A PRELIMINARY EVALUATION OF THE GREEN RIVER PROSPECT

For Confidential Client

By

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Preliminary Evaluation

of the

GREEN RIVER PROSPECT

HISTORY OF PROSPECT AREA

Uranium was discovered about 12 miles south of the small town of Green River, Utah in 1880. Oxidized radium ore, averaging 3% U_3O_8, was hand sorted from various surface exposures and sent to Europe for processing. Expanded production of uranium ore began in 1948 from the Wedding Bell Mine, the U.P. Shaft and other mines. Production continues sporadically to the present day. (See Figure 1)

The prospect lies within the Green River Uranium District which includes the Green River Desert - Orange Cliffs area as far south as the Fremont River, and also the area between the Green and Colorado Rivers south of the highly uraniferous Salt Valley anticline and Book Cliffs. (See Figure 2) Formations range in age from Pennsylvanian to Cretaceous and outcrop in steplike fashion above the deeply entrenched major rivers. The exposed sedimentary section is about 4000 feet thick.

The District lies in a shallow syncline which plunges gently north and into the Uinta Basin. The District borders the also highly uraniferous San Rafael District where shallow dips of about 2 degrees steepen to about 15 degrees. (See Figure 3)

GEOLOGY OF PROSPECT AREA

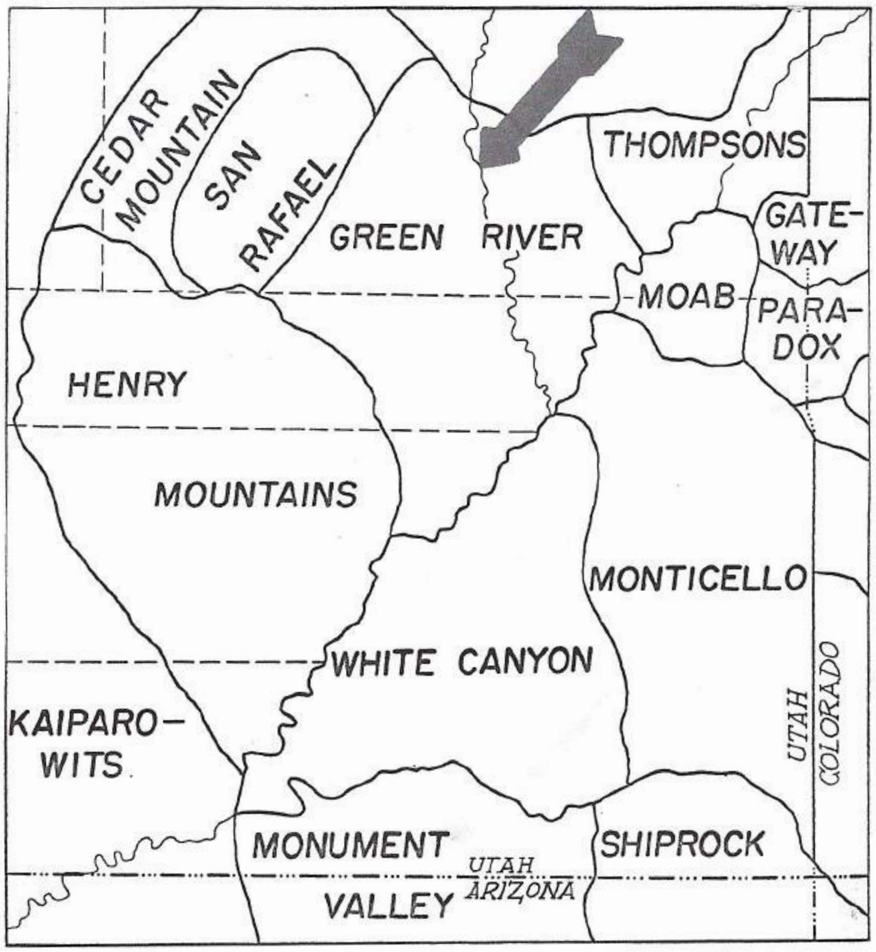
Uranium deposits of the District are in the Chinle formation and the Morrison formation, Upper Triassic and Upper Jurassic respectively. The most important deposits are relatively small and are clustered in the famous Salt Wash member of the Morrison formation on the flanks of the San Rafael swell about 12 miles west of Green River, Utah, (See Figure 4) and are mainly in

Figure 1

STATISTICS ON SIZE AND NUMBER OF URANIUM DEPOSITS - JANUARY 1, 1968

State	Area	Total Number Deposits	Total Production + Reserves Tons Ore	Maximum Size Deposit Production + Reserves Tons Ore *
Wyoming	Gas Hills	66	19,600,000	7,000,000
	Shirley Basin	22	14,400,000	3,500,000
	Crooks Gap	13	2,810,000	500,000
	Powder River Basin	104	702,000	200,000
New Mexico	Ambrosia Lake	67	28,100,000	4,750,000
	Todilto Limestone	39	1,210,000	250,000
Colorado	Uravan Mineral Belt	1,263	13,000,000	600,000
	Maybell-Baggs	25	1,840,000	500,000
	Tallahassee Creek	22	110,000	18,000
Utah	Big Indian Wash	61	9,450,000	1,500,000
	White Canyon	126	1,850,000	600,000
	Green River	153	720,000	120,000
	Henry Mtns.	180	64,000	10,000
	San Rafael	115	650,000	160,000
	Marysvale	23	410,000	225,000
	Thompsons	91	120,000	15,000
Arizona	Shiprock	119	910,000	300,000
	Little Colorado	135	310,000	40,000
	Globe	17	26,000	10,000
	Monument Valley	54	1,390,000	750,000
Dakotas	Black Hills	141	1,350,000	500,000
	Lignites	81	560,000	40,000

*Data as of January 1, 1968



Uranium mining districts of southeastern Utah.

Figure 3

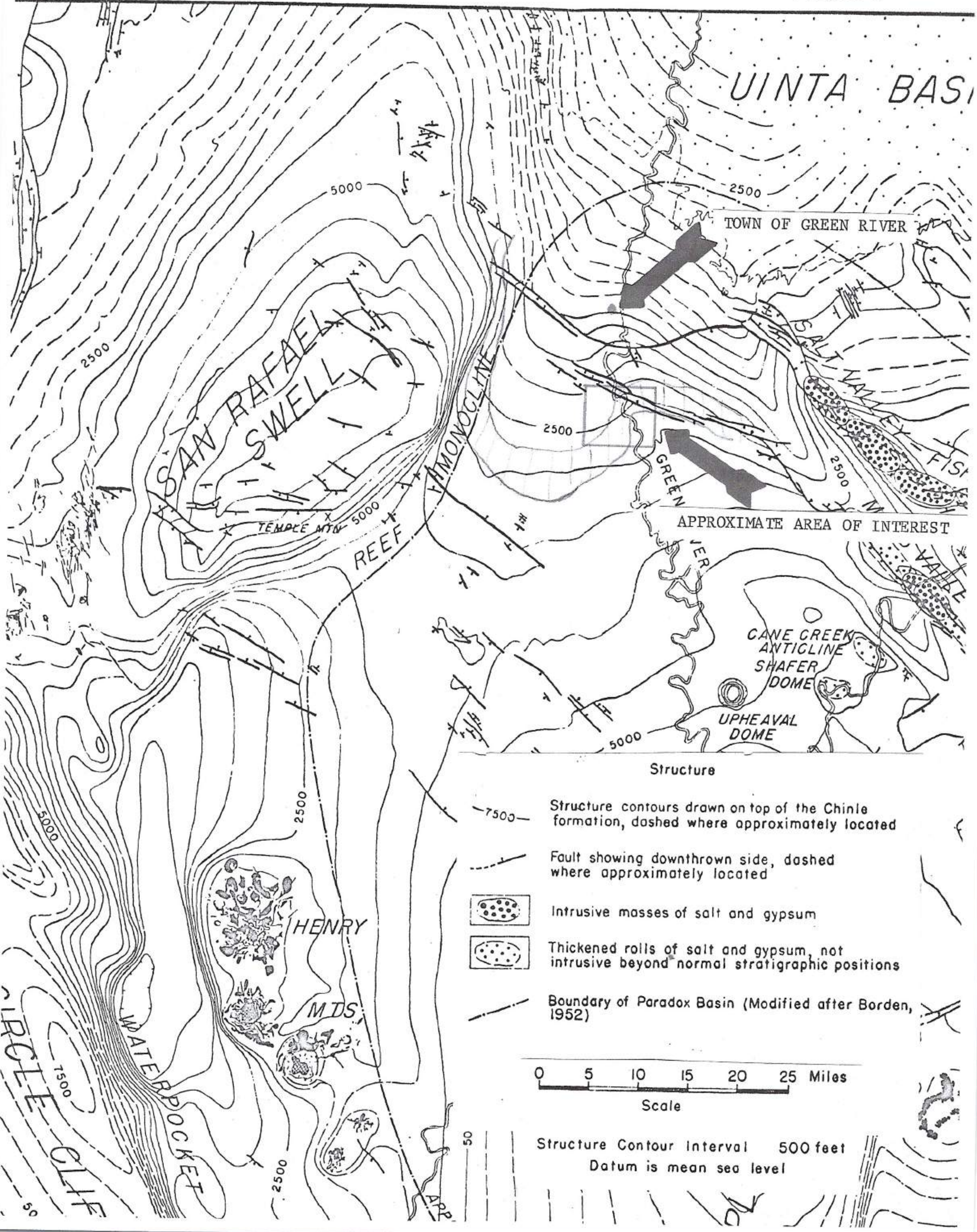
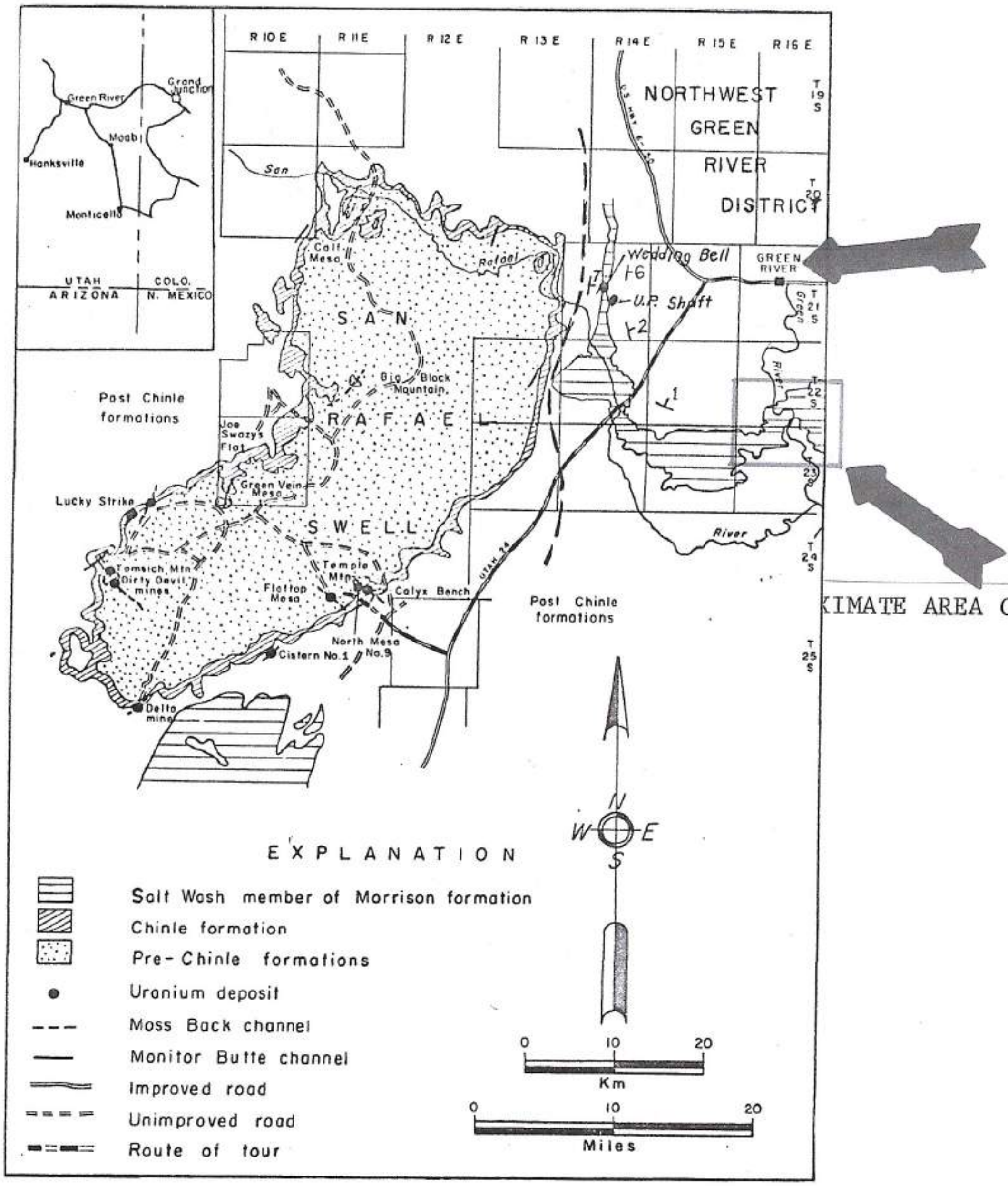

UINTA BAS
TOWN OF GREEN RIVER
APPROXIMATE AREA OF INTEREST
SAN RAFAEL SWELL
TEMPLE MTN
REEF
MONOCLINE
GREEN
SALT VALLEY
CANE CREEK ANTICLINE
SHAFER DOME
UPHEAVAL DOME
HENRY
MTS
WATERPOCKET
CIRCLE CLIFF
5000
2500
7500
Structure
Structure contours drawn on top of the Chinle formation, dashed where approximately located
Fault showing downthrown side, dashed where approximately located
Intrusive masses of salt and gypsum
Thickened rolls of salt and gypsum, not intrusive beyond normal stratigraphic positions
Boundary of Paradox Basin (Modified after Borden, 1952)
0 5 10 15 20 25 Miles
Scale
Structure Contour Interval 500 feet
Datum is mean sea level

Figure 4



XIMATE AREA OF INTEREST

a narrow belt along the western margin of the broad, north plunging syncline previously mentioned. Tabular ore bodies ranging up to 5,000 tons are generally concordant with bedding and occur in the upper third of the Salt Wash member. The ore is in a conglomeratic sandstone unit, 40 to 70 feet thick. There is a distinct northeastward trend to the sand lenses and ore bodies of the Wedding Bell and U.P. Shaft Mines. Drilling along this trend starting from surface ore bodies (oxidized) has been successful in making new discoveries. For example, Four Corners Uranium Corporation has drilled several hundred thousand feet in their areas under lease prior to 1968. The extent of their leases are unknown at this date. A few "small" deposits have been reported in the Salt Wash exposures south and southeast of the mines mentioned above, which places uranium mineralization very near the prospect area.

