START

OCT 07 1992 (11)

Station # 21

0024184

77

ENGINEERING DATA TRANSMITTAL

Page 1 of 1

1. EDT 159729

2. To: (Receiving Organization) Distribution	3. From: (Originating Organization) Environmental Engineering Support	4. Related EDT No.:
5. Proj./Prog./Dept./Div.: 300-FF-1 Treatability	6. Cog. Engr.: Jim G. Field	7. Purchase Order No.:
8. Originator Remarks: For Approval		9. Equip./Component No.:
		10. System/Bldg./Facility:
11. Receiver Remarks:		12. Major Assm. Dwg. No.:
		13. Permit/Permit Application No.:
		14. Required Response Date:

OCT 1992 RECEIVED EDMC

9413146.0002

15. DATA TRANSMITTED

(A) Item No.	(B) Document/Drawing No.	(C) Sheet No.	(D) Rev. No.	(E) Title or Description of Data Transmitted	(F) Impact Level	(G) Reason for Transmittal	(H) Originator Disposition	(I) Receiver Disposition
1	WHC-SD-EN-TI-049		0	Contaminant Concentration vs. Particle Size for 300 Area North Process Pond Samples	4	1	1	

16. KEY

Impact Level (F)	Reason for Transmittal (G)	Disposition (H) & (I)
1, 2, 3, or 4 (see MRP 5.43)	1. Approval 2. Release 3. Information 4. Review 5. Post-Review 6. Dist. (Receipt Acknow. Required)	1. Approved 2. Approved w/comment 3. Disapproved w/comment 4. Reviewed no/comment 5. Reviewed w/comment 6. Receipt acknowledged

17. SIGNATURE/DISTRIBUTION (See Impact Level for required signatures)

(G) Reason	(H) Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN	(J) Name	(K) Signature	(L) Date	(M) MSIN	(G) Reason	(H) Disp.
1	1	Cog.Eng. J. G. Field	J. G. Field	9/28/92	H4-55	EDMC (2)			H4-22		
1	1	Cog. Mgr. J. G. Woolard	J G Woolard		H4-55	Central Files			L8-04		
		QA									
		Safety									
		Env.									
1	1	G. C. Henckel	G C Henckel	9/29/92	H4-55						
1	1	R. D. Belden	Ron Belden	9/29/92	H4-55						

18.	19.	20.	21. DOE APPROVAL (if required)
J. G. Field 9/28/92 Signature of EDT Originator Date	Authorized Representative for Receiving Organization Date	J G Woolard 9/29/92 Cognizant/Project Engineer's Manager Date	Ltr. No. [] Approved [] Approved w/comments [] Disapproved w/comments

BD-7400-172-2 (07/91) GEF097

BD-7400-172-1 (02/89)

SUPPORTING DOCUMENT

1. Total Pages ~~65~~ 73

2. Title	3. Number	4. Rev No.
Contaminant Concentration vs. Particle Size for 300 Area North Process Pond Samples	WHC-SD-EN-TI-049	0

5. Key Words

Soil Washing
Treatability
300-FF-1 Operable Unit
Characterization

6. Author

Name: J. G. Field

Jim G. Field
Signature

Organization/Charge Code 81224/PC17A

APPROVED FOR PUBLIC RELEASE
10/5/92 N. Solis

7. Abstract

8. PURPOSE AND USE OF DOCUMENT - This document was prepared for use within the U.S. Department of Energy and its contractors. It is to be used only to perform direct, or integrate work under U.S. Department of Energy contracts. This document is not approved for public release until reviewed.

PATENT STATUS - This document copy, since it is transmitted in advance of patent clearance, is made available in confidence solely for use in performance of work under contracts with the U.S. Department of Energy. This document is not to be published nor its contents otherwise disseminated or used for purposes other than specified above before patent approval for such release or use has been secured, upon request, from the Patent Counsel, U.S. Department of Energy Field Office, Richland, WA.

DISCLAIMER - This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, nor any of their contractors, subcontractors or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or any third party's use or the results of such use of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

10. RELEASE STAMP

OFFICIAL RELEASE (11)
BY WHC
DATE OCT 07 1992
Station # 21

9. Impact Level 4

9413145.0003

A-6400-073 (11/91) (EF) WEF124

9413145.0004

CONTAMINANT CONCENTRATION VS. PARTICLE SIZE FOR 300 AREA NORTH PROCESS POND SAMPLES

R. Jeff Serne
Clark W. Lindenmeier
Pushpa K. Bhatia
Virginia L. LeGore

June 19, 1992

Letter Report Prepared for
Westinghouse Hanford Company

Pacific Northwest Laboratory
Richland, Washington 99352

SUMMARY

Three sediment samples from the 300 Area North Process Pond were characterized for ^{238}U, ^{235}U, gamma emitters, and selected metals as a function of particle size. Based on dry sieving, all three sediments are coarse with greater than 70% of the particles being gravel and less than 2.5% silt and clay. The sediments show elevated concentrations of ^{238}U, ^{235}U and numerous metals such as Cr, Ni, Cu, Zr, Zn, Ag and Sr compared to nearby undisturbed 300 Area sediments. In general, the concentrations of metals show a progression of higher concentrations as the particle size decreases. But because the sediments are so coarse the majority of the mass of each metal present in the sediment is found in the sand fractions especially the medium through coarse sand (425 μm to 2 mm). The sediments may contain very minor amounts (<0.5 pCi/g) of ^{60}Co and ^{137}Cs but these values are at our limit of detection.

Based on dry sieving, physical separation of all particles smaller than 250 μm would remove between 24 and 65% of the uranium present in the three sediments studied and would separate from 1.3 to 5.7% of the mass of bulk sediment. The one question still unanswered is whether or not the removal of the <250 um material will be enough to leave a clean soil. Since no cleanup goals have been set as of yet, this cannot be answered. However, when they are determined, it may be necessary to adjust the amount of sediments removed by raising or lowering the split point in order to achieve a clean soil. For example, a split at 2 mm would remove 21 to 30% of the sediment and would contain 85 to 92% of the uranium. A treatability test that simulates actual soil washing could provide additional information on this issue. There is a distinct possibility that wet sieving would show more contaminants in the finer fractions because of fines clinging to larger particles during the dry sieving. Alternatively, soil washing with attrition of larger particle sizes or washing with chemical reagents might remove the uranium and other contaminants from the larger sized material that constitutes the bulk of the Process Pond sediments.

ACKNOWLEDGEMENTS

We wish to thank the following Westinghouse Hanford staff for the funding to perform this work, Jim Field and George Henckel, Jr. We also acknowledge Jim Field, George Henckel, Dave Weekes and Ron Belden [Westinghouse Hanford staff] for helpful comments that improved this report.

Ron Sanders and co-workers at PNL performed the x-ray fluorescence analyses on the various size fractions. We also thank Betty LaMar for typing this manuscript. Bob Erikson (PNL) provided internal technical review of the report.

9413146.0006

CONTENTS

SUMMARY iii
ACKNOWLEDGEMENTS iv
INTRODUCTION 1
MATERIALS 2
METHODS 2
ANALYTICAL DETAILS 3
RESULTS 4
CONCLUSIONS AND OBSERVATIONS 39
REFERENCES 44
APPENDIX A - Calculations of Average Chemical Concentrations . . . 45
APPENDIX B - Calculations of Concentrations Remaining 49
APPENDIX C - XRF Data 54
APPENDIX D - Counting Data 63

9413145.0007

FIGURES

1. Particle Size Distribution for Sediment NPT-1 6

2. Particle Size Distribution for Sediment NPT-2 7

3. Particle Size Distribution for Sediment NPT-3 8

4. Cr Concentration in Sediment NPT-1 as a Function of Particle Size 14

5. Mn Concentration in Sediment NPT-1 as a Function of Particle Size 15

6. Cu Concentration in Sediment NPT-1 as a Function of Particle Size 16

7. Zr Concentration in Sediment NPT-1 as a Function of Particle Size 17

8. U Concentration in Sediment NPT-1 as a Function of Particle Size 18

9. Cr Concentration in Sediment NPT-2 as a Function of Particle Size 23

10. Mn Concentration in Sediment NPT-2 as a Function of Particle Size 24

11. Cu Concentration in Sediment NPT-2 as a Function of Particle Size 25

12. Zn Concentration in Sediment NPT-2 as a Function of Particle Size 26

13. Zr Concentration in Sediment NPT-2 as a Function of Particle Size 27

14. U Concentration in Sediment NPT-2 as a Function of Particle Size 28

15. Cr Concentration in Sediment NPT-3 as a Function of Particle Size 32

16. Mn Concentration in Sediment NPT-3 as a Function of Particle Size 34

17. Cu Concentration in Sediment NPT-3 as a Function of Particle Size 35

18. Zn Concentration in Sediment NPT-3 as a Function of Particle Size 36

9413145.0008

19. Zr Concentration in Sediment NPT-3 as a Function of Particle Size 37

20. U Concentration in Sediment NPT-3 as a Function of Particle Size 38

9413145.0009

TABLES

1. Particle Size Distribution 5

2. Chemical Data for NPT-1 Size Fractions <0.53 in. 9

3. Average Concentrations of Constituents in Background Soils . . . 10

4. Cumulative Weight % for Chemicals in NPT-1 13

5. ^{60}Co and ^{137}Cs Activity for NPT-1 Size Fractions 19

6. ^{238}U and ^{235}U Activity for NPT-1 Size Fractions 20

7. Chemical Data for NPT-2 Size Fractions <0.53 in. 21

8. Cumulative Weight % for Chemicals in NPT-2 22

9. ^{60}Co and ^{137}Cs Activity for NPT-2 Size Fractions 29

10. ^{238}U and ^{235}U Activity for NPT-2 Size Fractions 30

11. Chemical Data for NPT-3 Size Fractions <0.53 in. 31

12. Cumulative Weight % for Chemicals in NPT-3 33

13. ^{60}Co and ^{137}Cs Activity for NPT-3 Size Fractions 40

14. ^{238}U and ^{235}U Activity for NPT-3 Size Fractions 41

15. Comparison of Performance Goals and N Process Pond Samples . . . 42

A-1. Concentrations of Chemicals in Various Size Fractions (Soil NPT-1) 46

A-2. Concentrations of Chemicals in Various Size Fractions (Soil NPT-2) 47

A-3. Concentrations of Chemicals in Various Size Fractions (Soil NPT-3) 48

B-1. Calculated Concentrations of Chemicals in Residual NPT-1 Sediment 50

B-2. Calculated Concentrations of Chemicals in Residual NPT-2 Sediment 51

B-3. Calculated Concentrations of Chemicals in Residual NPT-3 Sediment 52

B-4. Calculated Activities of U in Residual Sediment 53

D-1. Raw Counting Data 65

9413145.0010

INTRODUCTION

The sediments in the 300 Area North Process Pond are being considered for clean up using soil washing processes. The criteria for success of the proposed treatability study using physical separation of fines are described in DOE (1992). They include separation and proper containment of the contaminant-rich fines and residual liquid effluent (if it should be deemed potentially hazardous) and release of the coarse "clean" fraction should it meet minimum performance levels for residual contaminant concentration (see DOE 1992 for specific values) to the site being cleaned. The success of the demonstration has been set on concentrating the contaminants into ≤30% of the soil volume excavated and therefore being allowed to release ≥70% of the soil back to the inactive burial ground. To support optimization of soil washing schemes for the proposed treatability study, some sediment characterization data are being collected. This letter report documents particle size distributions, and chemical and gamma emitting radionuclide contents as a function of particle-size distribution for three representative samples provided to Pacific Northwest Laboratory by Westinghouse Hanford Company. The particle fractions were separated by dry sieving.

There have been several earlier studies that describe the history of Process Ponds (Young, Fruland and Fruchter 1990; Young and Fruchter 1991), past sediment characterization (Dennison, Sherwood and Young 1989; Gerber et al. 1991) and the proposed soil washing treatability plan (DOE 1992).

The North Process Pond (~10 acres) was constructed in late 1948 to function as a percolation pond for fuels fabrication liquid wastes. The liquid wastes contained sodium aluminate from decladding the Al metal container around the uranium fuel. Later Zircaloy-2, a zirconium-beryllium based clad, was used. Thus, the waste stream likely contained Zr and Be in later years. Part of the fuel canning process also entailed use of tin and bronze (Cu). Mineral acids HF, HNO_3 and H_2SO_4, caustic (NaOH), and organic solvents and degreasers also ended up in the waste stream.

Radionuclides that were present in the liquid waste streams included uranium (natural with 0.7% ^{235}U, enriched to 0.95% ^{235}U and enriched to 1.25% ^{235}U) and small quantities of activation products (^{65}Zn, ^{59}Fe and ^{60}Co) from reprocessing fuel elements that had lost their seals.

9413145.0001

MATERIALS

Three bulk sample containers from the 300 Area North Process Ponds were received from Westinghouse Hanford Company. The samples were marked B01F87-NPT-1, B01F93-NPT-2, and B01FB3-NPT-3. A fourth smaller container was also labelled B01FB3-NPT-3 and was to be used for moisture content determination.

METHODS

The moisture content sample (B01FB3-NPT-3) was quickly homogenized, by hand mixing and split into three aliquots. Moisture content was determined on the three samples from measurements of wet and dry weights after oven drying at 105°C using ASTM D2216.

The three bulk samples were removed from the shipping containers and spread out individually in glass cake pans and oven dried at 105°C for three days with mixing once per day. After three days the samples appeared to be dry and a total sample weight was obtained. The bulk samples were then dry sieved into various fractions. The weights of each fraction were recorded.

Subsamples of each size fraction were taken to perform XRF chemical analyses and gamma counting. For the gamma counting, the larger size fractions (>2 in., 1.5 to 2 in., 1.0 to 1.5 in. and 0.53 to 1.0 in.) were washed with deionized water prior to being analyzed. This was performed to assure that no fine "dust" particles were clinging to the gravel/rocks that might contain higher activity of uranium. The XRF analyses were performed only on the size fractions ≤0.53 in. That is, no chemical data were collected for particles 0.53 to 1.0 in., 1.0 to 1.5 in., 1.5 in. to 2.0 in. and >2.0 in.

The sieves that were used to dry sieve the oven dried bulk samples were 2-in. (50.8 mm), 1.5 in. (38.1 mm), 1.0 in. (25.4 mm), 0.53 in. (13.2 mm), #4 (4.75 mm), #10 (2.00 mm), #40 (425 μm), #60 (250 μm), #100 (150 μm), #200 (75 μm), #325 (45 μm) and the catch pan.

Approximately 100 cm^3 of dry material was placed in the top of the stacked sieves and the sieves mechanically shaken for 10 minutes. The sieves were tapped to be certain that no smaller particles were trapped. The

9413146.0012

retained material on each screen was placed in a separate container. The process was repeated until all the sediment samples were sieved. A final weight of dried material in each size fraction was measured.

ANALYTICAL DETAILS

The subsamples that were 0.53 in. (~13.2 mm) and smaller were submitted to Ron Sanders (PNL) for x-ray fluorescence analyses. Approximately 1 gram of material was ground to a fine powder in a mortar. The powders were mounted in XRF slides and analyzed using four excitation sources: Tl, Zr, Ag and Gd. Elements that are measured using each source include Tl (Al, Si, S, Cl), Zr (Si, K, Ca, Tl, V, Cr, Fe, Ga, Hg, Se, Pb, As, Br), Ag (Rb, Sr, Y, Zr, Nb, Mo, U) and Gd (Ru, Pd, Ag, Cd, In, Sn, Sb, Te, I, Cs, Ba, La, Ce).

Gamma-ray analyses were performed on all subsamples. The finer size fractions (≤4.75 mm) were mixed with a cellulose binder and compressed into thin cylindrical wafers. Size fractions between 4.75 and 37.5 mm were packed in the bottom of 100 mL polyethylene bottles with a diameter similar to the wafers. A thin layer (~20 to 80 g) of sediment was packed into the bottles to simulate the wafer geometry. A representative (random) rock specimen from each sediment sample and each size fraction larger than 37.5 mm was wrapped in Saran Wrap and counted directly on top of the detector. That is, not every large rock particle was individually counted.

Samples were counted for variable time periods from 1 hour to 16 hours dependent upon activity level. A planar intrinsic Ge detector (1500 mm^2 active surface area, 16 mm thickness with a resolution of 604 eV at 122 keV) was used. The detector was calibrated with known standards of natural uranium ore and uranium mill tailings. Upon reviewing the raw data we determined that the spectra were essentially lacking most of the uranium daughter products with long half-lives. Therefore, ^{238}U was inferred from the activity of its daughter ^{234}Th at 63 keV. ^{235}U was calculated from its gamma emission at 185 kev. We assumed that there was no contribution from the ^{226}Ra activity at 186 kev. ^{137}Cs and ^{60}Co values were determined using their gamma peaks at 662 keV, and 1173 and 1332 keV respectively.

9413245.0013

RESULTS

Table 1 presents the particle size data for the three sediment samples. The oven-dried material is rather coarse. All three sediments are 70% or greater gravel, 21 to 28% sand and 0.2 to 2.4% silt and clay assuming 2 mm and 75 μm as cuts between gravel/sand and sand/silt and clay, respectively. Sample B01F87-NPT-1 is slightly coarser than the other two samples. Figures 1, 2, and 3 are bar charts that tabulate the particle size distribution for each sediment.

The moisture content of sample B01FB3-NPT-3 (taken on December 16, 1991 between the surface and a depth of 15 cm) was 19.71 ± 1.57 percent by weight. This is rather wet compared to natural Hanford conditions (<5%). The samples may have been taken after a precipitation event in the winter of 1991.

Table 2 lists the chemical data for sample B01F87-NPT-1. Only the metals with potentially elevated concentrations are listed. The raw data also gives values for Al, Si, S, Cl, K, Ca, Tl, V, Fe, Ga, Br, Rb, Y, Nb, Mo, Ru, Pd, In, Sn, Sb, Te, I, Cs, and La. Raw data for chemicals are found in Appendix C.

The data are available for only size fractions 0.53 in. (13.2 mm) and smaller. The entries in Table 2 show the measured concentrations of selected metals in each size fraction subsample in μg/g (ppm). Directly below each metal's concentration entry is the actual mass in mg that is contained in the total mass of the size fraction of the sample received from WHC. The sample weights of each size fraction are shown in Table 1. The column labelled Sum Fraction (mg) represents the total mass of the constituent in the material analyzed and is the sum of the product (measured concentration x mass of size fraction) for all subsamples analyzed. The Total "Bulk" column represents an estimate of what the metal's concentration would be in a bulk sample (all the ≤13.2 mm material mixed together). The material larger than 13.2 mm represents a considerable fraction of the field sample but was not analyzed. An estimate of actual chemical composition of the bulk material found in the pond can be conservatively estimated by assuming all material >13.2 mm has a concentration equal to the largest size analyzed 4.75 to 13.2 mm. Such calculations are shown in Appendix A. In general, the estimated concentrations of the bulk sediment drop by a factor between 1.1 and 2 compared to the values in the last column of Table 2. Appendix B presents

9413145.0014

TABLE 1. Particle Size Distribution

300 AREA NORTH PONDS SOIL ANALYSIS
SAMPLE ID: BO1F87-NPT-1
DATE: 4/20/92

Fraction Size millimeters	Fraction Weight grams	Fraction Weight percent
>50	238.48	7.73
50-37.5	655.89	21.25
37.5-25	690.83	22.38
25-13.2	495.57	16.06
13.2-4.75	153.95	4.99
4.75-2.0	206.92	6.70
2.0-0.425	556.20	18.02
0.425-0.25	47.43	1.54
0.25-0.15	21.26	0.69
0.15-0.075	12.54	0.41
0.075-0.045	5.38	0.17
<0.045	1.76	0.06
Total	3086.206	100

300 AREA NORTH PONDS SOIL ANALYSIS
SAMPLE ID: BO1F93-NPT-2
DATE: 4/17/92 and 4/20/92

Fraction Size millimeters	Fraction Weight grams	Fraction Weight percent
>50	1050.08	33.12
50-37.5	270.96	8.55
37.5-25	387.31	12.22
25-13.2	278.75	8.79
13.2-4.75	244.93	7.72
4.75-2.0	125.78	3.97
2.0-0.425	488.21	15.40
0.425-0.25	145.39	4.59
0.25-0.15	57.63	1.82
0.15-0.075	46.32	1.46
0.075-0.045	28.77	0.91
<0.045	46.51	1.47
Total	3170.64	100

300 AREA NORTH PONDS SOIL ANALYSIS
SAMPLE ID: BO1FB3-NPT-3
DATE: 4/16/92 to 4/20/92

Fraction Size millimeters	Fraction Weight grams	Fraction Weight percent
>50	620.32	18.71
50-37.5	127.61	3.85
37.5-25	917.82	27.68
25-13.2	358.37	10.81
13.2-4.75	174.51	5.26
4.75-2.0	138.45	4.18
2.0-0.425	812.37	24.50
0.425-0.25	28.55	0.86
0.25-0.15	44.54	1.34
0.15-0.075	31.62	0.95
0.075-0.045	22.66	0.68
<0.045	39.25	1.18
Total	3316.07	100

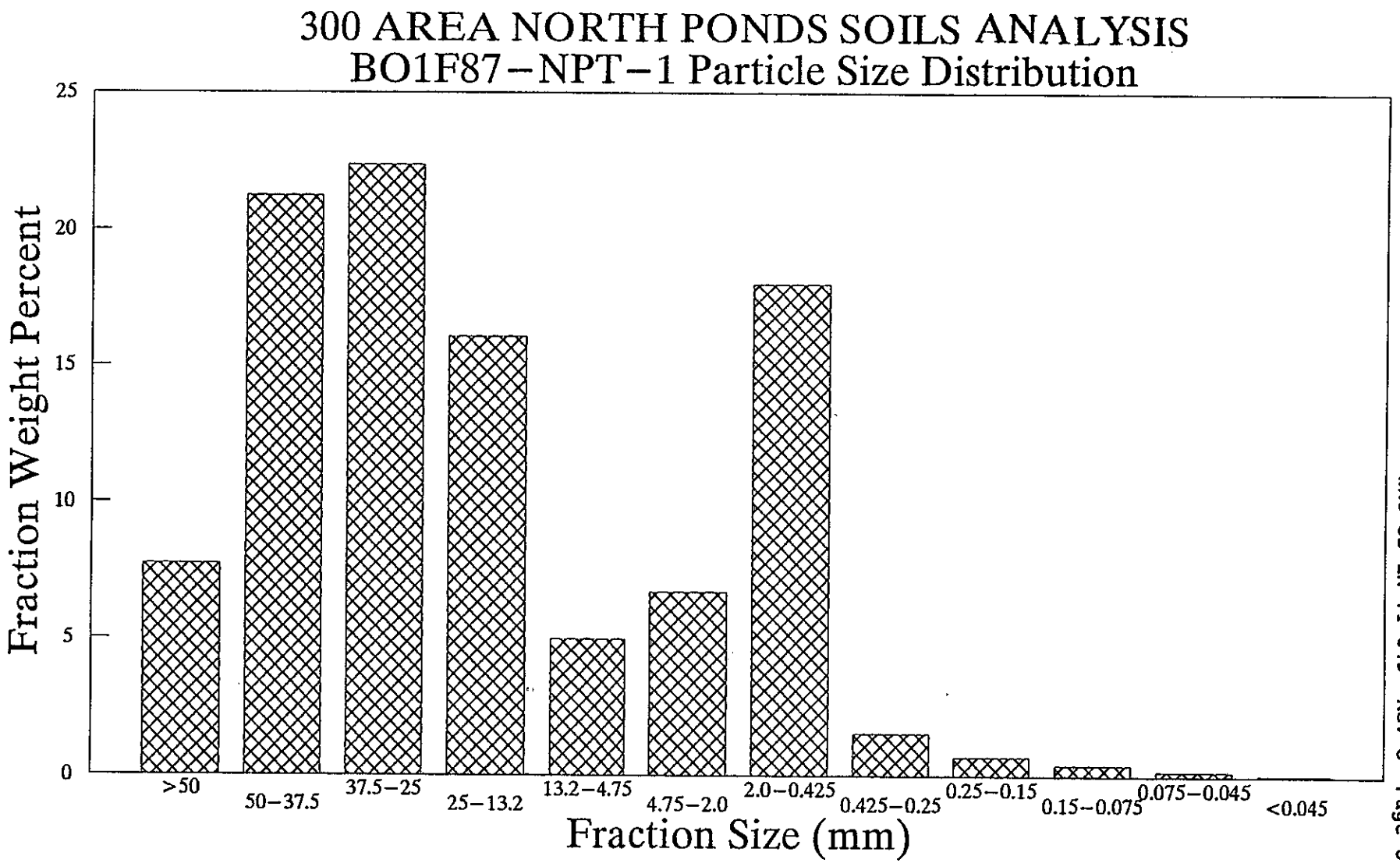

FIGURE 1. Particle Size Distribution for Sediment NPT-1

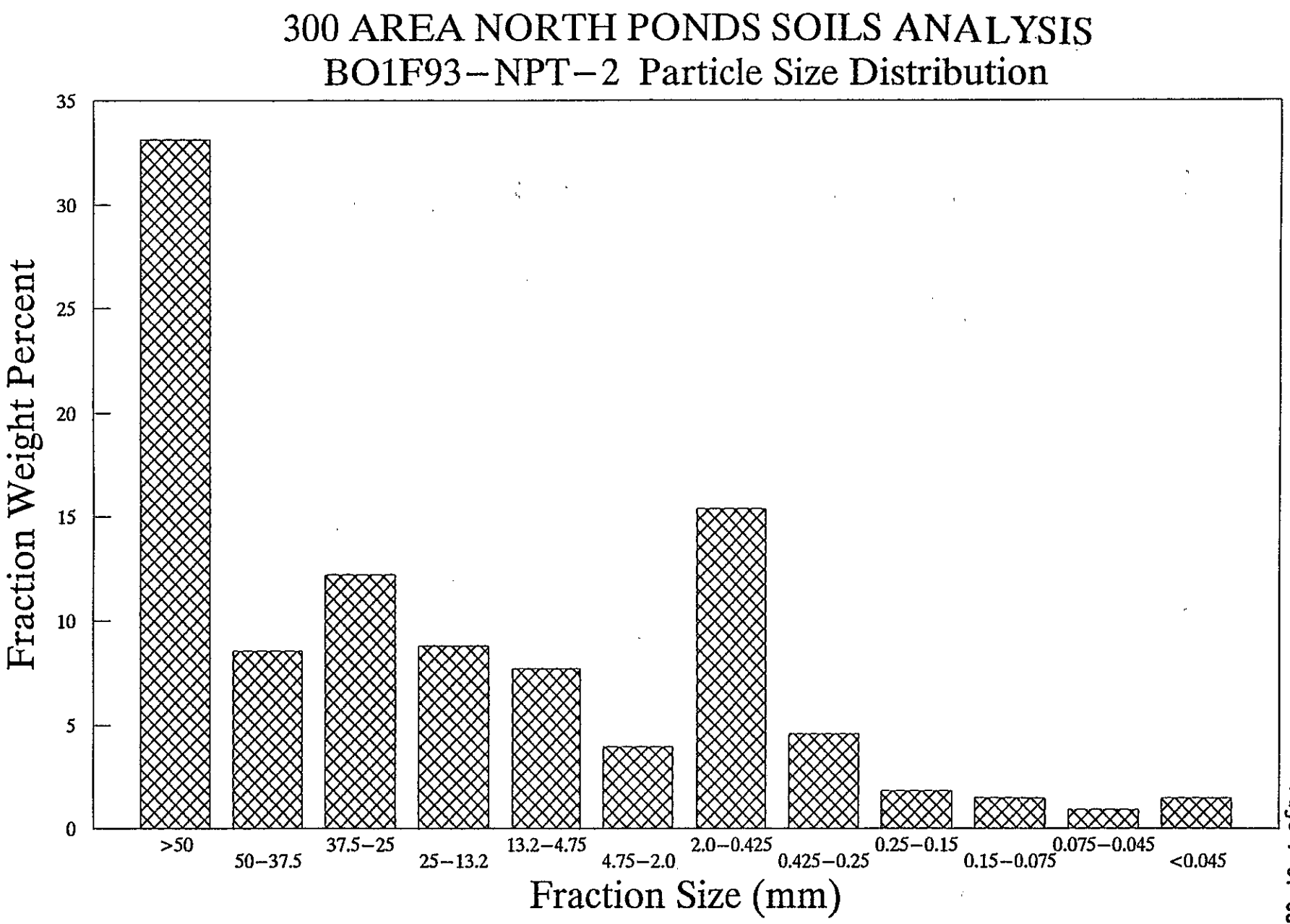

FIGURE 2. Particle Size Distribution for Sediment NPT-2

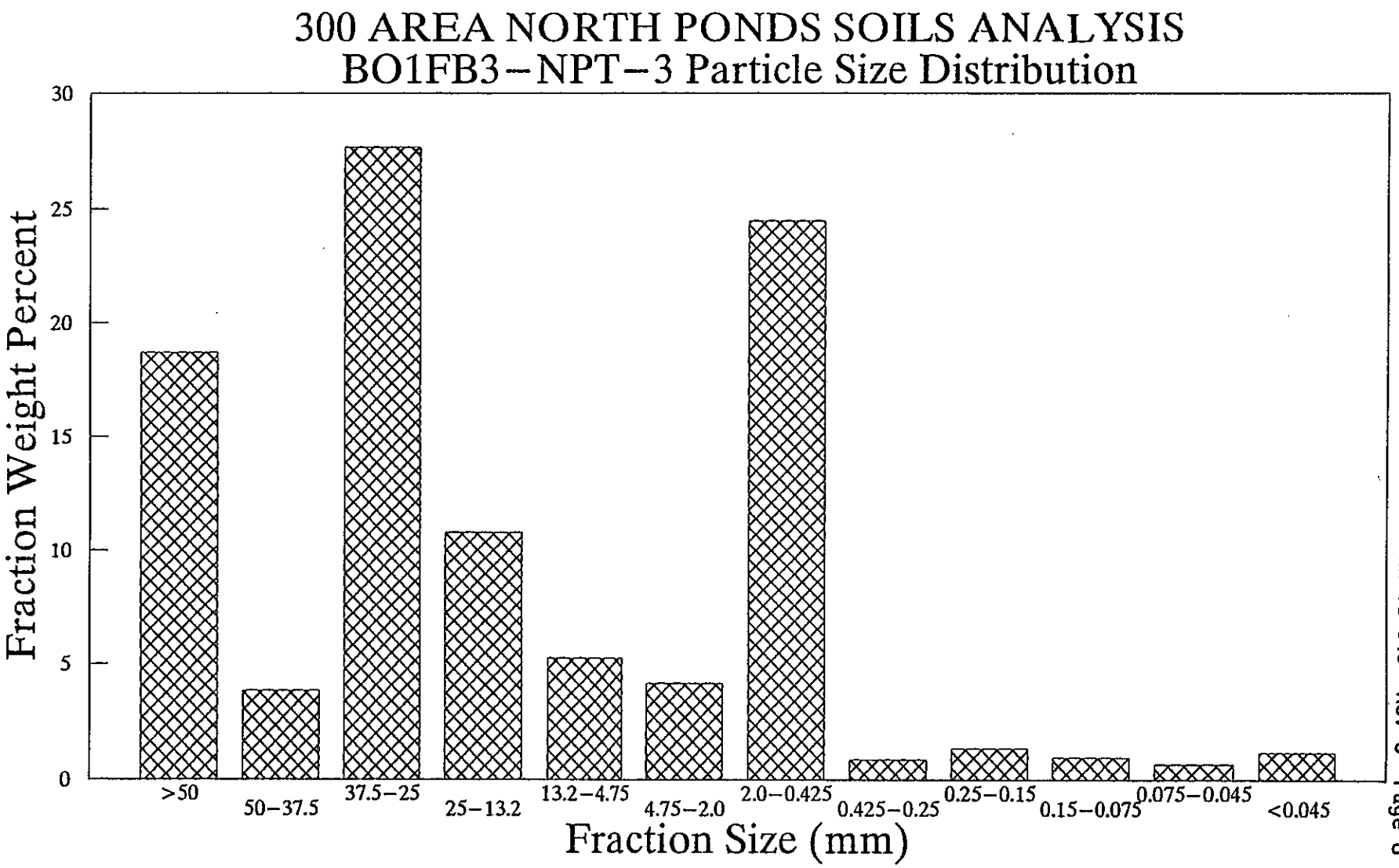

FIGURE 3. Particle Size Distribution for Sediment NPT-3

TABLE 2. Chemical Data for NPT-1 Size Fractions <0.53 in.

