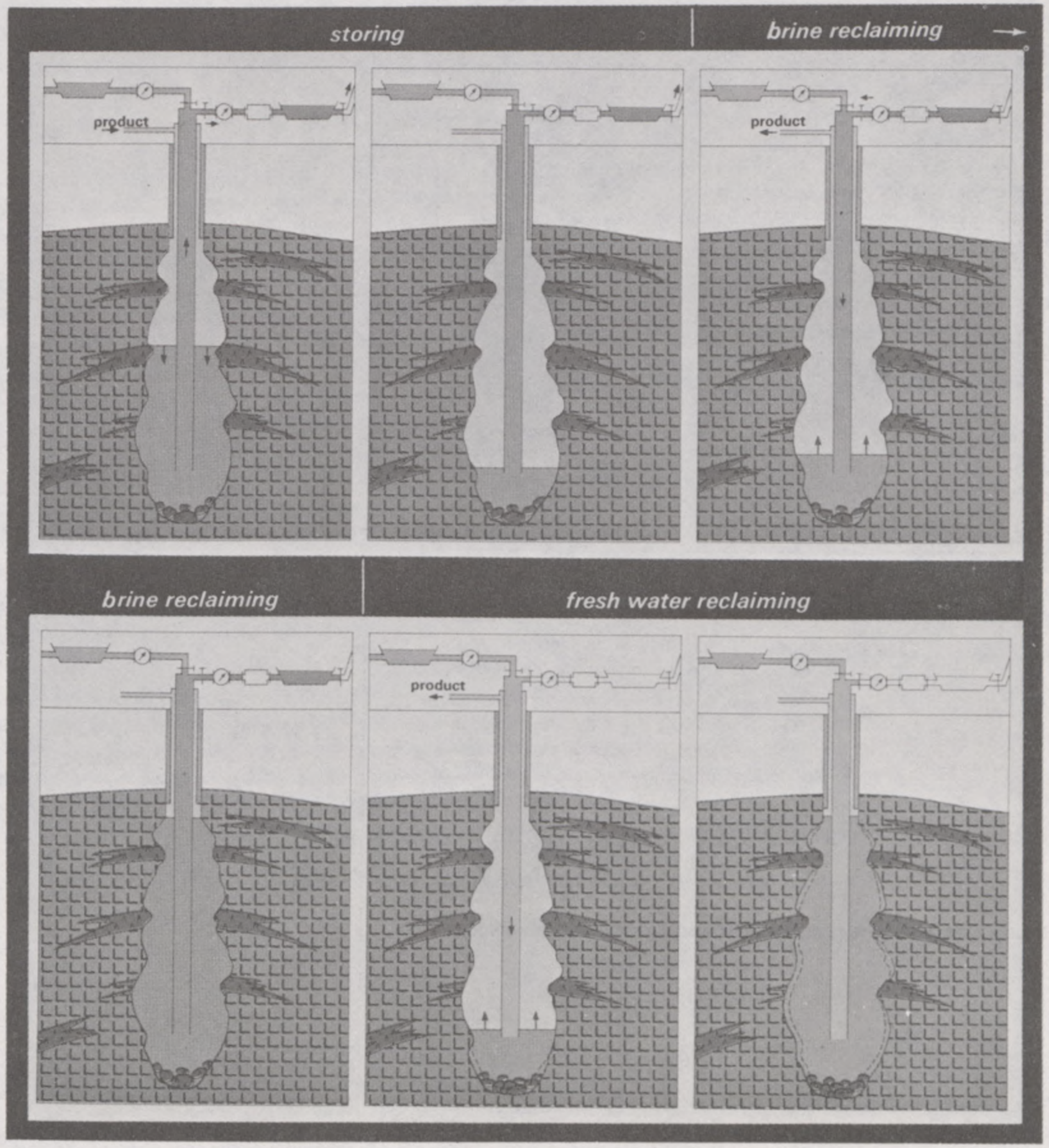
### *Storing*

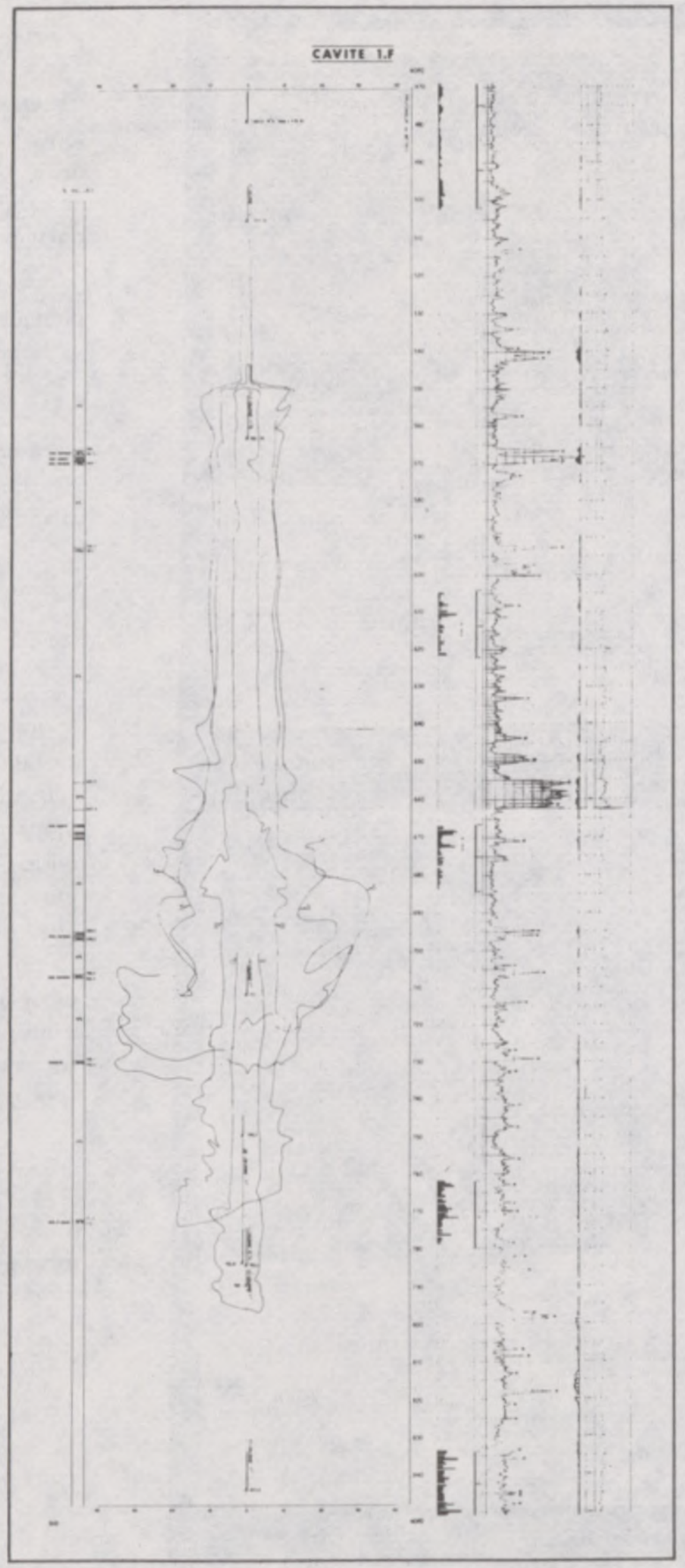
The product to be stored is pumped to the cavity via the annulus between the cemented casing and the tubing while brine is displaced via the tubing.

### *Reclaiming*

The process is reversed. Brine or fresh water is injected via the tubing and the product is displaced to surface via the annulus.

It must be noted that when fresh water is used to displace the product, the leaching process continues thus enlarging the cavity (by 15 % to 17 % of the initial capacity) thus, after a number of cycles, the stability of the cavity may be adversely affected.





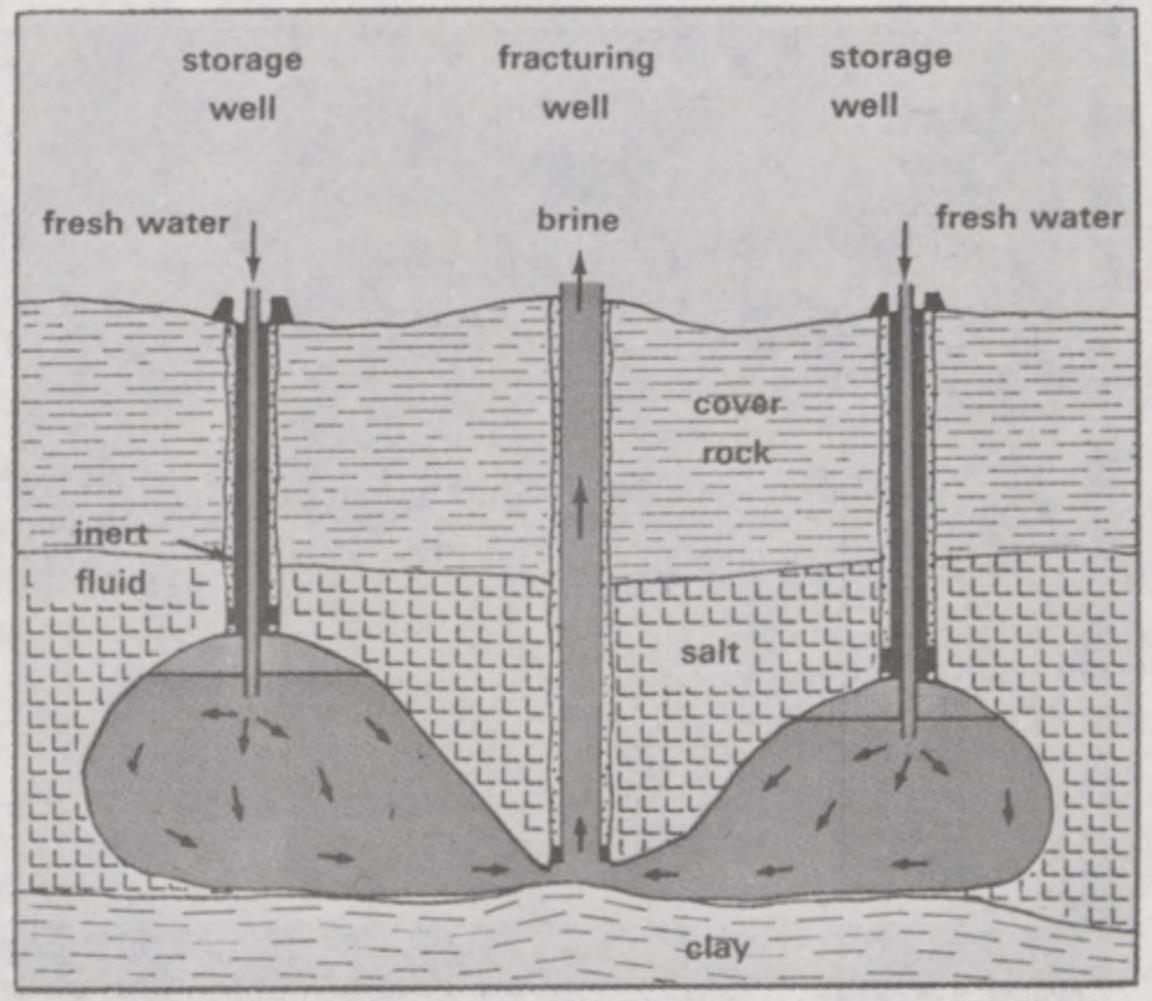

actual cavity measurements

## *horizontal leached cavities*

When thin salt beds are encountered, a different technique may be employed :

a fracture in the lower part of the formation is created by an injection of water at high pressure and high capacity. The fracture makes a communication between two or more wells.

The leaching of the cavity then proceeds making use of the fracture well to return the brine to the surface.



# *crude and diesel oil stored in leached cavities*

## *manosque*

At a point 85 km North-North East of Marseille, Geostock has since 1967 been building (and managing) an underground storage facility for petroleum products of worldwide importance, **63 million bbls** by 1976. This storage facility is linked to the Etang de Berre refineries and the South European and Mediterranean-Rhône pipelines.



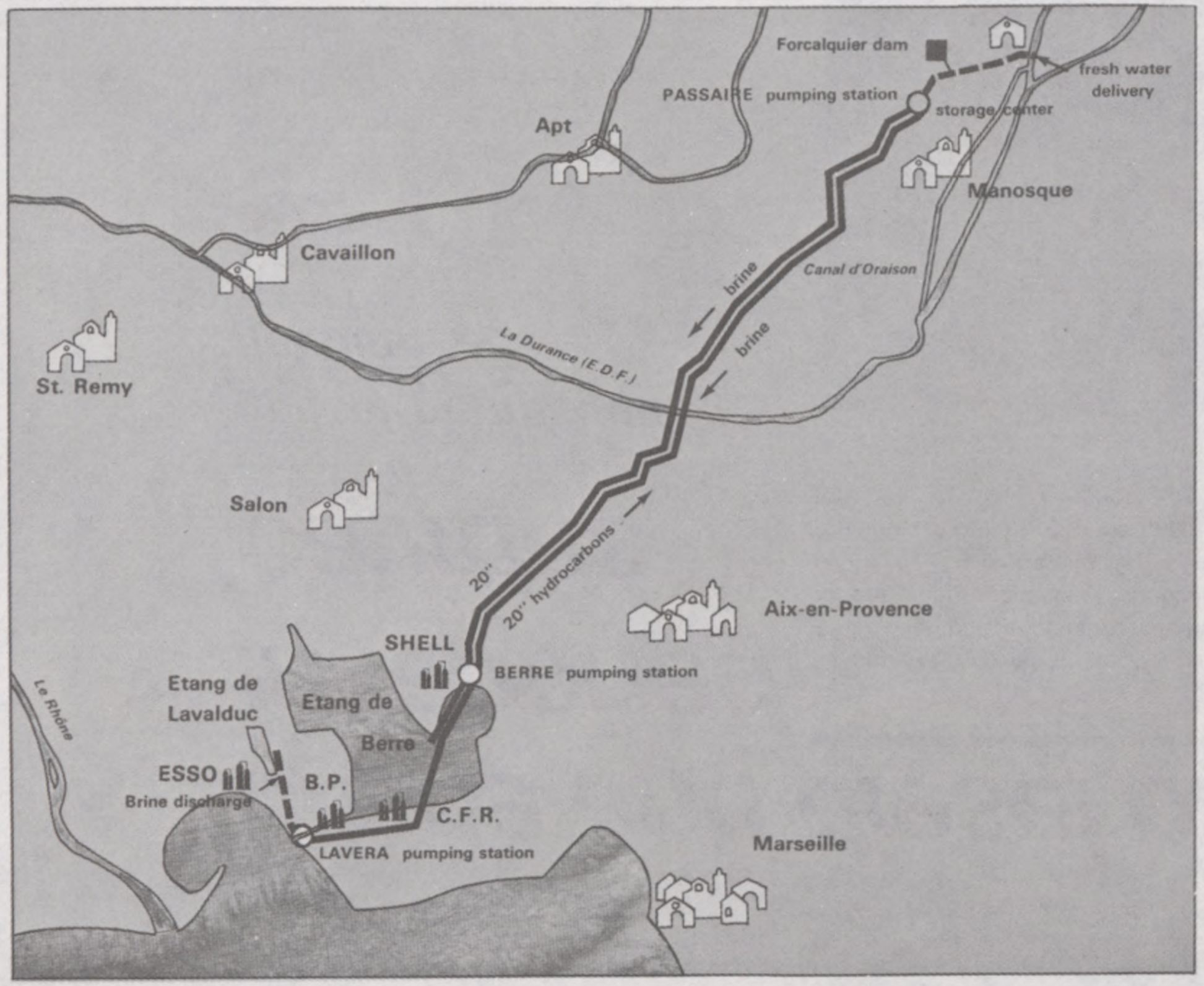



***geosel-manosque geopipe****

* Shell Française 26.7 % - Société Française des Pétroles B.P. 19.9 % - Compagnie Française de Raffinage (Total) 26.7 % - Elf 26.7 %.

***geostock***

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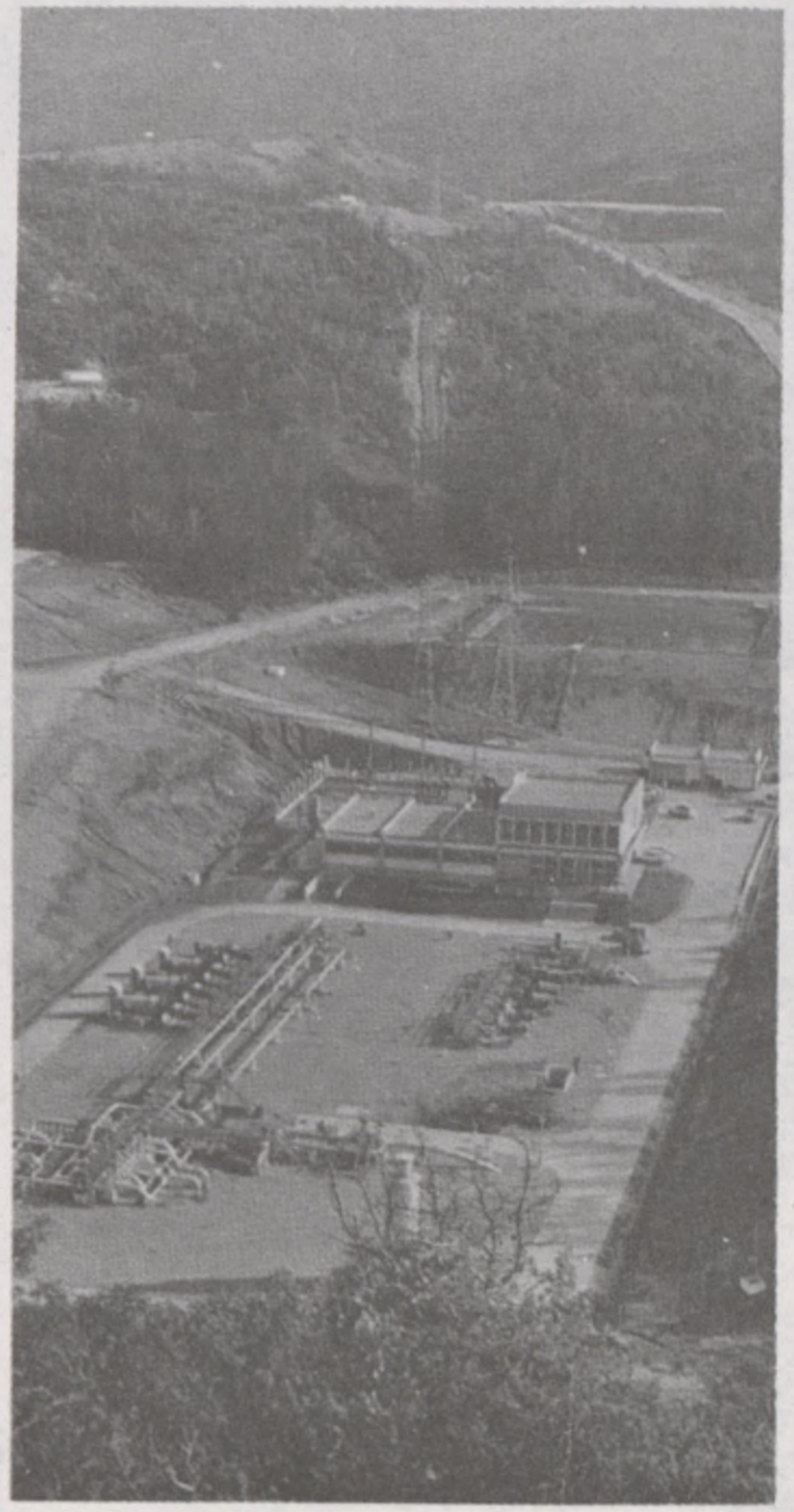

## *drilling*

- Nearly 35,000 feet of exploratory wells were drilled to explore the Manosque rock salt formations.
- Over 130,000 feet of production wells will have been drilled for the creation of the actual cavities.
- The top of the salt structure is encountered between 1,100 and 3,000 feet.

## *leaching*

- The cavities were leached over a height varying from 250 to 1,600 feet having diameters from 65 to 250 feet.
- Fresh water consumption is, in Manosque, about ten times the volume of storage created.
- The requirements for fresh water have been met by the local water works : The Durance canal and the Forcalquier dam.

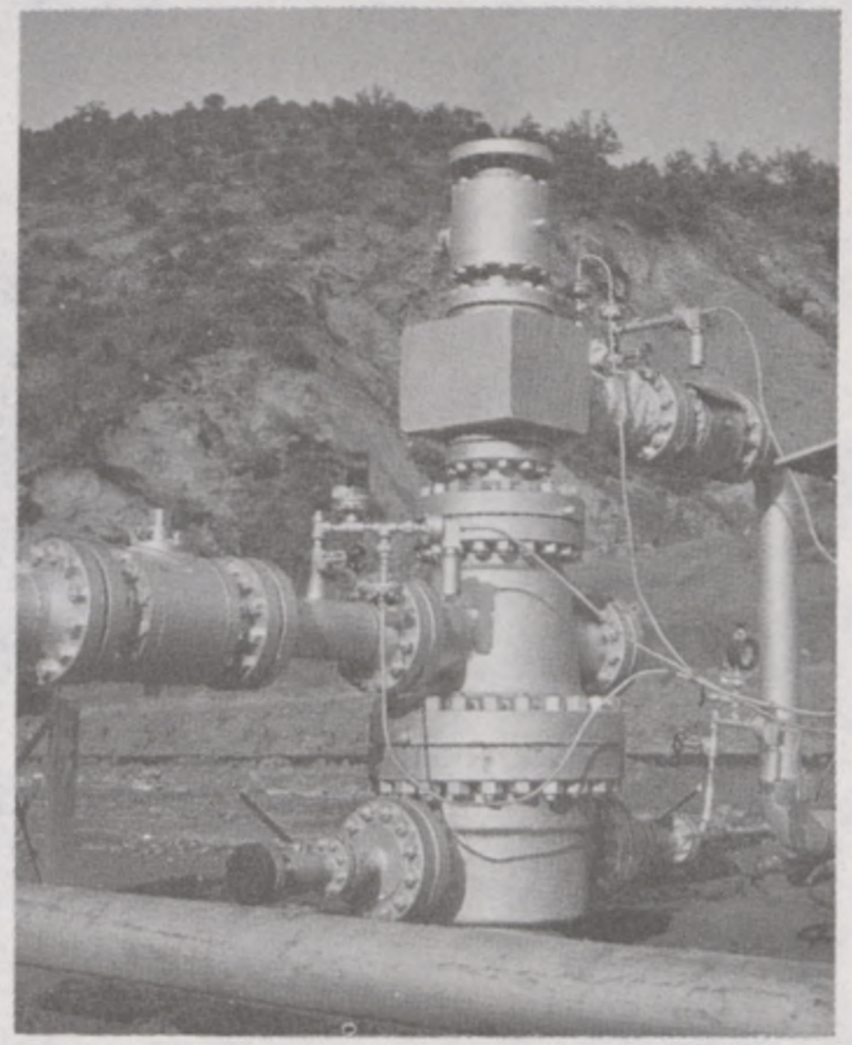


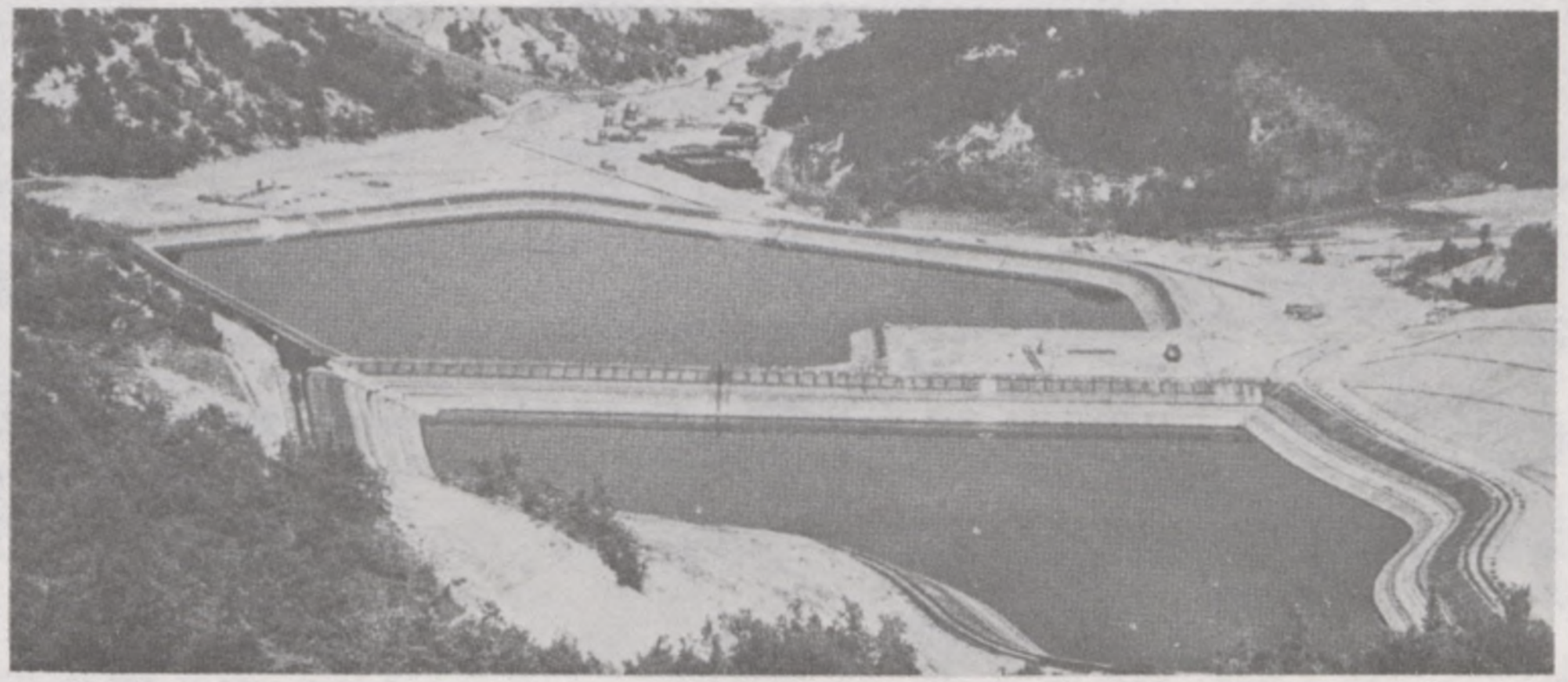


### *storage*

- *Each year approximately 5.5 million bbls of storage are added.*

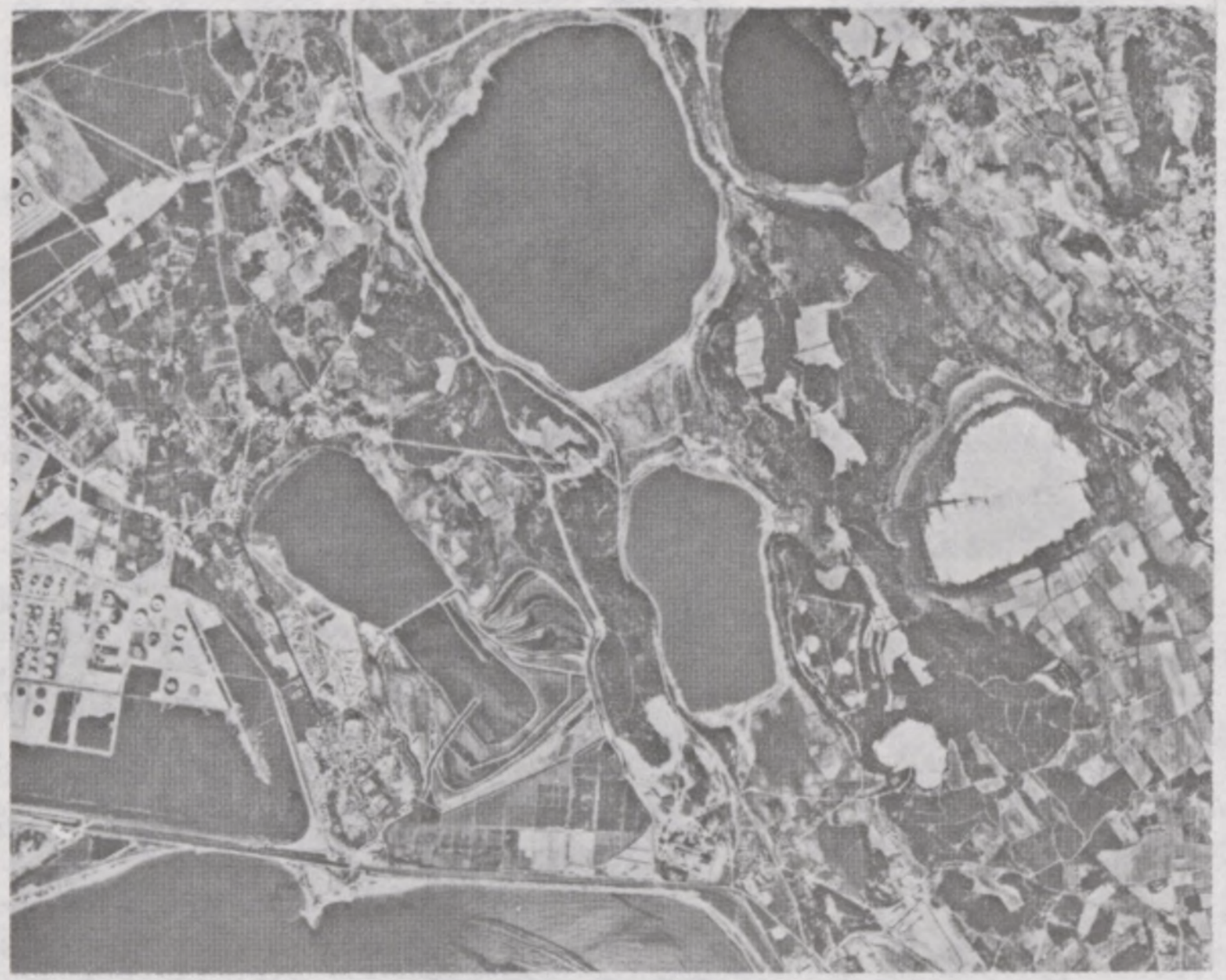
*The cavities are from 250 to 1 600 feet high (Eiffel Tower is 1 065 feet) and from 65 to 250 feet wide (Notre-Dame de Paris is 150 feet) and capacities range from 550,000 to 2.3 million bbls (storage capacity required for a refinery of 2 to 3 million tons per year).*



