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Memorandum: To File

From: Chas. A. Rohrmann
Separations Process Survey Committee

Metal Recovery Process Comparisons

I. Introduction and Objective

On December 8, 1948 the Separations Process Survey Committee was organized and began work toward an evaluation of various metal recovery alternatives.

With major revisions proposed in the processes operated by the General Electric Company at Hanford by way of currently recovering metal along with improved plutonium processing and also the separate problem of recovering old waste, it is apparent that the undesirable possibility exists for the operation of a number of costly and different kinds of processes, many of which may be obsoleted in a few years. There is the need, therefore, to review these processes with the object of combining some and also of fitting others into present idle facilities. It was, therefore, the object of the studies by the Separations Process Survey Committee to review a variety of process combinations and to develop facts and costs relating to each proposal in order to provide information on which to base decisions relating to the future course of action of the General Electric Company at the Hanford Works in the production of plutonium and the recovery of uranium for reuse.

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This present report details the progress and results of the study to date. Additional considerations will be the subject of future reports including comparative advantages and disadvantages of the proposals and the effects of a change in basis such as capacity increase.

II. The Process Proposals

The following are the cases or proposals which have been studied. They comprise combinations of the present bismuth phosphate ($BiPO_4$), solvent extraction* and uranyl ammonium phosphate** processes to yield plutonium and decontaminated uranium compounds as the end products from currently processed slugs and stored metal waste:

Proposal or Case No.	Process or Combination	Plants Eventually Made Obsolete	Future Plants in Operation
1.	$BiPO_4$ plus uranyl ammonium phosphate (UAP) for two year old waste	None	$BiPO_4$ plus UAP (at less than maximum capacity)
2.	$BiPO_4$ plus Solvent Extraction (S. E.) for two year old waste	None	$BiPO_4$ plus S. E. (at less than maximum capacity)
3.	$BiPO_4$ plus UAP for aged and current waste	None	Same as 1.
4.	$BiPO_4$ plus S. E. for aged and current waste	None	Same as 2.
5.	Redox plus UAP for old waste	$BiPO_4$ and UAP	Redox
6.	Redox plus S. E. for old waste	$BiPO_4$ and S. E.	Redox
7.	Redox for old and current metal waste	$BiPO_4$	Redox at less than maximum capacity
8.	Solvent extraction to separate Pu from U; Pu processed as at present via $BiPO_4$. U decontaminated via S.E. plus separate S.E. plant for aged waste	S.E. for aged waste	S.E. for separating Pu from U and decontamination of U; $BiPO_4$ for Pu decontamination
9.	Solvent extraction to separate Pu from U in current waste; Pu decontaminated via $BiPO_4$, U decontaminated via solvent extraction	None	S.E. for separating Pu from U and decontaminating U, operated at less than maximum capacity; plus $BiPO_4$ for Pu

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* Including Redox

** This is the process proposed for aged (2 yr.) waste by Carbide and Carbon Chemicals Co., Oak Ridge National Laboratory, Status Report of October, 1948.

[redacted] [redacted]

We recognize that work has been in progress on other processes for metal recovery, for example, a straight fluorination process and the electrolytic process. It is our opinion, however, that the UAP and solvent extraction processes are further developed and that design work on either could proceed on the basis of available information.

An additional proposal 10 has been considered recently. It involves one-half of 7 and one-half of 9 above.

III. Study Bases

The essential bases used in this study were as follows:

1. The nine proposals above are being compared at capacities which will yield plutonium and four metric tons of decontaminated uranium compound per day from stored and current waste, until the stored waste is totally recovered or reaches the constant inventory as required by Proposals 1 and 2.

2. All proposals are to yield the hexafluoride as the end product. It is assumed that all steps required to yield this product need not be conducted at this site, except in those cases wherein fluorination is a required step for decontamination (UAP Proposals 1, 3, and 5). Unit costs and capacities of other manufacturing locations will be used where applicable in our study.

3. Consideration is not being given at this time to the details of process revisions which may also yield recovered plutonium from metal wastes. For Proposals 7 and 9, however, such is probable at low cost.

4. All solvent extraction processes are expected to yield decontaminated uranium nitrate solution.

5. For solvent extraction processes, waste metal preparation for feed is assumed to be by the UAP - caustic metathesis process.

6. The sluicing method as proposed by both Carbide and Kellex will be used for removal of waste from storage tanks. Kellex construction cost figures for this step will be used where applicable.

7. The UAP processes will be based on two UAP precipitations. Carbide has provided data to show the satisfactory decontamination obtained by this departure from the proposal of their "Status Report".

8. Solvent extraction processing will vary as follows:

    a. For processes in which column feed is prepared directly from current metal (Proposals 5, 6, 7, 8, 9,), three uranium cycles will be used.

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b. For processes in which UAP - Metathesis is used to prepare feed from $BiPO_4$ process current and aged waste (Proposals 2, 4, 6, 7, and 9), two uranium cycles will be used.

c. For Redox processes, the third cycle waste will be "cribbed".

d. For processes utilizing UAP - Metathesis, second cycle wastes in the solvent extraction step will be "cribbed".

We recognize that "cribbing" of any activity may have to be abandoned. Such a policy will, however, apply to any present or future process considerations.

9. For UAP processes all wastes containing ammonia are treated with caustic soda to discharge the ammonia. Stored concentrated solutions then contain sodium nitrate instead of ammonium nitrate.

10. All preparation of the tetrafluoride is to be done via dry methods. Carbide has shown satisfactory decontamination by this means as a step in their UAP processes yielding the hexafluoride as the final product.

11. A 99+% yield is assumed for all processes.

12. For neutralized process wastes which can be concentrated, consideration will be given to concentrating in the plant buildings to a crystallization temperature of 20°C. Further concentration (to magma) may be considered at the point of final storage.

13. Existing spare or idle facilities (U - Canyon) will be used wherever economically possible in the proposed processes. No investment charge is to be included for use of existing facilities. No obsolescence charge is proposed for obsoleted facilities.

14. Construction cost estimates will be made utilizing in the best possible manner cost data now available on presently proposed construction(Redox). It may also be necessary to bring the cost of existing types of construction to present-day figures in some cases, for the comparison.

15. Value of existing facilities which may be utilized will not be included in construction cost figures. Cost of adaptation will, of course, be added into construction costs.

16. For those proposals in which a plant is built separately for old waste recovery and which is obsolete when the recovery program is completed, we propose a single plant to process waste from both areas (200-E and 200-W).

17. For permanent operations, complete facilities will be provided in both areas. This requirement may be limited to processing of active material; economics should favor centralized processing of decontaminated products.

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TABLE I
COST SUMMARY OF METAL RECOVERY PROCESSES

For period of stored waste recovery, 1949-1958 inclusive, and annually thereafter.
Estimated actual expenditures only. When existing facilities are used their value is not included.
(New Money Only)

P R O P O S A L S

	1	2	3	4	5	6	7	8	9	10
CONSTRUCTION COST*										
Process**	63,000,000	53,000,000	63,000,000	53,000,000	76,000,000	69,000,000	62,000,000	72,000,000	52,000,000	57,000,000
Waste Storage	23,000,000	28,000,000	13,200,000	20,200,000	19,200,000	24,900,000	23,100,000	23,100,000	23,100,000	22,900,000
Subtotal	86,000,000	81,000,000	76,000,000	73,000,000	95,000,000	94,000,000	85,000,000	95,000,000	75,000,000	80,000,000
OPERATING COST										
Raw Materials	24,300,000	25,000,000	24,200,000	25,600,000	20,300,000	20,700,000	20,600,000	24,000,000	24,000,000	22,200,000
Labor, Repairs, Power	75,000,000	71,000,000	78,000,000	72,000,000	66,000,000	63,000,000	61,000,000	70,000,000	66,000,000	64,000,000
Security, Overhead	64,000,000	62,000,000	66,000,000	62,000,000	58,000,000	56,000,000	54,000,000	61,000,000	57,000,000	56,000,000
Subtotal	163,000,000	158,000,000	168,000,000	160,000,000	144,000,000	140,000,000	136,000,000	155,000,000	147,000,000	142,000,000
UNIT COSTS										
UNH Shipping		1,500,000		1,810,000	910,000	1,810,000	1,810,000	1,810,000	1,810,000	1,810,000
UNH → UO_2		1,080,000		1,260,000	630,000	1,260,000	1,260,000	1,260,000	1,260,000	1,260,000
UO_2 → UF_4		7,500,000		8,800,000	4,400,000	8,800,000	8,800,000	8,800,000	8,800,000	8,800,000
UF_4 → UF_6		16,900,000		19,700,000	9,900,000	19,700,000	19,700,000	19,700,000	19,700,000	19,700,000
UF_6 Shipping	1,060,000		1,240,000		620,000					
Subtotal	1,060,000	27,000,000	1,240,000	32,000,000	16,500,000	32,000,000	32,000,000	32,000,000	32,000,000	32,000,000
GRAND TOTAL (UF_6)	250,000,000	266,000,000	245,000,000	265,000,000	256,000,000	266,000,000	253,000,000	282,000,000	254,000,000	254,000,000
TOTAL COST per Lb. U in $	13.20	14.00	11.10	11.90	11.50	11.90	11.30	12.70	11.50	11.40
TONS U PRODUCED, 10 YEAR PERIOD	8,600	8,600	10,100	10,100	10,100	10,100	10,100	10,100	10,100	10,100
½ UF_4, ½ UF_6 BASIS										
LESS: ½ Cost UF_4 → UF_6		-8,400,000		-9,900,000	-9,900,000	-9,900,000	-9,900,000	-9,900,000	-9,900,000	-9,900,000
LESS: ½ Cost UF_6 Shipping	-530,000		-620,000							
ADD: Cost UF_4 Shipping	480,000		560,000							
ADD: Cost UF_6 → UF_4	650,000		760,000							
GRAND TOTAL (½UF_4, ½UF_6)	251,000,000	258,000,000	246,000,000	255,000,000	246,000,000	256,000,000	243,000,000	272,000,000	244,000,000	244,000,000
TOTAL COST per Lb. U in $	13.20	13.60	11.10	11.50	11.10	11.50	10.90	12.20	11.00	10.90
ANNUAL COSTS, 1959 and THEREAFTER (Basis: 1 Ton U as UF6, 1 Ton as UF4)										
Waste Storage Costs	1,330,000	1,770,000	970,000	1,410,000	1,360,000	1,360,000	1,360,000	1,390,000	1,390,000	1,380,000
Operating Cost	16,500,000	16,100,000	16,200,000	15,900,000	11,700,000	11,700,000	11,900,000	13,700,000	13,800,000	12,800,000
Unit Costs	142,000	1,600,000	142,000	1,600,000	1,600,000	1,600,000	1,600,000	1,600,000	1,600,000	1,600,000
GRAND TOTAL	18,000,000	19,500,000	17,300,000	18,900,000	14,700,000	14,700,000	14,900,000	16,700,000	16,800,000	15,800,000
TOTAL COST per Lb. U in $	11.20	12.10	10.80	11.80	9.10	9.10	9.20	10.40	10.50	9.90

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* Includes 28% Construction Overhead.
** New Construction plus Revision of Existing Facilities

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18. The degree of overdesign incorporated in our study will be essentially the same as for the present Redox design. This includes spare cells and a 20% process capacity safety factor.

19. Remote control and remote maintenance will be proposed in all processing wherein shielding and contamination are involved.

20. The operating year is to be 365 days.

21. Chemical cost figures have been obtained from the Purchasing Division. Fluorine was taken at $0.50/lb, the figure used by Carbide in its "Status Report".

IV. Comparisons

Emphasis in this study has been placed on obtaining data on which to base overall cost comparisons. Detailed evaluation of the proposals from various viewpoints is to be the subject of another document. Comments on the various proposals as considered to date along the line of the chemistry, engineering and economics are, however, included here (See Item V). These comments are intended to show process weak points on which decision and study may be required rather than as an evaluation or comparison of process advantages and disadvantages.

In the overall cost comparisons (See Cost Summary, Table I) the cost of the proposals may be compared over the period of stored waste recovery on the basis of construction cost including new waste storage and operating cost including raw materials. Unit Costs for converting UNH for solvent extraction proposals to UF_6 at an existing plant at St. Louis are included to bring all process to the common basis. These unit costs are derived from approximate costs furnished by the local A. E. C.