300 AREA NORTH PONDS SOIL ANALYSIS
SAMPLE ID: BO1F87-NPT-1
DATE: 4/20/92

XRF Analysis	Fraction Size (mm) 13.2-4.75	4.75-2.0	2.0-0.425	0.425-0.25	0.25-0.15	0.15-0.075	0.075-0.045	<0.045	Sum Fraction mg	Total "Bulk" ppm
Cr (ppm)	98.00	52.90	95.00	248.00	401.00	760.00	1108.00	1311.00		116.32
Cr (mg)	15.09	10.95	52.84	11.76	8.52	9.53	5.96	2.31	116.96	
Mn (ppm)	1515.00	1313.00	1486.00	964.00	969.00	1013.00	974.00	981.00		1409.76
Mn (mg)	233.23	271.69	826.51	45.72	20.60	12.70	5.24	1.73	1417.42	
Ni (ppm)	80.80	69.60	149.00	245.00	316.00	484.00	582.00	625.00		137.60
Ni (mg)	12.44	14.40	82.87	11.62	6.72	6.07	3.13	1.10	138.35	
Cu (ppm)	511.00	973.00	2430.00	5180.00	6840.00	10740.00	12870.00	14190.00		2239.37
Cu (mg)	78.67	201.33	1351.57	245.69	145.39	134.68	69.24	24.97	2251.54	
Zn (ppm)	113.70	113.50	133.50	111.70	112.30	147.80	219.00	256.00		125.73
Zn (mg)	17.50	23.49	74.25	5.30	2.39	1.85	1.18	0.45	126.41	
Hg (ppm)	2.90	2.90	3.10	3.50	4.10	6.00	8.40	10.20		3.15
Hg (mg)	0.45	0.60	1.72	0.17	0.09	0.08	0.05	0.02	3.16	
Se (ppm)	0.91	0.89	0.92	0.83	0.83	0.84	0.84	0.85		0.90
Se (mg)	0.14	0.18	0.51	0.04	0.02	0.01	0.00	0.00	0.91	
Pb (ppm)	7.20	10.80	12.30	19.90	28.50	48.80	75.20	97.70		12.85
Pb (mg)	1.11	2.23	6.84	0.94	0.61	0.61	0.40	0.17	12.92	
As (ppm)	1.50	1.50	1.60	5.13	5.27	9.30	12.00	11.20		1.98
As (mg)	0.23	0.31	0.89	0.24	0.11	0.12	0.06	0.02	1.99	
Sr (ppm)	271.00	350.00	313.00	330.00	328.00	315.00	294.00	271.00		315.15
Sr (mg)	41.72	72.42	174.09	15.65	6.97	3.95	1.58	0.48	316.87	
Zr (ppm)	176.00	225.00	330.00	1009.00	1740.00	3820.00	5670.00	6990.00		430.41
Zr (mg)	27.10	46.56	183.55	47.86	36.99	47.90	30.50	12.30	432.75	
Ag (ppm)	6.00	5.20	5.00	14.50	27.70	63.30	100.30	135.50		7.59
Ag (mg)	0.92	1.08	2.78	0.69	0.59	0.79	0.54	0.24	7.63	
Cd (ppm)	5.20	5.50	5.30	4.70	4.70	5.30	8.00	9.90		5.31
Cd (mg)	0.80	1.14	2.95	0.22	0.10	0.07	0.04	0.02	5.34	
Ba (ppm)	44.60	732.00	634.00	696.00	646.00	656.00	653.00	633.00		567.47
Ba (mg)	6.87	151.47	352.63	33.01	13.73	8.23	3.51	1.11	570.56	
Ce (ppm)	61.00	46.00	45.00	51.20	53.50	95.00	99.00	88.00		49.12
Ce (mg)	9.39	9.52	25.03	2.43	1.14	1.19	0.53	0.15	49.38	
U (ppm)	33.00	35.30	123.90	387.00	586.00	1073.00	1369.00	1490.00		134.82
U (mg)	5.08	7.30	68.91	18.36	12.46	13.46	7.37	2.62	135.55	

estimates of what the residual concentration of sediment would be if all particles smaller than a certain size fraction were removed as would occur in soil washing.

Based on data presented in Dennison, Sherwood and Young (1989), natural (background) soils near the 300 Area Process Ponds contain concentrations shown in Table 3. The values shown in Table 2 show several trends. Most trace metals (Cr, Ni, Cu, Hg, Pb, As, Zr, Ag and U) show progressively larger concentrations as particle size becomes smaller. The values for Cr, Ni, Cu, Sr, Ag and U are significantly larger than the background values reported in Dennison, Sherwood and Young (1989). Recall that our analyses do not include the larger sized particles that likely contain lower concentrations of the metals. Dennison, Sherwood and Young (1989) also removed material larger than 1.2 to 3.3 mm (0.05 to 0.13 in.) prior to submitting samples for analysis. Their report does not specify which sieve was used among three designated in the test plan. The analytical methods used by Dennison, Sherwood and Young (1989) to measure the metal concentrations was concentrated nitric acid leaching and atomic absorption or emission spectroscopy analyses. This procedure does not guarantee that all the metal is removed from the soil. Therefore, direct comparison of our XRF results with Dennison, Sherwood and Young's background sediment concentrations is not possible.

9413146.0020

TABLE 3. Average Concentrations of Constituents in Background Soils

	μg/g (ppm)
Cr	9.8 ± 1.2
Mn	396 ± 63
Ni	7.6 ± 1.0
Cu	18.4 ± 4.9
Zn	50.2 ± 8.2
Hg	<0.1
Se	<0.7
Pb	5.1 ± 0.9
As	3.0 ± 1.4
Sr	31 ± 0.8
Zr	NR[a]
Ag	<1.0
Cd	0.5 ± 0.3
Ba	97 ± 26
Ce	NR
U	19 ± 6 [b]

(a) NR = not reported in reference
(b) based on assumming that background total alpha value is from ^{238}U

Table 4 shows the cumulative weight percentage of each metal that is found as the particle size increases (labelled subtractive weight %) or as the particle size decreases (labelled cumulative weight %). The data may be used to estimate the total percentage of a metal that could be removed if all particles of a certain size were removed such as can be performed by physical separation soil washers. For example, if all particles less than 250 μm were removed from sample B01F87-NPT-1 then 26.5% of the uranium would be removed yet only 1.3% of the sediment (see Table 1) would be removed. Again this analysis assumes that there is no uranium present on the large particles ($\geq$13.2 mm) not analyzed by XRF.

Figures 4, 5, 6, 7 and 8 show bargraphs on the concentration of Cr, Mn, Cu, Zr and U versus particle size in sample B01F87-NPT-1. Despite the increasing concentrations of Cr, Cu, U and Zr as particle size decreases, the bulk of these metals are found in the coarse sand ($\geq$425 μm) and larger sized particles because the particle size distribution of this sediment is predominately larger than 425 μm. This fact is not important as long as the clean-up criteria are based solely on concentration remaining in the coarse "tailings" to be returned to the excavated site.

Table 5 presents the gamma-ray data for ^{60}Co and ^{137}Cs. All the subsamples show below detection limit or very close to detection limit values of 0.1 pCi/g concentrations. Only the 425 to 2000 μm size fraction show slightly above detection limit levels of both ^{137}Cs and ^{60}Co.

Table 6 shows the gamma analyses for uranium, the ratio between ^{238}U and ^{235}U activity, and a comparison between the XRF chemical data for U and the ^{238}U converted to mass data, for sediment sample B01F87-NPT-1. Raw counting data including calculated standard deviations are shown in Appendix D.

As discussed previously for chemical data, the ^{238}U activity consistently increases as the particle size decreases. The average $^{238}U/^{235}U$ activity ratio is 14.2 which is enriched in ^{235}U versus natural ore. Besides natural uranium, fuel with 0.95% ^{235}U (activity ratio 16.2) and 1.25% ^{235}U (activity ratio 12.3) were fabricated in facilities that released waste to the ponds. The average activity ratio of 14.2 falls between the two enrichments which is plausible for a mixture of fuel types. The XRF chemical data for U on the smaller size fractions agrees fairly well with the gamma scan data suggesting that the ^{234}Th activity data used to estimate ^{238}U content is reasonable. Data

9413145.0021

in Table 6 show that ^{238}U activities on the rock-sized particles above 13.2 mm are in fact low and represent only 5.4% of the total activity in the bulk sample. Removal of all particles smaller than 250 μm would remove 24.2% of the ^{238}U activity present in the bulk soil. This number compares with the value of 26.5% based on chemical analysis from the XRF data that ignores any U contribution of larger rocks.

Tables 7 and 8 list the XRF chemical data and Figures 9-14 show the concentration per particle size for selected metals in sediment sample B01F93-NPT-2. The trends are quite similar to those for sediment sample B01F87-NPT-1. The chemical data show the same elevated concentrations for the metals Cr, Ni, Cu, Sr, Ag, and U compared to background values. The Cu, U and Zr concentrations of the bulk sample are lower than for sample B01F87-NPT-1. Using the XRF data, if all particles less than 250 μm were removed then 66.2% of the uranium would be removed while only 5.7% of the sediment mass would be removed. Appendices A and B present more calculations on the concentrations of contaminants in the field samples and the expected concentrations left in tailings if fine particles are removed.

Tables 9 and 10 present the radionuclide data. Again there is very little indication of the presence of ^{60}Co and ^{137}Cs in the sediments. Only the size fraction 250 to 425 μm shows measurable ^{60}Co and ^{137}Cs present together. Table 10 shows ^{238}U activity increases faily consistently as the particle size drops. The overall average activity ratio for $^{238}U/^{235}U$ is 15.9 showing slightly less enrichment than sample B01F87-NPT-1. The ^{238}U data converted to a mass basis agrees fairly well with the XRF data for uranium. The radionuclide data suggest that 57.3% of the uranium could be removed if all particles less than 250 μm were removed. This compares with the value 66.2% based on XRF data that assumes that the larger rocks do not contain any uranium. The radionuclide data suggest that rocks >13.2 mm contain 4.8% of the total U.

Tables 11 and 12 present the XRF chemical data for sample B01FB3-NPT-3. The Cu and Zr concentrations are intermediate compared to the other two sediments and the U content is lower. The chemical data suggest that 44.5% of the uranium would be removed if all particles smaller than 250 μm were removed. This would represent only 4.2% by weight of the bulk sediment. Figures 15-20 show the concentration distribution of selected contaminants

9413145.0022

TABLE 4. Cumulative Weight % for Chemicals in NPT-1

300 AREA NORTH PONDS SOIL ANALYSIS
SAMPLE ID: BO1F87-NPT-1
DATE: 4/20/92

		Fraction Size (mm)							
		13.2-4.75	4.75-2.0	2.0-0.425	0.425-0.25	0.25-0.15	0.15-0.075	0.075-0.045	<0.045
Cr (mg)	Cumulative Weight %	12.90	22.26	67.44	77.49	84.78	92.93	98.03	100.00
	Subtractive Weight %	100.00	87.10	77.74	32.56	22.51	15.22	7.07	1.97
Mn (mg)	Cumulative Weight %	16.45	35.62	93.93	97.16	98.61	99.51	99.88	100.00
	Subtractive Weight %	100.00	83.55	64.38	6.07	2.84	1.39	0.49	0.12
Ni (mg)	Cumulative Weight %	8.99	19.40	79.30	87.70	92.55	96.94	99.20	100.00
	Subtractive Weight %	100.00	91.01	80.60	20.70	12.30	7.45	3.06	0.80
Cu (mg)	Cumulative Weight %	3.49	12.44	72.46	83.38	89.83	95.82	98.89	100.00
	Subtractive Weight %	100.00	96.51	87.56	27.54	16.62	10.17	4.18	1.11
Zn (mg)	Cumulative Weight %	13.85	32.43	91.17	95.36	97.25	98.71	99.64	100.00
	Subtractive Weight %	100.00	86.15	67.57	8.83	4.64	2.75	1.29	0.36
Hg (mg)	Cumulative Weight %	14.12	33.09	87.62	92.87	95.62	98.00	99.43	100.00
	Subtractive Weight %	100.00	85.88	66.91	12.38	7.13	4.38	2.00	0.57
Se (mg)	Cumulative Weight %	15.40	35.65	91.91	96.24	98.18	99.34	99.84	100.00
	Subtractive Weight %	100.00	84.60	64.35	8.09	3.76	1.82	0.66	0.16
Pb (mg)	Cumulative Weight %	8.58	25.87	78.81	86.12	90.80	95.54	98.67	100.00
	Subtractive Weight %	100.00	91.42	74.13	21.19	13.88	9.20	4.46	1.33
As (mg)	Cumulative Weight %	11.62	27.24	72.01	84.26	89.89	95.76	99.01	100.00
	Subtractive Weight %	100.00	88.38	72.76	27.99	15.74	10.11	4.24	0.99
Sr (mg)	Cumulative Weight %	13.17	36.02	90.96	95.90	98.10	99.35	99.85	100.00
	Subtractive Weight %	100.00	86.83	63.98	9.04	4.10	1.90	0.65	0.15
Zr (mg)	Cumulative Weight %	6.26	17.02	59.43	70.49	79.04	90.11	97.16	100.00
	Subtractive Weight %	100.00	93.74	82.98	40.57	29.51	20.96	9.89	2.84
Ag (mg)	Cumulative Weight %	12.11	26.21	62.66	71.68	79.40	89.80	96.87	100.00
	Subtractive Weight %	100.00	87.89	73.79	37.34	28.32	20.60	10.20	3.13
Cd (mg)	Cumulative Weight %	15.00	36.33	91.57	95.75	97.62	98.87	99.67	100.00
	Subtractive Weight %	100.00	85.00	63.67	8.43	4.25	2.38	1.13	0.33
Ba (mg)	Cumulative Weight %	1.20	27.75	89.55	95.34	97.75	99.19	99.80	100.00
	Subtractive Weight %	100.00	98.80	72.25	10.45	4.66	2.25	0.81	0.20
Ce (mg)	Cumulative Weight %	19.02	38.29	88.98	93.89	96.20	98.61	99.69	100.00
	Subtractive Weight %	100.00	80.98	61.71	11.02	6.11	3.80	1.39	0.31
U (mg)	Cumulative Weight %	3.75	9.14	59.98	73.52	82.71	92.63	98.07	100.00
	Subtractive Weight %	100.00	96.25	90.86	40.02	26.48	17.29	7.37	1.93

