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Wastewaters at SRS Where Heavy Metals are a Potential Problem

by

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1.0 INTRODUCTION

The principal objective of this report is to identify and prioritize heavy metal-containing wastewaters at the Savannah River Site (SRS) in terms of their suitability for testing of and clean-up by a novel bioremediation process being developed by SRTC. This process involves the use of algal biomass for sequestering heavy metal and radionuclides from wastewaters.

Two categories of SRS wastewaters were considered for this investigation:

(1) waste sites (primarily non-contained wastes managed by Environmental Restoration), and

(2) waste streams (primarily contained wastes managed by Waste Management).

An attempt was made to evaluate all sources of both categories of waste throughout the site so that rational decisions could be made with regard to selecting the most appropriate wastewaters for present study and potential future treatment.

The investigation included a review of information on surface and/or groundwater associated with all known SRS waste sites, as well as waters associated with all known SRS waste streams. Following the initial review, wastewaters known or suspected to contain potentially problematic concentrations of one or more of the toxic metals listed in Table 1 were given further consideration.

Table 1. Toxic Metals And Regulatory Limitations

Metal	Priority Pollutant [a]	National Drinking Water Std.[b] mg/l	Aquatic Life Freshwater Std. [c] *ug/l*	EPA Quality Criteria Freshwater *ug/l*	Water Quality Criteria Human Health *ug/l*	Maximum Contaminant Concentrations mg/l [e]	Waste Std., Regulatory Conc. Units ppm [f]
Aluminum	no	(.05)	0.174	-	-	-	-
Antimony	yes	0.005	-	1600	4308	1	-
Arsenic	yes	0.05	360	190	1.4	5	5
Barium	no	2	-	-	-	200	100
Beryllium	yes	0.004	-	5.3	1.17	0.1	-
Cadmium	yes	0.005	1.79	0.66 [d]	10	0.5	1
Chromium (III)	yes	0.1	984	120[d]	673077	10	5
Copper	yes	1.3	9.2	6.5[d]	-	-	-
Lead	yes	0.015	34	1.3 [d]	50	1.5	5
Mercury	yes	0.002	2.40	0.012[d]	0.153	0.2	0.2
Nickel	yes	0.1	789	56 [d]	4584	10	-
Selenium	yes	0.05	20	35[d]	10	5	1
Silver	yes	(.09)	1.23	1.2[d]	50	20	5
Zinc	yes	-	65	59[d]	-	700	-

[a] Classified by the Clean Water Act, Section 307

[b] Secondary DW standards in parentheses

[c] S.C. Aquatic Life Standard, criterion maximum concentration

[d] At hardness 50

[e] 40 CFR, 1, pg374, Section 261.24 (7/1/86)

[f] Federal Register 1992

2.0 WASTE SITES

Information on SRS waste sites was obtained by numerous discussions with Environmental Restoration (ER) personnel (see acknowledgment section) and by reviewing published and unpublished documents provided by ER and other SRS personnel. The two most useful and comprehensive documents obtained by this effort were the Savannah River Site Environmental Report for 1992 (WSRC-TR-93-075 and a 1992 report containing RCRA Facility Investigation/ CERCLA Remedial Investigation (RFI/RI) work plan summaries (WSRC-IM-92-117). These reports provided a starting point for the process of investigating and selecting the most appropriate waste sites for future bioremediation.

The initial screening effort resulted in the identification of over 30 ER waste units (listed in WSRC-IM-92-117) that were reported to contain surface and/or groundwaters with heavy metals as pollutants, often in combination with radionuclides and/or toxic organic compounds (Table 2). The current ER contact person for each of these sites was identified and interviewed to obtain the most recent information about each site.

Questions that were asked in the process of gathering information about the waste sites included the following:

What type of water is contaminated? (groundwater, surface water, neither, or both?)
Are characterization data available?
What metals are contaminants?
Is the water radioactive?
What other contaminants are present?
Is remediation of the water needed?
What is the status of a remediation plan?

