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TITLE

HISTORY: METAL RECOVERY WASTE SCAVENGING PROGRAM

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Richland, Washington
May 10, 1956

T. Prudich, Superintendent
Metal Recovery Plant Sub-Section
Separations Section

HISTORY: METAL RECOVERY WASTE SCAVENGING PROGRAM

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This interim report is being issued to summarize the history of the TBP waste treatment program to date. Complete data from the scavenged waste batches Nos. 1 through 30, including the analytical results of samples from the receiving tanks and from the discharge line to each crib, are reported in Table I. This summary includes all the scavenged waste batches prior to stopping of waste cribbing where Co^{60} was detected in the ground water. The amounts of scavenged waste produced, supernatant cribbed, and tank space saved as a result of the scavenging program are also presented in graphical form.

INTRODUCTION

Routine scavenging of the liquid waste, containing radioactive material from the TBP Plant, was started on September 29, 1954. Since this date approximately nineteen million gallons of waste solution have been chemically treated to remove cesium and strontium activities from the waste solution. Because of their long half life (Cs^{137} - 30 years, Sr^{90} - 20 years), these two radio-isotopes were considered to be the most critical of those that may seep to the ground water level. The other radio-isotopes, which contribute more than 10 percent of the total beta activity in the waste solution, were not considered objectionable since they have a short (less than three years) half life and have good soil-retention properties. However, to provide an adequate inventory of radioactive material released to the ground, complete analyses of crib line samples have been in effect throughout the waste scavenging program.

The policy governing ground disposal of radioactive liquid waste during the early stages of the waste scavenging program was based on an MPL (maximum permissible limit) in drinking water of 8×10^{-7} uc/cc for Sr^{90} and 1.5×10^{-3} uc/cc for Cs^{137} activities. The limit at Hanford, however, is only 0.1 MPL and it was necessary to control the scavenged waste disposal so that this limit is not exceeded in the ground water. Also, at the start of the program, it was estimated that the ground water flow would require 50 years to reach the Columbia River. In February 1955, however, additional findings indicated that the underground water flow may take only one to ten years to reach the river.

All of the TBP Plant scavenged and neutralized waste material has been allowed to settle for a minimum of seven days. The supernatant liquid was then discharged to ground, via underground cribs in the 200 East Area, when soil-column tests showed that retention by the soil of cesium and strontium activities was adequate.

To date, almost fifteen million gallons of scavenged waste supernatant have been transferred to the disposal cribs. Three tanks of scavenged waste (6-108-NY, 8-110-NY, and 9-107-NY) collected during February, March, and April 1955 could not be cribbed because of cesium and strontium break-through during the soil-column tests.

INITIAL PLANT-SCALE SCAVENGING TEST

As a result of intensive studies and laboratory-scale tests by the Chemical Development Subsection during the summer and fall of 1953, it was determined that treatment of the TBP Plant waste solutions with potassium ferrocyanide and nickel sulfate would be economically feasible if the supernatant liquid could be discarded to underground

cribs (Ref. 1 and 2). Accordingly, a plant-scale test was run during October 1953 in which the waste was treated under the following flowsheet conditions:

1) Addition of $K_4Fe(CN)_6$ to 0.005 M
2) Neutralization with NaOH to a pH of 9.0 ± 1.0
3) Addition of $NiSO_4$ to 0.005 M

The scavenged waste solution (530,000 gallons) was routed to the 101-T tank for settling. Control of the pH during the neutralization step was rather poor during the first part of the plant test, consequently only the last half (255,000 gallons) could be discharged to ground.

CRIBS FOR SCAVENGED WASTE DISPOSAL

A project proposal (CG-587) for construction of eight 30' x 30' cribs and a flush box to be located in the BY tank farm was approved in April 1954 and the work completed by Minor Construction forces in October 1954. During the interim period, scavenging chemicals were ordered and piping changes made in the TBP Plant so that continuous chemical additions to the waste would be possible.

Additional funds (on Project CG-603) were allocated in May 1955 for construction of six 40' x 40' cribs for disposal of CR farm scavenged waste solutions. These cribs were located southwest of the 200 East Area and are known as the BC cribs. The height of the soil column (surface to ground water) at the BC site is approximately 340 feet as compared with 200 feet at the BY crib site. Thus the BC crib area is a much more favorable location for ground disposal of scavenged waste solutions.

Due to the detection of beta activity in the ground water under the BY cribs in December 1955, and confirmation that Cs^{137} was also present, the scavenged supernatant liquid from TBP Plant waste has been routed to the BC cribs since January 31, 1956.