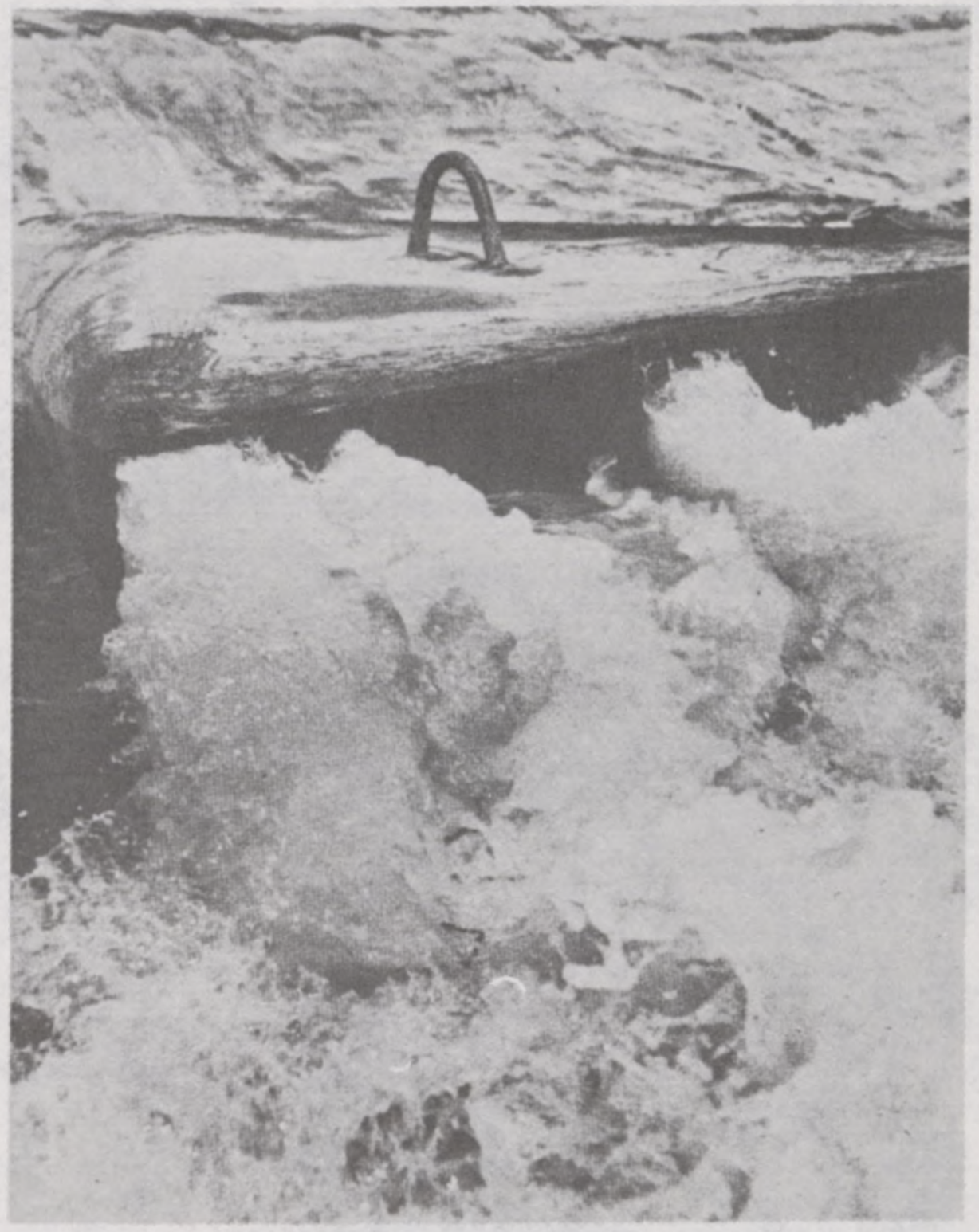


*Brine pit capacity is 1,26 million bbls.*

Pumping capacities :
leaching pumps : 10,000 IGPM:
brine and oil product pumps : 3,700 IGPM from
Berre to Manosque: 11,000 IGPM from Manosque to Berre.



*6,600 million gallons of brine can be stored in the self concentrating (solar evaporation) brine ponds for which the natural ponds of Lavalduc and Engrenier are used. This storage is used to supply brine to the local chlorine industry.*



[Excerpts from Dow Chemical Co.]

# Underground Petroleum Storage

Public attention has recently been focused on the concept of underground petroleum storage. Several factors have contributed to this newfound interest.

First, the current shortage of petroleum products has increased concern for stockpiling large oil inventories. Second, underground oil storage has proved to be the safest and most economical answer for large storage needs.

Underground storage is not a new concept. The Canadians used this method during World War II * * *.

*The Salt Dome*

Millions of years ago (during the Jurassic period) a vast sea covered most of what is today Texas and Oklahoma. Over a great span of geologic time, the sea receded towards its present coastline along the Gulf of Mexico. As it retreated, large quantities of salt were deposited by evaporation.

These salt beds were eventually covered by deposits of sediments. During long periods of time, the thickness of these sediment deposits increased to many thousands of feet (fig. 1).

The original layer or bed of salt is called the mother salt bed. As sediments mounted above it, the mother salt bed began to move in accordance with basic physical laws.

First, the salt was less dense than the sediments that covered it. Salt has a specific gravity of 2.2. Sediments vary from 1.7–2.0 near the surface to 2.4–2.8 at depth. Thus, the salt was lighter or more buoyant than its overburden and started to rise just as a piece of wood will float in water.

Second, the salt was buried at such a great depth that tremendous pressures were exerted on it. Under certain conditions of high pressure and elevated temperature, salt behaves in a plastic manner—it begins to flow like a think, viscous fluid. The salt isn't molten, but it flows like a glacier—very slowly, over great lengths of time (fig. 2). The salt started to rise under the influence of high pressure and density differential.

Wherever the sediment overlying it was thin or weak, the salt began to rise as a giant plug or dome, several thousand feet across. The surrounding sediments sank as the salt squeezed up through it. Eventually, the salt dome reached a point where the pressure was relieved and the densities were in equilibrium, much like a ship floats at a certain level by displacing an equal weight of water.

At some locations, the salt made a pronounced mound at the surface. These mounds, or salt domes, dot the Texas and Louisiana coast.

Physically, salt domes are giant plugs that have risen to within a few hundred feet of the surface. A typical dome might be 1 to 2 miles across at a depth of 1,200 feet (fig. 3). The top of the salt dome is usually covered by 300 to 400 feet of cap rock, made up of limestone,

gypsum, and sulfates. The formation of cap rock is usually attributed to water reacting with the salt mass to precipitate insoluble residues.

The salt plug shaft continues down to the mother salt bed, believed to lie at a depth of 30–50,000 feet along the gulf coast. This dome, from the top down to a level of about 10,000 feet, would contain almost 10 cubic miles of salt.

A great deal is known about salt domes because oil, gas, and valuable minerals are often found near them. The sides of the dome form traps that hold oil and gas. The cap rock area contains sulphur deposits. And, of course, the salt itself is a valuable mineral.

*Mining the Salt*

One method to bring the salt to the surface would be to dig a mine-shaft down to the dome and mine the salt like coal. This would be possible only if the salt were near the surface.

A second and more economical technique involves dissolving the salt with fresh water forced down a well drilled into the deposit. The resulting brine is returned back up a second pipe to the surface.

In practice, drilling a brinewell involves several important steps. Here's a simplified version (fig. 4).

First, a large hole about 3 feet in diameter is drilled to a depth of 200 to 300 feet. A pipe casing is put in place and cemented to the surrounding earth. This pipe penetrates the zone where ground water is found. Actually, only water near the surface is potable on the gulf coast domes. Down below 2 to 300 feet, the water is brackish. Inside the first casing, a smaller hole is sunk into a cap rock above the salt. Typically, the drill might hit rock at 800 feet and emerge through it at 1,100 to 1,300 feet. Pipe is inserted down near the bottom of the cap rock and cemented in place along its length to the surface. This pipe terminates above the top of the salt.

Inside this casing, a smaller hole is drilled to a minimum of 500 feet into the salt. Casing is run in this hole, from ground level to drill depth, and cemented back to the surface.

Next, a smaller hole is drilled to the bottom of the well (typically 400 feet) and two concentric strings of casing are hung off the wellhead with the outer casing being approximately 200 feet shorter than the inner casing.

Fresh water is forced down the annulus between these last two casing strings at several hundred pounds of pressure and dissolves the salt into brine. Because the brine is heavier than the fresh water, it collects at the bottom of the well where the innermost pipe returns it to the surface.

Oil is added to the top of the mining zone to protect the salt at the top of the well from the action of the mining water.

The quantities of brine recovered are carefully monitored. Additionally, a special sonar device is lowered into the well to check progress. In this way, an accurate picture of the cavern created in the salt can be drawn. The sonar device bounces sound waves off the cavern walls at depth intervals of several feet. The resulting echoes are used to plot the shape and dimensions of the cavern, much like a depth gaging sonar can be used to make a contour map of a sea bottom.

Dow practices in brinewell management are extremely conservative. Zero surface subsidence is a strict Texas division policy. Thus

the ground level is unaltered. No ground water is pumped in the mining operation. River water is used.

Additionally, when a cavity reaches a predetermined width, conservative by accepted standards, mining is halted. The abandoned brinewell can now be used as an immense storage tank below ground. To get an idea of its size, consider that a typical well might have a cavity 800 feet high with a width of 50 to 75 feet near the top and 150 feet near the bottom—larger than a 50-story building, such as One Shell Plaza in Houston. The Washington Monument would fit comfortably within this cavity (fig. 5). A cavity this size could store almost 2 million barrels of oil. That's nearly 84 million gallons.

The process of storing and retrieving oil from such a cavity is relatively simple. Oil is forced down the fresh water pipe, displacing brine which rises through the bottom pipe to the surface. Because oil won't dissolve the salt, it's safely stored and uncontaminated.

To retrieve the oil, the process is reversed. Brine forced down the central pipe forces the oil back to the surface.

Each cavity is tested thoroughly and surveyed before being used for storage. Besides the sonar mapping, the cavity is pressure tested for a period of several days to insure that no fissures exist. By evaluating pressure readings, an engineer can be certain of the cavity's integrity.

*Underground Storage*

The economic advantages of underground storage compared to above ground tanks are obvious. Cavity storage requires no container maintenance. Cavities can be made with much greater capacities than steel tanks.

Underground storage is extremely desirable over above ground tanks, but what about its safety and environmental impact?

*Fire.*—Salt cavity storage is the safest container known for flammable substances. The oil in the caverns can't burn because no air is present. The salt itself will not support combustion.

*Earthquake.*—Geologically, the gulf coast area is extremely stable. It is not an active earthquake zone. In the unlikely event of a tremor, past experience with salt domes in other areas has shown that the salt has enough elasticity to absorb most earth movements without fracturing. If a quake sheared the well pipe, a second well could be easily drilled to recover the oil.

*Collapse.*—Because of DOW's conservative mining practices, cavity collapse is an extremely remote possibility. A typical cavity represents a void of only a few million cubic feet in a salt mass of several cubic miles (fig. 6). The roof of the cavity is narrow so that no wide areas of salt or cap rock are unsupported. Additionally, Dow policy is to constantly maintain a positive pressure in all wells of several hundred pounds. This pressure on the oil or brine pushes against all sides of the cavity just as the salt did before removal.

All Texas division wells are in salt domes far beneath the surface, typically 1,600 to 3,400 feet down. Thus, the roof of the cavern is quite thick in comparison to the small volume of the cavity. Brine wells are always spaced several hundred feet apart. Dow's policies of conservative mining and constant positive pressure have resulted in a perfect safety record. No Dow brine or storage well has ever collapsed causing any surface subsidence.

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*Spills and leaks.*—The salt cavity is impermeable to oil, since oil can't dissolve the walls. Any brine in the cavity is saturated and can't dissolve any more salt. The oil is contained by solid salt walls, thousands of feet thick on the base and sides. Because each cavity was pretested with high pressure, engineers are certain that no fissures or leaks exist. Additionally, the stored product's level and pressure are monitored. Any change in level or pressure would be detected and the cavity pumped out.

Because the oil is under pressure, could it escape back up the drill hole? The probability of such an occurrence is extremely low. The well casings are set in solid cement along their entire length down to the top of the cavity and capped with extremely reliable wellheads (valve assemblies). These wellheads are built to withstand pressures several times those they are required to handle in use.

In the unlikely event that a wellhead failed, less than 1 percent of the oil would come to the surface. The spill could be easily contained with dikes around the well area.

The chance of a fire is remote. Crude oil has a very high flash point and unlike an oil well, no natural gas would escape to feed a fire. Moreover, the fire would extinguish itself when the oil flow stopped.

*Environmental Impact*

Cavity storage is also the most desirable alternative from an environmental viewpoint.

*Water.*—Cavity storage of oil will not pollute ground water in any way. The oil is stored several hundred feet below any ground water. It's prevented from entering the water acquifer zone by thick steel pipes set in cement in the well. No ground water zones exist at the depth of the salt cavity.

Dow has used oil to protect the salt cavity roof from mining water action for over 20 years and has never experienced any oil pollution of underground water. The chances of a spill contaminating above ground water are also remote. Unlike a leak in an aboveground tank which would discharge oil down to the leak level, any blowout in a cavity would release less than 1 percent of the contents. Once the few hundred pounds of pressure were released, the flow would cease. A spill of this magnitude could be easily contained with earthen dikes.

Because Dow utilized brine for the production of caustic soda and chlorine, none is ever discharged as waste. The brine displaced when oil is stored in a cavity is piped to a Dow plant, not discharged into a river or stream.

*Air.*—Underground storage presents no air pollution problems. Unlike aboveground tanks, cavities are not vented to the atmosphere—no oil vapors can escape. The brine that comes into contact with the oil will pick up an odor, but Dow engineers have devised a scrubbing system that will cleanse the brine of any odor before it is stored on the surface.

*Appearance.*—Cavern storage is by nature much more acceptable aesthetically than aboveground tanks. The only evidence of a cavity containing a million barrels of oil is a small wellhead. Aboveground storage for an equal volume would consist of a tank farm covering many acres.

Dow believes that oil storage in mature brine wells represents the safest, most economical, practical, and environmentally attractive solution to the petroleum stockpiling problems.

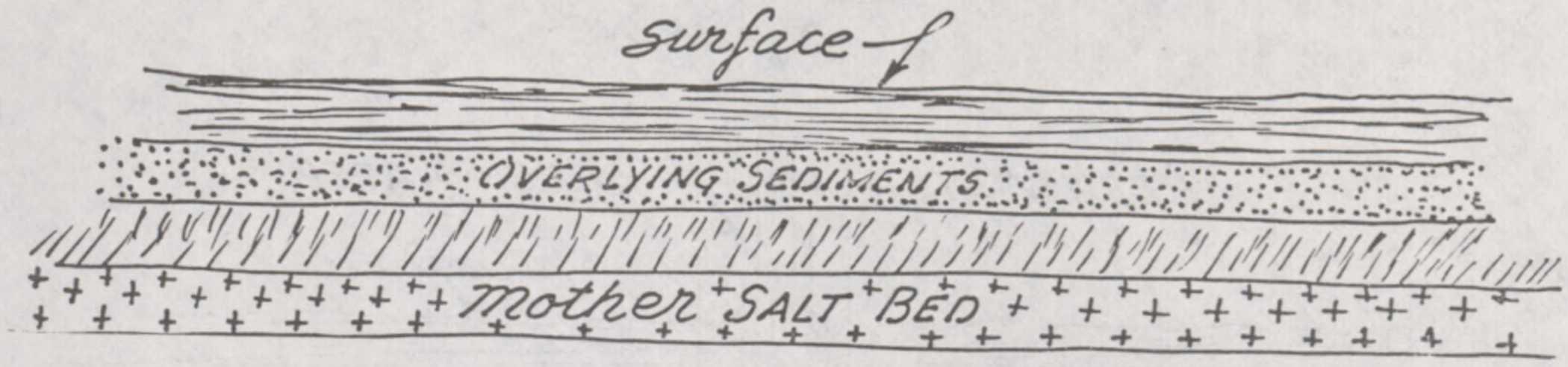



FIGURE 1

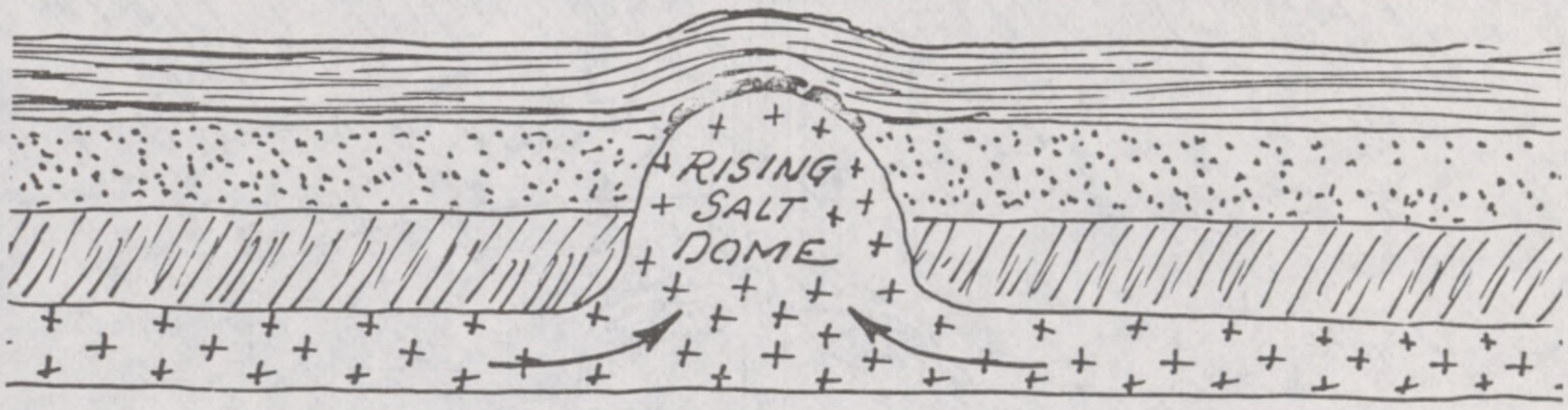



FIGURE 2

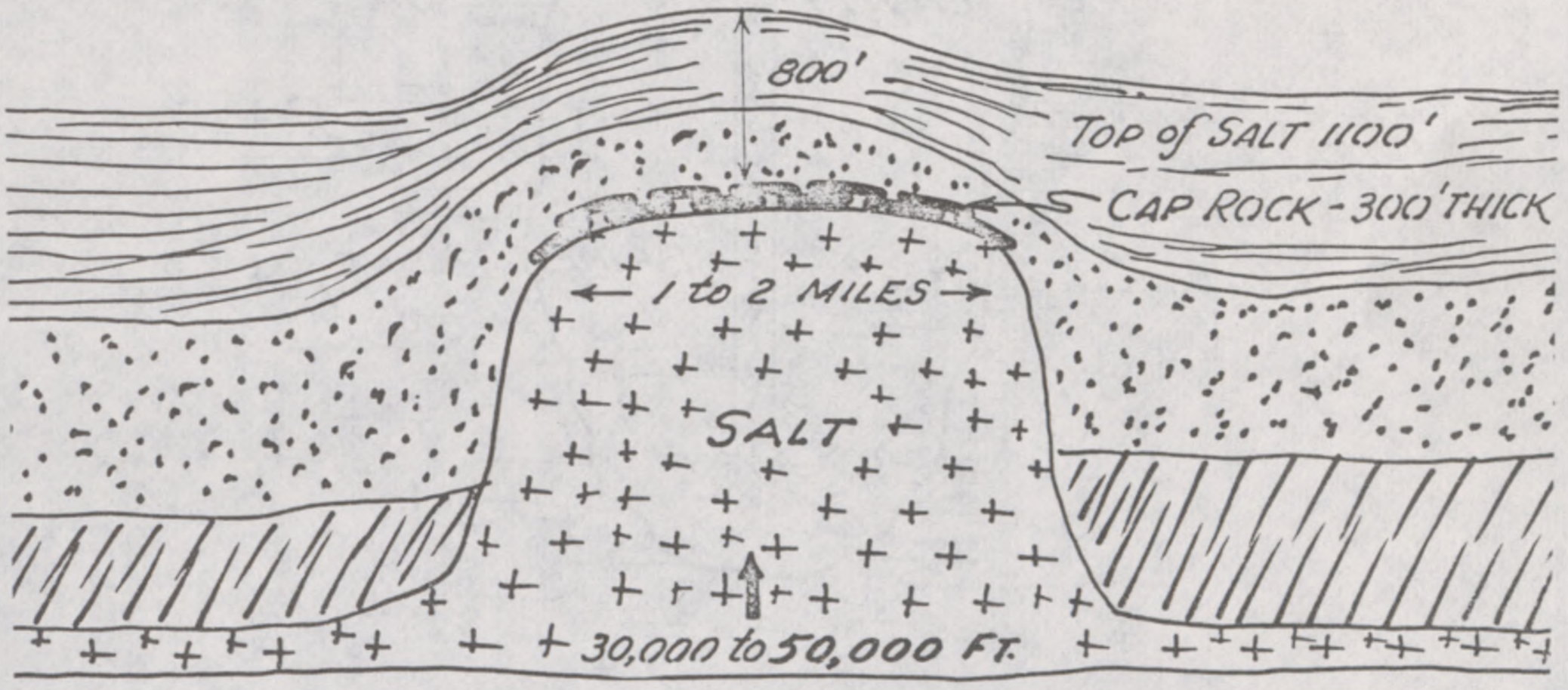



FIGURE 3

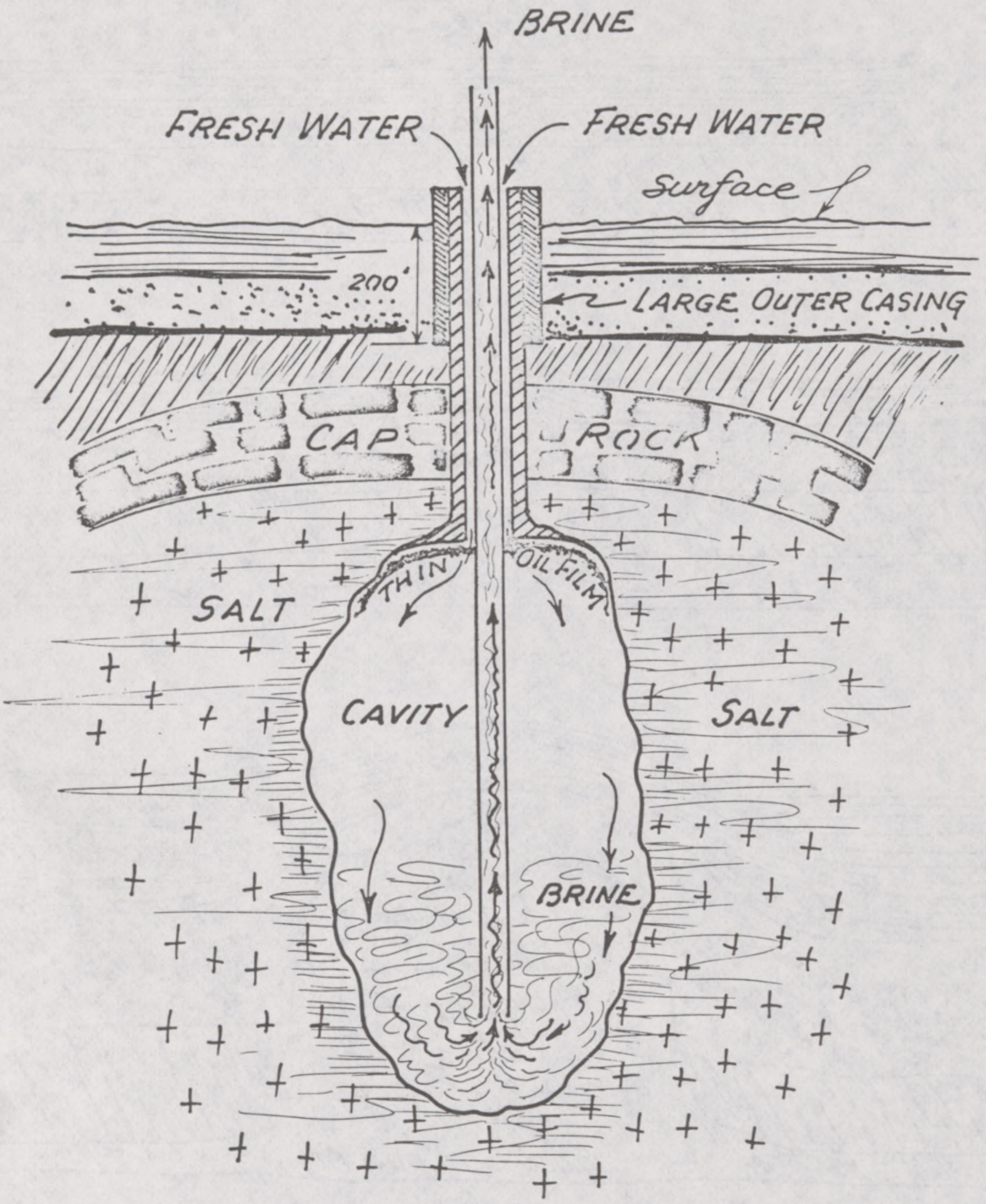

BRINE
FRESH WATER
FRESH WATER
Surface
200'
LARGE OUTER CASING
CAP
ROCK
THIN
OIL FILM
SALT
CAVITY
SALT
BRINE

FIGURE 4

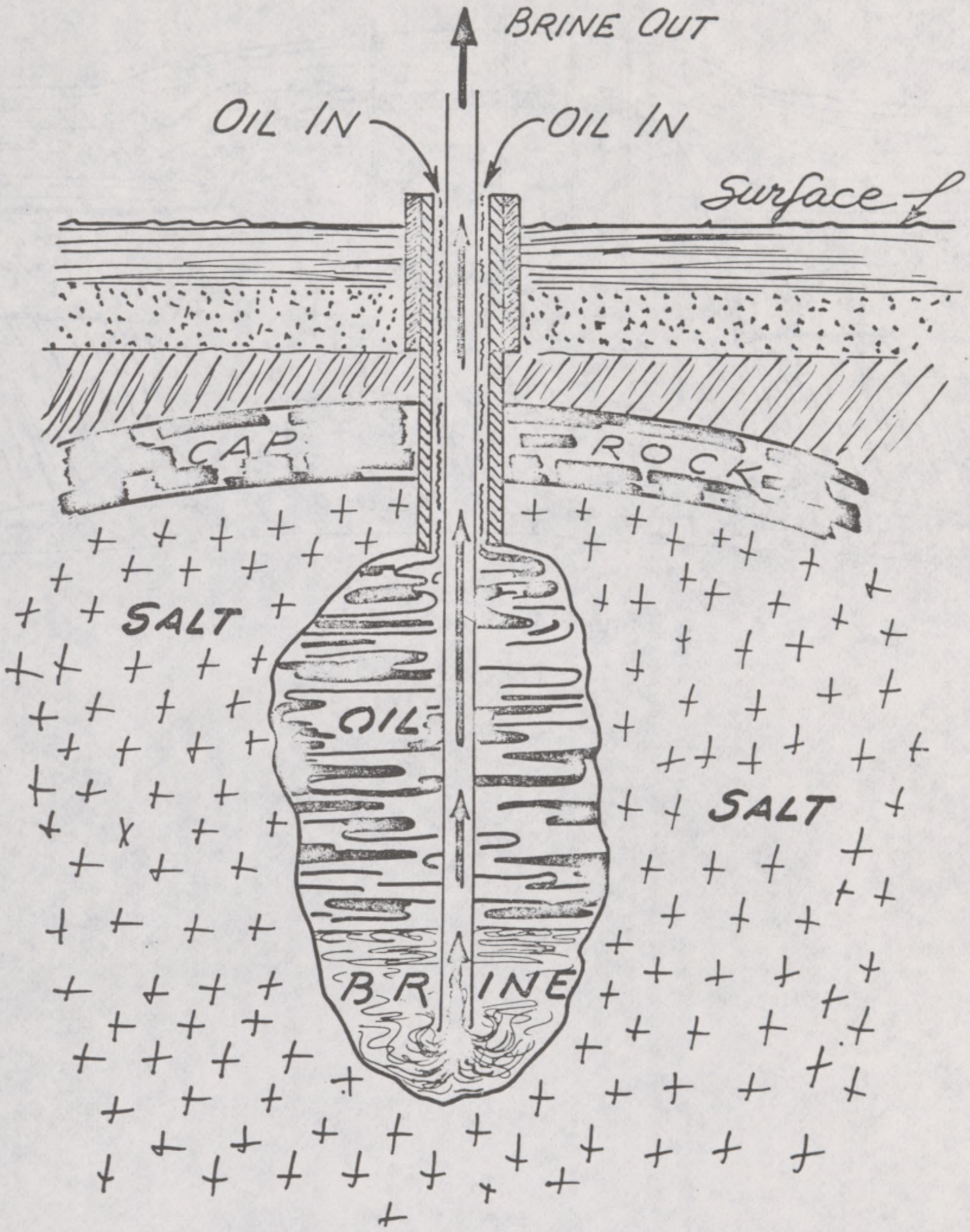



FIGURE 5.—Oil Storage.