In addition to holding discussions with ER personnel, recent (1993) groundwater monitoring data were obtained and screened for

Table 2. Units With Potential for Bioremediation of Toxic Metals and/or Radionuclides Showing Information Contacts

Section #[a]	Waste Unit Name	Building #	Contact & Phone #	Document # & Rev (#)
C-5	C-Area Burning/Rubble Pit	131-C	R. Plunkett (4-6797)	WSRC-RP-91-1122 (1)
C-9	CMP pits (7)	080-17g,-17.1g,-18g,18.1g,-18.2g,-18.3g,-19g	R. Soucha (4-6908)	wsrc-rp-91-1106(0)
C-10	D-Area Burning/Rubble Pits (2)	431-D, -1D	J. Hammock (4-1801)	WSRC-RP-90-485 (1)
C-11	F-Area Burning/Rubble Pits (3)	231-F, 1F,-2F	J. Hammock(4-1801)	WSRC-RP-90-486 (1)
C-12	K-Area Burning/Rubble Pit	131-K	J. Hammock (4-1801)	WSRC-RP-91-1117(1)
C-13	K-Area Rubble Pile	631-20G	J. Hammock (4-1801)	WSRC-RP-91-537(0)
C-14	L-Area Burning/Rubble Pit	131-L	J. Hammock (4-1801)	WSRC-RP-91-1124(1)
C-15	L-Area Rubble Pit 131-1L	131-1L	J. Hammock (4-1801)	WSRC-RP-91-595(0)
C-16	L-Area Rubble Disposal Pile 131-3L	131-3L	J. Hammock (4-1801)	WSRC-RP-91-547(1)
C-17	Misc. Chem Basin/Metals Burn Pit	731-4A,-5A	J. Hammock (4-1801)	WSRC-RP-92-483(0)
C-18	P-Area Burning/Rubble Pit	131-P	J. Hammock (4-1801)	WSRC-RP-91-1123(1)
C-19	R-Area Burning/Rubble Pits (2)	131-R, 131-1R	J. Hammock (4-1801)	WSRC-RP-91-1125(1)
D-2	488-D Ash Basin	488-D	K. Ward (4-6941)	WSRC-RP-91-102(0)
D-3	716-A Motor Shop Seep. Basin	904-101G	R. Plunkett (4-6796)	WSRC-RP-90-581(0)
D-4	Coal Pile Runoff Basins A,C,D,F,H,K,& P	189-C,-K,-P, 788-3A, 489-D, 289-F,-H	K. Ward (4-6941)	WSRC-RP-90-585(1)
D-5	D-Area Oil Seepage Basin	631-G	R. Plunkett (4-6797)	WSRC-RP-90-704(0)
D-6	F- and H-Area Retention Basins	281-3H, 281-3F	K. Kuelske (4-6659)	
D-8	K-Area Reactor Seepage Basin	904-65G	G. Blount (4-6775)	WSRC-RP-92-16(0)
D-9	L-Area Oil/Chem Basin	904-83G	G. Blount (4-6775)	WSRC-RP-90-1028(1)
D-10	L- and R-Area Acid/Caustic Basins	904-77G, 904-79G	G. Blount (4-6775)	WSRC-RP-90-584(1)
D-12	New TNX Seepage Basin	904-102G	R. Soucha (4-6908)	WSRC-RP-92-438(0)
D-13	Old F-Area Seepage Basin	904-49G	K. Kuelske (4-6659)	WSRC-RP-90-731(1)
D-14	Old TNX Seepage Basin	904-76G	K. Kuelske (4-6659)	WSRC-RP-91-872(0)
D-15	R-Reactor Seepage Basins	904-57G,-58G, 59G, 60G,-103G,-104G	K. Wise (4-1819)	WSRC-RP-91-12(0)
D-16	Road A Chemical Basin	904-111G	R. Soucha (4-6908)	WSRC-RP-93-374(0)
D-17	SRL Seepage Basins (4)	904-53G1,-53G2, 54G,-55G	K. Jerome (4-6786)	WSRC-RP--91-16(0)
E-1	Tank 16	241-H	T. Gaughan (4-6773)	WSRC-RP-90-497(0)
E-4	Gunsite 218	631-23G	H. Hickey (4-1802)	WSRC-RP-90-1048(0)
E-6	Burial Ground Complex	643-E, 643-7E	K. Lewis (4-6750)	WSRC-RP-90-1140(1)
E-7	Central Shops Sludge Lagoon	080-24G	R. Plunkett (-4-6797)	WSRC-RP-91-473(0)
E-10	Ford Building SeepageBasin	904-91G	G. Blount (4-6775)	WSRC-RP-91-597(0)
E-19	Silverton Road Waste Site	731-3A	K. Ward (4-6941)	WSRC-RP-90-1139(1)
E-20	TNX Burying Grounds	643-5T	K. Kuelske (4-6659)	WSRC-RP-91-1102(0)

[a] - Section numbers referenced in WSRC-IM-92-117 Rev. 2 RCRA Facility Investigation/CERCLA Remedial Investigation Workplan Summaries

measurements of toxic metal and radionuclides that exceeded regulatory limits. Sites with known or alleged metal contamination were also compared with groundwater monitoring data (summarized in WSRC-TR-93-075) to determine if drinking water standards were exceeded at these sites in 1992. This screening resulted in the selection of 25 RFI/RI waste sites that clearly have heavy metal polluted water. They are listed in Table 3 along with information used for evaluating the sites in terms of their suitability for incorporation into metal bioremoval studies.

