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**Leaching Tendencies of Uranium and
Regulated Trace Metals from the
Hanford Site 300 Area North Process
Pond Sediments**

**R. J. Serne
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September 1994

**Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830**

**Pacific Northwest Laboratory
Operated for the U.S. Department of Energy
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Richland, Washington 99352

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ABSTRACT

Data are presented that address the leaching tendencies and the total chemical composition of metals in feed materials and soil-washed fines generated by Alternative Remediation Technology, Inc. during a pilot-scale soil physical separation test performed at the 300 Area North Process Pond (Facility 316-2) on the Hanford Site in the spring of 1994.

Four 300 Area North Process Pond sediments and one sediment from outside the pond's fenced area were leach-tested using the Toxicity Characteristic Leach Procedure (TCLP) and other modified U.S. Environmental Protection Agency and American Society for Testing and Materials protocols. Finally, leachate from the most contaminated sediment was used to load the Hanford sediment obtained outside the facility to evaluate the potential for contaminant adsorption onto natural sediments.

The sediment characterization, leach, and adsorption results will be used in the evaluation of remedial alternatives in the 300-FF-1 Operable Unit Remedial Investigation/Feasibility Study.

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SUMMARY

Total chemical analyses of representative samples of 300 Area North Process Pond sediments, both before and for the fines segregated by a field demonstration of physical soil washing, show elevated concentrations of Al, Cu, Fe, Ni, U, and Zr.

Various leach tests were performed on the 300 Area North Process Pond sediments, a sample from outside the pond, and the fine sludges obtained by physical soil washing pond sediments. None of the Toxicity Characteristic Leach Procedure (TCLP) leach tests generated leachates that exceeded limits for RCRA regulated metals that would require designating the sediments as hazardous waste. Site-specific leach tests using simulated rainwater were also performed to provide leachate data that could be used to evaluate transport of contaminants in the vadose zone and potential impacts to groundwater. Rainwater leachates show Cu and U as the two potential contaminants that merit further detailed analyses. Rainwater leachates are significantly lower in concentrations than TCLP leachates. Uranium is the only element that consistently leached at concentrations above current or proposed drinking water standards. Copper concentrations in leachates exceed purge water criteria by up to a factor of 100. A few of the observed leachate concentrations for Cr and Fe approach or slightly exceed primary or secondary drinking water standards, respectively, and thus these elements may merit some consideration in any further fate analyses that may be performed during the final selection of preferred remedial alternatives.

Adsorption tests were performed to evaluate the potential for contaminant removal by uncontaminated sediments underlying the 300 Area North Process Pond and in the upper unconfined aquifer. The sediment obtained outside the Pond and used in these adsorption tests contained significant amounts of evaporite salts that dissolved and released significant quantities of chemicals, including the contaminants of interest. Therefore, direct quantification of adsorption is not possible. However, after the evaporites

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dissolve and flush from the sediments, it appears that the sediment will adsorb Cu but likely will not adsorb the dissolved U in leachates. The evaporite salts may signify that the sediment taken outside of the pond is actually sediment that contacted liquid waste discharged into the pond during the active life of the pond. If the contaminant fate analyses of various remedial alternatives would benefit from more accurate consideration of sediment adsorption, additional testing on 300 Area sediments without evaporites or sediments flushed before use could be performed to provide adsorption data. Such data would allow more realistic (e.g., less conservative) evaluations of the long-term consequences of leaving 300 Area North Process Pond sediments in place or performing remediation such as physical soil washing, in which cleaned sediments with lowered concentrations of contaminants are returned to the excavation.

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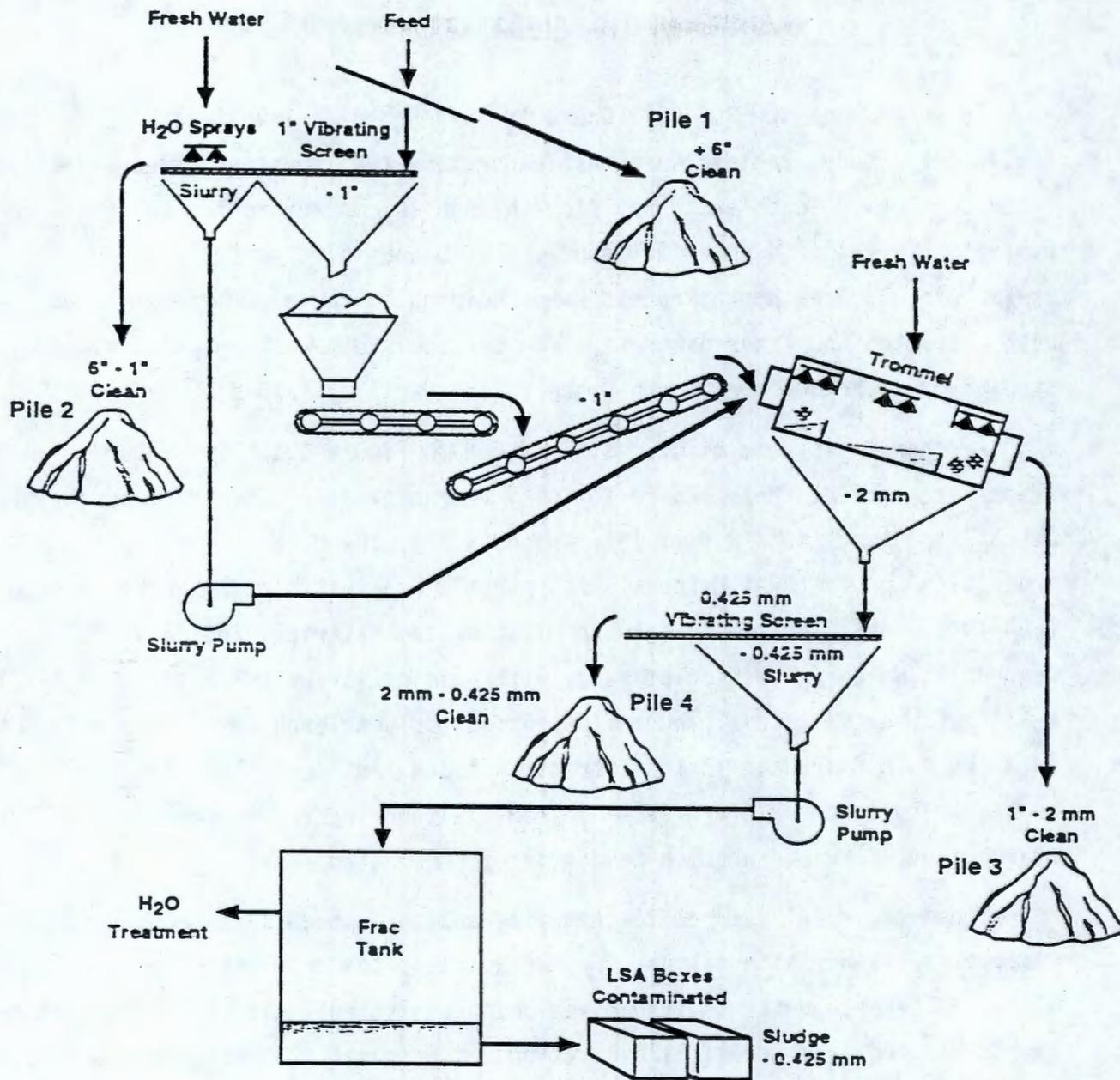
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1.0 INTRODUCTION

In support of the 300-FF-1 Operable Unit Remedial Investigation/ Feasibility Study, Pacific Northwest Laboratory (PNL) has performed several laboratory-scale leach tests and flow-through column adsorption tests to evaluate the fate and potential mobility of U and selected trace metals present in 300 Area North Process Pond sediments. These sediments include both untreated and fines generated from physical soil washing pilot plant studies from the 300 Area North Process Pond Facility (316-2).

A schematic of one pilot test is shown in Figure 1.1. The laboratory tests used include the standard Toxicity Characteristic Leach Procedure (TCLP) batch leach test (40 CFR Part 161, Appendix II), the U.S. Environmental Protection Agency (EPA) Method 1312 Synthetic Precipitation Leaching Procedure (EPA 1990), the American Society for Testing and Materials (ASTM) draft Sequential Batch Extraction of Waste with Acidic Extraction Fluid (ASTM 1994), a 1:1 batch extract test, and a flow-through column leach test. The effluents from the ASTM Sequential Batch Extraction leach test were also used, in sequence, to load a Hanford Site sediment neighboring the Process Pond to evaluate potential adsorption tendencies for selected metals.

These empirical data on leachability and adsorption will be used in evaluating cleanup alternatives for contaminated soils in the 300-FF-1 Operable Unit. Alternatives being evaluated include: 1) No Action; 2) institutional controls; 3) excavation and disposal at a solid waste burial ground (such as the Environmental Restoration Disposal Facility [ERDF]); and 4) excavation, physical soil washing and fines disposal. The results of the leach testing will also be used to determine whether sediment (bulk or soil washed fines) removed for disposal require further treatment such as fixation to meet waste acceptance criteria at the disposal facility. In addition to presenting these data, the report discusses general technical issues, such as



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Figure 1.1. Schematic of WHC Pilot Test

the stability of Cr(III) versus Cr(VI) in soils, to provide references for staff who are preparing the 300-FF-1 Phase III Feasibility Study (DOE 1994b).

A significant amount of data have been collected and published regarding the 300 Area North Process Pond disposal history, sediment characterization and laboratory, field, and pilot-scale soil washing testing. A brief synopsis is provided below. Young et al. (1990) and Young and Fruchter (1991) give further details on site history; Dennison et al. (1989), Serne et al. (1992), and Westinghouse Hanford Company (WHC) (1994a) provide additional information about sediment characterization; and Gerber et al. (1991), U.S. Department of Energy (DOE) (1994a), and Alternative Remedial Technologies, Inc. (ART 1994, WHC 1994c) provide information on the soil washing results.

The 300 Area North Process Pond (~10 acres) was constructed in late 1948 to function primarily as a percolation pond for fuels fabrication liquid wastes. The liquid wastes contained large quantities of sodium aluminate and Zr from fuels cladding removal, Cu from bronze fuel canning, and U from the fuel itself. Disposal of wastes ceased in 1974, and the pond soon dried. The individual grains in the pond are mainly coarse-grained sediments of glacio-fluvatile origin, with more than 75% by weight >2 mm. The sediments are typically considered a gravelly sand with cobbles. Only 1-5% of the sediments is silt and clay. Near the inlet of the pond, thin layers of whitish and green material are visible within the profile. These colored materials contain high levels of aluminum oxyhydroxides and calcium carbonate, and they are very enriched in Cu and Zr and fairly enriched in other trace metals and U. Uranium was selected as the key contaminant of concern in the pond sediments based on preliminary risk analyses. Preliminary soil washing studies (both laboratory and field) showed that the bulk of the U could be segregated into the fines with particle sizes <0.425 mm or from <0.150 to 0.075 mm, using attrition scrubbing to further break up agglomerates. Because no agreed-upon cleanup levels have been negotiated, the washed coarse materials have not been declared free from future environmental risk. The

process of concentrating the fines could create a waste that may need further treatment (e.g., solidification, vitrification, etc.) before disposal.

The empirical leach and adsorption studies presented here give site-specific data to assess the impacts of U, and other metals present in the pond sediments, on cleanup alternatives. The alternatives range from no action to transport and disposal of fines generated from physical soil washing and reburial of washed sands and larger particle sizes within the pond. Some data on stabilizing the fines generated during physical soil washing using vitrification are also available (WHC 1994b).

2.0 SAMPLES RECEIVED

Five 4-L (1-gal) plastic buckets of sediments were transferred from the 300 Area North Process Pond and environs to PNL. The samples were labeled A, B, C, D and Clean. The first four samples were taken on April 14, 1994, from piles formed during the ART physical separation pilot plant study performed in spring 1994 (see WHC 1994c). Sample A was the <50-mm composite soil used in the "non-green" process replication run. Sample C was the <50-mm composite soil that contained visual signs of the green contaminant-enriched calcium carbonate. These two samples represent sediments before physical soil washing that were pre-screened to remove large pebbles, cobbles, and boulders. These pond sediments were used to generate leaching data for the No-Action alternative. Based on ART (1994) summary data, the non-green composite feed sediment, Sample A, differs from existing pond sediment in that 27% of the sediment has particle sizes >50 mm. For Sample C, 17.5% of the existing pond material was >50 mm and was removed before pilot-scale soil washing and shipment to PNL.

Samples B and D came from the ART pilot study "fines" sludge cake. Sample B came from processing non-green composite material during the replication run, and Sample D came from processing the green carbonate material. The fines had a particle size ≤ 0.075 mm. The Clean soil sample was sampled by WHC on May 18, 1994, at a location 9 m (10 yd) north of the north side fence surrounding the 300 Area North Process Pond. Approximately 30.5 cm (1 ft) of sediment was removed with a shovel and the 4-L (1-gal) sample was taken from the depression. As shown in Section 4.0, this sample may not represent "clean" natural background 300 Area sediments and will be renamed "Nearby" in further discussions.

Samples A, C, and Nearby were air-dried and dry-sieved through a 9.5-mm sieve to remove pebbles and coarser material. The larger material (>9.5 mm) represented 52.1%, 44.1%, and 36.5% by weight of the as-received

materials for Samples A, C, and Nearby, respectively. Combining these data with the ART particle size data (ART 1994, WHC 1994c) suggests that our sieved composite Samples A and C contained only 35% and 46.1%, respectively, of the bulk material in the pond. That is, the samples used in these tests do not contain the coarse-sized material that represents 65% and 54% of the existing pond sediments in the regions sampled to obtain the starting feed for the pilot tests.

Samples B and D were not sieved further. All five samples were individually well-mixed by cone and quartering the air-dried samples (A, C, and Nearby) and kneading the wet fine filter cakes (samples B and D). Representative aliquots were then taken to measure (using X-ray fluorescence [XRF]) total metals and U contents and to perform various leach tests. All aliquots were oven-dried at 105°C for 24 hours before performing metals analyses or leach testing.

3.0 METHODS

The total metals content of each oven-dried sample was determined using energy-dispersive XRF that used two secondary excitation sources, Fe/Ag and Ag. Aliquots used to perform XRF were ground to <300 mesh (<0.05 mm). Two standard rock samples, USGS AGV-1 and BCR-1, were processed with the 300 Area North Process Pond sediments to assure quality control. Known U spikes were added to BCR-1 to check the recovery of U and to determine accuracy. Matrix corrections were performed using the backscatter with fundamental parameter method that allows accurate analyses of "unknown" samples without prior knowledge of the sample matrix (Arthur and Sanders 1992, Nielson et al. 1982, and Sanders et al. 1983).