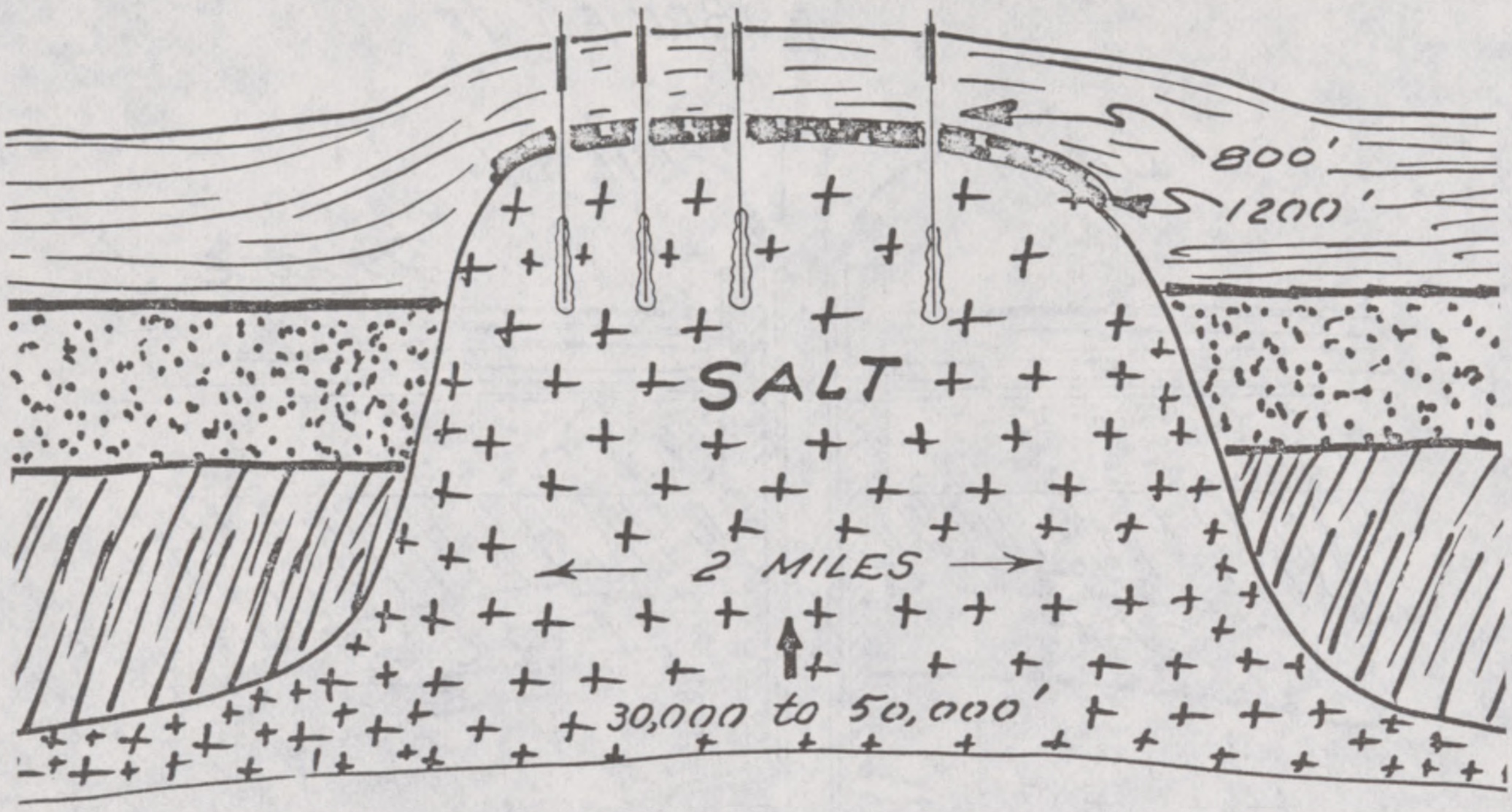



FIGURE 6.—Storage Well.

[From the Oil and Gas Journal, Oct. 28, 1974]

## Rock-Cave n-Type Storage Can Be Cheaper Option

Over the past decade, mined, unlined rock-cavern storage for crude oil and refined products has become economically more attractive. This trend is likely to continue—on the one hand because of advances in blasting technology, on the other hand because of rising steel costs for aboveground tankage and larger capacity requirements.

Though this type storage has had its greatest application in Finland, Norway, and Sweden, attractive geological conditions exist in many parts of the world.

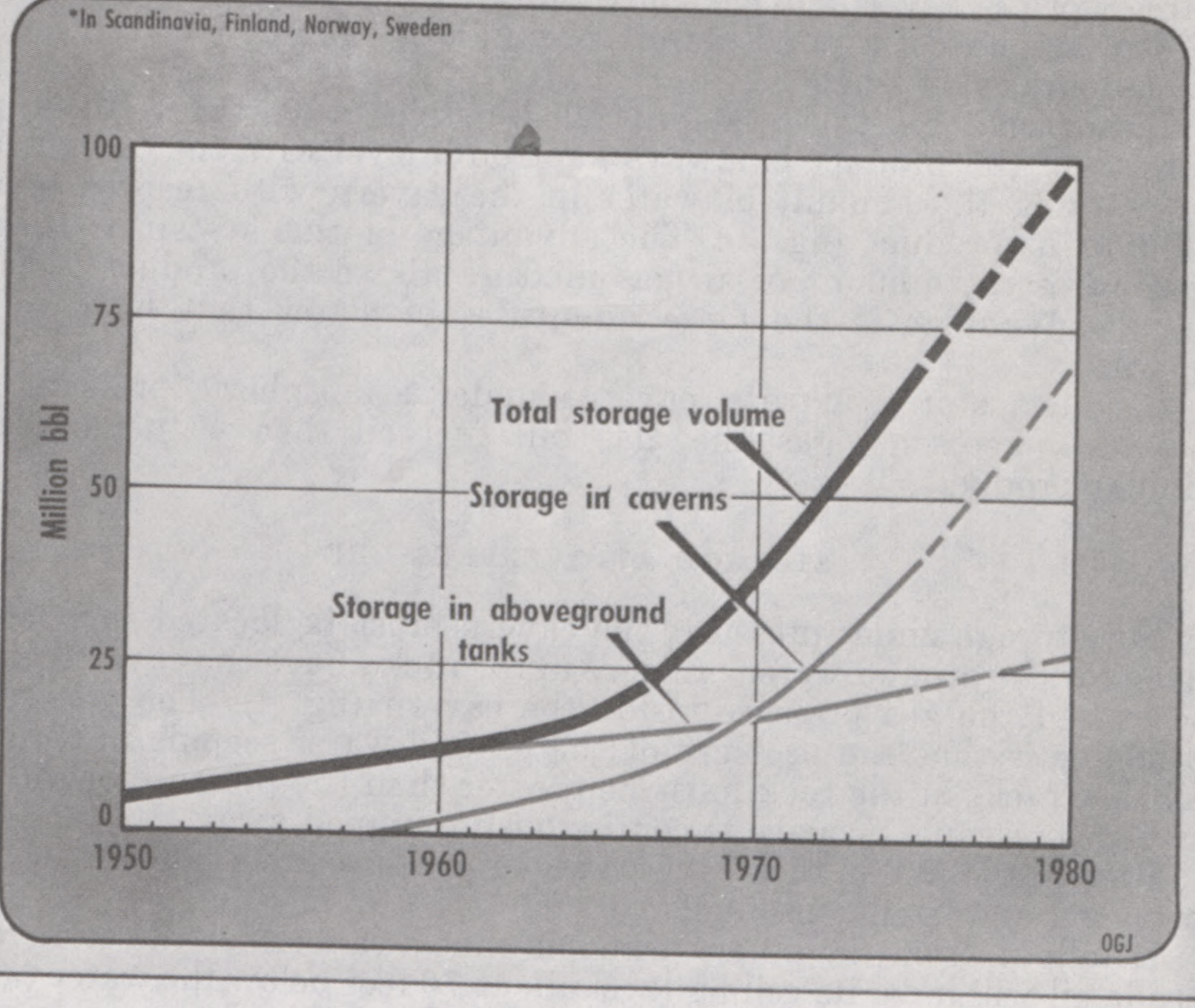
Mined caverns were first used for hydrocarbon storage in Scandinavia in the late 1950's. As figure 1 shows, this capacity has been greatly expanded since then. Almost all new storage is the rock-cavern type.

The first rock caverns were blasted mainly for military purposes. However, experience revealed that the cost of this type of storage was favorable enough to compete successfully with aboveground tankage.

Before the 1960's, a large proportion of Scandinavia's refined product needs were imported. But in the 1960's and early 1970's, refining capacity was greatly expanded. And because of the recent oil crisis, efforts are under way to expand domestic refining capacity even more.

Fig. 1

Underground refinery storage leaping ahead*



Underground storage will be exploited to the maximum in these new refineries.

In fact, this is even a factor in site selection.

## GENERAL PRINCIPLES

The principles for the cavern storage of petroleum products vary somewhat depending on whether the product is stored at atmospheric pressure or at overpressure. In either case, the following four prerequisites apply:

The product must be lighter than water.

The product must be insoluble in water.

The rock must be strong enough to allow the construction of fairly large caverns.

The water table must be constant and its level fairly exactly known.

## STORAGE AT ATMOSPHERIC PRESSURE

For storage at atmospheric pressure, the cavern roof is located at least 15 feet below the lowest occurring ground water level (fig. 2). Ground water seeping into the cavern is continuously pumped away by seepage pumps placed just above cavern flood level. Thus a bed of water forms at a constant level just above the cavern floor (fixed water bed), and the water table in the rock forms a local depression draining down toward the water bed in the cavern.

The stored product floats on the water bed, filling the cavern and the cracks in the rock, but is contained by the depression in the water table (rock is never homogeneous, but always contains cracks).

The amount of ground water continuously seeping into the cavern is comparatively small.

In a variant of this system, called mobile water bed, the upper surface of the product is always kept on a level with the cavern roof by varying the amount of water in the cavern with respect to the amount of product (fig. 3). The advantage of this system is that it minimizes the amount of air/gas mixture above the product surface. Its disadvantage is the large quantities of water that have to be handled.

Products stored in rock caverns under atmospheric pressure are naphtha, kerosene, gasoline, gas oil, fuel oil, heavy fuel oil, and similar products.

## STORAGE AT OVERPRESSURE

For storage under pressure, the cavern must be located sufficiently deep for the ground water pressure in the rock above the cavern ceiling to exceed the gas pressure inside the cavern (fig. 4). The governing principle is that the pressure of the ground water seeping in through all the cracks in the rock must be greater than the pressure of the gas trying to escape. Seepage is continuously pumped away.

Products stored in rock caverns under pressure are crude oil, butane, propane, and similar products.

It follows from the above principle that a cavern for the storage of crude oil will have its ceiling level about 70 feet below the water table, and a cavern for propane about 330 feet below the water table.

The preceding description of storage under pressure assumes that the temperature of the stored product is above the freezing point of water. However, storage can take place at lower temperatures. In this case the rock around the cavern is cooled, so that the groundwater in all the cracks freezes to ice and expands (fig. 5). The cavern is thus surrounded by a gas-tight envelope of frozen rock.

Products stored in this way are propane, butane, et cetera. In this case there is no need for the cavern to be situated at a great depth, as long as groundwater is present above the cavern ceiling.

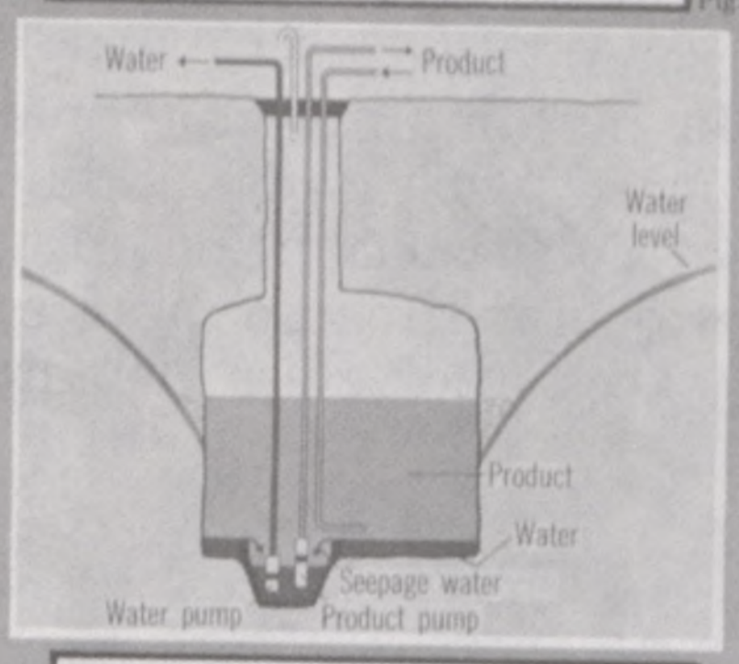
## PRODUCT SEEPAGE

It is occasionally difficult to keep up a natural groundwater barrier to separate two neighboring storage caverns for different products. To prevent seepage of products between the caverns, it is then necessary to create an artificial water barrier consisting of a small tunnel filled with pressurized water through boreholes (fig. 6).

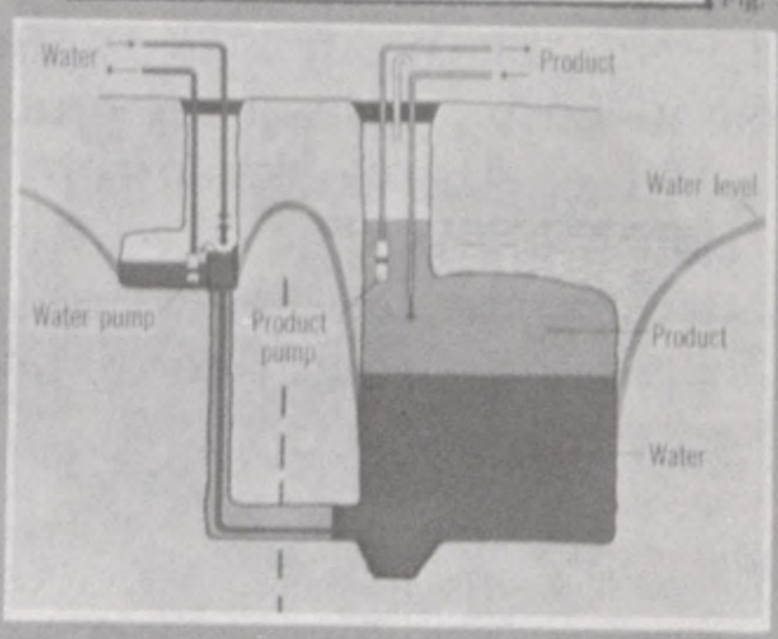
Figs. 2-7

In-ground layouts

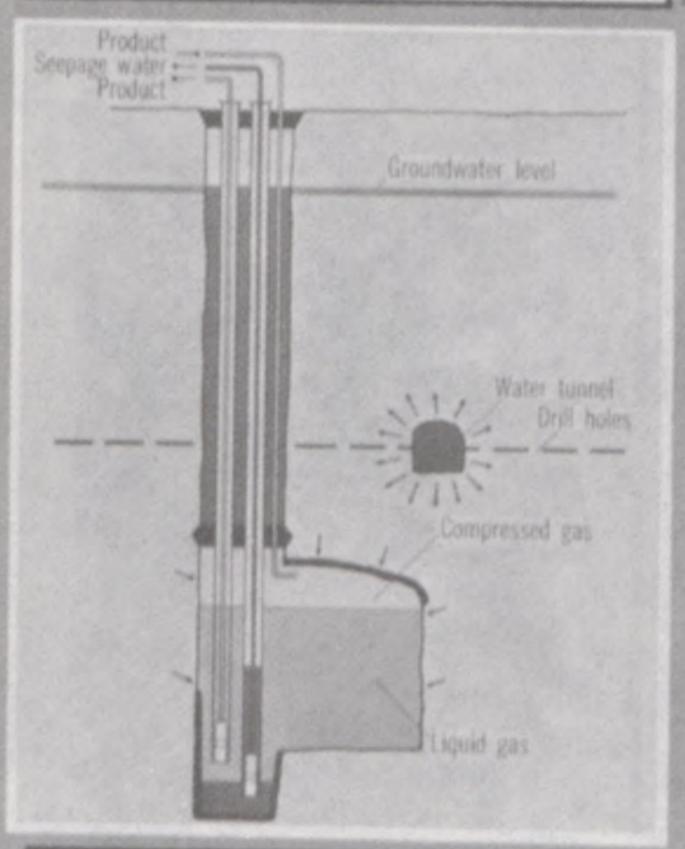
Fixed water-bed storage Fig. 2



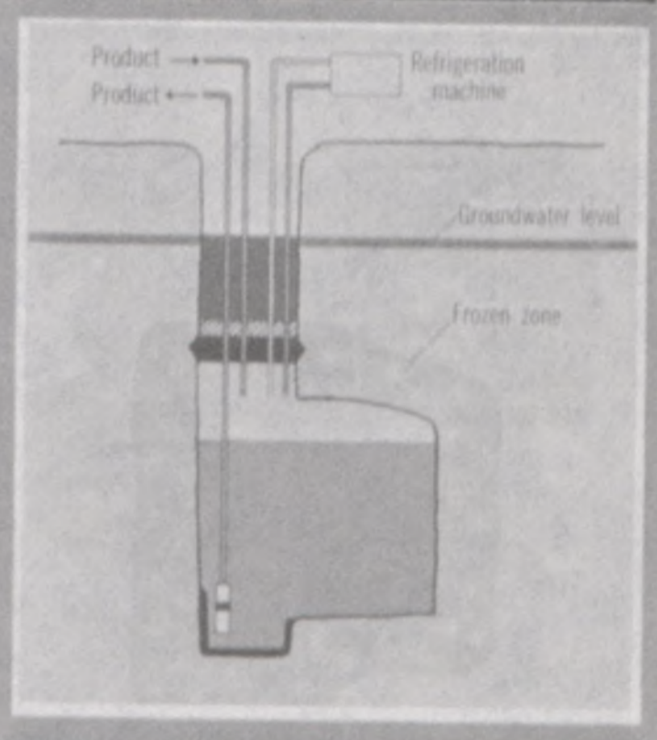

Mobile water-bed storage Fig. 3



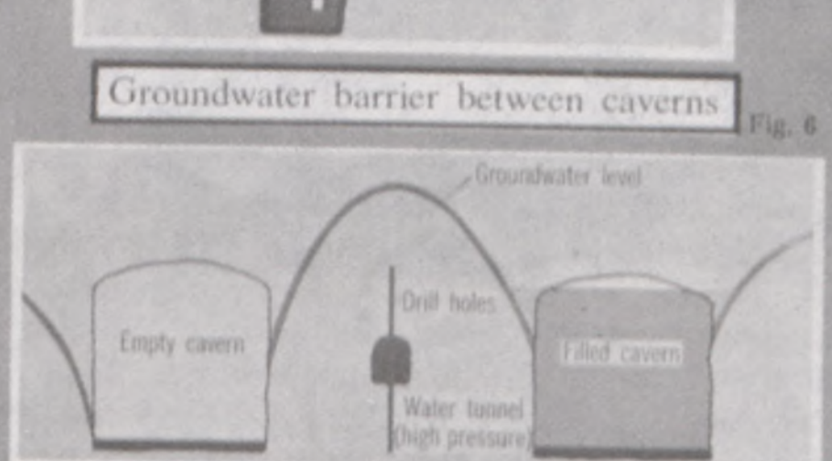

Storing LP-gas under pressure Fig. 4




LP-gas in frozen storage Fig. 5




Groundwater barrier between caverns Fig. 6




Pump installation below cavern Fig. 7



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## CAVERN DESIGN, CONSTRUCTION

The commonest types of rock in the Scandinavian countries are good quality granite and gneiss. This means that caverns can have a span of 50 to 80 feet and a height of 65 to 100 feet. Caverns are designed in the form of horizontal tunnels with length between 600 and 1,300 feet according to the storage capacity desired. The normal volume of a large storage cavern varies between 600,000 and 2 million barrels. Often a number of caverns are placed parallel to each other, separated by rock of at least 70-foot thickness.

The Scandinavian coasts are particularly rich in outcrops of rock with only negligible soil cover, through which a temporary tunnel of cross-section 300 to 500 square feet gradient of 1:7 can be driven down to the caverns. The tunnel functions as a service road by which heavy, modern quarrying equipment can be taken down to the caverns (fig. 8). The loosened rock can be driven away by truck.

When blasting is completed, the tunnel is blocked with a concrete wall near the cavern and filled with water.

Actual blasting of the cavern takes place in three main stages. First, a gallery is blasted out at ceiling level; then the cavern is deepened by the successive blasting out of one, two, or more benches.

Disposal of the excavated rock varies from case to case, and the solution to this problem is a major factor in final costs. The rock is often crushed and sold as road-making or building material or used in the extensive earth works often associated with the building of a refinery. The rock can be used in harbor construction, or dumped in the sea as filling in land-reclamation projects. In unfavorable cases, however, it can be difficult to dispose of excess rock close at hand.



FIGURE 8

Heavy quarrying equipment, such as this drilling machine, are used in mining the caverns (fig. 8). Cavern in advanced stage has pumps suspended into it through shaft (fig. 9). This is the piping for a heavy fuel-oil-storage cavern. The installation is in a tunnel above the vertical pipe shaft (fig. 10).

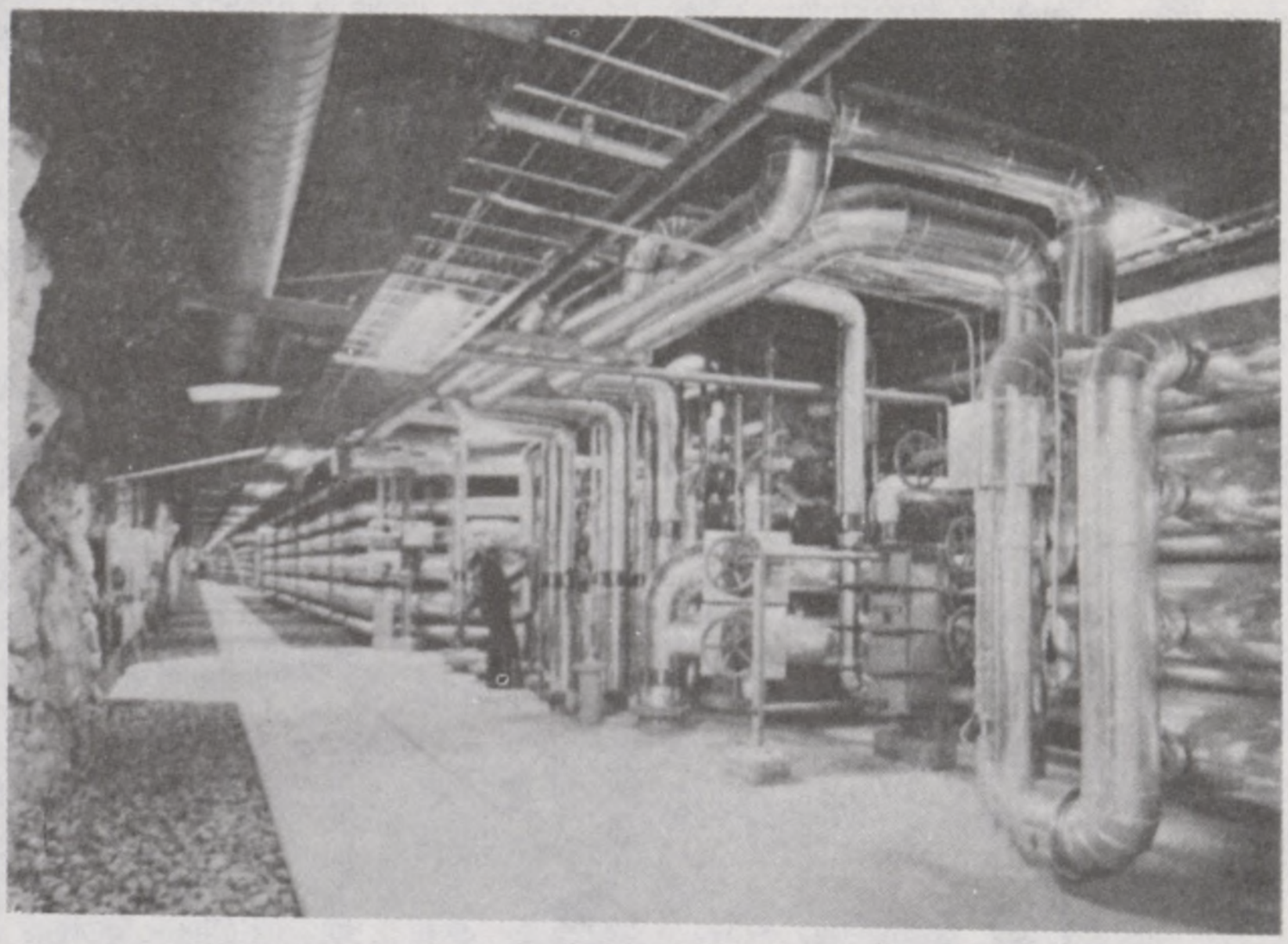


FIGURE 9

## PUMPING

There are two different principles for connections down to the rock cavern for pumping, heating, et cetera—submerged and dry pumps.

For submerged pumps a vertical shaft is blasted from the cavern ceiling either directly up to the ground surface or up to a horizontal tunnel which is in turn connected to the surface. The pumps are suspended in the cavern from a concrete deck at the top of the shaft (figs. 9 and 10). The submersible pumps are of the centrifugal type.

The pump and motor are constructed as a single unit which hangs in the riser pipe. The cables for the motor are run in cable conduits fixed to the riser. Both conduits and motor are filled with water. If the product is stored warm, the water is circulated through the motor and cooled.

Turbine pumps may be installed if the product is stored at a higher temperature. In this case, the motor is placed on the concrete deck and drives the pump in the cavern via a long axle.