A thorough review of WSRC-TR-93-075 also resulted in the identification of several other SRS facilities at which groundwater monitoring well samples contained heavy metal contamination. Table 4 lists all sites displaying heavy metal containing groundwaters along with the specific metal contaminant(s), the drinking water standard (DWS) for the metal, the highest concentration of the contaminant observed in 1992, the number of wells sampled, and the number of wells where drinking water standards were exceeded. As shown in the table, much of the groundwater contaminated with toxic metals is also contaminated with radionuclides and toxic organic compounds.

Following the data gathering process, the authors prioritized the ER waste units in terms of their potential for remediation by and compatibility with the heavy metal/radionuclide bioremediation process being developed. Since the initial studies are planned to be conducted in a non-radiation control area, the initial selection process was restricted to RFI/RI sites with non-radioactive, metal-containing waste waters that appear to require remediation and can be readily sampled by the researchers. Sites selected for initial study include the following three types, listed below in order of preference:

Coal Pile Runoff Basins (surface waters)
TNX Burying Ground (groundwater)
Road A Chemical Basin (groundwater)

Although only non-radioactive sites were selected for the initiation of laboratory studies, it should be emphasized that radioactive metal-containing wastewaters may be more amenable to the

Table 3. ER Waste Units With Best Potential for Bioremediation of Toxic Metals and/or Radionuclides Showing Selection Criteria

Sect.#[a]	Waste Unit Name	Building #	Type Water[b]	Char. Data Avail?	Metal Contam.[c]	Rad. Contam.[c]	Remed. Req'd
C-9	CMP Pits (7)	080-17g,-17.1g,-18g,18.1g,-18.2g,-18.3g,-19g	GW	YES	Pb	NO	YES
C-11	F-Area Burning/Rubble Pits (3)	231-F, 1F,-2F	GW	YES	Al,Sr	YES	YES
C-12	K-Area Burning/Rubble Pit	131-K	GW	YES	Al,Pb	NO	YES
C-14	L-Area Burning/Rubble Pit	131-L	GW	YES	Pb	NO	YES
C-15	L-Area Rubble Pit 131-1L	131-1L	GW	YES	Pb	NO	YES
C-17	Misc. Chem Basin/Metals Burn Pit	731-4A,-5A	GW	YES	Pb	YES	YES
C-18	P-Area Burning/Rubble Pit	131-P	GW	YES	Pb,Al	NO	YES
D-2	488-D Ash Basin	488-D	SW & GW	YES	Cd,Cr, As, Al,Co, Ni,	NONE	YES
D-3	716-A Motor Shop Seep. Basin	904-101G	GW	YES	Sb	YES	YES
D-4	Coal Pile Runoff Basins A,C,D,F,H,K,& P	189-C,-K,-P, 788-3A, 489-D, 289-F,-H	SW & GW	YES	Cd,Cr, As, Al,Co, Ni,	GW ONLY	YES
D-5	D-Area Oil Seepage Basin	631-G	GW	YES	Al,Pb	YES	YES
D-6	H-Area Retention Basin	281-3H	GW SW	YES	Al,Pb,Sb	YES	YES
D-8	K-Area Reactor Seepage BasSin	904-65G	GW?	YES	Al,Pb	YES	YES
D-9	L-Area Oil/Chem Basin	904-83G	GW	YES	Cd,Pb,Al	YES	YES
D-10	L- and R-Area Acid/Caustic bAsins	904-77G, 904-79G	GW	YES	Al,Pb	NO	YES
D-12	New TNX Seepage Basin	904-102G	GW&SW	YES	Al	NO	YES
D-13	Old F-Area Seepage Basin	904-49G	GW&SW ?	YES	Al,Cd	YES	YES
D-14	Old TNX Seepage basin	904-76G	GW	YES	Pb, Hg,Al	NO	YES
D-15	R-Reactor Seepage Basins	904-57G,-58G, 59G, 60G,-103G,-104G	GW	YES	Al,Cd,Pb,Hg	YES	YES
D-16	Road A Chemical Basin	904-111G	GW	YES	Hg, Pb	NO	YES
E-1	Tank 16	241-H	GW	NO	Al,Cd,Pb	YES	YES
E-6	Burial Ground Complex	643-E, 643-7E	GW	YES	Cd,Pb,Hg,Sb, Ni,Al	YES	YES
E-10	Ford Building Seepage Basin	904-91G	GW&SW	YES	Pb,Al	YES	?
E-19	Silverton Road Waste Site	731-3A	GW	YES	AL,Pb,Be,Sb	NO	YES
E-20	TNX Burying Ground	643-5T	GW	YES	Hg,Pb,Al	YES?	YES