Triassic rocks contain many small uranium deposits in the San Rafael swell, a few miles west of Green River, Utah. This mineralization is associated with channels cut into the Moenkopi formation which is filled with conglomeratic sandstone of the Moss Back member of the Chinle formation. Unusal quantities of trace elements and rare earths are found in association with uranium in the Triassic of the area; as much as 3% neodymium and 1.5% europium is found in asphalt-like material...Reduction Bubble applicable?

Jurassic host rocks of the Salt Wash member (Morrison formation) consist of white to light brown lenses of fluvial conglomeratic sandstones. Coffinite is the most abundant uranium mineral, but uranite is also present. Most mines in the area west of Green River are relatively shallow and mined both oxidized and unoxidized ore. Production of the District is summarized in Figure 5. Early field mapping of the Salt Wash member records its general lithology as a pink (oxidized?) or gray (unoxidized?) sandstone interbedded with red or green mudstone. Ore minerals are closely associated with carbonaceous material consisting of plant residues and petroleum residues.

ORE PRODUCTION SUMMARY BY DISTRICTS TO END OF SECOND QUARTER—FISCAL YEAR 1967*

District	Tons of Ore	Contained U_3O_8	Av. Grade-% U_3O_8
Gateway	210,691	1,326,518	0.31
Green River	542,116	2,565,365	0.24
Gypsum Valley	8	63	0.41
Henry Mountains	56,837	457,523	0.40
Moab	99,884	598,039	0.30
Monticello	7,287,284	54,438,650	0.37
Monument Valley	81,675	480,128	0.29
Paradox	156,348	893,764	0.29
San Rafael	593,809	3,033,566	0.26
Shiprock	8,882	60,017	0.34
Thompsons	106,177	526,683	0.25
Uinta	580	1,958	0.17
White Canyon	1,680,105	8,439,065	0.25
Arizona	38	63	0.08
Salt Lake	445,179	1,883,093	0.21
Unnamed Districts	1,875	9,450	0.25
All Districts,	11,271,488	74,713,941	0.33

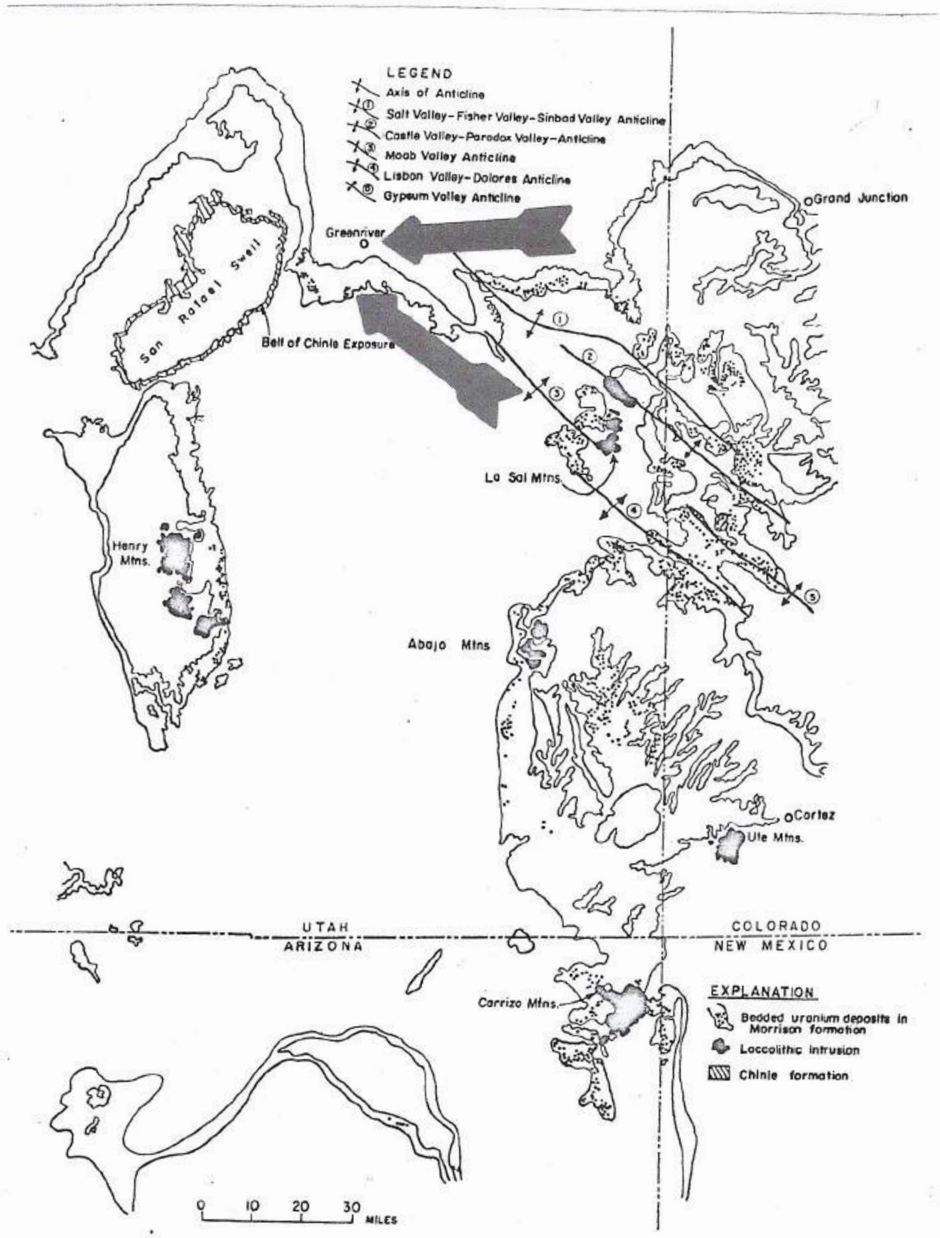
*Compiled by the Ore Reserves Branch, U.S. AEC, Grand Junction Office.

Morrison uranium deposits are however widespread in the four state area. (See Figure 6) Many are being mined, many can not be presently mined for a variety of reasons, e.g. poor ore grade; lack of adequate tonnages; isolated location causing transportation problems; apparently unsolvable ground water problems; ore grade material with serious contaminants causing metalurgical problems; lack of development money; decision to postpone mining until 72 or 73, or until market improves considerably; etc. An important feature of the ore of this area is its vanadium content, which is commonly either equal to or twice the uranium content of the ores. By-product of U.S. uranium production include vanadium, molybdenum and copper. Also, in subsequent processing rhenium may be separated from the molybdenum concentrate and silver from the copper concentrate. Some of the uranium ores from Arizona and southern Utah contain enough copper to make its recovery profitable.

Statigraphic distribution and relative importance of the various uranium deposits in southeastern Utah are shown in Figure 7. A generalized cross-section showing correlation of formations in southeastern Utah uranium region is shown in Figure 8.

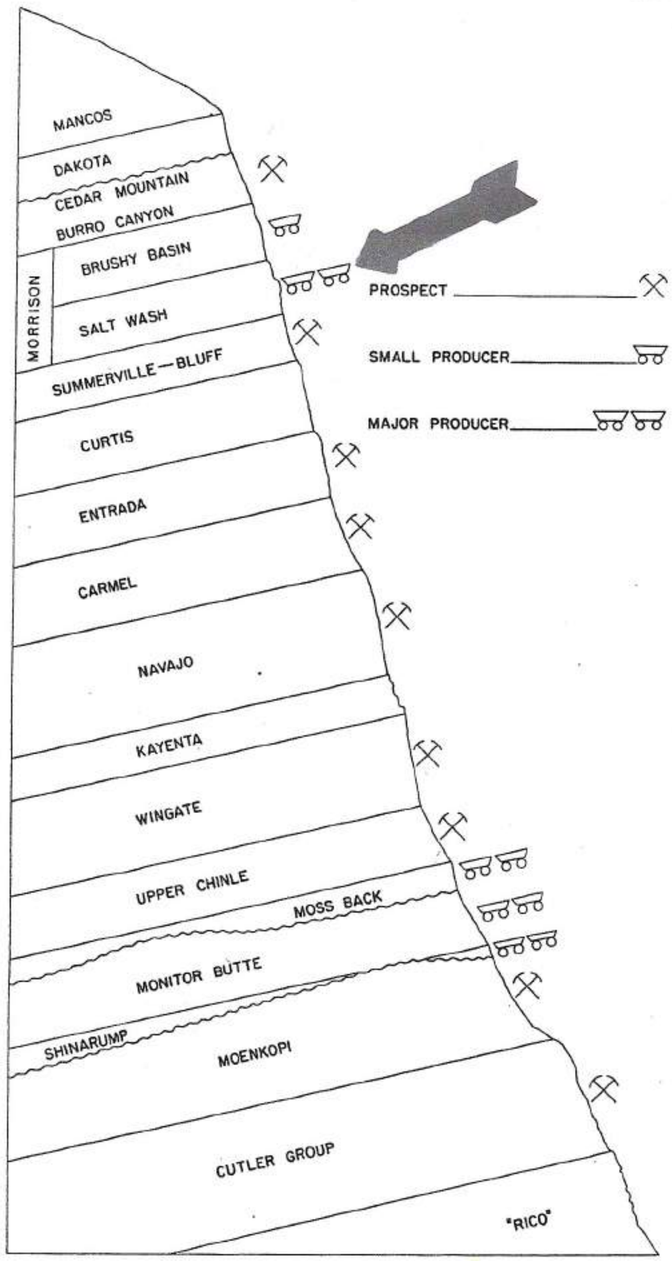
PRELIMINARY CONCLUSIONS FOR PROSPECT AREA

The question arises as to whether an ore body of minimum economic tonnages and grade could exist in the area 10 - 12 miles south of Green River, Utah at depths of 400 - 500 feet. Based on a preliminary evaluation of (1) the nature of the uranium deposits in the general area, (2) the possibility of favorable ground containing unoxidized ore extending into the prospect area from areas of existing mines, (3) the necessary lithologic criteria and structural environment of the prospect area, defined as well as possible at this stage of the evaluations and (4) the geographic location with respect to transportation to mills, I consider the area to be highly prospective uranium country, especially if the prospect area is very near known mineralization which could contain unoxidized ore. If the prospect has been drilled, all data,



Outcrop belts of Morrison formation showing general distribution of uranium deposits. Prepared by M. V. Anthony from information by U. S. Geological Survey.

Figure 7



Generalized stratigraphic section of formations exposed in southeastern Utah showing distribution and relative importance of the uranium deposits.

electric and geologic logs, should be examined in detail with respect to the alteration characteristics of the sediments and to the location of potentially unproductive oxidized ground and nearby potentially productive unoxidized or fresh ground. The alteration characteristics and relative location of such characteristics within a specific area are commonly difficult to establish without detailed examination of the electric logs and recovered samples. Most of the Morrison uranium deposits are genetically of the bedded paleostream type. Many have characteristics very similar, if not nearly identical, to the roll-type found in other states and other formations, and a knowledge of roll-type deposits is essential in order to understand the bedded paleostream type. To this end, see Figure 9 for a roll-front type general description of characteristics. The electric log can be very useful in determining whether a specific exploration hole is near a bedded paleostream channel, with potential uranium mineralization. If, for example, enticing shows, either expressed in an electric-gamma log or in sample chemical analysis, are known from the prospect, even near ore grade (.10 to .20% $_cU_3O_8$), this does not necessarily indicate proxcimity to an ore body. On the other hand, shows of .01 to .10% $_cU_3O_8$ from a sand-shale contact could well indicate an encouraging protore location (unaltered) or altered (oxidized) location. An unoxidized "ore body" is preferred over an oxidized "ore body" for the following reasons: (1) greater tonnages of more consistent grade can be expected, (2) oxidized ore contains uranium which is out of chemical balance in favor of radiometrics over chemical U_3O_8, (3) unoxidized ore, therefore, is either in direct balance 1:1 $_e$ versus $_c$ or contains greater chemical U_3O_8 than is indicated by the gamma producing daughter products, which suggests relatively young mineralization. Of course, an ore must contain maximum chemical U_3O_8 to assure economic mining without dangers of losing chemical U_3O_8 during the mining operations, which has happened in the early days of uranium mining.