Five leach tests were used to gather information on contaminant fate using regulatory waste designation protocol as well as more realistic and site-specific protocol that simulates Hanford environmental conditions. All five sediment samples were leached using the standard TCLP (Method 1311) (40 CFR Part 261 Appendix II) and Acid-Rain (Method 1312) (EPA 1990) protocols. Both methods rely upon an 18-hour batch soil contact with a designated leachant at a solid-to-solution ratio of 1 g:20 ml. The TCLP method uses one of two extract fluids that simulate municipal landfill leachates. Fluid 1 is a pH=4.93 sodium acetate buffer, and fluid 2 is a pH=2.88 acetic acid. One of these extraction fluids is chosen based on the results of soil buffering capacity testing completed before the TCLP test is performed. For sediments A, B, C, and Nearby, extraction fluid 1 was appropriate, while sediment D (green run fines) required the harsher extraction fluid 2 because of its inherent basicity.

Our slightly modified Method 1312 used a less corrosive extracting solution of dilute tap water (as opposed to deionized water cited in the EPA protocol) adjusted to pH=5.00, with 60/40% by weight sulfuric and nitric acid. This extractant simulates acid rain for the western United States. We used

tap water instead of deionized water because Hanford sediments readily leach cations such as Ca and Mg and anions such as bicarbonate. These three species are the major constituents of tap water. At the present time acid rain impacts at Hanford are nil. We elected to use simulated acid rainwater because the minor amount of acid added would, if there were any effect, increase metals release. Further, in the future increased anthropomorphic activities could increase the probability of acid rain effects in Eastern Washington State. As shown in Tables 4.6 to 4.11, the various Hanford sediments completely dominate the pH and solution composition of the rainwater leachates. Therefore, it is immaterial whether the leachant was deionized water or tap water and whether the water was treated with minute additions of sulfuric and nitric acids to obtain an initial pH of 5. The sediments quickly buffer the solutions by dissolution of readily soluble salts such that leachates from any of these four permutations (deionized water with or without pH adjustment or tap water with or without pH adjustment) would yield similar results. Tap water does not contain concentrations of any RCRA regulated metal or U at concentrations high enough to confound the evaluation of leach potential in these Hanford sediments.

For the TCLP and acid-rain methods, containers were shaken gently for 18 hours, then supernatant solution was removed from the containers after centrifuging and filtering (0.45 μm). The filtrates were subdivided and pH and trace metals were measured. The trace metal aliquot was preserved to pH <2 with ultra pure nitric acid and measured using inductively coupled plasma emission mass spectroscopy (ICP-MS). Appropriate multielement standards and spike additions were used to assure accuracy.

For the green run fines, a third leach test was performed. The test was modified from the ASTM D5284-92 Standard Method for Sequential Batch Leaching of Waste with Acidic Extraction Fluid (ASTM 1994). The method used a repetitive extraction of the solid (contaminated Hanford sediment) with the simulated acid rain extractant of Method 1312. We modified the extractant by

using acidified tap water (pH=5.0) instead of deionized water. As mentioned, this change should have no impact on metals leaching and better simulates vadose zone pore waters at Hanford. The ASTM procedure calls for 10 sequential extracts each of a duration of about 18 hours. We performed five extractions; the first three with durations of about 18 hours each and the last two with durations of about 70 hours each. This yielded a total extraction time that was similar to the standard 180-hour duration. We changed extraction times when it became apparent that the tests had reached an apparent steady state in leaching after the first three extracts. The change cut the analytical costs in half but allowed the overall leach time to remain the same as ASTM protocol. Each of the five sequential extracts was analyzed after filtration as described for the single-contact leach tests. The excess sequential extractants were saved and used in column adsorption tests to see if uncontaminated sediment could re-adsorb leached contaminants.

A fourth leach test was performed on Sample D. In this test, 176.13 g of oven-dry material was placed in 176.14 g of simulated acid rain and contacted for 187 hours. This test was run to evaluate solubility constraints on the various contaminants. We assumed that the 1:1 solution-to-solid ratio would not dissolve all the metals out of the soil, whereas the 20:1 solution-to-solid ratio, used in Methods 1311 and 1312, might dissolve all the contaminant and negate the excess solid assumption needed to calculate solubility controls. In addition to measuring pH and trace metals, major cation and anion analyses were performed to allow chemical speciation calculations to be performed to help elucidate the meaning of the empirical data. Major cations were measured by ICP-MS and ICP, and anions were measured by ion chromatography, alkalinity titration, and total carbon analyzer.

The final leach test performed occurred after it was discovered that the Nearby soil sample appears to contain higher than background levels of U and other trace metals. A column (length=13.3 cm, diameter 4.0 cm, and total volume 167 cm³) was packed with the <9.5-mm Nearby sediment (275.8 g) and

leached with tap water at a linear velocity of 20.1 cm/d (residence time = 0.66 d or 15.9 hr). This test was performed to compare the Nearby sediment leach breakthrough curve with the Nearby soil adsorption breakthrough curve that used sequential batch leachate. The sequential batch leachate was pumped through an identical Nearby soil column (same column dimensions, same weight soil, and flow rate) to determine whether U and other soluble contaminants would be adsorbed from the sequential batch leachate. The five leachates from the sequential batch leach test were pumped through the Nearby soil in sequence at the 20.1 cm/d linear velocity. This test would simulate the ability of the sediments underlying the 300 Area North Process Pond, and aquifer sediments, to scavenge contaminants leached from slightly contaminated sediments that would be left in the pond after soil washing or, in the No-Action alternative, the test would simulate natural recharge water slowly transporting contaminants towards the water table and accessible environment.

4.0 RESULTS

The total metal content found in the <9.5-mm composite feeds and Nearby soil and the <0.075-mm fines collected after physical soil washing are shown in Tables 4.1 through 4.5. The tables also include soil analyses on similar but not identical samples from previous field soil washing demonstrations in the N Process Pond performed by WHC in the summer of 1993 and ART in the spring of 1994 (WHC 1994c, DOE 1994a). The PNL (this report) and WHC (summer of 1993) sediments were analyzed on the same XRF instrument by the same operator using a set protocol. The ART data (spring of 1994) were generated with a less sophisticated field screening XRF because data were needed rapidly to allow equipment optimization during each washing campaign. Thus, when making comparisons, one must remember that the samples analyzed were not replicate splits but were only from the same inactive, contaminated pond. Further, the PNL and WHC samples were analyzed by the same protocol and operator on the same instrument. The ART samples used a different protocol and instrument known to have less accuracy but much more rapid turnaround. Further, the PNL Samples A and C contain only particle sizes <9.5 mm while the ART samples contain particles <50 mm. For Samples B and D, all analyses represent fines <0.075 mm. The total chemical analyses are listed by atomic number. The PNL XRF units can measure elements as light as Al and measures most heavier elements with a detection limit of a few ppm. Only those elements that consistently appeared above these limits are reported.

Tables 4.6 through 4.10 list the concentration of selected metals in 18-hour extracts of the five soil samples using the TCLP (Method 1311) and the simulated acid rain (Method 1312) leach tests. In general, we would expect the TCLP leach test to remove more transition metals (e.g., Ag, Cd, Cr, Cu, Fe, Mn, Pb, Zr) and U from the sediments than the weak acid rainwater extractant of the Method 1312 leach test.

TABLE 4.1. Soil Data for Sample A ($\mu\text{g/g}$)

Element	A ^(a)	ART ^(b)
Al	81,500	3750 - 5700
Si	260,000	--
P	1970	--
S	<780	--
Cl	<340	--
K	15,100	--
Ca	40,700	--
Ti	10,810	--
V	264	--
Cr	29	12 - 50
Mn	1267	242 - 466
Fe	75,600	18,550 - 40,200
Ni	63	13 - 29
Cu	379	79 - 145
Zn	120	31 - 52
As	<4.5	--
Se	<2.5	--
Br	<2.3	--
Rb	57	--
Sr	317	--
Y	32	--
Zr	238	--
Nb	13.7	--
Mo	<1.8	--
Hg	<10	0.05 to 0.07
Pb	14.3	3.4
Th	5.1	--
U	16.9	3.6 - 4.3

(a) A = <9.5 mm composite soil non-green material (feed to soil washing demo).

(b) Alternative Remedial Technologies, Inc. (ART 1994).

TABLE 4.2. Soil Data for Sample B ($\mu\text{g/g}$)

Element	B ^(a)	ART ^(b)	WHC ^(c)
Al	88,300	22,200-24,100	91,800
Si	251,000	--	234,000
P	1500	--	<640
S	<740	--	470
Cl	<330	--	
K	20,200	--	18,700
Ca	25,200	--	23,100
Ti	6990	--	7000
V	145	--	203
Cr	81	50-59	193
Mn	1304	945-951	1200
Fe	59,500	34,500-36,000	58,900
Ni	109	76-97	182
Cu	824	714-972	2310
Zn	139	88-110	185
As	10.7	--	10.3
Se	<2.4	--	<1.1
Br	<2.2	--	--
Rb	119.5	--	108
Sr	257	--	267
Y	29.4	--	--
Zr	426	--	971
Nb	14.1	--	--
Mo	<2	--	--
Hg	<9.3	1.0-1.4	<4.7
Pb	23.4	24-36	38
Th	8.3	--	--
U	38.6	44-55	186

(a) B = <75 μm fine sludge non green material.

(b) Alternative Remedial Technologies, Inc. (ART 1994).

(c) Westinghouse Hanford Company (DOE 1994a).

TABLE 4.3. Soil Data for Nearby Soil Sample ($\mu\text{g/g}$)

Element	Nearby ^(a) Replicate 1.	Nearby ^(a) Replicate 2.
Al	69,000	80,500
Si	273,000	298,000
P	1700	<1400
S	790	<780
Cl	<310	<340
K	14,500	14,400
Ca	36,100	38,400
Ti	7960	7780
V	140	195
Cr	37	23
Mn	865	901
Fe	53,800	51,100
Ni	<14	28
Cu	34.2	146
Zn	80.9	76.4
As	4.3	7.8
Se	<2.3	<2.4
Br	<2	<2.2
Rb	51.4	46.4
Sr	407	377
Y	24.2	24.9
Zr	129.6	177
Nb	8.9	8.4
Mo	<1.7	<1.6
Hg	<8.8	<9.3
Pb	12.9	8.4
Th	<4.4	<4.6
U	26	46.5

(a) Nearby = <9.5 mm soil from outside the 300 Area North Process Pond.

TABLE 4.4. Soil Data for Sample C ($\mu\text{g/g}$)

Element	C ^(a)	ART ^(b)
Al	98,400	10,800
Si	214,000	--
P	5000	--
S	1050	--
Cl	<350	--
K	10,230	--
Ca	51,100	--
Ti	10,080	--
V	307	--
Cr	382	177
Mn	1114	357
Fe	70,700	31,900
Ni	606	223
Cu	6140	2770
Zn	194	83
As	14.8	--
Se	<3.1	--
Br	3	--
Rb	39.2	--
Sr	325	--
Y	33.1	--
Zr	2510	--
Nb	7.2	--
Mo	<4.7	--
Hg	<12	2.2
Pb	40.1	20
Th	44.9	--
U	756	397

(a) C = <9.5 mm composite green material (feed to soil washing demo).

(b) Alternative Remedial Technologies, Inc. (ART 1994).

TABLE 4.5. Soil Data for Sample D ($\mu\text{g/g}$)

Element	D ^(a)	ART ^(b)	WHC ^(c)
Al	103,800	63,860	89,200 - 103,800
Si	118,200	--	117,800 - 180,000
P	7200	--	4270 - 4490
S	1300	--	740 - 750
Cl	<310	--	--
K	6680	--	7500 - 10,600
Ca	50,000	--	41,000 - 45,400
Ti	2340	--	4200 - 5400
V	118	--	<25
Cr	1323	1213	610 - 743
Mn	5514	400	652 - 805
Fe	24,900	13,340	28,600 - 36,200
Ni	2050	1550	756 - 976
Cu	23,700	21,960	6700 - 9560
Zn	389	397	184 - 254
As	62	--	6.4 - 9.8
Se	<4.2	--	<2.2
Br	10.4	--	--
Rb	124	--	152 - 240
Sr	301	--	416 - 446
Y	17.7	--	--
Zr	13,540	--	2740 - 3840
Nb	<5.3	--	--
Mo	56.2	--	--
Hg	31.5	16.7	8.1 - 12.4
Pb	157	155	132 - 179
Th	242	--	--
U	4200	4978	5540 - 8615

(a) D = <75 μm fine sludge green material.

(b) Alternative Remedial Technologies, Inc. (ART 1994).

(c) Westinghouse Hanford Company (DOE 1994a).

TABLE 4.6. Leach Data for Sample A^(a) (ng/ml)

Element	TCLP ^(b)	EPA ^(c)
Na	77,700	2550
Mg	6840	4610
Al	516	33.1
K	8530	6390
Ca	37,000	30,000
Cr	21.1	8.9
Mn	301	8.8
Fe	120	310
Cu	780	24
As	<1	<1
Se	23.4	5.2
Sr	253	133
Zr	1.4	1.8
Ag	<1	<1
Cd	2.7	<1
Ba	463	42
Hg	<1	<1
Tl	78	58
Pb	<1	<1
U	157	26.3
Ending pH	5.08	7.31

(a) A = <9.5 mm composite soil non-green material
(feed to soil washing demo).

(b) TCLP = Method 1311.

(c) EPA = Method 1312.

TABLE 4.7. Leach Data for Sample B^(a) (ng/ml)

Element	TCLP ^(b)	EPA ^(c)
Na	79,100	3640
Mg	22,100	4750
Al	308	23
K	10,000	7800
Ca	196,000	31,000
Cr	23.5	6.7
Mn	2080	37.7
Fe	120	360
Cu	1370	48
As	<1	2.8
Se	19	9
Sr	812	150
Zr	2.4	2.1
Ag	<1	<1
Cd	2.37	1.1
Ba	1210	46
Hg	<1	<1
Tl	175	<1
Pb	1.56	<1
U	365	146
Ending pH	5.32	7.90

(a) B = <75 μm fine sludge non-green material.

(b) TCLP = Method 1311.

(c) EPA = Method 1312.

TABLE 4.8. Leach Data for Nearby^(a) Soil Sample (ng/ml)

Element	TCLP ^(b)	EPA ^(c)
Na	73,500	8830
Mg	9380	4330
Al	261	36.5
K	7880	5680
Ca	135,000	32,500
Cr	23	1.7
Mn	408	837
Fe	200	190
Cu	28	6.1
As	2.7	4.3
Se	<1	4.2
Sr	494	173
Zr	2.7	1
Ag	<1	<1
Cd	1.7	1
Ba	1230	46.6
Hg	<1	<1
Tl	56	<1
Pb	<1	<1
U	643	537
Ending pH	5.23	7.15

(a) Nearby = soil from outside the 300 Area North Process Pond.