CRITERIA FOR CRIBBING SCAVENGED WASTE

The original limitations for cribbing scavenged waste supernatant liquid (Ref. 3), reported in Document HW-30652, January 1954 were:

Maximum concentration of Cs^{137} or Sr^{90} in cribbed waste	- 0.2 uc/cc
Volume to crib, gallons/sq. ft. ground area	- 3,000 to 6,000
Total curies per crib (BY) of Cs^{137} and/or Sr^{90}	- 4,100 maximum

Definite sampling and analytical requirements were set up to determine whether or not the scavenged waste could be cribbed, after settling a minimum of seven days. Initially samples were taken at 3-ft. depth increments, then changed to successive 5-ft. levels in September 1955. Also, to provide an adequate inventory of material discharged to ground, samples were taken from the discharge line to each crib on a frequency of at least one sample from each 50,000 gallons cribbed. This was later, June 1955, changed to each 100,000 gallons cribbed.

The crib-line samples were composited in the laboratory. Rather complete analyses were made, including all beta-emitting radio-isotopes that contribute more than 10 percent of the total beta activity. Control samples were taken of the TBP Plant acid waste and neutralized scavenged waste streams so that processing changes could be made to control the variables, and to measure the effectiveness of scavenging.

Refinements in the analytical methods for Cs^{137} and Sr^{90} were under constant surveillance. In August 1955 it was found that ruthenium contaminant may have accounted for 80 percent or more of the activity previously reported as Cs^{137}.

Soil column tests have been made, on composited samples from each tankful of scavenged waste, by the Earth Sciences Group. Data from these tests were used to indicate how much of the scavenged supernatant could be discharged to ground before cesium and/or strontium would break through to the ground water. Hence, the soil column tests have been an important criteria for waste disposal.

CONTROL OF pH DURING WASTE NEUTRALIZATION

Probably the most important feature of successful waste scavenging performance is extremely careful pH control during the neutralization step. A pH of 9.0 is most desirable to attain maximum cesium and strontium scavenging, however, an operating range of 8.0 to 10.0 has been used during most of the scavenging program. At a pH above 10.0, cesium decontamination falls off abruptly, and at a pH below 8.0 strontium decontamination is similarly poor. Hence, it is necessary to maintain the pH as close to 9.0 as is possible. Experience has shown that a batch of waste that did not have close pH control of all increments will be poorly scavenged even though the average pH is in good control.

The pH monitoring and control instrumentation (Ref. 4) in the 11-6 neutralizer tank has been extremely valuable in maintaining the pH within the desired range.

FLOWSHEET CHANGES

Following, in chronological order, are the flowsheet and major operational changes that have been made during the waste scavenging program.

1954

9-29 Started routine scavenging of dilute TBP waste solution. (Ref. 5).
Flowsheet: 0.005 M $K_4Fe(CN)_6$ and 0.005 M $NiSO_4$ in the neutralized waste.

11-20 No waste produced. TBP Plant conversion to series operation.
12-21

1955

1-13 Started batch operation in the 11-6 neutralizer tank due to poor strontium scavenging. Ferrocyanide added to acid waste, nickel sulfate to 11-6 after neutralization.

2-1 Returned to continuous addition of $NiSO_4$ during neutralization. There had been no improvement in Sr^{90} scavenging.

2-15
3-1 Erratic pH control. Checking neutralized waste with litmus.

3-1 Started evaporating neutralized waste to conserve waste storage space. $NiSO_4$ added to waste after concentration.

3-18
4-8 Conducted plant tests (supplemental additions of $Ca(NO_3)_2$ to concentrated waste) for improved Sr^{90} scavenging (Ref. 6). Improvement in DF by 3.0 to 4.0, and by 6.0 when waste heated to 90°C.

3-29 Started automatic control of pH, waste and caustic addition rates. Set the pH at 9.3.

4-18 Use of commercial grade sodium ferrocyanide instead of potassium ferrocyanide was started (Ref. 7). Savings in chemical costs of $11.00 per ton U processed were effected.

4-21 Routine addition of $Ca(NO_3)_2$ to 9-7 tank. Marked improvement in Cs^{137} and Sr^{90} scavenging resulted.

5-3
5-6 Low pH values (6.7 to 7.8) in the concentrated waste. Adjusted pH setting to 10.0 to compensate for $Ca(NO_3)_2$ addition and concentration step which had lowered the pH about one unit.

5-20 Eliminated caustic ratio analyses of acid waste batch samples. Automatic control of the pH working efficiently.