I understand that the prospect is being offered by the Atlas Corporation. One of the obvious problems to consider is the caliber of exploration techniques they have within their geological staff. Many established uranium companies operate massive drilling programs on their leases without much detailed knowledge of sediment characteristics and find ore deposits only because of such massive exploration coverage. Atlas geologists should be questioned at depth to ascertain the level of their understanding of uranium exploration. By doing this and by noting the relative extent of exploration completed on the Green River prospect, some idea can be gained as to why they desire to "unload" this particular prospect. They may know, for example, that entirely fresh (unoxidized) ground with only minor, insignificant shows of uranium mineralization exist, or they may know the area is predominantly oxidized or altered ground with minor pockets of radiometric uranium. The latter is commonly excellent ground to "flog" because of its occasional high gamma or chemical values, especially to companies not too familiar with uranium exploration techniques.

If the prospect area has been sparsely drilled and the Atlas people are highly competent, then I would be quite skeptical of the possibilities of the area with the feeling that they are trying to "flog" the land they know is far from promising. If, on the other hand, Atlas are of the "massive drilling" type explorationists and the prospect has been sparsely drilled, and the logs and samples look good, then I would recommend taking up the prospect.

RECOMMENDATIONS

The present available information on the Green River Prospect suggest additional work is merited. The following procedures appear in order.

(1) Evaluation of Atlas Corporation uranium exploration competency.

(a) By direct contact

(b) Papers written by Atlas personnel

(c) Ex-Atlas personnel

(2) Evaluation of Atlas Corporation's financial position (sometimes difficult to access with any reliability)

- (a) Expansion without liquidation of assets
- (b) Expansion with liquidation of assets
- (c) Static
- (d) Other Atlas ventures which require capital

(3) Determination of land position in Green River Area

- (a) Tight and expensive land
- (b) Easy and inexpensive

(4) Evaluation of Mining and Exploration Activity in Green River Area

- (a) Type of activity and by whom
- (b) Type and amount of present drilling
- (c) Type and amount of present mining

(5) Evaluation of All Available Data from Atlas Corporation

- (a) Electric logs
- (b) Gamma logs
- (c) Lithologic logs
- (d) Samples
- (e) Sample analyses

(6) Determination of Ground Water Geochemistry Aspects*

- (a) Ground water sample from exploratory holes
- (b) Ground water sample from existing water wells

*<u>Note</u>: Will fill in later on details of use and implications

(7) Field Evaluation of Prospect Area and Nearby Areas

- (a) Up-dip outcrops
- (b) Atlas exploratory hole numbers and placements
- (c) Nearby mine inspection

(8) Final Report on Advisability of Acquiring Green River Prospect from Atlas Corporation

(a) Degree of favorability for future mining

(b) Degree of possibility for existence of economic ore

(c) Recommend exploration program

The above procedures could be completed within two-three weeks. All of the above, with the possible exception of (6), should be done in order to get a complete picture of the prospect. The relative worth of the prospect can be reasonably ascertained from the above procedures.

URANIUM MINING

The following charts and tables should aid in a preliminary understanding of uranium mining practices and costs.

Figure 10: (1) Distribution of Uranium Deposits by Depth of Ore

(2) Distribution of Uranium Deposits by Average Grade

Figure 11: Distribution of Uranium Deposit by Size

Figure 12: Uranium Mining Costs (Open Pit)

Figure 13: Uranium Mining Costs (Underground)

Figure 14: Median Estimate of Capital Consumption and Timing for Reaching and Sustaining a Production Capability of 500 Tons/Year U_3O_8 in Concentrates

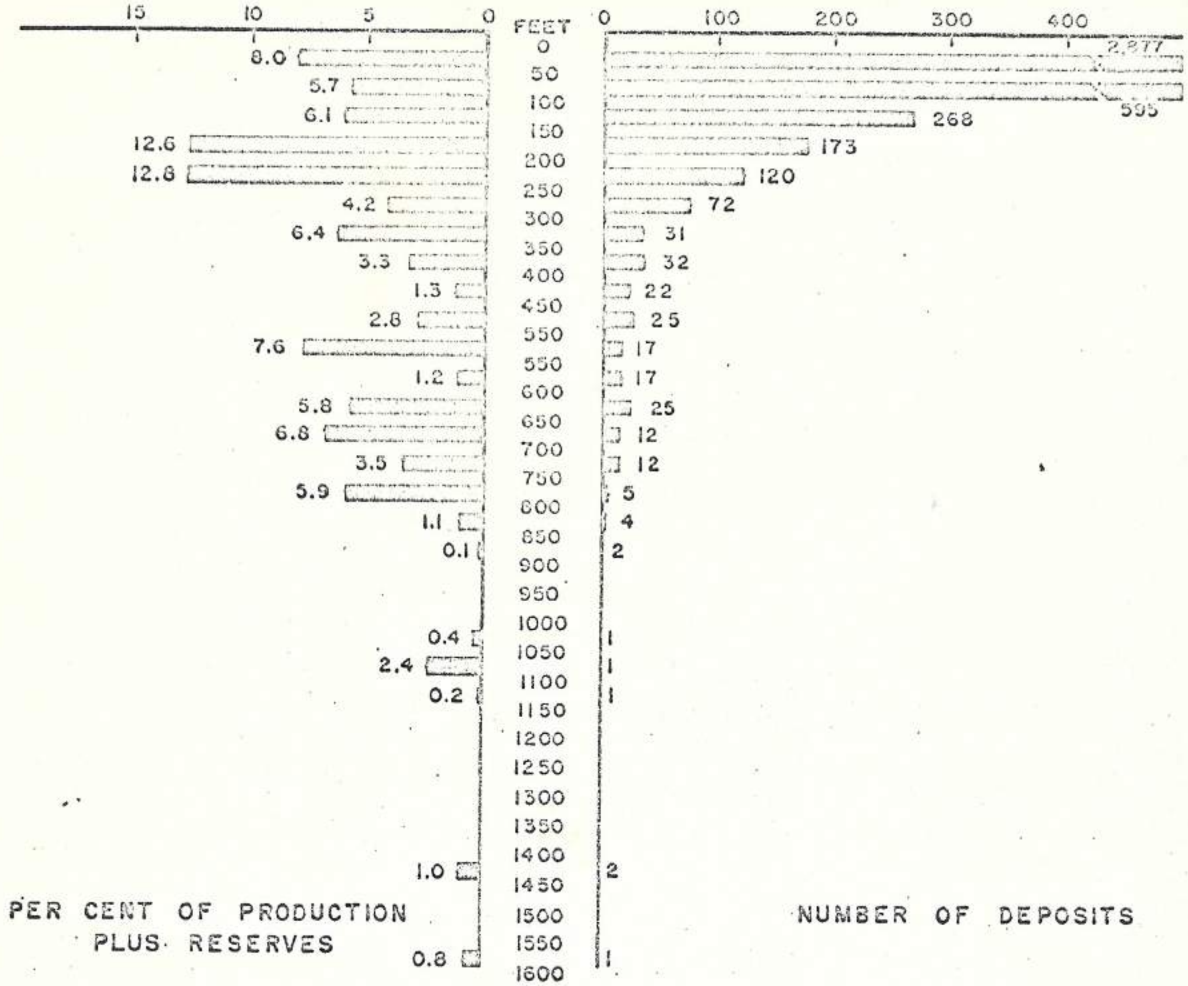
Figure 15: Rate of Capital Additions for Hypothetical 1,000,000 Pounds U_3O_8 per Year Operation.

Figure 16: Tabulations of Selected Underground Mines. Development Cost Per Ton U_3O_8.

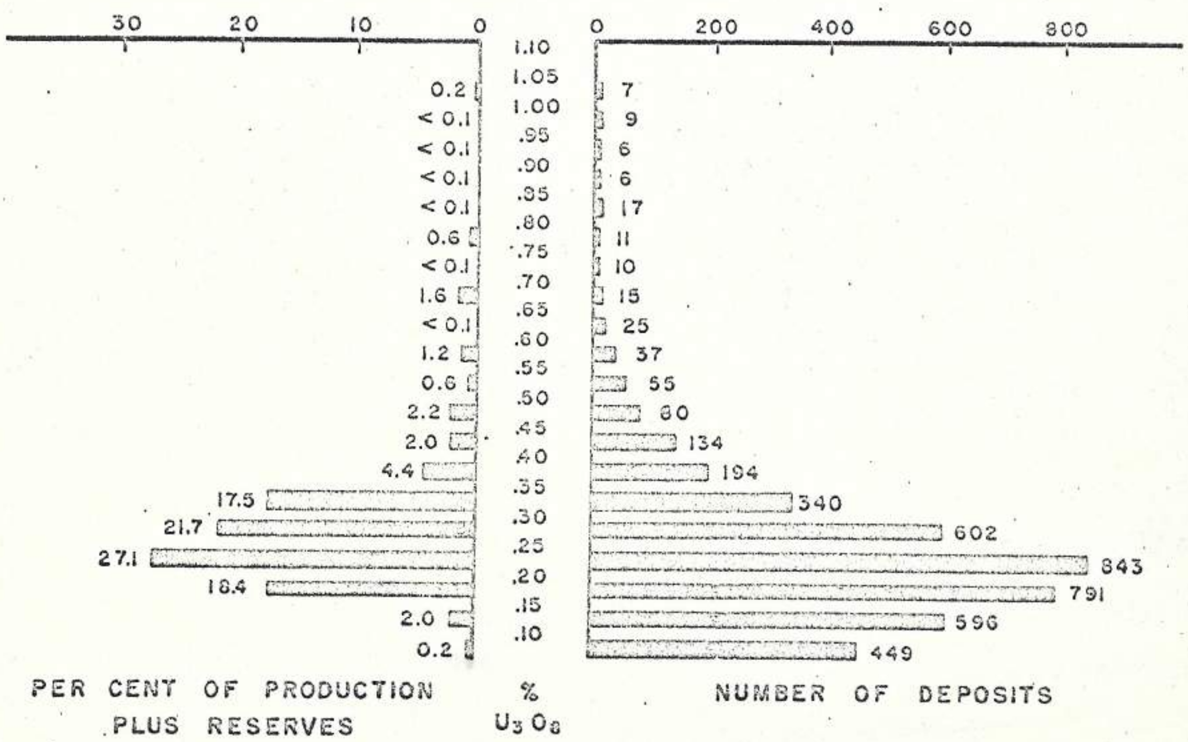
Figure 17: Mining Cost and Rate Calculations - Typical Costs. (Grants, N.M. Area: 5 Mines)

Figure 16 tabulations summarizes the primary development costs that were incurred at selected underground mines in the Grants area of New Mexico, the Big Indian area of Utah (30 miles southeast of Moab, Utah) and various areas of Wyoming. The tabulations were made on the following bases: Three underground mines in each of the above areas, represent the most difficult

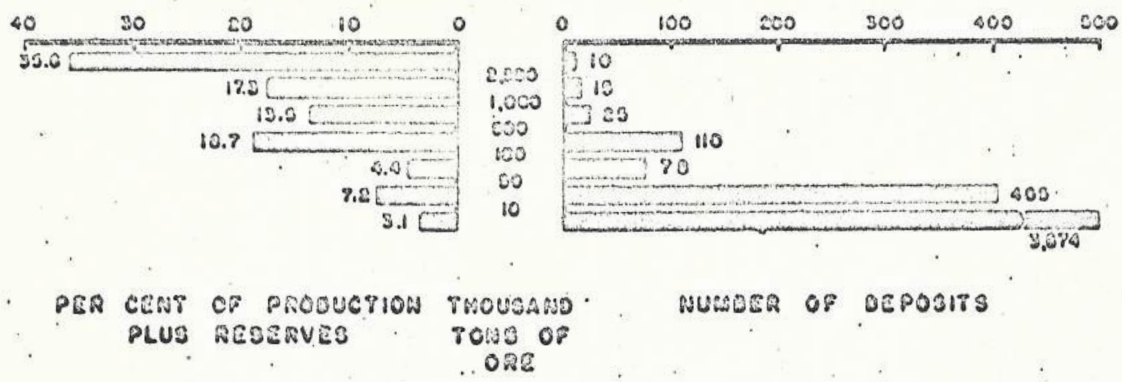
Figure 10



DISTRIBUTION OF URANIUM DEPOSITS BY DEPTH OF ORE 1/1/66



DISTRIBUTION OF URANIUM DEPOSITS BY AVERAGE GRADE 1/1/66



DISTRIBUTION OF URANIUM DEPOSITS BY SIZE

DISTRIBUTION OF URANIUM DEPOSITS BY SIZE

No. of Mines	Size	Thousands of Tons of Ore	Percent
10	Greater than 2,500,000	44,285	35.8
15	1,000,000 - 2,500,000	21,445	17.3
25	500,000 - 1,000,000	16,690	13.5
110	100,000 - 500,000	23,200	18.7
78	50,000 - 100,000	5,395	4.4
405	10,000 - 50,000	8,910	7.2
3,674	1 - 10,000	3,890	3.1
4,317		123,815	100.0

Uranium Mining Costs

Open Pit

	Range	Average
Stripping		
Soft Sediments	\$0.19 to \$0.30/Yd.	\$0.25/Yd.
Hard Sediments	\$0.30 to \$0.50/Yd.	\$0.35/Yd.
Mining		
Soft Sediments	\$1.50 to \$3.00/Ton	\$2.50/Ton
Hard Sediments	\$3.00 to \$4.50/Ton	\$4.00/Ton

Stripping costs include depreciation of equipment of approximately \$0.03 per yard. Mining costs include labor, supplies, maintenance, supervision, insurance, taxes such as production taxes and payroll taxes, and administrative charges at the mine. Haulage costs of approximately \$0.04 per ton mile from mine stockpiles to the mill and offsite charges are not included.