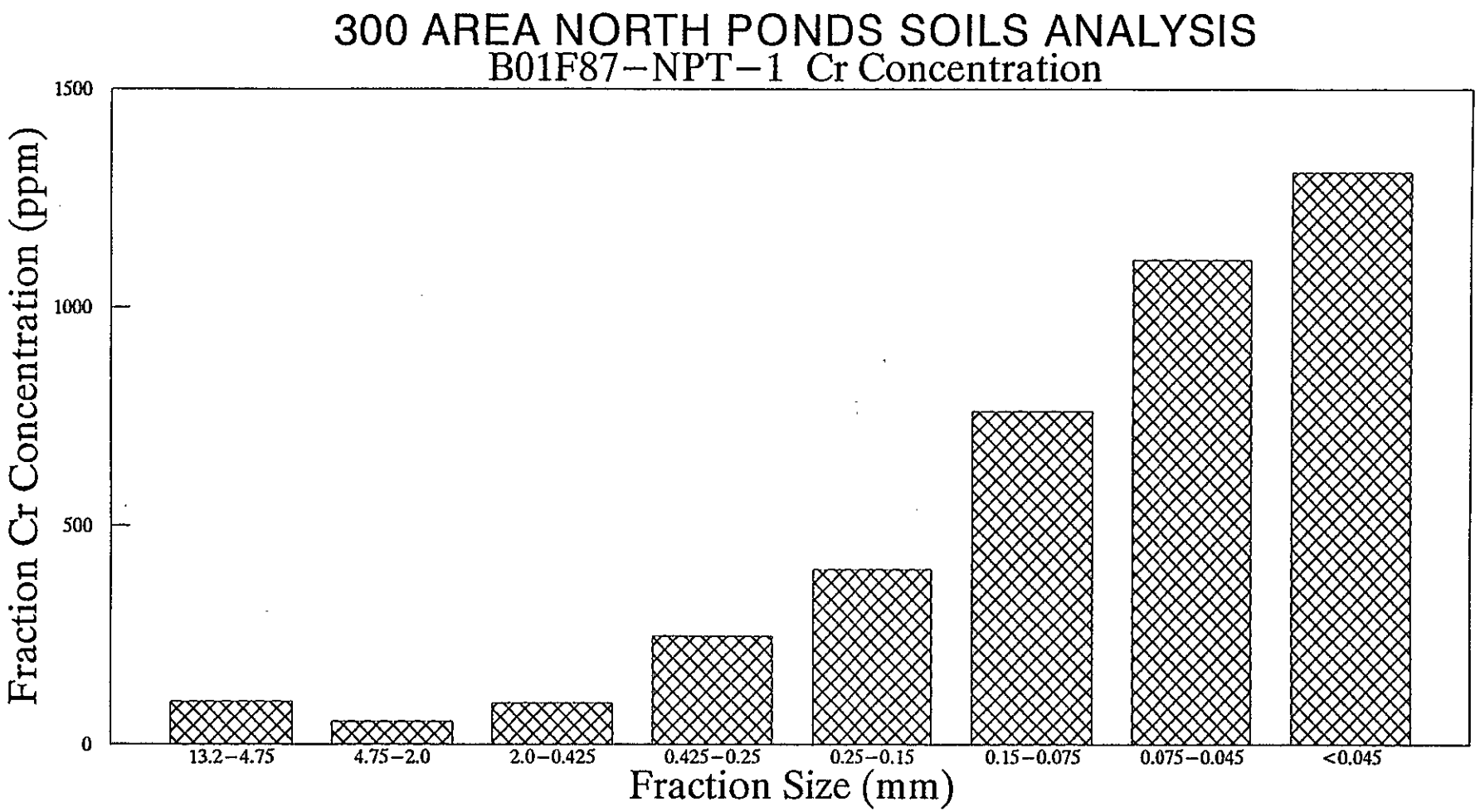

FIGURE 4. Cr Mass in Sediment NPT-1 as a Function of Particle Size

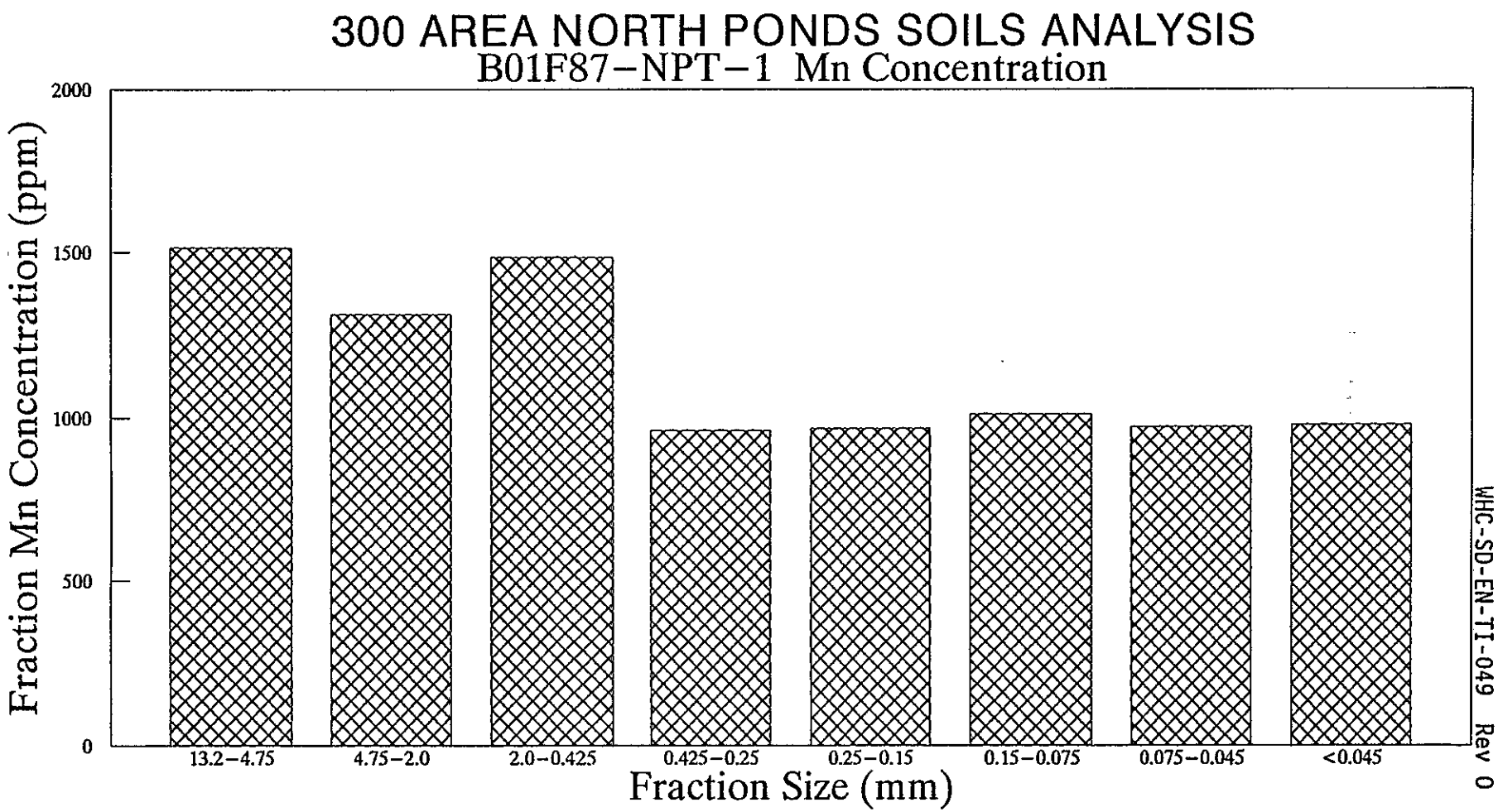

FIGURE 5. Mn Mass in Sediment NPT-1 as a Function of Particle Size

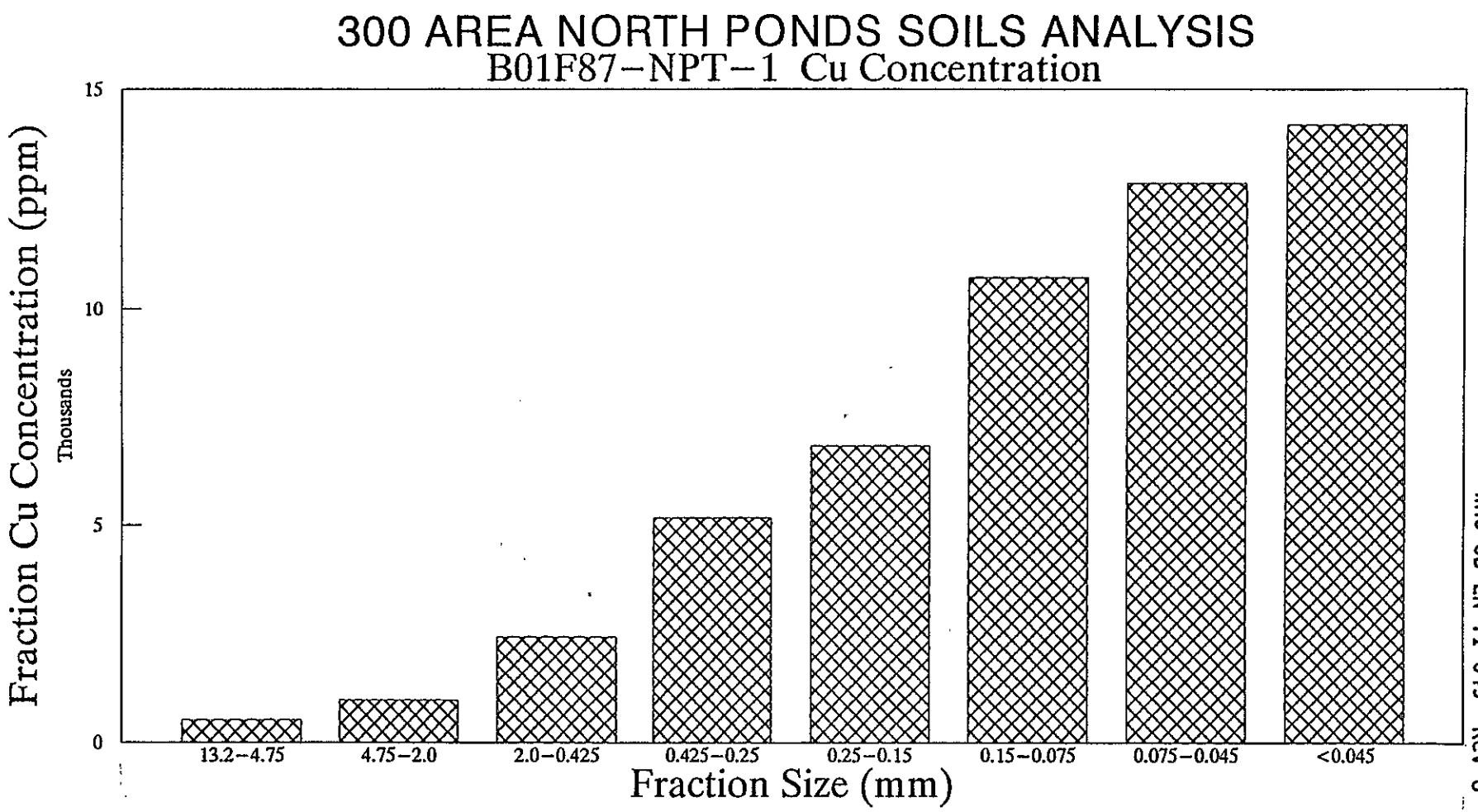

FIGURE 6. Cu Mass in Sediment NPT-1 as a Function of Particle Size

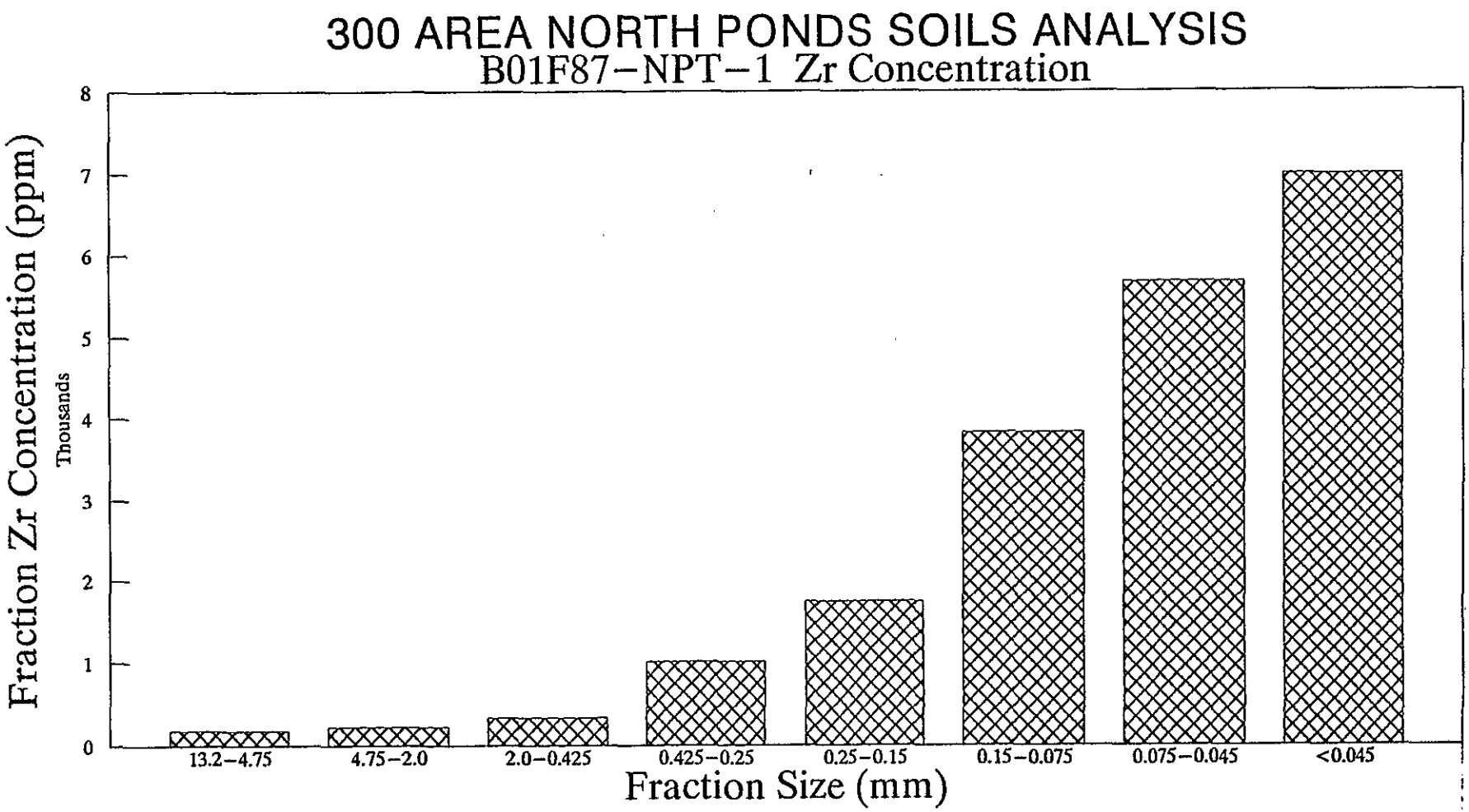

FIGURE 7. Zr Mass in Sediment NPT-1 as a Function of Particle Size

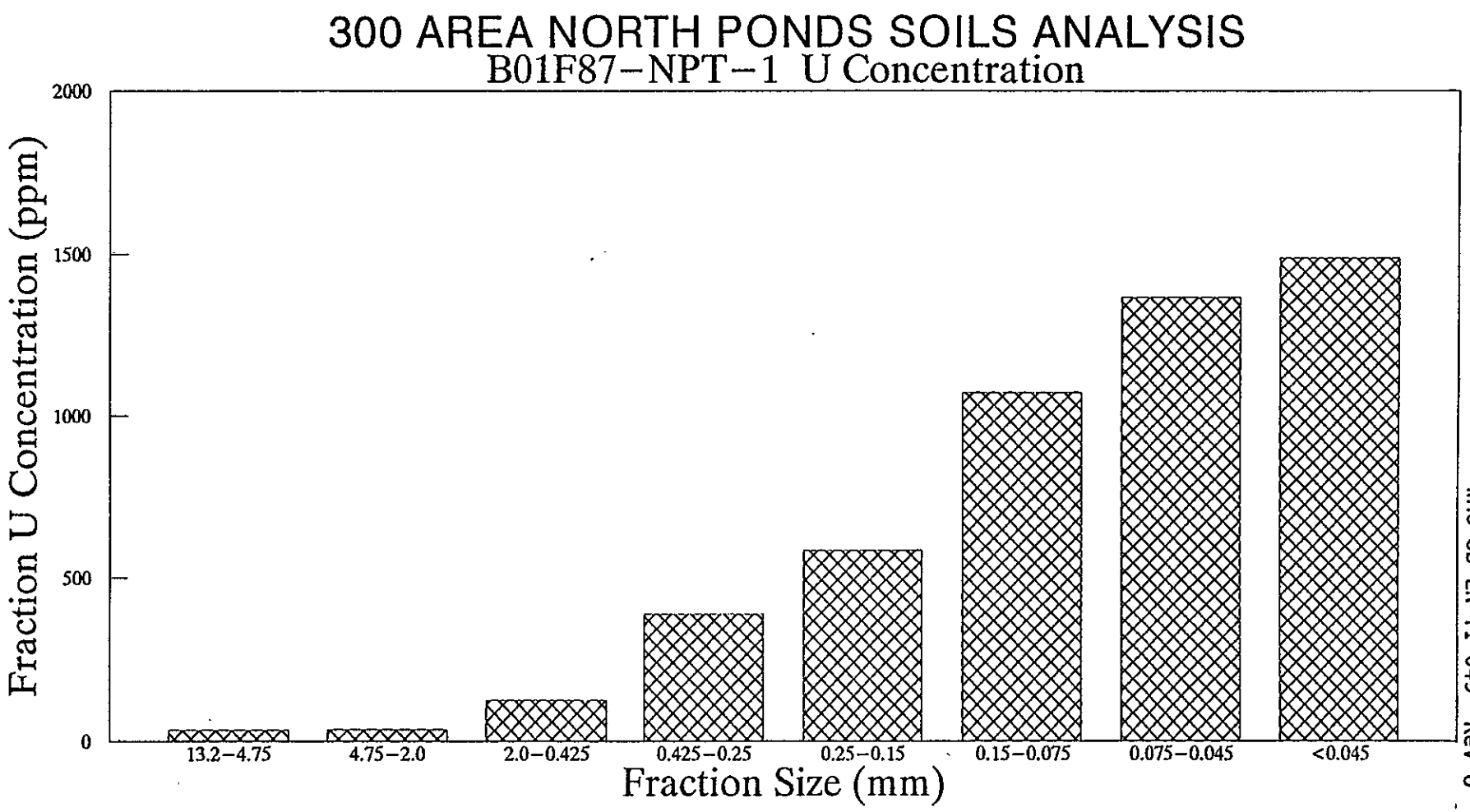

FIGURE 8. U Mass in Sediment NPT-1 as a Function of Particle Size

300 AREA NORTH PONDS SOIL ANALYSIS
SAMPLE ID: BO1F87-NPT-1
DATE: 4/20/92
Gamma Scan Analysis Parameters

TABLE 5. ^{60}Co and ^{137}Cs Activity for NPT-1 Size Fractions

	Co-60	Cs-137
Efficiency	0.0032	0.0068
Abundance	0.9999	0.8500
dpm/uCi	2.22E+06	2.22E+06
MDA (uCi/gm)	1.00E-07	1.00E-07

Sample Number	Fraction Size (mm)	Fraction Weight (gm)	Sample Weight (gm)	Co-60 1173 dps	Co-60 1332 dps	Co-60 Ave dps	Corr. dps	Sample uCi	Sample uCi/gm	Fraction uCi
1	>50	238.48	238.49	-<MDA-	-<MDA-	-<MDA-	-<MDA-	-<MDA-	1.00E-07	2.38E-05
2	50-37.5	655.89	209.37	-<MDA-	-<MDA-	-<MDA-	-<MDA-	-<MDA-	1.00E-07	6.56E-05
3	37.5-25	690.83	82.77	-<MDA-	-<MDA-	-<MDA-	-<MDA-	-<MDA-	1.00E-07	6.91E-05
4	25-13.2	495.57	36.38	-<MDA-	-<MDA-	-<MDA-	-<MDA-	-<MDA-	1.00E-07	4.96E-05
5	13.2-4.75	153.95	22.72	-<MDA-	-<MDA-	-<MDA-	-<MDA-	-<MDA-	1.00E-07	1.54E-05
6	4.75-2.0	206.92	12.89	-<MDA-	-<MDA-	-<MDA-	-<MDA-	-<MDA-	1.00E-07	2.07E-05
7	2.0-0.425	556.20	10.08	7.70E-04	8.04E-04	7.87E-04	2.46E-01	6.65E-06	6.60E-07	3.67E-04
8	0.425-0.25	47.43	11.02	-<MDA-	-<MDA-	-<MDA-	-<MDA-	-<MDA-	1.00E-07	4.74E-06
9	0.25-0.15	21.26	11.04	-<MDA-	-<MDA-	-<MDA-	-<MDA-	-<MDA-	1.00E-07	2.13E-06
10	0.15-0.075	12.54	11.01	-<MDA-	-<MDA-	-<MDA-	-<MDA-	-<MDA-	1.00E-07	1.25E-06
11	0.075-0.045	5.38	4.73	-<MDA-	-<MDA-	-<MDA-	-<MDA-	-<MDA-	1.00E-07	5.38E-07
12	<0.045	1.76	1.25	-<MDA-	-<MDA-	-<MDA-	-<MDA-	-<MDA-	1.00E-07	1.76E-07

Sample Number	Fraction Size (mm)	Fraction Weight (gm)	Sample Weight (gm)	Cs-137 662 dps	Corr. dps	Sample uCi	Sample uCi/gm	Fraction uCi
1	>50	238.48	238.49	-<MDA-	-<MDA-	-<MDA-	1.00E-07	2.38E-05
2	50-37.5	655.89	209.37	4.67E-03	8.08E-01	2.18E-05	1.04E-07	6.84E-05
3	37.5-25	690.83	82.77	2.83E-03	4.90E-01	1.32E-05	1.60E-07	1.10E-04
4	25-13.2	495.57	36.38	-<MDA-	-<MDA-	-<MDA-	1.00E-07	4.96E-05
5	13.2-4.75	153.95	22.72	-<MDA-	-<MDA-	-<MDA-	1.00E-07	1.54E-05
6	4.75-2.0	206.92	12.89	-<MDA-	-<MDA-	-<MDA-	1.00E-07	2.07E-05
7	2.0-0.425	556.20	10.08	1.60E-03	2.77E-01	7.48E-06	7.42E-07	4.13E-04
8	0.425-0.25	47.43	11.02	-<MDA-	-<MDA-	-<MDA-	1.00E-07	4.74E-06
9	0.25-0.15	21.26	11.04	-<MDA-	-<MDA-	-<MDA-	1.00E-07	2.13E-06
10	0.15-0.075	12.54	11.01	-<MDA-	-<MDA-	-<MDA-	1.00E-07	1.25E-06
11	0.075-0.045	5.38	4.73	-<MDA-	-<MDA-	-<MDA-	1.00E-07	5.38E-07
12	<0.045	1.76	1.25	-<MDA-	-<MDA-	-<MDA-	1.00E-07	1.76E-07

300 AREA NORTH PONDS SOIL ANALYSIS
SAMPLE ID: BO1F87-NPT-1
DATE: 4/20/92

TABLE 6. ^{238}U and ^{235}U Activity for NPT-1 Size Fraction

Gamma Scan Analysis Parameters

	Fraction Size (mm)	Fraction Weight (gm)	U-238 (as Th-234) uCi/gm	U-238 Fraction uCi	U-235 uCi/gm	U-235 Fraction uCi	Ratio U-238/U-235
1	>50	238.48	4.84E-07	1.15E-04	4.08E-08	9.73E-06	11.86
2	50-37.5	655.89	3.94E-07	2.59E-04	6.18E-08	4.05E-05	6.38
3	37.5-25	690.83	2.01E-06	1.39E-03	2.13E-07	1.47E-04	9.45
4	25-13.2	495.57	2.11E-06	1.04E-03	2.75E-07	1.36E-04	7.66
5	13.2-4.75	153.95	9.09E-06	1.40E-03	3.52E-07	5.42E-05	25.83
6	4.75-2.0	206.92	1.84E-05	3.80E-03	1.29E-06	2.67E-04	14.24
7	2.0-0.425	556.20	4.51E-05	2.51E-02	2.95E-06	1.64E-03	15.30
8	0.425-0.25	47.43	1.38E-04	6.54E-03	1.02E-05	4.83E-04	13.54
9	0.25-0.15	21.26	1.95E-04	4.15E-03	1.47E-05	3.12E-04	13.29
10	0.15-0.075	12.54	3.84E-04	4.82E-03	2.30E-05	2.89E-04	16.71
11	0.075-0.045	5.38	4.93E-04	2.65E-03	2.65E-05	1.42E-04	18.60
12	<0.045	1.76	5.92E-04	1.04E-03	3.41E-05	6.00E-05	17.37
Average							14.19
Standard Deviation							5.27

Comparison of XRF Uranium Analysis to U-238 Gamma Scan Analysis

	Fraction Size (mm)	XRF Uranium ppm	Gamma Scan U-238 ppm
5	13.2-4.75	33.00	27.31
6	4.75-2.0	35.30	55.17
7	2.0-0.425	123.90	135.38
8	0.425-0.25	387.00	413.81
9	0.25-0.15	586.00	586.49
10	0.15-0.075	1073.00	1154.35
11	0.075-0.045	1369.00	1479.28
12	<0.045	1490.00	1778.68

TABLE 7. Chemical Data for NPT-2 Size Fractions <0.53 in.

300 AREA NORTH PONDS SOIL ANALYSIS
SAMPLE ID: BO1F93-NPT-2
DATE: 4/17/92 and 4/20/92

XRF Analysis	Fraction Size (mm) 13.2-4.75	4.75-2.0	2.0-0.425	0.425-0.25	0.25-0.15	0.15-0.075	0.075-0.045	<0.045	Sum Fraction mg	Total "Bulk" ppm
Cr (ppm)	25.50	25.00	88.00	144.00	292.00	387.00	469.00	639.00		127.80
Cr (mg)	6.25	3.14	42.96	20.94	16.83	17.93	13.49	29.72	151.26	
Mn (ppm)	617.00	1561.00	1342.00	1069.00	849.00	780.00	760.00	836.00		1101.67
Mn (mg)	151.12	196.34	655.18	155.42	48.93	36.13	21.87	38.88	1303.87	
Ni (ppm)	36.20	51.77	56.50	69.70	117.10	147.00	187.00	290.00		72.26
Ni (mg)	8.87	6.51	27.58	10.13	6.75	6.81	5.38	13.49	85.52	
Cu (ppm)	101.20	75.00	134.90	285.00	560.00	742.00	947.00	1216.00		246.68
Cu (mg)	24.79	9.43	65.86	41.44	32.27	34.37	27.25	56.56	291.96	
Zn (ppm)	38.70	133.40	121.50	111.30	156.60	155.80	172.40	215.00		112.34
Zn (mg)	9.48	16.78	59.32	16.18	9.02	7.22	4.96	10.00	132.96	
Hg (ppm)	2.20	3.10	2.90	2.70	2.80	6.50	7.30	10.10		3.28
Hg (mg)	0.54	0.39	1.42	0.39	0.16	0.30	0.21	0.47	3.88	
Se (ppm)	0.71	0.92	0.91	0.83	0.82	0.85	0.95	1.13		0.86
Se (mg)	0.17	0.12	0.44	0.12	0.05	0.04	0.03	0.05	1.02	
Pb (ppm)	10.30	12.40	15.60	22.70	36.80	44.90	56.20	73.40		20.47
Pb (mg)	2.52	1.56	7.62	3.30	2.12	2.08	1.62	3.41	24.23	
As (ppm)	1.46	1.60	2.60	3.70	5.09	6.90	9.20	8.10		3.06
As (mg)	0.36	0.20	1.27	0.54	0.29	0.32	0.26	0.38	3.62	
Sr (ppm)	417.00	318.00	378.00	409.00	410.00	418.00	412.00	409.00		388.67
Sr (mg)	102.14	40.00	184.54	59.46	23.63	19.36	11.85	19.02	460.01	
Zr (ppm)	111.10	209.00	180.00	197.00	284.00	352.00	446.00	456.00		200.02
Zr (mg)	27.21	26.29	87.88	28.64	16.37	16.30	12.83	21.21	236.73	
Ag (ppm)	4.40	4.90	15.70	43.00	106.80	135.40	170.70	253.00		37.78
Ag (mg)	1.08	0.62	7.66	6.25	6.15	6.27	4.91	11.77	44.72	
Cd (ppm)	4.80	5.10	5.10	5.20	5.80	5.50	8.20	6.80		5.24
Cd (mg)	1.18	0.64	2.49	0.76	0.33	0.25	0.24	0.32	6.20	
Ba (ppm)	136.70	761.00	649.00	725.00	774.00	780.00	769.00	914.00		588.76
Ba (mg)	33.48	95.72	316.85	105.41	44.61	36.13	22.12	42.51	696.83	
Ce (ppm)	18.70	53.70	40.20	62.80	69.00	50.00	50.00	39.00		41.94
Ce (mg)	4.58	6.75	19.63	9.13	3.98	2.32	1.44	1.81	49.64	
U (ppm)	5.10	6.70	39.80	108.60	272.00	357.00	454.00	598.00		93.28
U (mg)	1.25	0.84	19.43	15.79	15.68	16.54	13.06	27.81	110.40	

TABLE 8. Cumulative Weight % for Chemicals in NPT-2

300 AREA NORTH PONDS SOIL ANALYSIS
SAMPLE ID: BO1F93-NPT-2
DATE: 4/17/92 and 4/20/92

		Fraction Size (mm)							
		13.2-4.75	4.75-2.0	2.0-0.425	0.425-0.25	0.25-0.15	0.15-0.075	0.075-0.045	<0.045
Cr (mg)	Cumulative Weight %	4.13	6.21	34.61	48.45	59.58	71.43	80.35	100.00
	Subtractive Weight %	100.00	95.87	93.79	65.39	51.55	40.42	28.57	19.65
Mn (mg)	Cumulative Weight %	11.59	26.65	76.90	88.82	92.57	95.34	97.02	100.00
	Subtractive Weight %	100.00	88.41	73.35	23.10	11.18	7.43	4.66	2.98
Ni (mg)	Cumulative Weight %	10.37	17.98	50.24	62.08	69.98	77.94	84.23	100.00
	Subtractive Weight %	100.00	89.63	82.02	49.76	37.92	30.02	22.06	15.77
Cu (mg)	Cumulative Weight %	8.49	11.72	34.28	48.47	59.52	71.30	80.63	100.00
	Subtractive Weight %	100.00	91.51	88.28	65.72	51.53	40.48	28.70	19.37
Zn (mg)	Cumulative Weight %	7.13	19.75	64.36	76.53	83.32	88.75	92.48	100.00
	Subtractive Weight %	100.00	92.87	80.25	35.64	23.47	16.68	11.25	7.52
Hg (mg)	Cumulative Weight %	13.89	23.94	60.44	70.56	74.72	82.48	87.89	100.00
	Subtractive Weight %	100.00	86.11	76.06	39.56	29.44	25.28	17.52	12.11
Se (mg)	Cumulative Weight %	17.03	28.36	71.87	83.69	88.32	92.18	94.85	100.00
	Subtractive Weight %	100.00	82.97	71.64	28.13	16.31	11.68	7.82	5.15
Pb (mg)	Cumulative Weight %	10.41	16.85	48.28	61.90	70.65	79.24	85.91	100.00
	Subtractive Weight %	100.00	89.59	83.15	51.72	38.10	29.35	20.76	14.09
As (mg)	Cumulative Weight %	9.88	15.44	50.50	65.35	73.46	82.28	89.59	100.00
	Subtractive Weight %	100.00	90.12	84.56	49.50	34.65	26.54	17.72	10.41
Sr (mg)	Cumulative Weight %	22.20	30.90	71.02	83.94	89.08	93.29	95.86	100.00
	Subtractive Weight %	100.00	77.80	69.10	28.98	16.06	10.92	6.71	4.14
Zr (mg)	Cumulative Weight %	11.49	22.60	59.72	71.82	78.73	85.62	91.04	100.00
	Subtractive Weight %	100.00	88.51	77.40	40.28	28.18	21.27	14.38	8.96
Ag (mg)	Cumulative Weight %	2.41	3.79	20.93	34.91	48.68	62.70	73.68	100.00
	Subtractive Weight %	100.00	97.59	96.21	79.07	65.09	51.32	37.30	26.32
Cd (mg)	Cumulative Weight %	18.95	29.29	69.42	81.61	86.99	91.10	94.90	100.00
	Subtractive Weight %	100.00	81.05	70.71	30.58	18.39	13.01	8.90	5.10
Ba (mg)	Cumulative Weight %	4.80	18.54	64.01	79.14	85.54	90.72	93.90	100.00
	Subtractive Weight %	100.00	95.20	81.46	35.99	20.86	14.46	9.28	6.10
Ce (mg)	Cumulative Weight %	9.23	22.84	62.38	80.77	88.78	93.45	96.35	100.00
	Subtractive Weight %	100.00	90.77	77.16	37.62	19.23	11.22	6.55	3.65
U (mg)	Cumulative Weight %	1.13	1.89	19.50	33.80	48.00	62.98	74.81	100.00
	Subtractive Weight %	100.00	98.87	98.11	80.50	66.20	52.00	37.02	25.19