Costs are also shown for the revised basis which involves the production of half of the recovered uranium as tetrafluoride (potentially for metal manufacture) and half as the hexafluoride. This basis for comparison is considered because it is our understanding that UF_6 could not be consumed at the four metric ton per day (uranium basis) rate and that storage of large quantities of this material would be undesirable.

The costs for continuing on this basis after stored metal recovery is completed are also shown as annual costs. In all cases, the total cost per pound of uranium has not had the cost of plutonium processing subtracted. This per pound cost is therefore the total cost of uranium recovery and plutonium manufacture calculated on a per pound of uranium basis. All costs in the summary are "rounded off" figures from machine calculations.

A. Chemical Costs

See Table II. These quantities are based on present $BiPO_4$ process consumptions; proposed Redox consumptions are used also in the other solvent extraction processes where applicable; UAP consumptions are based on process requirements proposed by Carbide and Carbon since their Status Report of October, 1948.

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TABLE II
COMPARISON OF DAILY CHEMICAL COSTS

Unit Cost	Material	UaP-2 Yr. Waste lb/tu	UaP-2 Yr. Waste Cost a	UaP-Current Waste lb/tu	UaP-Current Waste Cost b	BiPO$_4$ From Metal lb/tu	BiPO$_4$ From Metal Cost c	BiPO$_4$ After 3E lb/tu	BiPO$_4$ After 3E Cost d	Metathesis, 2 Yr. Waste lb/tu	Metathesis, 2 Yr. Waste Cost e	Metathesis, Current Waste lb/tu	Metathesis, Current Waste Cost f	Redox lb/tu	Redox Cost g	Solvent Extraction from Metal lb/tu	Solvent Extraction from Metal Cost h	Solvent Extraction from Metathesis lb/tu	Solvent Extraction from Metathesis Cost i
3.76	HNO_3 (100%)	13,924	523.54	4,812	180.93	6,733	[illegible]	[illegible]	[illegible]	10,858	408.26	1,747	56.27	4,080	153.41	3,076	115.66	18	.68
26.50	HF (100%)	1,714	542.10	1,714	542.10	95	25.18	95	25.18										
3.30	NaOH (100%)	2,868	94.58	1,200	39.60	5,342	176.29	3,507	115.73	2,211	72.96	2,202	72.67	6,080	200.64	5,850	193.05	2,638	87.05
5.00	NH_3 (100%)	2,177	108.85	2,162	108.10					935	46.75	920	46.00	113	5.65	23.3	.12	23.3	.12
12.00	H_3PO_4 (100%)	24	2.88	118	14.16	1,800	216.00	978.5*	117.42	24	2.88	118	14.16						
1.28	H_2SO_4 (100%)					856	109.57	1	.01					1	.01				
15.00	Oxalic acid (hydrate)					79.3	11.90	79.3*	11.90										
11.90	KOH (anhydrous)					181.2	21.56	181.2	21.56										
2.10	Na_2CO_3			-4,278	-89.84	4,278	89.84												
13.51	$(NH_4)_2 SiF_6$					178.3	24.09	178.3*	24.09										
9.40	$NaNO_2$					264	24.82	84	7.90										
355.00	$NaBiO_3$					30.4	107.92	30.4*	107.92										
10.02	$Na_2Cr_2O_7 \cdot 2H_2O$					10.4	1.04	10.4	1.04					150	15.03				
14.08	$Fe(NH_4)_2(SO_4)_2 \cdot 6H_2O$					324	45.62	324*	45.62										
27.61	$KMnO_4$					9.2	2.54	9.2	2.54										
199.37	$BiONO_3$					107.8	214.92	52.6*	104.87										
16.11	H_2O_2					13	2.09	13	2.09					10	1.61				
185.00	$La(NH_4)_2(NO_3)_5 \cdot 4H_2O$					11.3	20.90	11.3	20.90										
56.98	Zr Carbonate					3	1.71	3	1.71										
112.23	$Ce(NH_4)_2(NO_3)_6$					3	3.37	3	3.37										
2.56	$NaNO_3$					333.7	8.54		8.54					420	10.75	333.7	8.54		
8.42	NH_4NO_3	4,400	370.48	4,400	370.48					2,200	185.24	2,200	185.24						
0	H_2	20.5	--	20.5	--														
?	Cu Wool	?	--	?	--														
12.00	$Al(NO_3)_3 \cdot 9H_2O$													8,760	1,051.20	7,886	946.32	5,626	675.12
18.00	Fe Sulfamate													255	45.90	239.2	43.06	182	32.76
14.50	Hexone													2,630	381.35	2,246	325.67	1,522	220.69
			1,642.43		1,165.53		1,361.06		845.37		716.09		374.94		1,865.55		1,632.42		1,016.42

* Reduction in quantity consumed by reason of reduced volume is possible.

	1	2	3	4	5	6	7	8	9
Proposal Formula	2c+4a	2c+4e+4i	2c+2b+2a	2c+2e+2f+4i	2g+2a	2g+2e+2i	2g+2e+2i	2h+2d+2e+2i	2h+2d+2e+2i
Daily cost, 1952-3	9,292	9,652	8,338	8,970	7,016	7,196	7,196	8,420	8,420
Formula	2c+2a	2c+2e+2i	2c+2b	2c+2f+2i	2g	2g	2g	2h+2d	2h+2d
Daily Cost, 1959	6,007	6,187	5,053	5,505	3,731	3,731	3,731	4,955	4,955
Total Cost 1949-1958 Incl.	24,132,000	24,910,000	24,093,000	25,447,000	20,0[illegible]0,000	20,479,000	20,479,000	23,843,000	23,843,000
Annual Cost, 1959 on	2,192,000	2,256,000	1,744,000	2,009,000	1,362,000	1,363,000	1,362,000	1,808,000	1,808,000

Bases: (1) All processes are compared at a daily production rate of 1 metric ton of decontaminated uranium.

(2) All processes contain chemical costs sufficient to lead to the most desirable decontaminated U compound for that process.

(3) Unit costs were obtained from latest plant cost figures where available, otherwise from vendor's quotation, late price listing plus freight cost or estimate.

(4) Proposals 1-9 are compared at a daily production rate of 4 metric tons of decontaminated uranium; current slug metal is processed at a rate of 2 tons per day and stored waste is depleted at a rate of 2 tons of uranium per day, until a 2 yr. inventory is reached in proposals 1 and 2, and until all stored waste is gone in other proposals.

(5) Proposals 1 and 3 include costs of HF both for direct process use and for the manufacture of F_2, with reasonable losses allowed.

(6) All proposals include sufficient NaOH for waste neutralization to the point where ammonium salts are decomposed.

(7) Daily costs of the proposals are summed from the process costs by the formulas shown.

(8) Ten year cost summations for proposals 1-9 are based upon operation of the $BiPO_4$ process at a rate of 2 tons uranium per day from January, 1949, until the estimated startup date for the new process, operation of the new process at the rates described above until the stored waste is depleted (or until a 2 year inventory is reached in proposals 1 and 2), and operation of the new process at the 1959 rate thereafter.

(9) Operating year [illegible] days.

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B. Waste Volumes and Costs

See Table III. This table covers the waste volumes and costs in thousands of gallons and thousand of dollars annually and over the ten year period. Costs do not include the 28% overhead figure which has been added to give the waste volume costs shown in the Table VI and Cost Summary - Table I. In Table III by "Gallons of Neutralized Evaporated Wastes" we mean the volume obtained by evaporating to the concentration at which crystals will first appear when the solution is cooled to 20° C.

To emphasize the potential gains or reduced costs obtainable by major reduction in volumes by techniques which would give a thick slurry or magma in the final storage vessel, we have included on the table volume and cost figures applicable to such conditions.

In waste storage costs, we have included the cost of existing, empty tanks. We consider the cost of such tanks to be written off or charged to the operation as these tanks are filled. At thirty-three cents per gallon this existing empty tankage amounts to $5,075,000 without overhead. This is in excess of the amount for black iron tanks charged to Proposals 5, 6, 7, and 10.

C. Cell Requirements

In order to get an accurate basis on which to estimate costs for new building construction, the cost of revising existing facilities and operating costs for each proposal was sketched out in cells to determine the space requirement for the proposal or the cells required. These cell requirements are shown on the attached drawing H-2-1671. These layouts are for detailing space requirements only and do not show the optimum arrangement of cells. Uranium and plutonium streams are shown and waste streams are shown only in the waste processing facilities.

D. Operating Costs

For a given proposal and cell layout as indicated in C above operating costs were determined (See Tables IV and V) in accordance with the following bases and procedure with example detailed for Proposal 5:

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TABLE III

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COMPARISON OF VOLUMES OF NEUTRALIZED EVAPORATED AND MAGMA WASTES

[redacted]

BASIS

1. Decontaminated uranium produced at rate of 4 metric tons per day.
   - a. Irradiated slugs to be processed at rate of two metric tons per day.
   - b. Stored metal waste to be depleted at rate of two metric tons uranium per day.
2. Decontaminated uranium produced as 60% UNH except in cases 1, 3 and 5 where fluorination to UF_6 is required for adequate decontamination. Volumes of waste produced by fluorination steps are not included, but are covered by fluorination cost estimates.
3. Cost of storing waste solutions estimated at $.33 per gallon for black iron lined tanks and $.55 per gallon for stainless steel lined tanks.
4. $BiPO_4$ process waste volumes include second cycle decontamination wastes now cribbed.
5. Concentrated volumes estimated for saturation at 20° C.
6. Final cycle wastes from solvent extraction processes assumed to be cribbed. (Total cribbed activity per ton U processed comparable with present 224 Bldg. wastes.
7. 2,840,000 gallons of black iron line storage emptied per year by metal recovery. Empty tanks refilled with uranium and plutonium recovery wastes but no credit assumed for tankage available after 1958 because of obsolescence.

GALLONS OF NEUTRALIZED EVAPORATED WASTES

In Thousands

COST In Thousands

Proposal	Total Gal. of Storage Per Year Black Iron	Total Gal. of Storage Per Year Stainless Steel	Years Req'd for Metal Recovery at 2 Ton Rate	Total Gal. Req'd From Jan. 1949 thru Dec.1958 Blk Iron	Total Gal. Req'd From Jan. 1949 thru Dec.1958 Stainl. Steel	Total Gal. Req'd per Year After 1958 Black Iron	Total Gal. Req'd per Year After 1958 Stainl. Stl.	Cost for Storage from Jan. 1949 Thru Dec. 1958 Black Iron	Cost for Storage from Jan. 1949 Thru Dec. 1958 Stainless Stl.	Total	Cost For Storage After 1958 Black Iron	Cost For Storage After 1958 Stanl. Stl.	TOTAL
1	5560		4.83	53349		4040		$17605	$	$ 17605	$ 1333	$	$ 1333
2	4960	1960	3.83	46306	12600	3740	980	15281	6930	22211	1234	539	1773
3	1910		6.83	31226		2926		10305		10305	966		966
4	1312	1960	5.84	25216	13560	2626	980	8321	7458	15779	867	539	1406
5	100	2480	6.08	13379	19240		2480	4415	10582	14997		1364	1364
6	-200	E-1240 W-2220	6.08	12771	E-10550 W-17140		1240 1240	4214	5803 9427	19444		1364	1364
7	-200	3460	5.58	12671	25178		2480	4181	13848	18029		1364	1364
8	764	E- 976 W-1956	5.84	19066	E-7820 W-13520	964	976 976	6292	4301 7436	18029	318	1074	1392
9	764	2932	5.84	19066	21340	964	1952	6292	11737	18029	318	1074	1392
10 E	-100	1730	5.34	5893	12781		1240	1945	7030	8975		682	682
10 W	382	1466	5.84	9154	10669	482	976	3024	5868	8892	159	537	696