Figure 13

Uranium Mining Costs

Underground

	Range	Average
Surface Plant	$150,000 - $800,000	$600,000
Equipment	$0.20 - $0.40/Ton	$0.25/Ton
Shafts:		
Rectangular	$300 - $700/Ft.	$450/Ft.
Circular Concrete	$500 - $800/Ft.	$600/Ft.
Drilled	$720 - $950	
Shaft Stations		$0.55 Cu. Yd.
Drifting (Tracked)		
Wet	$50 - $90/Ft.	$60/Ft.
Dry	$40 - $60/Ft.	$50/Ft.
Raising	$30 - $60/Ft.	
Operating		
Dry Room and Pillar (On Level)	$4.50 - $7.00/Ton	$6.00/Ton
Wet Room and Pillar (Sub-Ore Haulage)	$7.50 - $13.00/Ton	$9.50/Ton (up to $10.00)
Long Wall Retreat	$8.00 - $13.00/Ton	$11.00/Ton

Operating costs include labor, supplies, maintenance, supervision, engineering, insurance, taxes, and administrative charges at the mine.

MEDIAN ESTIMATE OF CAPITAL CONSUMPTION AND TIMING FOR REACHING AND SUSTAINING A PRODUCTION CAPABILITY OF 500 TONS/YR. U_3O_8 IN CONCENTRATES. THOUSANDS OF DOLLARS.

	Time in Years											
	1	2	3	4	5	6	7	8	9	10	11	12
Major Activities												
Exploration and Acquisition	150	300	450	600 1/	50	50	100	150	250	300	300	300
		1,500 or 30¢/lb. U_3O_8 in reserves										
Development Drilling					500	250	50	100	150	150	150	150
					750 or 15¢/lb. U_3O_8 in reserves							
Mine Planning, Development & Equipment					350 2/	1,150	3,000	50	150	300	300	300
					4,500	or 9/annual	ton U_3O_8					
Process Planning, Design, Construction and Startup					150 6/	1,350 3/	3,500 4/ 5/	50 7/	100	150	200	250
					5,000	or 10/annual	ton U_3O_8					
Total By Years	150	300	450	600	1,050	2,800	6,650	350	650	900	950	1,000
Total Cumulative	150	450	900	1,500	2,550	5,350	12,000	12,350	13,000	13,900	14,850	15,850
Cumulative Interest on Pre-production Investment @6% compounded							1,450					
Total Pre-Production Investment and Interest							13,450					
Operating Capital Employment Estimate						250	1,200	1,600				
Investment excluding Exploration Cost							10,250	= 20 per annual ton U_3O_8 production capability				

Footnotes indicating approximate critical dates:

1/ Decision to Develop for Production.
2/ Mine Development Contracting.
3/ Plant Design and Construction Contracting.
4/ Plant Startup and Ore Stockpiling.
5/ Start of Full-Scale Production.
6/ Execute Contracts for Future Delivery of Product.
7/ Start Product Deliveries

Figure 14

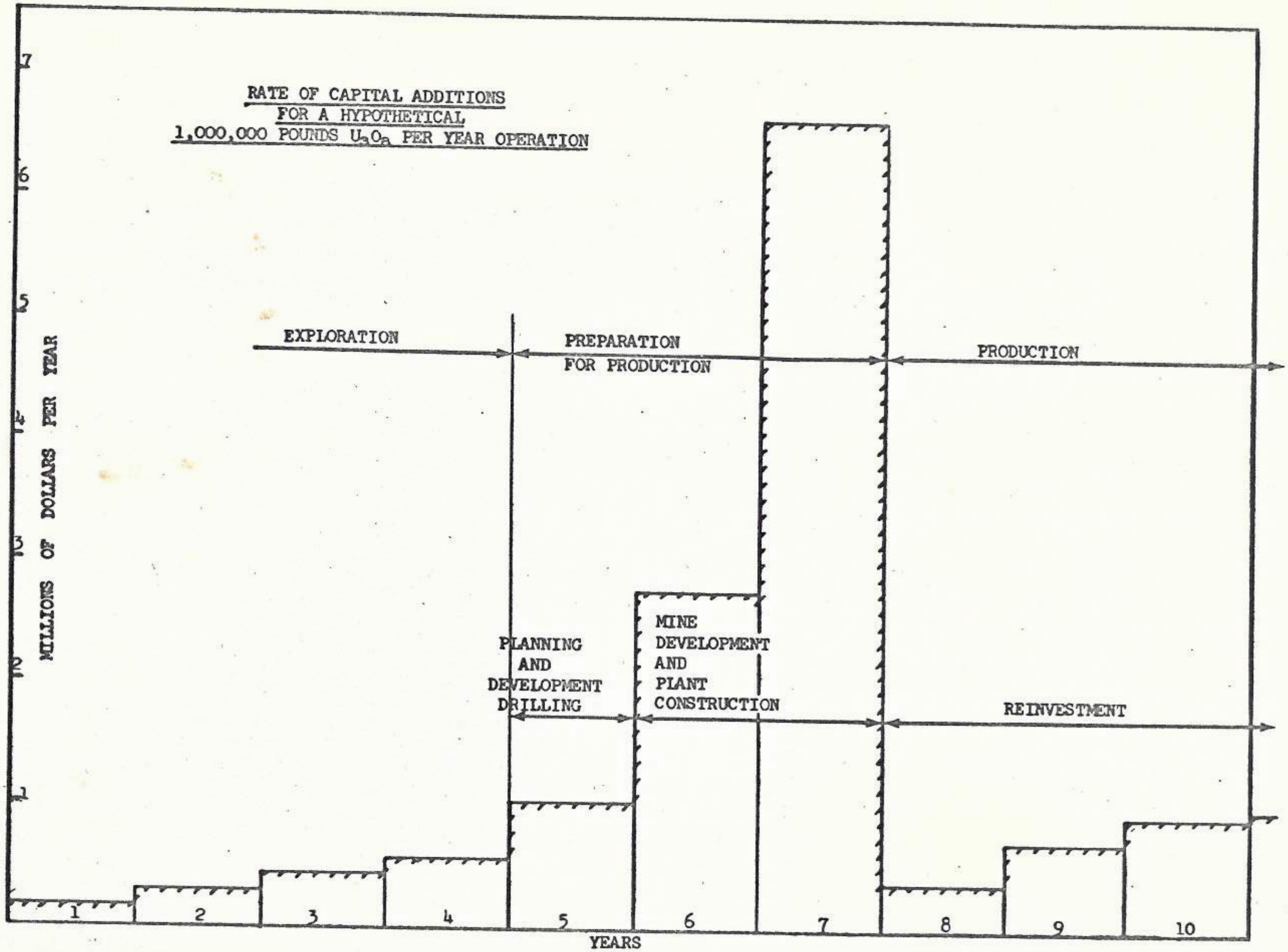

RATE OF CAPITAL ADDITIONS
FOR A HYPOTHETICAL
1,000,000 POUNDS U_3O_8 PER YEAR OPERATION
MILLIONS OF DOLLARS PER YEAR
1
2
3
4
5
6
7
EXPLORATION
PREPARATION FOR PRODUCTION
PRODUCTION
PLANNING AND DEVELOPMENT DRILLING
MINE DEVELOPMENT AND PLANT CONSTRUCTION
REINVESTMENT
1
2
3
4
5
6
7
8
9
10
YEARS

Figure 15

Tabulations of Selective Underground Mines

Development Cost/Per Ton U_3O_8

Development Cost ($/# U_3O_8)

(1) TONS PER DAY	1960 150		1955 ($/# U_3O_8) 200		1957 200	
DEVELOPMENT DRILLING (Pre-Production) (Exploration)						
Development Footage Drilled		90,000'		57,000'		119,000'
Development Drilling Cost		$0.01 (*)		$0.03		$0.16
MINE DEVELOPMENT (Pre-Production)						
Timing (Shaft Collaring-Sustained Prod.)		29 Months		11 Months		8 Months
Surface Plant & Equipment	56% =	$0.05	17% =	$0.01	29% =	$0.05
Shaft (Production)	11% =	0.01	33% =	0.02	*24% =	0.04
Shaft (Ventilation)	11% =	0.01	Nil	Nil	Nil	Nil
Shaft Station	Nil (< ½%)	Nil	Nil	Nil	See (*) above	
Shaft Pocket & Sump	Nil	Nil	Nil	Nil	See (*) above	
Drifts, Crosscuts, Raises, etc.	11% =	0.01	17% =	0.01	35% =	0.06
Underground Equipment	11% =	0.01	33% =	0.01	12% =	0.02
(2) Mine Development Cost	100% =	$0.09	100% =	$0.06	100% =	$0.17
COST SUMMATION		$0.10		$0.09		$0.33
(*) ← Cost per pound of yellow cake in place						
Development Conditions						
(3)#U_3O_8 (Reserves & Production) (1/1/64)		16,000,000		7,200,000		2,700,000
Dev. Cost Per Daily Ton of Production Capacity (2x3 ÷ 1)		$9,600		$2,160		$2,295
Dev. Cost Per Ton (Excluding Drilling)		$1.02/Ton		$0.79/Ton		$2.31/Ton
Shaft Depth		350'		700'		600'
Shaft Configuration		13' Diameter		Rectangular		Rectangular
Number Of Compartments		2½		3		2½
Number Of Development Levels		1		1		3
Water Inflow During Sinking (*)		3000 GPM Max.		Nil		Nil
Shaft Lining Or Set Type		Concrete		Timber		Timber
Water Control (Shaft) Required		None		None		None
Ground Control (Stopes) Required		Square Sets & Spiling		Nil		Pillars
Development Relative To Ore Zone		Below Ore		Below Ore		On Ore
Mainline Haulage Type		Tracked		Tracked		Tracked
General Orebody Configuration		Bedded Roll-Front		Bedded Paleochannel		Bedded Paleochannel
Number Of Ore Horizons		Multiple		Single		Multiple
Ore Thickness Range--Min.-Max. (Avg.)		5'-30' (7')		2'-9' (5½')		4'-12' (8')

Development Cost ($/# U_3O_8)

	1958		1959		1960	
(1)			$/# U_3O_8			
TONS PER DAY	1000		1000		1000	
DEVELOPMENT DRILLING (Pre-Production)						
Development Footage Drilled		510,000'		510,000'		121,500'
Development Drilling Cost		$0.05		$0.03		$0.09
MINE DEVELOPMENT (Pre-Production)						
Timing (Shaft Collaring-Sustained Prod.)		33 Months		35 Months		-
Surface Plant & Equipment	33% =	$0.05	26% =	$0.05	12% =	$0.07
Shaft (Production)	20% =	0.03	22% =	0.04	38% =	0.21
Shaft (Ventilation)	7% =	0.01	Nil	Nil	-	-
Shaft Station	7% =	0.01	* 5% =	0.01	* 3% =	0.02
Shaft Pocket & Sump	7% =	0.01	See (*)	above	See (*)	above
Drifts, Crosscuts, Raises, etc.	13% =	0.02	21% =	0.04	29% =	0.16
Underground Equipment	13% =	0.02	26% =	0.05	18% =	0.10
(2) Mine Development Cost	100% =	$0.15	100% =	$0.19	100% =	$0.56
COST SUMMATION		$0.20		$0.22		$0.65

	1958	1959	1960
Development Conditions			
(3)# U_3O_8 (Reserves & Production) (1/1/64)	12,200,000	20,000,000	1,200,000
Dev. Cost Per Daily Ton Of Production Capacity (2x3 ÷ 1)	$1,830	$3,800	$672
Dev. Cost Per Ton (Excluding Drilling)	$0.66/Ton	$1.05/Ton	$2.90/Ton
Shaft Depth	850'	850'	800'
Shaft Configuration	Rectangular	Rectangular	Rectangular
Number Of Compartments	3	5	3
Number Of Development Levels	3	3	5
Water Inflow During Sinking	150 GPM Max.	200 GPM Max.	30 GPM Max.
Shaft Lining Or Set Type	Timber	Timber	Timber
Water Control (Shaft) Required	None	Grouting	None
Ground Control (Stopes) Required	Pillars	Nil	Sand Fill
Development Relative To Ore Zone	On Ore	On Ore	Below Ore
Mainline Haulage Type	Trackless	Trackless	Tracked
General Orebody Configuration	Bedded Stack	Bedded Paleochannel	Bedded Roll-Front
Number Of Ore Horizons	Multiple	Multiple	Multiple
Ore Thickness Range--Min.-Max. (Avg.)	6'-79' (10')	6'-54' (7')	6'-60' (13')

Development Cost ($/# U_3O_8)

	1955		1963		1959	
			$/# U_3O_8			
(1) TONS PER DAY	300		300		400	
DEVELOPMENT DRILLING (Pre-Production)						
Development Footage Drilled		60,000'		200,000'		-
Development Drilling Cost		$0.03		$0.21		$0.07
MINE DEVELOPMENT (Pre-Production)						
Timing (Shaft Collaring-Sustained Prod.)		12 Months		34 Months		10 Months
Surface Plant & Equipment	26% =	$0.05	28% =	$0.27	31% =	$0.07
Shaft (Production)	16% =	0.03	17% =	0.16	*34% =	0.10
Shaft (Ventilation)	5% =	0.01	2% =	0.02	Nil	Nil
Shaft Station	5% =	0.01	* 4% =	0.04	See (*)	above
Shaft Pocket & Sump	Nil	Nil	See (*)	above	See (*)	above
Drifts, Crosscuts, Raises, etc.	11% =	0.02	38% =	0.37	14% =	0.04
Underground Equipment	37% =	0.07	11% =	0.11	21% =	0.06
(2) Mine Development Cost	100% =	$0.19	100% =	$0.97	100% =	$0.29
COST SUMMATION		$0.22		$1.18		$0.36