For dry pumps, a separate pumproom is blasted out alongside the ends of the caverns at or just below cavern floor level. A vertical shaft leads from the pumproom to the ground surface, and small horizontal tunnels connect the pumproom to each of the caverns (fig. 7).

The small tunnels are closed off with concrete walls with pipe apertures, so that caverns are connected via pipes with the pumproom. Conventional centrifugal pumps, installed dry in the pumproom, pump the product directly from the caverns up to the surface via pipes in the shaft.

It is important to design and locate the pumproom so product cannot seep through the rock from the caverns into the pumproom. In the case of explosive products such as crude oil, seepage into pumproom and shaft must be prevented by concrete walls standing free from the rock. The space between the concrete wall and the rock is filled with pressurized water.

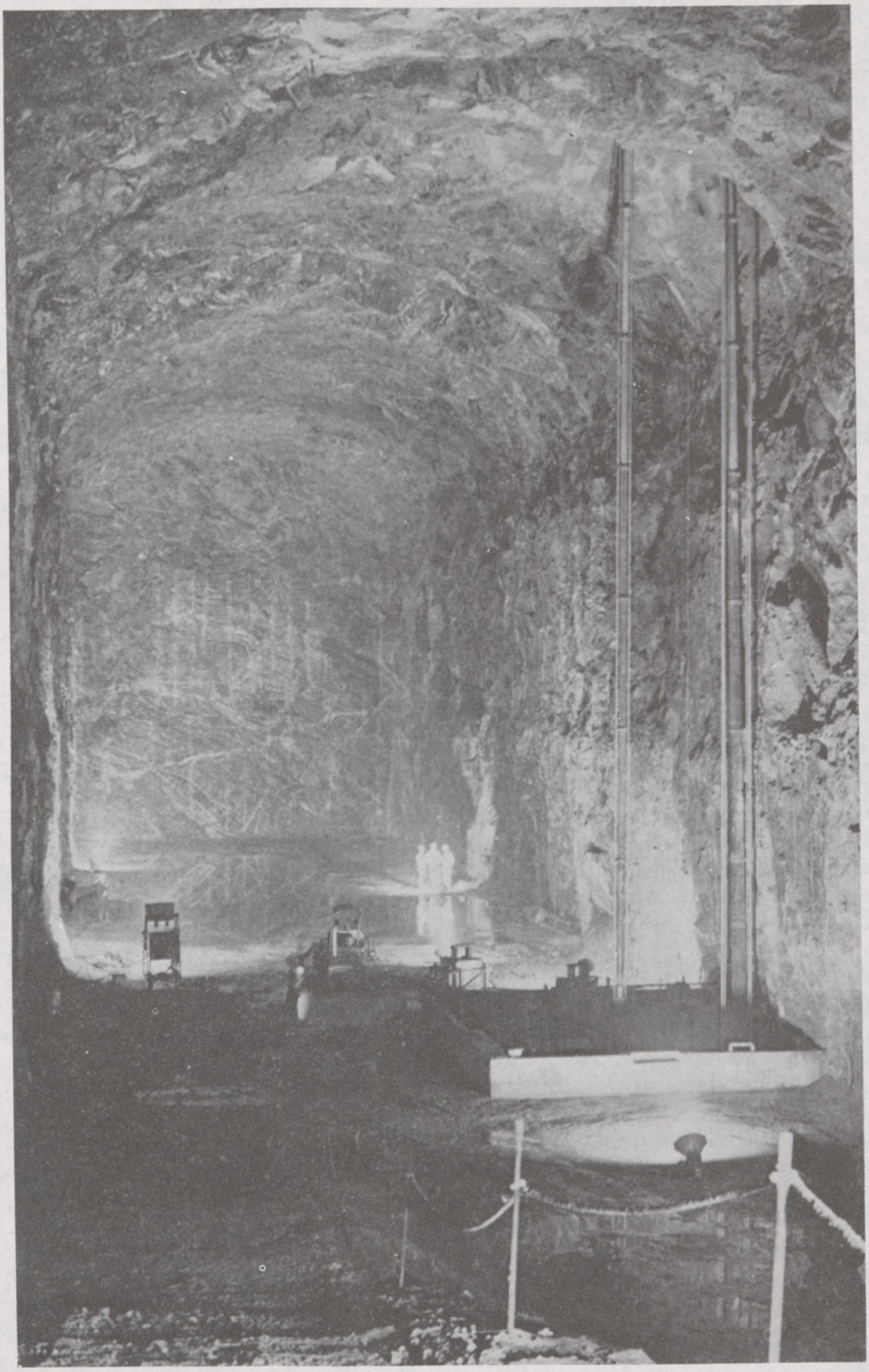


FIGURE 10

In the case of medium pump capacities, submersible pumps are economically preferable. If a high pump capacity is required, it is more economical to choose dry pumps in a pump room at a deep level, expecially if the same pumps can be used to serve a number of caverns.

About half of the crude-oil storage that has been built for refineries has submersible pumps and the rest dry pumps.

## HEATING

When necessary, products are heated or kept warm either by heating the water bed or by circulating the oil through a heat exchanger.

The water is warmed by pumping it with a circulation pump from one end of the cavern up through a heat exchanger and back to the other end of the cavern.

If the oil is heated directly, it is pumped out of the cavern by a circulation pump through a heat exchanger and then back to the cavern via a pipe system which distributes the heated oil to a number of points in the cavern. In some cases, both systems are installed and used in combination to heat the product.

If viscous products are to be stored at a high-temperature, it is more practical to heat the product directly because if the water bed were heated there would be a risk of a troublesome emulsion layer forming between the water bed and the product. For heating of crude oil and other light products, the less expensive system of heating the water bed is preferable.

## STORING CRUDE OIL

Two special problems are associated with crude-oil stores: sludge and gas.

The question of how to deal with sludge in crude oil gave rise to much anxiety at first because once a rock cavern has been taken into service it is not a practical possibility to go down into the cavern to remove sludge. Experience has shown, however, the sludge has not caused the difficulties that had been feared. Caverns are made deeper, to give a water bed of 2 to 3 foot depth.

The product is pumped in at one end of the cavern and out at the other, and the sludge is allowed to settle into the water bed. The long-term risk exists that the accumulated quantities of sludge will eventually reduce the storage volume, but it is felt that this must be accepted, especially since the amount of sludge after 5 to 10 years operation has proven less than had been feared.

To minimize the escape of gas and avoid loss of storage volume, a number of caverns are connected together so that gas can be transferred from a cavern with high pressure to one with lower pressure. It is also possible to connect caverns to aboveground storage if these exist. Crude oil is stored under a pressure of 0.5 –2.5 bar.

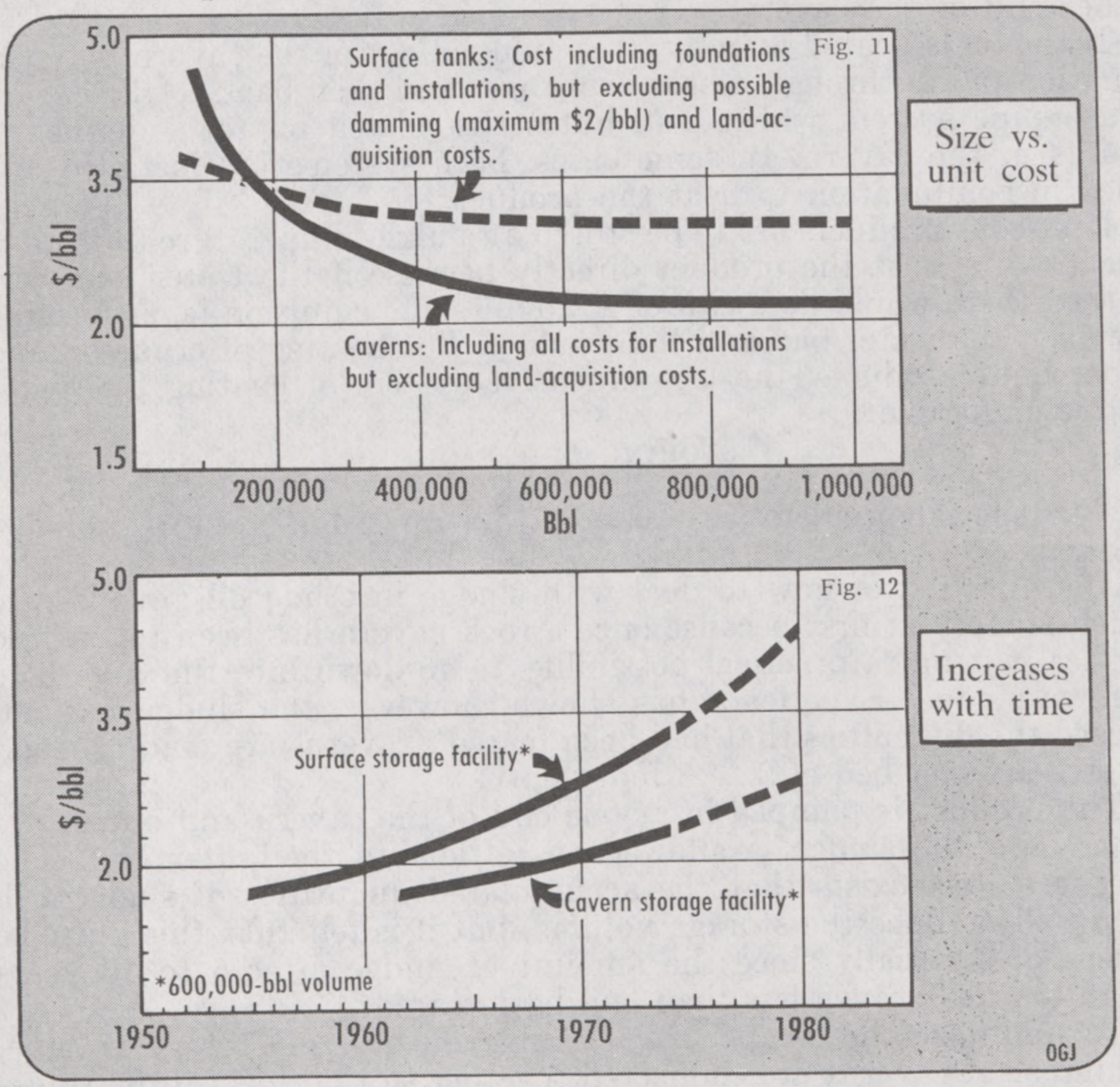
## LEVEL CONTROL

The level of the product surface in the cavern is controlled by means of float gauges with high and low-level alarm contacts. The high-level contact operates a valve in the incoming pump line, which closes and thus prevents overfilling. The low-level contact stops the product pumps.

The interface between the product and the water bed is controlled by means of a set of probes which are normally of the conductive type, though ultrasonic sounding is also used. Controls start and stop the seepage pumps, and trigger alarms indicating excessively high- or low-interface levels. The high-interface alarm stops the product pumps to avoid water being drawn up with the product. The low-interface alarm stops the seepage pumps to prevent product being pumped along with the seepage water.

Figs. 11, 12

## Cost comparisons, above and belowground

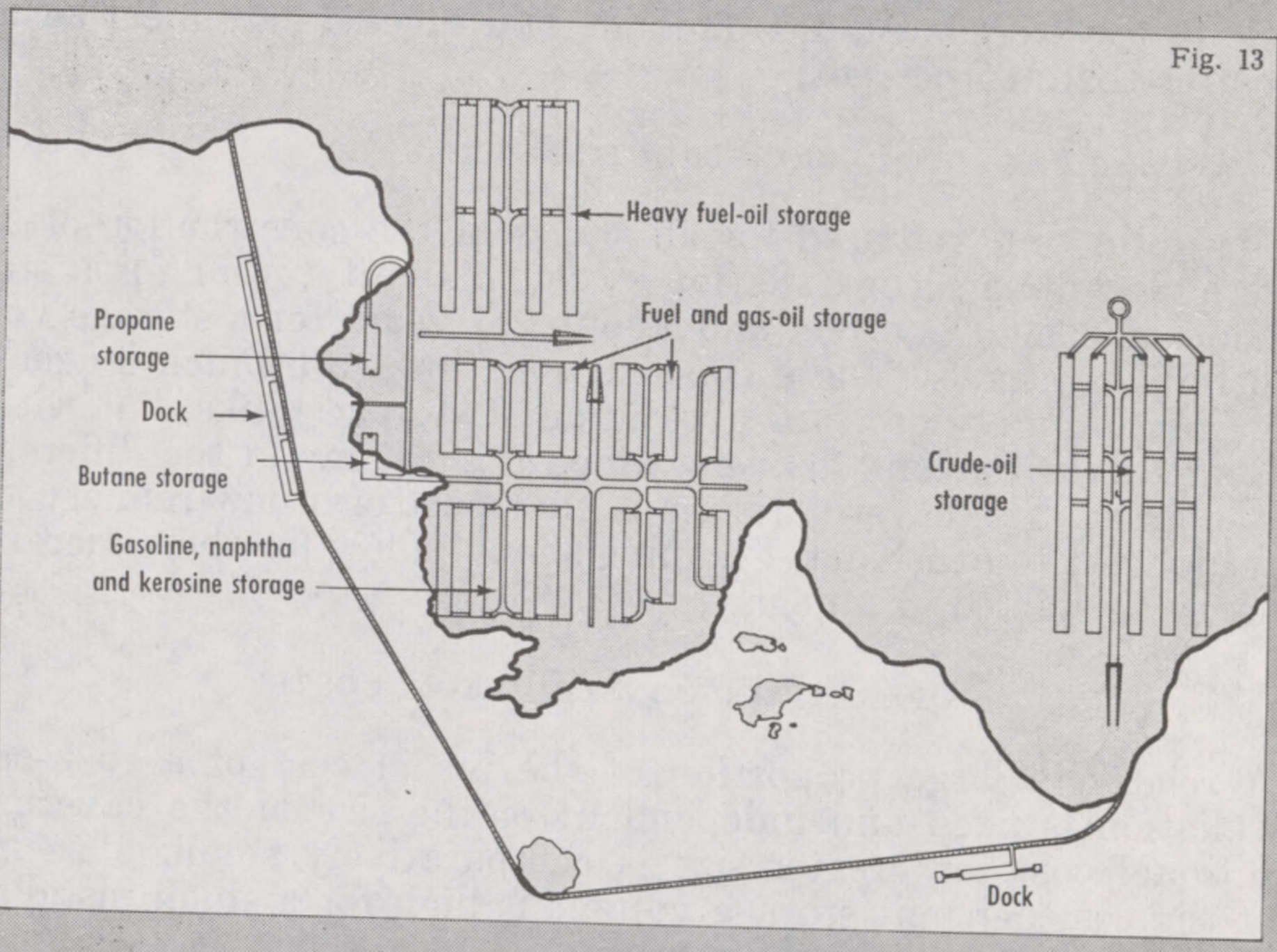


Figs. 13, 14

# Above and belowground plan of refinery

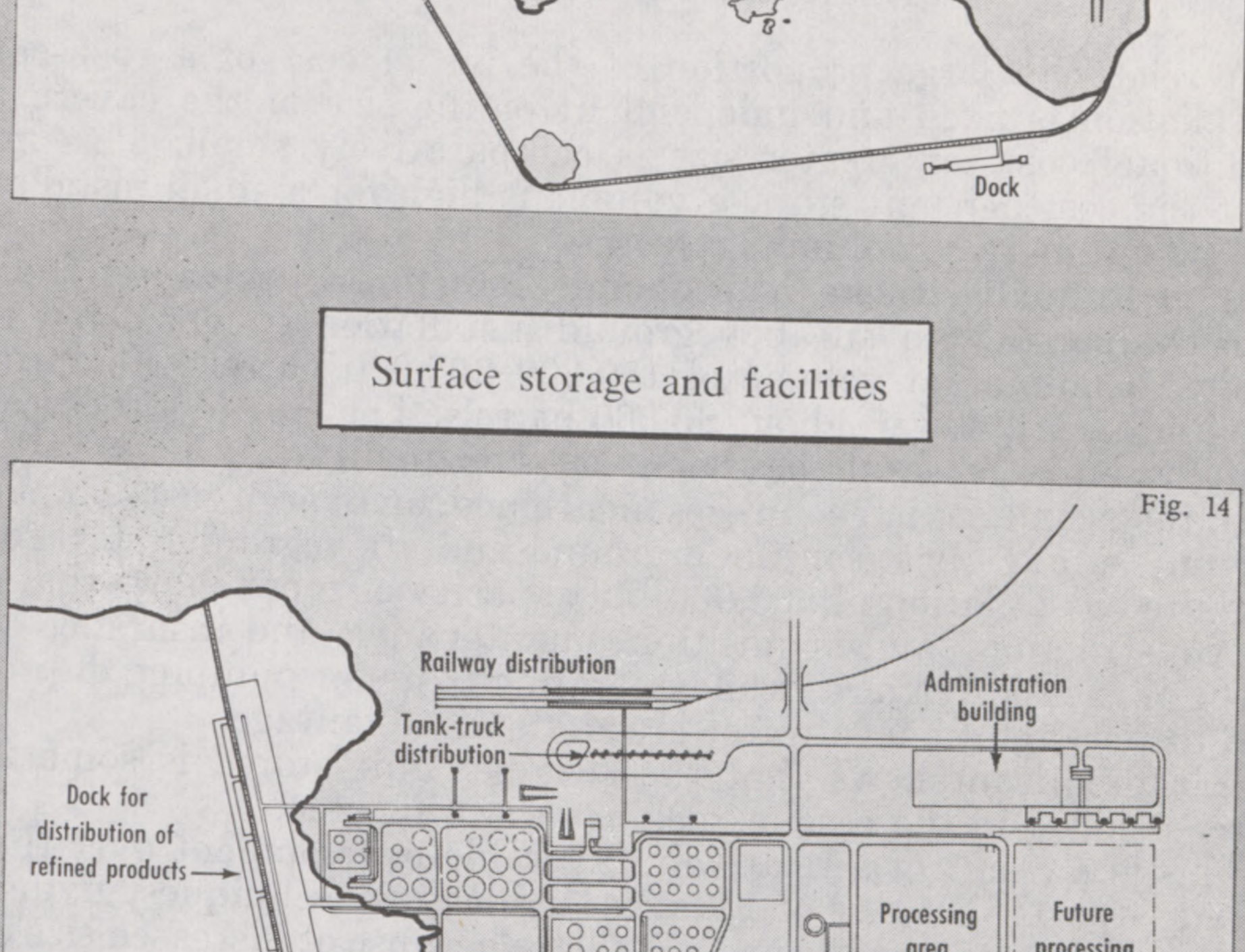
## Cavern storage

Fig. 13




## Surface storage and facilities

Fig. 14




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## VOLUME MEASUREMENT

The walls of a rock cavern are not flat and smooth, but relatively irregular. To allow determination of the volume of stored product, the volume of the cavern is measured photogrammetrically immediately after blasting is completed. This measurement gives the area of the horizontal surface at all levels desired. The level controls indicate the levels between which the product is stored. An estimate can now be made of the stored volume. This method gives a statistical accuracy of better than 0.5 percent.

## CONSTRUCTION TIME

The total time required for all stages of the construction of a rock cavern, including all installation work, is about 1 year for a storage volume of 600,000 barrels and about 2.5 years for a storage volume of 6 million barrels. These construction times are much longer than those normally required for aboveground storage tanks, but with the present extremely long delivery time for sheet metal the difference is not so great. The cavern storage is that part of a new refinery which takes longest to construct. Planning should allow for the underground work to be started at an early stage.

## OPERATING, CONSTRUCTION COSTS

A relatively large proportion of the initial cost of a rock-cavern installation is fixed and independent of the size of the cavern. The additional cost for greater size is comparatively small. This means that the cost per unit storage volume is high for a small installation, but falls rapidly as volume increases.

In good-quality rock, the economic limit for a rock-cavern installation compared with an aboveground installation is considered to be around a minimum volume of 150,000–200,000 barrels. For propane the limit is still lower, about 60,000 barrels. The cost of a rock-cavern installation increases if the rock is of poor quality.

In the Scandinavian countries mentioned, an overall cost comparison per unit storage between underground and aboveground storage in a fair-sized installation of 600,000-bbl capacity or more shows that costs for construction, land acquisition, maintenance, and insurance are in favor of the rock cavern, while operating costs for pumping of product and disposal of seepage water are to its disadvantage.

A comparison shows that the cost per unit stored is some 20–40 percent lower in the case of rock caverns (Fig. 11).

This is a result of a relatively favorable development over the last decade—partly because of advances in blasting techniques, giving proportionally lower wage costs, and partly because of increased size of the installations (Fig. 12).

The cost of aboveground storage tanks has developed less favorably as a result of rising steel costs and increasing quality and capacity demands. Embankments around these tanks are also a factor.

These developments mean that it has become economical to blast cavern installations in poorer quality bedrock because a margin exists to cover the costs of reinforcing poor-quality rock.

Underground storage also offers important environmental and security benefits.

## ENVIRONMENTAL ASPECTS

Storing of petroleum and products in rock caverns has many advantages from the viewpoint of environmental protection. The installation is not visible aboveground and therefore does not spoil the landscape. The risk of fire is very small, and the installation is easily protected against sabotage.

In areas where the variations of the water table are known there is absolutely no risk of pollution of the groundwater. On the other hand, great caution must be exercised in planning an installation in a place where the groundwater is used for water supply, since this can cause the water table to fall in the future. Seepage water must be treated and purified, just like all other water from a refinery which may be polluted with oil products.

An unlined rock cavern can also be designed to withstand earthquakes.

## REFINERY STORAGE

A goal when planning a new refinery is to store the greater part of the crude oil and about 75 percent of final products in rock caverns. Similarly, when an existing refinery is expanded, rock caverns may be used to give the additional storage volume required. Until now, however, all storage of intermediate products has been in tanks aboveground. The ground surface above the caverns can be used as processing area, for aboveground stores, or for other purposes. Fig. 13 and 14 show how underground storage can be collocated beneath surface-storage and processing facilities.

Because crude oil and products are stored at different depths and because the explosion risks are different, it is usually preferable to separate the two. The distance between the two stores should be at least 1,500 ft.

The import harbor, crude-oil storage, and processing area are placed in proximity to each other in that order. A refinery with a yearly capacity of 8–10 million tons (160,000–200,000 b/d) requires a crude-oil store consisting of 3 to 4 separate rock caverns each with a volume of 1–2 million bbl, so that the total crude-oil store amounts to 6 million bbl.

The final product-storage area is similarly placed at a convenient point between the process area and the road, ship, or railway distribution terminals as the case may be.

The location of the individual caverns relative to each other is determined by the type of product, the risk of explosion, and the risk of product seepage in and between neighboring caverns. A refinery with a yearly capacity of 8–10 million tons will normally have stores for five or six different final products with a volume totaling 3 million bbl.

Seven of the nine refineries in Norway, Finland, and Sweden use rock caverns for storage (Table 1).

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Table 1

## Cavern storage in Scandinavia

| Country, company | Refinery location | Annual production, million tons | Hydrocarbons stored in caverns* |
|---|---|---|---|
| **FINLAND** | | | |
| Neste OY | Naantali | 2.6 | Crude oil |
| Neste OY | Porvo | 6.4 | Crude oil, Refined product |
| **NORWAY** | | | |
| Raffinor A/S & Co - (in operation 1975) | Mongstad | 4.0 | Crude oil, Refined product |
| A/S Norske Shell | Sola | 2.4 | Crude oil |
| A/S Norske Esso | Slagen | 5.0 | 0 |
| **SWEDEN** | | | |
| BP Raffinaderi AB | Gothenburg | 5.2 | 0 |
| Koppartrans Oljeaktiebolag | Gothenburg | 4.4 | Crude oil, propane |
| AB Nynas Petroleum | Nynashamn | 2.8 | Crude oil |
| Scanraff (OK - TEXACO) | Lysekil | 6-8 | Crude oil, Refined product |

*20 million bbl crude oil out of 30 million total crude-oil storage.
15 million bbl refined products out of 20 million bbl total product storage.

In this group, total crude-oil storage amounts to 30 million barrels of which 18 million is stored in rock caverns Other stores amount to 18 million barrels of which 12 million are stored in rock caverns.

### OTHER REGIONS

Underground oil storage exists or is under construction in the following types of rock: granite, gneiss, limestone, sandstone, and chalk. Poor-quality rock needs reinforcement and may not have been subjected to major tectonic disturbances.

On the basis of the geological properties of the bedrock, a rough classification is made below of a large number of regions with reference to the chances of finding rock suitable for underground petroleum and product storage:

Regions richly endowed with places suitable for rock-cavern storage: eastern Canada, western and southern Greenland, northern and eastern South America, Red Sea coast, Tanzania, Mozambique, Madagascar, South Africa, Angola and Liberia, India, the northern part of western Saudi Arabia, Southwestern Australia, parts of the Soviet Union, especially Murmansk and the Taimyr Peninsula, Scandinavia, western France, possibly western Spain and Portugal.

Regions where it should be possible to find sites suitable for rock storage: Eastern United States of America including South Carolina, North Carolina, Virginia, Pennsylvania, New Jersey, Massachusetts and farther north, Western Africa, northern, northeastern, and southeastern Australia, Tasmania, England, Ireland, and certain parts of Central Europe.

Regions where systematic searching may reveal isolated places suitable for rock-cavern storage: western Canada, western United States of America, western South America, northwestern Africa, Iran, Indonesia, Japan, and New Zealand.

There are cheaper methods of storing petroleum and products than in blasted rock caverns, such as in salt domes, exploited oil bores, or in abandoned mines. But such alternatives are not available everywhere and it is certain that rock-cavern storage in the future will be used more frequently. It is an alternative worthy of consideration in the planning of refinery storage.

OIL & GAS JOURNAL

# Abandoned coal mine converted into man-made oil field

H. W. Brandt

Reprinted from the December 25, 1972, edition

# Abandoned coal mine converted into man-made oil field

WHAT IS the most practical method for storing a huge quantity of crude oil for a long period to assure availability if conditions curtail supply? Underground storage is a logical answer.

Can abandoned mines be used for this purpose? That is the proposal Fenix & Scisson International Inc. submitted to the S.F.F. Association (acting in behalf of the Department of Industries of the Republic of South Africa), Johannesburg, South Africa, in October 1966. Fenix & Scisson's previous experiences made the firm reasonably certain that a mine could indeed be used for storing crude oil.

And subsequent work has borne out this conviction. A coal mine was converted to store a quantity of crude oil equivalent to a sizable oil field. Total cost of purchasing, testing, and converting the mine was less than 15% of that for conventional steel tanks. Operating and maintenance costs are proving to be about 2% of those experienced at two large tank farms owned and operated by the association.

**Selection of a mine.** Fenix & Scisson briefly looked at a number of mines on the client's behalf before selecting one which appeared to be worthy of detailed study to determine if:

1. The mine was structurally stable.
2. Formations surrounding the mine are relatively impermeable, and free of fractures.
3. Formations in contact with the stored crude oil are either chemically inert or not reactive to the product.
4. Water inflows into the mine are free of contaminants which would adversely affect the stored product.
5. The groundwater level is high enough above the mine to provide sufficient hydrostatic pressure to prevent loss of crude oil into formations surrounding the mine.

H. W. Brandt says . . .
Purchase of large mine and its conversion to store crude oil cost less than 20¢/bbl of capacity. Performance to date indicates long-term stability for mine and for stored oil.

First step in conversion of the mine was a detailed feasibility study to determine if it met those criteria.

Ventilation was reestablished in the mine, after which more than 6 miles of perimeter workings and many miles of entries were inspected. General condition of the mine was determined in terms of: present and continuing stability; existence of open fractures, fissures, and dykes; and sources and rates of water inflows.

**Structural stability.** The mine, in operation from June 1937 to January 1962, was developed by the room-and-pillar method. Openings averaged 6.5 ft in height and were from 16 to 22 ft wide. Pillars (spaced at 40-ft centers) ranged in size from 18 to 24 ft on a side. Inspection revealed no evidence of any weight on either roof or pillars. There was considerable slabbing of the coal roof in older sections, but this was confined to a thickness of 1 ft or less, and was the result of weathering rather than stress failure.

The pillars were found to be in excellent condition throughout the mine. They were closely examined for spalling which normally would indicate they had been subjected to abnormal loading conditions. Such a condition often causes a pillar to spall until it resembles an hourglass rather than its original cube shape.

No evidence of spalling was found. Next question was whether the mine would retain its stable condition over the years. Extensive calculations were made to determine long-term theoretical stability. Physical dimensions (height, width, length, and shape) of the rooms and pillars were surveyed in 10 representative areas of the mine. Compressive strength of the coal seam was determined from core samples which were tested in a laboratory. The core samples were taken from test holes drilled for that purpose. This information was used to calculate the theoretical safety factor of the mine by employing a method developed by Dr. M. P. G. Salamon.[1]

The calculated safety factors indicate that the mine will remain in a stable condition for many years. Small thin, calcite-filled fractures were found throughout the mine in the pillars and coal roof. The coal seam was, however, almost entirely free of open fractures and fissures.