(b) TCLP = Method 1311.

(c) EPA = Method 1312.

TABLE 4.9. Leach Data for Sample C^(a) (ng/ml)

Element	TCLP ^(b)	EPA ^(c)
Na	86,700	3260
Mg	20,200	6130
Al	216	278
K	9300	6520
Ca	436,000	33,900
Cr	36.6	30.2
Mn	226	8.2
Fe	490	19
Cu	13,700	72
As	<1	2.2
Se	7	9
Sr	1370	131
Zr	1.8	3.4
Ag	<1	<1
Cd	11.4	<1
Ba	1450	41.8
Hg	1	1
Tl	217	<1
Pb	6.1	<1
U	2340	876
Ending pH	6.00	7.95

(a) C = <9.5 mm composite green material (feed to soil washing demo).

(b) TCLP = Method 1311.

(c) EPA = Method 1312.

TABLE 4.10. Leach Data for Sample D^(a) (ng/ml)

Element	TCLP ^(b)	EPA ^(c)
Na	12,000	5130
Mg	59,500	6580
Al	259	259
K	8080	8400
Ca	1,230,000	29,000
Cr	50.7	59.7
Mn	679	8.9
Fe	1240	480
Cu	24,600	117
As	<1	<1
Se	11	3.1
Sr	4480	140
Zr	6.9	2.7
Ag	1.1	<1
Cd	22	1.2
Ba	2940	49
Hg	1	<1
Tl	<1	<1
Pb	8.3	<1
U	8070	1442
Ending pH	5.9	7.3

(a) D = <75 μ m fine sludge green material.

(b) TCLP = Method 1311.

(c) EPA = Method 1312.

Table 4.11 presents the chemical composition of the five sequential extractants (simulated acid rainwater) after contact with Sample D. The first extract generally contains the highest concentration of leached species for readily soluble elements. For slightly soluble constituents present in the solid at elevated concentrations, we would expect the extracts to have similar concentrations for the duration of the test or until the controlling solid is completely leached.

Table 4.12 lists the static leach test final solution concentrations after contacting sample D with simulated acid rainwater for 187 hours at a solid-to-solution ratio of 1:1. This test was expected to yield the most useful results for predicting the solubility or highest dissolved concentrations expected for water slowly percolating through the contaminated sediments.

Table 4.13 lists the chemical composition of the effluent from the flow-through column test in which tap water was run through the Nearby soil sample. Table 4.14 lists the chemical composition of the effluent from the flow-through column test in which the sequential extract solution from contacting sample D was pumped through the Nearby soil sample to evaluate the adsorption of contaminants that readily leached from sample D (i.e., U and Cu).

Figures 4.1 and 4.2 present the effluent breakthrough curves for U and Cu for the two columns filled with the Nearby soil sample.

TABLE 4.11. Sequential Extraction Data for Sample D (ng/ml)

Element	Extract #				
	1	2	3	4	5
	Cumulative Time (hr)				
	18	36.8	55.3	124.6	194.4
Na	5130	5900	2600	2710	2480
Mg	6580	6230	9090	7240	7530
Al	259	249	188	185	150
K	8400	9000	9180	1240	840
Ca	29,000	36,400	46,500	54,800	58,800
Cr	59.7	23	11.2	11.7	6.4
Mn	8.9	9.1	13.3	12.2	9.8
Fe	480 ^(a)	780 ^(a)	150 ^(a)	63	<10
Cu	117	62	89	34	46
As	<1	2.2	1.1	6.2	2.1
Se	3.1	7.2	<1	15	<1
Sr	140	120	198	180	201
Zr	2.7	2.2	2.8	1.1	<1
Ag	<1	<1	<1	<1	<1
Cd	1.25	1.1	<1	<1	1.2
Ba	49	38.6	81	51.5	59.5
Hg	<1	<1	<1	<1	<1
Pb	<1	7.8	8	8.3	<1
U	1442	1140	1180	1520	1440
Ending pH	7.3	8.0	7.7	7.1	7.2

(a) Semiquantitative estimate; Fe channel instrument was not performing adequately.

TABLE 4.12. Chemical Composition of 1/1 Extract of Sample D (ng/ml)

<u>Element</u>	<u>Concentration</u>
Na	13,000
Mg	13,800
Al	3510
K	1400
Ca	94,000
Cr	138
Mn	38.2
Fe	170
Cu	2150
As	4.5
Se	<1
Sr	267
Zr	18
Ag	<1
Cd	2
Ba	117
Hg	<1
Pb	16.8
U	1330

9513302.2382

TABLE 4.13. Chemical Composition of Effluent from Tap Water Flowing Through Nearby Soil Sample

Element	Units	Tap Water (Inf)	Concentration (see Units)												
			Cumulative Pore Volumes of Effluent												
			0.1	1.4	5.7	14.5	21.7	33.6	48.4	70.8	110	209	250	296	401
Na	ppm	2.2	363	205	70	52	42	34	26	20	13	5	5	4	4
Mg	ppm	4.1	86	24	4	3	3	4	4	4	4	4	3	4	4
Al	ppm	<0.01	10	11	0.8	1.4	2.8	2.3	6.4	3.2	1.9	0.05	0.03	0.02	0.02
K	ppm	0.9	16	7.7	3.4	2.7	2.1	2.9	2.3	2.4	2.8	1.0	0.4	0.8	1.0
Ca	ppm	25.7	296	142	<20	<20	<20	<20	<20	<20	<20	31	27	30	30
Cr	ppb	<2	114	31	7	5	3	1.4	1.8	2.1	<1	6	4	5	4
Mn	ppb	4	47	31	24	<1	10	2	10	<1	<1	4	3	1.2	1.6
Fe	ppb	30	310	260	260	54	50	64	75	<50	<50	190	120	220	300
Cu	ppb	0.5	268	170	112	26	39	18	13	8.7	4.9	6.4	3.9	4.9	3.6
As	ppb	<1	5	12	16	10	11	11	14	<5	<5	<5	<5	<5	<5
Se	ppb	<3	NA ^(a)	NA ^(a)	NA ^(a)	NA ^(a)	NA ^(a)	NA ^(a)	NA ^(a)	NA ^(a)	NA ^(a)	NA ^(a)	NA ^(a)	NA ^(a)	NA ^(a)
Sr	ppb	102	1900	590	114	93	94	102	125	128	149	149	128	138	140
Ba	ppb	28	217	126	150	49	50	47	48	41	38	38	34	39	38
Pb	ppb	<5	13	8	5	10	5	8	4	12	4	4	4	4	4
U	ppm	<0.05	3.9	8.9	3.9	2.2	1.9	1.5	1.4	1.1	0.8	0.8	0.7	0.6	0.6
pH		NA	8.7	NA	8.9	NA	8.6	NA	8.7	NA	8.8	8.6	9.2	8.8	8.8

(a) NA = not analyzed.

4.15

TABLE 4.14. Chemical Composition of Effluent from Sequential Extraction Leachate Flowing Through Nearby Soil Sample

		Concentration (see Units)													
		Cumulative Pore Volumes of Effluent													
Element	Units	Seq. Extract (Inf)	Cumulative Pore Volumes of Effluent												
			0.1	1.6	6.5	14.6	26	41	59	132	240	277	317	374	
Na	ppm	3-7	469	210	85	56	38	25	19.7	8.4	16	7.1	7.0	7.1	
Mg	ppm	6-9	104	185	5.7	7.2	7.2	8.0	8.1	9.1	9.6	6.3	6.4	6.8	
Al	ppm	0.1-0.3	30.3	10.1	4.2	3.7	2.6	2.4	4.1	6.6	<0.02	0.02	0.02	0.02	
K	ppm	0.8-9	14.5	5.0	2.6	3.9	2.5	2.4	2.3	2.2	2.4	1.9	1.7	1.5	
Ca	ppm	29-59	475	109	27	35	35	45	44	50	55	59	64	55	
Cr	ppb	6-60	121	66	41	39	30	37	36	41	33	27	16	26	
Mn	ppb	9-13	105	24	7.5	12	6	14	11	1	2	<1	<1	2	
Fe	ppb	10-100	473	100	71	130	50	59	50	51	50	<100	<100	167	
Cu	ppb	30-120	286	158	94	67	32	34	31	30	21	13	14	17	
As	ppb	1-6	9	10	12	10	5	7	9	5	12	6	5	5	
Se	ppb	1-15	NA (a)	NA (a)	NA (a)	NA (a)	NA (a)	NA (a)	NA (a)	NA (a)	NA (a)	NA (a)	NA (a)	NA (a)	
Sr	ppb	120-200	2340	520	160	170	190	210	240	250	290	300	330	260	
Ba	ppb	40-80	334	87	46	42	37	35	42	41	46	48	53	42	
Pb	ppb	1-8	7	17	3	7	6	115	15	10	10	10	4	5	
U	ppm	1.1-1.5	4.5	5.3	3.5	2.7	1.7	1.4	1.4	1.8	2.0	1.8	3.2	1.3	
pH		7.1-8.0	9.0	8.8	8.8	8.8	8.8	8.7	8.7	8.8	8.7	8.7	8.7	8.7	

(a) NA = not analyzed.

4.16

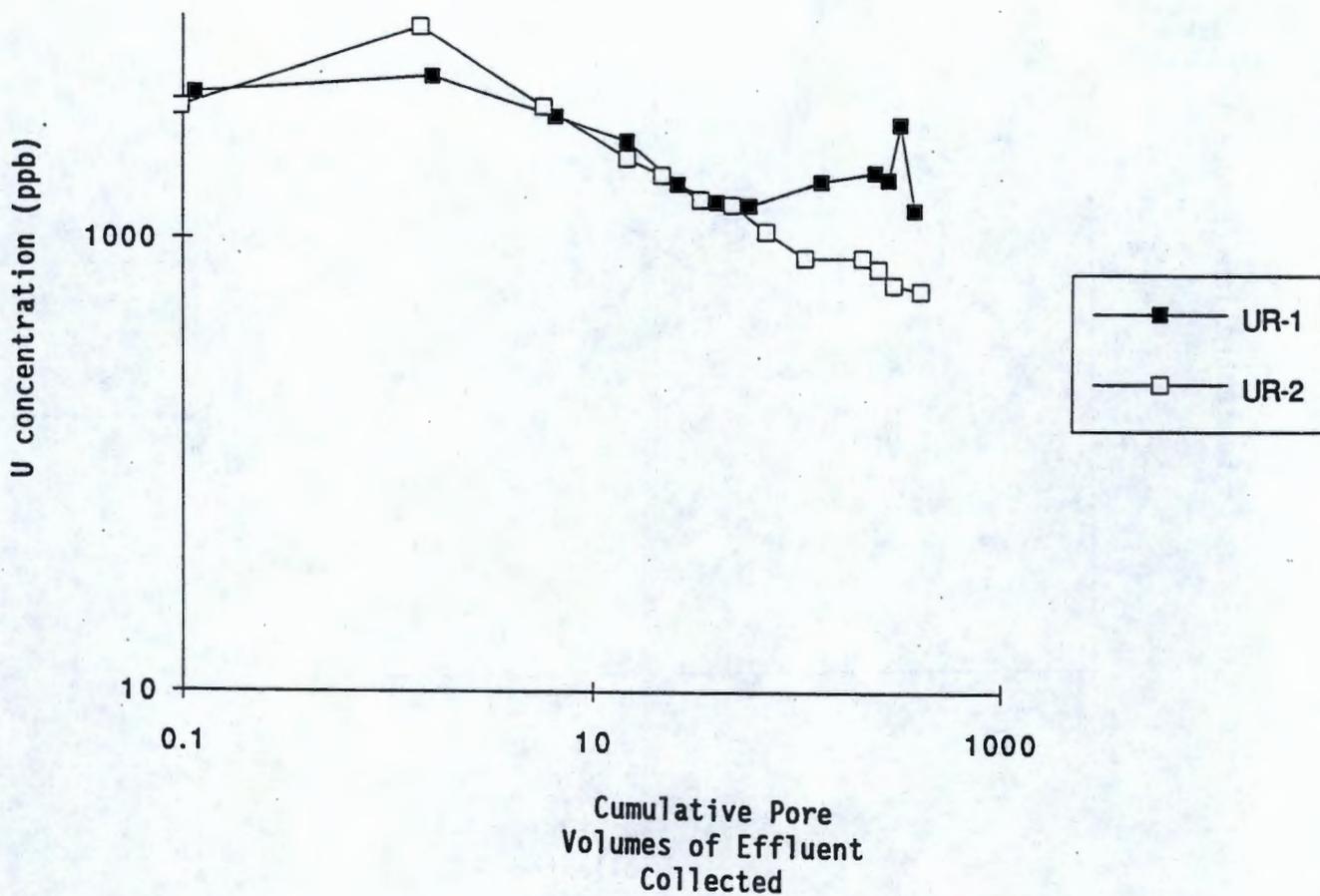


FIGURE 4.1. Effluent Solution Concentration of U from Percolating Simulated Acid Rain Extract of Sample D (UR-1) and Tap Water (UR-2) Through Nearby Soil Sample.