Development Conditions	1955	1963	1959
(3)# U_3O_8 (Reserves & Production) (1/1/64)	3,250,000	940,000	678,000
Dev. Cost Per Daily Ton Of Production Capacity (2x3 ÷ 1)	$2,060	$3,040	$491
Dev. Cost Per Ton (Excluding Drilling)	$1.52/Ton	$4.65/Ton	$1.51/Ton
Shaft Depth	600'	500'	300'
Shaft Configuration	Rectangular	7½' Diameter	Rectangular
Number Of Compartments	3	1	2
Number Of Development Levels	1	1	1
Water Inflow During Sinking	Nil	200 GPM Max.	Nil
Shaft Lining Or Set Type	Timber	Concrete	Timber
Water Control (Shaft) Required	None	Grouting	None
Ground Control (Stopes) Required	Nil	Square Sets	Pillars
Development Relative To Ore Zone	On and Below	Below Ore	Below Ore
Mainline Haulage Type	Tracked	Tracked	Tracked
General Orebody Configuration	Bedded Paleochannel	Bedded Roll-Front	Bedded Paleochannel
Number Of Ore Horizons	Single	Single	Multiple
Ore Thickness Range--Min.-Max. (Avg.)	6'-8' (6½')	5'-26' (9')	3'-9½' (7½')

Development Cost ($/# U_3O_8)

	1957	1950	1960
(1)		$/# U_3O_8	
TONS PER DAY	200	200	250
DEVELOPMENT DRILLING (Pre-Production)			
Development Footage Drilled	82,000'	146,000'	115,000'
Development Drilling Cost	$0.15	$0.06	$0.03
MINE DEVELOPMENT (Pre-Production)			
Timing (Shaft Collaring-Sustained Prod.)	20 Months	18 Months	-
Surface Plant & Equipment	22% = $0.06	19% = $0.10	18% = $0.02
Shaft (Production)	15% = 0.04	12% = 0.06	None
Shaft (Ventilation)	Nil Nil	Nil Nil	10% = 0.01
Shaft Station	See (*) below	*31% = 0.17	None
Shaft Pocket & Sump	See (*) below	See (*) above	None
Drifts, Crosscuts, Raises, etc.	*41% = 0.11	31% = 0.17	27% = 0.03
Underground Equipment	22% = 0.06	7% = 0.04	27% = 0.03
(2) Mine Development Cost	100% = $0.27	100% = $0.54	100% = $0.11
COST SUMMATION	$0.42	$0.60	$0.14

Development Conditions			
(3)#U_3O_8 (Reserves & Production) (1/1/64)	2,500,000	2,300,000	3,500,000
Dev. Cost Per Daily Ton of Production Capacity (2x3 ÷ 1)	$3,375	$6,210	$1,540
Dev. Cost Per Ton (Excluding Drilling)	$0.96/Ton	$2.10/Ton	$0.65/Ton
Shaft Depth	500'	450'	(Adit)
Shaft Configuration	Rectangular	Rectangular	None
Number Of Compartments	2½	3	None
Number Of Development Levels	1	2	1
Water Inflow During Sinking	Nil	30 GPM Max.	Nil
Shaft Lining Or Set Type	Timber	Timber	None
Water Control (Shaft) Required	None	None	None
Ground Control (Stopes) Required	Nil	Pillars	Pillars
Development Relative To Ore Zone	On and Below	Below Ore	Below Ore
Mainline Haulage Type	Tracked	Tracked	Tracked
General Orebody Configuration	Bedded Paleochannel	Bedded Roll-Front	Bedded Roll-Front
Number Of Ore Horizons	Single	Multiple	Multiple
Ore Thickness Range--Min.-Max. (Avg.)	4½'-10' (6')	5'-34' (7')	5'-60' (9½')

Development Cost ($/# U_3O_8)

	1960	1958	1959
		$/# U_3O_8	
(1) TONS PER DAY	400	600	800
DEVELOPMENT DRILLING (Pre-Production)			
Development Footage Drilled	225,000'	385,000'	148,000'
Development Drilling Cost	$0.05	$0.08	$0.02
MINE DEVELOPMENT (Pre-Production)			
Timing (Shaft Collaring-Sustained Prod.)	41 Months	23 Months	7 Months
Surface Plant & Equipment	17% = $0.11	31% = $0.14	47% = $0.07
Shaft (Production)	33% = 0.21	17% = 0.08	27% = 0.04
Shaft (Ventilation)	2% = 0.01	2% = 0.01	7% = 0.01
Shaft Station	11% = 0.07	2% = 0.01	Nil Nil
Shaft Pocket & Sump	9% = 0.06	2% = 0.01	Nil Nil
Drifts, Crosscuts, Raises, etc.	17% = 0.11	15% = 0.07	7% = 0.01
Underground Equipment	11% = 0.07	31% = 0.14	12% = 0.02
(2) Mine Development Cost	100% = $0.64	100% = $0.46	100% = $0.15
COST SUMMATION	$0.69	$0.54	$0.17

Development Conditions			
(3)#U_3O_8 (Reserves & Production) (1/1/64)	6,900,000	5,800,000	6,800,000
Dev. Cost Per Daily Ton Of Production Capacity (2x3 ÷ 1)	$11,000	$4,400	$1,275
Dev. Cost Per Ton (Excluding Drilling)	$7.19/Ton	$2.60/Ton	$0.75/Ton
Shaft Depth	1500'	750'	800'
Shaft Configuration	12' Diameter	Rectangular	Rectangular
Number Of Compartments	3	5	3
Number Of Development Levels	1	1	1
Water Inflow During Sinking	High	350 GPM Max.	Nil
Shaft Lining Or Set Type	Concrete	Timber & Steel	Timber
Water Control (Shaft) Required	Grouting	Grouting	None
Ground Control (Stopes) Required	Sand Fill	Sand Fill & Pillars	Pillars
Development Relative To Ore Zone	Below Ore	On Ore	On Ore
Mainline Haulage Type	Tracked	Trackless	Trackless
General Orebody Configuration	Bedded Paleochannel	Bedded Paleochannel	Bedded Paleochannel
Number Of Ore Horizons	Multiple	Single	Single
Ore Thickness Range--Min.-Max. (Avg.)	$1\frac{1}{2}$'-22' ($10\frac{1}{2}$')	8'-25' ($9\frac{1}{2}$')	($9\frac{1}{2}$')

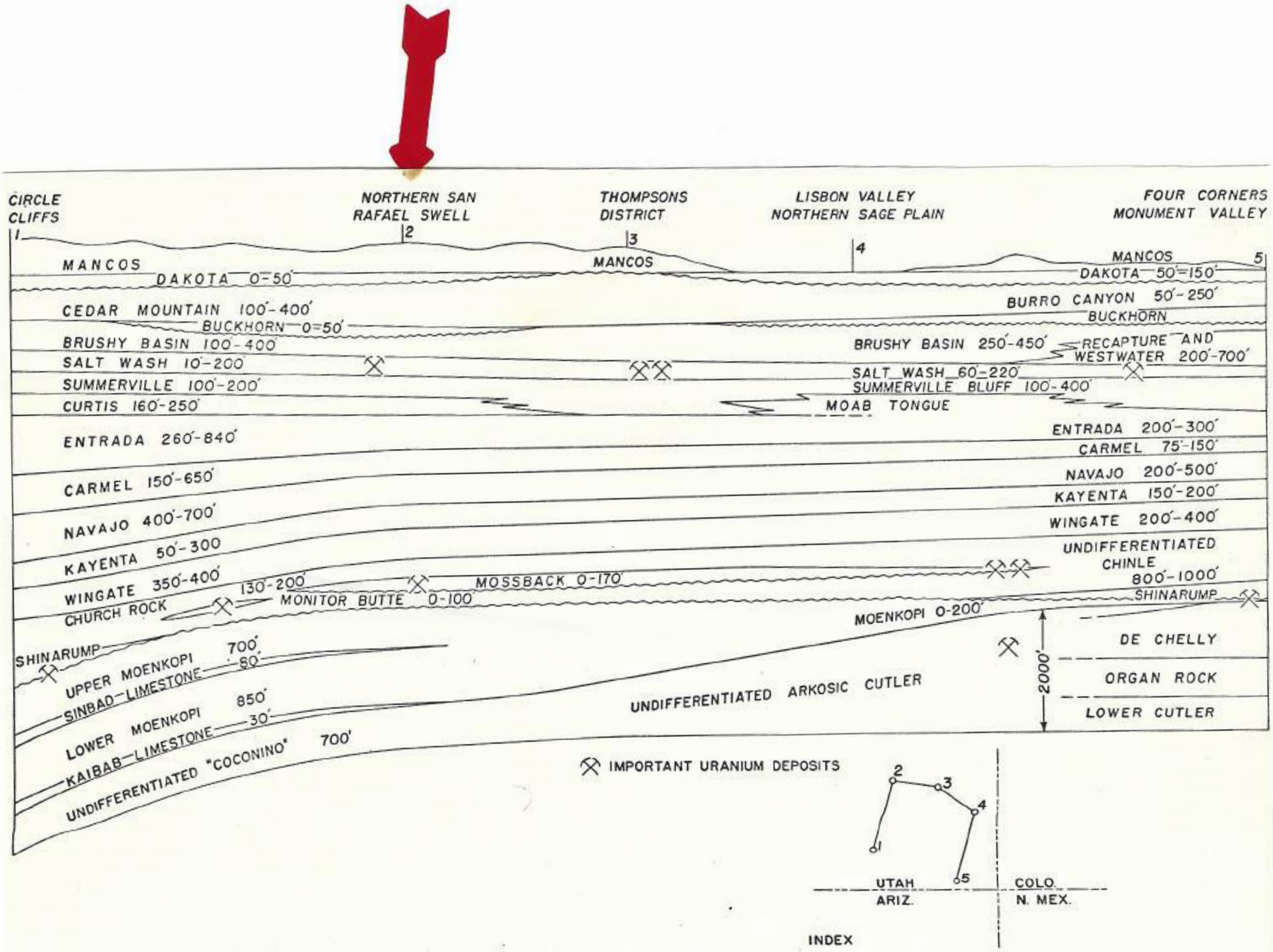
Development Cost ($/# U_3O_8)

(1) TONS PER DAY	1963		1955 ($/# U_3O_8)		1956	
	250		300		300	
DEVELOPMENT DRILLING (Pre-Production)						
Development Footage Drilled		40,000'		116,000'		26,000'
Development Drilling Cost		$0.04		$0.10		$0.01
MINE DEVELOPMENT (Pre-Production)						
Timing (Shaft Collaring-Sustained Prod.)		11 Months		16 Months		23 Months
Surface Plant & Equipment	16% =	$0.04	30% =	$0.03	19% =	$0.03
Shaft (Production)	20% =	0.05	30% =	0.03	*31% =	0.05
Shaft (Ventilation)	8% =	0.02	Nil	Nil	6% =	0.01
Shaft Station	4% =	0.01	Nil	Nil	See (*)	above
Shaft Pocket & Sump	4% =	0.01	Nil	Nil	See (*)	above
Drifts, Crosscuts, Raises, etc.	20% =	0.05	10% =	0.01	6% =	0.01
Underground Equipment	28% =	0.07	30% =	0.03	38% =	0.06
(2) Mine Development Cost	100% =	$0.25	100% =	$0.10	100% =	$0.16
COST SUMMATION		$0.29		$0.20		$0.11

Development Conditions	1963	1955	1956
(3)#U_3O_8 (Reserves & Production) (1/1/64)	1,200,000	4,800,000	3,700,000
Dev. Cost Per Daily Ton Of Production Capacity (2x3 ÷ 1)	$1,200	$1,600	$1,973
Dev. Cost Per Ton (Excluding Drilling)	$1.46/Ton	$0.69/Ton	$0.86/Ton
Shaft Depth	400'	550'	-15° Incline
Shaft Configuration	4' Diameter	Rectangular	8'x8'
Number Of Compartments	1	2½	1
Number Of Development Levels	1	1	-
Water Inflow During Sinking	100 GPM Max.	Nil	Nil
Shaft Lining Or Set Type	Concrete	Timber	Timber
Water Control (Shaft) Required	None	None	None
Ground Control (Stopes) Required	Square Sets & Lagging	Nil	Nil
Development Relative To Ore Zone	Below Ore	On Ore	On Ore
Mainline Haulage Type	Tracked	Trackless	Tracked
General Orebody Configuration	Bedded Roll-Front	Bedded Paleochannel	Bedded Paleochannel
Number Of Ore Horizons	Single	Single	Single
Ore Thickness Range--Min.-Max. (Avg.)	5'-35' (11')	4'-11' (7½')	5'-6½' (5½')

Mining Cost and Rate Calculations

Typical Costs in Grants, N.M. Area of 5 Operating Mines



Cross section showing correlation of formations in southeastern Utah uranium region.