8-12
8-26 Conducted plant-scale tests, using $Sr(NO_3)_2$ as a supplemental scavenging agent instead of $Ca(NO_3)_2$. Laboratory data had indicated a factor of two improvement in Sr^{90} removal would result (Ref. 8). Started one tank test using $SrNO_3$ additive. No concentration of waste. Flowsheet: 0.0025 M $NaFe(CN)_6$, 0.0025 M $NiSO_4$, and 0.004 M $SrNO_3$.

9-3 Supply of $SrNO_3$ depleted. Resumed $CaNO_3$ addition and waste concentration.

11-4 Started a three tank test using $SrNO_3$ as supplemental scavenging agent. Dilute neutralized waste routed to settling tanks.

12-9
12-30 Resumed concentration of waste and $CaNO_3$ addition; due to delay in delivery of $SrNO_3$.

12-30 Again started $SrNO_3$ treatment of waste, without concentration.

1956

1-3 Cs^{137} first detected in the ground water under the 216-BY crib.

1-6 Added Na_2HPO_4 to scavenged waste (WR-002) to increase the PO_4 concentration (Ref. 9). PO_4 low due to system flushes.

1-17 All scavenged waste produced using 0.0025 M $K_4Fe(CN)_6$, 0.0025 M $NiSO_4$, and
4-3 0.004 M $SrNO_3$ scavenging has been acceptable for cribbing.

3-5 Detected Co^{60} in the ground water under the BY cavern. Studies are in progress to assure removal of this contaminant before future scavenged waste supernatant is released to ground (Ref. 10).

5-5 On a test basis, cobalt sulfate is being added to the TBP Plant waste, to improve Co^{60} scavenging by isotopic dilution.
Flowsheet: 0.0025 M $K_4Fe(CN)_6$, 0.0025 M $NiSO_4$, 0.004 M $SrNO_3$, and 0.00012 M $CoSO_4$.

SUMMARY

Chemical costs for scavenging the first thirty (30) tankfuls of TBP Plant waste solutions have amounted to approximately $112,958.00, while the costs of all projects have totaled $305,505.00.

Despite these expenditures, treatment of the TBP Plant waste solutions and disposal of the scavenged supernatant have resulted in a total net savings of approximately $973,206.00 worth of tank storage space.

The savings calculations, shown below, are based on a standard waste volume of 4,200 gallons per ton of uranium in the tank farm feed. However, in previous experience of concentrating the waste in the TBP Plant, the actual volume of waste averaged about 5,700 gallons per ton uranium. Consequently, an additional space savings of about 750,000 gallons has been realized.

It is to be noted that since the start of the scavenging program, the total volume of heel remaining after cribbing (including the 6th, 8th, and 9th tankfuls which are to be re-scavenged) has amounted to 1,607 gallons per net tons of uranium processed, or 38.2 percent of the standard volume. However, during production of the last twenty-one tankfuls of scavenged waste (5-15-55 to 4-3-56) the remaining heel volume has been only 410 gallons per net ton, or 9.8 percent of standard volume. This compares quite favorable with the amount of residual heel that was expected during the scavenging operation.

1)	Volume scavenged waste produced (Tanks 1-30)	18,443,301 gals.
2)	Volume scavenged waste supernatant cribbed	14,989,559 gals.
3)	Volume heel remaining (includes 2,073,125 gals. set aside for re-scavenging)	3,453,742 gals.
4)	Standard waste volume at 4,200 gals./ton U (feed)	9,020,420 gals.
5)	Tank space saved (Item 4 minus Item 3)	5,566,678 gals.
6)	Value of tank space savings (at $0.25/gal.)	$1,391,669.00
7)	Expenditures (Projects and Chemicals)	$ 418,463.00

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CG-587	Installation TBP Plant scavenging equipment and BY cribs	$225,850.00
CG-603	In-farm scavenging equipment and BC cribs (total project $359,700.00 with 20% assignable to TBP operations)	$ 71,940.00
	Ditch BX-8	$ 7,715.00
	Chemicals	$112,958.00
8)	Net savings (Item 6 minus Item 7)	$973,206.00

Submitted: R B Abrams
R. B. Abrams
Process Unit
TBP Plant

RBA:ng

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1. Test Procedure to Evaluate Scavenging of TBP Plant Solvent Extraction Waste with Nickel Ferrocyanide
HW-29383 9-18-53 J. G. Bradley

2. Copper Ferrocyanide Scavenging of TBP Wastes
HW-28715 7-14-53 R. J. Sloat

3. TBP Waste Disposal Project Criteria for Cribbing Scavenged RAW
HW-30652 1-27-54 H. V. Clukey

4. pH Monitoring of Metal Recovery Neutralized Waste
HW-33148 9-25-54 C. E. Michelson