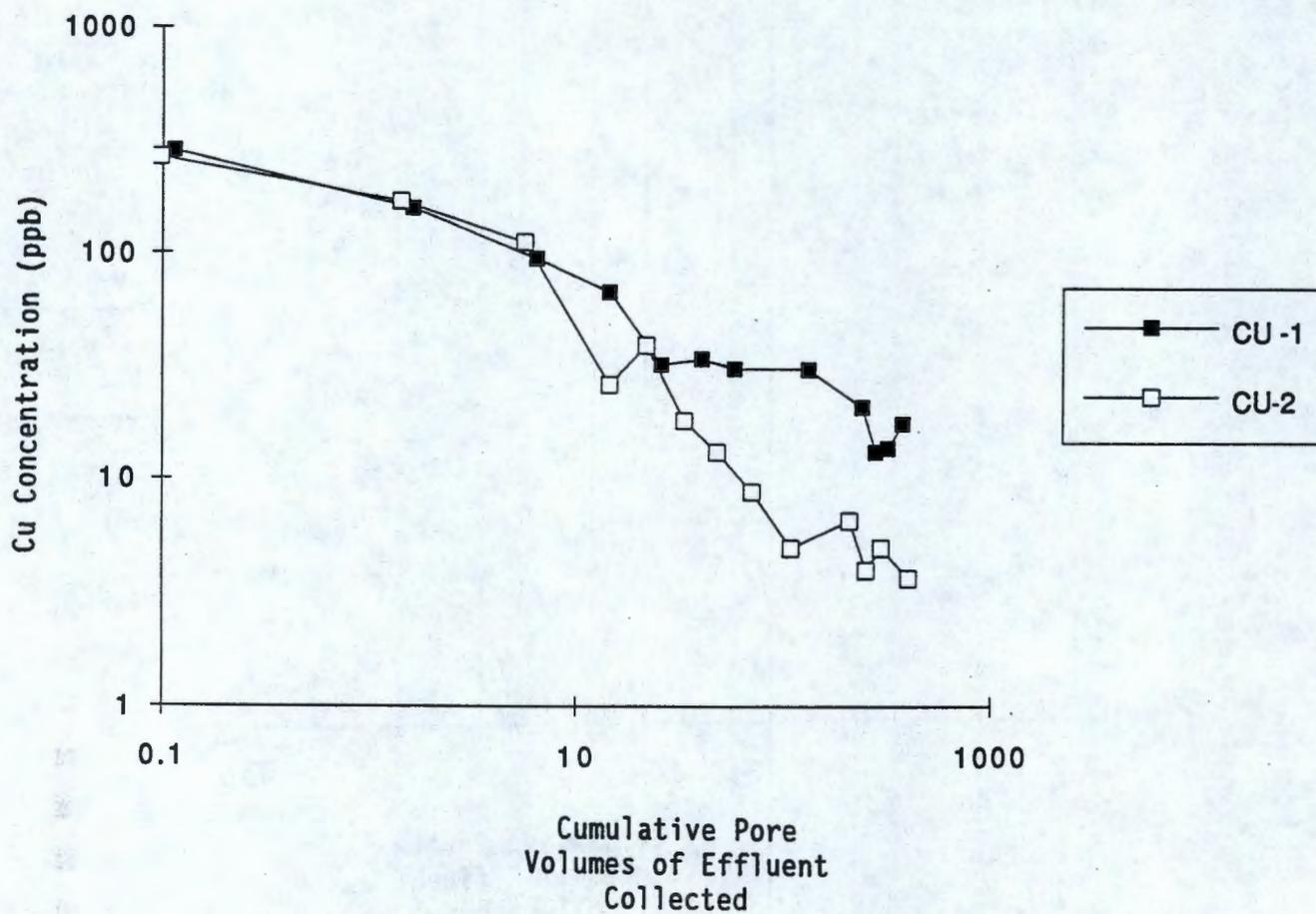


FIGURE 4.2. Effluent Solution Concentration of Cu from Percolating Simulated Acid Rain Extract of Sample D (Cu-1) and Tap Water (Cu-2) Through Nearby Soil Sample.

5.0 DISCUSSION

The chemical analyses of the soil samples (see Tables 4.1 to 4.5) suggest that the 300 Area North Process Pond sediments contain elevated concentrations of Al, Mn, Fe, Ni, Cu, and Zr, and in the green run material, P, S, Ca, Cr, Zn, As, Pb, Th, and U are elevated compared to the Nearby soil sample. Using the background concentrations that were determined with EPA SW-846 acid extraction procedures as shown in Dennison et al. (1989) and Table 1-1 of DOE (1993b), one would conclude that the 300 Area North Process Pond sediments are contaminated with Al, Cr, Mn, Fe, Cu, Zr, U, and V. This list, excepting V, is quite similar to our findings.

The 300 Area North Process Pond sediments show elevated concentrations of Al and Zr. These represent dissolved cladding, and during past operations Cu and Mn were major ingredients in the bronze used in welding the end caps onto the U fuel pellets. The elevated Ca in the green run sediments reflect the high calcium carbonate content of the sediment. The elevated ponds contents in the green material may represent phosphate and sulfate salts. The enriched levels of the other trace metals (Zn, As, and Pb) may represent minor components in the metal extrusion, canning, and welding processes performed in the Fuel Fabrication Facility.

The fine sludges generated from washing the composite soils showed only about two times higher concentrations of trace metals such as Cr, Cu, Ni, Pb, Zr, and U for the non-green replication run and four times higher concentrations for the green calcium carbonate material compared to the bulk composite soils that were washed. The fines (samples B and D) actually contain less iron and manganese than the <9.5-mm composite feed material, which suggests that Fe and Mn are concentrated in sand-sized material.

The ART data, shown in Tables 4.1 and 4.4, for composite feed material include particles of up to 50-mm, while our data are for samples in which the 9.5-50-mm grains were discarded. Given the general trend for trace metals to

increase in concentration as particle size decreases, our data could be expected to show higher metals concentrations. This was observed for samples A and C.

On the other hand, for samples B and D, the PNL, ART, and previous WHC data should compare more directly because all three measurements are for <0.075-mm material. However, one should consider that all three analyses shown in Tables 4.2 and 4.5 are from different samples taken up to one year apart, and there was soil disturbance between the two soil washing demonstrations. Qualitatively, the data in Tables 4.2 and 4.5 suggest that the ART field screening XRF underestimates Al and Fe content in the soils but measures trace metals such as Cr, Mn, Ni, Cu, Zn, Pb, and U accurately. The WHC non-green sediments used in the 1993 field demonstration appear to have contained higher levels of U, Zr, Cu, Ni, Fe and Ni than the ART non-green sediment, based on the fines that were generated. For the green material, the fines generated during the WHC field demonstration contained significantly less Ni, Zr, and Cu but more U than the ART fines. ART used several passes through an attrition scrubber, which was perhaps more efficient at creating fines enriched in these metals, although the U data do not show this trend. More likely, the green material in the 300 Area North Process Pond exhibits variable ratios of elements such as Ni, Zr, Cu, and U such that sample location is an important determinant of metal concentrations, and direct comparisons of the fine sludges from different field demonstrations may not yield straightforward data to assess contaminant concentration versus particle size during soil washing.

The leaching data presented in Tables 4.6 through 4.10 show that the TCLP test, which simulates municipal landfill leaching, dissolves more Cu, Ba, U, Al, Pb, Cd, Se, and Mn than the simulated acid rainwater of the Method 1312 leach test. It should be noted, however, that none of the RCRA regulated metals leached sufficiently to cause the sediments to be classified as hazardous. The ending pH of the TCLP extracts varies between 5 and 6 while

the simulated rain extracts rose to pH values between 7.2 and 7.9 because of the significant acid-neutralizing capacity of Hanford soils. The simulated rain leach tests better represent the probable leaching environment for the Hanford Site alternatives of "no action" and direct burial of contaminated fines without additional stabilization into a designated disposal unit such as ERDF.

As stated, the leach data in Tables 4.6 through 4.10 show that the soils pass the TCLP criteria for being nonhazardous based on regulatory concentration limits of the regulated metals As, Ba, Cd, Cr, Pb, Hg, Se, and Ag, which are 5000; 100,000; 1000; 5000; 5000; 200; 1000, and 5000 ng/ml, respectively. The TCLP extracts are three orders of magnitude below the regulatory limits for As, Ag, and Pb; two orders of magnitude below the limits for Ba, Cr, Hg and almost two orders of magnitude below the limits for Cd and Se.

The TCLP data suggest that the 300 Area North Process Pond sediments, including the "contaminated" fines, leach only small, incremental quantities of a few of these regulated metals compared to the Nearby soil sample outside the pond that may or may not contain representative background levels of the RCRA regulated metals. The Nearby soil sample appears to contain elevated U concentrations and may thus be suspect as a background sample.

The data in Table 4.11 show what occurs when the Sample D sediment is leached repeatedly with fresh batches of simulated rainwater. In general, the first contact leachant dissolves more material than subsequent batches of leachant, but there are several elements whose leachate concentration peaks in later extracts. Metals such as Mg, U, and Ba appear to rise to about the same concentration in each leachate, suggesting that solubility controls their release. Other elements show high initial leaching followed by steady decreases in later extracts (e.g., Cu, Na, Al, K, and Cr). Calcium leaching appears to increase as the extraction process continues. Again, none of the RCRA regulated metals approach the concentration limits set forth in the TCLP test protocol.

The one-to-one extract data on the most contaminated sediment (Sample D) suggest that none of the RCRA regulated metals exceed TCLP regulatory limits, although we do observe the highest Cr, Pb, and Ba values in this extract in comparison to all the simulated rain extracts from the various tests. More soluble metals such as Na, Ca, and Mg show much larger increases in the one-to-one extract. Copper release in the one-to-one extract is higher than in other tests using rainwater extractant, but still is an order of magnitude lower than TCLP extract solutions. Interestingly, the U solution concentrations in rainwater leach tests remain about 1.5 ppm regardless of the solid-to-solution ratio or the number of times a solid is leached with fresh leachant. This suggests that dissolution of a slightly soluble U-bearing solid is occurring.

There are several water standards that have been considered or that are being proposed to regulate release of potentially hazardous liquid wastes and/or spent process waters. A listing is provided in Table 5.1, but without implication that any of them should be used to regulate process water disposal from soil washing at the Hanford Site or leachate generated from natural recharge water contacting disposed contaminated sediments. The table is intended to show where the leachates from the 300 Area North Process Pond sediments are, relative to selected water criteria. At present, the most applicable regulation for the sediments used in this study would be the RCRA TCLP regulations. As mentioned, all sediments would be considered nonhazardous based on TCLP leaching.

The various water quality criteria shown in Table 5.1 have been extracted from various Code of Federal Regulations (CFR) and Hanford-specific documents. The Purge Water Collection Criteria were prepared to set limits on the release of excess groundwater pumped from monitoring wells to assure that samples removed for analyses were not biased by interactions with borehole

TABLE 5.1. Toxicity Characteristic, Purge Water, Groundwater, and Drinking Water Quality Criteria and the EPA Regulatory Levels for Waste Waters

Constituent	Toxicity Characteristics	Purge Water Collection Criteria ^(a)	Groundwater Quality Criteria ^(a)	Land Disposal Restrictions (40 CFR Part 268.43)	Hazardous Waste Injection Restrictions (40 CFR Part 148)	Derived Concentration Guide DOE Order 5400.5	Effluent Limits NRC 10 CFR Part 20	Drinking Water Regulations 40 CFR Parts 141, 143
μg/L								
Ag	5000	10 ^(b)	--	42	42	--	--	100 ^(g)
As	500	480 ^(b)	--	5000	1400	--	--	50 ^(h)
Ba	100,000	10,000 ^(c)	1000	1200	1200	--	--	1000 ^(h)
Be	-- ^(d)	53 ^(b)	--	820	820	--	--	4 ⁽ⁱ⁾
Cd	1000	11	10	200	200	--	--	10 ^(h) , 5 ⁽ⁱ⁾
Cr	5000	110 ^(b)	50	370	370	--	--	50 ^(h)
Cu	--	120 ^(b)	1000	1300	--	--	--	1300 ⁽ⁱ⁾ , 1000 ^(g)
Fe	--	3000 ^(c)	300	--	--	--	--	300 ^(g)
Hg	200	0.1 ^(b)	2	150	150	--	--	2 ^(h)
Mn	--	500 ^(c)	50	--	--	--	--	50 ^(g)
Ni	--	1600 ^(b)	--	550	550	--	--	100 ⁽ⁱ⁾
Pb	5000	32 ^(b)	50	280	280	--	--	50
Sb	--	16,000 ^(b)	--	1900	1900	--	--	--
Se	1000	100 ^(c)	10	820	820	--	--	10 ^(h)
U	--	590 ^(e)	--	--	--	1800	1.1 x 10 ⁵	43, 78 ^(j)
V	--	400 ^(f)	--	290	290	--	--	5000 ^(g)
Zn	--	1100 ^(b)	5000	1000	1000	--	--	--

- (a) Tables 8.1 and 8.3 in Environmental Compliance Manual (WHC-CM-7-5) 1993.
 (b) 10x of Chronic Fresh Water Toxicity Level (CFWTL) as defined in EPA 440/5-86-001.
 (c) 10x of Maximum Contamination Level (MCL) as defined in 40 CFR Part 141, 40 CFR Part 143, and EPA 570/9-76-003.
 (d) -- No standard has been set.
 (e) 10x one twenty-fifth of the Derived Concentration Guide (DCG) as listed in DOE Order 5400.5.
 (f) 10x of Practical Quantitation Limit (PQL) as listed in Appendix IX of 40 CFR Part 264.
 (g) Nonenforceable secondary standard for aesthetic reasons.
 (h) Enforceable primary standard.
 (i) Nonenforceable Maximum Contaminant Level Goal.
 (j) Proposed standard for ²³⁸U; value varies with risk level allowed.

casing. The purge water criteria may be reasonable criteria to judge whether soil washing spent process water may be disposed into the Hanford vadose zone sediments.

The Groundwater Quality Criteria in column 2 are WHC internal best management practices for the release of any new liquid effluents to the Hanford environment.

The Land Disposal Restrictions found in 40 CFR 268.43 identify hazardous wastes and the concentrations of their associated hazardous constituents, which may not be exceeded if disposal is to be by placement on or in (e.g., injection well) the land. The values listed in Table 5.1 come from CFR Part 268.43 Table CCW (Constituent Concentration Wastes) for waste code F039. Waste code F039 is multi-source leachate.

The Hazardous Waste Injection Restrictions (40 CFR 148) identifies hazardous wastes and concentrations of their associated hazardous constituents, which may not be injected back to the ground through injection wells. The values in Table 5.1 are proposed standards and as yet have not been promulgated.

The DOE Order 5400.5 establishes standards and requirements for operations of the DOE and its contractors with respect to protection of members of the public and the environment against undue risk from radiation. The limits shown in Table 5.1 come from Chapter III, Derived Concentration Guides for Air and Water. The values listed are for ingestion of drinking water resulting in 100 mrem/yr doses for each radionuclide. The value shown in Table 5.1 is for the isotope ^{238}U , the predominant U isotope found in the 300 Area North Process Pond sediments. The values are rounded up from the exact value of 1783 $\mu\text{g/L}$.

In 10 CFR Part 20 (Standards for Protection Against Radiation), the Nuclear Regulatory Commission sets limits on activity of radionuclides that

may be discharged to air and to water. We calculated the value for the isotope ^{238}U only because U in the pond sediment had been separated from its daughter products, and on a mass basis ^{238}U predominates.

The final column in Table 5.1 lists Primary and Secondary Drinking Water Standards applicable to public water systems that pipe water to at least 15 service connections or 25 individuals for human consumption. Secondary drinking water regulations control contaminants that primarily affect aesthetic qualities. They are not federally enforceable and are intended as guidelines. Within the Primary Drinking Water Standards, there is a category maximum contaminant level goals (MCLG). These are nonenforceable health goals that water supply companies should try to meet for health reasons.