Average of 5 Mines in the Grants, N.M. Area

EXAMPLE - TYPICAL COSTS

BJ.PD.5 (REV. 1/60)

MINING COST AND RATE CALCULATIONS

MINE NAME OR CLAIM GROUP	PREPARED BY	REPORT DATE
± 10,000,000 Pound U_3O_8 Property 600 tons Per Day - Production Rate	DISTRICT	
LOCALITY	COUNTY	STATE
OWNED BY	OPERATED BY	

PART I CALCULATION OF TOTAL ESTIMATED ORE PRODUCTION, CONTAINED U_3O_8, AND MINING COSTS

TYPE OF ENTRY	MINING METHOD
Shaft	

1. % U_3O_8 IN ORE RESERVES	.22	10. PRODUCTION TONS TO ITEM (4) DATE	
2. ÷ DILUTION FACTOR	1.10	11. X % U_3O_8 (PRODUCTION GRADE TO DATE)	
3. = MINING GRADE, % U_3O_8 (1 ÷ 2)*	.20	12. = U_3O_8 TONS TO DATE (10 X 11)	
4. ORE RESERVES, TONS, AS OF..........	2,700,000	13. + U_3O_8 TONS IN RESERVES (9) lbs.	
5. X % OF EXTRACTION	.90	14. = TOTAL U_3O_8 ~~TONS~~ (12 + 13)	10,692,000
6. X DILUTION FACTOR (2)	1.10	15. TONS TOTAL MUCK FROM RESERVES (7)	
7. = TOTAL MUCK, AS OF ITEM (4) DATE (4 X 5 X 6)	2,673,000	16. + TONS MUCK PRODUCED (10)	
8. MINING GRADE (3)	.20	17. = TONS TOTAL MUCK (15 + 16)	2,673,000
9. U_3O_8 POUNDS	10,692,000	18. ESTIMATED PRODUCTION GRADE, % U_3O_8 (14 ÷ 17)	.20

TOTAL EXTRACTABLE RESERVES	MINE LIFE @ CURRENT RATE	TONS	DEPTH OF BURIAL	THICKNESS	GRADE
	18 yrs.	2,673,000	700'		.22
MINE COST DATA PERIOD COVERED:	FROM	TO	ORE PRODUCTION	PER MONTH 12,600	FOR PERIOD

A. EXPLORATION COST

OPERATION	NO. OF HOLES	FOOTAGE	COST/FOOT	TOTAL COST	COST/TON
DRILLING					
DRIFTS OR ADDITS					
RAISES					
		TOTAL EXPLORATION COSTS			

Historically about 8#'s of U_3O_8 have been discovered per foot of drilling. Future discoveries could require a greater amount of drilling.

B. SURFACE PLANT COST

STRUCTURE OR EQUIPMENT	TYPE	ITEM COST	INSTALL'N. COST	YEARS TO DEPRECIATE	TOTAL COST	COST/TON
BUILDINGS						
MACHINE SHOP						
HOIST						
HEAD FRAME						
GENERATORS						
COMPRESSORS						
OTHER						
		TOTAL SURFACE PLANT COSTS			$800,000	.30

Average cost for an orebody of this size.

* NUMBERS IN PARENTHESES ( ) REFER TO CALCULATION ITEM NUMBERS UNLESS OTHERWISE EXPLAINED.

MINING COST AND RATE CALCULATIONS

REPORT DATE

C. EQUIPMENT COST

EQUIPMENT ITEM AND TYPE	QUANTITY	ITEM COST	YEARS TO DEPRECIATE	TOTAL COST	COST/TON
Average cost for an orebody of ± 10,000,000 pounds U_3O_8 producing at rate of 600 tons per day.					
			TOTAL EQUIPMENT COSTS	$600,000	.22

D. DEVELOPMENT COST

DEVELOPMENT ITEM		SIZE	LENGTH OR DEPTH	COST PER FOOT	TOTAL COST	COST/TON
ENTRY	TYPE					
SHAFT STATION						
POCKETS						
DRIFTS AND CROSS CUTS						
RAISES						
STRIPPING	CUBIC YARDS		COST/CUBIC YARD			
				TOTAL DEVELOPMENT COSTS		1.22

Average Primary Development cost of several representative mines.

E. DIRECT MINING COST

SALARIES: CLASSIFICATION	JOB TITLE	MONTHLY SALARY COST	TOTAL COST	COST/TON
ADMINISTRATIVE				
SUPERVISORY				
TECHNICAL				
CLERICAL				
		TOTAL SALARY COSTS		.65

Average cost for orebody this size

DIRECT LABOR: JOB TITLE	NUMBER	HOURLY RATE	COST PER MONTH	TOTAL COST	COST/TON
Average cost of direct labor, mines of this size and production rate of 600 tons per day.					
			TOTAL DIRECT LABOR COSTS		7.08

REPORT DATE

MINING COST AND RATE CALCULATIONS

E. DIRECT MINING COST (CONT'D.)

SUPPLIES ITEM	QUANTITY	UNIT COST	TOTAL COST	COST/TON
POWDER				
BITS				
RODS				
LUBRICATING OIL				
DIESEL OIL				
GASOLINE				
AIR HOSE				
WATER HOSE				
POWER				
TIMBER				
RAIL				
TUGGER ROPE				
OTHER	Average			
TOTAL SUPPLY COSTS				$2.00

MAINTENANCE MATERIALS ITEM	QUANTITY	UNIT COST	TOTAL COST	COST/TON
TOTAL MAINTENANCE MATERIALS COSTS			Average	.52

HAULAGE MILL	MILES	TONS OF ORE	GROSS TON MILES	COST/TON MILE	TOTAL COST	COST/DRY TON
TOTAL DIRECT MINING COSTS						.50

F. INDIRECT MINING COST

COST DETAILS		$10.75
TAXES		
TOTAL TAX COSTS		
INSURANCE		
TOTAL INSURANCE COSTS		
OTHER INDIRECT		
TOTAL OTHER COSTS		
TOTAL INDIRECT COSTS		.50

G., H. COMPUTATION OF ORE VALUE/TON, ROYALTY AND ACQUISITION COSTS/TON AND TOTAL ALLOWABLE LIFE

19. ORE VALUE/TON, AT ESTIMATED PRODUCTION GRADE (18)		21. MONTH DURING WHICH FULL PRODUCTION FIRST ACHIEVED	
20. *ROYALTY AND ACQUISITION COST/TON (15% × (19))		22. TOTAL ALLOWABLE LIFE = MONTHS FROM (21) UNTIL DECEMBER 1966	

REMARKS:

* COMPLETE ONLY IF ACTUAL ROYALTY AND ACQUISITION COSTS ARE UNKNOWN

MINING COST AND RATE CALCULATIONS

REPORT DATE

C O S T S U M M A R Y		COST ITEMS	TOTAL COST	COST/TON
	A.	EXPLORATION		
	B.	SURFACE PLANT	800,000	.30
	C.	EQUIPMENT	600,000	.22
	D.	DEVELOPMENT		1.22
		TOTAL EPED COSTS		1.74
	E.	DIRECT MINING		10.75
	F.	INDIRECT MINING		.50
	G.	ACQUISITION [ITEM (20) OR ACTUAL]		--
	H	ROYALTY [ITEM (20) OR ACTUAL]		1.55
	TOTAL ALLOWABLE LIFE (22)* MONTHS	ORE VALUE/TON (19) $	TOTAL MUCK (17) TONS	GRAND TOTAL COST/TON $14.54

PART II COST AND PROFIT CALCULATIONS AT OPTIMUM MINING RATE

23.	ESTIMATED OPTIMUM TONS PRODUCTION PER DAY	600	32. =	TOTAL COSTS/TON, EXCLUDING ROYALTY & ACQUISITION (29+30+31)	13.91
24.	EST. TONS/MONTH [26 DAYS X (23)]	12,600	33. +	ROYALTY AND ACQUISITION COSTS [COST SUMMARY ITEMS G + H ABOVE]	1.55
25.	MINE LIFE IN MONTHS (17 ÷ 24)	212	34. =	TOTAL COST/TON (32 + 33)	$15.46
26.	TOTAL EPED COSTS/TON [COST SUMMARY, ABOVE]	1.74	35. +	PROFIT (19 — 34)	
27. X	INTEREST FACTOR [.0025 RATE X (25)]	.53	36. =	ORE VALUE OR SALE PRICE/TON (19)	
28. =	INTEREST ALLOWANCE, EPED COSTS (26 X 27)	.92	37.	% PROFIT IN RELATION TO MINING COSTS, EXCLUDING ROYALTY & ACQ. COSTS (35 ÷ 32)	
29.	TOTAL ALLOWABLE EPED COSTS/TON (26 + 28)	2.66		REMARKS	
30. +	DIRECT MINING COSTS/TON	10.75			
31. +	INDIRECT MINING COSTS/TON	.50			

REMARKS

Exclusive of Acquisition and Exploration.

Mine Condition - Wet. Roof bolting and Timber required.

PART III COST AND PROFIT CALCULATIONS AT MINIMUM AND REASONABLE MINING RATES

		MINIMUM A	MINIMUM B	MINIMUM C	MINIMUM D	REASONABLE E	REASONABLE F
38.	EST. TONS/DAY						
39.	EST. TONS/MONTH [26 DAYS X (38)]						
40.	LIFE IN MONTHS [MAY NOT EXCEED (22)] (17 ÷ 39)						
41.	MONTHS STRETCHOUT (40 — 25)						
42.	ADJUSTMENT FACTOR, DIRECT AND INDIRECT MINING COSTS (23 ÷ 38)						
43.	ADDED INTEREST FACTOR FOR STRETCHOUT [.005 RATE X (41)]						
44. +	EPED COSTS/TON (29)						
45. +	ADDED INTEREST FOR STRETCHOUT (26 X 43)						
46. +	ADJUSTED DIRECT MINING COSTS/TON (30 X 42 [NOT TO EXCEED 1.5])						
47. +	ADJUSTED INDIRECT MINING COSTS/TON (31 X 42)						
48. =	TOTAL COSTS/TON, EXCLUDING ROYALTY & ACQUISITION (44 + 45 + 46 + 47)						
49. +	ROYALTY AND ACQUISITION COSTS/TON [COST SUMMARY ITEMS G + H ABOVE]						
50. =	TOTAL COSTS/TON (48 + 49)						
51. +	PROFIT/TON (19 — 50)						
52. =	ORE VALUE OR SALE PRICE/TON (19)						
53.	% PROFIT IN RELATION TO MINING COSTS EXCLUDING ROY. & ACQ. COSTS (51 ÷ 52)						

*NUMBERS IN PARENTHESES ( ) REFER TO CALCULATION ITEM NUMBERS UNLESS OTHERWISE EXPLAINED.

and costly primary development projects, and three represent the least difficult and least costly primary development projects. Only mines utilizing vertical shaft entry to ore were incorporated where possible. Daily production ranges from 150 to 1,000 tons.

SUMMARY STATUS OF URANIUM INDUSTRY (1969)

I. Present Status

A. Production Facilities (See Figure 18 & 19)

1. Physical

a. Major mining districts

b. 27 mills at one time or another

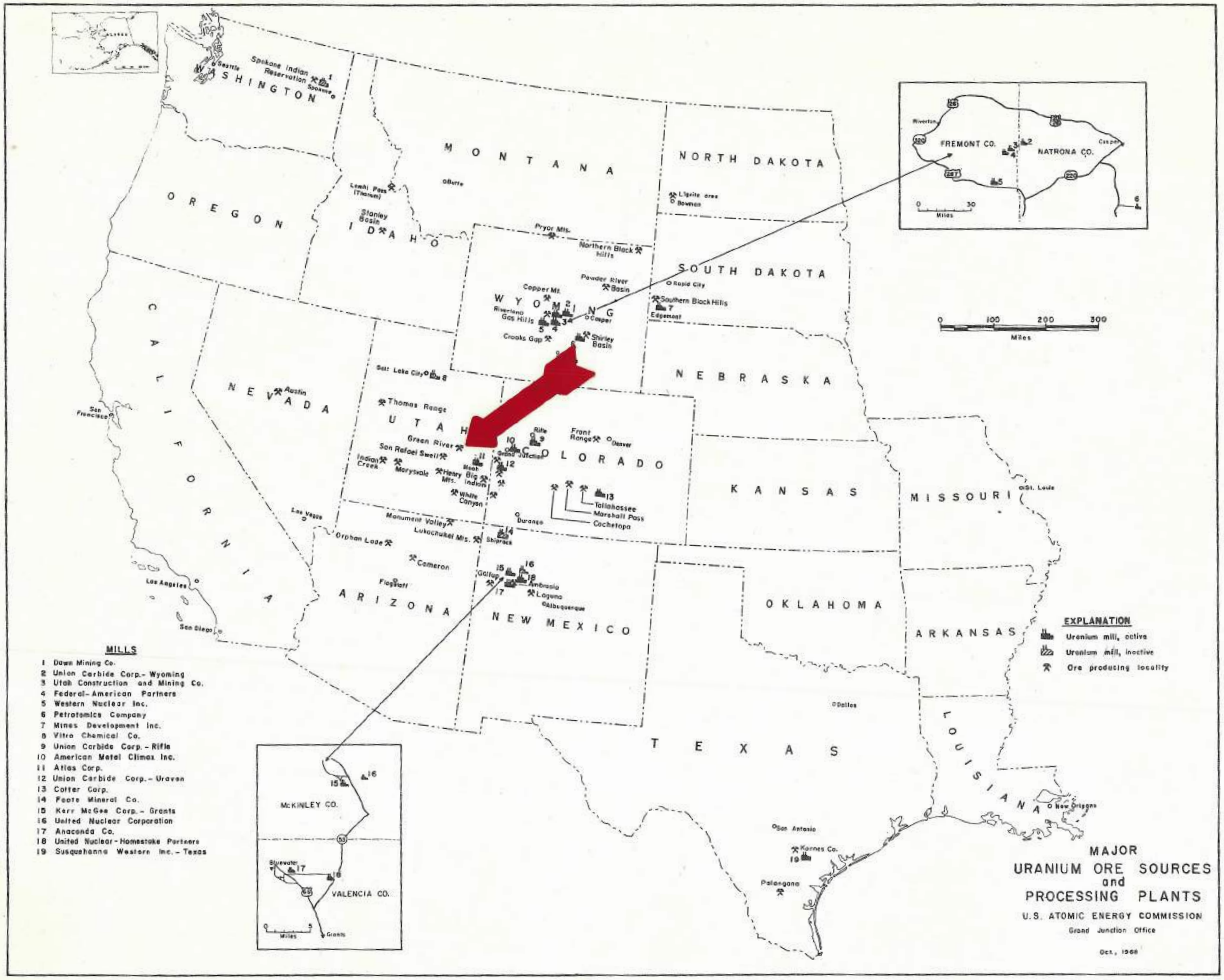
c. 5 concentrators

d. Current production centers shown by 50-mile radius circles around existing milling facilities.