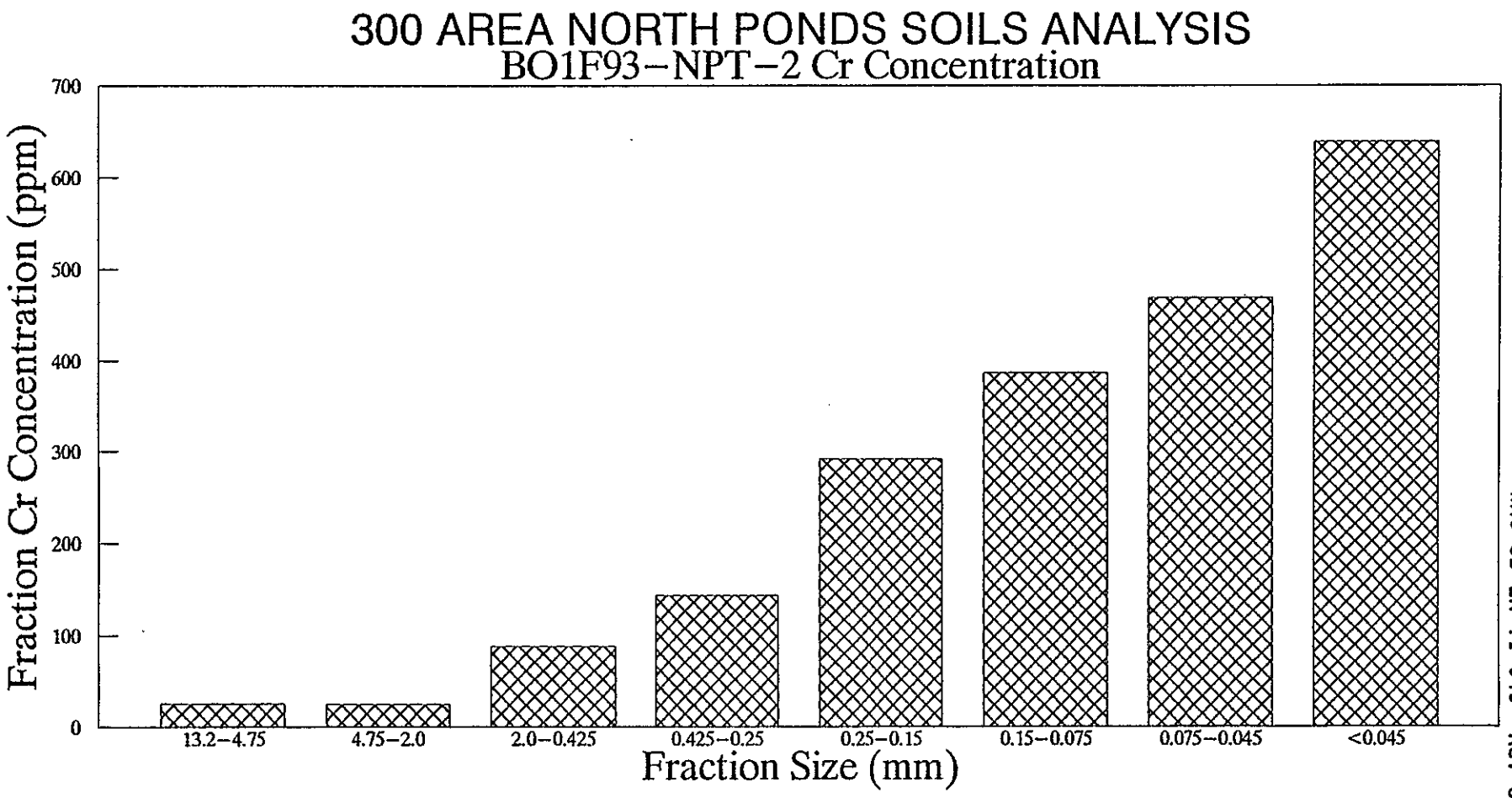

FIGURE 9. Cr Mass in Sediment NPT-2 as a Function of Particle Size

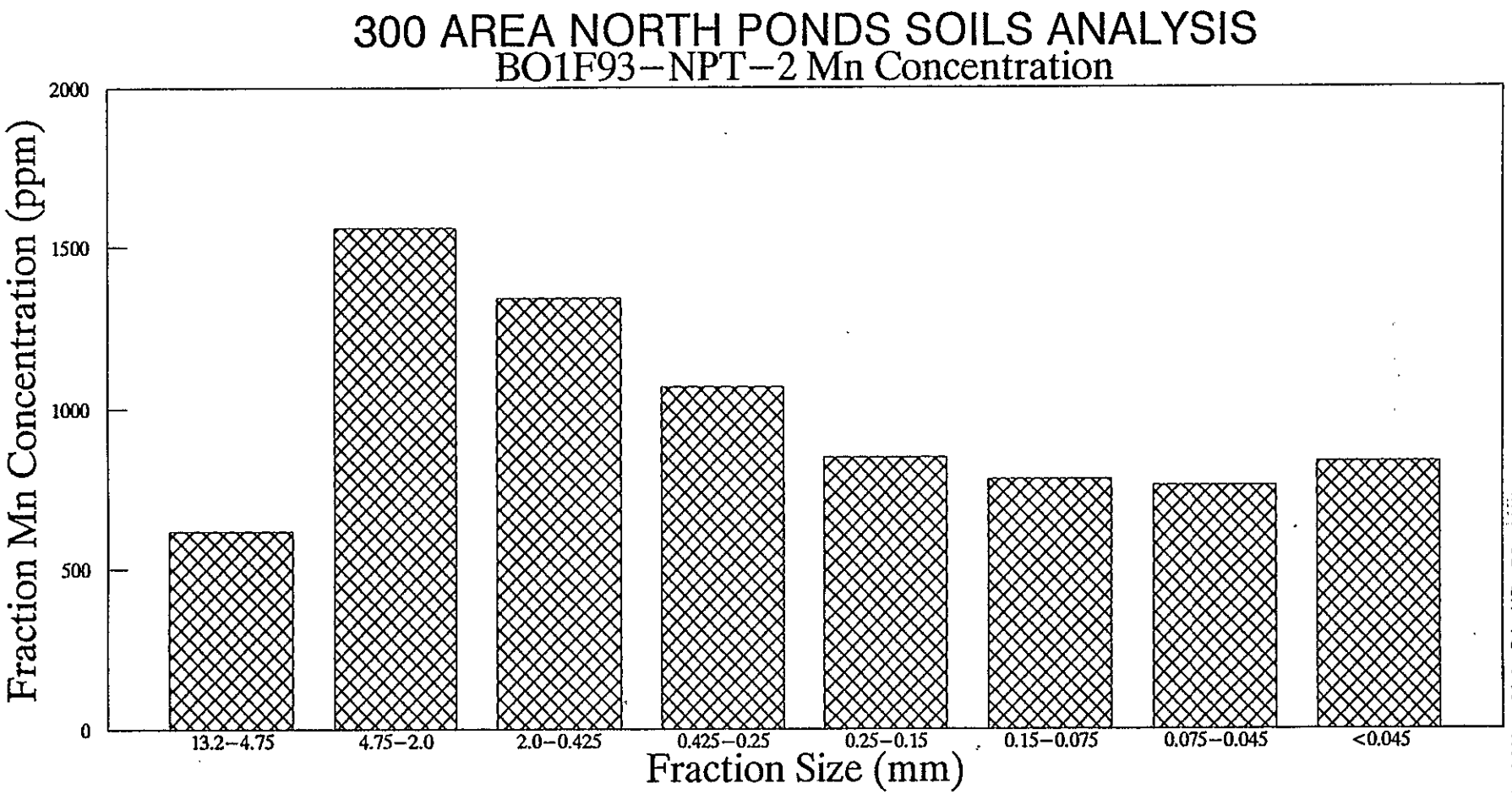

FIGURE 10. Mn Mass in Sediment NPT-2 as a Function of Particle Size

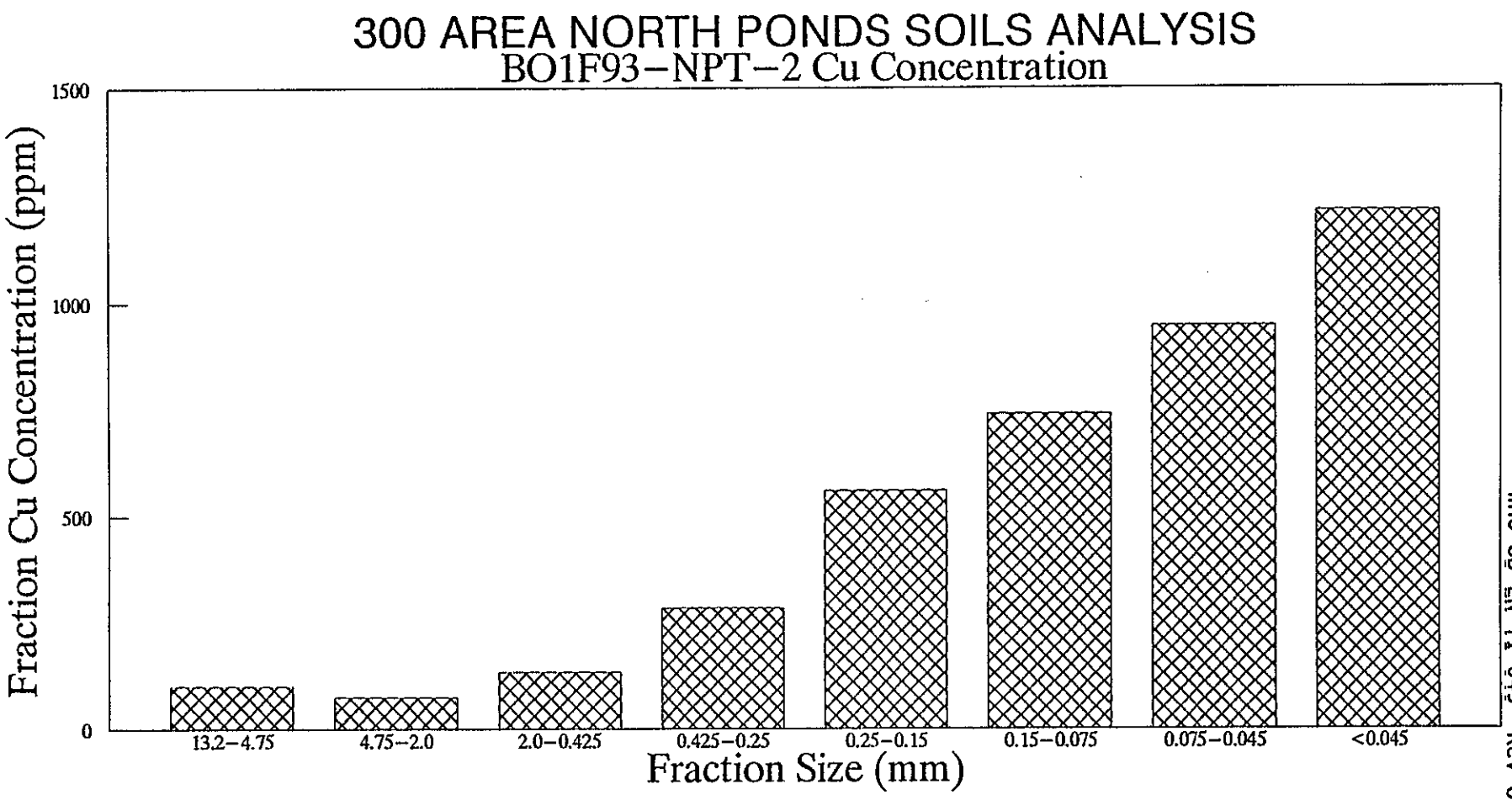

FIGURE 11. Cu Mass in Sediment NPT-2 as a Function of Particle Size

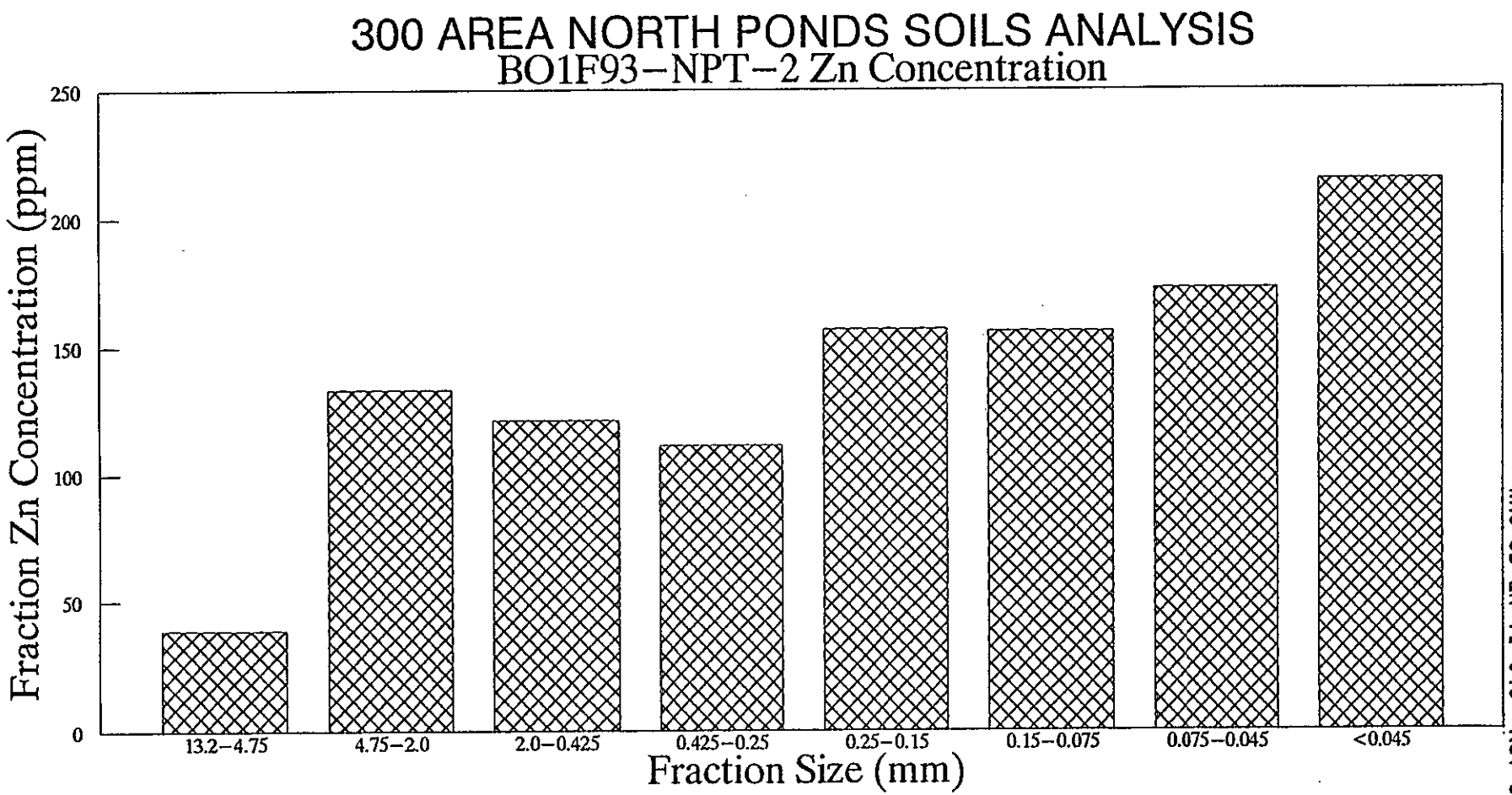

FIGURE 12. Zn Mass in Sediment NPT-2 as a Function of Particle Size

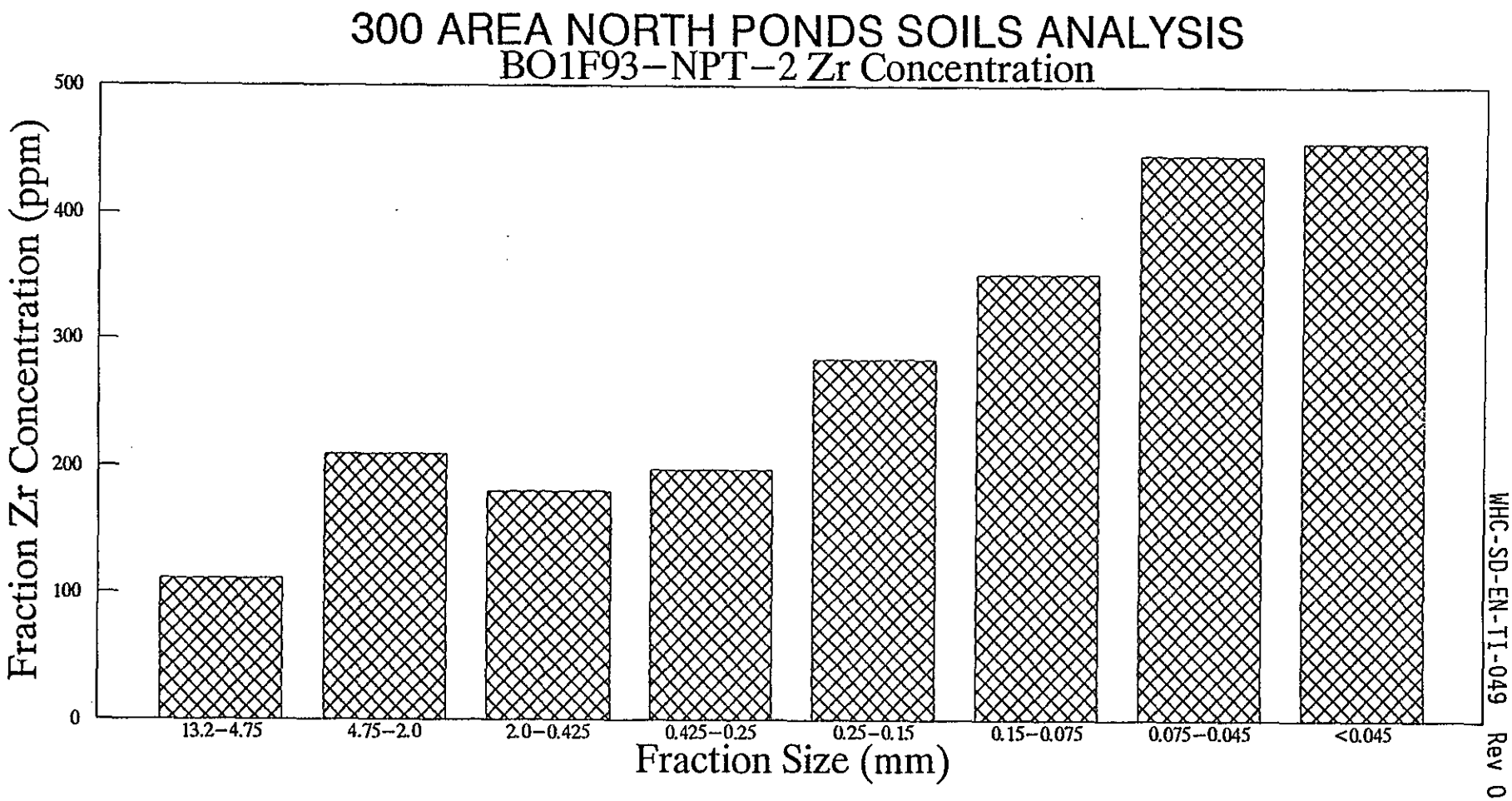

FIGURE 13. Zr Mass in Sediment NPT-2 as a Function of Particle Size

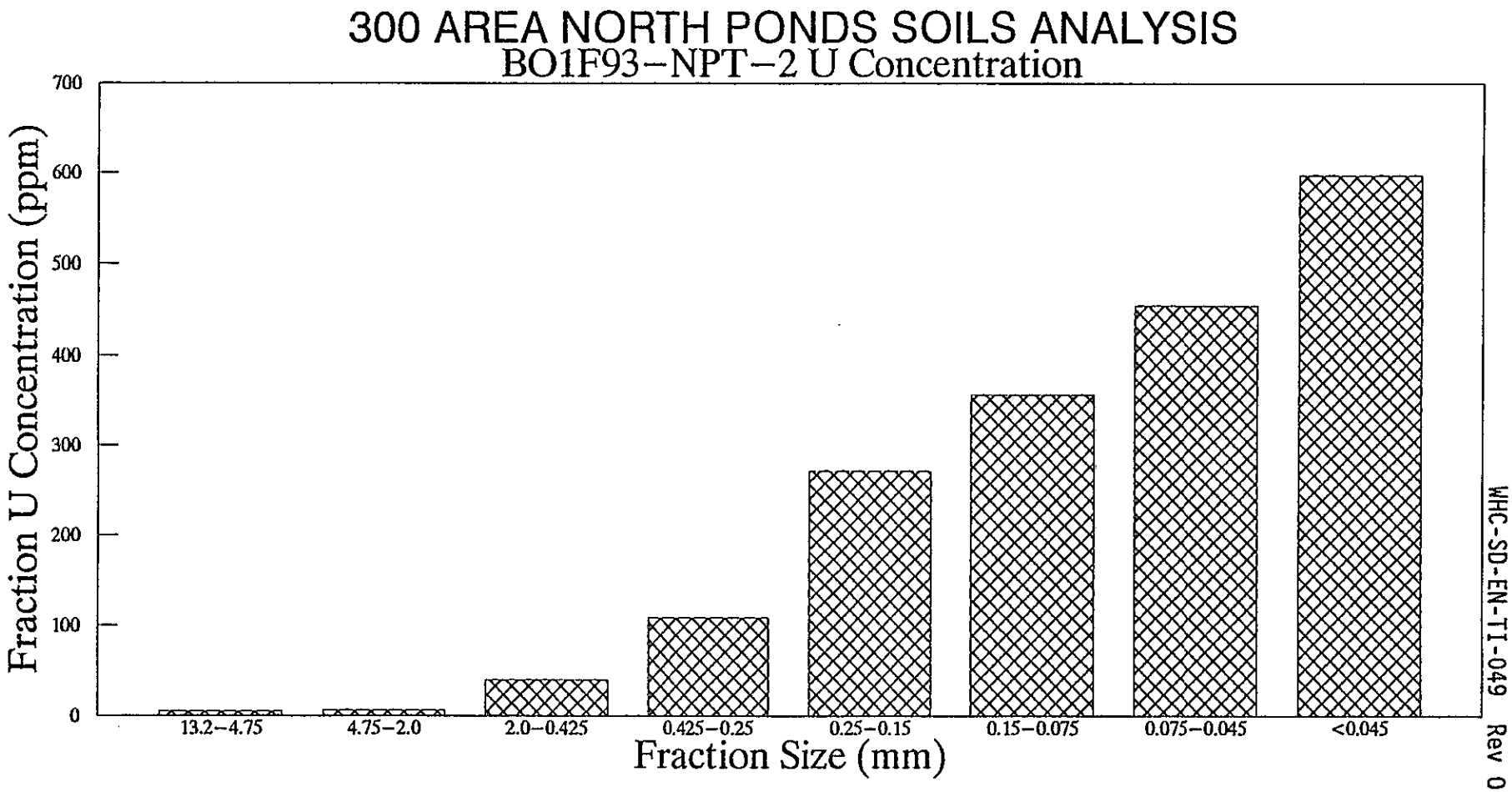

FIGURE 14. U Mass in Sediment NPT-2 as a Function of Particle Size

300 AREA NORTH PONDS SOIL ANALYSIS
SAMPLE ID: BO1F93-NPT-2
DATE: 4/17/92 and 4/20/92
Gamma Scan Analysis Parameters

TABLE 9. ^{60}Co and ^{137}Cs Activity for NPT-2 Size Fractions

	Co-60	Cs-137
Efficiency	0.0032	0.0068
Abundance	0.9999	0.8500
dpm/uCi	2.22E+06	2.22E+06
MDA (uCi/gm)	1.00E-07	1.00E-07

Sample Number	Fraction Size (mm)	Fraction Weight (gm)	Sample Weight (gm)	Co-60 1173 dps	Co-60 1332 dps	Co-60 Ave dps	Corr. dps	Sample uCi	Sample uCi/gm	Fraction uCi
1	>50	1050.08	371.47	-<MDA-	-<MDA-	-<MDA-	-<MDA-	-<MDA-	1.00E-07	1.05E-04
2	50-37.5	270.96	143.50	-<MDA-	-<MDA-	-<MDA-	-<MDA-	-<MDA-	1.00E-07	2.71E-05
3	37.5-25	387.31	68.12	-<MDA-	-<MDA-	-<MDA-	-<MDA-	-<MDA-	1.00E-07	3.87E-05
4	25-13.2	278.75	33.01	-<MDA-	-<MDA-	-<MDA-	-<MDA-	-<MDA-	1.00E-07	2.79E-05
5	13.2-4.75	244.93	22.98	-<MDA-	-<MDA-	-<MDA-	-<MDA-	-<MDA-	1.00E-07	2.45E-05
6	4.75-2.0	125.78	12.84	-<MDA-	-<MDA-	-<MDA-	-<MDA-	-<MDA-	1.00E-07	1.26E-05
7	2.0-0.425	488.21	10.00	-<MDA-	-<MDA-	-<MDA-	-<MDA-	-<MDA-	1.00E-07	4.88E-05
8	0.425-0.25	145.39	11.02	9.18E-04	6.45E-04	7.82E-04	2.44E-01	6.60E-06	5.99E-07	8.71E-05
9	0.25-0.15	57.63	11.04	-<MDA-	-<MDA-	-<MDA-	-<MDA-	-<MDA-	1.00E-07	5.76E-06
10	0.15-0.075	46.32	11.03	-<MDA-	-<MDA-	-<MDA-	-<MDA-	-<MDA-	1.00E-07	4.63E-06
11	0.075-0.045	28.77	10.97	-<MDA-	-<MDA-	-<MDA-	-<MDA-	-<MDA-	1.00E-07	2.88E-06
12	<0.045	46.51	10.95	-<MDA-	-<MDA-	-<MDA-	-<MDA-	-<MDA-	1.00E-07	4.65E-06

Sample Number	Fraction Size (mm)	Fraction Weight (gm)	Sample Weight (gm)	Cs-137 662 dps	Corr. dps	Sample uCi	Sample uCi/gm	Fraction uCi
1	>50	1050.08	371.47	-<MDA-	-<MDA-	-<MDA-	1.00E-07	1.05E-04
2	50-37.5	270.96	143.50	3.54E-03	6.12E-01	1.66E-05	1.15E-07	3.13E-05
3	37.5-25	387.31	68.12	-<MDA-	-<MDA-	-<MDA-	1.00E-07	3.87E-05
4	25-13.2	278.75	33.01	-<MDA-	-<MDA-	-<MDA-	1.00E-07	2.79E-05
5	13.2-4.75	244.93	22.98	-<MDA-	-<MDA-	-<MDA-	1.00E-07	2.45E-05
6	4.75-2.0	125.78	12.84	-<MDA-	-<MDA-	-<MDA-	1.00E-07	1.26E-05
7	2.0-0.425	488.21	10.00	-<MDA-	-<MDA-	-<MDA-	1.00E-07	4.88E-05
8	0.425-0.25	145.39	11.02	1.85E-03	3.20E-01	8.65E-06	7.85E-07	1.14E-04
9	0.25-0.15	57.63	11.04	5.71E-03	9.88E-01	2.67E-05	2.42E-06	1.39E-04
10	0.15-0.075	46.32	11.03	-<MDA-	-<MDA-	-<MDA-	1.00E-07	4.63E-06
11	0.075-0.045	28.77	10.97	-<MDA-	-<MDA-	-<MDA-	1.00E-07	2.88E-06
12	<0.045	46.51	10.95	-<MDA-	-<MDA-	-<MDA-	1.00E-07	4.65E-06

300 AREA NORTH PONDS SOIL ANALYSIS
SAMPLE ID: BO1F93-NPT-2
DATE: 4/17/92 and 4/20/92

TABLE 10. ^{238}U and ^{235}U Activity for NPT-2 Size Fractions

Gamma Scan Analysis Parameters

	Fraction Size (mm)	Fraction Weight (gm)	U-238 (as Th-234) uCi/gm	U-238 Fraction uCi	U-235 uCi/gm	U-235 Fraction uCi	Ratio U-238/U-235
1	>50	1050.08	2.54E-07	2.67E-04	1.58E-08	1.66E-05	16.12
2	50-37.5	270.96	5.76E-07	1.56E-04	7.65E-08	2.07E-05	7.52
3	37.5-25	387.31	2.74E-06	1.06E-03	1.13E-07	4.37E-05	24.26
4	25-13.2	278.75	1.10E-06	3.05E-04	1.17E-07	3.27E-05	9.33
5	13.2-4.75	244.93	1.39E-06	3.39E-04	2.91E-07	7.12E-05	4.77
6	4.75-2.0	125.78	1.41E-05	1.77E-03	1.13E-06	1.42E-04	12.47
7	2.0-0.425	488.21	1.55E-05	7.56E-03	1.02E-06	4.96E-04	15.25
8	0.425-0.25	145.39	5.19E-05	7.55E-03	3.05E-06	4.44E-04	17.01
9	0.25-0.15	57.63	1.05E-04	6.05E-03	5.07E-06	2.92E-04	20.71
10	0.15-0.075	46.32	1.58E-04	7.31E-03	6.69E-06	3.10E-04	23.60
11	0.075-0.045	28.77	1.51E-04	4.36E-03	7.99E-06	2.30E-04	18.95
12	<0.045	46.51	1.67E-04	7.77E-03	8.09E-06	3.76E-04	20.65
Average							15.89
Standard Deviation							6.29

Comparison of XRF Uranium Analysis to U-238 Gamma Scan Analysis

	Fraction Size (mm)	XRF Uranium ppm	Gamma Scan U-238 ppm
5	13.2-4.75	5.10	4.16
6	4.75-2.0	6.70	42.28
7	2.0-0.425	39.80	46.52
8	0.425-0.25	108.60	155.92
9	0.25-0.15	272.00	315.32
10	0.15-0.075	357.00	473.87
11	0.075-0.045	454.00	454.65
12	<0.045	598.00	501.50

TABLE 11. Chemical Data for NPT-3 Size Fractions <0.53 in.

300 AREA NORTH PONDS SOIL ANALYSIS
SAMPLE ID: BO1FB3-NPT-3
DATE: 4/16/92 to 4/20/92

XRF Analysis	Fraction Size (mm) 13.2–4.75	4.75–2.0	2.0–0.425	0.425–0.25	0.25–0.15	0.15–0.075	0.075–0.045	<0.045	Sum Fraction mg	Total "Bulk" ppm
Cr (ppm)	50.00	46.10	63.00	129.00	144.00	237.00	387.00	916.00		99.54
Cr (mg)	8.73	6.38	51.18	3.68	6.41	7.49	8.77	35.95	128.60	
Mn (ppm)	1406.00	5090.00	1614.00	3010.00	2950.00	2920.00	2700.00	2500.00		2113.24
Mn (mg)	245.36	704.71	1311.17	85.94	131.39	92.33	61.18	98.13	2730.20	
Ni (ppm)	51.20	48.70	71.10	127.40	172.00	232.00	279.00	460.00		90.13
Ni (mg)	8.93	6.74	57.76	3.64	7.66	7.34	6.32	18.06	116.45	
Cu (ppm)	188.00	124.30	856.00	1740.00	2420.00	3290.00	3670.00	4630.00		984.40
Cu (mg)	32.81	17.21	695.39	49.68	107.79	104.03	83.16	181.73	1271.79	
Zn (ppm)	137.40	87.30	140.80	132.60	152.20	180.90	193.00	240.00		139.73
Zn (mg)	23.98	12.09	114.38	3.79	6.78	5.72	4.37	9.42	180.52	
Hg (ppm)	2.80	2.50	3.00	2.70	2.60	2.90	4.80	6.80		3.04
Hg (mg)	0.49	0.35	2.44	0.08	0.12	0.09	0.11	0.27	3.93	
Se (ppm)	0.86	0.83	0.91	0.81	0.77	1.40	0.77	0.81		0.89
Se (mg)	0.15	0.11	0.74	0.02	0.03	0.04	0.02	0.03	1.16	
Pb (ppm)	8.50	15.30	12.50	20.70	25.40	31.90	38.60	53.50		15.06
Pb (mg)	1.48	2.12	10.15	0.59	1.13	1.01	0.87	2.10	19.46	
As (ppm)	1.40	4.11	3.52	6.80	8.52	9.60	9.90	13.70		4.11
As (mg)	0.24	0.57	2.86	0.19	0.38	0.30	0.22	0.54	5.31	
Sr (ppm)	463.00	295.00	322.00	303.00	290.00	270.00	257.00	236.00		331.60
Sr (mg)	80.80	40.84	261.58	8.65	12.92	8.54	5.82	9.26	428.42	
Zr (ppm)	174.00	208.00	227.00	512.00	644.00	841.00	964.00	1387.00		301.67
Zr (mg)	30.36	28.80	184.41	14.62	28.68	26.59	21.84	54.44	389.75	
Ag (ppm)	6.30	5.80	6.70	17.20	32.90	42.20	58.70	89.80		11.99
Ag (mg)	1.10	0.80	5.44	0.49	1.47	1.33	1.33	3.52	15.49	
Cd (ppm)	5.60	5.90	5.00	5.60	5.50	5.50	5.50	5.20		5.24
Cd (mg)	0.98	0.82	4.06	0.16	0.24	0.17	0.12	0.20	6.76	
Ba (ppm)	596.00	1094.00	686.00	919.00	1028.00	1001.00	977.00	948.00		755.28
Ba (mg)	104.01	151.46	557.29	26.24	45.79	31.65	22.14	37.21	975.78	
Ce (ppm)	77.00	84.00	52.20	51.00	70.00	59.10	68.00	85.00		60.99
Ce (mg)	13.44	11.63	42.41	1.46	3.12	1.87	1.54	3.34	78.79	
U (ppm)	13.10	8.00	17.10	53.80	75.40	100.10	106.80	157.00		26.26
U (mg)	2.29	1.11	13.89	1.54	3.36	3.17	2.42	6.16	33.93	

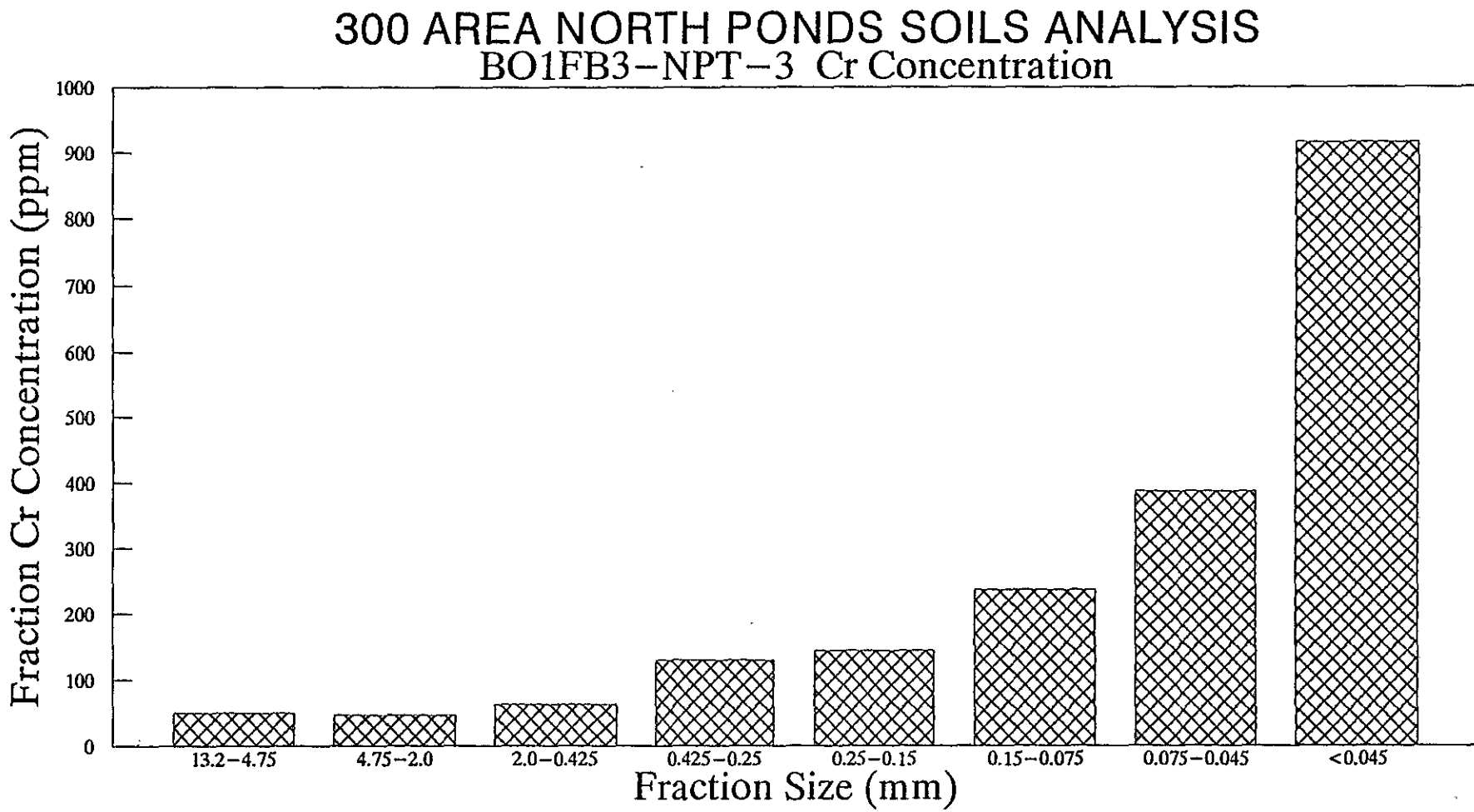

FIGURE 15. Cr Mass in Sediment NPT-3 as a Function of Particle Size

TABLE 12. Cumulative Weight % for Chemicals in NPT-3

300 AREA NORTH PONDS SOIL ANALYSIS
SAMPLE ID: BO1FB3-NPT-3
DATE: 4/16/92 to 4/20/92

		Fraction Size (mm)							
		13.2-4.75	4.75-2.0	2.0-0.425	0.425-0.25	0.25-0.15	0.15-0.075	0.075-0.045	<0.045
Cr (mg)	Cumulative Weight %	6.78	11.75	51.55	54.41	59.40	65.22	72.04	100.00
	Subtractive Weight %	100.00	93.22	88.25	48.45	45.59	40.60	34.78	27.96
Mn (mg)	Cumulative Weight %	8.99	34.80	82.82	85.97	90.78	94.17	96.41	100.00
	Subtractive Weight %	100.00	91.01	65.20	17.18	14.03	9.22	5.83	3.59
Ni (mg)	Cumulative Weight %	7.67	13.46	63.06	66.19	72.77	79.07	84.50	100.00
	Subtractive Weight %	100.00	92.33	86.54	36.94	33.81	27.23	20.93	15.50
Cu (mg)	Cumulative Weight %	2.58	3.93	58.61	62.52	70.99	79.17	85.71	100.00
	Subtractive Weight %	100.00	97.42	96.07	41.39	37.48	29.01	20.83	14.29
Zn (mg)	Cumulative Weight %	13.28	19.98	83.34	85.44	89.19	92.36	94.78	100.00
	Subtractive Weight %	100.00	86.72	80.02	16.66	14.56	10.81	7.64	5.22
Hg (mg)	Cumulative Weight %	12.43	21.23	83.21	85.17	88.11	90.45	93.21	100.00
	Subtractive Weight %	100.00	87.57	78.77	16.79	14.83	11.89	9.55	6.79
Se (mg)	Cumulative Weight %	12.99	22.94	86.93	88.94	91.91	95.74	97.25	100.00
	Subtractive Weight %	100.00	87.01	77.06	13.07	11.06	8.09	4.26	2.75
Pb (mg)	Cumulative Weight %	7.62	18.51	70.68	73.72	79.53	84.72	89.21	100.00
	Subtractive Weight %	100.00	92.38	81.49	29.32	26.28	20.47	15.28	10.79
As (mg)	Cumulative Weight %	4.60	15.31	69.14	72.80	79.94	85.65	89.88	100.00
	Subtractive Weight %	100.00	95.40	84.69	30.86	27.20	20.06	14.35	10.12
Sr (mg)	Cumulative Weight %	18.86	28.39	89.45	91.47	94.49	96.48	97.84	100.00
	Subtractive Weight %	100.00	81.14	71.61	10.55	8.53	5.51	3.52	2.16
Zr (mg)	Cumulative Weight %	7.79	15.18	62.49	66.24	73.60	80.43	86.03	100.00
	Subtractive Weight %	100.00	92.21	84.82	37.51	33.76	26.40	19.57	13.97
Ag (mg)	Cumulative Weight %	7.10	12.28	47.42	50.59	60.05	68.66	77.25	100.00
	Subtractive Weight %	100.00	92.90	87.72	52.58	49.41	39.95	31.34	22.75
Cd (mg)	Cumulative Weight %	14.45	26.53	86.58	88.95	92.57	95.14	96.98	100.00
	Subtractive Weight %	100.00	85.55	73.47	13.42	11.05	7.43	4.86	3.02
Ba (mg)	Cumulative Weight %	10.66	26.18	83.29	85.98	90.67	93.92	96.19	100.00
	Subtractive Weight %	100.00	89.34	73.82	16.71	14.02	9.33	6.08	3.81
Ce (mg)	Cumulative Weight %	17.05	31.81	85.63	87.48	91.44	93.81	95.77	100.00
	Subtractive Weight %	100.00	82.95	68.19	14.37	12.52	8.56	6.19	4.23
U (mg)	Cumulative Weight %	6.74	10.00	50.95	55.48	65.37	74.70	81.84	100.00
	Subtractive Weight %	100.00	93.26	90.00	49.05	44.52	34.63	25.30	18.16