[a] - Section numbers referenced in WSRC-IM-92-117 Rev. 2 RCRA Facility Investigation/CERCLA Remedial Investigation Workplan Summaries

[b] - GW - Ground Water
SW - Surface Water

[c] - Based on exceedances reported in 1992/1993 SRS Monitoring Reports

Table 4. SRS Waste Sites where heavy metal concentrations in underlying ground waters exceed drinking water standards (based on data from the SRS Environmental Report for 1992, WSRC-TR-93-075).

Site	contaminant	unit	standard	maximum value	#wells sampled	#wells above STD
A-Met Burn PIT	Pb	mg/l	0.015	0.029	6	1
M-Area HWMF	Sb	mg/l	0.005	0.015	41	2
	Pb	mg/l	0.015	0.073	42	5
	Hg	mg/l	0.0020	0.0024	42	1
	U	mg/l	0.0020	0.029	41	2
	toxic organics				42	40
	radionuclides				42	8
Misc. Chem Basin	Pb	mg/l	0.015	0.036	7	2
	radionuclides				7	1
	toxic organics				7	6
Motor Shop Oil Basin	Sb	mg/l	0.005	0.0085	7	2
	radionuclides				7	1
	toxic organics				7	6
Plume def. wells A&M	Cd	mg/l	0/005	0.0081	203	2
	Pb	mg/l	0.015	0.14	204	12
	Hg	mg/l	0.002	0.0034	209	1
	radionuclides				208	20
	Toxic organics				210	111
Silverton Rd. Waste Site	Sb	mg/l	0.0050	0.0097	29	3
	Be	mg/l	0.0010	0.0043	29	1
	Pb	mg/l	0.015	0.040	29	5
	Radionuclides				29	1
	Toxic organics				29	5
C-Dis. Basin	Pb	mg/l	0.015	0.16	2	2
	radionuclides				2	2
C-Seep. Basin	Pb	mg/l	0.015	0.044	4	1
	tritium				4	4
K-Acid/Caustic Basin	Pb	mg/l	0.015	0.022	9	2
K- BR Pit	Pb	mg/l	0.015	0.033	4	2
K-Dis. Basin	Pb	mg/l	0.015	0.090	3	3
	radionuclides				3	3
K-Ret Bas.	Pb	mg/l	0.015	0.017	4	1
	radionuclides				4	4

Table 4. (Cont'd)

Site	contaminant	unit	standard	maximum value	#wells sampled	#wells above STD
L-acid/caustic & Oil & chem. bas.	Cd	mg/l	0.005	0.068	4	1
	Pb	mg/l	0.015	0.047	4	1
	Pb	mg/l	0.015	0.033	4	1
	Cd	mg/l	0.005	0.0059	4	1
	Te-99				4	1
	radionuclides				4	2
	toxic organics				4	2
L-BR pit	Pb	mg/l	0.015	0.069	4	3
L-Dis. Bas.	Pb	mg/l	0.015	0.074	2	2
L-RX Seep. bas.	Pb	mg/l	0.015	0.046	4	1
	tritium				4	3
P-BR Pit	Pb	mg/l	0.015	0.049	4	2
	toxic organics				4	1
P-CPRB	Pb	mg/l	0.015	0.034	4	1
P-Dis. Bas.	Pb	mg/l	0.015	0.093	2	1
	tritium				2	2
P-Seep Bas.	Pb	mg/l	0.015	0.047	7	5
	tritium				7	7
	toxic organics				7	1
R-Acid/Caustic basin	Pb	mg/l	0.015	0.022	4	1
	radionuclides				4	1
R-Dis. bas.	Pb	mg/l	0.015	0.023	3	2
R-Seep Bas.	Cd	mg/l	0.005	0.096	21	16
	Pb	mg/l	0/015	0.020	21	1
	Hg	mg/l	0.0020	0.0080	21	6
	Sr-90				21	4
	radionuclides				16	50
	Sb	mg/l	0.005	0.0069	4	1
E-Area Haz. waste/mixed waste stor. fac.	Pb	mg/l	0.015	0.042	4	3
	tritium				4	1
Old Burial grnd	Cd	mg/l	0.0050	0.028	37	8
	Pb	mg/l	0.015	0.23	37	13
	Hg	mg/l	0.002	0.004	37	5
	radionuclides				48	35
	toxic organics				30	6