2. In 1968 approximately 300 mines (captive and independent) produced 6.2 million tons of ore containing nearly 13,000 tons U_3O_8. 1st 1/2 '69 about the same rate (2.9 million tons containing 6,200 tons U_3O_8).

3. Currently 15 mills operating

Anaconda	)	
Kerr-McGee	)	Grants, New Mexico
United Nuclear-Homestake	)	
Federal	)	
Petrotomics	)	
Union Carbide	)	Wyoming
Utah Construction	)	(Crooks Gap, Gas Hills, Shirley Basin)
Western Nuclear	)	



MAJOR
URANIUM ORE SOURCES
and
PROCESSING PLANTS
U.S. ATOMIC ENERGY COMMISSION
Grand Junction Office
Oct., 1968
EXPLANATION
Uranium mill, active
Uranium mill, inactive
Ore producing locality
MILLS
1 Dawn Mining Co.
2 Union Carbide Corp.- Wyoming
3 Utah Construction and Mining Co.
4 Federal-American Partners
5 Western Nuclear Inc.
6 Petrotomics Company
7 Mines Development Inc.
8 Vitro Chemical Co.
9 Union Carbide Corp. - Rifle
10 American Metal Climax Inc.
11 Atlas Corp.
12 Union Carbide Corp. - Uravan
13 Cotter Corp.
14 Foote Mineral Co.
15 Kerr McGee Corp. - Grants
16 United Nuclear Corporation
17 Anaconda Co.
18 United Nuclear - Homestake Partners
19 Susquehanna Western Inc. - Texas
WASHINGTON
OREGON
CALIFORNIA
NEVADA
IDAHO
MONTANA
WYOMING
UTAH
COLORADO
ARIZONA
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MISSOURI
ARKANSAS
LOUISIANA
FREMONT CO.
NATRONA CO.
McKINLEY CO.
VALENCIA CO.

URANIUM ORE PROCESSING PLANTS

Operating Mills

Company	Location of Mill	First U_3O_8 Delivered to AEC	Type Process Used **
American Metal Climax *	Grand Junction, Colo.	June 1951	AL, CCD, SX
Anaconda Company	Grants, New Mexico	Sept. 1953	AL, RIP
Atlas Corporation *	Moab, Utah	Nov. 1956	Alk, RIP & AL, CCD, SX
Cotter Corporation	Canon City, Colorado	Aug. 1958	Alk, C-ppt. AL, SX
Federal-American Partners	Fremont Co., Wyoming	Dec. 1959	AL, RIP, Eluex
Kerr-McGee Corporation *	Grants, New Mexico	Dec. 1958	AL, CCD, SX
Mines Development, Inc. *	Edgemont, S. Dakota	Aug. 1956	AL, RIP, Eluex
Petrotomics Company	Carbon Co., Wyoming	April 1962	AL, CCD, SX
Susquehanna-Western, Inc.	Falls City, Texas	June 1961	AL, CCD, SX
Union Carbide Corporation-Rifle *	Rifle, Colorado	March, 1958	AL, CCD, SX
Union Carbide Corporation-Uravan *	Uravan, Colorado	March, 1950	AL, CCD, IX
Union Carbide Corporation-Wyoming	Natrona Co., Wyoming	Feb. 1960	AL, RIP
United Nuclear-Homestake Partners	Grants, New Mexico	Sept. 1958	Alk, C-ppt.
Utah Construction & Mining Co.	Fremont Co., Wyoming	March 1958	AL, CCD, IX Eluex
Western Nuclear Inc.	Jeffrey City, Wyoming	Aug. 1957	AL, RIP, Eluex

* Produce products other than U_3O_8
** Abbreviations used:

Alk.	- Alkaline leach
AL	- Acid leach
CCD	- Counter-current decantation
C-ppt	- Caustic precipitation
RIP	- Resin-in-pulp
IX	- Column ion exchange
SX	- Solvent extraction
Eluex	- H_2SO_4 elution of resin followed by SX

Figure 19

American Metals Climax)
Union Carbide @Uravan) Uravan Mineral Belt, Colorado
Union Carbide @ Rifle)

Atlas Minerals (Big Indian District, Utah)
Cotter Corporation (Front Range, Colorado)
Mines Development (Black Hills)
Susquehanna-Western (Fall City, Texas)

4. Rehabilitation and Expansion

Restart Dawn Mining Company Mill @ Ford, Washington
Increase Capacity Petrotomics @ Shirley Basin
" " Kerr-McGee @ Grants, New Mexico

5. Announced new mills - Varying degrees of physical and financial commitments and likelihood. Include:

Utah Construction @ Shirley Basin, Wyoming
Rio Algom @ Big Indian, Utah
Susquehanna-Western @ Ray Point, Texas
United Nuclear @ Ray Point, Texas
United Nuclear @ Churchrock, New Mexico
Western Nuclear @ Spokane Indian Reservation, Washington
Amarillo Oil @ Texas
Kerr-McGee @ Powder River Basin, Wyoming

B. Reserves (Western U.S. 1/1/69)

Function of Price

116,000 tons U_3O_8 at \$ 6.00 price
161,000 tons " " \$ 8.00 "
206,000 tons " " \$10.00 "

95% of these reserves are within 50 mile radii of exiting milling facilities

C. Prices per lb./U_3O_8

1. AEC - $8.00 - Expired 12/31/68

   Formula Price - 1969 and 1970

   85% (63-68 costs) + $1.60

   Maximum $6.70

   Vary from $4.75 to $6.70 - average $5.75

2. Commercial Prices

   Information difficult

   Sales now made look like:

	1969 & 70	1971	1972	1973	1974
Range	$6.45/7.85	$6.88/8.00	$7.13/8.20	$7.13/8.90	$7.13/9.85
Average	$6.85	$7.20	$7.47	$7.71	$7.95

D. Industry Production Capability

1. Operated at a rate of about 13,000 tons U_3O_8 in 1968 and is operating at about the same rate for 1969, with capability rising to about 15,000 in 1970.

2. At its peak in 1961 was around 18,000 tons per year. Could reach this peak again in 1971 or 1972 if need be. (Requirements won't meet that level until after 1974)

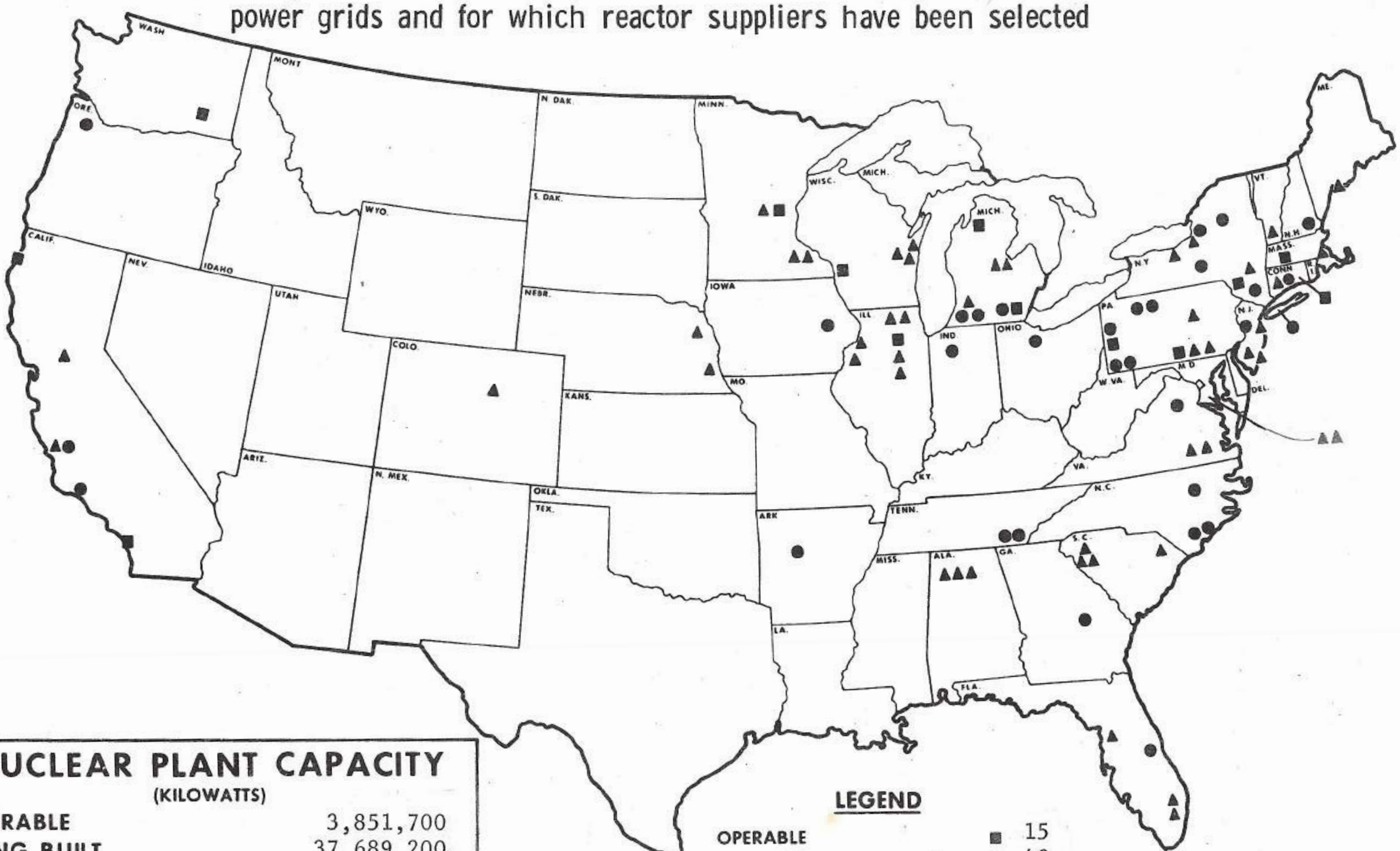
II. Nuclear Power Industry (in terms of Megawatts) - See Figure 20

1. Shows reactors which will be on stream at the end of 1975.

15	plants operations	3,852 MW
48	under construction	37,689 MW
32	planned (reactor ordered)	28,375 MW
9	announced (reactor not ordered)	8,455 MW
104		78,371 MW

NUCLEAR POWER PLANTS IN THE UNITED STATES

The nuclear power plants included in this map are ones whose power is being transmitted or is scheduled to be transmitted over utility electric power grids and for which reactor suppliers have been selected



NUCLEAR PLANT CAPACITY
(KILOWATTS)

OPERABLE		3,851,700
BEING BUILT		37,689,200
PLANNED	REACTORS ORDERED	28,375,006
	REACTORS NOT ORDERED	8,455,000
	TOTAL	78,370,900

ELECTRIC UTILITY CAPACITY BY CONVENTIONAL MEANS AS OF JANUARY 31, 1969: 291,163,554 KILOWATTS

LEGEND

OPERABLE	■	15
BEING BUILT	▲	48
*PLANNED (Reactors Ordered)	●	32

*9 more plants have been announced for which reactors have not yet been ordered.

(over)