One small section of the mine contained a large number of filled fractures which had affected the mining operations. Evidence of this was two small caved areas and presence of the only timber supports found in the mine. The caved area were subsequently isolated from the remainder of the mine by installing bulkheads in the connected openings.

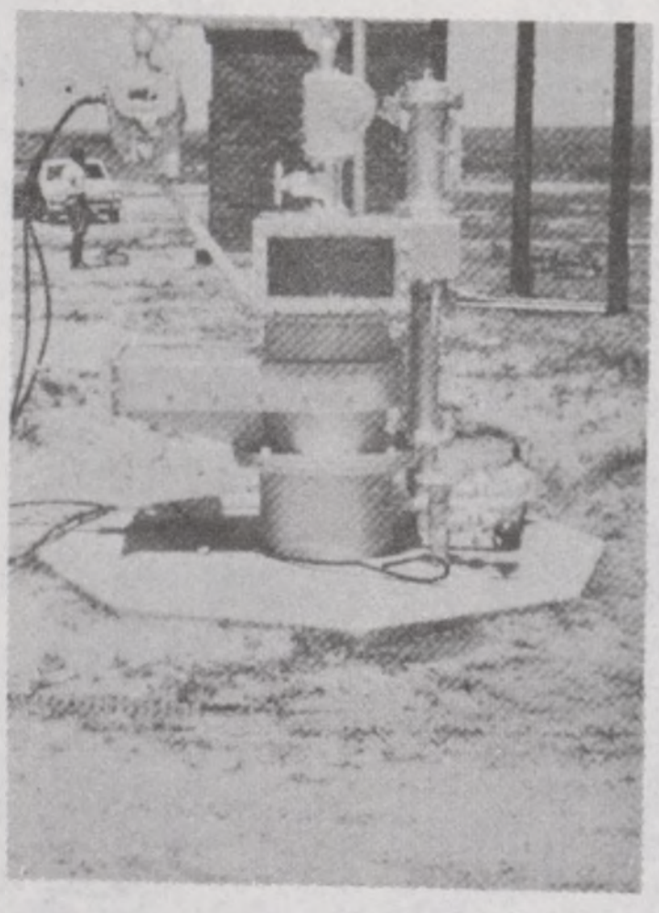
**Surrounding formations.** Formations surrounding the mine were studied to be assured they were relatively impermeable and free of fractures. Twenty-six NX-sized (3-in. diameter) boreholes were drilled at regular intervals outside the mine perimeter. Each hole was subjected to fluid-injection tests in an interval extending through the coal seam from 30 ft above it to 30 ft below it.

Two inflatable packers were mounted at predetermined intervals on ¾-in. pipe and run into the hole to the proper depth. The packers were inflated to isolate the formation between

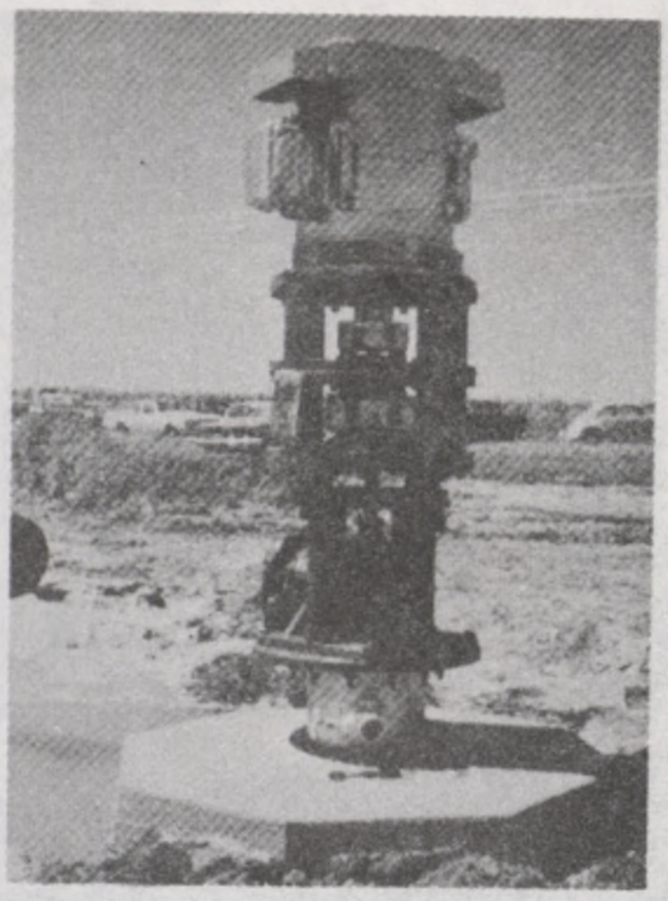
The author . . .
H. W. Brandt is a senior mining engineer with Fenix & Scisson Inc., Tulsa. Since joining the firm in 1963, he has participated in engineering studies for USAEC, solution mining studies, and underground storage-cavern construction. From 1966 to 1972, he was resident manager in Johannesburg, South Africa. After obtaining BSc in mining engineering at Lehigh University in 1950, he worked in the coal and mining industries, serving in various capacities for Hudson Coal Co., International Salt Co., and Jeffrey Manufacturing Co.



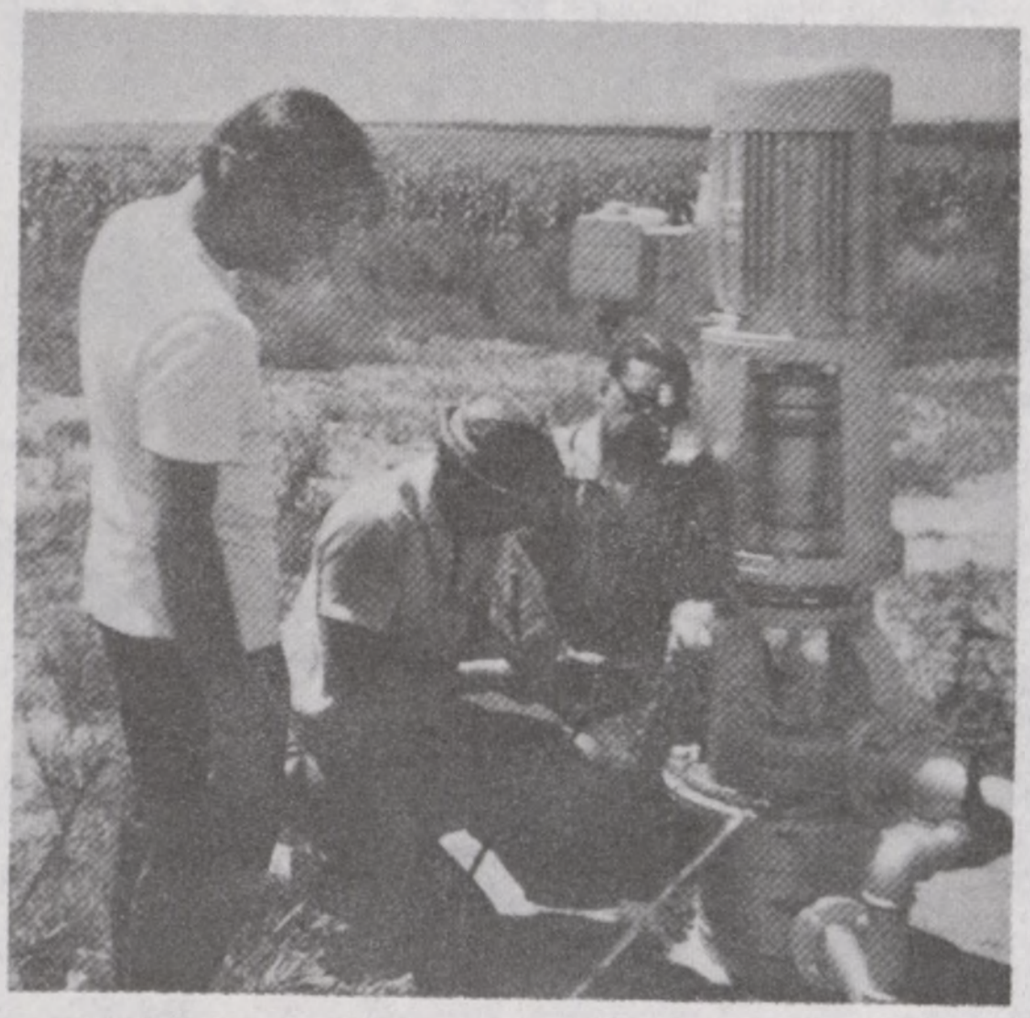
H. W. Brandt

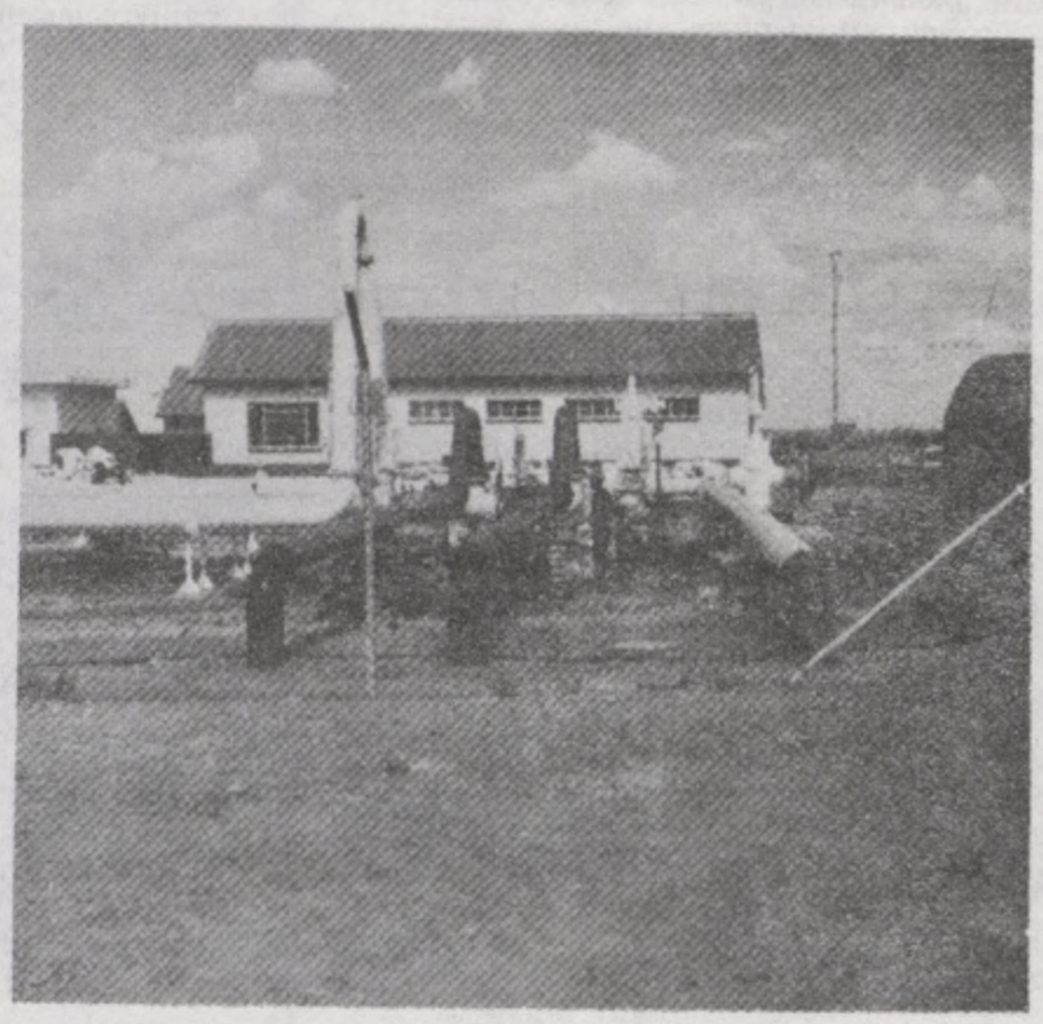






**ABOVE GROUND:** Facilities on the surface include the head (above, left) for a measuring hole, containing apparatus for remotely and manually gauging liquid levels and temperatures. The 12-in. vapor stack (above, center) has flame arrestor for venting gases from stored crude. Two-thousand-gpm pumps (above, right) lift oil from storage to surface. Water pumps (below, left) remove excess groundwater which may accumulate in the mine. Pump station (below, right) moves crude into and out of storage.





them. Sufficient water was injected to fill the open space between the packers as well as the ¾-in. pipe back to the surface. Pressures ranging from 0 to 10 psig were then applied to the system at the surface and the rate of fluid loss to the formation was measured.

This procedure was repeated until the entire test section had been traversed. Permeabilities of the formations surrounding the mine were generally low. This indicated that formations surrounding the perimeter would contain the fluid when the mine was filled. Samples of the cores from test intervals were analyzed in a laboratory to determine permeability, porosity, and uniaxial compressive strength. Permeability measurements compared very favorably with the in situ test results.

Decision was then taken to proceed with the final test—a hydrostatic test of the mine itself.

**Mine hydrostatic test.** As a final test of the integrity of the mine as a storage vessel, it was to be filled with water. Pumping operations were begun, and the desired level was reached in March 1967.

During the first few days after level observations began, it behaved erratically. At the same time, large air bubbles were observed at a shaft located in a low section of the mine. A review of the mine contours revealed that a lot of air could have been trapped above the water in domed areas.

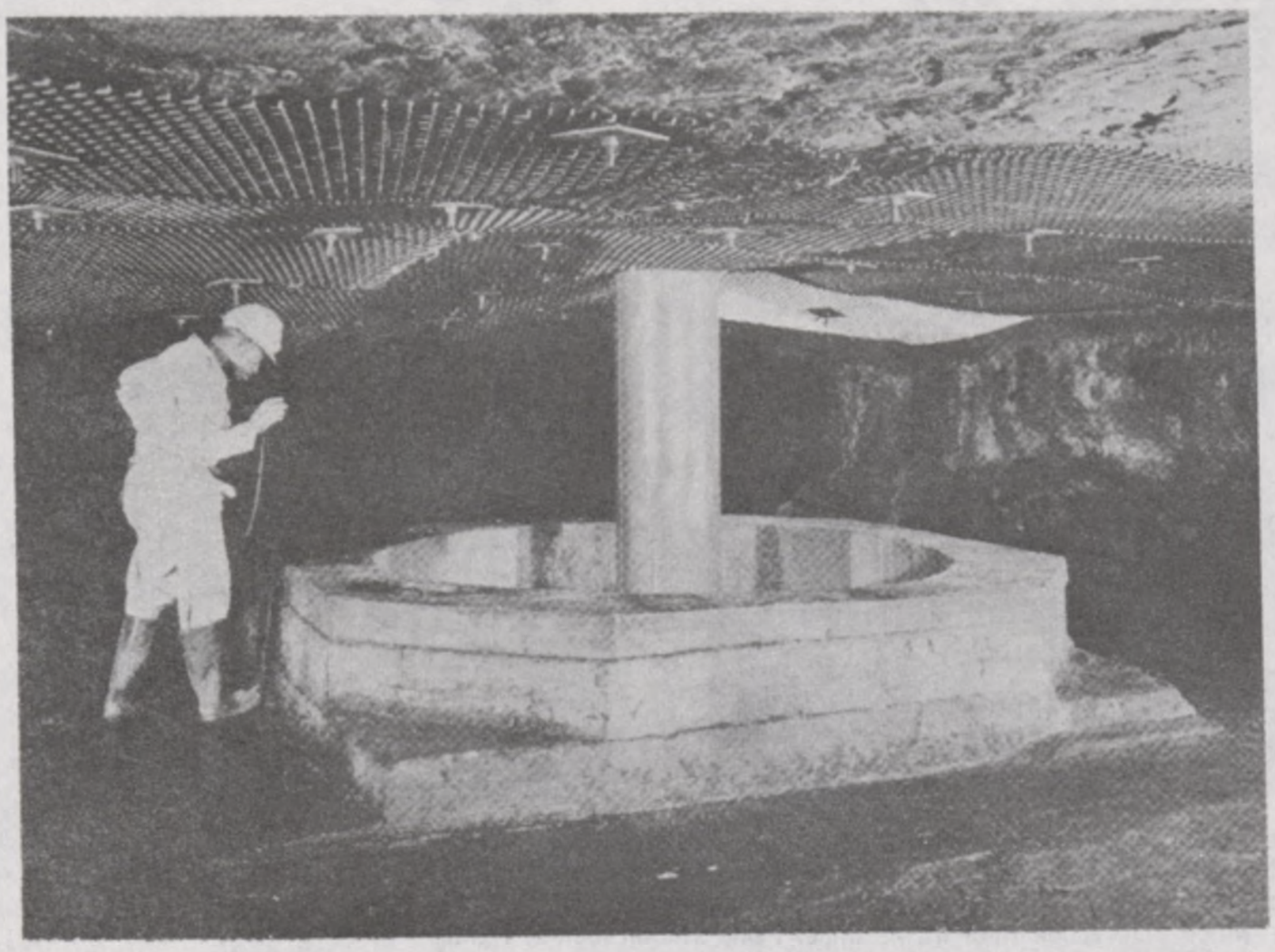
These domes would have to be vented before stable test conditions could be reached.

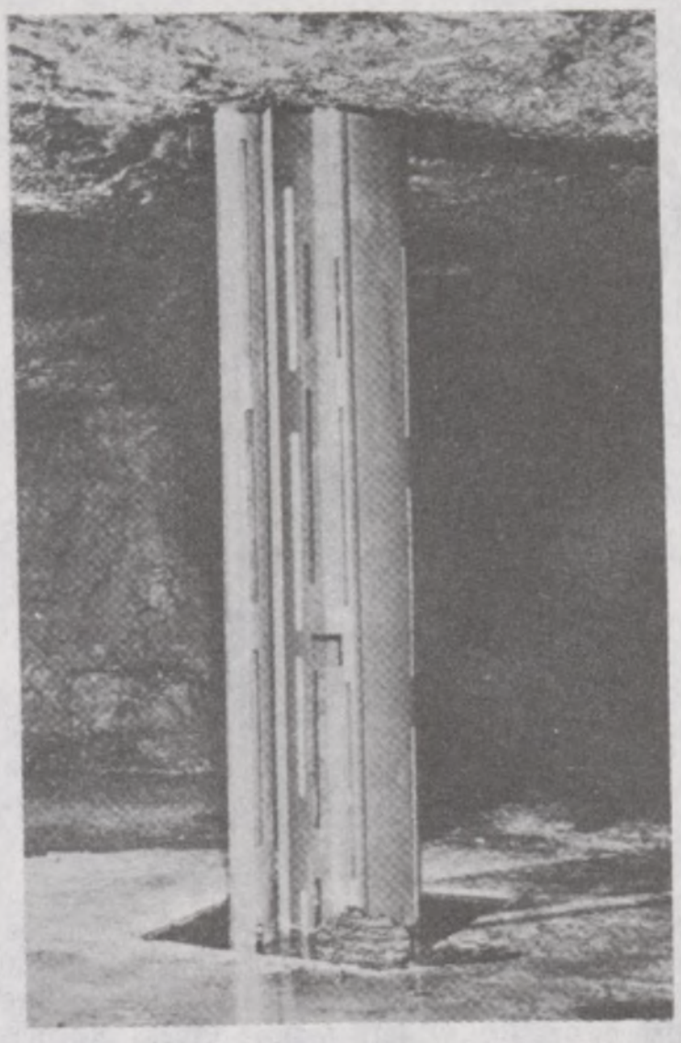
Accordingly, vent holes were drilled from the surface into the approximate centers of the five major domes. Trapped air was released. Water-level conditions stabilized shortly afterwards, and tests continued for 21 days. During that time, water level remained constant.

During tests, charts of the water-level recorder showed two cyclic traces—one regular with a 12-hr period and a ¼-in. amplitude; and one irregular. Tidal movements of the earth's crust, believed to be the cause of the regular trace, were confirmed by a gravity-meter survey.

The irregular trace was attributed to changes in atmospheric pressure, affecting the level of the "underground lake" which covered more than 330 acres.

The water was not pumped from the mine until 2 months after the test had been officially declared at an end. During that time, the level remained constant.





**BELOW GROUND:** Fill hole and typical curbing (above, left) indicate simplicity of mine preparation to receive crude. Triply completed measuring hole (above, right) houses float and recording thermometer. Third string can be used for hand dipping or for manually measuring levels and temperatures. Oil pump-out holes (below, left) uses protective screens, one bolted to mine roof. Typical casing support in pump-out hole (below, right) fits in 8-ft-diameter, 12-ft-deep concrete-lined sump.





Ventilation fans were activated and the mine reentered as the water level dropped. When the mine was pumped dry, it was found that approximately 66% of the roof area had never been in contact with the water. This denotes a roof impervious to gases as well as liquids.

Also important to the water test was the static water levels in the perimeter boreholes. These levels responded to changes in the mine water level during the filling, testing, and emptying periods. While filling and emptying, the respective rise and fall of levels in the perimeter holes was coincidental with, and almost equal to, rise and fall in the mine water level.

Water levels in all of the perimeter holes were above the coal, even when the mine was empty. Hence, the fluctuations confirmed that there was communication between the coal seam and the overlying water table.

**Additional information.** During the mine inspection, samples of the coal and mine water were taken. These samples were analyzed at a laboratory to determine that neither the coal nor the water would react to the crude oil.

Water seepage into the mine through the perimeter workings was very slight, and almost nonexistent in the remainder of the mine. In all instances, seepage was noted as coming from clay-filled fractures in the coal. Although quantity of seepage was small, its presence served as a warning that liquids could be lost through these channels should the hydrostatic head be reversed at the time the mine was filled with liquid. Total inflow was calculated at 27 gpm, most of which was entering through shafts and boreholes which would be sealed off before conversion was complete.

Studies of the effect of earthquakes in the general area disclosed no evidence of damage to any of the mines. Records indicate the area is subject to an occasional tremor of very low magnitude.

Underground and surface facilities were completed, and the mine filled with crude oil in 1969. Facilities include pumps to deliver the oil to the main pipeline when needed. Conversion cost, including purchase of the mine, was less than 20¢/bbl of oil stored.

Based on the success of the first operation, several other similar containers have been completed.

### Reference

1. "A Method of Designing Bord (Room) and Pillar Workings," Dr. M. P. G. Salamon, Collieries Research Laboratories, Chambers of Mines of South Africa, C.O.M. Reference: Project No. 804-66, Research Report No. 72/66.

# VIII. Status of Naval Petroleum Reserves—Presentation by the Department of the Navy

STATEMENT
OF
JACK L. BOWERS
ASSISTANT SECRETARY OF THE NAVY
(INSTALLATIONS & LOGISTICS)
BEFORE A JOINT MEETING OF THE
ARMED SERVICES COMMITTEE
AND THE
INTERIOR AND INSULAR AFFAIRS COMMITTEE
UNITED STATES SENATE.

MARCH 11, 1975

Mr. Chairman and members of the Armed Services and Interior and Insular Affairs Committees, I am very pleased to be afforded the opportunity to discuss the Naval Petroleum and Oil Shale Reserves and plans for allowing them an increasing contribution to our energy needs.

I would first like to provide background information, starting with a brief history of the Reserves, then telling you of accelerated activity during the last two fiscal years.

The Naval Petroleum and Oil Shale Reserves were created between 1912 and 1924. Upon recommendations of United States Geological Survey, Presidents Taft, Wilson, Coolidge and Harding established the petroleum reserves by withdrawal of relatively small but selective acreages of domain to be administered by the Navy as an assured defense fuel supply. Congress placed these Reserves under authority of the Secretary of the Navy by an Act dated June 4, 1920 (41 Stat. 813).

The abbreviated table below provides pertinent statistics on the Naval Petroleum and Oil Shale Reserves system:

| | Proved Reserves | | Estimated New Reserves | | Area |
|---|---|---|---|---|---|
| | MM/bbls Oil | MM/Mcf Gas | MM/bbls Oil | MM/Mcf Gas | Acres |
| NPR #1 | 1,009.6 | 1,180 | 482 | 300 | 46,095* |
| NPR #2 | 15.6 | NA | 0 | 0 | 30,181* |
| NPR #3 | 43.0 | 8.0 | 0 | 0 | 9,481 |
| NPR #4 | 100.1 | 160.6 | 10,000-33,000 | 60,000-192,000 | 23,680,000 |
| NOSR (jointly) | -0- | -0- | 16,000 | -0- | 145,333 |

*Contains both Government and private titled land. NPR-1 is under a Unit plan with the Standard Oil Company of California who participates in the amount of 20%. SOCAL also operates NPR-1 under contract to the Department of the Navy.

During the last decade significant additions to knowledge of the reserves have been obtained. However, owing to funding at the $5M-$8M per year level, no substantial progress was made toward establishing the full potential of the Naval Petroleum Reserves as a rapidly available source of emergency oil. In 1967, the Navy initiated preparation of a complete plan for the exploration and development of all reserves. The plan was completed in April of 1973 and forwarded to the President, and in the fall of 1973, when the oil embargo created shortages, the Secretary of the Navy made a determination that NPR-1 should be produced. This action was approved by the President and sent to the Congress. A modification of the administration bill was passed in the Senate, and in the House of Representatives the Armed Services Committee held comprehensive hearings. Production from NPR-1, Elk Hills, was not recommended by the Committee at that time. The Committee concluded, however, that NPR-2 and NPR-3 were of little value as viable reserves and, therefore, the Navy should consider producing at these locations and using funds so derived to finance exploration and development of NPR-1 and NPR-4.
While the original bill for production at Elk Hills was not passed in Congress, there was, however, an appropriation provided for exploration and development at NPR-1 and NPR-4 of $11.5M and $47.5M, respectively, and a substantial program was initiated. The budgetary figures appearing in the legislation were drawn from the Navy plan of 1973. Congress followed in FY 75 with $64.4 million to continue the program. DOD has now established in their planning a continuation of this effort through the Fiscal Year Defense Plan years.

As related above, the budget actions of 1974 and 1975 together with the ongoing Fiscal Year Defense Plan have been derived from the exploration and development plan submitted by the Navy in April of 1973. I would like to summarize the objectives of that plan.

The Development Plan for Naval Petroleum Reserve No. 1 calls for the creation of a 400,000 barrel of oil per day production capability and includes all projects that are typical of any major oil field development. Not only must additional wells be drilled, but the allied surface facilities must be installed within the Reserve to handle the oil, gas, and water in accordance with sound oil field engineering practices. Our five year exploration and development plan calls for the drilling of some 50 to 76 exploratory wells at a cost of about $30 million and completing the development of the field with 829 wells together with production facilities at a cost of $417 million. The exploratory effort is designed to more completely define the extent of the Elk Hills reserves, and the development program will establish the desired expanded production capabilities from the various oil pools. Of the development wells to be drilled, about 550 will take approximately 30 days each to drill to 8,000' - 10,000' depths (Stevens and Carneros Zones). The remaining development wells will be drilled to an average depth of about 3,500' to penetrate the shallower oil and gas zones. The exploration wells will vary in depths from 1,500' to 20,000' (basement rock). Prior to this time, the deepest well at Elk Hills has been 12,856'. Thus, we will be drilling to basement rock for the first time. When completed, the wells will be connected to tanks and gauging facilities to handle the produced oil, gas, and water. Over 75 tank settings will be upgraded and 24 new settings will be constructed over the next

five years. These tank settings would then stage the produced hydrocarbons through approximately 260 miles of new oil and gas lines across the Reserve to shipping facilities and gas processing plants.

Additional automated crude oil shipping facilities referred to as LACTS (leasing automatic custody transfer stations) are being installed at the perimeter of the Reserve for possible connection to the various available commercial pipelines. Produced gas will be stripped of its liquids for sale at competitive bid and the residual dry gas would be reinjected into the reservoir to maintain pressure, thereby maximizing ultimate oil recovery. Although proposed funding allows for construction of natural gas processing plants on the Reserve capable of processing 300,000 MCF per day of gas, negotiations are presently underway for the purchase or lease of existing privately owned plants located near the Reserve. Successful negotiations in this area may reduce the overall costs of the development plan. Other surface facilities to be constructed include storage facilities, cathodic protection, vapor recovery systems, electrical service extensions, new pumping units, and construction of over 120 miles of access roads.

Of the $93 million dollars provided by Congress to date, over $64 million dollars has been committed in the awarding of 25 construction contracts and multiple well drilling contracts. The remaining $29 million will be committed to additional drilling contracts as soon as the availability of casing and materials allows. The commitment rate of funds to date has been slowed by the world-wide heavy demand for oil field supplies. For example, it takes at least six months to obtain steel casing, pumping units are delivered 18 to 24 months after ordering, and compressors take 18 months to obtain.