5. Nickel Ferrocyanide Scavenging Flowsheet for Neutralized Concentrated RAW
HW-33536 10-26-54 R. E. Smith

6. Routine UR Plant Strontium Scavenging with $Ca(NO_3)_2$
HW-36293 4-19-54 R. J. Sloat

7. Letter: Recommendation for Purchase of Alternate Waste Scavenging Chemicals
10-5-54 J. G. Bradley to C. R. Anderson

8. Letter: Supplemental Strontium Scavenging with $Sr(NO_3)_2$
8-10-55 R. J. Sloat to L. W. Finch

9. Letter: Phosphate Adjustment of the UR Plant Waste
7-20-55 R. J. Sloat to L. W. Finch

10. Meeting Minutes - TBP Waste Scavenging
4-25-56 L. W. Finch to Distribution

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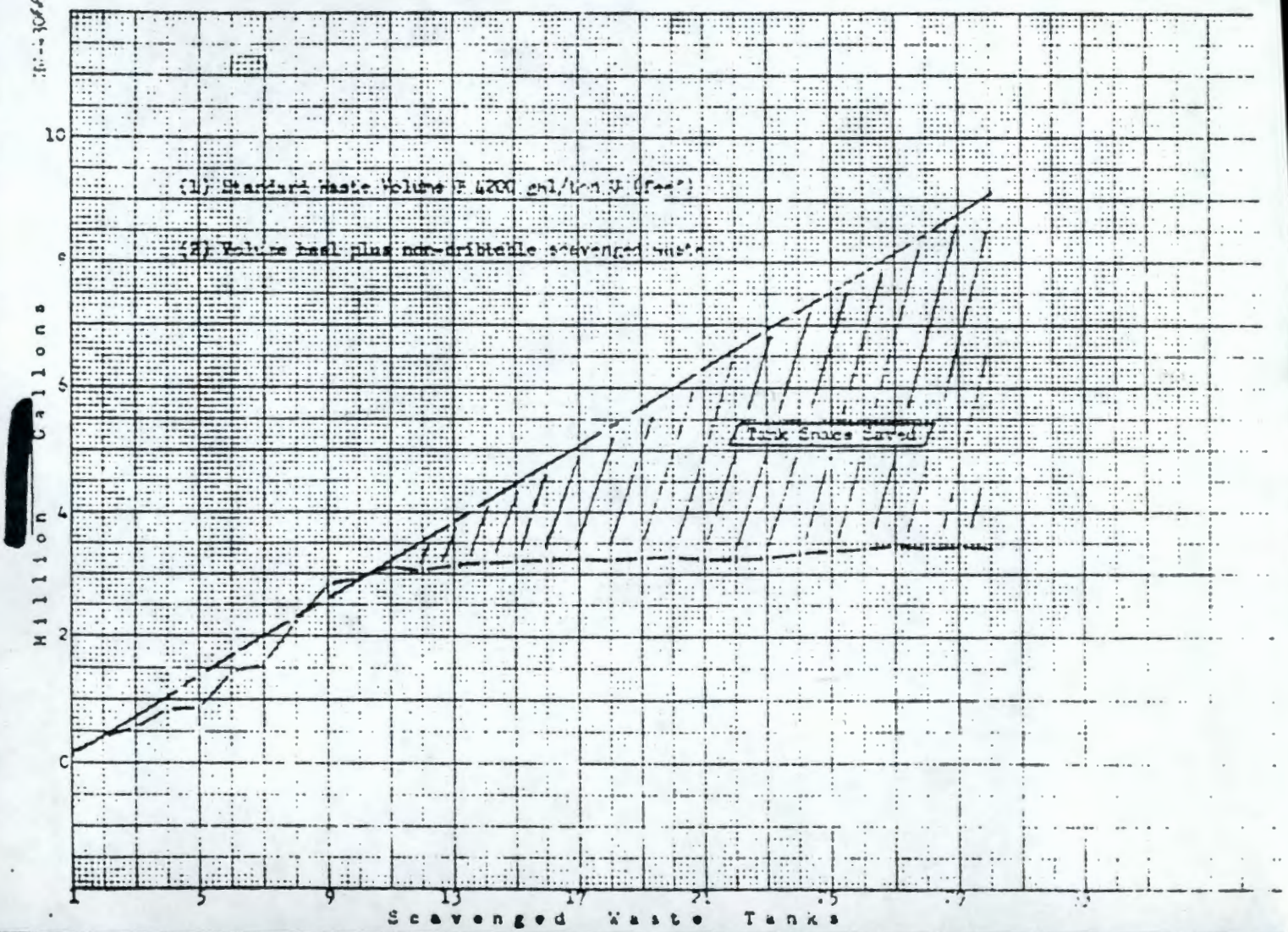