NEUTRALIZED MAGMA WASTES

In Thousands

Proposal	Total Gal. of Storage Per Year Black Iron	Total Gal. of Storage Per Year Stainless Steel	Years Req'd for Metal Recovery at 2 Ton Rate	Total Gal. Req'd From Jan. 1949 thru Dec.1958 Blk Iron	Total Gal. Req'd From Jan. 1949 thru Dec.1958 Stainl.Steel	Total Gal. Req'd per Year after 1958 Black Iron	Total Gal. Req'd per Year after 1958 Stainl. Stl.	Cost for Storage from Jan. 1949 Thru Dec. 1958 Black Iron	Cost for Storage from Jan. 1949 Thru Dec. 1958 Stainless Stl.	Total	Cost for Storage After 1958 Black Iron	Cost for Storage After 1958 Stainl.Stl.	TOTAL
1	1068		4.83	25949		1438		$ 8563	$	$ 8563	$ 475		$ 475
2	704	288	3.83	19706	1700	1256	144	6503	935	7438	414	79	493
3	-1180		6.83	17679		1024		5834		5834	338		338
4	-1544	288	5.84	11786	1996	842	144	3889	1098	4987	278	79	357
5	-1790	398	6.08	12771	3084		398	4214	1696	5910		219	219
6	-1972	E-199 W-343	6.08	12771	E-1691 W-3481		E-199 W-199	4214	E- 930 W-1915	7059		109 109	218
7	-1972	542	5.58	11785	3955		398	3889	2175	6064		218	218
8	-1650	E-150 W-294	5.84	11786	E-1200 W-2039	322	E-150 W-150	3889	E- 660 W-1121	5670	106	83 83	272
9	-1650	444	5.84	11786	3239	322	300	3889	1781	5670	106	166	272
10 E	- 986	269	5.34	5893	2001		199	1945	1101	3046		109	109
W	- 825	222	5.84	5893	1620	161	150	1945	891	2836	53	83	136

Legend

	Neutralized Waste gal/ton	Neutralized Waste gal/ton/yr. in thousands	Neutralized Evaporated Waste gal/ton	Neutralized Evaporated Waste gal/ton/yr. in thousands	Neutralized Magma Waste gal/ton	Neutralized Magma Waste gal/ton/yr. in thousands
*A. UAP waste from 2 yr. old metal waste recovery	12,310	4,493	4,030	1,475	1,440	525
*B. UAP waste from current metal waste	8,285	3,024	2,500	913	872	318
*C. $BiPO_4$ waste from existing 200 A process	4,192	1,530	1,500	550	532	194
*D. $BiPO_4$ waste after solvent extraction process	4,012	1,464	1,320	482	442	161
*E. Metathesis waste from 2 yr. old metal waste recovery	7,900	2,884	3,620	1,320	1,190	434
*F. Metathesis waste from current metal waste recovery	3,875	1,414	2,088	763	622	227
G. Redox wastes	4,142	1,512	3,393	1,240	545	199
H. Solvent extraction wastes from current metal	3,297	1,203	2,678	976	412	150
J. Solvent extraction wastes after metathesis processes	1,760	642	1,341	490	197	72

*These wastes to be stored in black iron lined tanks because of the conversion of ammonium nitrate to sodium nitrate.

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Operating Expense - Work Sheet

Bases for the operating expenses of the ten proposals were formulated from present $BiPO_4$ plant practices and from the "Financial Statement and Operating Expense Report for the Six Month Period Ended June 30, 1948, Schedule 4-D-200-E Area Expenses and Schedule 4-E-200-W Area Expenses".

The total operating expense was broken down into the following accounts and the accounts computed according to the following bases for a one year period.

1. Production

Manpower requirement was estimated from process flow diagrams.

The cost was calculated by multiplying $4385 by the manpower. $4385 was based on $16/man day x 261 working days + 5% of this figure to cover production material (present ratio).

2. Technical - (a) Analytical

The number of required samples was estimated from process flow diagrams. From this figure the manpower was estimated as follows: 2 samples per analyst with a constant manpower figure of 30 for both areas, consisting of

8 dishwashers (1 per shift)
4 clerks
14 supervisors (1 per shift plus 3 day and relief supervisors per area)
4 relief analysts

All estimates were based on a laboratory for each area.

The cost was calculated by multiplying $3654 by the manpower. This figure includes technical materials per man according to present plant comparison.

(b) Plant Assistance

Manpower was estimated according to the present manpower and the complexity of the proposed plant. The cost was calculated by multiplying $4750 by the manpower.

3. HI Plant Assistance

Constant, assuming continuation of present cost. (Includes HI Plant Assistance and Radio Biology).

4. Patrol

It was estimated that approximately 138 men patrol the present $BiPO_4$ areas. Additional requirements were estimated as follows: All new buildings were assumed to be located close enough to present buildings so that the present plant enclosure fences could be extended to include the new construction. An increase of 6 patrolmen per area was required due to an increase of manpower. An increase of 15 patrolmen was required if U Plant and T Plant are operated simultaneously. 5 patrolmen were required for the guarding of an obsolete plant.

The cost was calculated by multiplying $3300 by the manpower.

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5. Safety and Fire Protection

Constant, assuming continuation of present cost.

6. Janitor and Laundry Service

The estimation was made on present cost plus the amount proportional to 50% of the increase in production manpower.

Present cost $\left(1 + 50\% \ \frac{\text{Future production manpower - Present}}{\text{Present production manpower}}\right)$ where present cost is $170,988 and present production manpower is 244 (2 areas).

7. Industrial Medical

It was estimated that the cost would increase in direct proportion to the increase in total manpower.

$$\frac{\text{Future manpower}}{\text{Present Manpower (1026)}} \times \$46,342$$

8. Health Instrument

Estimation of manpower was made as follows: (1) The present manpower requirements for two areas consist of 60 men for operation survey, site survey, and development for two areas. For additional operating buildings within the same plant enclosure 5 men were added for operating survey work. For additional operating areas 10 men were added for operating survey work. (2) Present manpower of 46 men are assigned to badges, pencils, and laundry survey. This requirement was estimated to increase in direct proportion to the increase in total manpower.

The cost was calculated by multiplying $3720 by the manpower.

9. Building and Equipment Maintenance

According to present cost figures approximately 70% of the total area maintenance is chargeable to the 221 and 224 Buildings. To obtain an estimated cost figure per operating 221 section or 224 cell this 70% of the total figure was divided by 36, the number of present operating sections or cells in 221 and 224, giving a figure of $14,550 for the maintenance cost for one section per year. Maintenance cost was assumed to be equivalent for one redox cell, one 221 section, or one 224 cell.

The cost was calculated by multiplying $14,550 by (total operating cells or sections - 36) plus the present maintenance cost figure, $748,614.

It was estimated that there are 160 maintenance men in both areas at present. An additional operating cell or section over 36 will require 2 additional maintenance men, according to present proportions of manpower and material cost requirements.

10. O.L., Substations, R & F Lighting

Constant, assuming continuation of present cost.

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11. Grounds Maintenance

Constant, but greater than present cost by 17%. This percentage figure was obtained by estimating the increase in East Area's cost by 10%, due to the enlarging of the present plant, and the increase in West Area's cost by 25%, due to the activation of U Plant. Present cost is $26,114.

12. Shops, Tools, and Supplies

Assuming a direct relationship between Shops, Tools, and Supplies Costs to Building and Equipment Costs, this estimation was made by taking 30% of the Building and Equipment Maintenance cost according to the present cost ratio of the two accounts.

The manpower requirements for this account was estimated as 1 man per $10,000 according to the present ratio of manpower and material cost of this account.

13. Process Material Handling

The estimation was made by multiplying the cost of process material by .006 according to the present ratio of the cost of process material to process material handling.

14. Clerical

Estimation was made on present cost plus the amount proportional to 50% of the increase of the total manpower.

$$\text{Present cost } \left(1 + 50\% \ \frac{\text{Future manpower} - \text{Present manpower}}{\text{Present manpower}}\right)$$

where present cost is $71,236 and the present total manpower is 1026 (2 areas)

15. Roads, Streets, and Walkways

Estimation was made on the same basis as Grounds Maintenance.

16. Idle Time

This account consists of time spent by the service departments (chiefly maintenance and instruments) during travel to the job or between areas, waiting on Special Work Permits, clean up, and other miscellaneous jobs. Assuming a direct relationship between maintenance manpower and idle time, this estimate was made by taking 11% of the maintenance manpower according to the present ratio of salaries of the two accounts.

The cost was calculated by multiplying $4200 by the manpower.

17. Meeting Time

It was estimated that the cost would increase in direct proportion to the increase in total manpower.

$$\frac{\text{Future manpower}}{\text{Present manpower (1026)}} \times \$11,502$$

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18. Transporting Personnel

It was estimated that the cost would increase in direct proportion to the increase in total manpower.

$$\frac{\text{Future Manpower}}{\text{Present Manpower (1026)}} \times 50,492$$

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19. Process Material

20. Power Expenses

It was estimated that the present power expenses are distributed as follows: 50% to cell and gallery requirements, and 50% to the requirements of the remainder of the area. To obtain an estimated cost figure per operating 221 section or 224 cell this 50% of the total figure was divided by 36, the number of present operating sections or cells in 221 and 224, giving a figure of $9725 for the power cost for one section per year.

The cost was calculated by multiplying $9725 by (total operating cells or sections - 36) plus the present power cost figure, $700,100.

It was estimated that there are 86 power men in both areas at present. Five additional men were estimated to be required per new building for air conditioning. Area power house requirement for the additional load was estimated at two additional men per shift per power house and two additional men on day shift.

21. Purchased Electricity

The present electrical expense distribution for the $BiPO_4$ areas is approximately 32% Air Conditioning, 5% Centrifuges, 16% Process Motors, and 47% other area requirements. Therefore, it was estimated that 50% of the present cost was relative to cell area. Dividing this 50% cost figure by 36, the number of sections or cells operating, $1585 was obtained as the cost figure per operating section.

The present electrical cost was obtained by using the present electrical cost $88,034, plus $1585 x (total operating cells or sections - 36).

22. Administrative and General Expense

This expense is distributed according to total salaries in the areas of the plant. Since it was impractical to break down the above 21 accounts into salaries and material cost, the total direct expense minus the process material cost plus the total power expense minus the power process material was obtained. The present expenses were likewise totaled and compared to the administrative and general expense that was charged. A ratio of 90% was obtained. Therefore, 90% of the above total was used for the estimation of this account.

23. 231 Building

In order to obtain a 2-T capacity cost figure for the operation of this building from present capacity and cost figures of approximately 3 Tons an estimation of the reduction of labor, technical, and process material costs indicated it to be 90% of pres st figures.

24. 200-N Area

Constant, assuming continuation of present cost.

25. Meteorological Tower

Constant, assuming continuation of present cost.

Present Manpower in One $BiPO_4$ Area (Based on salaries reported in Cost Statement)

	Estimated from Financial Summary	Estimated from Process Requirement	
Production			
Technical	122	Estimated	122
Patrol	44	Estimated	44
HI	69	Estimated	69
Maintenance	53	Estimated	30
Janitor and Laundry	99	Estimated	99
Clerks	22		
Power	10		
Transportation	43	Estimated	43
Process Material Handling	21		
Industrial Medical	1	Estimated	1
Idle Time	8		
Safety and Fire	13	Estimated	13
	8	Constant	8
	513 TOTAL		429

A total manpower figure is required for the cost estimations of several of the 21 accounts. Those manpower figures which can be estimated comprise 83.6% of the total manpower of the present $BiPO_4$ process. It is felt that the remaining manpower would vary in proportion to the estimated portion of the manpower. Therefore, the total manpower for a proposal is obtained by estimating those portions which can be estimated and dividing the sum by 0.836.

$$\frac{\text{Constant + Estimated}}{\text{Total Manpower}} \quad \frac{429}{513} = 0.836$$

Sample Requirement Estimates

2T	S. E.		
2T	UAP Metathesis	13 hot samples	13 cold samples
1T	SE Coupling	9 hot samples	2 cold samples
1T	UAP Metathesis	5 hot samples	2 cold samples
1T	SE	5 hot samples	2 cold samples
1T	$BiPO_4$	13 hot samples	13 cold samples
1T	$BiPO_4$ minus Extraction	24 hot samples	11 cold samples
1T	Redox	19 hot samples	10 cold samples
2T	UAP	57 samples as per detailed in Report on Redox Estimate	
2T	F_2	15 hot samples	2 cold samples
1T	F_2	5 hot samples	15 cold samples
1T	UAP	5 hot samples	10 cold samples
		9 hot samples	2 cold samples

Above estimates are the sample requirements per day with consideration to process flow diagram, batch control, and product accountability.

Total sample requirement per proposal was obtained by the addition of the above various components which make up the proposal.

Exhibit A which follows on the next 3 pages, is a typical work sheet made for the cost estimations of all of the proposals. The work sheet for Proposal #5 was chosen as the example.