The leachate data reported herein and the groundwater criteria in Table 5.1 could be used to model the impacts of leachate reaching the underlying aquifers at both the final disposal facility of the fines and the 300 North Process Pond should the coarse fractions be left in place after soil washing.

Based on the rainwater leachate analyses (Tables 4.5 through 4.12), only U is consistently, and perhaps Cr and Cu in a few instances, are above the most stringent potential groundwater quality criteria shown in Table 5.1. It would thus appear that U is the key potential contaminant that leaches from the sediments. The actual process waters generated in the various ART pilot-scale tests (ART 1994, WHC 1994c) from both the non-green and green pond sediments are compared to the water quality criteria in Table 5.2. The spent process water from the ART field demonstration contains elevated U and perhaps Fe in comparison with the water quality criteria. For the spent process water generated during attrition of the green pond sediments, Cu and U appear elevated above some of the water quality criteria. The spent process water generated in the ART field demonstrations was evaporated and residuals added to the fine (0.075 mm) materials destined for transport to a designated burial facility or further treatment. During further treatability considerations, it

TABLE 5.2. Actual Soil Washing Process Water Concentrations versus Selected Water Quality Criteria ($\mu\text{g/L}$)

Element	Water from Non-Green Soil	Water from Green Soil	Range of Criteria
Ag	1.3 to <4.1	10.1	10 - 42
As	NM ^(a)	NM	480 - 5000
Ba	NM	NM	100 - 10,000
Cd	<2.6	<2.6	10 - 200
Cr	3.7 - 52	78	50 - 370
Cu	86 - 126	1556	120 - 1300
Fe	1362 - 1661	754	300 - 3000
Hg	<0.1	0.7	0.1 - 150
Mn	43 - 62	33.4	50 - 500
Ni	<10 - 12.6	116	550 - 1600
Pb	5.7 - 12	11.6	32 - 280
Sb	<25	<25	1900 - 16,000
Se	NM	NM	10 - 820
U	94 - 122	2141	78.6 - 1800
Zn	48 - 80	58.7	1000 - 5000

(a) NM = not measured.

would be useful to consider the fate of U, and for completeness Cr, Cu, and Fe, which may leach from the 300 Area North Process Pond sediments naturally or during physical soil washing.

Based on the mass of metals present in the various sediments, neither the water leach tests nor the harsher TCLP extract mobilize a significant fraction of the regulated, and other, transition metals found in the sediments. For example, for five elements found in extracts and the ART process water above the most stringent water quality criteria listed in Table 5.1, we find that U leaches at most 18% of the sediment's total content in TCLP

extract tests, 4% during acid rain leach tests for the non-green sediments, and 6% for the green sediments. For Cu, the TCLP extracts leach about 4% of the sediment's total while the rainwater leaches, at most 0.1%. For Cr, the TCLP extract leaches at most 1.5%, while rainwater leaches at most 0.6%. TCLP testing extracts at most 0.1% of the sediment's total Fe, and rainwater extracts at most 0.04%. When the green fines are leached with simulated acid rain at a solid-to-solution ratio of 1:1, only hundredths of a percent of these elements are released. The percent release data for five elements are shown in Table 5.3.

The replicate analyses of the Nearby soil sample are shown in Table 4.3. Two separate samples (~1 g) were generated for XRF analyses from the bulk 4-L (1-gal) sample using the cone and quartering technique. The results show that the Nearby soil sample contains as much, and perhaps more, U than does the composite soil (Sample A) from within the 300 Area North Process Pond that was used in the first ART field soil washing campaign. The Nearby soil sample does appear to contain less Ni, Cu, and Zr than sediment samples from within the 300 Area North Process Pond. It is thus difficult to determine whether

TABLE 5.3. Percent (%) Metal Release from Various Sediments

Element	Non-Green Composite		Non-Green Fines		Green Composite		Green Fines	
	TCLP	Acid Rain	TCLP	Acid Rain	TCLP	Acid Rain	TCLP	Acid Rain
Cu	4.1	0.03	3.3	0.12	4.5	0.02	2.1	0.01
Cr	1.5	0.6	0.6	0.2	0.2	0.2	0.08	0.09
Fe	0.003	0.008	0.004	0.012	0.014	0.005	0.1	0.04
Se	18.7	4.2	15.8	7.5	4.5	5.8	5.2	1.5
U	18.6	3.1	18.9	7.6	6.2	2.3	3.8	0.7

the Nearby soil sample is representative of background sediments in the vicinity of the 300 Area inactive disposal facilities.

Tables 4.13 and 4.14 present data on the chemical composition of the effluents from percolating tap water and ASTM sequential batch extract from Sample D, respectively, through columns packed with the Nearby soil sample. Figures 4.1 and 4.2 show the effluent curves for U and Cu for the two columns. The rainwater extract from the sequential batch leach test contains significantly more U and Cu than tap water. If these two potential contaminants of concern were not present in the Nearby soil sample and also adsorbed readily onto the soil, then the effluent curves in Figures 4.1 and 4.2 would exhibit the classical "S" shaped breakthrough curves in which concentration in the effluent shows low values at first and slowly increases with an increasing rate until total breakthrough is observed. In contrast to ideal adsorption breakthrough curves, the data in Tables 4.13 and 4.14 and Figures 4.1 and 4.2 show that the Nearby soil sample leaches significant masses of most constituents, including Cu and U, in the first one to five pore volumes and then slowly drops to low values slightly above or near the solution concentrations of the percolating solutions, tap water, or sequential batch leachate. The Cu concentration in the later effluents for the column that was flushed with extract from the sequential batch leach test is below the influent concentration (Sample D sequential batch extract, see Table 4.11), suggesting that dissolved Cu does adsorb to the sediments once readily soluble evaporites, which include some Cu, are flushed from the soil. It is less clear that any mass of U is being removed from the sequential batch leachate that was flushed through the column after the evaporites were flushed. The effluent U concentrations shown in Table 4.14 remain above 1.3 ppm and are indistinguishable from the solutions used to load the column (see Table 4.11). A similar argument holds for dissolved Cr but the observed Cr concentration is not considered high in comparison to potential water quality criteria. It appears

that the Nearby soil sample obtained contains evaporites and measurable quantities of U from natural causes or past 300 Area North Process Pond liquid disposals.

To ascertain conclusively whether sediments underneath the ponds can retard contaminants leached from the 300 Area North Process Pond, we would have to first flush the sediment to remove evaporites and then percolate contaminated extracts through the flushed soil columns. Such an approach might allow us to quantify adsorption. Alternatively, we would need to obtain a true background soil that is not suspect. At present, we can only address adsorption qualitatively and state that Cr and U adsorption onto the Nearby sediment is small, if it exists at all, and that Cu adsorption is larger. At present, we recommend that risk assessment exercises assume no adsorption of these and other potential contaminants of concern and base risk calculations on extract concentrations shown in Tables 4.6, 4.7, 4.9-4.12, and 4.14 for the various remediation alternatives and transport scenarios of interest. Should risk results with no provision for adsorption identify health consequences, then more detailed laboratory adsorption studies may be warranted to quantify the influence sorption could apply to long-term contaminant migration. If risk assessment calculations show that leachate dilution into the aquifer presents no risks, then further laboratory studies may not be needed. Unfortunately, the standard flow-through column technique to quantify adsorption did not succeed for this particular sediment (Nearby soil)-solution (sequential batch extract) combination, so the importance of soil adsorption remains unresolved for the 300-FF-1 operable unit clean-up.

The Cr leach data in Tables 4.6-4.12 suggest that the sediments contain predominately Cr (III) even though most anthropomorphic Cr release at Hanford originated as Cr (VI). General soils literature yields a logical explanation. Rai et al. (1984) explains that Cr (VI) in solution or in soils is stable only at strongly oxidizing conditions. At most natural Eh-pH conditions, Cr (III) species predominate (MacNaughton 1977). Soil organic matter and other

naturally occurring reducing agents readily reduce Cr (VI) to Cr (III). Cr (III) forms very insoluble oxyhydroxides and coprecipitates readily with ferric hydroxides. Cr (III) and its hydrolysis species also adsorb readily onto most soil minerals. Conversely, Cr (VI) is generally only weakly adsorbed or not adsorbed at all on most soil minerals at pH values greater than 7. It is likely that Cr (VI) disposed in the 300 Area North Process Ponds was converted to Cr (III) over time. Any Cr (VI) that was not reduced has likely already percolated with water to the Columbia River. The most accurate leach test to evaluate the presence of Cr (VI) still bound to sediments would employ a leachant at pH near 8 and contain a good competing anion such as sulfate (SO_4^{2-}) to release Cr (VI) from any available oxide adsorption sites. The TCLP extractant is not a good reagent to release Cr (VI) as CrO_4^{2-} because at pH <7 to 8 many common iron and aluminum oxides exist with positively charged surface sites that can adsorb CrO_4^{2-} . Bartlett and Kimble (1976a, b) and Bartlett and James (1989) provide a good discussion of the fate of Cr in soils.

Even if more detailed risk assessments on the metals concentration in the leachate from the contaminated soil fines or the composite feeds suggest a water quality threat, leach data on vitrified sediments suggest that such stabilization can lower solution concentrations several orders of magnitude for relatively mobile constituents such as U (WHC 1994b). Solidification with cements or grouts would also lower the release rate of most metals by several orders of magnitude. Thus, there are established stabilization/solidification processes available to reduce the hazards potential of fine-grained sludges generated during soil washing treatment.

6.0 CONCLUSIONS

The sediments in the 300 Area North Process Pond, especially those that contain the green and white precipitates, contain elevated levels of Al, Mn, Fe, Ni, Cu, Zn, Zr, U, and perhaps other transition metals. Neither the feed composite soils or the fines generated through soil washing exceed TCLP test limits, one standard method to establish a hazard potential.

Neither TCLP nor various leach tests using simulated rainwater show that the sediments release significant percentages of these metals. The sediments themselves would not be classified as an RCRA hazardous waste per TCLP protocol. Nevertheless, the solution concentrations of some metals from the leach tests and actual spent process water from the ART pilot-scale study approach or exceed some water quality criteria that could be used by regulators. The key element that should be further evaluated by more detailed groundwater impact analyses is U. For completeness Cu, Cr, and Fe could be evaluated as they showed elevated concentrations in at least one of the various leachates or actual spent process waters.

The leach data from the various bench scale tests that used simulated rainwater are more realistic than the TCLP tests and should be used in any future groundwater impact analyses. The sequential acid rain leach test yields the most realistic data for assessing future groundwater impacts, and the data suggest that U may be controlled by a slightly soluble compound that will fix leachate concentrations at a value between 1150 and 1520 $\mu\text{g/L}$, depending on the percentage of enriched green sludge in the sediment. Such concentrations will occur for at least 800 pore volumes of flushing through the sediment.

Sequential leach data suggest that other trace metals such as Cu and Cr will show the greatest release in the first ten pore volumes, and then concentrations will steadily decline.

Two flow-through column tests were performed to study the adsorption of leached contaminants such as Cr, Cu, and U. Adsorption of the leached contaminants by the sediments underlying the 300 Area North Process Pond and in the upper unconfined aquifer between the pond and the Columbia River could significantly reduce any potential groundwater hazards. The sediment sample used in the column tests to represent uncontaminated sediments below the 300 Area North Process Pond (Nearby soil sample), apparently contains significant quantities of evaporated salts and elevated U concentrations. Upon wetting the Nearby soil sample, significant quantities of salts, including the contaminants of interest, dissolved and confounded the interpretation of the sediment adsorption tendencies. After the evaporite salts flush from the columns, it appears that Cr and U present in 300 Area North Process Pond sediment leachates does not adsorb significantly. It appears that the Nearby soil sample does adsorb much of the dissolved Cu after the evaporites are flushed through the column. It is impossible to quantify the adsorption of Cu using the Kd concept, given the complicated breakthrough curve obtained in the laboratory tests.

At present, we recommend that any future groundwater impact analyses be performed using the simulated rainwater leachate data to estimate solution concentrations that would percolate through vadose zone sediments. For the No-Action alternative, in which the process ponds are left as is, the leachates from Samples A and C should bracket the probable maximum concentrations of metals that would percolate toward the water table. For the disposal of soil-washed fine-grained sediments in a separate burial ground, the observed leachates from Samples B and D should bracket the probable maximum concentrations.

The impact of replacing the coarse-grained sediments ($>75 \mu\text{m}$) into the 300 Area North Process Pond and removing the fine-grained ($<75 \mu\text{m}$) sediments after soil washing, as was performed by ART during the field demonstration, could be estimated by assuming that soil-washed coarse-grained sediments would

leach no more than Sample A. The fines removed and transported to a separate burial ground would leach no more contamination than observed for Sample D. Some data also are available (WHC 1994b) that show solidification of the soil washing fine sludge lowers leaching potential at least two orders of magnitude for mobile contaminants such as U.

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APPENDIX A

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RAW XRF DATA

(Total Concentration of Metals in Sediments)

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APPENDIX A

RAW XRF DATA

The following seven pages contain the total concentration of selected metals found in the air-dry samples of the five sediments discussed in this report. These data were used to construct Tables 4.1 through 4.5.

The samples marked A <9.5 Comp Non-Green and B <150 μm Fines Non-Green, C <9.5 Comp Green, and D <150 μm Fine Green are the same as samples A, B, C, and D described in the text. The samples labeled Clean Soil ART and Clean Soil (94-8912) are the analyses of two separate aliquots of the soil called Nearby in the text.

Samples USGS AGV-1 and BCR-1 are standard rock samples used to confirm that the XRF instrument is performing adequately. BCR-1 + X ppm U are standards spiked with known amounts of U to assure accuracy in the U measurement.

Final Report

SPONSOR: GINNY LEGORE / PNL REQUEST 3720-94-32
DATE OF WORK: 6-08-94
WORK ORDER NUMBER: K16851 ALO* 94-007605 TO 007609
TYPE OF MATERIAL: SOILS

ASR# 931

Page 966 -> 969

SERIES NAMES ASSOCIATED WITH THIS SAMPLE SET:

FAGL61
AGL601

DESCRIPTION OF XRFA TECHNIQUES USED

NORMAL PROCEDURE FOR LOOSED POWDER SAMPLES. SAMPLES WERE GROUND TO LESS THAN 300 MESH PRIOR TO XRFA. SAMPLE WERE PROCESSED IN COMPLIANCE WITH PNL TEST PROCEDURE ALO* 266.