Table 4. (Cont'd)

Site	contaminant	unit	standard	maximum value	#wells sampled	#wells above STD
Radioactive waste bur. Grnds.	Pb	mg/l	0.015	0.033	45	2
	Hg	mg/l	0.002	0.0026	45	1
	Ni	mg/l	0.10	0.11	45	1
	radionuclides				45	33
	toxic organics				45	17
	more Pb &Sb					
F-Acid/Caustic Basin	Pb	mg/l	0.015	0.097	6	1
	radionuclides				6	2
F-Burma Rd. Rubble Pit	Pb	mg/l	0.015	0.025	5	4
	radionuclides				5	3
F-BRPits &RP	no metals					
F-canyon etc.	Pb	mg/l	0.015	0.86	10	5
	Sr-90				9	2
	Cs-137				3	1
	Toxic organics				10	6
	Radionuclides				10	5
F-CPRB	Pb	mg/l	0.015	0.15	5	3
	Radionuclides				5	1
	toxic organics				5	1
F-Process Sewer	Pb	mg/l	0.015	0.020	3	1
(inactive)	radionuclides				3	2
	toxic organics				3	2
F-Seep basin	Sb	mg/l	0.005	0.012	67	3
	Cd	mg/l	0.005	0.037	67	19
	Pb	mg/l	0.015	0.13	67	19
	Hg	mg/l	0.002	0.012	67	6
	Ni	mg/l	0.10	0.38	67	3
	U	mg/l	0.02	5.4	67	27
	radionuclides				73	58
	toxic organics				27	2
	NO2+NO3-N	mg/l	10	885	67	45
	As	mg/l	0.050	0.096	18	1
F-sludge land Appl. site	Pb	mg/l	0.015	0.15	4	3
	Hg	mg/l	0.002	0.0058	4	1
	radionuclides				4	2

Table 4. (Cont'd)

Site	contaminant	unit	standard	maximum value	#wells sampled	#wells above STD
Old F seep bas.	Sr-90				4	2
	U	mg/l	0.02	0.077	4	1
	radionuclides				4	3
	toxic organics				4	2
H-Canyon Bldg.	Pb	mg/l	0.015	0.063	4	2
	radionuclides				4	4
	toxic organics				4	2
H-CPRB	Pb	mg/l	0.015	0.036	4	2
	radionuclides				4	4
H-inactive Process sewer	Pb	mg/l	0.015	0.020	7	1
	tritium				7	7
H-Ret. basins	Sb	mg/l	0.005	0.012	5	2
	Pb	mg/l	0.015	0.024	5	2
	radionuclides				5	4
H-Seep bas.	Sb	mg/l	0.005	0.013	108	13
	As	mg/l	0.050	0.10	108	2
	Cd	mg/l	0.005	0.0098	108	1
	Co-60				40	10
	Pb	mg/l	0.015	0.071	108	13
	Hg	mg/l	0.002	0.0079	108	15
	NO2+NO3-N	mg/l	10	90	108	49
	radionuclides				113	88
	toxic organics				26	5
H-area tank farm	Cd	mg/l	0.005	0.34	25	9
	Pb	mg/l	0.015	1.0	32	19
	Hg	mg/l	0.0020	0.0039	32	8
	radionuclides				32	18
Z-Area Saltstone Facility	Sb	mg/l	0.005	0.008	3	1
N-BR Pits	Pb	mg/l	0.015	0.054	4	1
N-Diesel Spill	Pb	mg/l	0.015	0.021	9	1
	toxic organics				5	3
Ford Bldg Seep Basin	Pb	mg/l	0.015	0.022	5	1
	radionuclides				5	1
Hydrofluoric Acid Spill	Pb	mg/l	0.015	0.040	4	1
D-CPRB & Ash basins	Cd	mg/l	0.005	0.030	14	2
	Cr	mg/l	0.10	0.82	14	3
	radionuclides				14	4
	toxic organics				14	4