U.S. Atomic Energy Commission
October, 1969

Figure 20

SITE	PLANT NAME	CAPACITY (Kilowatts)	UTILITY	STARTUP
ALABAMA				
Decatur	Browns Ferry Nuclear Power Plant: Unit 1	1,064,500	Tennessee Valley Authority	1970
Decatur	Browns Ferry Nuclear Power Plant: Unit 2	1,064,500	Tennessee Valley Authority	1971
Decatur	Browns Ferry Nuclear Power Plant: Unit 3	1,064,500	Tennessee Valley Authority	1972
ARKANSAS				
London	Arkansas Nuclear One	850,000	Arkansas Power & Light Co.	1972
CALIFORNIA				
Humboldt Bay	Humbolt Bay Power Plant: Unit 3	68,500	Pacific Gas & Electric Co.	1963
San Clemente	San Onofre Nuclear Generating Station	430,000	Southern Calif. Edison and San Diego Gas & Electric Co.	1967
Corral Canyon	Malibu Nuclear Plant: Unit1	462,000	L.A. Dept of Water & Power	1974
Diablo Canyon	Diablo Canyon Nuclear Power Plant: Unit 1	1,060,000	Pacific Gas & Electric Co.	1972
Diablo Canyon	Diablo Canyon Nuclear Power Plant: Unit 2	1,060,000	Pacific Gas & Electric Co.	1974
Clay Station	Rancho Seco Nuclear Generating Station	800,000	Sacramento Municipal District	1972
COLORADO				
Platteville	Ft. St. Vrain Nuclear Generating Station	330,000	Public Service Co. of Colorado	1972
CONNECTICUT				
Haddam Neck	Conn. Yankee Atomic Power Plant	567,000	Conn. Yankee Atomic Power Co.	1967
Waterford	Millstone Nuclear Power Station: Unit 1	652,100	Northeast Utilities	1969
Waterford	Millstone Nuclear Power Station: Unit 2	828,000	Northeast Utilities	1973
FLORIDA				
Turkey Point	Turkey Point Station: Unit 3	651,500	Florida Power & Light Co.	1970
Turkey Point	Turkey Point Station: Unit 4	651,500	Florida Power & Light Co.	1971
Red Level	Crystal River Plant: Unit 3	825,000	Florida Power Corp.	1972
Ft. Pierce	Hutchinson Island	825,000	Florida Power and Light Co.	1973
GEORGIA				
Baxley	Edwin I. Hatch Nuclear Plant	786,000	Georgia Power Co.	1973
ILLINOIS				
Morris	Dresden Nuclear Power Station: Unit 1	200,000	Commonwealth Edison Co.	1959
Morris	Dresden Nuclear Power Station: Unit 2	715,000	Commonwealth Edison Co.	1969
Morris	Dresden Nuclear Power Station: Unit 3	715,000	Commonwealth Edison Co.	1969
Zion	Zion Station: Unit 1	1,050,000	Commonwealth Edison Co.	1972
Zion	Zion Station: Unit 2	1,050,000	Commonwealth Edison Co.	1973
Cordova	Quad-Cities Station: Unit 1	715,000	Comm. Ed. Co.–Ia.–Ill. Gas & Elec. Co.	1970
Cordova	Quad-Cities Station: Unit 2	715,000	Comm. Ed. Co.–Ia.–Ill. Gas & Elec. Co.	1971
INDIANA				
Dunes Acres	Bailly Generating Station	515,000	Northern Indiana Public Service Co.	1970's
IOWA				
Cedar Rapids	Duane Arnold Energy Center: Unit 1	545,000	Iowa Electric Light and Power Co.	1973
MAINE				
Wiscasset	Maine Yankee Atomic Power Plant	790,000	Maine Yankee Atomic Power Co.	1972
MARYLAND				
Lusby	Calvert Cliffs Nuclear Power Plant: Unit 1	800,000	Baltimore Gas and Electric Co.	1973
Lusby	Calvert Cliffs Nuclear Power Plant: Unit 2	800,000	Baltimore Gas and Electric Co.	1974
MASSACHUSETTS				
Rowe	Yankee Nuclear Power Station	175,000	Yankee Atomic Electric Co.	1960
Plymouth	Pilgrim Station	625,000	Boston Edison Co.	1971
MICHIGAN				
Big Rock Point	Big Rock Point Nuclear Plant	70,300	Consumers Power Co.	1962
South Haven	Palisades Nuclear Power Station	700,000	Consumers Power Co.	1969
Lagoona Beach	Enrico Fermi Atomic Power Plant: Unit 1	60,900	Detroit Edison Co.	1963
Lagoona Beach	Enrico Fermi Atomic Power Plant: Unit 2	1,126,000	Detroit Edison Co.	1974
Bridgman	Donald C. Cook Plant: Unit 1	1,054,000	Indiana & Michigan Electric Co.	1972
Bridgman	Donald C. Cook Plant: Unit 2	1,060,000	Indiana & Michigan Electric Co.	1973
Midland	Midland Nuclear Power Plant: Unit 1	533,000	Consumers Power Co.	1974
Midland	Midland Nuclear Power Plant: Unit 2	792,000	Consumers Power Co.	1975
MINNESOTA				
Elk River	Elk River Nuclear Plant	22,000	Rural Cooperative Power Assoc.	1962
Monticello	Monticello Nuclear Generating Plant	545,000	Northern States Power Co.	1970
Red Wing	Prairie Island Nuclear Generating Plant: Unit 1	530,000	Northern States Power Co.	1972
Red Wing	Prairie Island Nuclear Generating Plant: Unit 2	530,000	Northern States Power Co.	1974
NEBRASKA				
Fort Calhoun	Ft. Calhoun Station: Unit 1	457,400	Omaha Public Power District	1971
Brownville	Cooper Nuclear Station	778,000	Consumers Public Power District and Iowa Power and Light Co.	1972
NEW HAMPSHIRE				
Seabrook	Seabrook Nuclear Station	860,000	Public Service Co. of N.H.	1974
NEW JERSEY				
Toms River	Oyster Creek Nuclear Power Plant: Unit 1	515,000	Jersey Central Power & Light Co.	1969
Salem	Salem Nuclear Generating Station: Unit 1	1,050,000	Public Service Gas and Electric Co. of New Jersey	1971
Salem	Salem Nuclear Generating Station: Unit 2	1,050,000	Public Service Gas and Electric Co. of New Jersey	1973
NEW YORK				
Indian Point	Indian Point Station: Unit 1	265,000	Consolidated Edison Co.	1962
Indian Point	Indian Point Station: Unit 2	873,000	Consolidated Edison Co.	1970
Indian Point	Indian Point Station: Unit 3	965,300	Consolidated Edison Co.	1971
Scriba	Nine Mile Point Nuclear Station	500,000	Niagara Mohawk Power Co.	1969
Rochester	R. E. Ginna Nuclear Power Plant: Unit 1	420,000	Rochester Gas & Electric Co.	1969
Shoreham	Shoreham Nuclear Power Station	800,000	Long Island Lighting Co.	1975
Lansing	Bell Station	838,000	New York State Electric & Gas Co.	1973
*		1,115,000	Consolidated Edison Co.–Orange and Rockland Utilities, Inc.	1973
Scriba	Nine Mile Point Nuclear Station	815,000	Power Authority of State of N.Y.	1973
NORTH CAROLINA				
Southport	Brunswick Steam Electric Plant: Unit 1	821,000	Carolina Power and Light Co.	1973
Southport	Brunswick Steam Electric Plant: Unit 2	821,000	Carolina Power and Light Co.	1974
*		821,000	Carolina Power and Light Co.	1976
OHIO				
Oak Harbor	Davis-Besse Nuclear Power Station	872,000	Toledo Edison-Cleveland Electric Illuminating Co.	1974
OREGON				
Rainier	Trojan Station	1,118,000	Portland General Electric Co.	1974
PENNSYLVANIA				
Peach Bottom	Peach Bottom Atomic Power Station: Unit 1	40,000	Philadelphia Electric Co.	1966
Peach Bottom	Peach Bottom Atomic Power Station: Unit 2	1,065,000	Philadelphia Electric Co.	1971
Peach Bottom	Peach Bottom Atomic Power Station: Unit 3	1,065,000	Philadelphia Electric Co.	1973
*		1,065,000	Philadelphia Electric Co.	1975
*		1,065,000	Philadelphia Electric Co.	1977
Shippingport	Shippingport Atomic Power Station: Unit 1	90,000	Duquesne Light Co.	1957
Shippingport	Beaver Valley Power Station: Unit 1	847,000	Duquesne Light Co.–Ohio Edison Co.	1973
Goldsborough	Three Mile Island Nuclear Station: Unit 1	831,000	Metropolitan Edison Co.	1971
Goldsborough	Three Mile Island Nuclear Station: Unit 2	810,000	Metropolitan Edison Co.	1973
*		1,052,000	Pennsylvania Power and Light	1975
*		1,052,000	Pennsylvania Power and Light	1977
SOUTH CAROLINA				
Hartsville	H. B. Robinson S. E. Plant: Unit 2	663,000	Carolina Power & Light Co.	1970
Seneca	Oconee Nuclear Station: Unit 1	841,100	Duke Power Co.	1971
Seneca	Oconee Nuclear Station: Unit 2	841,100	Duke Power Co.	1972
Seneca	Oconee Nuclear Station: Unit 3	841,100	Duke Power Co.	1973
TENNESSEE				
Daisy	Sequoyah Nuclear Power Plant: Unit 1	1,124,000	Tennessee Valley Authority	1973
Daisy	Sequoyah Nuclear Power Plant: Unit 2	1,124,000	Tennessee Valley Authority	1973
VERMONT				
Vernon	Vermont Yankee Generating Station	513,900	Vermont Yankee Nuclear Power Corp.-Green Mt. Power Corp.	1970
VIRGINIA				
Gravel Neck	Surry Power Station: Unit 1	783,000	Virginia Electric & Power Co.	1971
Gravel Neck	Surry Power Station: Unit 2	783,000	Virginia Electric & Power Co.	1972
Louisa County	North Anna Power Station: Unit 1	845,000	Virginia Electric & Power Co.	1974
WASHINGTON				
Richland	N-Reactor/WPPSS Steam	790,000	Washington Public Power Supply System	1966
WISCONSIN				
Genoa	LaCrosse Boiling Water Reactor	50,000	Dairyland Power Cooperative	1967
Two Creeks	Point Beach Nuclear Plant: Unit 1	454,600	Wisconsin Michigan Power Co.	1970
Two Creeks	Point Beach Nuclear Plant: Unit 2	454,600	Wisconsin Michigan Power Co.	1971
Carlton	Kewaunee Nuclear Power Plant: Unit 1	527,000	Wisconsin Public Service Co.	1972

* Site not selected

2. Annual replacement of burned up material requires ranges from 0.25 tons U_3O_8 per MW in the first year to around 0.11 tons per year in later years. Varies with the time and amount of plutonium recycling. Overall average about 0.15 tons U_3O_8 per MW per year.

3. During 30 year life of a nuclear plant somewhere between 4 and 5 tons U_3O_8 will be required per MW.

4. Lead Times

   a. 18 to 30 months U_3O_8 to initial core (24 months most commonly used) 12 to 24 months U_3O_8 to reload (15 months most commonly used)

   b. The uranium mining industry concerned about lead times necessary to:

      (i) remove material from place of deposit and convert to concentrate

      (ii) find and develop new deposits and facilities to maintain a continuing production capability

      (iii) 8 to 12 years ((i) + (ii))

IV. Market for U_3O_8

1. Fast moving situation

2. Annual Rates

   a. Requirements (U.S.)

      1969 - 11,900 tons U_3O_8

      (6,300 AEC plus 5,600 commercial)

      1970 - 11,200

      (3,700 AEC plus 7,500 commercial)

      1971 - 9,200 - (AEC gone)

      1975 - 21,000 tons

      (Exceeds 1961 peak of 18,000 tons produced)

      1980 - 38,000 tons

      1990 - 65,000 to 70,000

b. Delivery Commitments

1969 - 6,300 tons AEC

4,700 tons U.S. Commercial (Compare with 5,600 ton requirement)

460 tons Foreign

1970 - Peak year of Commitment

3,700 tons AEC

9,400 tons U.S. Commercial (Requirement 7,500)

150 tons Foreign

1972 - Peak year of Commercial Commitment

12,400 tons U.S. (Requirement 12,500)

210 tons Foreign

No commitments past '80

3. Cumulative Requirements & Commitments

a. Requirements 69 thru 80 AEC & Commercial - 250,000 tons U_3O_8

b. As of 7.1/69, 80,000 tons U_3O_8 known to be committed to contract (AEC and Commercial) through same period.

V. Capability vs. Demand (Domestic)

1. Looking forward to demands by 1980 which are about 3 times the current productive capability.

2. Looking at reserves which could be depleted before 1980 if not replaced. Not indicating a lack of confidence.

3. Since the major element of capability is reserves, we should examine the amounts which are to be converted to reserves between 1969 and 1980 inclusive, a 12 year period.

a. Falls into two elements:

(i) Replacement of Production

(ii) Maintenance of sufficient reserve to sustain production for a time equal to that necessary to find and develop new deposits and bring to the point of sustained production so as not to endanger capability (8 to 12 years).

b. Talk about 8 year forward demand as a minimum adequate reserve (personally prefer 10 year).

1/1/69 = 120,000 (161,000 in reserve @ $8)

1/1/81 = 410,000 tons U_3O_8

c. Look at amounts converted to reserves 1969-1980 from 3 standpoints

(i) To keep from complete depletion by 1980 -- 104,000 tons

(ii) To replace requirements -- 250,000 tons U_3O_8 or 22,000 tons/year. (Compare with 1968 - 26,000 tons)

(iii) To meet requirements and end up with 8 year forward reserve at the end of 1980 -- 500,000 tons U_3O_8 or 40,000 tons/yr. (1969 will probably hit this rate)

VI. Estimates of Forward Expenditure and Effort

1. Each annual ton of new capability represents a capital expenditure of $20,000 (some estimates as high as $30,000).

   a. To raise capability to 38,000 tons per year by 1980 will cost at least $500,000,000 in capital investment other estimates suggest closer to 1 billion.

   b. Does not include exploration. Another 1/2 billion

2. Barometers of Exploration and Development Effort

   a. Land Acquisition

      (i) Around 21 million acres acquired during last 3 years. Nearly half of it in 1968.

      (ii) Rate began to diminish first 1/2 1969 (3,000,000 acres) and will probably level off and reach equilibrium.

   b. Drilling

      1966 - 4,200,000 feet 42% Expl. 58% Dev.

      1967 - 10,764,000 feet 50% Expl. 50% Dev.

1968 - 23,800,000 feet 68% Expl. 32% Dev.

1/2 1969 - 14,500,000 feet 66% Expl. 34% Dev.

Industry predicts 110,000 feet 69-72 at a cost of $180,000,000

3. Amount of drilling effort needed 1969 thru 1980 to convert 500,000 tons. (SWAG Method).

   a. Several lb./foot factors could be drived.

Historical (194801968)	7#/ft.
Last ten years (1959 - 1968)	2.4#/ft.
Last 3 years (1966-1968)	2.6#/ft.
Last year (1968)	2.2#/ft.

   b. Dealers choice as to which is applicable, if any.

      (i) On the basis of 7#/ft., 140,000,000 needed for 12 year period (12,000,000 feet per year - 24,000,000 1968)

      (ii) On the basis of 2.5, 400,000,000 feet (33,000,000 feet/year a rate which is being approached in 1969)

GENERAL REFERENCES

1. A.E.C. Issues Report of Nuclear Industry Fuel Supply Survey, May 20, 1969, Press Release 521.

2. Hill, D. R., 1969, Status of the Industry, A.E.C. Combined Reports.

3. Wright, R. J., 1955, Ore Controls in Sandstone Uranium Deposit, White Canyon, San Juan County, Utah

4. Hintze, et alia, Eds., 1967, Guidebook to the Geology of Utah, No. 21, Uranium Districts of Southeastern Utah, Utah Geological Society, Salt Lake, Utah.

5. Stokes, W. L., Ed., 1954, Guidebook to the Geology of Utah, No. 9, Uranium Deposits and General Geology of Southeastern Utah, Utah Geol. Society, Salt Lake, Utah

6. A.E.C., 1969, Miscellaneous Reports on Uranium Exploration and Development. Workshop Papers (unpublished)