STANDARD OF USGS AGV-1 AND URANIUM SPIKED USGS BCR-1 WERE PROCESSED WITH THE SAMPLES FOR TEST EQUIPMENT CHECK AND FOR CONTROL.

A.2

ANALYST: RON SANDERS
PHONE: 376-3877

*Ron Sanders
6-9-94*

REVIEW:

[Signature] 6/9/94

056

SS UNITS	EL	D <150UM FINE GREEN		CLEAN SOIL ART		BCR-1 +100PPM U		BCR-1 +200PPM U				
			+/-		+/-		+/-		+/-			
PPM	AL	103800.	9600.	AL	69000.	7300.	AL	75200.	8100.	AL	81300.	8500.
PPM	SI	118200.	9200.	SI	273000.	20000.	SI	254000.	19000.	SI	272000.	20000.
PPM	P	7200.	1100.	P	< 1700.		P	< 1800.		P	1960.	990.
PPM	S	1300.	410.	S	790.	390.	S	< 800.		S	< 940.	
PPM	CL	< 310.		CL	< 310.		CL	< 340.		CL	< 380.	
PPM	K	6680.	520.	K	14500.	1000.	K	14700.	1100.	K	15500.	1100.
PPM	CA	50800.	3500.	CA	36100.	2500.	CA	46000.	3200.	CA	46800.	3300.
PPM	TI	2340.	170.	TI	7960.	570.	TI	12760.	900.	TI	12820.	910.
PPM	V	118.	22.	V	140.	36.	V	354.	51.	V	463.	56.
PPM	CR	1323.	96.	CR	37.	12.	CR	< 27.		CR	< 28.	
PPM	MN	551.	48.	MN	865.	68.	MN	1440.	110.	MN	1410.	110.
PPM	FE	24900.	1700.	FE	53800.	3800.	FE	94600.	6600.	FE	96200.	6700.
PPM	NI	2850.	150.	NI	< 14.		NI	< 18.		NI	< 22.	
PPM	CU	23700.	1700.	CU	34.2	5.6	CU	15.2	6.3	CU	45.3	8.3
PPM	ZN	389.	30.	ZN	80.9	7.2	ZN	121.	10.	ZN	120.	11.
PPM	GA	168.	13.	GA	16.8	2.6	GA	23.5	3.3	GA	19.4	3.6
PPM	HG	31.5	7.7	HG	< 8.8		HG	38.6	7.1	HG	< 13.	
PPM	SE	< 4.2		SE	< 2.3		SE	< 2.7		SE	< 3.0	
PPM	PB	157.	14.	PB	12.9	3.2	PB	16.4	4.3	PB	11.1	4.2
PPM	AS	62.0	6.3	AS	4.3	2.1	AS	< 4.9		AS	< 5.3	
PPM	BR	10.4	2.5	BR	< 2.0		BR	< 2.9		BR	< 2.7	
PPM	RB	64.2	8.3	RB	49.4	3.9	RB	41.8	3.6	RB	44.3	3.8
PPM	U	4130.	290.	U	23.4	2.8	U	95.7	7.3	U	198.	14.
PPM	SR	293.	21.	SR	402.	28.	SR	326.	23.	SR	309.	22.
PPM	Y	18.0	3.1	Y	27.3	2.2	Y	36.2	2.9	Y	36.1	2.8
PPM	ZR	12560.	880.	ZR	128.7	9.3	ZR	224.	16.	ZR	212.	15.
PPM	NB	< 7.0		NB	7.1	1.0	NB	9.4	1.3	NB	8.8	1.2
PPM	MO	< 12.		MO	< 1.8		MO	< 2.6		MO	< 2.0	
PPM	TH	228.	17.	TH	< 4.2		TH	< 5.1		TH	< 5.0	
AG			+/-		+/-		+/-		+/-		+/-	
PPM	RB	124.	12.	RB	51.4	3.8	RB	48.1	3.8	RB	44.5	3.7
PPM	U	4200.	290.	U	26.0	2.9	U	103.9	7.9	U	213.	15.
PPM	SR	381.	21.	SR	407.	29.	SR	355.	25.	SR	337.	24.
PPM	Y	17.7	3.0	Y	24.2	1.9	Y	39.5	3.0	Y	38.7	2.9
PPM	ZR	13540.	950.	ZR	129.6	9.2	ZR	243.	17.	ZR	231.	16.
PPM	NB	< 5.3		NB	8.94	0.90	NB	11.8	1.2	NB	10.6	1.1
PPM	MO	56.2	7.6	MO	< 1.7		MO	3.2	1.3	MO	4.7	1.2
PPM	TH	242.	20.	TH	< 4.4		TH	< 6.0		TH	< 6.1	

11/10/00

PI
E/M

A.4

AG

SI UNITS EL USGS AGV-1 DUP

TI

			+/-
PPM	AL	91800.	8400.
PPM	SI	285000.	21000.
PPM	P	2380.	880.
PPM	S	< 760.	
PPM	CL	< 330.	
PPM	K	24400.	1700.
PPM	CA	35100.	2500.
PPM	TI	6280.	450.
PPM	V	63.	33.
PPM	CR	< 22.	
PPM	MN	763.	61.
PPM	FE	47300.	3300.
PPM	NI	21.6	7.1
PPM	CU	66.0	7.4
PPM	ZN	80.9	7.2
PPM	GA	17.0	2.7
PPM	HG	< 8.8	
PPM	SE	< 2.3	
PPM	PB	34.2	4.6
PPM	AS	< 4.5	
PPM	BR	< 2.2	
PPM	RB	65.9	4.9
PPM	U	< 5.1	
PPM	SR	651.	46.
PPM	Y	20.3	1.9
PPM	ZR	213.	15.
PPM	NB	11.7	1.2
PPM	MO	< 2.0	
PPM	TH	6.2	2.2

A.5

AG

			+/-
PPM	RB	66.8	4.8
PPM	U	< 5.0	
PPM	SR	657.	46.
PPM	Y	17.6	1.5
PPM	ZR	220.	16.
PPM	NB	12.2	1.1
PPM	MO	< 1.9	
PPM	TH	6.5	2.4

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Final Report

SPONSOR: GINNY LEGORE PROJECT NUMBER 21118
DATE OF WORK: 07-18-94
WORK ORDER NUMBER: K16851 ASR NUMBER: 1060
TYPE OF MATERIAL: CLEAN SOIL ACL NUMBER: 94-008912-7-20-94

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SERIES NAMES ASSOCIATED WITH THIS SAMPLE SET:
FAGL71
ZGL701
AGL701

DESCRIPTION OF XRFA TECHNIQUES USED

9.5

NORMAL PROCEDURE FOR LOOSE POWDER SEDIMENT SAMPLES.
SAMPLES PROCESSED IN COMPLIANCE WITH PNL TEST PROCEDURE
ALO: 266. THE RECEIVED SAMPLE WAS SIEVED TO 1MM AND
500 MG OF THE SIEVED MATERIAL GROUND TO LESS THAN
37 MICRONS FOR XRFA.

ANALYST:
PHONE:

RON SANDERS
376-3877

Ron Sanders
7-19-94

REVIEW:

Paul Thomas Sammis
7-20-94

AG

PPM	PB	13.9	2.3	PB	7.3	1.8	PB	13.7	2.3	PB	13.5	2.5
PPM	S	3.3	1.4	AS	7.1	1.2	AS	< 2.7		AS	< 2.8	
PPM	R	< 1.5		BR	< 1.2		BR	< 1.9		BR	< 1.6	
PPM	RB	41.2	2.3	RB	49.9	2.7	RB	42.9	2.4	RB	47.7	2.6
PPM	SR	341.	18.	SR	400.	21.	SR	327.	17.	SR	318.	17.
			+/-			+/-			+/-			+/-
PPM	RB	43.5	3.5	RB	43.8	3.3	RB	45.7	3.6	RB	47.4	3.6
PPM	U	196.	14.	U	46.9	3.9	U	103.1	7.8	U	< 5.7	
PPM	SR	293.	21.	SR	356.	25.	SR	317.	22.	SR	328.	23.
PPM	Y	37.2	2.8	Y	24.0	1.8	Y	36.5	2.8	Y	34.8	2.7
PPM	ZR	208.	15.	ZR	168.	12.	ZR	226.	16.	ZR	185.	13.
PPM	NB	18.9	1.1	NB	9.46	0.93	NB	12.3	1.3	NB	12.6	1.3
PPM	MO	4.7	1.1	MO	< 1.6		MO	2.8	1.3	MO	< 2.3	
PPM	TH	< 6.1		TH	< 4.3		TH	< 6.0		TH	7.1	3.8

A.8

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APPENDIX B

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RAW ICP-MS DATA

(Solution Concentrations of Leachates and Soil Column Effluents)

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APPENDIX B

RAW ICP-MS DATA

The following thirteen pages contain the solution concentrations of selected metals in the various TCLP and simulated rainwater leachates of the five sediments discussed in the report. The column effluent solution concentrations from the two tests, which were either tap water or sequential batch extract that were percolated through Nearby sediment, are also included.

Samples labeled TCLP-1A, TCLP-1B, TCLP-1C, TCLP-1D, and TCLP-1 Clean represent the TCLP leachates described in Tables 4.6 to 4.10. EPA-2A, EPA-2B, EPA-2C, EPA-2D, and EPA-2 Clean represent the EPA Method 1312 extracts shown on Tables 4.6 to 4.10. In the text sample, Clean has been renamed Nearby sediment to avoid confusion in that the sample may not represent background or clean soil.

Samples labeled EPA 2D-Leach 2, Leach 3, Leach 4, and Leach 5 are the second through fifth sequential extractions discussed in Table 4.11. The first sequential extraction was EPA-2D, present in both Table 4.10 and 4.11. The sample labeled 1/1 Rain to Soil 2D is the extract described in Table 4.12.

Samples labeled 1A through 49A and A53 through A62 represent column effluents from the test where sequential leachate was percolated through the Nearby sediment (see Table 4.14). Samples labeled 1B through 36B and B49 through B65 are column effluents from the test in which tap water was percolated through Nearby sediment as described in Table 4.13. The labeling system A or B denotes which column test, and the number represents the aliquot number taken in succession. Not all aliquots were measured for chemicals but the total volume collected was considered when constructing Tables 4.13 and 4.14 and Figures 4.1 and 4.2.

0015 5800129

All other samples listed on the outputs are control standards to check instrument performance. Each data set comes with a brief narrative that describes performance and flags any substandard performance.



Date June 27, 1994
To Ginny LeGore
From James Bramson
Subject ICP/MS Results of Submitted Samples
(ALO#94-7693-7702 and 94-07892-07894)

Persuant to your request, the 13 samples that you submitted on 6/8/94 were analyzed by ICP/MS. The results of this analysis are summarized in the attached data table.

Dilutions of NIST standards were used to generate the calibration curves, NIST water standards (1643c and 1641c), NIST multi-element standards (3171a and 3172a), a Perkin-Elmer multi-element standard (ICP-4), and EPA water standards, previously characterized for their uranium content, were used as the continuing calibration verification (CCV) standards. Results are reported in ng/ml (ppb) of submitted solution. Unless otherwise specified, the overall uncertainty of the values is estimated at $\pm 15\%$ and is based on the accuracy of the check standard results as well as the precision between consecutive analytical runs.

Fe, Se and K results should be considered semiquantitative (uncertainty +100%/-50%) based on high blank concentrations, poor CCV standard results, and unacceptable variability between consecutive analytical runs. The two parenthesized Ca results were higher than the highest standard (47.5 ppm) and should be considered semiquantitative. It is suspected that copper has dropped out of 1643c which would explain the unacceptable result obtained for this CCV standard. However, NIST 3172a does confirm the accuracy of the calibration for copper.

If you have any questions regarding this analysis, feel free to call me at 372-0624.

Legore Analysis

June 27, 1994

Results reported ng/ml (ppb) of solution submitted

Sample Number	ICPMS Number	Dilution Factor	*Na (23) ng/ml	Mg (25) ng/ml	Al (27) ng/ml	*K (39) ng/ml	Ca (44) ng/ml	Tl (47) ng/ml	Cr (52) ng/ml	Mn (55) ng/ml	*Fe (56) ng/ml
1% HNO_3	4614b1		<50	12±4	4.7±7.1	(390±50)	870±680	<10	<1	<1	(80±20)
CFW TCLP	4614b33	1.053x	73400	464	318	(42000)		<10	81.7	<1	(230±170)
CFW TCLP	4614b47	10x					(616000)				
EPA 2D Leach 2	4614b31	1.053x	5900±2800		249	(9000±1200)		<10	23±3	9.1±1.2	(780±555)
EPA 2D Leach 2	4614b45	10x		8230			36400				
EPA 2D Leach 3	4614b32	1.053x	2600±400		188	(9180)		<10	11.2	13.3	(150±30)
EPA 2D Leach 3	4614b46	10x		9090			46500				
EPA-2 Clean	4614b30	1.053x	8830		36.5	(5680)		<10	1.74	8.7±1.0	(190±220)
EPA-2 Clean	4614b35	5x		4330			32500				
EPA-2A	4614b28	1.053x	2550		33.1	(6390)		58±15	8.88	8.8±2.2	(310±200)
EPA-2A	4614b36	5x		4810			30000±5000				
EPA-2B	4614b27	1.053x	3640		23.1	(7800±1200)		<10	6.68	37.7	(360±380)
EPA-2B	4614b37	5x		4750			31000±7000				
EPA-2C	4614b28	1.053x	3260		278	(6520)		<10	30.2	8.21	(19±59)
EPA-2C	4614b38	5x		6130			33900				
EPA-2D	4614b29	1.053x	5130		259	(8400±900)		<10	59.7	8.9±1.4	(480±150)
EPA-2D	4614b39	5x		6580			29000±7000				
TCLP-1 Clean	4614b25	1.053x	73500		261	(7880)		56±33	23±3	408	(200±140)
TCLP-1 Clean	4614b40	20x		9380			135000				
TCLP-1A	4614b21	1.053x	77700		516	(8530)		78±46	21.1	301	(120±160)
TCLP-1A	4614b41	20x		6840			37000				
TCLP-1B	4614b22	1.053x	79100		308	(10000±1900)		175	23.5		(120±400)
TCLP-1B	4614b42	20x		22100			196000			2080	
TCLP-1C	4614b23	1.053x	86700		216	(9300±1400)		217	36.6	226	(490±160)
TCLP-1C	4614b43	20x		20200			436000±52000				
TCLP-1D	4614b24	1.053x	12000±3300		259	(8080)		<10	50.7	679	(1240)
TCLP-1D	4614b44	20x		59500			(1230000)				
1641c	4614b14	500x									
1641c	4614b51	200x									
True Value											
1643c	4614b52	1.053x	11900	10700	145	1950	32900		20.5	38.4	138
1643c	4617a27	1.053x	13800			2530					152
1643c	4617a28	2x	15100			2810					126
True Value			12200	9450	115	2300	36800		19.0	35.1	107
ICP-4 500 ppb	4614b16	1x						594			
ICP-4 2000 ppb	4614b34	1x						1940			
3171a 100 ppb	4614b18	1x		109	98.6				110	102	
†3171a 500 ppb	4614b49	1x	500±80	562	560	2500			546	473	530
†3171a 1000 ppb	4617a8	1x	1000			4060					1090
3171a 2000 ppb	4614b50	1x		2020	2030				2060	1750	
††3172a 20 ppb	4614b17	1x									
††3172a 100 ppb	4614b48	1x									
7.6 pCi/L U	4614b15	0.6854x									
41.0 pCi/L U	4614b53	0.6854x									