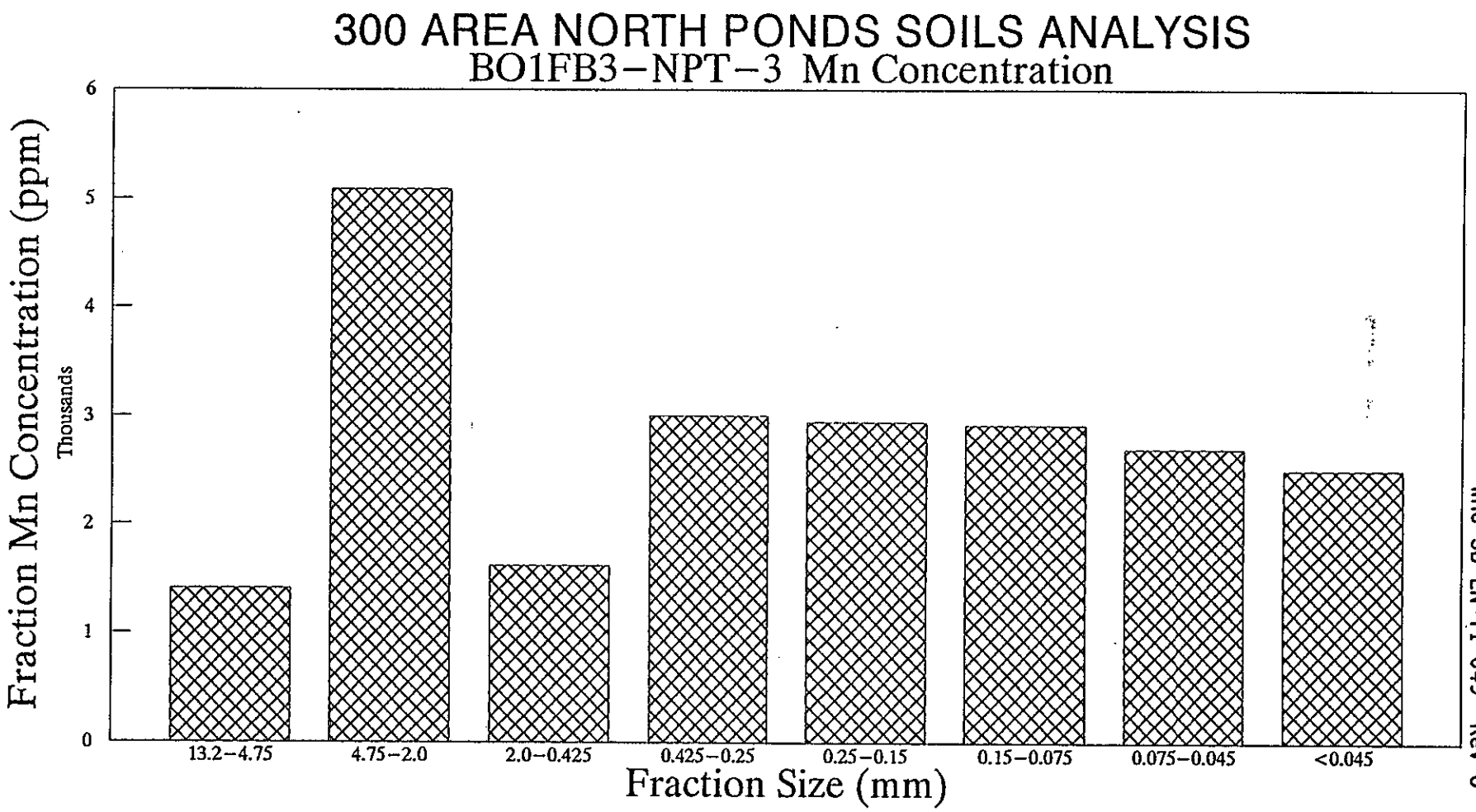

FIGURE 16. Mn Mass in Sediment NPT-3 as a Function of Particle Size

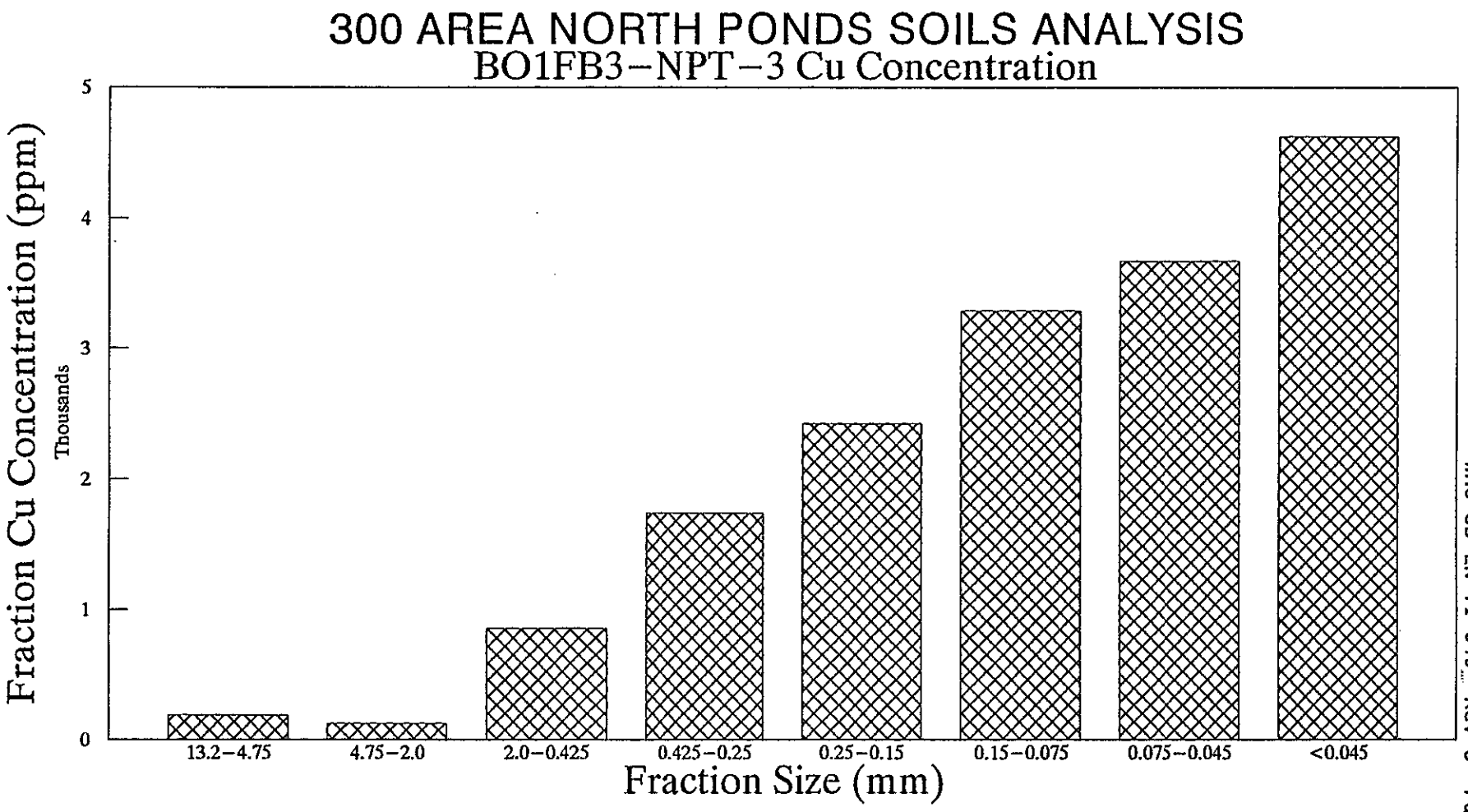

FIGURE 17. Cu Mass in Sediment NPT-3 as a Function of Particle Size

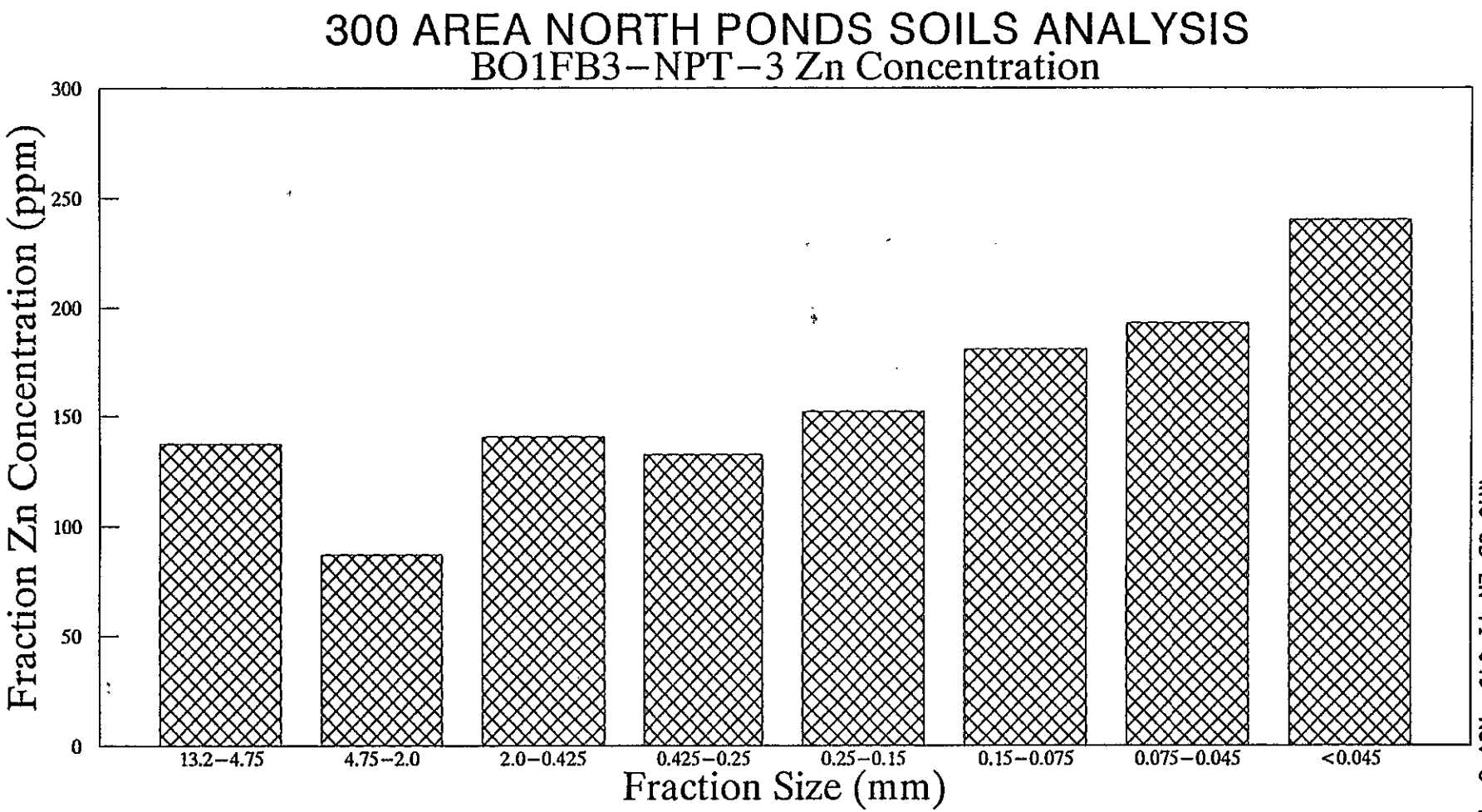

FIGURE 18. Zn Mass in Sediment NPT-3 as a Function of Particle Size

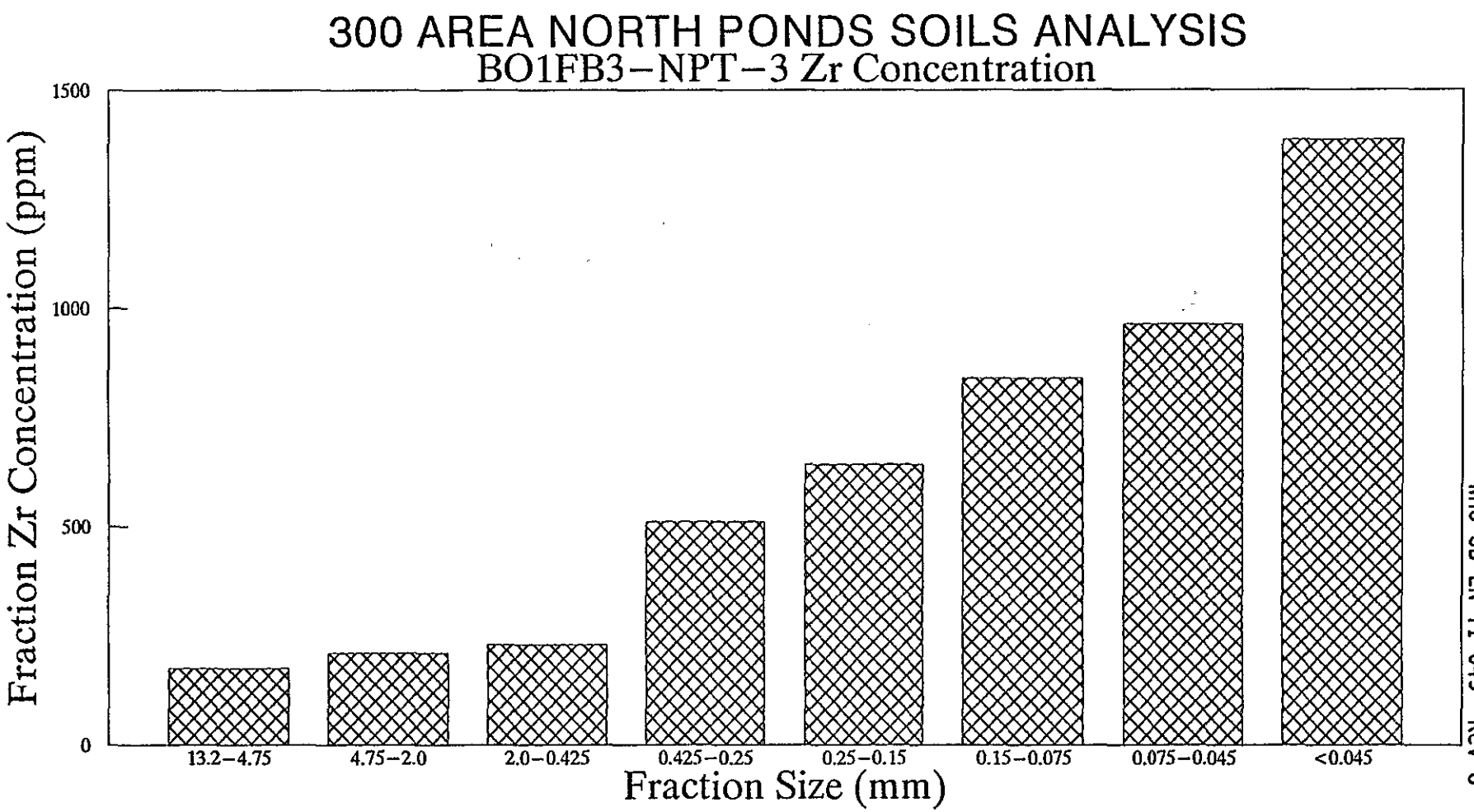

FIGURE 19. Zr Mass in Sediment NPT-3 as a Function of Particle Size

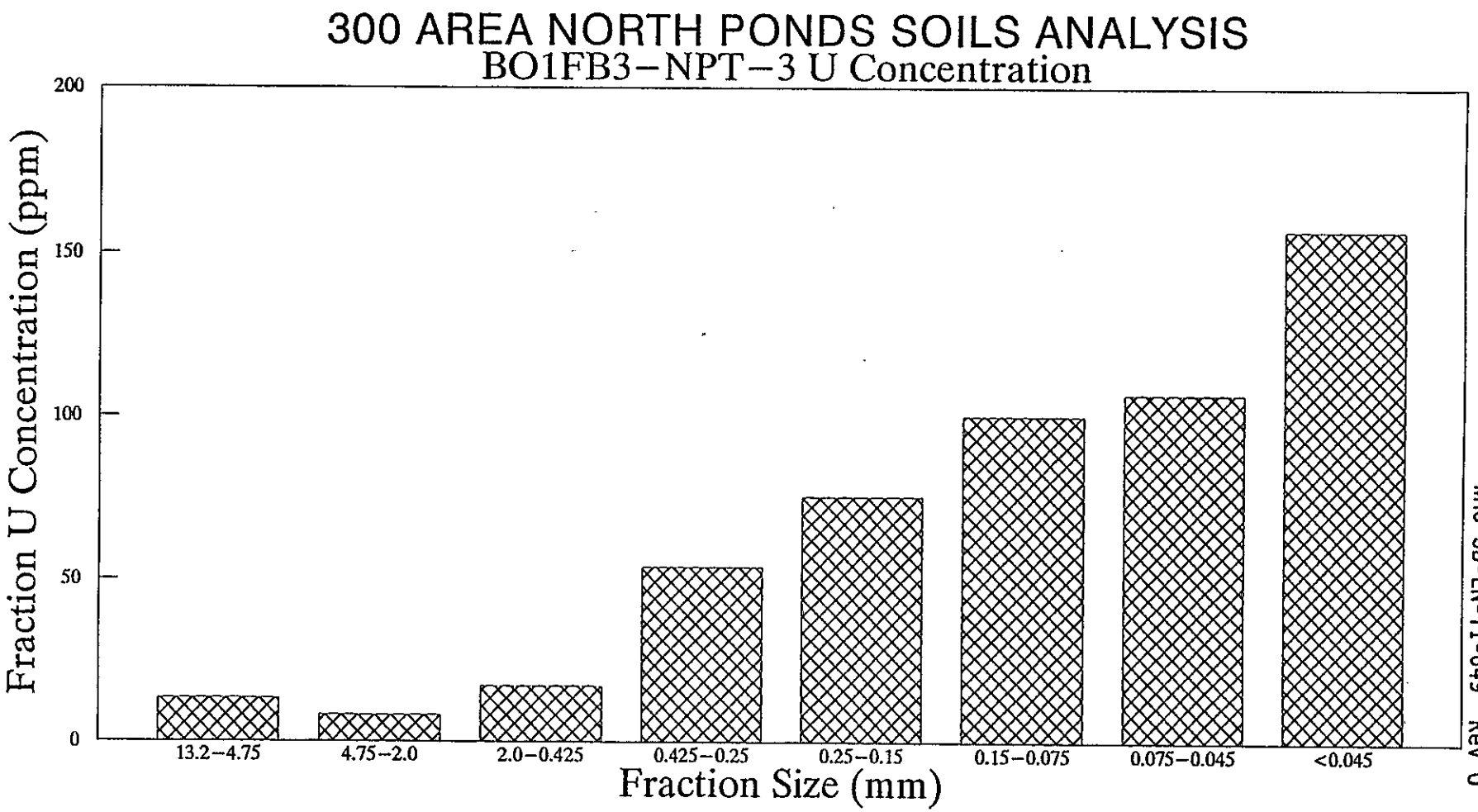

FIGURE 20. U Mass in Sediment NPT-3 as a Function of Particle Size

versus particle size. The trend is similar to the other two sediments in that the 425 μm to 2 mm size fraction contains the most mass of each metal but the concentrations as a function of particle size are inversely proportional. This inverse relationship for most metals is the relationship upon which the success of soil physical washing is predicated.

Tables 13 and 14 present the radionuclide data. Again there is very low or undetectable amounts of ^{60}Co and ^{137}Cs in sample B01FB3-NPT-3. Sediment B01FB3-NPT-3 contains the lowest activity of uranium among the three sediments studied. The $^{238}U/^{235}U$ activity is 11.7 which suggests high enrichment in ^{235}U. The ^{235}U activities are quite small and the data may be biased to values larger than actually occurring. Based on the ^{238}U activities, 26.4% of the uranium would be removed if particle sizes below 250 μm were removed from the sediment. This value is lower than the value calculated from chemical data because the large particle sized material (>13.2) mm contains 8.6% of the ^{238}U. The chemical data do not consider the contribution of larger particles.

9413145.0049

CONCLUSIONS AND OBSERVATIONS

Even though the concentrations of suspected contaminants (U, Cu, Zr, etc.) do increase as the particle size decreases these sediments are very coarse such that removal of particles below 250 μm remove on average only 40% of the uranium present in the Process Pond sediments. Washing the larger sized particles, >13.2 mm, did not remove all of the ^{238}U activity so a more vigorous process than distilled water rinsing may be needed before they can be considered "clean" for regulatory release. The proposed treatability test should provide this information (DOE 1992).

On the other hand if performance goals such as those listed in DOE (1992) in Tables 1-1, 1-2 and 2-1 become the acceptance criteria for what constitutes clean sediment then the data on the three sediments studied suggest that physical separtation could be successful. Possible performance goals identified in DOE (1992) that clean soil must meet for sixteen potential contaminants are shown in Table 15 along with the observed concentrations that would occur if selected size fractions were removed by physical soil washing from the three bulk sediments studied.

300 AREA NORTH PONDS SOIL ANALYSIS'
SAMPLE ID: BO1FB3-NPT-3
DATE: 4/16/92 to 4/20/92
Gamma Scan Analysis Parameters

TABLE 13. ^{60}Co and ^{137}Cs Activity for NPT-3 Size Fractions

	Co-60	Cs-137
Efficiency	0.0032	0.0068
Abundance	0.9999	0.8500
dpm/uCi	2.22E+06	2.22E+06
MDA (uCi/gm)	1.00E-07	1.00E-07

Sample Number	Fraction Size (mm)	Fraction Weight (gm)	Sample Weight (gm)	Co-60 1173 dps	Co-60 1332 dps	Co-60 Ave dps	Corr. dps	Sample uCi	Sample uCi/gm	Fraction uCi
1	>50	620.32	217.09	-<MDA-	-<MDA-	-<MDA-	-<MDA-	-<MDA-	1.00E-07	6.20E-05
2	50-37.5	127.61	127.40	-<MDA-	-<MDA-	-<MDA-	-<MDA-	-<MDA-	1.00E-07	1.28E-05
3	37.5-25	917.82	72.44	-<MDA-	-<MDA-	-<MDA-	-<MDA-	-<MDA-	1.00E-07	9.18E-05
3A	25-13.2	358.37	34.61	-<MDA-	-<MDA-	-<MDA-	-<MDA-	-<MDA-	1.00E-07	3.58E-05
4	13.2-4.75	174.51	23.37	-<MDA-	-<MDA-	-<MDA-	-<MDA-	-<MDA-	1.00E-07	1.75E-05
5	4.75-2.0	138.45	12.15	-<MDA-	-<MDA-	-<MDA-	-<MDA-	-<MDA-	1.00E-07	1.38E-05
6	2.0-0.425	812.37	10.04	-<MDA-	-<MDA-	-<MDA-	-<MDA-	-<MDA-	1.00E-07	8.12E-05
7	0.425-0.25	28.55	11.02	-<MDA-	-<MDA-	-<MDA-	-<MDA-	-<MDA-	1.00E-07	2.86E-06
8	0.25-0.15	44.54	11.02	-<MDA-	-<MDA-	-<MDA-	-<MDA-	-<MDA-	1.00E-07	4.45E-06
9	0.15-0.075	31.62	11.05	1.31E-03	1.84E-03	1.58E-03	4.92E-01	1.33E-05	1.20E-06	3.81E-05
10	0.075-0.045	22.66	10.98	6.11E-03	3.17E-03	4.64E-03	1.45E+00	3.92E-05	3.57E-06	8.09E-05
11	<0.045	39.25	11.06	-<MDA-	-<MDA-	-<MDA-	-<MDA-	-<MDA-	1.00E-07	3.93E-06

Sample Number	Fraction Size (mm)	Fraction Weight (gm)	Sample Weight (gm)	Cs-137 662 dps	Corr. dps	Sample uCi	Sample uCi/gm	Fraction uCi
1	>50	620.32	217.09	-<MDA-	-<MDA-	-<MDA-	1.00E-07	6.20E-05
2	50-37.5	127.61	127.40	-<MDA-	-<MDA-	-<MDA-	1.00E-07	1.28E-05
3	37.5-25	917.82	72.44	-<MDA-	-<MDA-	-<MDA-	1.00E-07	9.18E-05
3A	25-13.2	358.37	34.61	-<MDA-	-<MDA-	-<MDA-	1.00E-07	3.58E-05
4	13.2-4.75	174.51	23.37	-<MDA-	-<MDA-	-<MDA-	1.00E-07	1.75E-05
5	4.75-2.0	138.45	12.15	-<MDA-	-<MDA-	-<MDA-	1.00E-07	1.38E-05
6	2.0-0.425	812.37	10.04	3.09E-03	5.35E-01	1.44E-05	1.44E-06	1.17E-03
7	0.425-0.25	28.55	11.02	-<MDA-	-<MDA-	-<MDA-	1.00E-07	2.86E-06
8	0.25-0.15	44.54	11.02	-<MDA-	-<MDA-	-<MDA-	1.00E-07	4.45E-06
9	0.15-0.075	31.62	11.05	4.90E-03	8.48E-01	2.29E-05	2.07E-06	6.56E-05
10	0.075-0.045	22.66	10.98	-<MDA-	-<MDA-	-<MDA-	1.00E-07	2.27E-06
11	<0.045	39.25	11.06	-<MDA-	-<MDA-	-<MDA-	1.00E-07	3.93E-06

300 AREA NORTH PONDS SOIL ANALYSIS
SAMPLE ID: BO1FB3-NPT-3
DATE: 4/16/92 to 4/20/92

TABLE 14. ^{238}U and ^{235}U Activity for NPT-3 Size Fractions

Gamma Scan Analysis Parameters

	Fraction Size (mm)	Fraction Weight (gm)	U-238 (as Th-234) uCi/gm	U-238 Fraction uCi	U-235 uCi/gm	U-235 Fraction uCi	Ratio U-238/U-235
1	>50	620.32	4.09E-07	2.54E-04	3.62E-08	2.24E-05	11.30
2	50-37.5	127.61	1.59E-07	2.03E-05	1.35E-08	1.73E-06	11.73
3	37.5-25	917.82	7.28E-07	6.68E-04	1.84E-07	1.69E-04	3.96
3A	25-13.2	358.37	1.14E-06	4.07E-04	1.84E-07	6.59E-05	6.17
4	13.2-4.75	174.51	2.48E-06	1.98E-04	5.23E-07	9.13E-05	4.74
5	4.75-2.0	138.45	9.63E-06	3.43E-04	1.21E-06	1.67E-04	7.97
6	2.0-0.425	812.37	7.01E-06	7.83E-03	8.12E-07	6.59E-04	8.63
7	0.425-0.25	28.55	3.76E-05	2.00E-04	1.95E-06	5.55E-05	19.32
8	0.25-0.15	44.54	3.02E-05	1.67E-03	1.56E-06	6.95E-05	19.31
9	0.15-0.075	31.62	4.48E-05	9.53E-04	2.41E-06	7.60E-05	18.61
10	0.075-0.045	22.66	5.22E-05	1.01E-03	4.23E-06	9.58E-05	12.35
11	<0.045	39.25	5.96E-05	2.05E-03	3.63E-06	1.42E-04	16.45
Average							11.71
Standard Deviation							5.63

Comparison of XRF Uranium Analysis to U-238 Gamma Scan Analysis

	Fraction Size (mm)	XRF Uranium ppm	Gamma Scan U-238 ppm
5	13.2-4.75	13.10	3.41
6	4.75-2.0	8.00	7.44
7	2.0-0.425	17.10	28.93
8	0.425-0.25	53.80	21.04
9	0.25-0.15	75.40	112.82
10	0.15-0.075	100.10	90.54
11	0.075-0.045	106.80	134.38
12	<0.045	157.00	156.76

TABLE 15. Comparison of Performance Goals and N Process Pond Samples

Constituent	Performance Goal	Ave. Conc.[a] (ppm) in Coarse Sediment Returned to Fill After Soil Washing Removes Fines								
		Remove ≤425 μm			Remove ≤250 μm			Remove ≤150 μm		
		1[b]	2	3	1	2	3	1	2	3
Cr	1,600 ppm	94	36	53	97	41	54	99	46	55
Mn	64,000 ppm	1496	783	1622	1487	797	1634	1484	798	1652
Ni	6,400 ppm	93	40	56	95	42	57	97	43	58
Cu	11,840 ppm	899	106	358	966	115	370	1006	123	398
Zn	64,000 ppm	117	57	136	117	60	136	117	62	136
Hg	96 ppm	3	2	3	3	2	3	3	2	3
Se	960 ppm	1	1	1	1	1	1	1	1	1
Pb	4,480 ppm	8	11	10	9	12	10	9	12	10
As	320 ppm	2	2	2	2	2	2	2	2	2
Sr	---	284	406	419	285	406	418	285	406	416
Zr	---	208	127	189	220	131	192	231	134	198
Ag	960 ppm	6	6	6	6	8	6	6	10	7
Cd	320 ppm	5	5	5	5	5	5	5	5	5
Ba	22,400 ppm	201	252	641	209	275	644	212	285	649
Ce	---	57	24	71	57	26	71	57	27	71
^{238}U	426; 50[c]	11	4	3	13	6	3	14	8	4
% Sediment Returned as fill		97	90	95	99	94	96	99	96	97

(a) Average concentrations calculated as shown in Appendix B

(b) 1, 2, 3 are the three sediments studied
1 = B01F87 - NPT-1
2 = B01F93 - NPT-2
3 = B01FB3 - NPT-3

(c) Two distinctly different goals are under consideration

Based on Table 15 and calculations shown in Appendix B, the 300 Area N Process Pond sediments easily meet the performance goals listed in Table 15. Therefore, physical separation of fines alone may produce a clean soil.