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TABLE IV

ANNUAL OPERATING EXPENSES DURING METAL RECOVERY PERIOD

		BLDG. - I T.	Proposal #1	Proposal #2	Proposal #3	Proposal #4	Proposal #5	Proposal #6	Proposal #7	Proposal #8	Proposal #9	Proposal #10	Metal Waste Dissolution 2T/Day	Transportation 2T/day per ½ year	UF_6 to UF_4 Conversion 2T/Day
	DIRECT EXPENSES														
L	Production	142,399	2,491,000	2,253,890	2,631,000	2,253,900	1,986,405	1,815,390	1,745,230	2,192,500	1,859,240	1,802,235	17,540	4,385	52,620
L	Technical	126,816	410,708	386,592	410,708	386,592	458,840	425,324	386,592	443,594	404,862	393,900	3,300		21,924
L	H I Plant Assistance	1,147	2,240	2,240	2,240	2,240	2,240	2,240	2,240	2,240	2,240	2,240			
S	Patrol	228,828	508,200	508,200	508,200	508,200	528,000	528,000	495,000	528,000	495,000	495,000	16,500		
S	Safety and Fire Protection	28,470	56,940	56,940	56,940	56,940	55,940	56,940	56,940	56,940	56,940	56,940			
L	Janitor and Laundry Service	80,939	295,725	265,590	295,725	265,590	243,960	230,550	224,940	260,687	234,050	229,853	2,800		4,200
S	Industrial Medical	20,912	78,862	70,600	78,862	70,600	59,794	65,270	61,070	72,272	65,000	63,283	587		903
L	Health Instrument	189,722	550,560	520,800	550,560	520,800	550,560	539,400	487,320	565,440	502,200	494,760	3,720	1,860	
L	Bldg. and Equip. Maintenance	318,161	1,709,214	1,403,364	1,709,214	1,403,364	1,345,152	1,199,664	1,126,914	1,403,364	1,301,514	1,211,014	12,500	500	7,275
S	O. L. Substations, R & F. Lighting	11,410	11,410	11,410	11,410	11,410	11,410	11,410	11,410	11,410	11,410	21,410			
S	Grounds Maintenance	13,047	30,530	30,530	30,530	30,530	30,530	30,530	30,530	30,530	30,530	30,530	1,500		
L	Shop, Tools and Supplies	95,188	512,764	421,009	512,764	421,009	403,549	359,899	338,074	421,009	370,454	363,304	2,750	150	2,700
R	Process Material Handling	2,981	20,349	21,138	18,260	19,644	15,365	15,759	15,759	18,440	18,440	17,100		10,500 (Train Crew)	3,300
L	Clerical	33,864	96,230	89,912	96,230	89,912	87,691	85,746	82,552	91,152	85,607	84,288			
S	Roads, Streets and Walkways	591	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400			
L	Idle Time	46,322	159,600	134,400	159,600	134,400	130,200	117,600	109,200	134,400	126,000	121,800	1,050		
L	Meeting Time	5,190	19,573	17,521	19,573	17,521	17,073	16,198	15,156	17,936	16,131	15,705	140		200
L	Transporting Personnel	22,785	85,921	76,915	85,921	76,915	74,947	71,108	66,531	78,736	70,813	68,943	540		984
R	Process Materials	496,787	3,391,580	3,522,980	3,043,370	3,224,050	2,560,840	2,626,540	2,626,540	3,073,300	3,073,300	2,849,920			-80,102
	TOTAL DIRECT EXPENSE	2,166,979	10,572,808	9,795,431	10,222,507	9,545,007	8,573,186	8,198,958	7,883,398	9,403,360	8,745,131	8,313,625	64,033	17,395	14,004
L	TOTAL POWER EXPENSES	350,046	1,341,953	1,137,725	1,341,950	1,137,725	1,098,825	1,001,575	952,950	1,137,725	1,069,657	1,011,300	3,300		4,800
	OTHER EXPENSES														
L	Purchased Electricity	44,017	192,644	159,359	192,644	159,359	153,019	137,169	129,244	159,359	148,264	138,754	500		700
S	Administrative and General Expense	1,660,604	6,901,583	6,083,685	6,899,703	6,082,341	5,887,391	5,491,465	5,156,010	6,173,334	5,543,127	5,355,814	59,115	15,655	90,455
L	231 Building	424,585	849,170	849,170	849,170	849,170	849,170	849,170	849,170	849,170	849,170	849,170			
L	200 N Area	113,404	226,808	226,808	226,808	226,808	226,808	226,808	226,808	226,808	226,808	226,808			
S	Meteorological Tower	24,873	49,746	49,745	49,746	49,746	49,746	49,744	49,746	49,746	49,745	49,716			
	TOTAL OTHER EXPENSES	2,267,483	8,219,951	7,368,768	8,218,071	7,367,424	7,166,134	6,754,358	6,410,978	7,458,417	6,817,115	6,620,292	59,615	15,655	91,155
	TOTAL AREA EXPENSES	4,784,407	20,134,707	18,301,924	19,782,528	18,050,156	16,838,145	15,945,901	15,247,326	17,999,502	16,631,896	15,945,217	126,948	33,050	109,959
	TOTAL MANPOWER REQUIREMENT	463	1,746	1,563	1,746	1,563	1,523	1,445	1,352	1,600	1,439	1,401	13	9	20
R	RAW MATERIALS	499,768	3,411,929	3,544,118	3,061,630	3,293,694	2,576,205	2,642,299	2,642,299	3,091,740	3,091,740	2,867,020	0	10,500	95,403
L	LABOR, REPAIRS, POWER	2,295,904	9,084,107	7,945,295	9,084,107	7,945,295	7,627,729	7,077,841	6,742,921	7,984,130	7,287,003	7,014,074	49,246	6,895	-76,802
S	OVERHEAD, SECURITY	1,988,735	7,638,671	6,812,511	7,636,791	6,811,167	6,634,211	6,234,761	5,862,106	6,923,632	6,253,153	6,064,123	77,702	15,655	91,358
T	TOTAL AREA EXPENSE	4,784,407	20,134,707	18,301,924	19,782,528	18,050,156	16,838,145	15,945,901	15,247,326	17,999,502	16,631,896	15,945,217	126,948	33,050	109,959

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TABLE V

ANNUAL OPERATING EXPENSES - 1959 and AFTER

HW-12348

		Proposal #1	Proposal #2	Proposal #3	Proposal #4	Proposal #5	Proposal #6	Proposal #7	Proposal #8	Proposal #9	Proposal #10
	DIRECT EXPENSES										
D	Production	2,227,590	2,025,870	2,227,590	2,025,870	1,118,870	1,118,870	1,118,870	1,525,980	1,525,980	1,337,425
L	Technical	361,014	368,322	361,014	368,322	346,398	346,398	346,398	364,668	364,668	357,360
U	H I Plant Assistance	2,240	2,240	2,240	2,240	2,240	2,240	2,240	2,240	2,240	2,240
S	Patrol	508,200	508,200	508,200	508,200	495,000	495,000	495,000	495,000	495,000	495,000
S	Safety and Fire Protection	56,940	56,940	56,940	56,940	56,940	56,940	56,940	56,940	56,940	56,940
L	Janitor and Laundry Service	263,490	247,370	263,490	247,370	177,295	177,295	177,295	206,020	206,020	192,711
S	Industrial Medical	69,155	66,490	67,155	66,495	50,906	50,906	51,494	57,908	58,224	54,881
S L	Health Instrument	517,080	505,920	517,080	505,920	450,120	450,120	450,120	472,140	476,160	461,280
L	Building and Equipment Maintenance	1,316,064	1,301,514	1,316,064	1,301,514	865,014	865,014	923,214	1,068,714	1,097,814	1,010,514
S	O. L. Substations, R. & P. Lighting	11,410	11,410	11,410	11,410	11,410	11,410	11,410	11,410	11,410	11,410
S	Grounds Maintenance	30,530	30,530	33,530	30,530	30,530	30,530	30,530	30,530	30,530	30,580
L	Shop, Tools, and Supplies	394,819	390,454	394,819	390,454	259,504	259,504	276,964	320,614	329,344	303,154
R	Process Mat'l. Handling	13,155	13,250	12,066	12,056	8,171	8,171	8,171	10,852	10,852	9,511
L	Clerical	88,800	86,718	88,800	86,718	74,776	74,776	75,193	80,122	80,400	77,831
S	Roads, Streets, and Railways	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,403
L	Idle Time	126,000	126,000	126,000	126,000	93,240	93,240	96,660	109,200	113,400	105,000
L	Meeting Time	17,163	16,512	17,163	16,512	12,634	12,634	12,779	14,371	14,450	13,620
L	Transporting Personnel	75,341	72,486	75,341	72,486	55,460	55,460	56,099	63,087	63,432	59,790
R	Process Materials	2,192,555	2,258,255	1,844,345	2,009,325	1,361,852	1,361,852	1,361,852	1,808,575	1,808,575	1,585,214
	TOTAL DIRECT EXPENSE	8,272,936	8,090,181	7,022,637	7,839,757	5,501,760	5,501,760	5,582,569	6,703,071	6,746,839	4,165,811
L	Total Power Expense	1,079,375	1,069,650	1,079,375	1,069,650	777,900	777,900	816,800	914,050	933,500	875,190
	OTHER EXPENSE										
L	Purchased Electricity	149,849	148,264	149,849	148,264	100,714	100,714	107,054	122,904	126,074	116,564
O	Administrative and General Expense	5,910,822	5,687,213	5,908,941	5,685,867	4,164,399	4,164,399	4,237,125	4,840,826	4,882,917	4,561,017
L	231 Building	849,170	849,170	849,170	849,170	849,170	849,170	849,170	849,170	849,170	849,170
L	200N Area	226,808	226,808	226,808	226,808	226,808	226,808	226,808	226,808	226,808	226,808
S	Meteorological Tower	49,746	49,746	49,746	49,746	49,746	49,746	49,746	49,745	49,746	49,746
	TOTAL OTHER EXPENSE	7,186,395	6,961,201	7,184,514	6,959,855	5,390,837	5,390,837	5,469,903	6,089,454	6,131,715	5,803,305
	TOTAL AREA EXPENSE	16,538,706	16,121,032	16,186,526	15,869,262	11,670,497	11,670,497	11,869,272	13,703,575	13,815,054	12,844,266
	TOTAL MANPOWER REQUIREMENT	1,531	1,473	1,531	1,473	1,127	1,127	1,140	1,282	1,289	1,215
R	Raw Materials	2,205,710	2,272,805	1,855,411	2,021,381	1,370,023	1,370,023	1,370,023	1,819,427	1,819,427	1,594,725
L	Labor, Repairs, Power	7,694,793	7,437,298	7,694,793	7,437,298	5,440,143	5,440,143	5,565,604	6,340,388	6,409,460	5,988,617
S	Overhead, Security	6,638,203	6,411,929	6,636,322	6,410,583	4,860,331	4,860,331	4,933,645	5,543,760	5,586,167	5,260,924
T	TOTAL AREA EXPENSE	16,538,706	16,121,032	16,186,526	15,869,262	11,670,497	11,670,497	11,869,272	13,703,575	13,815,054	12,844,266

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EXHIBIT A 17
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Work Sheet for Cost Estimations - Proposal No. 5

1. Plants and Cells in Operation

Two 1T Redox Plants
One 2T UAP Plant
One 2T Fluorination Plant

Total of 77 cells operating during metal recovery period
Total of 44 cells operating 1959 and after

2. Production Manpower - 1T. Redox Plant

Shifts 6 Supervisors (1 Sr. 5 Shifts (1) Dissolver & Feed Prep 3)2nd & 3rd U
(2) 1A to 1C 4)2nd & 3rd Pu
5) Waste & Hexone Recovery

1 Chief Operator
3 Samplers
1 Dispatcher
2 Chem. Makeup
1 Crane Operator
1 Metal Sol'n. Prep.
1 1A & Oxidizer
1 1B & 1C
1 1CU concentrator & 2D-2E
1 3D-3E & 2E-3E Concentrators
1 Cross over oxidizer & 2A-2B
1 3A-3B
1 3 BP Evaporator - Greenhouse
1 Hexone Recovery
2 Waste Neutralization
1 Rework Streams
3 Relief
29 per shift - 116 Total shifts.

Days

3 Top Supervisors
3 Special Assignment Supervisors
1 Numbers Man
1 Contaminated Waste Man
6 Relief Operators
1 Clerk
15 Total days

131 Total Manpower per 1T Redox

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Production Manpower - 2T UAP and Fluorination Plants

UAP to Wet UAP Cake

Shifts

3	Supervisors
1	Chief Operator
1	Dispatcher
1	Crane Operator
12	Centrifuge and Ppt'n. Operators
2	Waste Handling Operators
2	Chemical Make up
2	Samplers
4	Relief Operators
28	per shift - 112 total shift.