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May 1[illegible], 1956

Tank	[illegible]-106 BY	[illegible]-107 BY	[illegible]-108 BY	[illegible]-109 BY	[illegible]-110 BY
Filling					
Start	[illegible]-5-56	3-1[illegible]-56	[illegible], 3-14	3-10, 3-1[illegible]	3-2[illegible]-56
End	[illegible]-10-56	3-[illegible]-56	[illegible]-10, 3-17	3-1[illegible], 3-2[illegible]	[illegible]-56
Batch Size, Gals.	[illegible],750	[illegible],750	[illegible],000	[illegible],875	583,750
Sampled, Date	[illegible]-56	3-11-56	[illegible]-56	[illegible]-56	[illegible]-56
Cribbing					
Crib No.	BC-5	BC-5	BC-5	BC-3	BC-[illegible]
Start	3-10-56	3-13-56	[illegible]-56	[illegible]-11-56	[illegible]-30-56
End	3-1[illegible]-56	3-2[illegible]-56	[illegible]-56	[illegible]-16-56	[illegible]-56
Gals.	555,250	550,875	565,750	519,750	530,250
Heel					
To Tank	105-BY	105-BY	105-BY	105-BY	---
Gals.	20,625	17,875	33,000	34,375	---
Treatment					
Waste	Dilute	Dilute	Dilute	Dilute	Dilute
$NiSO_4$ M	0.0025	0.0025	0.0025	0.0025	0.0025
$NaFe(CN)_6$ M	0.0025	0.0025	0.0025	0.0025	0.0025
$SrNO_3$ M	0.004	0.004	0.00[illegible]	0.00[illegible]	0.004
$CaNO_3$ M	None	None	None	None	None
Tank Samples					
pH	10.0	9.9	9.6	[illegible]	9.8
Cs, uc/cc	0.063	0.019	0.012	0.025	0.032
Sr, uc/cc	0.026	0.025	0.012	0.021	0.029
Total B, uc/cc	3.46	5.25	6.76	20.08	19.18
AT, c/m/gal x 10^5	0.90	3.0	3.0	7.0	5.0
PO_4 M	0.049	0.071	0.073	0.071	0.098
Crib Line Samples					
pH	9.9	[illegible]	9.3	9.8	9.6
Cs, uc/cc	0.003	0.007	0.055	0.032	
Sr, uc/cc	0.007	0.008	0.023	0.029	0.017
Total B, uc/cc	4.41	5.26	5.15	12.60	14.2
AT, c/m/gal x 10^5	0.70	0.70	0.60	8.60	
PO_4, M	0.068	0.058	0.057	0.083	0.086
U, lbs/gal x 10^{-5}	19.0	35.0	37.0	32.0	
NO_3, lbs./gal.	0.93	0.94	0.67	0.94	1.25
Wt.% Solids	16.8	17.3	13.2	19.8	
R.E., uc/cc	0.05	0.06	0.05	0.10	0.16
Ce, uc/cc	0.12	0.11	0.25	0.63	1.05
Zr-Nb, uc/cc	0.02	0.04	0.11	0.22	0.13
Ru, uc/cc	0.34	0.15	0.30	0.73	0.40
Sb, uc/cc	0.19	0.23	0.15	0.25	0.38