One should also consider that there are small thin layers of fine material described as green slime and white slime in portions of the 300 N Process Pond that contain calcite ($CaCO_3$) and elevated concentrations of Cu, U and other metals (see Dennison, Sherwood and Young 1989). One sample contained 65,600 ppm Cu and 1270 pCi/g ^{238}U, both significantly higher in concentration than samples analyzed herein. It would seem prudent to study the contaminant distribution as a function of particle size in these distinct layers to complement the study of the bulk sediments within the ponds because they likely constitute the most contaminated material.

It is probable that the distribution of the contaminants as a function of particle size would change if the data were generated by wet sieving. Murarik et al. (1992) wet sieved NTS sediment contaminated with Pu from using convential explosives to blow up an atomic bomb (to simulate an airplane crash containing nuclear weapons). They show that the Pu distribution skewed to smaller particles than when the distribution was determined using dry sieving. The change was caused by fine "dust" particles clinging to the surfaces of coarser particles. Wetting and agitation loosened some of the "dust" such that they became discrete fine particles. Soil washing, both simple physical separation and washing with chemical reagents, would be expected to loosen the "dust" particles. Therefore, the dry sieving data reported herein may underestimate the percentage of uranium and metals found in fine particles. Thus the percentage removals of uranium discussed in the text could be underestimated because they are based solely on dry sieve data and not actual soil washing. As has been suggested before, the proposed treatability tests should provide valuable data regarding this issue.

9413146.0053

REFERENCES

Dennison, D. I., D. R. Sherwood and J. S. Young. 1989. Status Report on Remedial Investigation of the 300 Area Process Ponds. PNL-6442, Pacific Northwest Laboratory, Richland, Washington.

DOE. 1992. Hanford Site Physical Separations CERCLA Treatability Test Plan, DOE/RL-92-21, Department of Energy, Richland, Washington.

Gerber, M. A., H. D. Freeman, E. G. Baker and W. F. Riemath. 1991. Soil Washing: A Preliminary Assessment of Its Applicability to Hanford. PNL-7787, Pacific Northwest Laboratory, Richland, Washington.

Murarik, T. M., T. K. Wenstrand and L. A. Rogers. 1992. "Characterization Studies and Indicated Remediation Methods for Plutonium Contaminated Soils at the Nevada Test Site," preprint of paper to be presented at Spectrum '92 Boise, Idaho. August 23-27, 1992.

Young, J. S. and J. S. Fruchter. 1991. Addendum to Data Compilation Task Report for the Source Investigation of the 300-FF-1 Operable Unit Phase 1 Remedial Investigations, EMO-1026, Environmental Management Operations, Pacific Northwest Laboratory, Richland, Washington.

Young, J. S., R. M. Fruland and J. S. Fruchter. 1990. Data Compilation Task Report for the Source Investigation of the 300-FF-1 Operable Unit Phase 1 Remedial Investigation. PNL-7241, Pacific Northwest Laboratory, Richland, Washington.

APPENDIX A

Calculations of Average Chemical Concentrations of Bulk Sediment

Because large particles above 13.2 mm in size were not analyzed for chemicals we calculate the bulk sediment concentrations by assuming that large particles exhibit the same concentration as the largest size measured, 4.75 to 13.2 mm. Because the >13.2 mm material represents ≈70% of the weight of the bulk sediment this assumption is important in estimating the bulk concentration. The ^{238}U data measured on all particle sizes (see main text and Tables 6, 10 and 14) suggests that particles >13.2 mm in fact contain successively lower activities of contaminants than particles <13.2 mm. Thus, the estimates in this appendix could be biased high but this bias will allow conservatism when comparing to performance goals.

Tables A-1, A-2 and A-3 present the calculated average concentration for representative chemicals for the three soils studied as a function of particle size distribution. For example the first row in Table A-1 presents Cr data for sediment sample B01F87-NPT-1. The sediment with particle size greater than 13.2 mm is assigned a concentration the same as the largest particle size analyzed (<13.2 and >4.75 mm). The concentration is 98 ppm. Continuing across the row the value of 248 ppm is the measured concentration of Cr in the <425 and >250 μum size fraction. The final two values in the row, under the labels "Sum Fraction" are estimates of the Cr concentration in the mixed sediment (with particles greater than 13.2 mm removed) and the bulk sediment as found in the field, respectively. All but the last column are the same data shown in the text in Tables 2, 7 and 11 respectively.

9413145.0055

TABLE A-1. Concentrations of Chemicals in Various Size Fractions (Soil NPT-1)

300 AREA NORTH PONDS SOIL ANALYSIS
SAMPLE ID: BO1F87-NPT-1
DATE: 4/20/92

XRF Analysis	Fraction Size (mm) >13.2	13.2–4.75	4.75–2.0	2.0–0.425	0.425–0.25	0.25–0.15	0.15–0.075	0.075–0.045	<0.045	Sum Fraction 13.2–0.045	Sum Fraction >13.2–0.045
Cr (ppm)		98.00	52.90	95.00	248.00	401.00	760.00	1108.00	1311.00	116.32	103.97
Cr (mg)	203.92	15.09	10.95	52.84	11.76	8.52	9.53	5.96	2.31	116.96	320.87
Mn (ppm)		1515.00	1313.00	1486.00	964.00	969.00	1013.00	974.00	981.00	1409.76	1480.71
Mn (mg)	3152.37	233.23	271.69	826.51	45.72	20.60	12.70	5.24	1.73	1417.42	4569.79
Ni (ppm)		80.80	69.60	149.00	245.00	316.00	484.00	582.00	625.00	137.60	99.31
Ni (mg)	168.13	12.44	14.40	82.87	11.62	6.72	6.07	3.13	1.10	138.35	306.48
Cu (ppm)		511.00	973.00	2430.00	5180.00	6840.00	10740.00	12870.00	14190.00	2239.37	1074.07
Cu (mg)	1063.27	78.67	201.33	1351.57	245.69	145.39	134.68	69.24	24.97	2251.54	3314.81
Zn (ppm)		113.70	113.50	133.50	111.70	112.30	147.80	219.00	256.00	125.73	117.62
Zn (mg)	236.58	17.50	23.49	74.25	5.30	2.39	1.85	1.18	0.45	126.41	362.99
Hg (ppm)		2.90	2.90	3.10	3.50	4.10	6.00	8.40	10.20	3.15	2.98
Hg (mg)	6.03	0.45	0.60	1.72	0.17	0.09	0.08	0.05	0.02	3.16	9.20
Se (ppm)		0.91	0.89	0.92	0.83	0.83	0.84	0.84	0.85	0.90	0.91
Se (mg)	1.89	0.14	0.18	0.51	0.04	0.02	0.01	0.00	0.00	0.91	2.80
Pb (ppm)		7.20	10.80	12.30	19.90	28.50	48.80	75.20	97.70	12.85	9.04
Pb (mg)	14.98	1.11	2.23	6.84	0.94	0.61	0.61	0.40	0.17	12.92	27.90
As (ppm)		1.50	1.50	1.60	5.13	5.27	9.30	12.00	11.20	1.98	1.66
As (mg)	3.12	0.23	0.31	0.89	0.24	0.11	0.12	0.06	0.02	1.99	5.11
Sr (ppm)		271.00	350.00	313.00	330.00	328.00	315.00	294.00	271.00	315.15	285.38
Sr (mg)	563.89	41.72	72.42	174.09	15.65	6.97	3.95	1.58	0.48	316.87	880.75
Zr (ppm)		176.00	225.00	330.00	1009.00	1740.00	3820.00	5670.00	6990.00	430.41	258.88
Zr (mg)	366.22	27.10	46.56	183.55	47.86	36.99	47.90	30.50	12.30	432.75	798.97
Ag (ppm)		6.00	5.20	5.00	14.50	27.70	63.30	100.30	135.50	7.59	6.52
Ag (mg)	12.48	0.92	1.08	2.78	0.69	0.59	0.79	0.54	0.24	7.63	20.11
Cd (ppm)		5.20	5.50	5.30	4.70	4.70	5.30	8.00	9.90	5.31	5.23
Cd (mg)	10.82	0.80	1.14	2.95	0.22	0.10	0.07	0.04	0.02	5.34	16.16
Ba (ppm)		44.60	732.00	634.00	696.00	646.00	656.00	653.00	633.00	567.47	214.94
Ba (mg)	92.80	6.87	151.47	352.63	33.01	13.73	8.23	3.51	1.11	570.56	663.36
Ce (ppm)		61.00	46.00	45.00	51.20	53.50	95.00	99.00	88.00	49.12	57.13
Ce (mg)	126.93	9.39	9.52	25.03	2.43	1.14	1.19	0.53	0.15	49.38	176.31
U (ppm)		33.00	35.30	123.90	387.00	586.00	1073.00	1369.00	1490.00	134.82	66.17
U (mg)	68.67	5.08	7.30	68.91	18.36	12.46	13.46	7.37	2.62	135.55	204.22

TABLE A-2. Concentrations of Chemicals in Various Size Fractions (Soil NPT-2)

300 AREA NORTH PONDS SOIL ANALYSIS
SAMPLE ID: BO1F93-NPT-2
DATE: 4/17/92 and 4/20/92

XRF Analysis	Fraction Size (mm) >13.2	13.2–4.75	4.75–2.0	2.0–0.425	0.425–0.25	0.25–0.15	0.15–0.075	0.075–0.045	<0.045	Sum Fraction 13.2–0.045	Sum Fraction >13.2–0.045
Cr (ppm)		25.50	25.00	88.00	144.00	292.00	387.00	469.00	639.00	127.80	63.69
Cr (mg)	50.67	6.25	3.14	42.96	20.94	16.83	17.93	13.49	29.72	151.26	201.93
Mn (ppm)		617.00	1561.00	1342.00	1069.00	849.00	780.00	760.00	836.00	1101.67	797.92
Mn (mg)	1226.04	151.12	196.34	655.18	155.42	48.93	36.13	21.87	38.88	1303.87	2529.91
Ni (ppm)		36.20	51.77	56.50	69.70	117.10	147.00	187.00	290.00	72.26	49.66
Ni (mg)	71.93	8.87	6.51	27.58	10.13	6.75	6.81	5.38	13.49	85.52	157.45
Cu (ppm)		101.20	75.00	134.90	285.00	560.00	742.00	947.00	1216.00	246.68	155.51
Cu (mg)	201.09	24.79	9.43	65.86	41.44	32.27	34.37	27.25	56.56	291.96	493.05
Zn (ppm)		38.70	133.40	121.50	111.30	156.60	155.80	172.40	215.00	112.34	66.19
Zn (mg)	76.90	9.48	16.78	59.32	16.18	9.02	7.22	4.96	10.00	132.96	209.86
Hg (ppm)		2.20	3.10	2.90	2.70	2.80	6.50	7.30	10.10	3.28	2.60
Hg (mg)	4.37	0.54	0.39	1.42	0.39	0.16	0.30	0.21	0.47	3.88	8.25
Se (ppm)		0.71	0.92	0.91	0.83	0.82	0.85	0.95	1.13	0.86	0.77
Se (mg)	1.41	0.17	0.12	0.44	0.12	0.05	0.04	0.03	0.05	1.02	2.43
Pb (ppm)		10.30	12.40	15.60	22.70	36.80	44.90	56.20	73.40	20.47	14.10
Pb (mg)	20.47	2.52	1.56	7.62	3.30	2.12	2.08	1.62	3.41	24.23	44.70
As (ppm)		1.46	1.60	2.60	3.70	5.09	6.90	9.20	8.10	3.06	2.06
As (mg)	2.90	0.36	0.20	1.27	0.54	0.29	0.32	0.26	0.38	3.62	6.52
Sr (ppm)		417.00	318.00	378.00	409.00	410.00	418.00	412.00	409.00	388.67	406.43
Sr (mg)	828.62	102.14	40.00	184.54	59.46	23.63	19.36	11.85	19.02	460.01	1288.63
Zr (ppm)		111.10	209.00	180.00	197.00	284.00	352.00	446.00	456.00	200.02	144.29
Zr (mg)	220.77	27.21	26.29	87.88	28.64	16.37	16.30	12.83	21.21	236.73	457.50
Ag (ppm)		4.40	4.90	15.70	43.00	106.80	135.40	170.70	253.00	37.78	16.86
Ag (mg)	8.74	1.08	0.62	7.66	6.25	6.15	6.27	4.91	11.77	44.72	53.46
Cd (ppm)		4.80	5.10	5.10	5.20	5.80	5.50	8.20	6.80	5.24	4.97
Cd (mg)	9.54	1.18	0.64	2.49	0.76	0.33	0.25	0.24	0.32	6.20	15.74
Ba (ppm)		136.70	761.00	649.00	725.00	774.00	780.00	769.00	914.00	588.76	305.45
Ba (mg)	271.64	33.48	95.72	316.85	105.41	44.61	36.13	22.12	42.51	696.83	968.46
Ce (ppm)		18.70	53.70	40.20	62.80	69.00	50.00	50.00	39.00	41.94	27.37
Ce (mg)	37.16	4.58	6.75	19.63	9.13	3.98	2.32	1.44	1.81	49.64	86.79
U (ppm)		5.10	6.70	39.80	108.60	272.00	357.00	454.00	598.00	93.28	38.02
U (mg)	10.13	1.25	0.84	19.43	15.79	15.68	16.54	13.06	27.81	110.40	120.53

TABLE A-3. Concentrations of Chemicals in Various Size Fractions (Soil NPT-3)

300 AREA NORTH PONDS SOIL ANALYSIS
SAMPLE ID: BO1FB3-NPT-3
DATE: 4/16/92 to 4/20/92

XRF Analysis	Fraction Size (mm) >13.2	13.2–4.75	4.75–2.0	2.0–0.425	0.425–0.25	0.25–0.15	0.15–0.075	0.075–0.045	<0.045	Sum Fraction 13.2–0.045	Sum Fraction >13.2–0.045
Cr (ppm)		50.00	46.10	63.00	129.00	144.00	237.00	387.00	916.00	99.54	69.30
Cr (mg)	101.21	8.73	6.38	51.18	3.68	6.41	7.49	8.77	35.95	128.60	229.81
Mn (ppm)		1406.00	5090.00	1614.00	3010.00	2950.00	2920.00	2700.00	2500.00	2113.24	1681.54
Mn (mg)	2845.91	245.36	704.71	1311.17	85.94	131.39	92.33	61.18	98.13	2730.20	5576.12
Ni (ppm)		51.20	48.70	71.10	127.40	172.00	232.00	279.00	460.00	90.13	66.37
Ni (mg)	103.63	8.93	6.74	57.76	3.64	7.66	7.34	6.32	18.06	116.45	220.08
Cu (ppm)		188.00	124.30	856.00	1740.00	2420.00	3290.00	3670.00	4630.00	984.40	498.28
Cu (mg)	380.53	32.81	17.21	695.39	49.68	107.79	104.03	83.16	181.73	1271.79	1652.32
Zn (ppm)		137.40	87.30	140.80	132.60	152.20	180.90	193.00	240.00	139.73	138.31
Zn (mg)	278.11	23.98	12.09	114.38	3.79	6.78	5.72	4.37	9.42	180.52	458.64
Hg (ppm)		2.80	2.50	3.00	2.70	2.60	2.90	4.80	6.80	3.04	2.89
Hg (mg)	5.67	0.49	0.35	2.44	0.08	0.12	0.09	0.11	0.27	3.93	9.60
Se (ppm)		0.86	0.83	0.91	0.81	0.77	1.40	0.77	0.81	0.89	0.87
Se (mg)	1.74	0.15	0.11	0.74	0.02	0.03	0.04	0.02	0.03	1.16	2.90
Pb (ppm)		8.50	15.30	12.50	20.70	25.40	31.90	38.60	53.50	15.06	11.06
Pb (mg)	17.21	1.48	2.12	10.15	0.59	1.13	1.01	0.87	2.10	19.46	36.67
As (ppm)		1.40	4.11	3.52	6.80	8.52	9.60	9.90	13.70	4.11	2.46
As (mg)	2.83	0.24	0.57	2.86	0.19	0.38	0.30	0.22	0.54	5.31	8.15
Sr (ppm)		463.00	295.00	322.00	303.00	290.00	270.00	257.00	236.00	331.60	411.81
Sr (mg)	937.17	80.80	40.84	261.58	8.65	12.92	8.54	5.82	9.26	428.42	1365.58
Zr (ppm)		174.00	208.00	227.00	512.00	644.00	841.00	964.00	1387.00	301.67	223.74
Zr (mg)	352.20	30.36	28.80	184.41	14.62	28.68	26.59	21.84	54.44	389.75	741.94
Ag (ppm)		6.30	5.80	6.70	17.20	32.90	42.20	58.70	89.80	11.99	8.52
Ag (mg)	12.75	1.10	0.80	5.44	0.49	1.47	1.33	1.33	3.52	15.49	28.24
Cd (ppm)		5.60	5.90	5.00	5.60	5.50	5.50	5.50	5.20	5.24	5.46
Cd (mg)	11.34	0.98	0.82	4.06	0.16	0.24	0.17	0.12	0.20	6.76	18.10
Ba (ppm)		596.00	1094.00	686.00	919.00	1028.00	1001.00	977.00	948.00	755.28	658.06
Ba (mg)	1206.38	104.01	151.46	557.29	26.24	45.79	31.65	22.14	37.21	975.78	2182.16
Ce (ppm)		77.00	84.00	52.20	51.00	70.00	59.10	68.00	85.00	60.99	70.76
Ce (mg)	155.86	13.44	11.63	42.41	1.46	3.12	1.87	1.54	3.34	78.79	234.65
U (ppm)		13.10	8.00	17.10	53.80	75.40	100.10	106.80	157.00	26.26	18.23
U (mg)	26.52	2.29	1.11	13.89	1.54	3.36	3.17	2.42	6.16	33.93	60.44

APPENDIX B

Calculations of Concentrations Remaining in Coarse Sediment After Removing Fines by Soil Washing

The tables in this appendix allow one to compare the concentration of chemicals, ^{238}U and ^{235}U that would remain in the coarse sediment after removing fines at a given particle size cut-off. These data were calculated using the same assumption as Appendix A. The values in these tables are used to produce Table 15 in the text and can be compared to soil washing performance goals.

Tables B-1, B-2 and B-3 present the calculated average concentration for representative chemicals for the three soils studied as a function of cumulative particle size. For example, the first row in Table B-1 presents Cr data for sediment sample B01F87-NPT-1. The sediment with particle size greater than 13.2 mm is assigned a concentration the same as the largest particle size analyzed (<13.2 and >4.75 mm). The concentration is 98 ppm. Continuing across the row the value of 96.72 ppm is the estimated concentration of Cr in the residual sediment if all particles less than 250 um were removed. The final value in the row, under the label "Fines" is an estimate of the Cr concentration of the bulk (in the field) sediment, 103.97 ppm.

Table B-4 contains similar calculations for all three sediment's uranium activities. The key data are the ^{238}U and ^{235}U activities (μCi/g) found in the third and fourth columns. For example, the ^{238}U activity of sediment NPT-1 greater than 50 mm is 4.84×10^{-7} μCi/g while the activity of the fraction greater 0.425 mm is 1.10×10^{-5} μCi/g and the bulk sediment (all sizes) has an average activity of 1.69×10^{-5} μCi/g.

9413145.0059

TABLE B-1. Calculated Concentrations of Chemicals in Residual NPT-1 Sediment

300 AREA NORTH PONDS SOIL ANALYSIS
SAMPLE ID: BO1F87-NPT-1
DATE: 4/20/92

Cumulative part per million (ppm) including large fraction size estimate

Element (ppm)	>13.2	>4.75	>2.0	>0.425	>0.25	>0.15	>0.075	>0.045	fines
Cr	98.00	98.00	94.18	94.33	96.72	98.83	101.53	103.28	103.97
Mn	1515.00	1515.00	1497.88	1495.68	1487.40	1483.80	1481.89	1481.00	1480.71
Ni	80.80	80.80	79.85	92.68	95.05	96.58	98.16	99.01	99.31
Cu	511.00	511.00	550.15	898.93	965.61	1006.32	1045.97	1066.59	1074.07
Zn	113.70	113.70	113.68	117.36	117.27	117.24	117.36	117.54	117.62
Hg	2.90	2.90	2.90	2.94	2.95	2.95	2.97	2.98	2.98
Se	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91
Pb	7.20	7.20	7.51	8.39	8.57	8.71	8.88	8.99	9.04
As	1.50	1.50	1.50	1.52	1.57	1.60	1.63	1.65	1.66
Sr	271.00	271.00	277.69	284.25	284.96	285.26	285.38	285.39	285.38
Zr	176.00	176.00	180.15	207.95	220.43	230.96	245.58	255.04	258.88
Ag	6.00	6.00	5.93	5.76	5.90	6.05	6.28	6.44	6.52
Cd	5.20	5.20	5.23	5.24	5.23	5.23	5.23	5.23	5.23
Ba	44.60	44.60	102.85	201.40	209.10	212.13	213.94	214.71	214.94
Ce	61.00	61.00	59.73	57.00	56.91	56.88	57.04	57.11	57.13
U	33.00	33.00	33.19	50.02	55.27	58.95	63.08	65.36	66.17

TABLE B-2. Calculated Concentrations of Chemicals in Residual NPT-2 Sediment

300 AREA NORTH PONDS SOIL ANALYSIS
SAMPLE ID: BO1F93-NPT-2
DATE: 4/17/92 and 4/20/92

Cumulative part per million (ppm) including large fraction size estimate

Element (ppm)	>13.2	>4.75	>2.0	>0.425	>0.25	>0.15	>0.075	>0.045	fines
Cr	25.50	25.50	25.47	36.20	41.44	46.17	51.27	55.12	63.69
Mn	617.00	617.00	667.36	783.09	796.98	797.97	797.70	797.35	797.92
Ni	36.20	36.20	37.03	40.37	41.80	43.22	44.77	46.08	49.66
Cu	101.20	101.20	99.80	105.82	114.53	122.95	132.21	139.72	155.51
Zn	38.70	38.70	43.75	57.09	59.72	61.55	62.97	63.97	66.19
Hg	2.20	2.20	2.25	2.36	2.38	2.38	2.45	2.49	2.60
Se	0.71	0.71	0.72	0.75	0.76	0.76	0.76	0.76	0.77
Pb	10.30	10.30	10.41	11.30	11.86	12.33	12.81	13.21	14.10
As	1.46	1.46	1.47	1.66	1.76	1.82	1.90	1.97	2.06
Sr	417.00	417.00	411.72	405.93	406.08	406.16	406.33	406.39	406.43
Zr	111.10	111.10	116.32	127.25	130.64	133.53	136.80	139.65	144.29
Ag	4.40	4.40	4.43	6.36	8.14	10.01	11.88	13.35	16.86
Cd	4.80	4.80	4.82	4.86	4.88	4.90	4.91	4.94	4.97
Ba	136.70	136.70	170.00	252.17	275.15	284.58	291.99	296.39	305.45
Ce	18.70	18.70	20.57	23.93	25.82	26.64	26.99	27.20	27.37
U	5.10	5.10	5.19	11.12	15.86	20.70	25.73	29.68	38.02

TABLE B-3. Calculated Concentrations of Chemicals in Residual NPT-3 Sediment

300 AREA NORTH PONDS SOIL ANALYSIS
SAMPLE ID: BO1FB3-NPT-3
DATE: 4/16/92 to 4/20/92

Cumulative part per million (ppm) including large fraction size estimate

Element (ppm)	>13.2	>4.75	>2.0	>0.425	>0.25	>0.15	>0.075	>0.045	fines
Cr	50.00	50.00	49.77	53.18	53.86	55.11	56.88	59.16	69.30
Mn	1406.00	1406.00	1624.24	1621.60	1634.07	1652.26	1664.58	1671.74	1681.54
Ni	51.20	51.20	51.05	56.22	56.86	58.45	60.14	61.65	66.37
Cu	188.00	188.00	184.23	357.50	369.92	398.26	426.36	448.79	498.28
Zn	137.40	137.40	134.43	136.07	136.04	136.27	136.70	137.09	138.31
Hg	2.80	2.80	2.78	2.84	2.84	2.83	2.83	2.85	2.89
Se	0.86	0.86	0.86	0.87	0.87	0.87	0.87	0.87	0.87
Pb	8.50	8.50	8.90	9.83	9.93	10.14	10.35	10.55	11.06
As	1.40	1.40	1.56	2.07	2.11	2.20	2.27	2.32	2.46
Sr	463.00	463.00	453.05	419.25	418.20	416.43	415.01	413.91	411.81
Zr	174.00	174.00	176.01	189.17	192.07	198.31	204.56	209.81	223.74
Ag	6.30	6.30	6.27	6.38	6.48	6.84	7.19	7.54	8.52
Cd	5.60	5.60	5.62	5.46	5.46	5.46	5.46	5.46	5.46
Ba	596.00	596.00	625.50	641.11	643.60	648.92	652.34	654.58	658.06
Ce	77.00	77.00	77.41	70.91	70.73	70.72	70.61	70.59	70.76
U	13.10	13.10	12.80	13.91	14.27	15.11	15.94	16.57	18.23

300 AREA NORTH PONDS SOIL ANALYSIS
SAMPLE ID: BO1F87-NPT-1
DATE: 4/20/92

TABLE B-4. Calculated Activities of U in Residual Sediment

Gamma Scan Analysis Parameters

	Fraction Size (mm)	Fraction Weight (gm)	Cumulative U-238 uCi/gm	Cumulative U-235 uCi/gm	Cumulative Ratio U-238/U-235
1	>50	238.48	4.84E-07	4.08E-08	11.86
2	50-37.5	655.89	4.18E-07	5.62E-08	7.44
3	37.5-25	690.83	1.11E-06	1.24E-07	8.94
4	25-13.2	495.57	1.35E-06	1.60E-07	8.42
5	13.2-4.75	153.95	1.88E-06	1.74E-07	10.85
6	4.75-2.0	206.92	3.28E-06	2.68E-07	12.23
7	2.0-0.425	556.20	1.10E-05	7.65E-07	14.43
8	0.425-0.25	47.43	1.30E-05	9.12E-07	14.27
9	0.25-0.15	21.26	1.43E-05	1.01E-06	14.17
10	0.15-0.075	12.54	1.58E-05	1.10E-06	14.39
11	0.075-0.045	5.38	1.66E-05	1.14E-06	14.56
12	<0.045	1.76	1.69E-05	1.16E-06	14.61

300 AREA NORTH PONDS SOIL ANALYSIS
SAMPLE ID: BO1F93-NPT-2
DATE: 4/17/92 and 4/20/92

Gamma Scan Analysis Parameters

	Fraction Size (mm)	Fraction Weight (gm)	Cumulative U-238 uCi/gm	Cumulative U-235 uCi/gm	Cumulative Ratio U-238/U-235
1	>50	1050.08	2.54E-07	1.58E-08	16.12
2	50-37.5	270.96	3.20E-07	2.82E-08	11.34
3	37.5-25	387.31	8.68E-07	4.74E-08	18.31
4	25-13.2	278.75	9.00E-07	5.72E-08	15.73
5	13.2-4.75	244.93	9.53E-07	8.28E-08	11.51
6	4.75-2.0	125.78	1.65E-06	1.39E-07	11.93
7	2.0-0.425	488.21	4.03E-06	2.89E-07	13.93
8	0.425-0.25	145.39	6.35E-06	4.23E-07	15.01
9	0.25-0.15	57.63	8.22E-06	5.11E-07	16.07
10	0.15-0.075	46.32	1.05E-05	6.04E-07	17.32
11	0.075-0.045	28.77	1.18E-05	6.72E-07	17.50
12	<0.045	46.51	1.40E-05	7.81E-07	17.98

300 AREA NORTH PONDS SOIL ANALYSIS
SAMPLE ID: BO1FB3-NPT-3
DATE: 4/16/92 to 4/20/92

Gamma Scan Analysis Parameters

	Fraction Size (mm)	Fraction Weight (gm)	Cumulative U-238 uCi/gm	Cumulative U-235 uCi/gm	Cumulative Ratio U-238/U-235
1	>50	620.32	4.09E-07	3.62E-08	11.30
2	50-37.5	127.61	3.66E-07	3.23E-08	11.33
3	37.5-25	917.82	5.65E-07	1.16E-07	4.88
3A	25-13.2	358.37	6.66E-07	1.28E-07	5.21
4	13.2-4.75	174.51	7.03E-07	1.59E-07	4.42
5	4.75-2.0	138.45	8.09E-07	2.22E-07	3.65
6	2.0-0.425	812.37	3.08E-06	3.74E-07	8.25
7	0.425-0.25	28.55	3.12E-06	3.88E-07	8.05
8	0.25-0.15	44.54	3.60E-06	4.04E-07	8.90
9	0.15-0.075	31.62	3.85E-06	4.23E-07	9.10
10	0.075-0.045	22.66	4.14E-06	4.50E-07	9.20
11	<0.045	39.25	4.71E-06	4.87E-07	9.66

9413145.0053

APPENDIX C

Raw XRF Data

Many of the results presented in the appendix suggest that the values epresent detection limit values. Thus we suggest data for Cl, Ru, Pd, In, b, Te, I and Cs are likely detection limit values and should not be onsidered quantitative estimates of concentrations or evidence of the resence of certain regulated chemicals.