Fluorination Plant

Shifts

2	Supervisors
1	Chief Operator
3	Tube Operators
1	Waste Handling
1	Sampler
1	Tray Washing & charging
1	UF_6 Handling
2	Relief
3	Fluorine Mfg. Operators
15	per shift - 60 total shift.

Day Crew

3	Top Supervisors
3	Special Assignment Supervisors
1	Clerk
1	Numbers Man
1	Concentrated Waste
10	Relief Operators
19	Total days

191 Total Manpower for 2T UAP and Fluorination

Total Production Manpower Requirements - Proposal 5 453

Total Production Manpower Requirements 1959 and after

2 - 1T Redox Plants 262 Total Men

3. Technical Requirements

a) During Metal Recovery Period

114 + 20 + 17 = 151 total samples ≈

75	analysts
30	constant
8	Plant Assistance
113	Total

b) 1959 and after

114 Total samples ≈

57	analysts
30	constant
6	Plant Assistance
93	Total

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4. Total Manpower Requirements

Manpower	During Metal Recovery	1959
Production	453	262
Technical	113	93
Patrol	160	150
HI	80	70
Bldg. & Equip. Maintenance	242	176
Grounds Maintenance	8	8
Shops, Tools, & Supplies	40	26
Power	126	116
Process Mat'l Handling	4	3
Idle Time	31	22
Safety and Fire Protection	16	16
	1,273 Estimated	942 Estimated
÷ 0.836	1,523 Total	1,127 Total

5. Metal Waste Dissolution

Estimated cost figure on operations of the dissolution on a one shift basis - five days a week.

For proposal 5 the metal waste would be dissolved in one area and transported to the plant site.

a. Production Manpower Requirement

1 Supervisor
1 Nozzle and crane operator
2 Operators
4 Total

b. Total Manpower Requirements

Production	4
Technical	1 (2 samples/day)
Patrol	5
Maintenance	2
Laundry,Shops,etc	1
	13 Total per area.

6. Dissolved Metal Waste Transportation

Transportation by tank car will be needed for half of the total metal waste recovery, the other half of the metal work being in the same area as the plant. Therefore, the cost is added at a ½ year operating basis in the operating expense report.

Total Manpower Requirements

Train Crew	5
Production(Load and Unload)	2
HI	1
Maintenance	½
	8½

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Unit Costs for Coversion of 60% UNH to UF_6

		Cost/#U
60% UNH to UO_3	2.5¢/#UO_3	3.0¢/#
UO_3 to UO_2	2.5¢/#UO_2	2.84¢/#
UO_2 to UF_4	30¢/#UF_4	39.6¢/#
UF_4 to UF_6	60¢/#UF_6	88.7¢/#
		$1.34/#U

$2,152,040/year for 2 Ton Uranium
Above figures obtained from Sturgess, A. E. C.

1949 to 1958 Period Breakdown According to Processes in Operation

	PROPOSALS									
Years of Operation	1	2	3	4	5	6	7	8	9	10
Before Metal Recovery	3	2	3	2	2.25	2.25	2.25	2.00	2.00	2.00
During Metal Recovery	4.84	3.84	6.84	5.84	6.08	6.08	6.08	5.84	5.84	5.84
After Metal Recovery	2.16	4.16	0.16	2.16	1.67	1.67	1.67	2.16	2.16	2.16

E. Construction Comparisons

The attached Chart I - Construction Comparisons shows the constructions required for each proposal by areas and indicates the use made of existing facilities wherever possible.

F. Construction Costs

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TABLE VII

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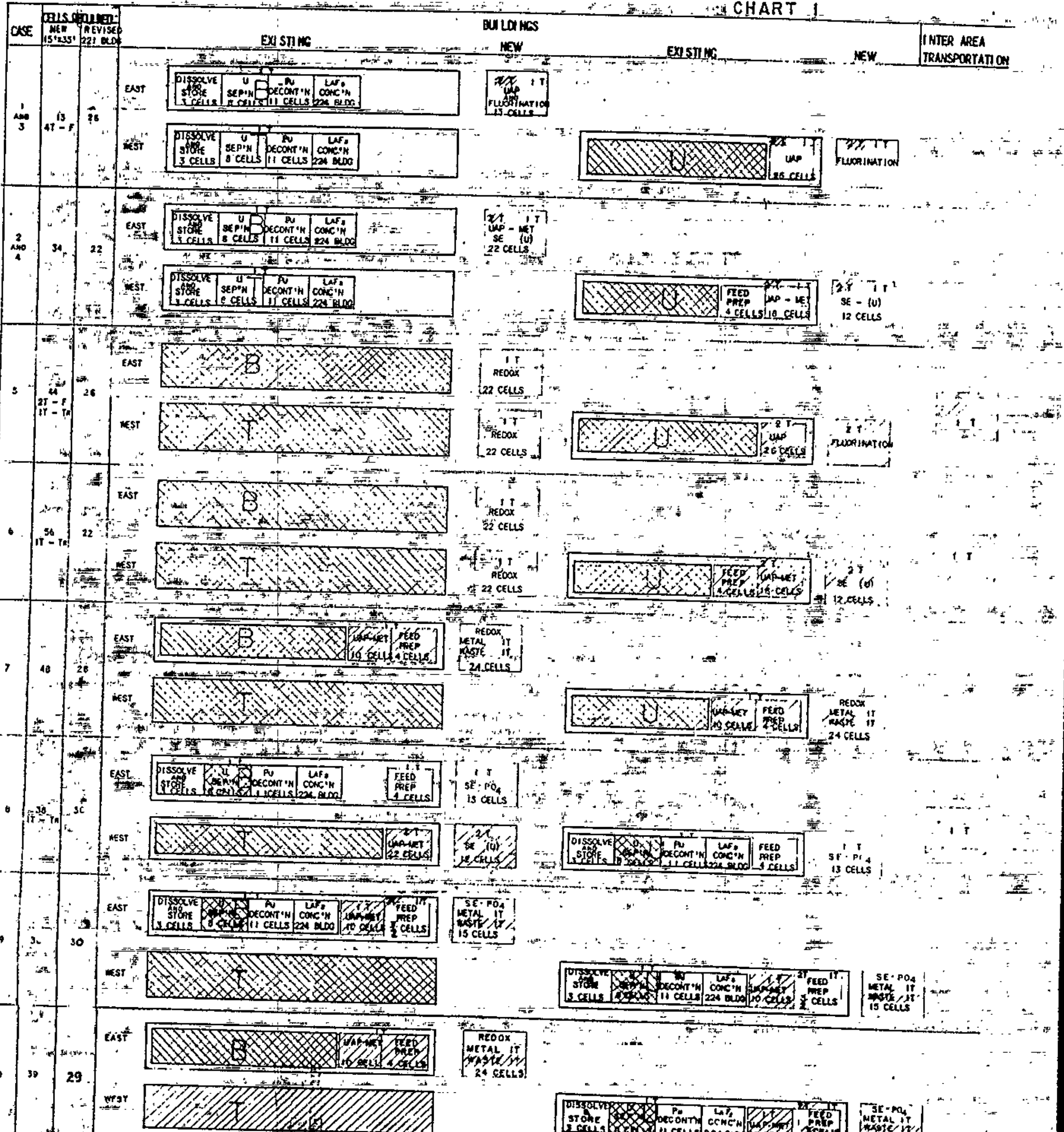
CONSTRUCTION COMPARISON

CHART 1



NOTE: BUILDING UNITS SEPARATED BY NARROW SPACE CONTAIN [illegible] OPERATIONS MAKING MINIMUM SEPARATION DESIREABLE.

LEGEND:
F – FLUORINATION FACILITIES
T – TONS URANIUM DAILY CAPACITY
Tr– TRANSPORTATION FACILITIES

CROSS HATCHING – SINGLE INDICATES OBSOLESCENCE AFTER STORED URANIUM HAS BEEN RECOVERED.
DOUBLE INDICATES OBSOLESCENCE AFTER REPLACEMENT UNIT IS IN OPERATION.

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BASIC PREMISES CONCERNING CONSTRUCTION COST ESTIMATES

Two methods were considered: (1) a detailed approach involving cell layouts in sufficient detail to permit determination of the number of instrument lines, transfer lines, jets, water lines, steam lines, etc.; (2) a generalized approach reducing processes to comparative equipment layouts which would then be costed using a suitable common variable. The latter approach was chosen as being the only one practicable within the time limits set for this study.

Following the choice of the second method of cost derivation various factors for relating construction costs were checked. It was found that the usual factors of square footage and cubic footage for the structure did not accurately reflect the major cost changes associated with variations in the cell part of the structure. Accordingly it was felt that the square footage of shielded cell area would be a more suitable primary variable for comparative cost estimation purposes for UAP, solvent extraction, Redox and S. E. - $BiPO_4$ processes. It was recognized that the use of shielded cell area might introduce some error into the cost figure for a fluorination plant since this process is somewhat foreign to the other processes considered. However, considering the construction cost of a fluorination plant relative to the entire picture (construction, operation and material cost) and the relatively sketchy factual data relative to "hot" fluorination, it was felt that the limit of error in the fluorination estimate would not justify a more detailed study.

In view of the costly basic facilities (crane, large reinforced concrete outer structure, complex galleries, etc.) included in any canyon structure it is clear that costs per square foot should be related to the size of the unit considered. Kellex cost estimates on the Redox production plant and the Redox test plant combined with an adjusted construction cost for the present canyon buildings were used to determine the canyon construction cost trend curve shown in Exhibit B, and the data shown in Exhibit C for cost of various sizes of cell structures. The derivation of this curve will be discussed under the following headings:

(1) Redox Production Plant

(2) Present Canyon Structures

(3) Redox Test Plant

Redox Production Plant

Document INDC-2338 gives an estimated cost of $26,750,000 for the cost of the canyon portion including 25% overhead and 10% contingencies. Included in this structure are 30 cells each 15.5 feet wide by 35 feet long with a 37 foot depth aggregating 16300 square feet of shielded cell space. All cost curves were prepared including contingencies, 6% spare cells or 2 in 30, a cell depth of 37 feet or the actual depth of the Redox production cell and no overhead allowance. On this basis the cost per square foot of shielded cell area was calculated as follows:

$$\frac{26{,}750{,}000 \times \frac{110}{135} \times 1.06}{16{,}300} = \$\ 1{,}420/ft^2$$

Included in this cost figure is the equipment and controls for all canyon operations as well as the complete canyon structure.

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Present Canyon Structures (221)

Data obtained from the cost group of the AEC at Hanford Works indicate an actual canyon construction cost of \$9,300,000 exclusive of overhead charges. The present canyons include 40 cells each 13 feet wide by 17.6 feet long and 22 feet deep aggregating 9,200 sq. ft. of shielded cell area. In order to make this building cost comparable with the Redox production plant it is necessary that funds be included for comparable service facilities (regulated shop, decontamination cell, air cell, etc.) also related equipment in Bldgs. 271 & 291. In addition it will be noted that the present cells are 22 feet deep whereas the Redox production plant cells are 37 feet deep which will require an additional correction factor. The sum of these adjustments (additional service facilities, solution preparation, deeper cells, etc.) is 13%.

Since the present buildings were constructed in 1943--1944, it is necessary that a correction factor be applied to the actual cost to bring it into line with current experience. The Engineering News Record Index is considered a good general index of construction cost and was used in this instance. The yearly ENR figures are as follows:

1940---242
1941---257
1942---276
1943---289
1944---299
1945---308
1946---346
1947---413
1948---460

The ratio of the 1948 figure (460) to the 1944 figure (299) is 1.54. This ratio was used for adjusting 1943 and 1944 costs to current levels. The overall calculation including all corrections was made as follows:

$$\frac{9,300,000 \times 1.13 \times 1.54}{9,200} = \$1,760/ft^2$$

Redox Test Plant

Document INDC-2338 gives an estimated cost of \$11,200,000 for the cost of the canyon portion including 25% overhead and 10% contingencies. Included in this structure are 14 cells each 8.5 feet wide by 24 feet long with an eighteen foot depth aggregating 2850 square feet of shielded cell space. All cost curves were prepared including contingencies, 6% spare cells, a cell depth of 37 feet (the actual depth of the Redox production cell) and no overhead allowance. On this basis the cost per square foot of shielded cell area was calculated as follows:

$$\frac{11,200,000 \times \frac{110}{135} \times 1.06 \times 1.08}{2850} = \$3680/ft^2$$

Included in this cost figure is the equipment and controls for all canyon operations as well as the complete canyon structure.