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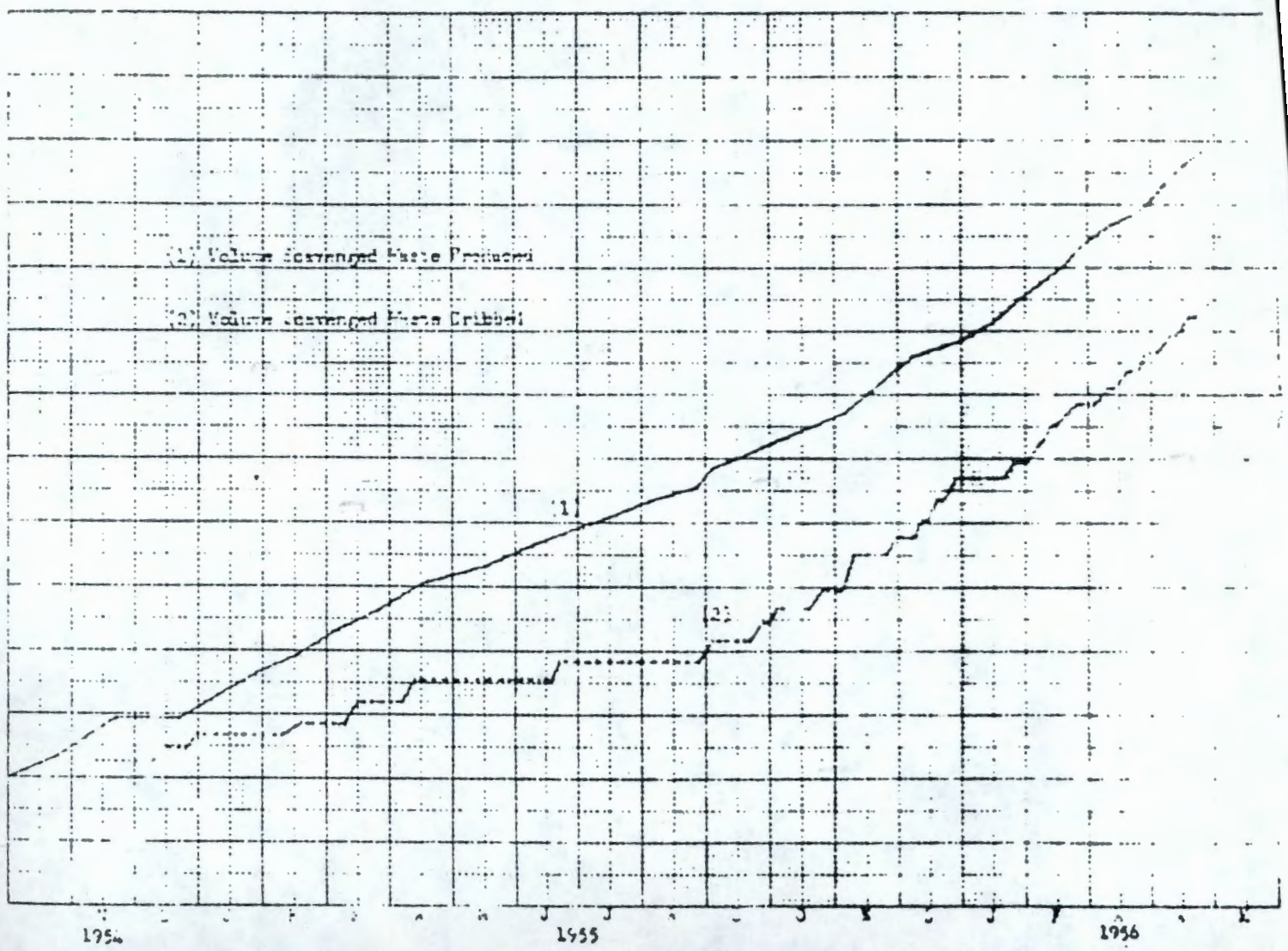

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Tank	6-10 BY	7-106 BY	8-110 BY	9-107 BY	10-108 BY
Filling					
Start	1-29-55	2-16-55	3-4-55	3-26-55	4-15-55
End	2-16-55	3-[illegible]-55	3-26-55	4-15-55	5-16-55
Batch Size, Gals	613,250	749,000	679,250	668,250	657,250
Sampled, Date	2-27-55	3-13-55	4-3-55	4-24-55	5-23-55
Cribbing					
Crib No.		BY-3			BY-3
Start	3-26-55	4-5-55	4-12-55	[illegible]	6-17-55
End	4-15-55	4-11-55	4-25-55	6-15-55	6-20-55
Gals.	660,000(101-BY)	712,750	595,000(102-BY)	561,000(103BY) 112,750(104BY)	591,937
Heel					
To Tank	---	---	---	105-BY to 103-BY	---
Gals.	---	---	---	333,438	---
Treatment					
Waste	Dilute	Dilute(Conc3/1)	Conc.	Conc.	Conc.
$NiSO_4$ M	0.005	0.005	0.005	0.005	0.005
$NaFe(CN)_6$ M	0.005	0.005	0.005	0.005	0.005
$SrNO_3$ M	None	None	None	None	None
$CaNO_3$ M	None	None	None	None	0.016 (4/21)
Tank Samples					
pH	9.4	9.4	9.5	9.0	9.1
Cs, uc/cc	0.11	0.11	0.82	0.[illegible]	0.48
Sr, uc/cc	1.90	1.34	4.02	2.35	0.26
Total B, uc/cc	13.61	7.95	35.14	33.55	13.82
AT, c/m/gal x 10^5	0.17	---	7.0	14.0	3.0
PO_4 M	0.178	0.104	0.146	---	0.189
Crib Line Samples					
pH	Not Cribbed	9.4	Not Cribbed	Not Cribbed	No Line Samples Obtained During Cribbing
Cs, uc/cc		0.15			
Sr, uc/cc		0.83			
Total B, uc/cc		5.24			
AT, c/m/gal x 10^5		9.0			
PO_4 M		---			
U, lbs/gal x 10^{-5}		0.20			
NO_3, lbs/gal		---			
Wt.% Solids		---			
R.E., uc/cc		1.57			
Ce, uc/cc		1.66			
Zr-Nb, uc/cc		1.33			
Ru, uc/cc		2.06			
Sb, uc/cc		0.31			