Table 4. (Cont'd)

Site	contaminant	unit	standard	maximum value	#wells sampled	#wells above STD
TNX Burying Ground	Pb	mg/l	0.015	0.016	5	1
	Hg	mg/l	0.002	0.0029	5	1
	radionuclides				5	2
	toxic organics				5	2
G-Area CMP Pits	Pb	mg/l	0.015	0.073	19	5
	toxic organics				19	3
	radionuclides				19	1
IWT sites	Pb	mg/l	0.015	0.026	2	1
Par sludge land appl. site	Pb	mg/l	0.015	0.015	4	1
NPR site	Cd	mg/l	0.005	0.008	14	1
	Pb	mg/l	0.015	0.044	14	2
	radionuclides				14	1
Road A Chem. Basin	Pb	mg/l	0.015	0.054	5	3
	Hg	mg/l	0.002	0.0027	5	1
Sanitary Landfill	Sb	mg/l	0.005	0.012	30	21
	Cd	mg/l	0.005	0.031	42	2
	Pb	mg/l	0.015	0.021	42	1
	Hg	mg/l	0.002	0.0029	42	1
	radionuclides				56	4
	toxic organics				56	15

bioremediation process being developed since it is expected that the process will be equally or more efficient at sequestering some radionuclides than non-radioactive heavy metals. Thus, the logistics of conducting the initial
laboratory work was the principal criterion used in selecting the sites listed above and described in more detail below.

2.1 Coal Pile Runoff Basins (CPRBs)

It was concluded that the coal pile run-off basins are the best ER waste units for the initial testing of a bioremoval process because they are non-radioactive, contaminated with a variety of heavy metals, readily available for sample collection (especially the surface waters) and believed to be in need of future remediation.

There are seven CPRBs at SRS located in A,C,D,F,H,K, and P-Areas (WSRC, 1990). They provide receptacles for runoff from rainfall on coal piles located at these seven sites. The coal was used to fuel facilities producing steam and electricity for SRS. The facilities at A- and D-Areas are currently active, while the facilities in the other five areas have been shut down. Coal piles in C- and F-Areas were removed in 1985. Currently, rainwater runoff from the remaining coal piles (A,D,H,K, and P) flows into the CPRBs via gravity flow through ditches and sewers. The coal is generally moderate-to-low sulfur coal (1-2%) . Chemical and biological oxidation results in water that has a very low pH (due to the formation of sulfuric acid) and high concentrations of dissolved heavy metals. Contaminants leaching into the coal pile runoff basins during rainfall eventually contaminate underlying soil and groundwater. Principal toxic metal contaminants of concern include Al, As, Be, Cd, Cr, Cu, Hg, Ni, Pb, and Se. All of these metals have been measured at levels above drinking water standards in samples collected from the basins. Table 5 shows levels of metal contaminants in the basins from three studies including a recent one made by the authors (Wilde et. al.,1994; unpublished data). Maximum levels ranged from 107-11300% of the drinking water standards. Drinking water standards were exceeded by the biggest margins for Al, Cd, Ni, Be, and Pb. The D-Area CPRB typically had the highest levels of metal contaminants and is thus

Table 5. Maximum concentrations (mg/l) of selected heavy metals based on samples collected from Coal Pile Run Off Basins (CPRBs) at SRS during three studies. Area of CPRB shown in parenthesis.

Metal	DW Std.[a]	Study#1[b]	Study#2[c]	Study#3[d]	% DW Std.
Al	0.050	124 (P)	NS[e]	56.8 (D)	113600
As	0.050	0.077 (D)	0.10 (D)	0.086 (D)	200
Be	0.004	0.0274 (D)	NS	0.014 (D)	685
Cd	0.005	0.047 (D)	0.056 (D)	0.024 (D)	11200
Cr(III)	0.100	0.222 (D)	0.42 (D)	0.035 (D)	420
Cu	1.3	1.395 (D)	NS	0.296 (A)	107
Hg	0.002	0.00036 (K)	0.005 (D)	NS	250
Ni	0.100	4.7 (D)	NS	0.657 (D)	4700
Pb	0.015	0.0149 (C)	0.09 (H)	0.049 (D)	600
Se	0.05	0.018 (H)	0.05 (D)	0.200 (D)	400

[a] National drinking water standard. All are primary except Al which is secondary.

[b] O'Brien and Gere 1987.

[c] Corbley, A. L. 1992.