†[K] is 5x greater

††[As] 2x greater, [Se] 5x greater, [Sr] and [Ba] 10x less

*Results are from procedure 4617a (10x)

DATA REVIEW

Reviewed by: *[Signature]*

Date: 6/27/94 Pages: 1 of 2

9513382.2402

Legore Analysis

June 27, 1994

Results reported ng/ml (ppb) of solution submitted

Sample Number	ICP/MS Number	Dilution Factor	Cu (65) ng/ml	As (75) ng/ml	Se (82) ng/ml	Sr (88) ng/ml	Zr (91) ng/ml	Ag (107) ng/ml	Cd (114) ng/ml	Ba (138) ng/ml	Hg (202) ng/ml	Pb (208) ng/ml	U (238) ng/ml
1%HNO3	4614b1		3.1±0.8	<1	<20	<1	2.1±0.9	<1	<1	<1	1.6±0.5	<1	<1
CRW TCLP	4614b33	1.053x	<1	2.0±1.0	<20		2.4±0.5	<1	1.51	315	<1	11.7	2.1±2.2
CRW TCLP	4614b47	10x				3910							
EPA 2D Leach 2	4614b31	1.053x	62±7	2.2±1.6	<20	120	2.2±0.8	<1	1.1±0.5	38.8	<1	7.8±1.0	
EPA 2D Leach 2	4614b45	10x											1140
EPA 2D Leach 3	4614b32	1.053x	89.0	1.1±0.5	<20	198	2.8±2.1	<1	<1	81.0	<1	8.0±1.0	
EPA 2D Leach 3	4614b46	10x											1180
EPA-2 Clean	4614b30	1.053x	6.1±3.8	4.3±1.6	<20	173	1.8±0.5	<1	1.0±0.2	46.6	<1	<1	537
EPA-2 Clean	4614b35	5x											
EPA-2A	4614b26	1.053x	24±7	<1	<20	133	1.8±0.3	<1	<1	42.0	<1	<1	26.3
EPA-2A	4614b38	5x											
EPA-2B	4614b27	1.053x	48±8	2.79	<20	150	2.1±1.4	<1	1.1±0.4	48±7	<1	<1	146
EPA-2B	4614b37	5x											
EPA-2C	4614b28	1.053x	72±26	2.2±1.6	<20	131	3.4±0.5	<1	<1	41.8	1.0±0.5	<1	876
EPA-2C	4614b36	5x											
EPA-2D	4614b29	1.053x	117	<1	<20	140	2.7±1.1	<1	1.25	49.0	<1	<1	
EPA-2D	4614b39	5x											1442
TCLP-1 Clean	4614b25	1.053x	26±8	2.7±1.9	<20	494	2.7±0.9	<1	1.7±0.5		<1	<1	643
TCLP-1 Clean	4614b40	20x								1230			
TCLP-1A	4614b21	1.053x	780±90	<1	(23.4)	253	1.4±0.4	<1	2.7±1.8		<1	<1	157
TCLP-1A	4614b41	20x								463			
TCLP-1B	4614b22	1.053x		<1	<20	812	2.4±1.0	<1	2.37		<1	1.56	365
TCLP-1B	4614b42	20x	1370							1210			
TCLP-1C	4614b23	1.053x		<1	<20		1.8±0.9	<1	11.4		1.02	6.09	
TCLP-1C	4614b43	20x	13700			1370				1450			2340
TCLP-1D	4614b24	1.053x		<1	<20		6.9±0.7	1.1±0.4	22.0		1.0±0.2	8.30	
TCLP-1D	4614b44	20x	24600			4480				2940			8070
1641c	4614b14	500x									1530		
1641c	4614b51	200x									990±160		
True Value											1470		
1643c	4614b52	1.053x	12.7	101	16.8	243		2.21	19.3	51.5		33.5	
1643c	4617a27	1.053x											
1643c	4617a28	2x											
True Value			22.3	82.1	12.7	284		2.21	12.2	46.6		33.3	
ICP-4 500 ppb	4614b16	1x					480						
ICP-4 2000 ppb	4614b34	1x					1860						
3171a 100 ppb	4614b18	1x							101				
†3171a 500 ppb	4614b49	1x							567				
†3171a 1000 ppb	4617a8	1x											
3171a 2000 ppb	4614b50	1x							2070				
††3172a 20 ppb	4614b17	1x	21±4	37.1	77±12	2.8±0.3		19.8		2.2±1.7		20.4	
††3172a 100 ppb	4614b48	1x	112	222	460±70	9.8±1.2		102		12.3		101	
7.6 pCi/L U	4614b15	0.6854x											8.22 pCi/L
41.0 pCi/L U	4614b53	0.6854x											44.0 pCi/L

†[K] is 5x greater

††[As] 2x greater, [Se] 5x greater, [Sr] and [Ba] 10x

*Results are from procedure 4617a (10x)

Fig 2 of 2

Date June 27, 1994
To Ginny LeGore
From James Bramson
Subject ICP/MS Results of Submitted Samples
(ALO#94-008295 through 94-008297)

Persuant to your request, the 3 samples that you submitted on 6/20/94 were analyzed by ICP/MS. The results of this analysis are summarized in the attached data table.

Dilutions of NIST standards were used to generate the calibration curves, NIST water standards (1643c and 1641c), NIST multi-element standards (3171a, 3172a and 3179), a Perkin-Elmer multi-element standard (ICP-4), and EPA water standards, previously characterized for their uranium content, were used as the continuing calibration verification standards. Results are reported in ng/ml (ppb) of submitted solution. Unless otherwise specified, the overall uncertainty of the values is estimated at $\pm 10\%$ ($\pm 20\%$ for K and Ca) and is based on the accuracy of the check standard results as well as the precision between consecutive analytical runs.

Se results should be considered semiquantitative (uncertainty +100%/-50%) based on poor CCV standard results, and unacceptable variability between consecutive analytical runs. It is suspected that copper has dropped out of 1643c which would explain the unacceptable result obtained for this CCV standard. However, NIST standards 3172a and 3179 do confirm the accuracy of the calibration for copper.

If you have any questions regarding this analysis, feel free to call me at 372-0624.

Legore Analysis

June 27, 1994

Results reported in ng/ml (ppb) of solution submitted

Sample Number	ICP/MS Number	Dilution Factor	Na (23) ng/ml	Mg (25) ng/ml	Al (27) ng/ml	K (39) ng/ml	Ca (44) ng/ml	Cr (52) ng/ml	Mn (55) ng/ml	Fe (56) ng/ml	Cu (65) ng/ml	As (75) ng/ml
1%HNO3	4622a1	1.053x	<10	1.5±3.9	<1	<10	<10	<1	<1	<10	2.4±0.7	<1
1/1 Rain to Soil 2D	4622a31	10x	13000±1400	13800	3510		94000±20000				2150	
1/1 Rain to Soil 2D	4622a34	1.053x				1400±200		138	38.2	170±70		4.48
EPA 2D Leach 4	4622a32	10x		7240			54800					
EPA 2D Leach 4	4622a35	1.053x	2710		185	1240		11.7	12.2	63±19	34±6	6.21
EPA 2D Leach 5	4622a33	10x		7530			58800					
EPA 2D Leach 5	4622a36	1.053x	2480		150±20	840±560		6.4±0.7	9.8±1.6	<10	46±8	2.1±2.2
ICP-4 20 ppb	4622a21	1x										
ICP-4 100 ppb	4622a39	1x										
NIST 1641c	4622a13	500x										
NIST 1641c	4622a37	500x										
True Value												
NIST 1643c	4622a27	1.053x	15000±2000	9200	108	2870	43600	20.5	41.0		9.70	79.4
NIST 1643c	4622a41	1.053x	12900	9670	110	3440	41800	20.1	37.3		10.8	96.7
True Value			12200	9450	115	2300	36800	19.0	35.1		22.3	82.1
NIST 3172a 20 ppb	4622a26	1x									20.9	40±5
NIST 3172a 100 ppb	4622a40	1x									106	214
NIST 3179 1000 ppb	4622a16	1x	1040	1050	929	1070	1000±200	1020	1020	2040	986	2050
True Value			1000	1000	1000	1000	1000	1000	1000	2000	1000	2000
7.6 pCi/L U	4622a38	0.6854x										
41.0 pCi/L U	4622a20	0.6854x										

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DATA REVIEW

Reviewed by: *[Signature]*

Date: 6/27/94 Pages: 2

(1 of 2)

Legore Analysis

June 27, 1994

Pg 2 of 2

Results reported in ng/ml (ppb) of solution submitted

Sample Number	ICP/MS Number	Dilution Factor	Se (77) ng/ml	Sr (88) ng/ml	Zr (90) ng/ml	Ag (107) ng/ml	Cd (114) ng/ml	Ba (138) ng/ml	Hg (202) ng/ml	Pb (208) ng/ml	U (238) ng/ml
1%HNO3	4622a1	1.053x	<20	<1	<1	<1	<1	<1	<1	13.2	<1
1/1 Rain to Soil 2D	4622a31	10x									1330
1/1 Rain to Soil 2D	4622a34	1.053x	(<20)	267	18.8	<1	2.0±1.3	117	<1	16.8	
EPA 2D Leach 4	4622a32	10x									1520
EPA 2D Leach 4	4622a35	1.053x	(<20)	180	1.1±0.4	<1	<1	51.5	<1	8.30	
EPA 2D Leach 5	4622a33	10x									1440
EPA 2D Leach 5	4622a36	1.053x	(<20)	201	<1	<1	1.2±0.7	59.5	<1	<1	
ICP-4 20 ppb	4622a21	1x			20±4						
ICP-4 100 ppb	4622a39	1x			92.7						
NIST 1641c	4622a13	500x						2600±1900			
NIST 1641c	4622a37	500x						2040			
True Value								1470			
NIST 1643c	4622a27	1.053x	<1	268		1.9±0.7	13.3	49.1		35.4	
NIST 1643c	4622a41	1.053x	8±13	267		2.17	14.0	48.4		34.8	
True Value			12.7	264		2.21	12.2	49.6		35.3	
NIST 3172a 20 ppb	4622a26	1x	100±50			19.8				21.8	
NIST 3172a 100 ppb	4622a40	1x	518			93.1				106	
NIST 3179 1000 ppb	4622a16	1x		1040			972	1090		1040	
True Value				1000			1000	1000			
7.6 pCi/L U	4622a38	0.6854x									8.29 pCi/L
41.0 pCi/L U	4622a20	0.6854x									42.7 pCi/L

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Pacific Northwest Laboratories

Project Number

Internal Distribution

Date June 27, 1994
To Ginny LeGore
From James Bramson *James*
Subject ICP/MS Results of Submitted Samples
(ALO#94-008912 through 94-008931)

Persuant to your request, the 19 samples that you submitted on 7/7/94 were analyzed by ICP/MS. The results of this analysis are summarized in the attached data table.

Dilutions of NIST standards were used to generate the calibration curves, NIST water standards (1643c and 1641c), NIST multi-element standards (3172a and 3179), Perkin-Elmer multi-element standards (ICP-4, ICP-2), and an EPA water standard, previously characterized for their uranium content, were used as the continuing calibration verification standards. Results are reported in ng/ml (ppb) of submitted solution. Unless otherwise specified, the overall uncertainty of the values is estimated at $\pm 15\%$ ($\pm 20\%$ for K) and is based on the accuracy of the check standard results as well as the precision between consecutive analytical runs.

Calcium results should be considered semiquantitative (uncertainty $+100\%/-50\%$) due to a high background and a high blank concentration.

If you have any questions regarding this analysis, feel free to call me at 372-0624.

7/14/94

Ginny LeGore Analysis

July 14, 1994

by *CF Nyle* 7/14/94

Results are reported in ng/ml (ppb) of solution submitted

Sample Number	ICP/MS Number	Dilution Factor	Na (23)	Mg (25)	Al (27)	K (39)	Ca (44)	Cr (52)	Mn (55)
1% HNO3	4708a1	1.053x	<10	6.4±1.3	<1	<10	8600±2000	<1	<1
1% HNO3	4711a1	1.053x	23±8	<1	7.8±1.2	<10	10200	<1	<1
1A	4708a24	2x				14500		121	105
1A	4711a17	20x					(475000)		
1A	4711a45	50x	469000	104000	30300				
4A	4708a23	2x				5050	(109000)	66.1	24.5
4A	4711a16	20x		18500					
4A	4711a42	50x	210000		10100				
8A	4708a22	2x		5700±700		2600±1000	(27000±5000)	40.7	7.5±3.3
8A	4711a15	20x	85100		4170				
12A	4708a21	2x		7150		3900±1200	(35000±5000)	38.8	12.4
12A	4711a14	20x	55500		3710				
16A	4708a20	2x		7200		2500±600	(34900)	30.1	6.11
16A	4711a13	20x	37500		2590				
20A	4708a19	2x		8040		2390	(44900)	37±6	13.5
20A	4711a12	20x	24800		2420				
24A	4708a18	2x		8080		2300±800	(44300)	36±4	11±4
24A	4711a11	20x	19700		4070				
36A	4708a17	2x		9090		2180	(49600)	41.0	<1
36A	4711a10	20x	8390		6550				
49A	4708a16	2x		9640		2370	(54700)	33.3	1.80
49A	4708a40	20x	16000±4000						
1B	4708a36	2x				15900		114	46.6
1B	4711a28	20x					(296000)		
1B	4711a44	50x	363000	86100	10300				
4B	4708a35	2x				7700±1000	(142000)	31.1	31±8
4B	4711a27	20x		24200					
4B	4711a43	50x	205000		11000				
8B	4708a34	2x		3900		3400±400	(<20000)	6.7±2.0	24±6
8B	4711a26	20x	70500		826				
13B	4708a33	2x		3310		2700±400	(<20000)	5.4±1.6	<1
13B	4711a25	20x	52200		1390				
16B	4708a32	2x		3200		2100±800	(<20000)	3.1±1.2	10.5
16B	4711a24	20x	42400		2770				
20B	4708a31	2x		3700		2920	(<20000)	1.4±0.8	1.9±2.6
20B	4711a23	20x	34100		2310				
24B	4708a30	2x		3900		2470	(<20000)	1.8±2.1	10±2
24B	4711a22	20x	25800		6400				
29B	4708a29	2x		4300		2400±400	(<20000)	2.06	<1
29B	4711a21	20x	20000		3240				
36B	4708a28	2x		4520		2800±700	(<20000)	<1	<1
36B	4711a20	20x	13200		1880				
300 Area Process Water	4711a40	20x	35600	37700					
300 Area Process Water	4711a41	2x			42.8	4980	(74900)	9.7±1.3	26±4
1643c	4708a14	1.053x	11400	10662	110	2810	39700	20.7	39.0
1643c	4711a8	1.053x	10200	8570	105	2100±300	32000±4000	18.8	37.6
True Value			12200	9450	115	2300	36800	19.0	35.1
200 ppb 3179	4711a18	1x			200			210	207
1000 ppb ICP-2	4711a18	1x			1020				
20 ppb ICP-4	4708a27	1x							
20 ppb ICP-4	4711a34	1x							
100 ppb ICP-4	4708a12	1x							
20 ppb 3172a	4708a15	1x							
20 ppb 3172a	4711a38	1x							
1000 ppb ICP-2	4708a37	1x							
1641c (1470 ppb Hg)	4708a11	500x							
1641c (1470 ppb Hg)	4708a26	500x							
1641c (1470 ppb Hg)	4711a39	500x							
41.0 pCi/L U	4708a13	0.6854x							
41.0 pCi/L U	4711a9	0.6854x							