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Conversion of Existing Cells

Since the UAP metathesis and the UAP process include extensive centrifugation it is clear that existing cells in 221 T, U, B may be converted to this service. In the various proposals both "hot" and "cold" conversion's are included--the cold cells being in "U" building. The following cost schedule was used for these conversions:

Metathesis Conversions - Cold

Solid Bowl centrifuges with present tanks	$20,000/cell
Perforate & solid bowl centrifuges with new tanks	$70,000/cell
Feed preparation cell	$50,000/cell

UAP Conversions - Cold

Solid bowl centrifuges with approximately 50% new tanks	$40,000/cell
Perforate and solid bowl centrifuges with 60% new tanks	$50,000/cell

In the event of a "hot" cell conversion a uniform allowance of $20,000/cell was added to cover cost of cleaning and possible equipment or jumper discards necessary as a result of the contamination. In all cases existing piping in concrete is considered adequate.

Construction Cost for the Manufacture of Uranium Hexafluoride

The chemical conversion of UAP precipitate to uranium hexafluoride for purposes of decontamination requires canyon type construction since this is a "hot" reaction. In essence, the present cold method of manufacture was put in the thick concrete shielding of a canyon and the canyon cost curve applied to the enclosed area to determine total cost.

Present operating conditions as supplied by the AEC are listed as follows:

Hydrofluorination Reaction (reagent HF)

A 20 feet long hydrofluorination tube operating at a high temperature, (above 500°F), converts 340#/day of uranium from the UAP form to UF_4. The tube diameter is 12". The precipitate is charged wet in 30" long magnesium boats each holding approximately 42.5# of uranium. The treatment time is 24 hours.

Fluorination Reaction (reagent F_2)

A 20 foot long fluorination tube operating at a high temperature, (above 500°F), converts 340#/day of uranium from the UF_4 form to UF_6. The tube is identical in size with the hydrofluorination tube and receives the boats of UF_4 discharged from the former reaction. The treatment time is 24 hours.

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The 12" reaction tubes were spaced 3' apart (center to center) to allow for outer heating elements, insulation and remote connections and fastenings. The length of the reaction unit was determined as follows:

Extruder for UAP Cake	10'
Feed Mechanism for Hydrofluorination retort	10'
Hydrofluorination Retort	20'
Purge chamber & feed for fluorination retort	10'
Fluorination retort	20'
Copper Wool Barrier	5'
Air Cleaning Facilities	5'
TOTAL LENGTH	80'

80' length x 3' center to center x 13 tubes in parallel is 3120 sq. ft. for a 2 ton/day unit. At $3400 per sq. ft. the cost is $11,000,000 for the basic canyon structure. The addition of $3,000,000 was made to cover vent scrubbers, fluorine supply, pilot development, service area, sand filter, waste storage, supporting facilities and a cell mock up. The total cost of a 2 ton per day (uranium basis) plant was then considered as $14,000,000.

As mentioned above, the $14,000,000 figure is based on utilizing the present cold process. Studies now in progress show evidence that improvement in time cycle with resultant smaller plant may be possible with the use of a vibrating reactor.

Overhead Costs

All construction cost data include labor, materials and contingencies. Overhead has been added as a 28% lump sum which may be broken down as follows:

18%	construction
8%	general
2%	camp and hospital.

The above breakdown was prepared for use in the project covering the Redox laboratory and is considered applicable for purposes of this study.

It should be emphasized that development, village expense, engineering, and test plant costs have not been considered in the cost data for this report.

Waste Removal System Costs

The mechanical arrangement proposed is that included in Kellex Job 11 Report KLX-12. The Kellex estimate is also being used. It should be noted, however, that while Kellex proposes to dissolve the sludge chemically within the tanks, it is proposed herein to slurry the sludge and pump the slurry to settling tanks. Funds for settling tanks (2-50,000 gallon tanks for each tank farm) and acid storage equipment were included. Tank pumping, settling and dissolving totals $1,325,000 for each of East and West Areas.

Solution Transfer Costs

Transfers of present stored wastes will be by encased lines where area boundaries are not passed. Transfers of present stored waste by tank car is proposed where transfer between East and West Areas is required. An interarea tank car system is estimated t o cost $1,000,000 which is subdivided as follows:

4 - tanks of stainless steel with required concrete shielding @$125,000 each	$ 500,000
3 - tank car loading spots in East Area @$100,000 each	300,000
4500' trackage in East Area @ $20/foot	90,000
West Area trackage repairs	50,000
Contingencies	60,000
TOTAL	$1,000,000

Present main line trackage would be used for the actual transfer.

The alternative to tank car hauling would be an encased line between areas at an approximate cost of $3,500,000. It was felt that provision of suitable tank cars would avoid this extra cost. In the event the stainless steel tanks were made of heavy metal (better than 1" thick) and of adequate size for a generous air space safe transit should be assured.

Cell Requirements - Costs

The number of new or converted cells is shown in Chart I. These data were converted to cost through application of the factors shown in Exhibit B and by use of the data shown under "Conversion of Existing Cells".

Service Area Costs

A figure of $450,000 was used for service area construction (labor, material, and contingencies) in all instances. This figure is derived from the Kellex estimates on the service area for the Redox production plant and the test plant. These designs indicate the cost of the service area to be relatively constant for all except very small plants such as the test unit.

Supporting Facilities

The breakdown on the supporting facilities costs are shown in Exhibit D with all proposals listed. The basic costs are derived from Kellex figures.

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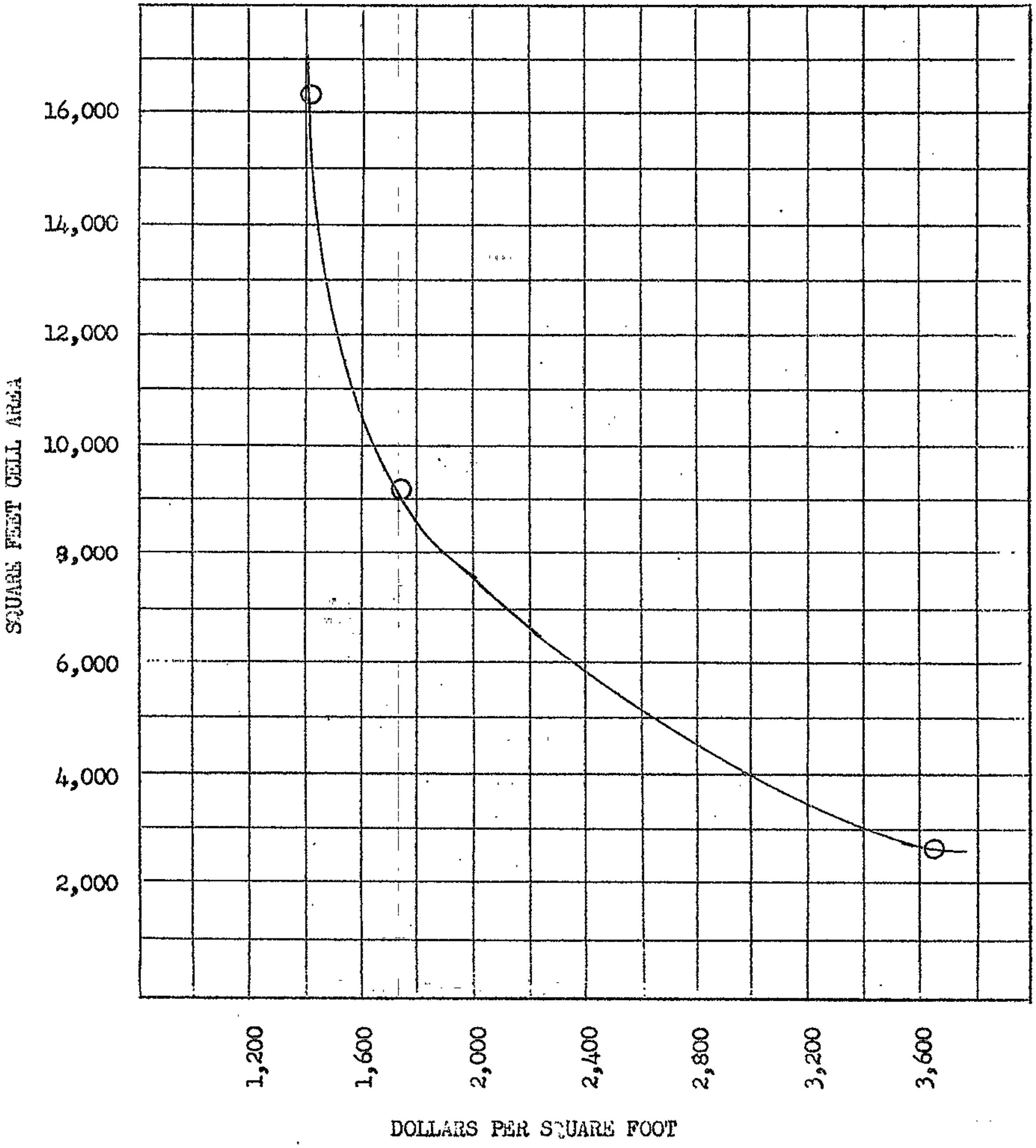
EXHIBIT B

COST PER SQUARE FOOT SHIELDED CELL AREA

Canyon Portion Process Building



Including vessels, piping in concrete, instrumentation and all other necessary services for a standard Redox Production Plant cell

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EXHIBIT C

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COST OF NEW PROCESS BUILDINGS

Based On Number of Standard Cells
15.5' x 35' x 37'

Number of Cells	Square Feet Cell Area	Cost Per Square Foot	Building Cost
7	3,800	$3,100	$11,750,000
8	4,350	2,900	12,600,000
9	4,900	2,700	13,200,000
10	5,420	2,525	13,700,000
11	5,950	2,400	14,300,000
12	6,500	2,250	14,600,000
13	7,050	2,100	14,800,000
14	7,600	2,000	15,200,000
15	8,150	1,900	15,450,000
16	8,700	1,825	15,850,000
17	9,200	1,765	16,200,000
18	9,750	1,700	16,550,000
19	10,300	1,650	17,000,000
20	10,900	1,600	17,500,000
21	11,400	1,550	17,700,000
22	11,950	1,520	18,200,000
23	12,500	1,500	18,800,000
24	13,000	1,485	19,300,000
25	13,550	1,460	19,800,000
26	14,100	1,440	20,300,000
27	14,700	1,425	20,950,000
28	15,200	1,425	21,700,000
29	15,800	1,420	22,400,000
30	16,300	1,410	22,900,000
31	16,900	1,400	23,650,000
32	17,400	1,400	24,400,000
33	18,000	1,400	25,200,000
34	18,500	1,395	25,800,000
35	19,000	1,395	26,500,000
36	19,600	1,395	27,300,000

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EXHIBIT D

COST ESTIMATE OF SUPPORTING FACILITIES - PROPOSALS 1 to 10

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		1 & 3		2 & 4		5		6		7		8		9		10	
FACILITY	COST	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W
Process Cooling Water Disposal	$ 105,000	1		1	1	1	1	1	2	1	1	1	2	1	1	1	1
Chemical Tank Farm	291,000	1		1	.6	1	.6	1	.6	1	.6	1	1	1	.6	1	.6
Waste Disposal Cribs	28,000	1		1	1	1	1	1	2	1	1	1	2	1	1	1	1
Organic Waste Disposal	17,000			1	1	1	1	1	2	1	1	1	2	1	1	1	1
Solvent Storage	58,000			1	1	1	1	1	2	1	1	1	2	1	1	1	1
Stack	215,000	1		1	1	1	1	1	2	1	1	1	2	1	1	1	1
Exclusion Area Fence	11,000	1		1	1	1	1	1	2	1	1	1	2	1	1	1	1
Propane Storage	18,000			1	1	1	1	1	2	1	1	1	2	1	1	1	1
Exclusion Area Guard Towers	12,000	1		1	1	1	1	1	2	1	1	1	2	1	1	1	1
Outside Lighting	21,000	1		1	1	1	1	1	2	1	1	1	2	1	1	1	1
Electrical Power Distribution	36,000	1		1	1	1	1	1	2	1	1	1	2	1	1	1	1
Fire Alarm System	6,000	1		1	1	1	1	1	2	1	1	1	2	1	1	1	1
Telephone And Intercommunications	16,000	1		1	1	1	1	1	2	1	1	1	2	1	1	1	1
Railroads	50,000	1		1	1	1	1	1	2	1	1	1	2	1	1	1	1
Roads and Walks	60,000	1		1	1	1	1	1	2	1	1	1	2	1	1	1	1
Steam Distribution	75,000	1		1	1	1	1	1	2	1	1	1	2	1	1	1	1
Water Systems	90,000	1		1	1	1	1	1	2	1	1	1	2	1	1	1	1
Sewer Systems	33,000	1		1	1	1	1	1	2	1	1	1	2	1	1	1	1
Process Sewer Lines	45,000	1		1	1	1	1	1	2	1	1	1	2	1	1	1	1
Mock up Building	370,000	1		1		1		1		1		1		1		1	
Sand Filter	200,000		1		1		1		1		1		1		1		1