Acceleration of materials installation could be made only if commercial orders were to be preempted, which we have tried to avoid since such action would be almost certain to impair the progress of private oil companies in the search for additional oil reserves. Only in the case of tubular goods have we resorted to priorities. To date, a total of 32 producing development wells have been drilled to 9,500' (Stevens Zone), two 25,000 barrel a day shipping facilities are under construction, 25 additional drilling sites have been constructed with an additional 100 under contract to be completed at a rate of 10 per month. We are presently drilling wells at a rate of 7 per month utilizing 5 drilling rigs. By September we should have 8 rigs working on the Reserve, completing 15 wells per month. A maximum of 12 rigs will be employed in the last three years of the program which will yield a rate of 20 well completions per month. The present natural gas processing plant on the Reserve is being increased in capacity from 50,000 MCF a day to 94,000 MCF per day, pumping units have been ordered and will arrive at a rate of 4 per month starting in March, increasing to 14 per month in January 1976. Twenty miles of primary roads have been constructed or upgraded.

As mentioned, an exploration program is also in progress. A total of 10 exploratory wells has been drilled to date in various areas of the Reserve. The exploration and development wells have demonstrated that recoverable oil in the reserve will be increased by at least 100 million barrels, and this is a conservative preliminary estimate. Our deep test exploration well will for the first time penetrate formations which are

productive in the vicinity of the Reserve. As a result, real potential exists for further increasing the total oil reserves.

Thus, the producing capability of the Reserve is actively in the process of being increased to 400,000 barrels of oil per day with a targeted completion date of 1980. With Congressional approval of Title I of the President's proposed Energy Independence Act, production of 130,000 BOPD should be possible within several months and 250,000 BOPD or more by 1977. Production at any significantly higher levels prior to completion of the on-going development plan may deny the attainment of capability to achieve the full 400,000 BOPD production level. The capability is similarly being rapidly developed to move this production to the various shipping points on the periphery of the Reserve. Movement of the crude oil beyond the Reserve shipping points is limited by the available surplus capacities in the various commercial pipelines which either are connected or could be connected to our shipping points. Currently the surplus capacity of these pipelines is about 130,000 BOPD. Within 18 months, connections could be made to accommodate the off-Reserve transport of 155,000 BOPD total Elk Hills production, and 355,000 BOPD total within 36 months. Each of these pipeline capacity levels has an attendant capital cost for additional off-Reserve pipeline connection, pumps, etc., increasing to $53 million to obtain a deliverability of 355,000 BOPD. No funds have been requested to meet any of these requirements. It appears that some private capital would be forthcoming in this regard should sustained increased production be guaranteed.

The obtainable pipeline transport capabilities recounted above have been found to accommodate the API gravity of oil produced at Elk Hills.

In this regard, and in a further effort to test the prospective outlets for possible increased levels of Elk Hills oil production, we have also surveyed the current and projected crude oil feed stock deficiencies at California refineries.

Due to the common practice of oil companies to trade or exchange various grades of crude oil to obtain gravities which can be utilized at a given refinery, it is not necessary to be concerned with the gravities of Elk Hills production other than to note that a range of gravities is producible which could be utilized at various California processing centers. The present apparent combined crude oil feedstock spare capacity at California refineries is about 139,000 BOPD, out of a total statewide refining capacity of 1,755,000 BOPD. That is to say, this additional rate could be processed with current commercial plant capabilities. Therefore, production open-up at Elk Hills beyond about 139,000 BOPD could not be accommodated by the present California refinery industry unless West Coast imports were commensurately curtailed. (Currently about 700,000 BOPD.) An alternative might be marine transport to extra-state refining centers. The current total refining spare capacity of about 139,000 BOPD is distributed among the Bakersfield/San Francisco/Los Angeles areas in 73,000/0/66,000 BOPD increments respectively, and the only major integrated company identifying any current spare capacity is the SOCAL refinery at Bakersfield (16,000 BOPD).

Projection of spare capacities one or more years ahead is extremely risky in view of the many variables involved. The impact of Alaskan oil, future of foreign imports, and uncertain plans for expanded refining capacities all serve to complicate the issue. However, no major integrated company projects any additional spare refining capacity for the next

five years, and expansion plans for the independents are contingent upon numerous complex variables, including long lead time materials and equipment, which preclude the reasonable projection of future spare capacities.

In summary, attainable pipeline capacities servicing Elk Hills and spare California refining capacities are currently projected to be in the 130,000 - 150,000 BOPD range for the next three years. Pipeline capacities could be more than doubled by the end of these three years, but no definitive growth in spare refining capacities can be accurately forecast. To the contrary, shrinkage of the current spare capacities can be anticipated when Trans-Alaska Pipeline comes on stream during the 3rd or 4th quarter 1977. Early open-up of Elk Hills production would be constrained by attainable pipeline capacities for 2 to 2 1/2 years, when production could increase to a field maximum efficient rate of 250,000 BOPD --- less than attainable pipeline capacities, but considerably more than current California spare refining capacity.

During the recent contacts with pipeline and refining companies, the Navy was cautioned that the figures provided were accurate as of the date submitted and are subject to change without notice.

Naval Petroleum Reserve No. 2, located at Buena Vista Hills, California, was leased out in the 1920s when the Reserves were under the jurisdiction of the Secretary of the Interior, is fully developed, and produces income of about $1 million per year.

Naval Petroleum Reserve No. 3 at Teapot Dome, Wyoming, is the smallest of the reserves and has approximately 150 productive wells and has the capability of producing 2,000 BOPD without additional drilling.

During the two past years, FY 74 and FY 75, this Reserve has been operating on a budget of approximately $300,000/year.

Development plans for this Reserve have been prepared which call for the drilling of 562 wells over a five year period. During this development phase, production could take place such that at the conclusion of the five years the average production would equal 12,700 BOPD. The estimated cost of this plan, including wells and shipping facilities, is $69.8 million. Discussions with the pipeline company in the area indicated that sufficient surplus capacity exists to handle NPR No. 3 production. Similar investigation into the spare refining capacity in the Casper, Wyoming, area resulted in the conclusion that the oil produced could be refined in the immediate area.

NPR 3 also has additional areas requiring exploration. The exploration plan identifies 16 possible locations for additional hydrocarbon accumulations which have excellent possibilities for increasing the productive potential of NPR 3. The cost of the 16 well exploration program is estimated at some $1.7 million and is planned to be accomplished over a five year period.

Naval Petroleum Reserve No. 4 in Alaska is actively being explored to determine the extent of the Reserve's assets. As with any property determined to contain hydrocarbons, exploration must take place prior to defining and preparing development plans. Over the seven year life of the Navy's current plan for NPR 4 exploration program, some 10,000 miles of seismic exploration will be conducted, and 26 exploratory wells drilled. The total cost of the program is estimated to be $382 million. Briefly, seismic exploration consists of transmitting shock waves through the earth and recording the return signals. Processing the return

signals allows the identification of structural changes in the subsurface depositions which have hydrocarbon potential. Only by drilling a well can one determine if the subsurface structures contain oil and/or gas.

For FY 74 and 75, $30 million has been provided for the exploration of NPR 4 of which $27.4 million has been expended or obligated. The remaining funds will be obligated by June of 1975. As in the fiscal obligation rate of Elk Hills development funds, the obligation of funds for NPR 4 has been slowed by the world wide shortage of oil field equipment. For example, in excess of six months are required to obtain steel for wells, well head equipment, and other equipment. The supply situation for NPR 4 is compounded due to the short 2 month shipping season on the Arctic coast. As a result, all materials required for the exploration effort must be purchased and delivered to Seattle, Washington by May of each year. Materials and supplies presently being utilized for exploration were shipped during May 1974. Because of the long lead time for materials and supplies acquisition and the short shipping season, it is extremely important that continuous funding be provided to prevent prolongation of the program. A one year funding gap will cause the program to suffer a two year setback. The funds provided in the FY 74 Supplemental appropriations and FY 75 Appropriations Acts have allowed significant progress outlined below to be made. Future funds requested for FY 76 will permit the Navy to conduct an additional 3,100 miles of seismic exploration and drill 3 wells to find the vast hydrocarbon deposits which underlie NPR 4.

The first year of the Navy's exploration was completed during FY 74 by conducting 1,049 miles of seismic exploration and by mid-1975 we

will have completed 3500 miles. Processing this information indicates that several predominant structures exist in the area covered. The initial pattern of the seismic exploration was on an approximate 6 mile square grid. After identification of the subsurface structures, detailed seismic work was accomplished in specified areas. As a result of the detail work, locations were chosen for the first two exploratory wells. The drilling of the first of these wells, at Iko Bay near Barrow, has been completed and testing of the well is now being done. We did not find significant oil, but it appears that the testing will show it to be a commercially productive gas well. This well was drilled to a depth of about 3000 feet. The drilling of the next exploration well will commence later this week. It is located near Cape Halkett (between Barrow and Prudhoe Bay) and it will be drilled to a depth of 10,000 - 12,000 feet.

Based on the data already in hand, together with the new information that we are obtaining every day, we would expect within 1-1/2 to 3-1/2 years to have sufficient data on which to base the development program which must precede production. Given the magnitude of this program, it can best be accomplished by entering into arrangements with private industry.

The program, as you can see, is well underway. It has been possible to accomplish this work under authorization provided by the existing statutes together with fiscal appropriations which have been increased during the last two years; with approval of the budget which has been submitted in FY 76, the program can continue. On the other hand, in order to meet our country's increasing energy challenge, it will be very important to take even more aggressive action. Some of

the measures that have been introduced in the House and Senate would take such action and I would like to comment briefly on them.

Senate Joint Resolution 13, introduced by Senator Cannon, would authorize the production of petroleum from NPR 1 for national defense purposes at a rate not to exceed the maximum efficient rate in accordance with sound engineering and economic principles. The proceeds from such production would be placed in a special account in the Treasury to be used for the exploration, development, and production of all of the Naval Petroleum and Oil Shale Reserves. This Joint Resolution, which is virtually identical to S.J. Res. 176, 93rd Congress, which as I noted earlier was passed by the Senate but not by the House, is based on a Determination made by the Secretary of the Navy on November 6, 1973, in accordance with our statutes (10 U.S.C. 7422), that production was needed for national defense purposes. In that Determination it was noted that the then present supplies of petroleum were not sufficient, even through mandatory allocation, to meet both the needs of military readiness and essential civilian needs, including those vital to defense. It was also noted that certain international events, i.e., mainly the embargo, were contributing seriously to the growing deficit in source of military petroleum supply and had led to reduced availability from sources outside the United States where the Armed Services normally procure 50% of their needs. As we all know, the conditions under which that Determination was made have changed considerably and therefore the Determination could now be challenged. We do feel that production of the Reserves for the purposes of constructing, managing, and filling a national strategic petroleum reserve could be justified as a national

defense requirement, but we have taken a different approach to this matter which I will discuss later in my statement.

S. 677, which was introduced by Senator Jackson, would create strategic energy reserves in storage capable of replacing energy imports for at least ninety days in order to reduce the impact of interruptions or reductions in imports of energy supplies. Included within the strategic reserve system would be (1) national strategic energy reserves; (2) industry storage reserves; (3) utility storage reserves; and (4) coal storage reserves. The national strategic energy reserve would be composed of crude oil produced from Federal lands, including the naval petroleum reserves to the extent authorized by law, and crude oil to which the United States is entitled as royalty from future production upon Federal lands, including the Outer Continental Shelf.

While we agree with the philosophy of a strategic reserve system as set forth in Senator Jackson's bill and with the concept of production in Senator Cannon's resolution, we have problems with specific provisions on which I defer to the FEA for discussion. Also, we feel that more aggressive, and more comprehensive, action should be taken.

To this end, the President has submitted to the Congress for action the Energy Independence Act of 1975 (S. 594). Titles I and II of that bill are closely linked and provide the President with general authority pertaining to the subject under discussion today. I would like to provide a brief summary of these titles, highlighting some of the actions which would be taken to implement its objectives. There is provision made for a National Strategic Petroleum Reserve of up to 1 billion barrels for the civilian economy which is provided in Title II and a 300 million barrel reserve for the military which is provided in Title I.

Title I also provides

for production at Elk Hills and other Naval Petroleum Reserves for storage in the National Strategic Petroleum Reserve, for replenishment of Department of Defense stocks, and for sale and exchange. A special fund would be established in the Treasury derived from the funds realized from sale of this petroleum. The special fund will provide monies for exploration and development of all of the petroleum reserves and will provide for the establishment of the National Strategic Petroleum Reserve. As you can see, Titles I and II are closely related and, when enacted, will provide the nation with a means for a viable storage "insurance policy" against interruption in transportation of petroleum. The Naval Petroleum Reserves that will be used in part to fill the 1.3 billion barrel system will simply be transferred to a form of storage that is more accessible should an emergency arise.

In addressing the issue of producing at Elk Hills we have commonly discussed an initial goal of 160,000 barrels per day. As I mentioned earlier in my statement, we are mindful of the transportation and refinery requirements and have recently been working with the owners of pipelines and refineries in the California area to determine what action needs to be taken to assure delivery. Our initial review shows in excess of 100,000 barrels per day can be accommodated rather quickly and that with additional connections to existing pipelines and assuming the requisite spare refinery capacity we would be able to approach 160,000 barrels per day in a matter of months.

The current proposal has followed the pattern of previously introduced legislation in assuring that the oil will be offered for sale in such a way that all companies, large and small alike, may be afforded a

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fair opportunity to participate. We have authority within current legislation and with the assistance of the Small Business Act to allocate appropriate amounts to the smaller companies.

As you know, Standard Oil Company of California is the partner of the Government at Elk Hills. They own approximately 20% of the field and we operate under an agreement which provides for sharing of production in that ratio. Much has been said about what would happen if Elk Hills were opened for other than national defense. We have initiated discussions on that subject with Standard Oil and would plan to negotiate modifications to the existing Unit Plan Contract which would protect the partners' positions under the new legislation.

In a separate relationship, Standard Oil of California has been for the last several years our operating contractor at Elk Hills. This is a competitively awarded contract renewable approximately every five years and is separate and distinct from the Unit Plan Contract.

On January 7th of this year, Standard Oil informed us of their desire to withdraw from the operating responsbility. They cited the fact that the very large drilling program planned for Elk Hills would demand management resources which they felt were sorely needed in other areas where they are trying to increase the supply of petroleum; in addition, they stated they are mindful of the frequent congressional and public concern regarding the potential conflict of interest which results from their several roles. While we agree with them that the parties have been able to maintain appropriately separated business relationships, we are sympathetic to both of their citations and, therefore, indicated a willingness to seek a replacement contractor. Thereupon Standard provided formal notice on February 13th. Our contract

allows either party to withdraw with nine months notice and Standard Oil has asked that we accelerate that schedule if.at all possible. We are moving out immediately to prepare a Request for Quotation for this job. Without this early severance of our relationship, a new competition would have been scheduled for June of 1976. Based on responses in the past and informal inquiries, we are confident that a capable contractor will be found. The Navy is proceeding to accomplish this action in as short a time as possible.

For NPR's 2 and 3, Title I provides for completion of development at NPR 3 and production from both fields. This was a recommendation from hearings conducted by the House Armed Services Committee last year.

Of the petroleum available at NPR-4 it is planned to utilize at least 20% for the National Strategic Petroleum Reserve or such other amount as determined by the President and to make the remainder available to the public economy. As was indicated earlier in the discussion, we are expecting to be ready in the near term for participation by commercial industry in the development program. Starting immediately, the Navy would plan to begin an analysis of the optimum contracting procedures for obtaining this participation. We will consider competitive leasing, competitively negotiated contracts and other arrangements. We will seek to establish the best means by which participation can be made attractive to Industry and yet will assure for the Government receipt of full value for the petroleum in NPR-4.

In summary, I would like to establish that we have in being a planned program that is on schedule. This will provide in the next several years a much needed improved development status of the Naval

Petroleum Reserves. In order to capitalize on the potential of these Reserves, the Administration has introduced a.Bill providing for the National Strategic Petroleum Reserve, which instead of shut-in production capability provided in the first instance, will provide a large volume of petroleum for ready delivery at high rates. This more aggressive program requires new legislation as proposed by the Energy Independence Act of 1975, which we believe has been carefully designed to assure optimum utilization of the Naval Petroleum Reserves for the increasing energy needs of the United States. The plan preserves the concept, inherent in the existing statute, of a protected source of supply for times of emergency for military and civilian economy alike.

We therefore strongly support enactment of S. 594 -- the President's Energy Independence Act of 1975.

# NAVAL PETROLEUM RESERVES CURRENT AND ON-GOING PROGRAM

RECENT EVENTS

NAVAL PETROLEUM AND OIL SHALE RESERVES

- NAVY PLAN - APRIL 1973
- INCREASED CONGRESSIONAL APPROPRIATIONS - 1974-75
- PIKE SUBCOMMITTEE HEARINGS
  - PRODUCE NPR2 AND NPR3
  - ACCELERATE EXPLORATION AND DEVELOPMENT OF NPR1 AND NPR4
- INCREASED DOD BUDGET PLANNING

NPR-1 - ELK HILLS, CALIFORNIA

STATUS AS OF JANUARY 1, 1974

1,000 WELLS

160,000 BOPD CAPABILITY

1.0 BILLION BARRELS OF OIL RESERVES

1.2 BILLION MCF OF GAS RESERVES

NPR-1 PLAN

OBJECTIVE: 400,000 BOPD

EXPLORATION

DRILLING OPERATIONS

76 WELLS
$30 MILLION

FACILITIES REQUIRED

-0-

DEVELOPMENT

DRILLING OPERATIONS

829 WELLS

$302 MILLION

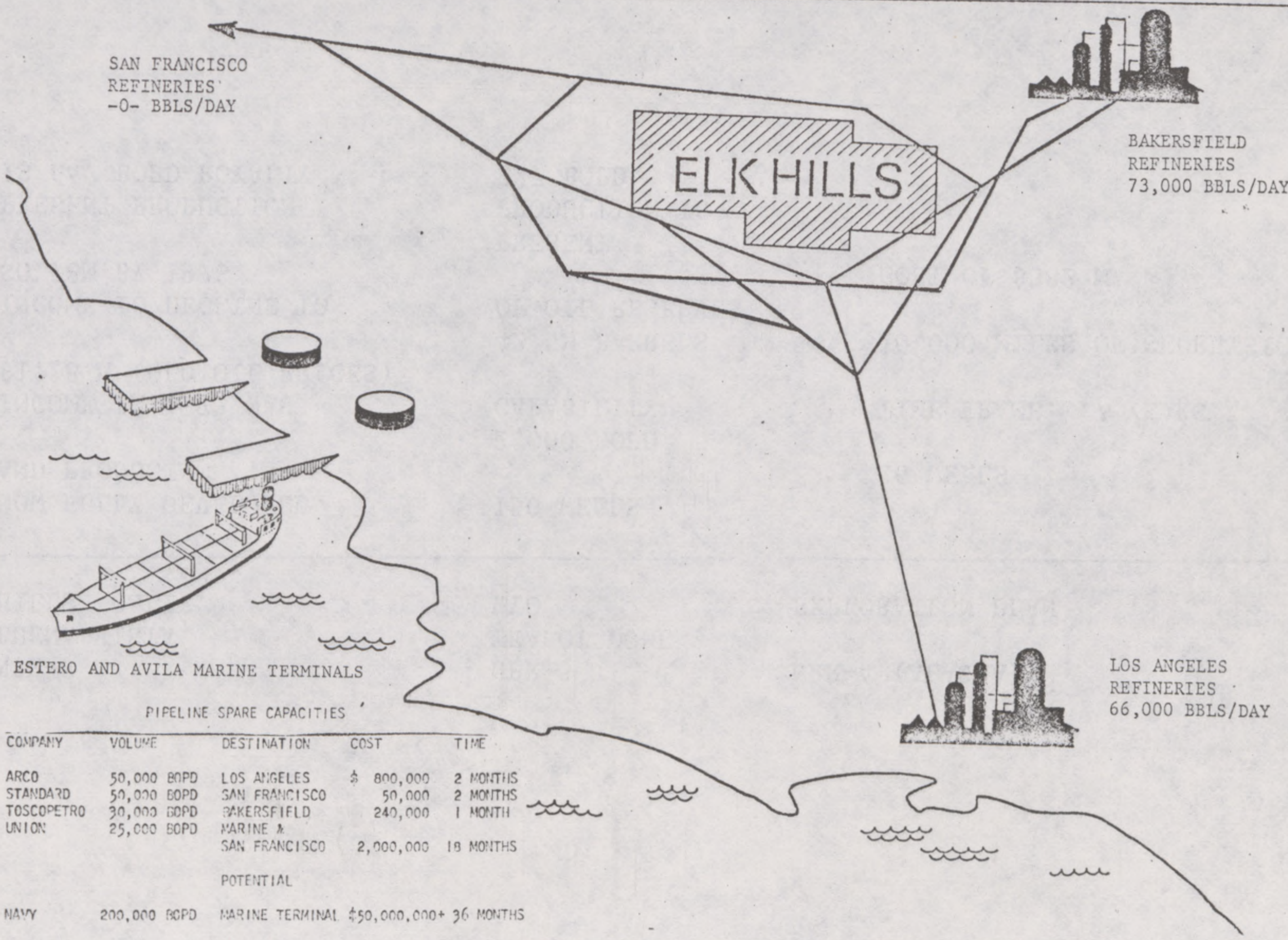
FACILITIES REQUIRED

SEPARATORS
OIL HANDLING
GAS HANDLING
WATER HANDLING
TRANSFER EQUIPMENT
PIPELINE TIE-INS
$115 MILLION

NPR-1 - PROGRESS TO DATE

- 42 WELLS
- 40,000 BOPD (FROM 100 MILLION BBLS OF NEW RESERVES)
- $16 MILLION FACILITIES CONSTRUCTION UNDERWAY
- SEEKING NEW OPERATOR

PIPELINE AND REFINERY SPARE CAPACITIES




ESTERO AND AVILA MARINE TERMINALS

PIPELINE SPARE CAPACITIES

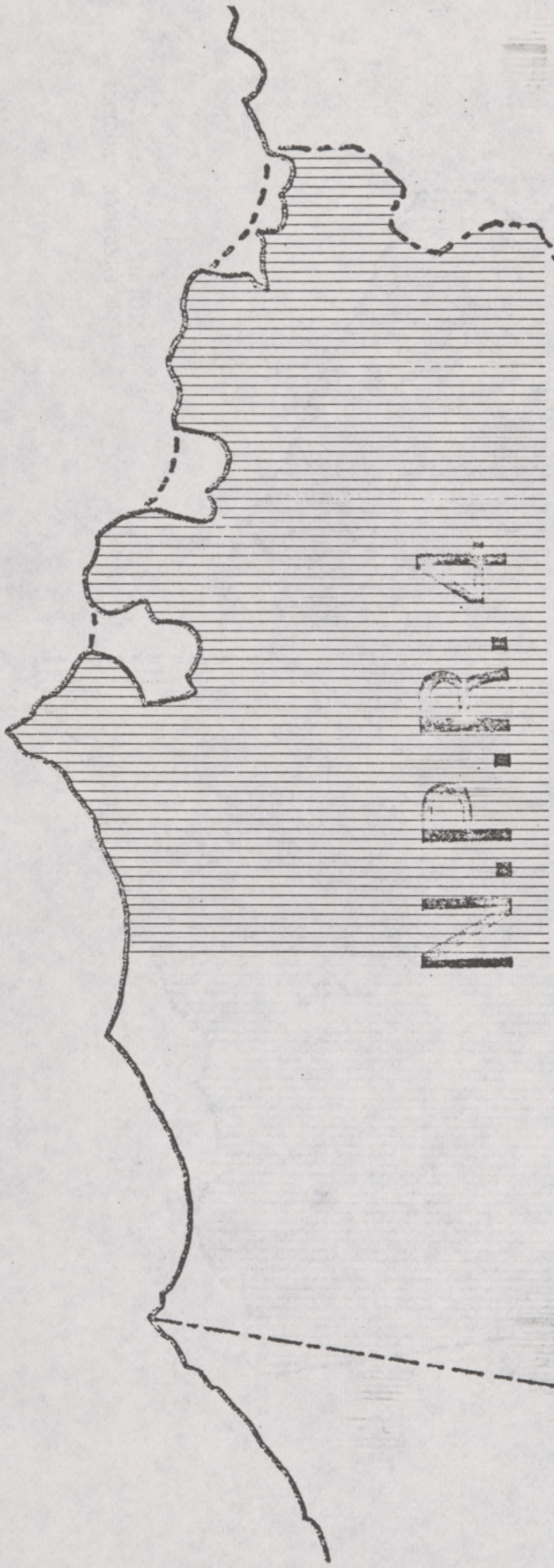
| COMPANY | VOLUME | DESTINATION | COST | TIME |
|---|---|---|---|---|
| ARCO | 50,000 BOPD | LOS ANGELES | $ 800,000 | 2 MONTHS |
| STANDARD | 50,000 BOPD | SAN FRANCISCO | 50,000 | 2 MONTHS |
| TOSCOPETRO | 30,000 BOPD | BAKERSFIELD | 240,000 | 1 MONTH |
| UNION | 25,000 BOPD | MARINE & SAN FRANCISCO | 2,000,000 | 18 MONTHS |
| | | POTENTIAL | | |
| NAVY | 200,000 BOPD | MARINE TERMINAL | $50,000,000+ | 36 MONTHS |

| NPR-2<br>BUENA VISTA<br>HILLS, CALIF. | NPR-3<br>TEAPOT DOME<br>WYO. | NPR-4 (ALASKA)<br><br>EXPLORATION PLAN |
|---|---|---|
| • NOW FULLY DEVELOPED AND PRODUCING | • 150 WELLS | • 26 WELLS |
| • INCOME IN 1973 WAS $1.28 M (OLD OIL PRICES) | • 2,000 BOPD CAPABILITY | • TIME FRAME: 7 YEARS |
| • INCOME TO DECLINE TO $0.78M BY 1978 | • 42.5M BARRELS OF OIL RESERVES | • 10,000 MILES OF GEOPHYSICS |
| • PRESENT PRODUCTION IS 647 BOPD ROYALTY | • PRESENT PRODUCTION IS 327 BOPD | • COST OF $382 M |

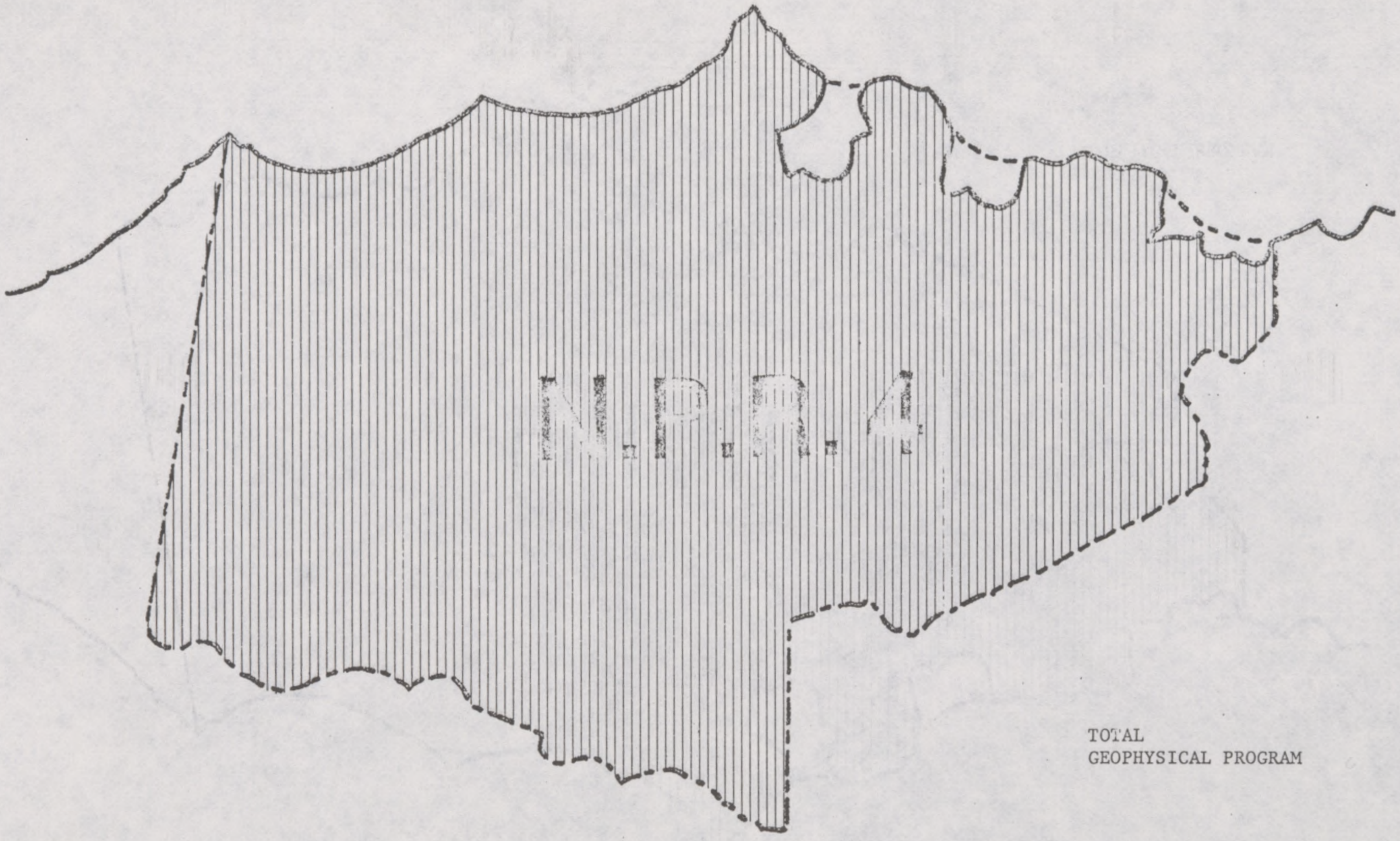

POINT
BARROW
PRUDHOE
BAYFIELD
N.P.R.4
UMIAT




FY 1974
GEOPHYSICAL PROGRAM



FY 1975
GEOPHYSICAL PROGRAM



TOTAL
GEOPHYSICAL PROGRAM


STRATIGRAPHIC AND
STRUCTURAL AREAS
OF INTEREST

## NPR-4
## PROGRESS TO DATE

- 3,500 MILES OF SEISMIC EXPLORATION TO BE COMPLETED JUNE 1975
- 2 EXPLORATORY WELLS TO BE COMPLETED BY JUNE 1975
- $27.4M EXPENDED/OBLIGATED TO DATE