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May 10, 1956

Tank	12-106 BY	12-110 BY	13-107 BY	14-108 BY	15-110 BY
Filling					
Start	5-16-55	6-10-55	7-3-55	6-5-55	8-29-55
End	6-10-55	7-3-55	8-5-55	8-26-55	9-3-55
Batch Size, Gals.	701,250	581,000	680,000	624,250	424,925
Sampled, Date	6-22-55	7-10-55	8-14-55	9-3-55	9-11-55
Cribbing					
Crib No.	BY-6	BY-7	BY-4	BY-5	BY-5
Start	11-2-55	12-7-55	8-29-55	9-21-55	9-28-55
End	11-8-55	12-11-55	9-3-55	9-25-55	10-3-55
Gals.	525,250	403,650	617,375	569,250	403,560
Heel					
To Tank	---	---	---	---	---
Gals.	---	---	---	---	---
Treatment					
Waste	Conc.	Conc.	Conc.	Conc.	Dilute
$NiSO_4$ M	0.005	0.005	0.005	0.005	0.0025
$NaFe(CN)_6$ M	0.005	0.005	0.005	0.005	0.0025
$SrNO_3$ M	None	None	None	None	0.004
$CaNO_3$ M	0.016	0.016	0.016	0.016	None
Tank Samples					
pH	8.8	9.2	9.9	10.2	9.3
Cs, uc/cc	0.37	0.12	0.30	0.004	0.005
Sr, uc/cc	0.52	0.36	0.30	0.35	0.31
Total B, uc/cc	11.12	5.92	15.72	14.05	16.19
AT, c/m/gal x 10^5	11.0	11.0	12.0	---	22.0
PO_4 M	0.086	0.055	0.134	0.126	0.101
Crib Line Samples					
pH	9.3	8.9	9.9	10.1	9.2
Cs, uc/cc	0.020	0.018	0.005	0.071	0.020
Sr, uc/cc	0.39	0.73	0.54	0.19	0.12
Total B, uc/cc	11.07	9.51	19.66	12.52	11.52
AT, c/m/gal x 10^5	3.0	5.0	12.0	4.0	4.0
PO_4 M	0.123	0.052	0.093	0.125	0.104
U, lbs/gal x 10^{-5}	0.70	26.0	0.32	0.50	2.40
NO_3, lbs/gal	1.76	1.92	0.96	1.40	1.45
Wt.% Solids	33.6	35.0	26.0	29.6	25.6
R&E., uc/cc	0.25	1.72	0.93	0.29	0.21
Cs, uc/cc	0.47	0.67	2.33	1.56	1.76
Zr, Nb, uc/cc	1.05	0.59	0.05	1.18	1.34
Ru, uc/cc	0.33	1.14	5.44	5.60	4.07
Sb, uc/cc	0.38	0.39	0.69	0.79	0.65

[redacted]