Data for Hg, Se, As, Br, Cd and Sn only show above detection limit oncentrations for the smallest particle size fractions so that calculations f average concentrations in bulk sediment are suspect.

The samples USGS AGV-1, BCR-1, SRM 1646, USGS-2 represent standards used y the XRF staff to assure proper calibration. The samples NPT-1, NPT-2 and PT-3 are followed by the smaller size cut off designation. For example NP-T3 75 mm is the NPT-3 sediment 13.2 to 4.75 mm size split, and NP-T3 45 μm is he 75 to 45 μ, size split.

The data suggest the presence of elevated concentrations of Cr, Ni, Cu, b, U, Zr, Ag, Sn and perhaps Hg, Mo and Cd versus typical Hanford ncontaminated sediments (see Table 3).

SS	UNITS	EL	USGS AGV-1	+/-		BCR-1 50-100	+/-		NP-5M13-P5M1 0055	+/-		NP-T1 2MM	+/-
TI													
	%	AL	8.76	0.49	AL	7.25	0.43	AL	7.36	0.43	AL	7.42	0.43
	%	SI	28.3	1.4	SI	27.3	1.4	SI	21.9	1.1	SI	27.2	1.4
	%	P	0.186	0.030	P	0.135	0.032	P	0.105	0.031	P	0.136	0.031
	%	S	0.024	0.007	S	0.086	0.010	S	0.052	0.009	S	0.034	0.008
	%	CL	< 0.008		CL	< 0.009		CL	< 0.008		CL	< 0.008	
ZR													
	%	SI	27.4	1.4	SI	27.3	1.5	SI	22.8	1.2	SI	27.7	1.5
	%	K	2.31	0.12	K	1.500	0.078	K	0.782	0.043	K	1.367	0.072
	%	CA	3.34	0.17	CA	5.03	0.25	CA	6.79	0.34	CA	4.97	0.25
	%	TI	0.583	0.030	TI	1.363	0.069	TI	1.008	0.051	TI	1.086	0.055
	PPM	V	81.	31.	V	438.	52.	V	291.	43.	V	291.	44.
	PPM	CR	< 14.		CR	35.	10.	CR	98.	11.	CR	52.9	9.6
	PPM	MN	722.	38.	MN	1414.	73.	MN	1515.	78.	MN	1313.	68.
	%	FE	4.51	0.23	FE	9.28	0.46	FE	8.72	0.44	FE	8.16	0.41
	PPM	NI	22.1	4.6	NI	30.5	7.4	NI	80.8	8.2	NI	69.6	7.6
	PPM	CU	53.5	3.4	CU	22.6	2.4	CU	511.	26.	CU	973.	49.
	PPM	ZN	86.6	4.7	ZN	125.5	6.8	ZN	113.7	6.2	ZN	113.5	6.2
	PPM	GA	21.3	1.4	GA	20.8	1.5	GA	22.8	1.6	GA	25.0	1.7
	PPM	HG	< 2.7		HG	42.7	3.0	HG	< 2.9		HG	< 2.9	
	PPM	SE	< 0.97		SE	< 0.95		SE	< 0.91		SE	< 0.89	
	PPM	PB	39.0	2.8	PB	15.3	1.7	PB	7.2	1.5	PB	10.8	1.6
	PPM	AS	< 1.9		AS	< 1.7		AS	< 1.5		AS	< 1.5	
	PPM	BR	< 1.1		BR	< 1.3		BR	< 0.92		BR	< 0.91	
	PPM	SR	643.	33.	SR	323.	17.	SR	271.	14.	SR	350.	18.
AG													
	PPM	RB	66.8	4.8	RB	45.5	3.4	RB	20.4	1.6	RB	40.8	3.0
	PPM	U	< 4.5		U	99.7	7.2	U	33.0	2.7	U	35.3	2.9
	PPM	SR	645.	45.	SR	313.	22.	SR	262.	18.	SR	338.	24.
	PPM	Y	19.5	1.6	Y	38.5	2.8	Y	43.7	3.1	Y	42.0	3.0
	PPM	ZR	219.	15.	ZR	230.	16.	ZR	176.	12.	ZR	225.	16.
	PPM	NB	14.8	1.2	NB	11.44	0.97	NB	12.5	1.0	NB	12.4	1.0
	PPM	MO	< 1.8		MO	4.86	0.83	MO	15.4	1.3	MO	8.61	0.95
AM gd													
	PPM	RU	< 5.7		RU	< 3.8		RU	< 3.8		RU	< 4.0	
	PPM	PD	< 6.9		PD	< 4.5		PD	< 4.4		PD	7.1	2.4
	PPM	AG	< 7.7		AG	< 5.0		AG	6.0	2.5	AG	< 5.2	
	PPM	CD	< 7.7		CD	15.0	2.7	CD	< 5.2		CD	< 5.5	
	PPM	IN	< 8.6		IN	< 5.5		IN	< 5.6		IN	< 6.0	
	PPM	SN	12.9	4.7	SN	6.6	3.0	SN	11.9	3.3	SN	< 6.8	
	PPM	SB	< 10.		SB	< 6.6		SB	< 6.8		SB	< 7.2	
	PPM	TE	< 13.		TE	< 8.3		TE	< 8.6		TE	< 9.1	
	PPM	I	< 15.		I	< 9.5		I	< 9.7		I	< 10.	
	PPM	CS	< 17.		CS	< 11.		CS	< 11.		CS	< 12.	
	PPM	BA	1198.	62.	BA	698.	36.	BA	446.	24.	BA	732.	38.
	PPM	LA	33.	13.	LA	29.9	8.0	LA	27.8	8.1	LA	< 18.	
	PPM	CE	81.	17.	CE	45.5	9.7	CE	61.	11.	CE	46.	11.

9419146.0066

SS UNITS	EL	NP-T1 425UM	+/-	NP-T1 250UM	+/-	NP-T1 150UM	+/-	NP-T1 75UM	+/-
TI									
%	AL	8.41	0.48	AL 9.75	0.54	AL 11.39	0.62	AL 13.55	0.72
%	SI	25.1	1.3	SI 26.2	1.3	SI 25.3	1.3	SI 22.0	1.1
%	P	0.163	0.033	P 0.312	0.034	P 0.398	0.037	P 0.606	0.043
%	S	0.043	0.008	S 0.040	0.008	S 0.028	0.008	S 0.037	0.008
%	CL	< 0.008		CL < 0.008		CL < 0.008		CL < 0.008	
ZR									
%	SI	25.5	1.4	SI 26.3	1.4	SI 23.9	1.3	SI 21.2	1.2
%	K	1.172	0.062	K 1.373	0.072	K 1.322	0.070	K 1.311	0.069
%	CA	5.54	0.28	CA 3.34	0.17	CA 3.26	0.16	CA 2.55	0.13
%	TI	1.419	0.072	TI 0.818	0.042	TI 0.794	0.040	TI 0.589	0.030
PPM	V	361.	50.	V 190.	38.	V 188.	37.	V 131.	32.
PPM	CR	95.	11.	CR 248.	15.	CR 401.	22.	CR 760.	39.
PPM	MN	1486.	77.	MN 964.	51.	MN 969.	51.	MN 1013.	53.
%	FE	9.14	0.46	FE 5.62	0.28	FE 5.45	0.27	FE 4.53	0.23
PPM	NI	149.	11.	NI 245.	14.	NI 316.	17.	NI 484.	25.
PPM	CU	2430.	120.	CU 5180.	260.	CU 6840.	340.	CU 10740.	540.
PPM	ZN	133.5	7.3	ZN 111.7	6.4	ZN 112.3	6.5	ZN 147.8	8.4
PPM	GA	33.4	2.1	GA 45.6	2.7	GA 53.1	3.1	GA 73.2	4.1
PPM	HG	< 3.1		HG 3.5	1.5	HG 4.1	1.5	HG 6.0	1.6
PPM	SE	< 0.92		SE < 0.83		SE < 0.83		SE < 0.84	
PPM	PB	12.3	1.6	PB 19.9	1.7	PB 28.5	2.0	PB 48.8	2.9
PPM	AS	< 1.6		AS 5.13	0.89	AS 5.27	0.95	AS 9.3	1.2
PPM	BR	< 0.96		BR < 0.89		BR < 0.93		BR < 1.0	
PPM	SR	313.	16.	SR 330.	17.	SR 328.	17.	SR 315.	16.
AG									
PPM	RB	35.0	2.7	RB 62.6	4.6	RB 64.9	4.8	RB 84.5	6.3
PPM	U	123.9	8.9	U 387.	27.	U 586.	41.	U 1073.	75.
PPM	SR	303.	21.	SR 316.	22.	SR 313.	22.	SR 319.	22.
PPM	Y	49.6	3.5	Y 33.7	2.5	Y 34.3	2.5	Y 33.6	2.6
PPM	ZR	330.	23.	ZR 1009.	71.	ZR 1740.	120.	ZR 3820.	270.
PPM	NB	15.2	1.2	NB 10.58	0.97	NB 9.7	1.0	NB 11.6	1.3
PPM	MO	42.2	3.1	MO 5.1	1.2	MO 10.1	1.7	MO 24.2	2.8
~~AM~~									
PPM	RU	< 4.6		RU < 3.6		RU < 3.6		RU < 4.0	
PPM	PD	< 4.6		PD < 4.1		PD < 4.2		PD < 5.0	
PPM	AG	< 5.0		AG 14.5	2.4	AG 27.7	2.7	AG 63.6	4.2
PPM	CD	< 5.3		CD < 4.7		CD < 4.7		CD < 5.3	
PPM	IN	< 5.8		IN < 5.0		IN < 5.1		IN < 5.6	
PPM	SN	8.7	3.3	SN 29.9	3.3	SN 44.1	3.7	SN 111.5	6.6
PPM	SB	< 6.8		SB < 5.9		SB < 6.1		SB < 6.8	
PPM	TE	< 8.8		TE < 7.6		TE < 7.2		TE < 8.5	
PPM	I	< 10.		I 9.6	4.4	I < 8.8		I < 9.9	
PPM	CS	< 11.		CS < 10.		CS < 10.		CS 14.6	5.8
PPM	BA	634.	33.	BA 696.	36.	BA 646.	33.	BA 656.	34.
PPM	LA	34.9	8.7	LA 15.8	7.5	LA 22.9	7.6	LA 43.9	8.7
PPM	CE	45.	11.	CE 51.2	8.9	CE 53.5	9.1	CE 95.	12.

SS	UNITS	EL	NP-T1 45UM	+/-	EL	NP-T1 -45UM	+/-	EL	BCR-1 9413146.0067	+/-	EL	SRM 1646 R-2	+/-
TI													
	%	AL	12.77	0.68	AL	11.08	0.60	AL	7.19	0.42	AL	7.59	0.43
	%	SI	19.72	0.99	SI	18.15	0.92	SI	26.3	1.3	SI	31.2	1.6
	%	P	0.727	0.047	P	0.762	0.049	P	0.180	0.032	P	0.101	0.025
	%	S	0.036	0.008	S	0.062	0.009	S	0.071	0.009	S	0.835	0.045
	%	CL	0.010	0.004	CL	0.014	0.004	CL	0.027	0.005	CL	1.432	0.073
ZR													
	%	SI	19.2	1.1	SI	17.9	1.0	SI	25.7	1.4	SI	30.2	1.6
	%	K	1.103	0.058	K	1.028	0.055	K	1.482	0.077	K	1.97	0.10
	%	CA	2.46	0.12	CA	2.66	0.14	CA	4.98	0.25	CA	0.861	0.045
	%	TI	0.435	0.022	TI	0.436	0.022	TI	1.364	0.069	TI	0.455	0.023
	PPM	V	81.	27.	V	113.	27.	V	428.	50.	V	55.	28.
	PPM	CR	1108.	56.	CR	1311.	66.	CR	< 19.		CR	83.9	8.3
	PPM	MN	974.	51.	MN	981.	51.	MN	1396.	72.	MN	322.	19.
	%	FE	3.81	0.19	FE	3.81	0.19	FE	9.27	0.46	FE	3.35	0.17
	PPM	NI	582.	30.	NI	625.	32.	NI	26.0	7.1	NI	31.0	4.2
	PPM	CU	12870.	640.	CU	14190.	710.	CU	20.5	2.2	CU	20.6	1.8
	PPM	ZN	219.	12.	ZN	256.	14.	ZN	126.2	6.8	ZN	126.7	6.7
	PPM	GA	78.6	4.4	GA	83.6	4.6	GA	22.8	1.6	GA	13.6	1.0
	PPM	HG	8.4	1.7	HG	10.2	1.8	HG	< 2.9		HG	< 2.3	
	PPM	SE	< 0.84		SE	< 0.85		SE	< 0.93		SE	0.89	0.38
	PPM	PB	75.2	4.2	PB	97.7	5.3	PB	16.5	1.8	PB	27.6	1.9
	PPM	AS	12.0	1.3	AS	11.2	1.4	AS	< 1.7		AS	12.1	1.0
	PPM	BR	< 1.1		BR	< 1.1		BR	< 0.93		BR	128.8	6.5
	PPM	SR	294.	15.	SR	271.	14.	SR	320.	17.	SR	137.6	7.4
AG													
	PPM	RB	91.4	6.9	RB	103.0	7.6	RB	45.8	3.3	RB	71.8	5.1
	PPM	U	1369.	96.	U	1490.	100.	U	< 3.4		U	< 3.1	
	PPM	SR	284.	20.	SR	254.	18.	SR	328.	23.	SR	128.6	9.0
	PPM	Y	31.8	2.5	Y	30.6	2.4	Y	37.2	2.7	Y	25.7	1.9
	PPM	ZR	5670.	400.	ZR	6990.	490.	ZR	186.	13.	ZR	368.	26.
	PPM	NB	8.5	1.3	NB	8.7	1.3	NB	12.6	1.0	NB	13.5	1.0
	PPM	MO	39.1	4.0	MO	59.8	5.1	MO	2.89	0.77	MO	2.00	0.64
AM gd													
	PPM	RU	< 4.4		RU	< 3.9		RU	< 4.6		RU	< 3.1	
	PPM	PD	< 5.4		PD	< 4.8		PD	< 5.4		PD	< 3.6	
	PPM	AG	100.3	5.8	AG	135.5	7.3	AG	< 5.9		AG	< 4.0	
	PPM	CD	8.0	3.1	CD	9.9	2.7	CD	< 6.2		CD	< 4.2	
	PPM	IN	< 6.2		IN	< 5.5		IN	< 7.0		IN	< 4.6	
	PPM	SN	224.	12.	SN	279.	14.	SN	< 7.9		SN	< 5.3	
	PPM	SB	< 7.7		SB	< 6.6		SB	< 8.2		SB	< 5.7	
	PPM	TE	< 9.0		TE	< 7.8		TE	< 10.		TE	< 7.1	
	PPM	I	< 11.		I	< 10.		I	< 12.		I	52.5	4.9
	PPM	CS	< 13.		CS	< 11.		CS	< 13.		CS	< 9.0	
	PPM	BA	653.	34.	BA	633.	33.	BA	683.	36.	BA	415.	22.
	PPM	LA	57.0	9.9	LA	47.7	8.4	LA	30.	10.	LA	29.0	7.3
	PPM	CE	99.	13.	CE	88.	12.	CE	65.	12.	CE	69.8	9.7

SS	UNITS	EL	B01F92 NP-T2 4.75MM	+/-	EL	B01F92 NP-T2 2MM	+/-	EL	B01F92 NP-T2 425UM	+/-	EL	B01F92 NP-T2 250UM	+/-
TI													
	%	AL	8.35	0.47	AL	7.28	0.43	AL	8.64	0.49	AL	8.66	0.49
	%	SI	31.5	1.6	SI	24.3	1.2	SI	26.9	1.4	SI	26.0	1.3
	%	P	0.098	0.027	P	0.079	0.031	P	0.147	0.033	P	0.179	0.032
	%	S	0.014	0.006	S	0.045	0.008	S	0.050	0.008	S	0.044	0.008
	%	CL	< 0.007		CL	< 0.008		CL	< 0.008		CL	< 0.008	
ZR													
	%	SI	30.5	1.6	SI	25.8	1.4	SI	26.8	1.4	SI	26.1	1.4
	%	K	1.752	0.091	K	1.306	0.069	K	1.199	0.063	K	1.303	0.069
	%	CA	2.69	0.14	CA	5.92	0.30	CA	5.49	0.28	CA	5.14	0.26
	%	TI	0.193	0.010	TI	1.351	0.068	TI	1.199	0.061	TI	0.933	0.047
	PPM	V	165.	24.	V	435.	52.	V	310.	47.	V	225.	41.
	PPM	CR	25.5	6.3	CR	25.	10.	CR	88.	11.	CR	144.	11.
	PPM	MN	617.	33.	MN	1561.	81.	MN	1342.	70.	MN	1069.	56.
	%	FE	2.95	0.15	FE	9.42	0.47	FE	8.04	0.40	FE	5.97	0.30
	PPM	NI	36.2	4.0	NI	51.7	7.7	NI	56.5	7.2	NI	69.7	6.6
	PPM	CU	101.2	5.5	CU	75.0	4.7	CU	134.9	7.4	CU	285.	15.
	PPM	ZN	38.7	2.3	ZN	133.4	7.2	ZN	121.5	6.5	ZN	111.3	6.0
	PPM	GA	18.0	1.2	GA	21.5	1.5	GA	20.4	1.5	GA	19.1	1.4
	PPM	HG	< 2.2		HG	< 3.1		HG	< 2.9		HG	< 2.7	
	PPM	SE	< 0.71		SE	< 0.92		SE	< 0.91		SE	< 0.83	
	PPM	PB	10.3	1.2	PB	12.4	1.6	PB	15.6	1.7	PB	22.7	1.8
	PPM	AS	1.46	0.64	AS	< 1.6		AS	2.60	0.85	AS	3.70	0.87
	PPM	BR	< 0.74		BR	< 0.95		BR	< 0.94		BR	< 0.91	
	PPM	SR	417.	21.	SR	318.	16.	SR	378.	19.	SR	409.	21.
AG													
	PPM	RB	48.0	3.4	RB	36.8	2.7	RB	38.4	2.8	RB	46.8	3.4
	PPM	U	5.1	1.4	U	6.7	1.6	U	39.8	3.2	U	108.6	7.8
	PPM	SR	368.	26.	SR	298.	21.	SR	354.	25.	SR	385.	27.
	PPM	Y	33.2	2.4	Y	46.0	3.3	Y	39.3	2.8	Y	31.3	2.3
	PPM	ZR	111.1	7.8	ZR	209.	15.	ZR	180.	13.	ZR	197.	14.
	PPM	NB	9.48	0.78	NB	15.9	1.2	NB	13.6	1.1	NB	11.38	0.95
	PPM	MO	18.0	1.4	MO	19.4	1.5	MO	14.6	1.2	MO	< 1.4	
AM													
	PPM	RU	< 3.8		RU	< 3.9		RU	< 3.8		RU	< 3.7	
	PPM	PD	< 4.0		PD	< 4.4		PD	< 4.3		PD	< 4.3	
	PPM	AG	< 4.4		AG	< 4.9		AG	15.7	2.6	AG	43.0	3.3
	PPM	CD	< 4.8		CD	< 5.1		CD	< 5.1		CD	< 5.2	
	PPM	IN	< 5.0		IN	< 5.6		IN	< 5.5		IN	< 5.4	
	PPM	SN	6.9	2.9	SN	< 6.3		SN	< 6.2		SN	< 6.1	
	PPM	SB	< 6.1		SB	< 6.7		SB	< 6.6		SB	< 6.5	
	PPM	TE	< 7.6		TE	< 8.5		TE	< 7.8		TE	< 7.6	
	PPM	I	< 8.7		I	< 9.6		I	< 9.4		I	< 8.2	
	PPM	CS	< 10.		CS	< 11.		CS	< 10.		CS	< 11.	
	PPM	BA	136.7	8.8	BA	761.	39.	BA	649.	33.	BA	725.	37.
	PPM	LA	< 14.		LA	27.0	7.8	LA	15.2	7.5	LA	27.7	6.9
	PPM	CE	18.7	9.4	CE	53.7	10.0	CE	40.2	9.5	CE	62.8	9.5

9413145.0069

UNITS	EL	B01F92 NP-T2 150UM	+/-	B01F92 NP-T2 75UM	+/-	B01F92	+/-		+/-		+/-
TI											
%	AL	8.93	0.51	AL 9.02	0.51	AL 10.19	0.56	AL	10.21		0.56
%	SI	21.4	1.1	SI 17.95	0.91	SI 17.71	0.90	SI	18.43		0.93
%	P	0.195	0.032	P 0.208	0.033	P 0.180	0.032	P	0.198		0.031
%	S	0.062	0.008	S 0.069	0.009	S 0.067	0.008	S	0.070		0.008
%	CL	< 0.008		CL < 0.008		CL < 0.007		CL	< 0.007		
ZR											
%	SI	21.6	1.2	SI 18.0	1.0	SI 18.7	1.0	SI	18.5		1.0
%	K	1.210	0.064	K 1.123	0.059	K 1.113	0.058	K	1.131		0.059
%	CA	6.95	0.35	CA 9.02	0.45	CA 9.33	0.47	CA	7.07		0.36
%	TI	0.678	0.035	TI 0.563	0.029	TI 0.449	0.023	TI	0.421		0.022
PPM	V	127.	34.	V 110.	33.	V 72.	29.	V	< 53.		
PPM	CR	292.	17.	CR 387.	21.	CR 469.	25.	CR	639.		33.
PPM	MN	849.	45.	MN 780.	42.	MN 760.	40.	MN	836.		44.
%	FE	4.79	0.24	FE 4.17	0.21	FE 3.60	0.18	FE	3.53		0.18
PPM	NI	117.1	7.8	NI 147.0	9.0	NI 187.	11.	NI	290.		15.
PPM	CU	560.	28.	CU 742.	38.	CU 947.	48.	CU	1216.		61.
PPM	ZN	156.6	8.2	ZN 155.8	8.2	ZN 172.4	9.1	ZN	215.		11.
PPM	GA	18.1	1.3	GA 18.1	1.3	GA 19.8	1.4	GA	20.3		1.4
PPM	HG	2.8	1.4	HG 6.5	1.4	HG 7.3	1.6	HG	10.1		1.6
PPM	SE	< 0.82		SE < 0.85		SE < 0.95		SE	1.13		0.45
PPM	PB	36.8	2.4	PB 44.9	2.8	PB 56.2	3.5	PB	73.4		4.2
PPM	AS	5.09	0.98	AS 6.9	1.0	AS 9.2	1.3	AS	8.1		1.3
PPM	BR	2.06	0.51	BR 1.82	0.53	BR 3.67	0.68	BR	4.65		0.66
PPM	SR	410.	21.	SR 418.	21.	SR 412.	21.	SR	409.		21.
AG											
PPM	RB	57.9	4.3	RB 58.3	4.4	RB 63.6	5.0	RB	69.1		5.3
PPM	U	272.	19.	U 357.	25.	U 454.	32.	U	598.		42.
PPM	SR	395.	28.	SR 399.	28.	SR 417.	29.	SR	406.		28.
PPM	Y	31.0	2.3	Y 26.0	2.0	Y 26.8	2.1	Y	25.7		2.0
PPM	ZR	284.	20.	ZR 352.	25.	ZR 446.	31.	ZR	456.		32.
PPM	NB	10.7	1.0	NB 9.44	0.96	NB 6.7	1.1	NB	6.8		1.1
PPM	MO	< 2.0		MO < 2.1		MO < 3.2		MO	7.2		1.6
AM											
PPM	RU	< 4.9		RU 5.3	2.4	RU < 6.9		RU	9.2		3.1
PPM	PD	< 5.3		PD < 5.0		PD < 7.5		PD	< 6.3		
PPM	AG	106.8	6.2	AG 135.4	7.4	AG 170.7	9.6	AG	253.		13.
PPM	CD	< 5.8		CD < 5.5		CD < 8.2		CD	< 6.8		
PPM	IN	< 6.3		IN < 5.9		IN < 8.6		IN	< 7.4		
PPM	SN	< 7.5		SN < 7.1		SN < 10.		SN	20.0		4.7
PPM	SB	< 7.7		SB < 7.1		SB < 10.		SB	< 8.9		
PPM	TE	< 9.7		TE < 8.5		TE < 12.		TE	< 11.		
PPM	I	< 11.		I < 9.3		I < 16.		I	< 13.		
PPM	CS	< 12.		CS < 12.		CS < 18.		CS	< 14.		
PPM	BA	774.	40.	BA 780.	40.	BA 769.	41.	BA	914.		47.
PPM	LA	< 18.		LA 27.3	8.0	LA < 24.		LA	< 21.		
PPM	CE	69.	11.	CE 50.	10.	CE 50.	17.	CE	39.		13.

SS	UNITS	EL	USGS AGV-1	+/-	BCR-1 50-100		+/-	B01F93 NP-T3 1.75MM		+/-	B01F93 NP-T3 2MM		+/-
TI													
	%	AL	8.36	0.47	AL	7.43	0.43	AL	7.08	0.41	AL	7.98	0.46
	%	SI	28.0	1.4	SI	27.0	1.4	SI	22.3	1.1	SI	24.4	1.2
	%	P	0.243	0.030	P	0.150	0.031	P	0.246	0.030	P	0.172	0.026
	%	S	0.034	0.007	S	0.072	0.010	S	0.041	0.008	S	0.019	0.007
	%	CL	< 0.007		CL	< 0.008		CL	< 0.007		CL	< 0.007	
ZR													
	%	SI	29.1	1.5	SI	27.9	1.5	SI	23.6	1.3	SI	26.0	1.4
	%	K	2.57	0.13	K	1.672	0.087	K	1.403	0.074	K	1.501	0.079
	%	CA	3.63	0.18	CA	5.31	0.27	CA	4.99	0.25	CA	3.39	0.17
	%	TI	0.656	0.033	TI	1.488	0.075	TI	1.358	0.069	TI	0.839	0.043
	PPM	V	101.	32.	V	459.	52.	V	306.	45.	V	104.	36.
	PPM	CR	< 15.		CR	30.	11.	CR	50.	10.	CR	46.1	9.2
	PPM	MN	811.	43.	MN	1617.	84.	MN	1406.	73.	MN	5090.	260.
	%	FE	4.98	0.25	FE	10.14	0.51	FE	8.54	0.43	FE	5.81	0.29
	PPM	NI	22.0	4.7	NI	30.8	7.4	NI	51.2	6.9	NI	48.7	5.7
	PPM	CU	57.9	3.6	CU	25.1	2.5	CU	188.	10.	CU	124.3	6.8
	PPM	ZN	94.6	5.1	ZN	133.2	7.2	ZN	137.4	7.3	ZN	87.3	4.8
	PPM	GA	19.6	1.4	GA	21.9	1.6	GA	20.5	1.4	GA	18.1	1.3
	PPM	HG	< 2.7		HG	43.0	3.1	HG	< 2.8		HG	< 2.5	
	PPM	SE	< 0.95		SE	< 0.93		SE	< 0.86		SE	< 0.83	
	PPM	PB	37.2	2.7	PB	16.4	1.7	PB	8.5	1.4	PB	15.3	1.6
	PPM	AS	< 1.8		AS	< 1.7		AS	< 1.4		AS	4.11	0.84
	PPM	BR	< 1.0		BR	< 1.3		BR	< 0.81		BR	< 0.83	
	PPM	SR	655.	33.	SR	325.	17.	SR	463.	24.	SR	295.	15.
AG													
	PPM	RB	66.7	4.8	RB	47.5	3.5	RB	41.9	3.1	RB	56.9	4.1
	PPM	U	< 4.5		U	98.2	7.1	U	13.1	1.9	U	8.0	1.9
	PPM	SR	648.	45.	SR	313.	22.	SR	444.	31.	SR	288.	20.
	PPM	Y	19.9	1.6	Y	38.4	2.8	Y	32.1	2.3	Y	31.8	2.3
	PPM	ZR	221.	16.	ZR	235.	16.	ZR	174.	12.	ZR	205.	14.
	PPM	NB	14.5	1.2	NB	11.80	0.99	NB	13.1	1.0	NB	18.0	1.4
	PPM	MO	< 1.8		MO	4.53	0.83	MO	8.83	0.94	MO	10.0	1.0
PGE													
	PPM	RU	< 5.7		RU	3.9	1.9	RU	< 4.2		RU	< 4.4	
	PPM	PD	< 6.9		PD	< 4.5		PD	< 4.9		PD	< 5.2	
	PPM	AG	< 7.8		AG	< 5.0		AG	6.3	2.7	AG	< 5.8	
	PPM	CD	< 7.9		CD	11.2	2.6	CD	< 5.6		CD	< 5.9	
	PPM	IN	< 8.6		IN	< 5.5		IN	< 6.3		IN	< 6.6	
	PPM	SN	< 9.6		SN	6.6	3.1	SN	< 7.0		SN	< 7.4	
	PPM	SB	< 10.		SB	< 6.7		SB	< 7.3		SB	< 8.0	
	PPM	TE	< 13.		TE	< 7.9		TE	< 8.9		TE	< 10.	
	PPM	I	< 15.		I	< 9.4		I	< 11.		I	< 12.	
	PPM	CS	< 17.		CS	< 10.		CS	< 13.		CS	< 13.	
	PPM	BA	1226.	63.	BA	715.	37.	BA	596.	31.	BA	1094.	56.
	PPM	LA	< 24.		LA	24.7	7.8	LA	19.4	8.9	LA	29.0	9.3
	PPM	CE	47.	17.	CE	55.	11.	CE	77.	11.	CE	84.	14.