1 of 3

Ginny LeGore Analysis

July 14, 1994

9513382.2405

Lot 3
7/14/94

Results are reported in ng/ml (ppb) of solution submitted

Sample Number	ICP/MS Number	Dilution Factor	Fe (56)	Cu (65)	As (75)	Sr (88)	Zr (90)	Ag (109)	Cd (114)	Ba (138)	Hg (202)
1% HNO3	4708a1	1.053x	<10	<1	<1	<1	<1	<1	<1	<1	<1
1% HNO3	4711a1	1.053x	<10	<1	<1	<1	<1	<1	<1	<1	<1
1A	4708a24	2x	473	286	8.6±3.6		1.5±2.8	<1	<5	334	2.2±0.4
1A	4711a17	20x				2340					
1A	4711a45	50x									
4A	4708a23	2x	100±20	158	10±3	522	<1	<1	<5	86.5	<1
4A	4711a16	20x									
4A	4711a42	50x									
8A	4708a22	2x	71±62	94.3	11.8	162	<1	<1	<5	46.3	1.2±1.1
8A	4711a15	20x									
12A	4708a21	2x	130±40	67±7	9.8±1.8	171	<1	<1	<5	42.3	2.00
12A	4711a14	20x									
16A	4708a20	2x	<50	32±12	<5	191	<1	<1	<5	37.3	2.1±0.8
16A	4711a13	20x									
20A	4708a19	2x	59±23	34±4	7.4±9.8	213	<1	<1	<5	35±4	<1
20A	4711a12	20x									
24A	4708a18	2x	<50	30.7	9.1±4.0	242	<1	<1	8.7±1.4	42.1	1.0±0.5
24A	4711a11	20x									
36A	4708a17	2x	51±69	30.5	<5	248	<1	<1	<5	41.4	1.4±0.3
36A	4711a10	20x									
49A	4708a16	2x	<50	20.7	12.1	288	<1	<1	<5	45.5	1.7±0.2
49A	4708a40	20x									
1B	4708a36	2x	313	268	<5		<1	<1	<5	217	<1
1B	4711a28	20x				1900					
1B	4711a44	50x									
4B	4708a35	2x	260±60	170±20	12±7	589	<1	<1	<5	126	3.2±0.6
4B	4711a27	20x									
4B	4711a43	50x									
8B	4708a34	2x	260±40	112	15.7	114	<1	<1	<5	150	1.85
8B	4711a26	20x									
13B	4708a33	2x	54±10	26±10	10±7	92.6	<1	<1	<5	49.1	<1
13B	4711a25	20x									
16B	4708a32	2x	<50	39±10	10.9	94	<1	<1	<5	50.2	1.3±2.1
16B	4711a24	20x									
20B	4708a31	2x	64±16	18±3	11±10	102	<1	<1	<5	46.6	2.17
20B	4711a23	20x									
24B	4708a30	2x	75±14	13.0	14±4	125	<1	<1	<5	48±12	2.72
24B	4711a22	20x									
29B	4708a29	2x	<50	8.7±1.0	<5	128	<1	<1	<5	41.4	<1
29B	4711a21	20x									
36B	4708a28	2x	<50	4.9±5.5	<5	138	<1	<1	<5	39.9	1.6±1.7
36B	4711a20	20x									
300 Area Process Water	4711a40	20x									
300 Area Process Water	4711a41	2x	154	112	7.08	329	<1	<1	<5	70.2	1.5±0.6
1643c	4708a14	1.053x	112	25±3	84.8	286		2.31	16.1	53.1	
1643c	4711a8	1.053x	120±20	23±4	84.4	259			9.6±1.9	47±6	
True Value			106	22.3	82.1	264		2.21	12.2	49.6	
200 ppb 3179	4711a18	1x	402	210	425	223			197	210	
1000 ppb ICP-2	4711a18	1x									
20 ppb ICP-4	4708a27	1x					23.4				
20 ppb ICP-4	4711a34	1x					27±6				
100 ppb ICP-4	4708a12	1x					105				
20 ppb 3172a	4708a15	1x		18±2	40±10			20.4			
20 ppb 3172a	4711a38	1x		25.8	56.3						
1000 ppb ICP-2	4708a37	1x									
1641c (1470 ppb Hg)	4708a11	500x									1200±400
1641c (1470 ppb Hg)	4708a26	500x									1600±300
1641c (1470 ppb Hg)	4711a39	500x									2400±1100
41.0 pCi/L U	4708a13	0.6854x									
41.0 pCi/L U	4711a9	0.6854x									

Ginny LeGore Analysis

July 14, 1994

Handwritten: 7/14/94

Results are reported in ng/ml (ppb) of solution submitted

Sample Number	ICP/MS Number	Dilution Factor	Pb (208)	U (238)
1% HNO3	4708a1	1.053x	2.22	<1
1% HNO3	4711a1	1.053x	<1	<1
1A	4708a24	2x	6.8±1.8	4480
1A	4711a17	20x		
1A	4711a45	50x		
4A	4708a23	2x	17±4	5310
4A	4711a16	20x		
4A	4711a42	50x		
8A	4708a22	2x	2.90	3480
8A	4711a15	20x		
12A	4708a21	2x	7.0±1.1	2700
12A	4711a14	20x		
16A	4708a20	2x	5.69	1730
16A	4711a13	20x		
20A	4708a19	2x	115	1440
20A	4711a12	20x		
24A	4708a18	2x	15±3	1390
24A	4711a11	20x		
36A	4708a17	2x	10.2	1780
36A	4711a10	20x		
49A	4708a16	2x	9.96	1950
49A	4708a40	20x		
1B	4708a36	2x	12.9	3860
1B	4711a28	20x		
1B	4711a44	50x		
4B	4708a35	2x	8.1±3.3	8940
4B	4711a27	20x		
4B	4711a43	50x		
8B	4708a34	2x	5.2±1.0	3870
8B	4711a26	20x		
13B	4708a33	2x	9.6±1.2	2250
13B	4711a25	20x		
16B	4708a32	2x	4.69	1900
16B	4711a24	20x		
20B	4708a31	2x	8.4±3.4	1480
20B	4711a23	20x		
24B	4708a30	2x	4.0±1.9	1400
24B	4711a22	20x		
29B	4708a29	2x	11.6	1070
29B	4711a21	20x		
36B	4708a28	2x	4.66	1000
36B	4711a20	20x		
300 Area Process Water	4711a40	20x		1420
300 Area Process Water	4711a41	2x		
1643c	4708a14	1.053x	38.6	
1643c	4711a8	1.053x	37.8	
True Value			35.3	
200 ppb 3179	4711a18	1x	217	
1000 ppb ICP-2	4711a18	1x		
20 ppb ICP-4	4708a27	1x		
20 ppb ICP-4	4711a34	1x		
100 ppb ICP-4	4708a12	1x		
20 ppb 3172a	4708a15	1x	19.8	
20 ppb 3172a	4711a38	1x	19.9	
1000 ppb ICP-2	4708a37	1x		984
1641c (1470 ppb Hg)	4708a11	500x		
1641c (1470 ppb Hg)	4708a26	500x		
1641c (1470 ppb Hg)	4711a39	500x		
41.0 pCi/L U	4708a13	0.6854x		44.5 pCi/L
11.0 pCi/L U	4711a9	0.6854x		38.1 pCi/L



Date July 26, 1994
To Ginny LeGore
From James Bramson *James*
Subject ICP/MS Results of Submitted Samples
(ALO#94-009385 through 94-009390)

Persuant to your request, the 7 samples that you submitted on 7/18/94 were analyzed by ICP/MS. The results of this analysis are summarized in the attached data table.

Dilutions of NIST standards were used to generate the calibration curves, NIST water standards (1643c and 1641c), NIST multi-element standards (3172a and 3171a), and Perkin-Elmer multi-element standards (ICP-4, ICP-2) were used as the continuing calibration verification (CCV) standards. Results are reported in ng/ml (ppb) of submitted solution. Unless otherwise specified, the overall uncertainty of the values is estimated at $\pm 10\%$, and is based on the accuracy of the check standard results as well as the precision between consecutive analytical runs.

Potassium and iron results should be considered semiquantitative (uncertainty $+100\%/-50\%$) due to high blank concentrations, high backgrounds, and poor CCV standard results. The cadmium background was high in comparison to the sample concentrations, so the detection limit for cadmium is conservatively estimated at <5 ppb.

If you have any questions regarding this analysis, feel free to call me at 372-0624.

J. Brown
7/26/94

DATA REVIEW

Reviewed by: *[Signature]*

Date: 7/26/94 Pages: 1 of 2

Ginny Legore Analysis
July 26, 1994

Results are reported in ng/ml (ppb)

Sample Number	ICP/MS Number	Dilution Factor	Na (23) ng/ml	Mg (25) ng/ml	Al (27) ng/ml	K (39) ng/ml	Ca (44) ng/ml	Cr (52) ng/ml	Mn (55) ng/ml	Fe (56) ng/ml	Cu (65) ng/ml	As (75) ng/ml
1%HNO3	4725a1	1.053x	41.5	5.3±1.4	2.30	<10	72±18	<1	<1	62.9	<1	<1
A53	4725a2	2x	7080	6340	21.3	(1900)	58600	27.3	<1	(<100)	13±3	6.5±5.9
A57	4725a3	2x	7030	6360	18.4	(1700±200)	63600	16±3	<1	(<100)	13.5	<5
A62	4725a4	2x	7060	6800	20.7	(1500)	54900	25.9	1.9±0.8	(167)	17.4	<5
B49	4725a5	2x	5420	3530	50±15	(950±340)	31000	5.8±2.7	3.5±0.4	(190±30)	6.45	<5
B53	4725a6	2x	4360	3470	32±6	(430±390)	26500	3.9±1.4	2.6±1.4	(121)	3.9±1.5	<5
B57	4725a7	2x	4300	3550	22.5	(829)	29800	4.71	1.2±1.0	(224)	4.9±4.1	<5
B65	4725a8	2x	4360	4090	22±4	1000±200	29600	4.5±1.0	1.6±0.6	(300±50)	3.6±1.3	<5
1643c	4725a19	1.053x	12100	9840	126	3230	39500	22.3	36.8		23.4	93.2
True Value			12200	9450	115	2300	36800	19.0	35.1		22.3	82.1
200 ppb 3717a	4725a23	1x		189	184	1370		207	208	279		
True Value				200	200	1000		200	200	200		
500 ppb 3171a	4725a24	1x		482	476	3100		544	514	542		
True Value				500	500	2500		500	500	500		
1641c	4725a16	2000x										
1641c	4725a25	2000x										
True Value												
20 ppb ICP-4	4725a17	1x										
20 ppb 3172a	4725a18	1x									18.5	33.7
True Value											20.0	40.0
20 ppb ICP-2	4726a12	1x										
200 ppb ICP-2	4726a7	1x										

B.14

J. Brown
7/26/94

DATA REVIEW

Reviewed by: *[Signature]*

Date: 7/26/94 Pages: 2 of 2

Ginny Legore Analysis

July 26, 1994

Results are reported in ng/ml (ppb)

Sample Number	ICP/MS Number	Dilution Factor	Sr (88) ng/ml	Zr (90) ng/ml	Ag (109) ng/ml	Cd (114) ng/ml	Ba (138) ng/ml	Hg (200) ng/ml	Pb (208) ng/ml	*U (238) ng/ml
1%HNO3	4725a1	1.053x	<1	<1	<1	1.10	<1	<1	<1	<1
A53	4725a2	2x	300	1.9±0.3	<1	<5	48±5	<1	9.93	1820
A57	4725a3	2x	333	1.97	<1	<5	52.8	<1	4.01	3210
A62	4725a4	2x	257	1.6±0.2	<1	<5	42.3	<1	4.6±0.8	1330
B49	4725a5	2x	149	1.6±0.4	<1	<5	38±6	<1	3.8±1.1	815
B53	4725a6	2x	128	1.25	<1	<5	33.8	<1	3.99	728
B57	4725a7	2x	138	1.6±0.3	<1	<5	38.7	<1	4.4±0.9	618
B65	4725a8	2x	140	1.48	<1	<5	38.2	<1	3.93	582
1643c	4725a19	1.053x	271		2.1±0.3	11.8	47.8		33.7	
True Value			264		2.21	12.2	49.6		35.3	
200 ppb 3717a	4725a23	1x				189				
True Value						200				
500 ppb 3171a	4725a24	1x				472				
True Value						500				
1641c	4725a16	2000x						1470		
1641c	4725a25	2000x						1600±400		
True Value								1470		
20 ppb ICP-4	4725a17	1x		21±4						
20 ppb 3172a	4725a18	1x			19.8				20.0	
True Value					20.0				20.0	
20 ppb ICP-2	4726a12	1x								20.3
200 ppb ICP-2	4726a7	1x								204

*Results from proc. 4726a (20x)

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