[d] Wilde, et. al., 1994 (unpublished data)

[e] Not Sampled

our first choice as a source of wastewater for initial experimental work.

2.2 TNX Burying Ground

The TNX Burying Ground is located within the fence that surrounds TNX near the western border. This waste site was created in 1953 when an experimental evaporator containing 590 kg of uranyl nitrate exploded. Contaminated material included structural steel, tin, timber, drums, rags, and other items. The contaminated material was buried in four trenches, 6-8 feet below land surface. The waste trenches were rediscovered in 1980 during construction of buildings. Most of the contaminated material was removed in 1982 and 1983. However, an estimated 27 kg of uranyl nitrate along with other contaminants remain under buildings or in locations where the use of excavation equipment was restricted. This site contains Pb and Hg above DWS (WSRC, 1993). Recent (1993) groundwater monitoring data also revealed high levels of Al. This site also has substantial contamination by toxic organic compounds. The TNX Burying Grounds is considered a prime site for the metal bioremoval research program because of its proximity to and association with other bioremediation activities being conducted by the ESS Biotechnology Group based within the TNX complex.

2.3 Road A Chemical Basin

The Road A Chemical Basin is located about 0.5 mile southwest of the intersection of Highway 125 and SRS Road 6. This basin was 100 ft x 175 ft x 10 ft deep. It reportedly received miscellaneous radioactive and chemical aqueous waste for several years, but no records of the materials disposed of at the basin are available. The basin was closed and backfilled in 1973. It is currently part of the RFI/RI program. Recent data from groundwater monitoring wells below the basin reveal levels of Pb and Hg above drinking water standards. No other contaminants were observed above DWS during 1992 (WSRC, 1993). Thus, the site is highly suitable for obtaining water samples from the groundwater monitoring sampling program and and for testing of metal removal techniques in laboratories not set up for handling radionuclides or carcinogens.

2.4 Other Sites

Additional waste sites that appeared particularly well suited for bioremediation by the process being developed are listed below, followed by a brief description:

- Burning Rubble Pits
- D-Area Ash basins
- Chemicals, Metals & Pesticide Pits (CMPs)
- Miscellaneous Chemicals Basin/Metals Burning Pit
- Retention Basin in H-Area
- Seepage Basins
- Silverton Road Waste Site
- Burial Ground Complex
- Acid/Caustic Basins
- L-Area Oil & Chem. Basin

2.4.1 Burning Rubble Pits (BRPs)

There are numerous BRPs (Table 3) with heavy metal contaminated underlying groundwater. The BRPs are primarily unlined pits that have received combustible wastes which were allowed to accumulate and periodically burned . These pits have subsequently been taken out of service, and backfilled with soil and sediments to grade level. Eight burning rubble pits were operated in A-, K-, P-, C-, L-, R-, and G-Areas for several years. Groundwater below these pits has been contaminated with heavy metals along with radionuclides and organics. Metals of concern include Pb, Cr, and Hg. Groundwater remediation is deemed necessary and remediation plans are being developed. Based on recent groundwater monitoring data (WSRC 1993), the BRPs in L-,N-,P-, and K-Areas have metal contaminated groundwater with no radioactive contaminants. Thus, water from these sites should be suitable for experimentation in a non-radiation controlled laboratories.

2.4.2 D-Area Ash Basin

The 488-D basin is located in the southwestern part of D-Area. It began operation in 1951 and was used to intercept, stabilize, and provide passive treatment of ash sluice water prior to discharge to local surface streams. The basin ceased receiving sluice water when two additional basins were constructed. It was subsequently used for placement of dry ash and coal crusher reject materials. Sampling of monitoring wells consistently shows heavy metals and toxic organics above regulatory limits in the groundwater below this basin.

2.4.3 Chemicals, Metals & Pesticide Pits (CMPs)

The CMP Pits are located approximately one mile north of L-Area and one mile northeast of the 131-3L Rubble Disposal Area. This complex originally consisted of seven unlined pits which were designed to receive non-radioactive wastes, such as spent solvents, pesticides and toxic metals. The pits were used from 1971 until 1979. In 1984, the pits were excavated, waste materials were removed, and the area was backfilled and capped with a geosynthetic material. Recent groundwater monitoring has demonstrated significant contamination by heavy metals. Remediation is deemed necessary and a formal remediation plan has not been developed.