SS UNITS	EL	B01F93 NP-T3 425UM	+/-	B01F93 NP-T3 250UM	+/-	B01F93 NP-T3 150UM	+/-	B01F93 NP-T3 75UM	+/-
TI									
%	AL	7.40	0.43	AL 7.94	0.45	AL 8.56	0.48	AL 9.33	0.52
%	SI	24.7	1.2	SI 26.2	1.3	SI 25.6	1.3	SI 25.1	1.3
%	P	0.179	0.031	P 0.179	0.027	P 0.180	0.026	P 0.168	0.026
%	S	0.035	0.008	S 0.029	0.007	S 0.023	0.007	S 0.028	0.007
%	CL	< 0.008		CL < 0.007		CL < 0.007		CL < 0.007	
ZR									
%	SI	25.8	1.4	SI 26.9	1.4	SI 26.1	1.4	SI 25.4	1.4
%	K	1.359	0.072	K 1.839	0.095	K 1.97	0.10	K 2.08	0.11
%	CA	5.24	0.26	CA 3.26	0.16	CA 2.51	0.13	CA 2.26	0.11
%	TI	1.410	0.071	TI 0.860	0.044	TI 0.702	0.036	TI 0.604	0.031
PPM	V	412.	50.	V 174.	37.	V 122.	33.	V 86.	31.
PPM	CR	63.	11.	CR 129.	11.	CR 144.	11.	CR 237.	15.
PPM	MN	1614.	83.	MN 3010.	150.	MN 2950.	150.	MN 2920.	150.
%	FE	8.81	0.44	FE 6.20	0.31	FE 5.47	0.27	FE 5.27	0.26
PPM	NI	71.1	7.8	NI 127.4	8.6	NI 172.	10.	NI 232.	13.
PPM	CU	856.	43.	CU 1740.	87.	CU 2420.	120.	CU 3290.	160.
PPM	ZN	140.8	7.6	ZN 132.6	7.2	ZN 152.2	8.1	ZN 180.9	9.5
PPM	GA	24.7	1.7	GA 28.1	1.8	GA 31.9	2.0	GA 37.0	2.2
PPM	HG	< 3.0		HG < 2.7		HG < 2.6		HG 2.9	1.4
PPM	SE	< 0.91		SE < 0.81		SE < 0.77		SE 1.40	0.38
PPM	PB	12.5	1.5	PB 20.7	1.7	PB 25.4	1.8	PB 31.9	2.1
PPM	AS	3.52	0.85	AS 6.80	0.91	AS 8.52	0.94	AS 9.6	1.0
PPM	BR	< 0.92		BR 1.10	0.45	BR 1.12	0.44	BR 1.91	0.46
PPM	SR	322.	17.	SR 303.	16.	SR 290.	15.	SR 270.	14.
AG									
PPM	RB	40.3	2.9	RB 79.3	5.7	RB 97.9	6.9	RB 108.6	7.7
PPM	U	17.1	1.9	U 53.8	4.2	U 75.4	5.7	U 100.1	7.3
PPM	SR	307.	22.	SR 306.	21.	SR 282.	20.	SR 259.	18.
PPM	Y	36.0	2.6	Y 32.3	2.4	Y 30.3	2.2	Y 29.7	2.2
PPM	ZR	227.	16.	ZR 512.	36.	ZR 644.	45.	ZR 841.	59.
PPM	NB	14.0	1.1	NB 14.6	1.1	NB 15.6	1.2	NB 14.9	1.2
PPM	MO	< 1.2		MO 3.72	0.91	MO 3.31	0.97	MO 5.8	1.1
AM									
PPM	RU	< 3.5		RU < 3.9		RU < 3.9		RU < 3.6	
PPM	PD	< 4.0		PD < 4.5		PD < 4.5		PD < 4.1	
PPM	AG	6.7	2.3	AG 17.2	2.7	AG 32.9	3.0	AG 42.2	3.2
PPM	CD	< 5.0		CD < 5.6		CD < 5.5		CD 5.5	2.4
PPM	IN	< 5.1		IN < 5.7		IN < 5.7		IN < 5.3	
PPM	SN	< 5.8		SN 8.9	3.3	SN 15.0	3.4	SN 28.6	3.4
PPM	SB	< 5.9		SB < 6.7		SB < 6.8		SB < 6.4	
PPM	TE	< 7.6		TE < 8.6		TE < 7.5		TE < 8.0	
PPM	I	< 8.7		I < 9.9		I < 9.9		I < 9.3	
PPM	CS	< 9.5		CS < 11.		CS < 11.		CS < 11.	
PPM	BA	686.	35.	BA 919.	47.	BA 1028.	52.	BA 1001.	51.
PPM	LA	< 13.		LA 40.2	8.2	LA 26.8	7.7	LA 37.8	7.3
PPM	CE	52.2	9.8	CE 51.	10.	CE 70.	10.	CE 59.1	9.6

SS UNITS	EL	B01F93 NP-T3 45UM	+/-		B01F93 NP-T3 -45UM	+/-		USGS BCR-1	+/-		SRM 1646	+/-
TI												
%	AL	10.26	0.56	AL	9.95	0.55	AL	7.17	0.42	AL	7.30	0.42
%	SI	25.1	1.3	SI	24.0	1.2	SI	26.4	1.3	SI	31.4	1.6
%	P	0.243	0.027	P	0.270	0.028	P	0.167	0.031	P	0.134	0.026
%	S	0.038	0.007	S	0.034	0.007	S	0.077	0.009	S	0.915	0.049
%	CL	< 0.007		CL	< 0.007		CL	0.026	0.004	CL	1.396	0.071
ZR												
%	SI	25.4	1.4	SI	24.2	1.3	SI	26.2	1.4	SI	30.4	1.6
%	K	2.15	0.11	K	2.09	0.11	K	1.647	0.086	K	1.97	0.10
%	CA	2.23	0.11	CA	2.37	0.12	CA	5.12	0.26	CA	0.817	0.043
%	TI	0.594	0.030	TI	0.639	0.033	TI	1.427	0.072	TI	0.452	0.023
PPM	V	78.	30.	V	102.	31.	V	443.	50.	V	64.	26.
PPM	CR	387.	21.	CR	916.	47.	CR	< 21.		CR	70.0	8.2
PPM	MN	2700.	140.	MN	2500.	130.	MN	1516.	79.	MN	328.	19.
%	FE	5.17	0.26	FE	5.67	0.28	FE	9.64	0.48	FE	3.30	0.17
PPM	NI	279.	15.	NI	460.	24.	NI	25.7	6.9	NI	34.0	4.0
PPM	CU	3670.	180.	CU	4630.	230.	CU	13.7	2.0	CU	17.4	1.6
PPM	ZN	193.	10.	ZN	240.	13.	ZN	126.1	6.8	ZN	122.3	6.4
PPM	GA	42.1	2.5	GA	43.9	2.6	GA	20.5	1.5	GA	13.04	0.98
PPM	HG	4.8	1.4	HG	6.8	1.5	HG	< 2.8		HG	< 2.1	
PPM	SE	< 0.77		SE	< 0.81		SE	< 0.91		SE	< 0.73	
PPM	PB	38.6	2.4	PB	53.5	3.1	PB	16.0	1.8	PB	26.8	1.8
PPM	AS	9.9	1.1	AS	13.7	1.3	AS	< 1.6		AS	9.77	0.94
PPM	BR	2.35	0.48	BR	3.45	0.54	BR	< 0.90		BR	120.7	6.1
PPM	SR	257.	13.	SR	236.	12.	SR	328.	17.	SR	139.7	7.5
AG												
PPM	RB	106.9	7.6	RB	116.0	8.2	RB	47.8	3.5	RB	74.3	5.3
PPM	U	106.8	7.8	U	157.	11.	U	< 3.5		U	< 3.1	
PPM	SR	243.	17.	SR	231.	16.	SR	327.	23.	SR	129.0	9.1
PPM	Y	29.7	2.2	Y	33.5	2.5	Y	37.7	2.7	Y	26.3	1.9
PPM	ZR	964.	67.	ZR	1387.	97.	ZR	193.	14.	ZR	377.	26.
PPM	NB	15.5	1.2	NB	17.7	1.4	NB	12.9	1.1	NB	14.4	1.1
PPM	MO	6.8	1.2	MO	18.4	1.8	MO	1.89	0.77	MO	2.02	0.65
AM												
PPM	RU	< 3.8		RU	< 3.8		RU	< 4.7		RU	< 3.2	
PPM	PD	< 4.4		PD	< 4.4		PD	< 5.5		PD	< 3.7	
PPM	AG	58.7	3.9	AG	89.8	5.2	AG	< 6.1		AG	< 4.1	
PPM	CD	< 5.5		CD	< 5.2		CD	< 6.8		CD	< 4.4	
PPM	IN	< 5.6		IN	< 5.6		IN	< 7.1		IN	< 4.8	
PPM	SN	45.2	4.0	SN	107.9	6.4	SN	< 7.8		SN	6.3	2.7
PPM	SB	< 6.9		SB	< 6.7		SB	< 8.8		SB	< 5.7	
PPM	TE	< 8.5		TE	< 8.5		TE	< 11.		TE	< 6.9	
PPM	I	< 10.		I	< 10.0		I	< 12.		I	47.8	4.9
PPM	CS	< 12.		CS	< 11.		CS	< 13.		CS	< 9.9	
PPM	BA	977.	50.	BA	948.	48.	BA	695.	37.	BA	389.	21.
PPM	LA	34.5	7.8	LA	39.2	7.8	LA	< 19.		LA	30.4	7.0
PPM	CE	68.	11.	CE	85.	12.	CE	37.	13.	CE	69.5	9.1

APPENDIX D

Raw Data on Gamma Scans

The original raw data for the gamma counting is quite copious and is not reproduced herein. The original data have been transferred to WHC (Jim Field) who can be contacted to determine their current whereabouts, if necessary. Some of the critical raw data are summarized in the following table. Data included in Table D-1 are the sample ID that is found on the counting records, the particle size split for each sample, the live time that each sample was counted (in seconds), the mass of sample counted (in grams), the counts (area) in the respective peak channels for ^{238}U, ^{235}U, ^{137}Cs and ^{60}Co, the counts in the background channels around each peak, the % error in the raw counting data based on peak counts minus background counts and the activity/gram values for each radionuclide (μCi/g) and the calculated standard deviation in μCi/g.

The calculations are performed internally within the ND6600 software system. The user supplies the energy levels and abundances of each desired peak for the radionuclides. With efficiency curves for the various energy levels produced using multiple nuclide standards that cover a wide energy range, the user inputs (sample ID, sample weight, geometry, etc), and the observed count rates the software automatically calculates activity.

As mentioned in the text, the data acquisition system was calibrated versus known uranium ore and mill tailings samples to assure proper operation of the system. The standard deviations reported herein only include counting uncertainty in the random decay occurrences. The uncertainty caused by sediment heterogeneity, potential hot particles etc. are not included. No duplicate samples were prepared from a given size split to ascertain the magnitude of these other types of "real world" uncertainties. Finally the large gravel and cobble sizes were counted by simply wrapping a representative rock in Saran Wrap and placing it directly on the detector. This is not a standard geometry for which we have calibrated efficiencies.

9413145.0073

TABLE D-1. Raw Counting Data

Sample ID	Particle Size (mm)	Count Time (s)	Sample Size (g)	^{238}U Area in Peak	^{238}U Bkgrd. Area	^{238}U % Error	^{238}U Activity (μCi/g)	^{238}U Std. Dev. (μCi/g)	^{235}U Area in Peak	^{235}U Bkgrd. Area	^{235}U % Error	^{235}U Activity (μCi/g)	^{235}U Std. Dev. (μCi/g)
NP T1-Rock	>50	7200	238.4	105	471	35.5	4.84×10^{-7}	1.72×10^{-7}	67	277	45.1	4.08×10^{-8}	1.84×10^{-8}
NP T1-2	<50 to >37.5	14400	209.4	132	775	40.5	3.94×10^{-7}	1.60×10^{-7}	155	470	30.1	6.18×10^{-8}	1.86×10^{-8}
NP T1-3	<37.5 to >25	14400	82.8	303	933	20.4	2.01×10^{-6}	4.10×10^{-7}	243	662	25.3	2.13×10^{-7}	5.38×10^{-8}
NP T1-4	<25 to >13.2	3600	36.4	35	183	90.9	2.11×10^{-6}	1.91×10^{-6}	34	93	57.3	2.75×10^{-7}	1.58×10^{-7}
NP T1-5	<13.2 to >4.75	3600	22.7	94	195	34.5	9.09×10^{-6}	3.13×10^{-6}	28	81	61.7	3.52×10^{-7}	2.17×10^{-7}
NP T1-6	<4.75 to >2.00	3600	12.9	108	149	22.7	1.84×10^{-5}	4.17×10^{-6}	57	86	33.5	1.29×10^{-6}	4.32×10^{-7}
NP T1-7	<2.00 to >0.42	43200	10.1	2478	2482	4.3	4.51×10^{-5}	1.93×10^{-6}	1224	1258	6.2	2.95×10^{-6}	1.82×10^{-7}
NP T1-8	<0.42 to >0.25	3600	11.0	690	570	8.7	1.38×10^{-4}	1.20×10^{-5}	385	189	10.1	1.02×10^{-5}	1.03×10^{-6}
NP T1-9	<0.25 to >0.15	2700	11.0	735	254	5.2	1.95×10^{-4}	1.02×10^{-5}	417	154	9.1	1.47×10^{-5}	1.34×10^{-6}
NP T1-10	<0.15 to >0.07	2700	11.0	1176	496	4.6	3.84×10^{-4}	1.76×10^{-5}	532	135	6.5	2.30×10^{-5}	1.49×10^{-6}
NP T1-11	<0.07 to >0.04	1800	4.7	529	217	7.0	4.93×10^{-4}	3.47×10^{-5}	215	61	9.6	2.65×10^{-5}	2.54×10^{-6}
NP T1-12	<0.045	1800	1.2	167	111	16.1	5.92×10^{-4}	9.52×10^{-5}	73	29	18.2	3.41×10^{-5}	6.20×10^{-6}
NP T2-Rock	>50	13358	371.4	543	1437	14.8	2.54×10^{-7}	9.33×10^{-8}	74	556	59.1	1.58×10^{-8}	9.31×10^{-9}
NP T2-2	<50 to >37.5	14400	143.5	150	630	32.0	5.76×10^{-7}	1.84×10^{-7}	152	522	34.9	7.65×10^{-8}	2.67×10^{-8}
NP T2-3	<37.5 to >25	7200	68.1	170	394	25.2	2.74×10^{-6}	6.91×10^{-7}	53	148	40.6	1.13×10^{-7}	4.58×10^{-8}
NP T2-4	<25 to >13.2	172800	33.0	789	14062	34.3	1.10×10^{-6}	3.75×10^{-7}	639	3885	17.4	1.17×10^{-7}	2.05×10^{-8}
NP T2-5	<13.2 to >4.75	3600	23.0	15	92	100	1.39×10^{-6}	1.55×10^{-6}	23	85	83.2	2.91×10^{-7}	2.42×10^{-7}
NP T2-6	<4.75 to >2.00	3600	12.8	82	115	30.9	1.41×10^{-5}	4.35×10^{-6}	48	64	40.9	1.13×10^{-6}	4.62×10^{-7}
NP T2-7	<2.00 to >0.42	28800	10.0	564	1223	12.3	1.55×10^{-5}	1.90×10^{-6}	279	751	19.5	1.02×10^{-6}	1.98×10^{-7}
NP T2-8	<0.42 to >0.25	28800	11.0	2081	2584	5.8	5.19×10^{-5}	3.01×10^{-6}	930	1192	9.4	3.05×10^{-6}	2.86×10^{-7}
NP T2-9	<0.25 to >0.15	3600	11.0	527	436	9.8	1.05×10^{-4}	1.03×10^{-5}	192	92	10.5	5.07×10^{-6}	5.33×10^{-7}
NP T2-10	<0.15 to >0.07	3600	11.0	792	167	4.2	1.58×10^{-4}	6.66×10^{-6}	254	171	13.2	6.69×10^{-6}	8.82×10^{-7}
NP T2-11	<0.07 to >0.04	3600	11.0	755	427	6.9	1.51×10^{-4}	1.04×10^{-5}	300	173	11.8	7.99×10^{-6}	9.40×10^{-7}
NP T2-12	<0.045	5400	10.9	1248	412	4.0	1.67×10^{-4}	6.64×10^{-6}	456	228	8.1	8.09×10^{-6}	6.52×10^{-7}
NP T3-Rock	>50	14400	217.0	161	863	39.7	4.09×10^{-7}	1.62×10^{-7}	166	481	30.7	3.62×10^{-8}	1.11×10^{-8}
NP T3-2	<50 to >37.5	14400	127.4	37	397	96.9	1.59×10^{-7}	1.54×10^{-7}	24	193	100	1.35×10^{-8}	1.35×10^{-8}
NP T3-3Rock	<37.5 to >25	14400	72.4	96	833	59.1	7.28×10^{-7}	4.30×10^{-7}	183	387	23.5	1.84×10^{-7}	4.34×10^{-8}
NP T3-3WAF	<25 to >13.2	28800	34.6	143	873	35.7	1.14×10^{-6}	4.05×10^{-7}	176	894	35.5	1.84×10^{-7}	6.51×10^{-8}
NP T3-4	<13.2 to >4.75	10800	23.4	79	574	60.3	2.48×10^{-6}	1.49×10^{-6}	126	250	26.6	5.23×10^{-7}	1.39×10^{-7}
NP T3-5	<4.75 to >2.00	3600	12.2	53	220	58.2	9.63×10^{-6}	5.61×10^{-6}	46	165	74.9	1.21×10^{-7}	9.06×10^{-7}
NP T3-6	<2.00 to >0.42	28800	10.0	256	1089	23.9	7.01×10^{-6}	1.67×10^{-6}	224	670	23.2	8.12×10^{-7}	1.88×10^{-7}
NP T3-7	<0.42 to >0.25	5400	11.0	282	192	9.9	3.76×10^{-5}	3.73×10^{-6}	111	132	21.9	1.95×10^{-6}	4.26×10^{-7}
NP T3-8	<0.25 to >0.15	5400	11.0	226	273	16.2	3.02×10^{-5}	4.87×10^{-6}	89	146	29.0	1.56×10^{-6}	4.53×10^{-7}
NP T3-9	<0.15 to >0.07	7344	11.1	459	279	7.5	4.48×10^{-5}	3.35×10^{-6}	187	179	14.9	2.41×10^{-6}	3.58×10^{-7}
NP T3-10	<0.07 to >0.04	3600	11.0	261	139	9.7	5.22×10^{-5}	5.06×10^{-6}	163	179	23.5	4.23×10^{-6}	9.95×10^{-7}
NP T3-11	<0.045	3600	11.1	300	144	8.4	5.96×10^{-5}	5.00×10^{-6}	138	106	18.5	3.63×10^{-6}	6.69×10^{-7}

TABLE D-1. Raw Counting Data (Con't)

Sample ID	Particle Size (mm)	Count Time (S)	Sample Size (g)	^{137}Cs Area in Peak	^{137}Cs Bkgrd. Area	^{137}Cs % Error	^{137}Cs Activity (µCi/g)	^{137}Cs Std. Dev. (µCi/g)	^{60}Co Area in Peak	^{60}Co Bkgrd. Area	^{60}Co % Error	^{60}Co Activity (µCi/g)	^{60}Co Std. Dev. (µCi/g)
NP T1-Rock	>50	7200	238.4	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}
NP T1-2	<50 to >37.5	14400	209.4	59	33	26.0	1.04×10^{-7}	0.3×10^{-7}	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}
NP T1-3	<37.5 to >25	14400	82.8	41	39	40.3	1.60×10^{-7}	0.6×10^{-7}	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}
NP T1-4	<25 to >13.2	3600	36.4	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}
NP T1-5	<13.2 to >4.75	3600	22.7	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}
NP T1-6	<4.75 to >2.00	3600	12.9	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}
NP T1-7	<2.00 to >0.42	43200	10.1	69	96	30.2	7.4×10^{-7}	2.2×10^{-7}	35	21	41.6	6.6×10^{-7}	2.7×10^{-7}
NP T1-8	<0.42 to >0.25	3600	11.0	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}
NP T1-9	<0.25 to >0.15	2700	11.0	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}
NP T1-10	<0.15 to >0.07	2700	11.0	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}
NP T1-11	<0.07 to >0.04	1800	4.7	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}
NP T1-12	<0.045	1800	1.2	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}
NP T2-Rock	>50	13358	371.4	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}
NP T2-2	<50 to >37.5	14400	143.5	51	45	35.1	1.15×10^{-7}	4.0×10^{-8}	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}
NP T2-3	<37.5 to >25	7200	68.1	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}
NP T2-4	<25 to >13.2	172800	33.0	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}
NP T2-5	<13.2 to >4.75	3600	23.0	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}
NP T2-6	<4.75 to >2.00	3600	12.8	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}
NP T2-7	<2.00 to >0.42	28800	10.0	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}
NP T2-8	<0.42 to >0.25	28800	11.0	53	88	35.2	7.8×10^{-7}	2.8×10^{-7}	19	16	50.2	5.99×10^{-7}	3.0×10^{-7}
NP T2-9	<0.25 to >0.15	3600	11.0	21	5	36.2	2.4×10^{-7}	8.8×10^{-7}	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}
NP T2-10	<0.15 to >0.07	3600	11.0	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}
NP T2-11	<0.07 to >0.04	3600	11.0	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}
NP T2-12	<0.045	5400	10.9	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}
NP T3-Rock	>50	14400	217.0	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}
NP T3-2	<50 to >37.5	14400	127.4	32	24	46.0	1.33×10^{-7}	6.1×10^{-8}	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}
NP T3-3Rock	<37.5 to >25	14400	72.4	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}
NP T3-3WAF	<25 to >13.2	28800	34.6	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}
NP T3-4	<13.2 to >4.75	10800	23.4	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}
NP T3-5	<4.75 to >2.00	3600	12.2	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}
NP T3-6	<2.00 to >0.42	28800	10.0	89	116	31.4	1.44×10^{-6}	4.5×10^{-7}	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}
NP T3-7	<0.42 to >0.25	5400	11.0	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}
NP T3-8	<0.25 to >0.15	5400	11.0	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}
NP T3-9	<0.15 to >0.07	7344	11.1	36	36	38.6	2.07×10^{-6}	8.0×10^{-7}	14	10	49.2	1.2×10^{-6}	5.9×10^{-7}
NP T3-10	<0.07 to >0.04	3600	11.0	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}	22	0	32.0	3.57×10^{-6}	1.1×10^{-6}
NP T3-11	<0.045	3600	11.1	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}	not detected			$<1.0 \times 10^{-7}$	1.0×10^{-7}

THIS PAGE INTENTIONALLY
LEFT BLANK

Date Received: 9/29/92

INFORMATION RELEASE REQUEST

Reference: WHC-CM-3-4

Complete for all Types of Release

Purpose

[] Speech or Presentation
- [] Full Paper
- [] Summary
- [] Abstract
- [] Visual Aid

(Check only one suffix)

[] Speakers Bureau
[] Poster Session
[] Videotape

[] Reference
[X] Technical Report
[] Thesis or Dissertation
[] Manual
[] Brochure/Flier
[] Software/Database
[] Controlled Document
[] Other

ID Number (include revision, volume, etc.)
WHC-SD-EN-TI-049, Rev. 0

List attachments.

Date Release Required
October 5, 1992

Title: Contaminant Concentration Versus Particle Size for 300 Area North Process Pond Sample

Unclassified Category: UC-N/A

Impact Level: 4

New or novel (patentable) subject matter? [X] No [] Yes
If "Yes", has disclosure been submitted by WHC or other company?
[] No [] Yes Disclosure No(s).

Information received from others in confidence, such as proprietary data, trade secrets, and/or inventions?
[X] No [] Yes (Identify)

Copyrights? [X] No [] Yes
If "Yes", has written permission been granted?
[] No [] Yes (Attach Permission)

Trademarks?
[X] No [] Yes (Identify)

Complete for Speech or Presentation

Title of Conference or Meeting: N/A

Group or Society Sponsoring:

Date(s) of Conference or Meeting: N/A

City/State: N/A

Will proceedings be published? [] Yes [] No
Will material be handed out? [] Yes [] No

Title of Journal: N/A

CHECKLIST FOR SIGNATORIES

Review Required per WHC-CM-3-4	Yes	No	Reviewer - Signature Indicates Approval: Name (printed)	Signature	Date
Classification/Unclassified Controlled Nuclear Information	[]	[X]			
Patent - General Counsel	[X]	[]	SW BERGEN	S W Bergen	9/30/92
Legal - General Counsel	[X]	[]			
Applied Technology/Export Controlled Information or International Program	[]	[X]			
WHC Program/Project	[]	[X]			
Communications	[]	[X]			
RL Program/Project	[]	[X]			
Publication Services	[X]	[]	L. Hermann	L. Hermann	10/5/92
Other Program/Project	[]	[X]			

Information conforms to all applicable requirements. The above information is certified to be correct.

	Yes	No
References Available to Intended Audience	[X]	[]
Transmit to DOE-HQ/Office of Scientific and Technical Information	[]	[X]

Author/Requestor (Printed/Signature): J. G. Field, J. Stone for — Date: 9/29/92

Intended Audience: [] Internal [] Sponsor [X] External

Responsible Manager (Printed/Signature): J. G. Woolard, J. Stone for — Date: 9/29/92

INFORMATION RELEASE ADMINISTRATION APPROVAL STAMP

Stamp is required before release. Release is contingent upon resolution of mandatory comments.

APPROVED FOR RELEASE — OFFICIAL DOCUMENT — NS — Date 10/5/92

Date Cancelled

Date Disapproved

BD-7600-062 (08/91) WEF074

Part 1

9413146.0076

Battelle
Pacific Northwest Laboratories

CLEARANCE OF PUBLICATIONS AND PRESENTATIONS

Complete for all Types of Release

Type of Release
- [x] Technical Report
- [ ] Speech or Presentation
  - [ ] Full Paper
  - [ ] Summary
  - [ ] Abstract
  - [ ] Slides
  - [ ] Poster Session
- [ ] Journal Article
- [ ] Book or Book Chapter
- [ ] Thesis or Dissertation
- [ ] Software Documentation
- [ ] Instruction Manual
- [ ] Brochure/Flier
- [ ] Trade Show Exhibit
- [ ] Other:

Document Number (Clearance Approval/Book will assign)

Other Number (e.g. NUREG/CR)

If Previously Cleared, List Document No.

Date Clearance Required

Title: Contaminant Concentration vs. Particle Size for 300 Area North Process Pond Samples

Lead Author Name, Payroll Number, Phone, Mailstop (MSIN): RJ Serne; 34031; 6-8429; K6-81

Other Author(s) Name(s): CW Lindenmeier; PK Bhatia; VL LeGore

Project or Program Title: 300 Area Pond Sediment Characterization

Lead Org. Code: D7D35

Editor Name (if edited), Phone: WHC

Client (Four Digit Code): LQ78

If 1830, Project No. and B&R No.

If Related Services, TD No. (and FIN No. if NRC)

If Non-1830, Contract No.

Complete for Speech, Article, Presentation

Complete Title of Conference

Group or Society Sponsoring

Dates of Conference

City/State

Will a Proceedings be Published? [ ] Yes [ ] No

Will you hand out material at the meeting? [ ] Yes [ ] No

For a journal submission, provide complete title of journal

Complete for Brochure, Flier

Intended Audience

Purpose of Publication/Presentation

Quantity | Production Cost | How will it be distributed?

I HAVE REVIEWED THE ATTACHED DOCUMENT AND HAVE CONSIDERED ALL OF THE APPROPRIATE ITEMS IN THE CHECKLIST ON THE BACK OF THIS FORM.

Author: R. Jeff Serne (R Jeff Serne)	Date: 9/23/92	Program Manager: R. Jeff Serne (R. Jeff Serne)	Date: 9/28/92
Peer Reviewer: RL Erikson (RL Erikson)	Date: 9/24/92	Other	Date
Editorial Reviewer: WHC	Date	Reviewers' Comments (Please Initial)	
Section Manager: CJ Hostetler (Charles Hostetler)	Date: 9/24/92		
Department Manager: JW Falco (JW Falco)	Date: 9/25/92		

Authorized Classifier Clearance — Date

- [ ] Unclassified
- [ ] Classified
- [ ] This document may contain UCNI
- [ ] Restricted distribution because of

Clearance Administration Will Route

Patent Reviewer — Date

DOE RL — Date

Approved for Release: Publication Services — Date

DRAFT - Clearance Only Through Department Level

Department Manager's Secretary:

Call the following person after the Department Manager's and other reviews are completed and signed off.

_____ _____ phone

Attention Patent Services: This document may contain or disclose _____ inventions.

SC (10/09/92) (10/88)

DISTRIBUTION SHEET

To	From	Page 1 of 1
Distribution	Station #21	Date
Project Title/Work Order		EDT No. 159729
		ECN No.

Name	MSIN	With Attach.	EDT/ECN & Comment	EDT/ECN Only
J G Field	HH-55	X		
J G Woolard	HH-55	X		
H C Henckel	HH-55	X		
L D Belden	HH-55	X		
EDMC	HH-22	X(2)		
Central Files	L8-04	orig+3		

9413115.9078

A-6000-135 (12/87)

THIS PAGE INTENTIONALLY
LEFT BLANK