## DOD PROPOSED FUNDING FOR NPRs

(IN MILLIONS)

| | |
|---|---|
| FY 1976 | $117.7 |
| FY 197T | $ 47.5 |
| FY 1977 | $173.6 |
| FY 1978 | $130.2 |
| FY 1979 | $139.3 |
| FY 1980 | $125.4 |

## 1975 ENERGY INDEPENDENCE ACT FEATURES

- PRODUCE NPR's 1,2,3 AND 4 (ULTIMATELY)

  DISPOSITION OF PRODUCTION

  - NATIONAL STRATEGIC PETROLEUM RESERVE
  - TOP-OFF DOD STOCKS
  - SALES (MILITARY PREFERENCE)

- EXPLORE & DEVELOP NPR's 1,3, AND 4
- SPECIAL FUND
- NATIONAL STRATEGIC PETROLEUM RESERVE

  (a) MILITARY (TITLE I)

  (b) DOMESTIC (TITLE II)

## NPR-1 PRODUCTION/DELIVERY CAPABILITY

| TIME | PRODUCTION (BBLS/OIL PER DAY) | PIPELINE CAPACITY (BBLS/OIL PER DAY) |
|---|---|---|
| 10 DAYS | 60,000 | 10,000 |
| 60 DAYS | 160,000 | 130,000 |
| 18 MONTHS | 230,000 | 155,000 |
| 3 YEARS | 250,000 | 355,000 |

- METHOD OF SALE: PUBLIC SALE WITH SMALL BUSINESS SET-ASIDE
- MODIFY UNIT PLAN CONTRACT

## NPR-3 (TEAPOT DOME) PRODUCTION

- PRESENT CAPABILITY: 2,000 BOPD
- POTENTIAL CAPABILITY: 12,000

FULL DEVELOPMENT PRODUCTION PLAN

- DRILL 562 ADDITIONAL WELLS
- COSTS: APPROX. $70 M
- WOULD EARN APPROX. $232.5 M OVER 5 YEARS (NEW OIL PRICES)

## NPR-4 DEVELOPMENT PLAN

FULL DEVELOPMENT WILL BEGIN AS EXPLORATORY PROGRAM DISCOVERS MAJOR RESERVOIRS

DISPOSITION OF PRODUCTION

- AT LEAST 20% FOR NSPR OR SALE PROCEEDS TO SPECIAL FUND
- UP TO 80% PUBLIC ECONOMY

## THE NATIONAL STRATEGIC PETROLEUM RESERVE PLAN

- PRODUCTS TO BE STORED
- GEOGRAPHICAL LOCATIONS
- TYPE OF STORAGE

# IX. Legislation Pending Before the Senate Committees on Armed Services and Interior and Insular Affairs on Strategic Reserves

94TH CONGRESS
1ST SESSION

# S. 594

IN THE SENATE OF THE UNITED STATES

FEBRUARY 5, 1975

Mr. HUGH SCOTT introduced the following bill; which was read twice and, by unanimous consent, referred to the Committees on Armed Services, Banking, Housing and Urban Affairs, Commerce, Finance, Government Operations, Interior and Insular Affairs, the Judiciary, Labor and Public Welfare, and Public Works

# A BILL

To increase domestic energy supplies and availability; to restrain energy demand; and to prepare for energy emergencies, and for other purposes.

To increase domestic energy supplies and availability by authorizing production of the Naval Petroleum Reserves, establishing a National Strategic Petroleum Reserve, assuring increased supplies of natural gas at reasonable prices, amending and extending the Energy Supply and Environmental Coordination Act of 1974, amending the Clean Air Act, altering regulatory practices and procedures of governing electric utilities, assuring timely siting, consideration, approval and construction of necessary energy facilities, and preventing foreign oil producing countries from undermining efforts to develop petroleum resources; to restrain energy demand by providing national energy conservation standards for new residential and commercial buildings, authorizing the Federal Energy Administration to

assist States in winterizing dwellings of low-income persons, and providing for the labeling of major appliances and motor vehicles; to prepare for energy emergencies by providing standby energy authorities and implementing the International Energy Program; and for other purposes.

*Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,*

That this Act may be cited as the "Energy Independence Act of 1975".

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Sec. 1. Short Title—Energy Independence Act of 1975.

**PART A—INCREASING DOMESTIC ENERGY SUPPLIES AND AVAILABILITY**

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Sec. 102. Amendments to chapter 641 of Title 10, U.S.C.
a. New section 7420.
b. Amendment to section 7421(a).
c. Amendment to section 7422(a).
d. Amendment to section 7422(b)(2).
e. Amendment to section 7422(c).
f. Amendment to section 7423.
g. Amendment to section 7426(d).
h. Amendment to section 7430(b).
i. Amendment to section 7431.
j. Amendment to section 7432.
k. Amendment to section 7433(b).
l. Amendment to section 7438(c)(2).
m. New sections 7439–7440.
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TITLE II—NATIONAL STRATEGIC PETROLEUM RESERVE (CIVILIAN) ACT OF 1975

Sec. 201. Short title.
Sec. 202. Findings.
Sec. 203. Declaration of policy.
Sec. 204. Definitions.
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Sec. 211. Special fund.
Sec. 212. Authorizations.
Sec. 213. Severability.

# PART A—INCREASING DOMESTIC ENERGY SUPPLIES AND AVAILABILITY

## TITLE I

### FINDINGS AND POLICY

SEC. 101. (a) The Congress finds that the Naval Petroleum and Oil Shale Reserves originally established to insure an adequate supply of oil for United States Navy requirements are of even greater importance today when the complete petroleum needs of the Department of Defense are much greater than that of the Department of the Navy alone; these needs, combined with the dependence of the total economy on energy, require assurance of a sufficient supply of petroleum readily available to meet the emergency requirements of national security, including defense mobilization, military and essential civilian needs. It is recognized that the dependence on imports of energy supplies is inappropriate because they are subject to disruption and, therefore, alternative solutions are necessary.

(b) The assets of the Naval Petroleum and Oil Shale Reserves, as yet not fully developed, are identified as powerful potential contributors to a domestic solution for this national problem. The development and utilization of these reserves require maintenance and management in the light of modern technology, not only to explore and develop such reserves to a state of ready availability for use, but also for

conversion thereof to such form, for sale and/or transportation to and storage thereof in a National Strategic Petroleum Reserve at such geographical locations, as will make the resources thereof readily available to meet the anticipated emergency needs of national security.

(c) It is hereby declared to be the policy of the United States to fully explore, develop, and produce the Naval Petroleum and Oil Shale Reserves and to create with the petroleum and revenue produced therefrom a National Strategic Petroleum Reserve capacity and maintain such reserves in storage until needed for the emergency needs of national security. The Reserve shall consist of not more than 1,300,000,000 barrels of which 300,000,000 barrels is for military use (military) and up to 1,000,000,000 barrels is for civilian use (civilian).

SEC. 102. Chapter 641 of title 10, U.S.C. is amended as follows—

(a) Immediately preceding section 7421, insert the following new section:

**"§ 7420. Definitions**

"(a) In this chapter—

"(1) The term 'national security' shall include the needs of, and planning and preparedness to meet essential civilian and military emergency energy requirements

relative to the national safety or economy, particularly resulting from foreign military or economic actions;

"(2) 'Naval Petroleum and Oil Shale Reserves' means the Naval Petroleum and Oil Shale Reserves established in this chapter, including Naval Petroleum Reserve Numbered 1 (Elk Hills), located in Kern County, California, established by Executive order of the President of September 2, 1912; Naval Petroleum Reserve Numbered 2 (Buena Vista Hills), located in Kern County, California, established by Executive order of the President of December 31, 1915; Naval Petroleum Reserve Numbered 3 (Teapot Dome), located in Wyoming, established by Executive order of the President of December 13, 1912; Naval Petroleum Reserve Numbered No. 4, Alaska, on the north slope of the Brooks Range; established by Executive order of the President of February 27, 1923; Oil Shale Reserve Numbered 1, located in Colorado established by Executive order of the President of December 6, 1916, as amended by Executive order of June 12, 1919; Oil Shale Reserve Numbered 2, located in Utah, established by Executive order of the President of November 17, 1924; Oil Shale Reserve Numbered 3, located in Colorado, established by Executive order of the President of September 27, 1924;

"(3) 'petroleum' shall be deemed to include crude

oil, gas, natural gasoline and other related hydrocarbons, oil shale, and the products of any of such resources; and

"(4) 'Secretary' means the Secretary of the Navy."

(b) Section 7421(a) is amended by striking out the words "in section 7438 hereof" and adding the following in lieu thereof: "by this title".

(c) Section 7422(a) is amended by striking out the word "Secretary of the Navy" where it appears in that section and substituting in lieu thereof the words "President, in consultation with the Secretary," and by striking out the words "subject to approval by the President".

(d) Section 7422(b)(2) is amended to read as follows:

"(2) The production of petroleum from the Naval Petroleum Reserves whenever and to the extent that the President finds that such production will contribute to the national security by making petroleum available for (i) storage as part of the National Strategic Petroleum Reserve in facilities at strategic locations; (ii) for sale or exchange pursuant to section 7430 for production of revenue to be covered into the Special Fund for the purpose enumerated in section 7432; (iii) the replenishment of the Peacetime Operating Stocks and the Prepositioned War Reserve Stocks of the Department of Defense upon transfer of credit to the National Strategic Petroleum Reserve Special Fund, hereinafter

established from the appropriation accounts available therefor, in the amount of the net value of such supplies so delivered."

(e) Section 7422 (c) is amended to read as follows:

"(c) In Naval Petroleum Reserve Numbered 4, the Secretary may under subsection (a):

"(1) develop the South Barrow gas field to supply gas to installations of the Department of Defense and other agencies of the United States located at or near Point Barrow, Alaska, the native village of Barrow, and other communities and installations at or near Point Barrow, Alaska, and,

"(2) develop and produce petroleum in accordance with the provisions of section 7439 of this chapter."

(f) Section 7423 is amended by striking out the words "national defense" and "Secretary" where they appear in that section and substituting in lieu thereof, respectively, the words "national security" and "the President in consultation with the Secretary".

(g) Section 7426 (d) is amended by striking out "one-third of".

(h) Section 7430 (b) is amended by adding at the end thereof the following: "The terms of such sales, or exchanges as provided in section 7430 (a), shall be so arranged as to give full and equal opportunity for acquisition of, or exchange

for, the petroleum by all interested companies, including major and independent oil refineries alike."

(i) Section 7431 is amended by adding "(a)" before the present section and then adding the following:

"(b) For those transactions provided for in section 7422 (b) (2) of this title, consultation (except for consultation on the overall plan for the exploration, development, and production of Naval Petroleum Reserve Numbered 4) is not required in connection with particular contracts or other similar transactions undertaken in the exploration, development, and production of Naval Petroleum Reserve Numbered 4 and in the implementation, filling, maintenance, and management of the National Strategic Petroleum Reserve."

(j) Section 7432 is amended to read as follows:

**"§ 7432. National Strategic Petroleum Reserve Special Fund**

"(a) There is established on the books of the Treasury a new account to be designated as the National Strategic Petroleum Reserve Special Fund (referred to in this chapter as the "Special Fund"). With the exception of proceeds realized from that portion of Naval Petroleum Reserve Numbered 4, made available to the public economy under section 7439 (b) which proceeds shall be covered into the Treasury as miscellaneous receipts, there shall be credited into the Special Fund:

"(1) all proceeds realized under chapter 641 from the disposition of the United States share of petroleum produced, including royalties;

"(2) the net proceeds, if any, realized from the exchanges of petroleum accruing to the benefit of any component of the Department of Defense or any other Federal agency as a result of such exchanges;

"(3) such sums as are or may be appropriated for the maintenance, operation, exploration, development, and production of the Naval Petroleum and Oil Shale Reserves; and

"(4) such sums as may be appropriated for the operation, maintenance, management, and construction of facilities and purchase of petroleum for the National Strategic Petroleum Reserve, (civilian) and (military).

"(b) The Special Fund shall be available to the President in such sums as are specified in annual appropriation acts for the expenses of (1) the exploration, prospecting, conservation, development, use, operation, and production of the Naval Petroleum and Oil Shale Reserves as authorized by chapter 641, (2) the construction and operation of facilities on or off the Naval Petroleum and Oil Shale Reserves, including pipelines from Reserve to point of sale, (3) the operation, maintenance, management and construc-

tion of facilities and purchase of petroleum for the National Strategic Petroleum Reserve (military) as provided in section 7440 of chapter 641, and (4) the operation, maintenance, management and construction of facilities and purchase of petroleum for the National Strategic Petroleum Reserve (civilian) as provided in title II of this Act. The budget estimates for this Fund shall be presented by the President independently of the budget of the Department of the Navy and the Department of Defense.

"(c) The President is authorized to transfer to departments and agencies such sums as he deems appropriate to carry out the purposes of subsection (b) and into the Treasury of the United States as miscellaneous receipts any amounts of the Special Fund determined by him to be in excess of projected requirements."

(k) Section 7433 (b) is amended by deleting the word "All" and substituting in lieu thereof the words "Except as may be otherwise expressly provided in this chapter with respect to the National Strategic Petroleum Reserve Special Fund, all".

(l) Section 7438 (c) (2) is amended by striking out the words "national defense" and substituting in lieu thereof the words "national security".

(m) Immediately following section 7438 insert the following new sections:

"§ 7439. Utilization of Naval Petroleum Reserve Numbered 4

"(a) As determined by the President, taking into consideration the recommendation of the Secretary, private capital may be utilized in the exploration, development, and production of Naval Petroleum Reserve Numbered 4, including provision for transportation and other facilities, under such arrangements as will provide an incentive for participation by such private capital consistent with the public interest and the objectives of the National Strategic Petroleum Reserve. In securing the participation of such private capital and as determined by the President taking into consideration the recommendation of the Secretary, the Secretary is authorized to enter into competitively bid leases or competitively negotiated contracts or other appropriate arrangements which provide adequate compensation to the United States in the form of bonuses, royalties, fixed prices, profit sharing agreements, or any other type of provision.

"(b) At least 20 per centum of the petroleum available in Naval Petroleum Reserve Numbered 4, or such other amount as is determined by the President to be necessary to insure an adequate supply of petroleum for the national security, shall be utilized for the purposes of the National Strategic Petroleum Reserve. The remainder of the petroleum shall be made available for the public economy.

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"(c) The Secretary is authorized to utilize the services of any other agency of the executive branch with the concurrence of the agency head affected in the exploration and development of the Naval Petroleum Reserve Numbered 4 subject to appropriate reimbursement.

**"§ 7440. National Strategic Petroleum Reserve (Military)**

"(a) There is hereby created under the management and responsibility of the Secretary a National Strategic Petroleum Reserve (military) which shall include a stock of readily deliverable petroleum in the amount of 300,000,000 barrels to meet the emergency needs of military use for national security. This reserve is in addition to a National Strategic Petroleum Reserve (civilian) as provided for in title II of the Energy Independence Act of 1975. In computing the above amount, the Peacetime Operating Stocks and Prepositioned War Reserve Stocks of the Department of Defense shall not be included. The National Strategic Petroleum Reserve (military) shall include petroleum as defined in section 7420, stored at strategic locations or available for delivery to such locations, facilities for storage, transportation or processing thereof.

"(b) The Secretary shall with the approval of the President define and publish in the Federal Register the scope and projected objectives of the National Strategic Petroleum Reserve (military), revised as may be appro-

priate to reflect the current status thereof. The Secretary shall include such information in the quarterly report to the Congress made pursuant to section 7434 of chapter 641.

"(c) The Secretary is authorized to request proceedings whenever he deems it necessary to implement and manage the National Strategic Petroleum Reserve (military) to be instituted by the Attorney General in any court having jurisdiction of such proceedings to acquire by condemnation, any real or personal property, including facilities, temporary use thereof, or other interests therein, together with any personal property located thereon or used therewith, that he deems necessary. Before condemnation proceedings are instituted pursuant to this chapter 641, an effort shall be made to acquire the property involved by negotiation unless, because of reasonable doubt as to the identity of the owner or owners, because of the large numbers of persons with whom it would be necessary to negotiate, or for other reasons, the effort to acquire by negotiation would involve, in the judgment of the Secretary, such delay in acquiring the property as to be contrary to the national interest. In any condemnation proceeding instituted pursuant to this section, the court shall not order the party in possession to surrender possession in advance of final judgment unless a declaration of taking has been filed, and a deposit of the amount estimated to be just compensation has been made. Unless title is in dispute, the

court, upon application, shall promptly pay to the owner at least 75 per centum of the amount so deposited, but such payment shall be made without prejudice to any party to the proceeding. Property acquired under this section may be occupied, used, and improved for the purposes of this chapter prior to the approval of title by the Attorney General.

"(d) Subject to appropriate reimbursement and the concurrence of the affected agency head, the Secretary is authorized to utilize the services of any other agency of the executive branch in the planning and performance of such functions as may be appropriately performed by such agencies in the accomplishment of the objectives of the National Strategic Petroleum Reserve (military).

"(e) If the President determines that the national security is threatened by an emergency such as an embargo by a foreign country or increased requirements caused by armed conflicts which result in a requirement for petroleum products in excess of the maximum supply thereof otherwise available in the United States, the resources of the National Strategic Petroleum Reserve (military) may be utilized as directed by the President to meet military requirements for the duration of such emergency.

"(f) After depletion during an emergency, the established level of petroleum to be maintained in the National Strategic Petroleum Reserve (military) for future use may

be replenished by production from the Naval Petroleum and Oil Shale Reserves or by petroleum purchased by expenditures from the Special Fund or other sources."

SEC. 103. The chapter analysis for chapter 641 of title 10, United States Code, is amended to read as follows:

"CHAPTER 641.—NAVAL PETROLEUM RESERVES

"Sec. 7420. Definitions.
"Sec. 7421. Jurisdiction and control.
"Sec. 7422. Administration.
"Sec. 7423. Periodic reexamination of production requirements.
"Sec. 7424. Protection of oil reserves; contracts for conservation.
"Sec. 7425. Acquisition by condemnation and purchase.
"Sec. 7426. Cooperative or unit plans affecting Naval Petroleum Reserve Numbered 1.
"Sec. 7427. Cooperative or unit plans in the naval petroleum reserves.
"Sec. 7428. Agreement and leases: provision for change.
"Sec. 7429. Re-lease of certain lands: lessee's preferential right.
"Sec. 7430. Disposition of products.
"Sec. 7431. Requirements as to consultation and approval.
"Sec. 7432. Expenditures: appropriations chargeable.
"Sec. 7433. Disposition of royalties.
"Sec. 7434. Quarterly reports to Armed Services Committees.
"Sec. 7435. Foreign interest.
"Sec. 7436. Regulations.
"Sec. 7437. Violations of lessee.
"Sec. 7438. Rifle, Colorado, Plant; possession, use, and transfer of.
"Sec. 7439. Utilization of Naval Petroleum Reserve Numbered 4.
"Sec. 7440. National Strategic Petroleum Reserve (military).".

## TITLE II

### SHORT TITLE

SEC. 201. This title may be cited as the "National Strategic Petroleum Reserve (Civilian) Act of 1975".

### FINDINGS

SEC. 202. The Congress hereby finds that—

(a) the Nation is and will continue to be depend-

ent upon imports from foreign sources to meet a significant portion of its energy needs;

(b) imports of energy supplies are subject to disruptions;

(c) such disruptions could impair the national health and welfare, adversely affect commerce, and jeopardize our national security;

(d) there is a need to protect the Nation from the deleterious effects of any oil import disruptions;

(e) emergency petroleum storage is a cost-effective and environmentally effective method for reducing the impact of an import disruption;

(f) a strategic petroleum reserve system will provide protection against a disruption of oil imports over a significant period of time;

(g) a strategic petroleum reserve system will support the energy requirements of the United States in time of import disruptions and national emergencies; and

(h) the public interest requires that a strategic petroleum reserve program be consistent with the objective of preserving an economically sound and competitive petroleum industry, and that the program provide

for a minimization of economic distortion, inflexibility, and unnecessary interference with market mechanisms.

DECLARATION OF POLICY

SEC. 203. It is hereby declared to be the policy of the United States to create a National Strategic Petroleum Reserve of up to 1,300,000,000 barrels of petroleum (consisting of 300,000,000 barrels in the National Strategic Petroleum Reserve (military) as authorized by title I of the Energy Independence Act of 1975, and up to 1,000,000,000 barrels for the National Strategic Petroleum Reserve (civilian) as authorized by this title) capable of reducing the impact of disruptions of oil imports.

DEFINITIONS

SEC. 204. As used in this Act—

(a) the term "petroleum" means—

(1) crude oil;

(2) natural gas liquids; and

(3) refined petroleum products, including but not limited to gasoline, naphtha, kerosene, distillates, residual fuel oil, refined lubricating oils, diesel fuel, unfinished oils, and liquefied petroleum gases.

(b) the term "interests in land" includes, but is not limited to, fee ownership, easements, leaseholds, subsurface and mineral rights;

(c) the term "storage facilities" means those facili-

ties in which significant amounts of petroleum are or can be stored;

(d) the term "related facilities" means those necessary appurtenances to storage facilities, including, but not limited to, pipelines, roadways, reservoirs, and salt brine lines;

(e) the term "National Strategic Petroleum Reserve" means the National Strategic Petroleum Reserve (military) as provided in title I of the Energy Independence Act of 1975 and the National Strategic Petroleum Reserve (civilian) as provided by this title;

(f) the term "National Strategic Petroleum Reserve (civilian)" means petroleum owned by the United States and stored in the civilian portion of the National Strategic Petroleum Reserve and the Industrial Strategic Petroleum Reserve (civilian);

(g) the term "Industrial Strategic Petroleum Reserve (civilian)" means that portion of the National Strategic Petroleum Reserve (civilian) which consists of petroleum owned by importers or refiners and stored pursuant to section 205 (j) of this title;

(h) the term "person" means any natural person, corporation, partnership, association, consortium, or any entity organized for a common business purpose which does business in any part of the United States, the Com-

monwealth of Puerto Rico, the United States territories and possessions, or the District of Columbia;

(i) the term "national security" shall include the needs of, and planning and preparedness to meet essential civilian or military energy requirements relative to the national safety or economy, particularly resulting from foreign military or economic actions.

GENERAL PROVISIONS

SEC. 205. There is hereby created a National Strategic Energy Reserve (civilian). To implement the creation of this Reserve, the President, in furtherance of and not in limitation of any other authority, is authorized to:

(a) promulgate rules, regulations, or orders necessary or appropriate to implement the provisions of this title;

(b) acquire by purchase, condemnation or otherwise, land or interests in land for the location of storage and related facilities;

(c) construct, purchase, lease or otherwise acquire storage and related facilities;

(d) use, lease, maintain, sell or otherwise dispose of storage and related facilities acquired pursuant to this title;

(e) create a National Strategic Petroleum Reserve (civilian) by acquiring petroleum for storage;

(f) execute any contracts necessary to carry out the provisions of this title;

(g) require that performance under contracts and orders (other than contracts for employment) which he deems necessary or appropriate to implement this title shall take priority over performance under any other contract or order, and for the purpose of assuring such priority, to require acceptance and performance of such contracts or orders in preference to other contracts or orders by any person he finds to be capable of their performance, and to allocate materials and facilities in such manner, upon such conditions and to such extent as he shall deem necessary or appropriate to achieve the objectives of this title;

(h) cause proceedings, whenever he deems it necessary to implement this title, to be instituted in any court having jurisdiction of such proceedings to acquire by condemnation, any real or personal property, including facilities, temporary use thereof, or other interests, therein, together with any personal property located thereon or used therewith, that he deems necessary to achieve the objectives of this title;

(i) waive application of the provisions of the Federal Property and Administrative Services Act of 1949, as amended, with respect to procurement necessary for

the purpose of this title, if he finds it is in the national interest to do so;

(j) create an Industrial Strategic Petroleum Reserve as part of the National Strategic Petroleum Reserve (civilian) by requiring any person engaged in the importation or refining of petroleum to acquire, store, and maintain reserves of petroleum under such terms as the President deems necessary;

(k) require that the Industrial Strategic Petroleum Reserve (civilian) portion of the National Strategic Petroleum Reserve (civilian) be stored in facilities owned, controlled, or audited by the United States at such reasonable terms as he may specify;

(l) require the replenishment of the Industrial Strategic Petroleum Reserve (civilian); and

(m) replenish the National Strategic Petroleum Reserve (civilian).

CONDEMNATION PROCEEDINGS

SEC. 206. Before condemnation proceedings are instituted pursuant to this title, an effort shall be made to acquire the property involved by negotiation unless, because of reasonable doubt as to the identity of the owner or owners, because of the large number of persons with whom it would be necessary to negotiate, or for other reasons, the effort to acquire by negotiation would involve, in the judgment

of the President, such delay in acquiring the property as to by contrary to the national interest. In any condemnation proceeding instituted pursuant to this section, the court shall not order the party in possession to surrender possession in advance of final judgment unless a declaration of taking has been filed, and a deposit of the amount estimated to be just compensation has been made, under the first section of the Act of February 26, 1931 (46 Stat. 1421), providing for such declarations. Unless title is in dispute, the court, upon application, shall promptly pay to the owner at least 75 per centum of the amount so deposited, but such payments shall be made without prejudice to any party to the proceeding. Property acquired under this section may be occupied, used, and improved for the purpose of this title prior to the approval of title by the Attorney General as required by section 355 of the Revised Statutes, as amended.

TERMS AND CONDITIONS

SEC. 207. (a) Upon a finding by the President that the national security is threatened, he is authorized, on such terms as he determines to be reasonable and equitable and in a manner consistent with the public interest requirements of 202(h), to use, sell, or otherwise dispose of all or any part of the government owned portion of the National Strategic Petroleum Reserve (civilian) and order the disposition and allocation of all or any part of the Industrial

Strategic Petroleum Reserve (civilian) portion of the National Strategic Petroleum Reserve (civilian).

(b) Upon a finding that all or any part of the National Strategic Petroleum Reserve (civilian) is no longer necessary to meet the requirements of this title, the President may, in a manner consistent with the public interests requirement of 202 (h) :

(1) dispose of all or any part of the government owned portion of the National Strategic Petroleum Reserve (civilian) at a reasonable price; and

(2) allow or require any person owning petroleum in the Industrial Strategic Petroleum Reserves (civilian) to remove or otherwise dispose of such petroleum.

INJUNCTIONS AND OTHER RELIEF

SEC. 208. Whenever it appears to any person authorized by the President to exercise authority under this title that any person has engaged, is engaged, or is about to engage in any acts or practices constituting a violation of any rule, order, or regulation issued under this title, the President may request the Attorney General to bring an action in the appropriate district court of the United States to enjoin such acts or practices, and upon a proper showing a temporary restraining order or a preliminary or permanent injunction shall be granted without bond. Any such court

may also issue mandatory injunctions commanding any person to comply with any such rule, order, or regulation.