Tank	1[illegible]-107 BY	17-108 BY	18-110 BY	19-107 BY	20-105 BY
Filling					
Start	[illegible]-55	[illegible]-55	10-1[illegible]-55	11-[illegible]-55	11-16-55
End	[illegible]-55	10-15-55	11-[illegible]-55	11-16-55	11-28-55
Batch Size, Gals	525,000	5[illegible]5,000	574,000	585,750	585,750
Sampled, Date	10-2-55	10-23-55	11-1[illegible]-55	11-22-55	12-7-55
Cribbing					
Crib No.	BY-[illegible]	BY-6	BY-7	BY-7	BY-4
Start	10-18-55	11-2-55	11-25-55	12-12-55	12-21-55
End	10-23-55	11-5-55	11-29-55	12-16-55	12-25-55
Gals.	591,250	555,500	591,250	552,750	572,000
Heel					
To Tank	---	---	105-BY	105-BY	105-BY
Gals.	---	---	19,250	60,000	90,750
Treatment					
Waste	Conc.	Conc.	Conc.	Dilute	Dilute
$NiSO_4$ M	0.005	0.005	0.005	0.0025	0.0025
$NaFe(CN)_6$ M	0.005	0.005	0.005	0.0025	0.0025
$SrNO_3$ M	None	None	None	0.004	0.004
$CaNO_3$ M	0.016	0.016	0.016	None	None
Tank Samples					
pH	9.3	10.2	9.3	9.9	9.7
Cs, uc/cc	0.03[illegible]	0.050	0.12	0.061	0.053
Sr, uc/cc	0.20	0.10	0.30	0.11	0.12
Total B, uc/cc	14.55	21.61	18.23	17.31	29.50
AT, c/m/gal x 10^5	17.0	0.50	6.0	4.0	5.0
PO_4 M	0.134	0.164	0.139	0.121	0.095
Crib Line Samples					
pH	9.4	9.5	10.5	9.95	9.6[illegible]
Cs, uc/cc	0.024	0.19	0.15	0.015	0.027
Sr, uc/cc	0.14	0.22	0.32	0.07[illegible]	0.045
Total B, uc/cc	13.87	18.10	23.22	16.20	14.79
AT, c/m/gal x 10^5	4.0	3.0	4.0	5.0	3.0
PO_4, M	0.131	0.164	0.0[illegible]	0.1[illegible]	0.126
U, lbs/gal x 10^{-5}	0.10	0.10	[illegible]	23.0	[illegible]2.7
NO_3, lbs/gal	1.60	1.60	1.[illegible]	1.26	1.1[illegible]
Wt.% Solids	29.9	32.2	33.[illegible]	22.5	20.5
R.E., uc/cc	0.39	0.78	1.1[illegible]	1.4[illegible]	0.[illegible]0
Ce, uc/cc	1.36	0.95	[illegible]	2.69	0.[illegible]7
Zr-Nb, uc/cc	1.21	0.96	[illegible]	[illegible]	1.01
Ru, uc/cc	1.30	0.39	1.[illegible]	[illegible]	[illegible]9
Sb, uc/cc	0.40	0.59	[illegible]	0.91	0.71

Tank	21-110 BY	22-110 BY	23-110 BY	24-110 BY	25-110 BY
Filling					
Start	11-21-55	12-9-55	12-30-55	1-17-56	1-27-56
End	12-8-55	12-30-55	1-17-56	1-27-56	2-7-56
Batch Size, Gals.	533,500	578,875	601,250	646,250	572,000
Sampled, Date	12-21-55	1-8-56	1-24-56	2-5-56	2-19-56
Cribbing					
Crib No.	BC-1	BC-1	BC-1	BC-1	BC-1
Start	1-17-56	1-19-56	2-7-56	2-14-56	3-2-56
End	1-19-56	1-25-56	2-13-56	2-19-56	3-9-56
Gals.	[illegible],500	550,000	591,250	572,000	547,250
Heel					
To Tank	---	---	---	---	105-BY
Gals.	---	---	---	---	12,375
Treatment					
Waste	Dilute	Conc.	Dilute	Dilute	Dilute
H_2SO_4 M	0.0025	0.005	0.0025	0.0025	0.0025
$K_4Fe(CN)_6$ M	0.0025	0.005	0.0025	0.0025	0.0025
$SrNO_3$ M	0.004	None	0.004	0.004	0.004
$CaNO_3$ M	None	0.016	None	None	None
Tank Samples					
pH	9.8	9.2	10.0	9.7	9.6
Cs, uc/cc	0.008	0.033	0.008	0.005	0.013
Sr, uc/cc	0.075	0.22	0.024	0.017	0.028
Total B, uc/cc	32.76	16.72	5.26	15.58	10.91
AT, c/m/gal x 10^5	12.0	2.0	13.0	7.0	12.0
PO_4 M	0.096	0.102	0.061	0.087	0.093
Crib Line Samples					
pH	10.3	9.3	10.2	9.8	9.3
Cs, uc/cc	0.045	0.062	0.004	0.003	0.047
Sr, uc/cc	0.042	0.12	0.015	0.013	0.048
Total B, uc/cc	22.85	15.80	10.89	12.12	9.16
AT, c/m/gal x 10^5	5.0	15.0	3.0	6.0	5.0
PO_4, M	0.039	0.059	0.050	0.044	0.073
U, lbs/gal x 10^{-5}	3.6	29.0	15.3	0.83	0.26
NO_3, lbs./gal	1.14	1.75	0.69	1.29	0.22
Wt.% Solids	21.1	39.7	15.9	19.1	20.6
R.E.β uc/cc	0.67	0.26	0.26	0.15	0.12
Ce, uc/cc	3.01	0.36	0.95	1.09	0.39
Zr-Nb, uc/cc	0.74	1.48	0.27	0.50	0.22
Ru, uc/cc	3.01	0.45	0.25	5.68	4.15
Sb, uc/cc	0.91	0.59	0.34	0.46	0.36