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CONSTRUCTION COSTS - Proposals 1 to 10

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TABLE VI

	Area or Building	1 BiPO$_4$ + U.A.P. Aged Waste	2 BiPO$_4$ + Solv.Extr. Aged Waste	3 BiPO$_4$ + U.A.P. Aged & Current Waste	4 BiPO$_4$ + Solv.Extr. Aged Waste & Current	5 U.A.P. + Redox	6 Solv.Extr. +Redox	7 Redox	8 Solv.Extr. +Solv.Extr. -BiPO$_4$	9 Solv.Extr. -BiPO$_4$	10 Redox + Solv.Extr. -BiPO$_4$
Waste Removal System											
Sludge Removal	West	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
	East	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
Sludge Treatment	West	325,000	325,000	325,000	325,000	325,000	325,000	325,000	325,000	325,000	325,000
	East	325,000	325,000	325,000	325,000	325,000	325,000	325,000	325,000	325,000	325,000
Transfer	West										
	East	574,000	574,000	574,000	574,000	1,000,000	1,000,000	574,000	1,000,000	574,000	574,000
Building Conversion	221-T								1,960,000		
	221-U	1,400,000	1,520,000	1,400,000	1,520,000	1,400,000	1,520,000	1,000,000	210,000	1,140,000	1,140,000
	221-B							1,280,000	360,000	1,460,000	1,280,000
New Construction canyon & service											
UAP	West										
	East	15,250,000		15,250,000							
Solvent Extraction	West		15,050,000		15,050,000		7,225,000		15,050,000		
	East		18,650,000		18,650,000						
Redox	West					18,650,000	17,025,000	19,750,000			
	East					18,650,000	18,650,000	19,750,000			19,650,000
Solvent Extraction - BiPO$_4$	West								15,250,000	15,900,000	15,900,000
	East								15,250,000	15,900,000	
Fluorination	West	14,000,000		14,000,000		14,000,000					
	East	14,000,000		14,000,000							
Supporting Facilities	West	200,000	1,294,000	200,000	1,294,000	1,294,000	2,200,000	1,294,000	2,294,000	1,294,000	1,294,000
	East	1,464,000	1,557,000	1,464,000	1,557,000	1,557,000	1,557,000	1,557,000	1,557,000	1,557,000	1,557,000
Subtotal Direct Cost		49,538,000	41,295,000	49,538,000	41,295,000	59,201,000	53,827,000	47,855,000	55,581,000	40,475,000	44,045,000
New Waste Storage											
Tanks	West	8,800,000	11,130,000	5,150,000	7,900,000	7,500,000	11,500,000	9,040,000	10,600,000	10,600,000	8,892,000
Encased Cines	West		185,000		185,000	140,000	140,000	185,000	185,000	185,000	185,000
Tanks	East	8,800,000	11,130,000	5,150,000	7,900,000	7,500,000	7,900,000	9,040,000	7,470,000	7,470,000	8,975,000
Encased Cines	East		175,000		175,000	175,000	175,000	175,000	175,000	175,000	175,000
Total Direct Cost		67,138,000	63,915,000	59,838,000	57,455,000	74,516,000	73,542,000	66,295,000	74,011,000	58,905,000	62,272,000
Construction Overhead 28%		18,799,000	17,896,000	16,755,000	16,087,000	20,864,000	20,592,000	18,563,000	20,723,000	16,493,000	17,436,000
Total Construction Cost*		85,937,000	81,811,000	76,593,000	73,542,000	95,380,000	94,134,000	84,858,000	94,734,000	75,398,000	79,708,000

* Does not include:
1. Development Expense
2. Engineering and Design
3. Village Expense
4. Test Plant Cost

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V. Metal Recovery Processes - Comments

A) Chemistry - General

1. Differing results have been obtained on the analysis of stored uranium waste in individual tanks. The sampling program in progress at present should be continued to provide satisfactory analytical results on which to base process development.

2. Will solid ammonium nitrate be acceptable as a raw material? Will the use of this salt in solution be acceptable?

3. All processes are being compared on the basis of yielding decontaminated uranium in the compound best suited for the process under consideration. Only the UAP processes require fluorination steps for completing the decontamination. All solvent extraction processes are designed to yield UNH decontaminated below the background of natural uranium.

4. A pretreatment to remove ruthenium by means such as follows would be of great help in simplifying the decontamination problem:

    a) Sweep out as RuO_4 from solutions oxidized with $KMnO_4$, ozone or persulfate.

    b) Absorption or "plating" of RuO_4 on Tygon, stainless steel, etc.

    c) Determine how to prevent colloided behavior of ruthenium in the column.

    d) Remove as ruthenate in diuranate or metathesis steps.

    e) Maintain in soluble form during UAP separation.

    f) Electrochemical methods.

5. The corrosion of metals under high pH, reducing (Fe^{++}) conditions should be studied along with the use of inhibitors in waste solutions stored in black iron tanks.

6. Means for removal of zirconium and columbium would also assist in the decontamination problem.

7. It is conceivable that circumstances may require the conversion of UF_6 in some processes back to UF_4. The chemical technology of such a process is required.

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Chemistry - Comments Relating to Each Proposal

Proposal No. 1

$BiPO_4$ Process

[redacted]

1. No comment

UAP Process for Aged Waste

2. Is there objectionable build-up of fission products in the course of the recycling of the filtrates from the uranium recovery precipitations?

3. What are the anticipated dust losses in the dry UAP and fluorination steps?

4. What yield losses are anticipated in the dry reduction and fluorination steps because of incompleteness of reaction?

5. Is there a possibility of substantial reduction in ammonium nitrate requirements by choice of pH or phosphate concentrations? What are the optimum conditions of pH, phosphate and ammonium ion concentration? Could ammonium sulfate or sulfuric acid be substituted for ammonium nitrate and nitric acid?

6. What are the yield losses on HF and F_2 in the fluorination steps?

7. The possibility of tetrafluorination in solution has been considered. The high and costly chemical consumption with attendant large waste volumes and the minor degree of decontamination makes this process unattractive.

Proposal No. 2

$BiPO_4$ Process

8. See comment 1.

Solvent Extraction Process for Aged Waste

9. In any solvent extraction process an essential problem is first to prepare from the metal waste a suitable feed solution, since the metal concentration in the waste is too low and the phosphate and sulfate ion concentration is too high to operate an extraction process at reasonable hexone rates. For estimating purposes we are considering the UAP-caustic metathesis process as the means for preparing the feed solution. We recognize the existence of other alternatives and are of the opinion that studies should be made on processes as follows:

   a) Homogeneous precipitation methods, for uranium.

   b) UAP-caustic metathesis. Efficiency of PO_4^{---} and SO_4^{--} removal and diuranate characteristics.

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c) Precipitation methods for SO_4^{--} and PO_4^{---}.

d) Crystallization (freezing) methods for PO_4^{---} and SO_4^{--}.

10. What is the effect of high activity levels on fission product distribution ratios?

11. What is the effect of through-put on decontamination at normal and high pH?

12. What is the effect of PO_4^{---} and SO_4^{--} concentration on distribution ratios of uranium at low acid concentrations?

13. It is of interest to have equilibrium curves on a high pH system and HETS as a function of acidity at pH >1 up to the pH where uranium precipitates.

14. Information is desired on the effect of pH on flooding (phase inversion).

15. What is the solubility and distribution ratio of the Ce-dichromate complex?

16. Can other oxidants be advantageously substituted for dichromate, such as ceric or persulfate ions?

17. Is the recycle of hexone a factor in flooding via chemical buildup? Data are also desired on hexone decomposition and effect of decomposition products in the concentration step and in subsequent extraction steps.

18. Is there a definite choice of nitrate salting agents for decontamination between aluminum, sodium, calcium, magnesium or potassium?

19. Which of the following methods, or others, are preferred for nitric acid neutralization in UNH concentration steps:

    a) urea

    b) ammonia

    c) formic acid

    d) evaporation

    More data are desired on the choice between continuous and batch concentration of UNH.

<u>Proposal No. 3</u>
<u>$BiPO_4$ Process</u>

[redacted]

20. See comment 1.

<u>UAP to Handle Current Together with Aged Waste</u>

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[redacted]

21. Current wastes contain fission products which are not present in aged waste because of their relatively short half-lives. Their fate in the UAP process is not known and could conceivably be carried to an extent in the UAP precipitate that would render

this process inoperative as a means for decontamination either in the UAP or fluorination steps. Experimental data are required to note the decontamination obtainable when current waste is treated by the UAP and fluorination steps.

22. See comments 2,3,4,5,6, and 7.

Proposal No. 4

$BiPO_4$ Process

23. See comment 1.

Solvent Extraction Process for Current and Aged Waste

24. As under comment 9 there is the problem of preparing suitable feed from the current waste as well as the aged waste. Process development is required.

25. See comment 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, and 19.

Proposal No. 5

Redox for Current Processing with UAP for Aged Waste

26. In this proposal a plant is required to recover all aged waste by the UAP-fluorination process. See comments 2, 3, 4, 5, 6, and 7.

27. In the Redox solvent extraction processes the similarity of the chemical behavior of cerium and ruthenium to plutonium makes desirable the continued study of decontamination.

28. Complete, accurate, and consistent material balances for plutonium should be provided. Present results from ANL show a range of ± 20%.

29. For comments applicable to Redox, see items 10, 11, 12, 13, 14, 15, 16, 17, 18, and 19.

30. Can a IA column operate at a high pH?

31. What is the effect of a high pH in the plutonium extraction section of the IB column evaluated on the basis of plutonium recovery and decontamination of uranium? What will be the effect on IC operation under these conditions?

Proposal No. 6

Redox for Current Processing with Solvent Extraction for Aged Waste

32. For solvent extraction of aged waste see comments 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, and 19.

33. For Redox, see comments 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 27, 28, 30, and 31.

Proposal No. 7

Redox to Handle Current Production Together with Aged Waste

34. See comments 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19. 27, 28, 30, and 31.

35. What is the preferred point in the process in which to feed prepared aged waste?

Proposal No. 8

Solvent Extraction - $BiPO_4$ to Handle Current Production with Solvent Extraction for Aged Waste

36. For comments on solvent extraction for aged waste see 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, and 19.

37. In this modification of the Redox process for uranium recovery to permit coupling with the present phosphate process for plutonium a closed cycle extraction is used in the coupling step. Information is desired on the chemical performance of the closed cycle extractor in a hexone system including:

a) Choice of oxidizing agent.

b) Stability of hexone when continuously recycled in contact with high level radiation.

38. There is the possibility of a major reduction in volume for the processing of plutonium from the closed cycle extractor through the present bismuth phosphate process. A study should be made as to the effects and advantages or disadvantages of the potential volume reduction. A single laboratory test has shown that one third of the $BiPO_4$ normally used gave satisfactory carrying of product from the solution from the closed cycle extractor.

39. The recovery of the plutonium from the closed cycle extractor and its recovery in the bismuth phosphate process must be demonstrated? A single laboratory test has recently demonstrated the chemical feasibility of the closed cycle extractor and the recovery in the phosphate process.

Proposal No. 9

Solvent Extraction - $BiPO_4$ to Handle Current Production Together with Aged Waste

40. See comments 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 37, 38, and 39.

B) Engineering and Design - General

1. The general proposal of Kellex and Carbide and Carbon for removing the waste from the tanks by use of recirculation with high pressure nozzles and deep well pumps appears feasible. Operation without use of an alkaline solvent in the storage tanks is preferred.