ANNUAL REPORTS

SEC. 209. (a) Within one year after the date of enactment of this title, the President shall prepare and submit to the Congress a report setting forth those actions taken and his plans for providing a strategic energy reserve system in accordance with sections 202 and 203 of this title. The report shall include, but not be limited to, consideration of:

(1) a comprehensive environment assessment;

(2) the manner(s) of storage, chosen from among the alternative types of storage facilities;

(3) the proposed locations of such facilities and the proximity of each to necessary transportation facilities;

(4) the most attractive substances for emergency storage;

(5) the size of the stockpile and the most economically efficient stockpile levels;

(6) a program schedule for this reserve system, taking into account the capability to construct related facilities and obtain sufficient petroleum products to free programmed storage in the desired time frame;

(7) the direct cost of the reserve system, including:

(a) cost of storage facilities;

(b) cost of petroleum to be stored; and

(c) maintenance and operation costs;

(8) the market impact of developing the storage program, taking into account:

(a) availability and price of oil field supplies and equipment and the effect upon domestic production;

(b) the level of world market price fluctuations stimulated by short-term increased petroleum demands during a build-up period;

(c) the extent to which the reserve system build-up may hold up prices in an otherwise declining price market; and

(d) the extent to which purchases for the reserve system will affect competitive markets.

(9) the ownership of the storage facilities; and

(10) the ownership of the stored substances.

(b) Each year thereafter, the President shall prepare and transmit to the Congress a report summarizing all actions taken under the authority of this title, with an analysis of their impact and an evaluation of their effectiveness in implementing the provisions of this title.

DELEGATION OF AUTHORITY

SEC. 210. The President may delegate any authority conferred upon him by this title to such officers, depart-

ments, and agencies of the United States as he deems appropriate.

SPECIAL FUND

SEC. 211. The President is authorized to use the Special Fund established by title I the Energy Independence Act of 1975 in any manner necessary to implement the provisions of this title.

AUTHORIZATIONS

SEC. 212. There are authorized to be appropriated such sums as may be necessary to carry out the provisions of this title.

SEVERABILITY

SEC. 213. If any provision of this title or the applicability thereof to any person or circumstances is held invalid, the remainder of this title and the application of such provisions to other persons or circumstances shall not be affected thereby.

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94TH CONGRESS
1ST SESSION

# S. 677

IN THE SENATE OF THE UNITED STATES

FEBRUARY 12, 1975

Mr. JACKSON introduced the following bill; which was read twice and referred to the Committee on Interior and Insular Affairs

# A BILL

To establish a Strategic Energy Reserve Office in the Federal Energy Administration, to create a strategic energy reserve system to minimize the impact of interruptions or reductions of energy imports, and for other purposes.

*Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,* That this Act may be cited as the "Strategic Energy Reserves Act of 1975".

## TITLE I—GENERAL PROVISIONS

SEC. 101. FINDINGS.—(a) The Congress hereby determines that—

(1) the Nation's increasing dependence on for-

eign energy sources poses a significant threat to the Nation's economy, security, and well-being;

(2) there is a continuing danger that imports of energy supplies will be subject to interruption or reduction for political or economic reasons;

(3) such interruptions or reductions would have a disruptive economic effect, creating hardship for millions of Americans; and

(4) there is a clear need to minimize the impact of such interruptions or reductions through the establishment of a national system of strategic energy reserves.

SEC. 102. DECLARATION OF POLICY.—It is hereby declared to be the policy of the United States to create over a period of five years, and to maintain thereafter, strategic energy reserves in storage capable of replacing energy imports for at least ninety days in order to reduce the impact of interruptions or reductions in imports of energy supplies.

## TITLE II—STRATEGIC ENERGY RESERVE SYSTEM

SEC. 201. GENERAL PROVISIONS.—(a) In order to protect the United States economy against interruptions in energy imports and to provide adequate energy inventories for national security purposes there is hereby created a strategic energy reserve system (hereinafter referred to as the "sys-

tem") for those fuels subject to the provisions of this Act which shall be composed of the following:

(1) national strategic energy reserves;

(2) industry storage reserves;

(3) utility storage reserves; and

(4) coal storage reserves.

(b) There shall be established in the Federal Energy Administration a Strategic Energy Reserve Office (hereinafter referred to as the "Office"). The Administrator acting through the Office shall exercise authority over the establishment, management, and replenishment of the strategic energy reserve system provided for in this Act. The Office shall have a Director appointed by the President with the advice and consent of the Senate.

(c) As used in this Act, the terms "refined petroleum products" means gasoline, naptha, kerosene, distillates, refined lubricating oils, diesel fuel, unfinished oils, and liquified petroleum gases.

SEC. 202. NATIONAL STRATEGIC ENERGY RESERVES.—(a) There are hereby authorized to be created national strategic energy reserves, which shall consist of crude oil stored in tanks, natural geological formations, or otherwise, and a national strategic coal stockpile.

(b) The Administrator is hereby authorized and di-

rected to establish within five years, and maintain thereafter, national strategic energy reserves equal to 25 per centum by volume of crude oil imports for three consecutive months.

(c) For the purpose of this section, the base period for determining the three-month equivalent of 25 per centum of crude oil imports shall be those three consecutive months in the preceding twelve months in which import levels were the highest.

(d) For the purpose of establishing and maintaining the reserves authorized in subsection (b) hereof, the Administrator is authorized to place in storage, transport, or exchange:

(1) crude oil produced from Federal lands, including the naval petroleum reserves to the extent authorized by law; and

(2) crude oil to which the United States is entitled as royalty from future production upon Federal lands, including the Outer Continental Shelf.

SEC. 203. INDUSTRY STORAGE RESERVE.—(a) For the purpose of creating an industry storage reserve, the Administrator is authorized to require that within five years after the date of this Act, every importer of crude oil, residual fuel oil, or refined petroleum products accumulate and thereafter maintain in storage in tanks, natural geological formations, or otherwise a strategic reserve for each such com-

munity equivalent to the highest three-month level of such commodities imported by him in the preceding twenty-four months. Such strategic reserves shall be available for distribution according to the terms and conditions set forth in title III of this Act.

(b) Within ninety days of the date of enactment of this Act, the Administrator shall review alternatives for financing the industry storage reserve, including but not limited to, financing solely by industry; financing by Government through grants, rebate of import fees, tax credits, or other means; and financing through some combination of industry and Government participation, and shall recommend to Congress a program for financing the industry storage reserve that equitably distributes the costs thereof among different regions of the country with regard for the impact on consumers and the need to maintain the competitive viability of all sectors of the petroleum industry.

(c) From the date of enactment of this Act until such time as the industry storage reserves authorized by subsection (a) of this section are complete, a per centum of readily available inventories (as defined in subsection (f) of this section) shall be reserved in storage and dedicated for use as strategic reserves, to be used under the terms and conditions set forth in title III. Such per centum shall be deter-

mined by the Administrator, but in no event shall exceed 10 per centum of readily available inventories.

(d) Every barrel of crude oil, residual fuel oil, or refined petroleum products imported and stored in the industry storage reserve shall be exempt from any import license fees now or hereafter imposed.

(e) Nothing in this section shall be construed to transfer title of any crude oil, residual fuel oil, or refined petroleum products to the United States or to a third party.

(f) For the purposes of this Act, the industry storage reserve shall consist of readily available inventories which can be drawn down without affecting the importer's operations at normal capacity. Such readily available inventories shall not include minimum working level inventories or otherwise unavailable stocks.

SEC. 204. UTILITY STORAGE RESERVES.—Within two years after the date of enactment of this Act, all fossil-fueled baseload electric power generating stations with a generating capacity of one hundred million British thermal units or more in an hour shall establish and thereafter maintain fuel reserves sufficient to maintain normal power generation for a period of not less than three months.

SEC. 205. COAL STORAGE RESERVES.—The Administrator, in cooperation with the Administrator of the General Services Administration, is authorized and directed within

five years after the date of enactment of this Act, to stockpile and maintain a national strategic coal reserve, equivalent to six months of coal consumption. Such reserve shall consist of (1) federally owned coal mined by or for the United States from federally owned coal lands, and (2) Federal coal lands from which coal could be mined for consumption within thirty days of an order to do so. Lands to be mined or dedicated for this purpose shall be selected by the Secretary of the Interior within six months of the date of enactment of this Act.

## TITLE III—ADMINISTRATION

SEC. 301. AUTHORITY OF THE ADMINISTRATOR.—To implement the establishment, management, and replenishment of the system, the Administrator, in furtherance of and not in limitation of any other authority, is authorized to—

(a) promulgate rules, regulations, or orders necessary or appropriate to implement the provisions of this Act;

(b) acquire by purchase, condemnation, or otherwise, land or interests in land for the location of storage and related facilities;

(c) construct, purchase, lease, or otherwise acquire storage and related facilities;

(d) use, lease, maintain, sell, or otherwise dispose

of storage and related facilities acquired pursuant to this Act;

(e) execute any contracts necessary to carry out the provisions of this Act;

(f) require that performance under contracts and orders (other than contracts for employment) which he deems necessary or appropriate to implement this Act shall take priority over performance under any other contract or order and for the purpose of assuring such priority, to require acceptance and performance of such contracts or orders in preference to other contracts or orders by any person he finds to be capable of their performance, and to allocate materials and facilities in such manner, upon such conditions, and to such extent as he shall deem necessary or appropriate to achieve the objectives of this Act;

(g) cause proceedings, whenever he deems it necessary to implement this Act, to be instituted in any court having jurisdiction of such proceedings to acquire by condemnation, any real or personal property, including facilities, temporary use thereof, or other interests, therein, together with any personal property located thereon or used therewith, that he deems necessary to achieve the objectives of this Act;

(h) waive application of the provisions of the Fed-

eral Property and Administrative Services Act of 1949, as amended, with respect to procurement necessary for the purpose of this Act, if he finds it is in the national interest to do so;

(i) order the use of all or part of the strategic reserves established pursuant to this Act, when imports of crude oil, residual fuel oil, and refined petroleum products have fallen significantly or will within thirty days in his judgment, fall significantly below existing requirements for such imports, resulting in an existing or prospective shortage of at least 10 per centum of import requirements;

(j) require that the replenishment of depleted reserves is accomplished expeditiously; and

(k) establish price levels and allocation procedures for the national strategic energy reserves created pursuant to sections 202 and 205 of this Act but nothing in this Act shall be deemed to authorize the Administrator to exercise such authority with respect to the industry and utility storage reserves created pursuant to section 204 of this Act.

SEC. 302. CONDEMNATION PROCEEDINGS.—Before any condemnation proceedings are instituted pursuant to this Act, an effort shall be made to acquire the property involved by negotiation unless, because of reasonable doubt as to the

identity of the owner or owners, because of the large number of persons with whom it would be necessary to negotiate, or for other reasons, the effort to acquire by negotiation would involve, in the judgment of the Administrator, such delay in acquiring the property as to be contrary to the national interest. In any condemnation proceeding instituted pursuant to this section, the court shall not order the party in possession to surrender possession in advance of final judgment unless a declaration of taking has been filed, and a deposit of the amount estimated to be just compensation has been made, under the first section of the Act of February 26, 1931 (46 Stat. 1421), providing for such declarations. Unless title is in dispute, the court, upon application, shall promptly pay to the owner at least 75 per centum of the amount so deposited, but such payments shall be made without prejudice to any party to the proceeding. Property acquired under this section may be occupied, used, and improved for the purpose of this Act prior to the approval of title by the Attorney General as required by section 355 of the Revised Statutes, as amended.

SEC. 303. STRATEGIC ENERGY RESERVES FUND.—There is hereby created in the Treasury of the United States a strategic energy reserves fund. All import fees levied on petroleum imports shall be paid into such fund. Such fund shall be used for the creation and maintenance of the national stra-

tegic energy reserves created by sections 202 and 205 of this Act.

SEC. 304. DISCLOSURE, INSPECTION, INVESTIGATION.—(a) Every importer or user of fuels subject to the provisions of this Act shall prepare such accounts, records of cost-accounting procedures, correspondence, memorandums, papers, books, and other records as the Administrator may by rule and regulation prescribe as necessary or appropriate for purposes of the administration of this Act.

(b) The Administrator shall at all times have access to and the right to inspect and examine all producing, transportation, storage, refining, or processing facilities, and all accounts, records, and memorandums of persons subject to the provisions of this Act; and it shall be the duty of such persons to furnish to the Administrator, within such reasonable time as the Administrator may order, any information with respect thereto which the Administrator may by order require.

SEC. 305. PETROLEUM STORAGE PROTOTYPE PROGRAM.—(a) To evaluate the practicality of and to identify the problems attendent upon the storage of petroleum in mines, salt domes, or other geological formations, the Administrator is authorized to establish a prototype program for such storage. This program shall provide for the actual

storage if necessary to achieve the purposes of this section, of such volumes of crude oil, residual fuel oil, or refined petroleum products as may be required for test and evaluation purposes in not less than one but no more than three mines, salt domes, or other geological formations, located onshore or offshore on the Federal lands.

(b) Within one year after the date of enactment of this Act the Administrator shall submit to the Congress a report on the prototype program if any, for the storage of petroleum in mines, salt domes, or other geological formations. This report shall include but not be limited to: (1) description of environmental, technological, and material problems encountered; (2) cost per barrel of petroleum stored; (3) evaluation of the practicability of large-scale, long-term storage of petroleum in mines, salt domes, or other geological formations; and (4) recommendations for and factors to be considered in the development of such a large-scale, long-term program.

(c) The Secretary of the Interior is authorized to claim in kind for the purposes of this section and the Administrator is authorized for the purpose of the establishment of the petroleum storage prototype program required by this section, to transport, exchange, and store incidental to that program such per centum as may be required of all crude oil which the United States owns or is entitled to as royalty

oil from future production upon Federal lands, including the Outer Continental Shelf.

SEC. 306. ANNUAL REPORTS.—The Administrator shall prepare, have printed, and transmit to the President and the Congress an annual report summarizing all actions taken under authority of this Act, with an analysis of their impact, an evalution of their effectiveness in fostering the objectives listed in section 102, and any recommendations he may address to Congress for legislation regarding the matters governed by this Act.

SEC. 307. AUTHORIZATION OF APPROPRIATIONS.—There are hereby authorized to be appropriated to the Administrator such funds as are necessary for implementation of the provisions of this Act.

SEC. 308. SEVERABILITY.—If any provision of this Act or the applicability thereof to any person or circumstance is held invalid, the remainder of this Act and the application of such provision to other persons or circumstances shall not be affected thereby.

94TH CONGRESS
1ST SESSION

# S. 1113

IN THE SENATE OF THE UNITED STATES

MARCH 7, 1975

Mr. HATFIELD introduced the following bill; which was read twice and referred to the Committees on Armed Services, Interior and Insular Affairs, and Banking, Housing and Urban Affairs, jointly, by unanimous consent.

## A BILL

To authorize the Secretary of the Interior to establish, on certain public lands of the United States, national petroleum reserves, the development of which needs to be regulated in a manner consistent with the total energy needs of the Nation, and for other purposes.

*Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,* That in order to develop petroleum reserves of the United States which need to be regulated in a manner to meet the total energy needs of the Nation including but not limited to national defense, the Secretary of the Interior is authorized to establish national petroleum reserves on any reserved or unreserved public lands of the United States (except lands

in the National Park System, the National Wildlife System, the Wild and Scenic Rivers System, the National Wilderness Preservation System, and areas now under review for inclusion in the Wilderness System in accordance with provisions of the Wilderness Act of 1964).

SEC. 2. No national petroleum reserve that includes all or part of an existing naval petroleum reserve shall be established without prior consultation with the Secretary of Defense and when so established the portion of such naval reserve included shall be deemed to be excluded from the naval petroleum reserve.

SEC. 3. (a) The oil and gas in the national petroleum reserves in the contiguous forty-eight States established pursuant to this section may be developed under terms and conditions prescribed by the Secretary of the Interior. Such terms and conditions shall be published in the Federal Register, but shall not become effective until sixty days after final notice has been published and submitted to the Congress (not counting days on which either the House of Representatives or the Senate is not in session for three consecutive days or more) and then only if neither the House of Representatives nor the Senate adopts a resolution of disapproval. Any such proposed plan shall explain in detail the method of development and production proposed, shall provide for disposal and

transportation of the oil consistent with the public interest, and shall give full and equal opportunity for development of or acquisition of, or exchange for, the petroleum by qualified persons including major and independent oil producers or refiners alike. Any such proposed plan by the Secretary shall also explain the relative need for developing the oil and gas resources in order to meet the total energy needs of the Nation, compared with the need for prohibiting such development in order to further some other public interest.

(b) Any oil or gas produced from such petroleum reserves, except such oil or gas which is either exchanged in similar quantities for convenience or increased efficiency of transportation with persons or the government of an adjacent foreign state, or which is temporily exported for convenience or increased efficiency of transportation across parts of an adjacent foreign state and reenters the United States, shall be subject to all of the limitations and licensing requirements of the Export Administration Act of 1969 (Act of December 30, 1969; 83 Stat. 841) and, in addition, before any oil or gas subject to this section may be exported under the limitation and licensing requirement and penalty and enforcement provisions of the Export Administration Act of 1969 the President must make and publish an express finding that such exports will not diminish the total quality or quantity

of oil and gas available to the United States and are in the national interest and are in accord with the Export Administration Act of 1969.

(c) The Secretary of the Interior is hereby authorized and directed to explore for oil and gas on Naval Petroleum Reserve Numbered 4 and he shall report annually to Congress on his plan for exploration of such reserve: *Provided*, That no development leading to production shall be undertaken unless authorized by Congress.

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94TH CONGRESS
1ST SESSION

# S. J. RES. 9

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IN THE SENATE OF THE UNITED STATES

JANUARY 21, 1975

Mr. TUNNEY (for himself and Mr. CRANSTON) introduced the following joint resolution; which was read twice and referred to the Committee on Armed Services

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# JOINT RESOLUTION

Relating to the development of and the production of petroleum from Naval Petroleum Reserve Numbered 1, and to direct the exploration of Naval Petroleum Reserves Numbered 1 and 4, and for other purposes.

*Resolved by the Senate and House of Representatives of the United States of America in Congress assembled,* That this joint resolution may be cited as the "Naval Petroleum Reserves Defense Production Authorization Act of 1975".

FINDINGS

SEC. 2. The Congress hereby determines that—

(1) nationwide shortages of crude oil, residual fuel oil, and refined petroleum products caused by

inadequate domestic production and other factors now exist;

(2) the threat of disruptions in the availability of imported energy supplies and the high prices for such supplies so imported, particularly crude oil and petroleum products, pose a serious risk to national security, economic well-being, and health and welfare of the American people;

(3) the result of domestic petroleum shortages and the threat of disruptions in the availability of petroleum to the Armed Forces of the United States from sources outside of the United States has been or is likely to deny to the Armed Forces petroleum essential to the national defense;

(4) the state of development of Naval Petroleum Reserve Numbered 1 is not adequate for the production of petroleum in the volume required for national defense; and

(5) Naval Petroleum Reserves Numbered 1 and 4 have the potential to contribute significantly to national defense petroleum requirements, but due to inadequate exploration the full extent of that potential is undetermined.

PURPOSES

SEC. 3. The purposes of this joint resolution are to—

(1) assure the production of Naval Petroleum Reserve Numbered 1 if the Secretary of the Navy, with the approval of the President, finds that such production is needed for national defense;

(2) grant the authorization of the Congress for the production and development of Naval Petroleum Reserve Numbered 1 as is required by chapter 641 of title 10, United States Code, and direct that production be commenced as provided for in this joint resolution; and

(3) authorize and direct the exploration of Naval Petroleum Reserves Numbered 1 and 4.

AUTHORITY FOR PRODUCTION

SEC. 4. If within thirty days following the enactment of this joint resolution the Secretary of the Navy, with the approval of the President of the United States, has transmitted to the Congress a finding that the production of Naval Petroleum Reserve Numbered 1 is needed for national defense, the production of petroleum from such reserve is hereby authorized and directed in order to insure that the needs of national defense are met. Such reserve shall be developed and produced at its maximum efficient rate in accordance with sound engineering and economic principles.

Subject to the provisions of section 9 of this joint resolution, such production shall commence within thirty days following the date on which such findings of the Secretary of the Navy are transmitted to the Congress.

DISPOSITION OF PRODUCTION

SEC. 5. Any disposition of the United States share of production authorized by this joint resolution shall be in accord with chapter 641 of title 10, United States Code, and shall be conducted in a manner so as to insure that an amount of petroleum equal in value to the crude oil supplied from Naval Petroleum Reserve Numbered 1 shall be made available to the Armed Forces of the United States for defense purposes. Any disposition shall be effected by competitive bid, and shall be so arranged as to give full opportunity for acquisition of the petroleum by all interested companies, particularly independent oil refineries. Any corporation or other entity operating a pipeline or other mode of transportation for transporting oil or gas from Naval Petroleum Reserve Numbered 1 shall, in transporting such oil or gas, be considered a common carrier for purpose of any Federal law.

DISPOSITION OF RECEIPTS

SEC. 6. There is hereby established in the Department of the Treasury a Naval Petroleum Reserve Account. During the period of increased production authorized by this joint

resolution or as may be hereafter authorized, there shall be transferred or credited to such account (1) any or all proceeds realized under chapter 641 of title 10, United States Code, from the disposition of the United States share of petroleum or refined products, oil and gas products produced, including royalty products, and the net proceeds, if any, realized from exchanges within the Department of Defense or refined products accruing to the benefit of any of the military departments of the Department of Defense as the result of such exchanges, and (2) such funds as may be appropriated by the Congress for the Naval Petroleum Reserve Account, to remain available until expended. Funds transferred, credited, or appropriated to such fund shall be available for expenditure only to the extent provided from time to time in appropriation Acts.

EXPLANATION

SEC. 7. The Secretary of the Navy shall conduct programs of exploration for oil and gas on Naval Petroleum Reserves Numbered 1 and 4 in order to determine the extent of oil and gas resources therein. These programs shall be completed—

(1) within five years from the date of enactment of this joint resolution in the case of Naval Petroleum Reserve Numbered 1, and

(2) within ten years from the date of enactment

of this joint resolution in the case of Naval Petroleum Reserve Numbered 4.

The Secretary of the Navy shall make annual reports to the Committees on Armed Services of the Senate and the House of Representatives regarding the progress, results, and findings of these exploration programs, and shall include in such reports such recommendations as he deems appropriate regarding development, production, sale, exchange, transportation, or storage of oil and/or natural gas found to exist on the naval petroleum reserves.

APPROPRIATIONS

SEC. 8. (a) For the exploration of Naval Petroleum Reserve Numbered 4, as required by this joint resolution, there is authorized to be appropriated to the Secretary of the Navy the sum of $24,000,000 for the fiscal year ending June 30, 1975, and $44,000,000 for the fiscal year ending June 30, 1976, to remain available until expended.

(b) For the production of Naval Petroleum Reserve Numbered 1, as required by this joint resolution, there is hereby authorized to be appropriated to the Secretary of the Navy the sum of $15,500,000 for the fiscal year ending June 30, 1975, and the sum of $12,000,000 for the fiscal year ending June 30, 1976. Funds appropriated under this subsection shall remain available until expended.

(c) For the exploration of Naval Petroleum Reserve

Numbered 1, as required by this joint resolution, there are authorized to be appropriated to the Secretary of the Navy from the Naval Petroleum Reserve Account established by this joint resolution such sums as are necessary to achieve the purposes of this joint resolution for the fiscal year ending June 30, 1975, and for the three succeeding fiscal years.

(d) For the exploration of Naval Petroleum Reserve Numbered 4, as required by this joint resolution, there are authorized to be appropriated to the Secretary of the Navy from the Naval Petroleum Reserve Account established by this joint resolution such additional sums as are necessary to achieve the purposes of this joint resolution for the fiscal year ending June 30, 1975, and for the nine succeeding fiscal years.

REPORTS

SEC. 9. (a) Within thirty days following the date of the enactment of this joint resolution, the Attorney General shall prepare and submit to the Committees on Armed Services of the Senate and the House of Representatives a report describing the rights, duties, and obligations of the United States and any other party or parties having any contractual or other interests in Naval Petroleum Reserve Numbered 1.

(b) Within thirty days following the date of the enactment of this joint resolution, the Administrator of the Fed-

eral Energy Administration shall prepare and submit to the Committees on Armed Services of the Senate and the House of Representatives a report on the estimated costs of production and methods of avoiding excess profits as a result of such production authorized by this joint resolution.

(c) Notwithstanding any other provision of this joint resolution, no funds appropriated pursuant to section 8 for production on Naval Petroleum Reserve Numbered 1 may be expended and no authority contained in sections 4 and 5 may be exercised until after the expiration of the fifteen-day period following the date of the submission of the last of such reports required by subsections (a) and (b) of this section.

DEFINITION

SEC. 10. As used in this joint resolution the term "petroleum" means petroleum, crude oil, and associated gas and other hydrocarbons.

SEPARABILITY

SEC. 11. If any provision of this joint resolution or the applicability thereof is held invalid, the remainder of this joint resolution shall not be affected thereby.

LOW SULFUR OIL

SEC. 12. Insofar as practicable, low sulfur oil produced pursuant to this joint resolution in Naval Petroleum Reserve Numbered 1 shall be made available to areas to meet the requirements of the Clean Air Act.

94TH CONGRESS
1ST SESSION

# S. J. RES. 13

IN THE SENATE OF THE UNITED STATES

JANUARY 23, 1975

Mr. ROBERT C. BYRD (for Mr. CANNON) introduced the following joint resolution; which was read twice and referred to the Committee on Armed Services

# JOINT RESOLUTION

Authorizing increased production of petroleum from the Elk Hills Naval Petroleum Reserve for national defense purposes.

Whereas chapter 641 of title 10, United States Code, directs the Secretary of the Navy, among other things, to use and operate all properties within the naval petroleum reserves as are or may become subject to the control and use by the United States for production of petroleum whenever and to the extent the Secretary, with the approval of the President, finds such production required for the national defense, and whenever such production is authorized by a joint resolution of the Congress; and

Whereas such a finding of the necessity for such production to the extent herein authorized has been made by the Secretary of the Navy in his action dated November 6, 1973,

which finding has been approved by the President: Now, therefore, be it

*Resolved by the Senate and House of Representatives of the United States of America in Congress assembled,* That the production of petroleum (including crude oil and associated gas and other hydrocarbons) from Naval Petroleum Reserve Numbered 1 is hereby authorized at a rate to help insure that the needs of national defense are met, but not to exceed the maximum efficient rate in accordance with sound engineering and economic principles. Such production (to the extent in excess of that otherwise authorized by chapter 641 of title 10, United States Code) is to commence within forty-five days after the date of enactment of this joint resolution.

DISPOSITION OF PRODUCTION

SEC. 2. The Secretary of the Navy shall dispose of the production herein authorized as provided in chapter 641 of title 10, United States Code, by means of sales, uses, or exchanges effected, determined, or agreed upon after the date of enactment of this joint resolution. As required by said United States Code, all sales shall be effected by competitive bid. The terms of the disposition shall be so arranged as to give full and equal opportunity for acquisition of the oil by all interested companies, including major and independent oil refineries alike.

DISPOSITION OF RECEIPTS

SEC. 3. (a) There is hereby established on the books of the Treasury Department the Naval Petroleum Reserve Account. This account shall be administered by the Secretary of the Navy under such regulations as the Secretary of Defense may prescribe. Into such account there shall be transferred or credited during the period of increased production authorized by this joint resolution or as may be hereafter authorized (1) unobligated balances of appropriations made available to the Department of the Navy for fiscal year 1975 for exploration, prospecting, conservation, development, use, and operation of the naval petroleum and oil shale reserves, (2) all proceeds realized under chapter 641 of title 10, United States Code, from the sale of petroleum or refined products, oil and gas products, including royalty products, (3) the net proceeds realized from sales within the Department of Defense of refined petroleum products accruing to the benefit of the Department of Defense as the result of exchanges, and (4) such funds as may be appropriated for the Naval Petroleum Reserve Account. All funds transferred or credited to such account shall remain available until expended.

(b) Funds available in the Naval Petroleum Reserve Account shall be available for the expenses of (1) production, including preparation for production, as authorized

by this joint resolution and as may hereafter be authorized, (2) all capital costs necessary for facilities both within and outside the reserve incident to production and delivery of crude petroleum, and (3) exploration, prospecting, conservation, development, use, and operation of the naval petroleum and oil shale reserves as authorized by chapter 641 of title 10, United States Code.

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