2. In order to proceed along the lines of the C & C proposal which involves recirculation with immediate settling, the reslurrying and settling characteristics of the sludge should be determined.

3. All moving equipment for waste recovery should be designed for remote maintenance and replacement.

4. Methods of transfer of waste solution should be studied. The proposals for single "one shot", expendable plants for metal recovery will require transfer from one area to another, a distance of several miles. The choice must be made between pipe lines and shielded tank cars.

5. The processes for reduction of all waste volumes by evaporation should be established and demonstrated.

6. The composition of waste solutions should be studied from the corrosion standpoint in present and proposed metals for liners in storage tanks.

7. Final selection of a process should involve consideration of the "on stream efficiency".

Engineering and Design - Comments Relating to Each Proposal

Proposal No. 1
$BiPO_4$ Process

1. No comment

UAP Process for Aged Waste

2. The choice of the filter-dissolver does not appear justified with consideration of other means such as perforate bowl centrifuges which may have much higher capacity per unit of space required and greater efficiency in dewatering and washing.

3. Difficulty is expected in the design of shielded, remotely operated UAP drying and fluorination processes. Manual handling is largely resorted to in existing non-radioactive processing.

   a) Process temperatures are high and require careful control (550° C maximum).

   b) Remote handling of wet and dry dusty, radioactive solids, products and wastes is required.

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c) Barrier filters for removing activity are required. Technology of these filters is not known.

d) Recycling of gaseous agents is not conducted in present "cold" fluorination, but may be required.

e) Multiplicity of relatively small production components is probably required; each to be operated remotely.

4. The fitting of a fluorination process into existing space or idle facilities does not appear feasible.

Proposal No. 2

$BiPO_4$ Process

5. See comment No. 1

Solvent Extraction for Aged Waste

6. A freeze out process for phosphate requires remote maintenance and is not highly effective for removal of both phosphate and sulfate. For column feed preparation the UAP-metathesis process is proposed. Study of the properties of the metathesis precipitate is required in order to properly design equipment for handling.

7. The selection and demonstration of a satisfactory "hot" metering pump for column feed has yet to be made.

8. Remote maintenance and replacement of long columns has to be demonstrated.

9. The effect of column top design and interface instruments on decontamination has yet to be demonstrated on high level materials.

10. Column extraction processes have a wide range of operating effectiveness. A three-fold throughput range has shown no change in operating characteristics.

Proposal No. 3

$BiPO_4$ Process

11. See comment No. 1

UAP Process to Handle Current Together with Aged Waste

12. See comments 2, 3, and 4

Proposal No. 4

$BiPO_4$ Process

13. See comment No. 1

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[redacted]

Solvent Extraction Process for Current and Aged Waste

14. See comments No. 6, 7, 8, 9, and 10.

Proposal No. 5

Redox for Current Processing with UAP for Aged Waste

15. For UAP process see comments 2, 3, and 4.

16. Equipment selection and demonstration for metal solution clarification for Redox has yet to be done.

17. See comments 7, 8, 9, and 10.

Proposal No. 6

Redox for Current Processing with Solvent Extraction for Aged Waste

18. For solvent extraction for aged waste see comments 6, 7, 8, 9, and 10.

19. For Redox see comments 7, 8, 9, 10, and 16.

Proposal No. 7

Redox for Current Production Together with Aged Waste

20. See comments 6, 7, 8, 9, 10, and 16.

Proposal No. 8

Solvent Extraction - $BiPO_4$ to Handle Current Production with Solvent Extraction for Aged Waste

21. For solvent extraction see comments 6, 7, 8, 9, and 10.

22. For Redox see comments 7, 8, 9, 10, and 16.

23. The selection and demonstration of the closed cycle extractor for hexone processing has yet to be done. It has been done in a single, small scale laboratory test only.

24. Present tanks should be satisfactory for handling reduced volumes to permit realization of correspondingly reduced chemical costs.

Proposal No. 9

Solvent Extraction - $BiPO_4$ to Handle Current Production Together with Aged Waste

25. See comments 7, 8, 9, 10, 16, 23, and 24.

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c) Economics - General

1. A "one shot" uranium recovery plant would logically require only one fluorination plant. This is contrary to the 200 Area practice of parallel major operating units. However, Bldgs. 231 and 234-5 are not duplicated; a single fluorination plant could be included in the same category.

2. The construction and operation of fluorination facilities at this site at the proposed capacities will obsolete existing plants located elsewhere.

3. If the expected life of present 200 Area facilities is relatively short the process selection will be influenced. An improved cell atmosphere by tank venting in 221-Bldg. to reduce contamination build-up and reduce corrosion rates of iron work should add substantially to building life.

4. Provision for plutonium accountability complicates process equipment, increases construction costs, and favors batch operation for Pu recovery.

5. Economics may require the conversion of all UNH from solvent extraction processes into UO_3 for shipment and further processing.

6. At present there is no known supplier of the large amounts of high quality aluminum nitrate required for the solvent extraction processes. Facilities for production may have to be furnished at this site or a plant may have to be built for a supplier to operate. This problem is being investigated.

Economics and Timing - Comments Relating to Each Proposal

Proposal No. 1

$BiPO_4$ Process

1. No comment

UAP Process for Aged Waste

2. This process requires an expensive "hot", dry fluorination plant including fluorine generating facilities.

3. Plant will eventually operate at about one-half capacity.

4. A two-year uranium storage inventory is required.

5. Aged waste should reduce shielding requirements.

6. It is estimated that three years will be required to begin operation at four tons per day.

Proposal No. 2

$BiPO_4$ Process

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7. No comment

Solvent Extraction for Aged Waste [redacted] ~~CONFIDENTIAL~~

8. See comments 3, 4, and 5.

9. Explosion proof electrical equipment is required.

10. There is a possibility of recovering plutonium at nominal cost.

11. It is estimated that two years will be required to begin operation at four tons per day.

12. In this and the other solvent extraction processes fluorination at this site is not proposed. Shipment of "cold" uranium to present processors is expected.

Proposal No. 3
BiPO$_4$ Process

13. No comment

UAP Process to Handle Current Together with Aged Waste

14. See comments 2, 3, 5, and 6.

15. Chemical consumption and waste volumes will be somewhat less than in Proposal 1.

16. It is estimated that three years will be required to begin operation at four tons per day.

Proposal No. 4
BiPO$_4$ Process

17. No comment

Solvent Extraction Process for Current and Aged Waste

18. See comments 3, 9, 10, and 12,

19. It is estimated that two years will be required to begin operation at four tons per day.

20. Chemical consumption and waste volumes will not be as large as in Proposal No. 2.

Proposal No. 5

Redox for Current Processing with UAP for Aged Waste

21. For UAP processing see comments 2, and 5.

22. UAP and fluorination plants are obsolete at conclusion of of metal recovery.

23. It is estimated that three years will be required to begin UAP operation at two tons per day.

24. Three BiPO$_4$ plants will be obsoleted.

25. Redox operation will commence after two years for one area and after two and one-half years in the other area.

Proposal No. 6

Redox for Current Processing with Solvent Extraction for Aged Waste

26. For solvent extraction see comments 5, 9, 10, and 12.

27. For Redox see comments 9, 12, 24, and 25.

28. Solvent extraction plant for aged waste will be obsolete at conclusion of metal recovery.

Proposal No. 7

Redox for Current Production Together with Aged Waste

29. See comments 9, 12, 24, and 25.

30. Plutonium is recoverable from waste.

31. Extra capacity for handling aged waste would become spare equipment at conclusion of waste recovery. Double capacity for future operation could be provided at little expense at start by over designing.

Proposal No. 8

Solvent Extraction - $BiPO_4$ to Handle Current Production with Solvent Extraction for Aged Waste

32. For solvent extraction see comments 5, 9, 10, 11, 12, and 28.

33. 221-T Bldg. is obsoleted or becomes a spare $BiPO_4$ process building at conclusion of metal recovery.

Proposal No. 9

Solvent Extraction - $BiPO_4$ to Handle Current Production Together with Aged Waste

34. See comments 9, 11, 12, and 33.

[redacted]

VI. References

In the course of this study the following related documents have been issued; most of these contain data which has been received and included in this present report:

HW-11765 - Metal Recovery Processes - Preliminary Survey

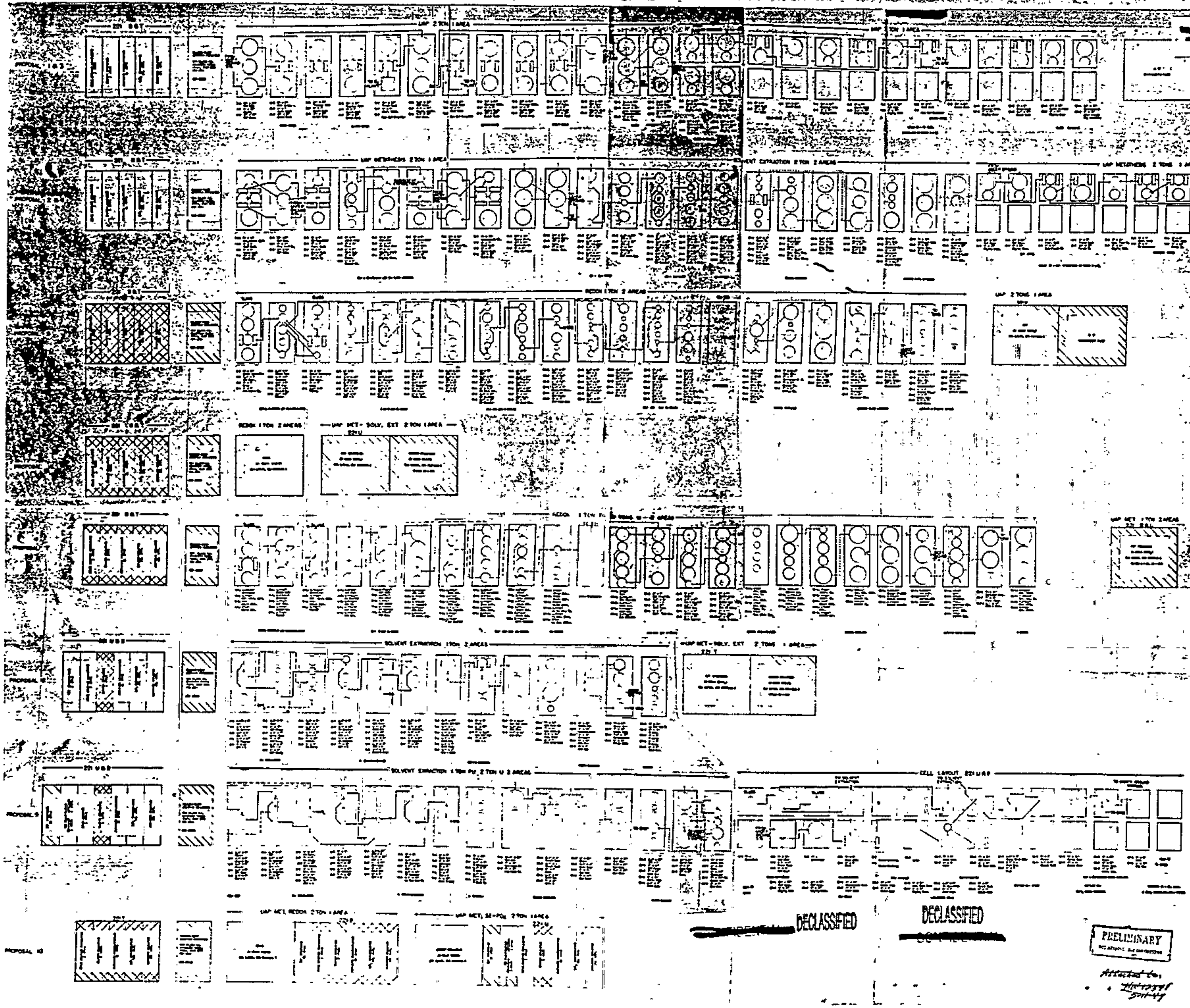
HW-11988 - Metal Recovery Processes Survey

HW-12058 - Metal Recovery Processes Survey - Comments on Solvent Extraction Methods

HW-12150 - Metal Recovery Processes - Construction Comparison

HW-12309 - Cost Summary of Metal Recovery Processes

[redacted] [redacted]



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PRELIMINARY

Attached to:
HW-12348
5-11-49

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GENERAL ELECTRIC CO
HANFORD WORKS
METAL RECOVERY PROCESSES
CELL REQUIREMENTS

HW-12348