2.4.4 Miscellaneous Chemicals Basin/Metals Burning Pit

This waste unit actually comprised two separate facilities in close proximity. Both are suspected to have polluted underlying ground waters. Contaminants of concern from the miscellaneous chemicals basin include Al (range 3483-7488 ppm), and Pb (range 2.65-10.5 ppm). Contaminants of concern from the metals burning pit include Al (range 1430-95,570 ppm) (WSRC, 1992).

2.4.5 H-Area Retention Basin

The old H-Area Retention basin (281-3H) is located just south of Road E near the intersection of Road E and Road 4. This basin was used for temporary emergency storage for cooling water derived from the chemical separations process and containing radionuclides and trace quantities of other chemicals. Groundwater monitoring data show Al, Pb, and Sb to be among the contaminants exceeding DWS.

2.4.6 Seepage Basins

Several seepage basins at SRS are considered waste sites and have potential for clean-up using bioremediation. These include the 716-A Motor Shop Seepage Basin, the D-Area Oil Seepage Basin, the new TNX Seepage Basin, the old F-and H-Area Seepage Basins, the Ford Building Seepage Basin and seepage basins in all the reactor areas. Some of these basins still contain standing waters and all have underlying groundwater contaminated with metals and other pollutants, especially radionuclides.

2.4.7.Silverton Road Waste Site

The Silverton Road Waste Site is located about 1.5 miles west-southwest of A/M Area. This unit consists of an approximately 700 ft. x 300 ft. x 7 ft deep area that existed as an open pit prior to construction of SRS. During and after construction of SRS, the pit and surrounding area was used for the disposal of construction debris such as metal shavings, drums, and storage tanks. Operations at this location ceased in 1974, and the waste material is presently covered with soil and vegetation. Underlying groundwater contains several constituents exceeding DWS. These include Sb, Be, and Pb.

2.4.8. Burial Ground Complex (BGC)

The BGC occupies approximately 194 acres in the central part of SRS between the F and H Separations Areas. It consists of several adjacent facilities which were former or are current disposal sites for hazardous and radioactive wastes and spent solvents generated from plant processes. Groundwater below the BGC is contaminated with numerous toxic metals in addition to radionuclides and toxic organic compounds.

2.4.9 Acid/Caustic Basins

Acid/caustic basins are located in several areas (F,H,K,L,P, and R) of SRS. These basins are unlined earthen pits, approximately 50 ft x 50 ft x 7 ft deep, that received dilute sulfuric acid and sodium hydroxide solutions used to regenerate ion exchange units used in water purification processes at the reactor and separations areas. Other wastes discharged to the basins included rinse water from the ion exchange units, steam condensate, and runoff from the spill containment enclosures in the storage tanks. The basins allowed mixing and neutralization of the dilute solutions before their discharge to nearby streams. All of the basins were constructed between 1952 and 1954. They were taken out of service between 1964 and 1982. These basins are part of the RFI/RI program, and closure, characterization and remediation plans are in various stages of development within the various areas. Basins in L- ands R- Areas are the farthest along in this process. However, all of the basins are expected to require remediation activities in the future.

2.4.10 L-Area Oil and Chemical Basin

The L-Area Oil and Chemical Basin is located in the southeastern portion of L-Area, just outside the L-Area perimeter fence. This basin (118 ft x 79 ft) was put into operation in 1961 and continued to receive waste liquids until 1979. Contaminants of concern include Cd, Pb, Cr, and Hg, along with radionuclides and organics (WSRC, 1992). Groundwater monitoring data revealed that concentrations of Cd and Pb exceeded DWS in groundwater below the basin.

3.0 WASTE STREAMS

In contrast to the case with waste sites, documents comprehensively describing waste streams in various sectors of SRS could not be found. Thus, a slightly different approach was taken to identify and prioritize the waste streams in terms of their suitability for the bioremoval process. Key personnel throughout the site, such as environmental coordinators and site waste coordinators, were canvassed in an attempt to obtain information relevant to the selection process.

The SRS (Fig. 1) is subdivided into 18 principal areas. These are listed in Table 6, along with major activities previously and/or currently conducted at them. In compiling information about waste streams in these areas, we attempted to determine the following:

General nature of the waste-generating process
Presence of radionuclides
Major metals present
Whether waste is currently generated
Volume stored or rate of generation
Availability of analytical data
Current method of treatment or disposal
Need for further treatment; problems with treatment or disposal

Information gained during the investigation is catalogued (according to site area) in Table 7. Only metal-containing aqueous wastes are included. Those areas listed in Table 6 but not in Table 7 proved not to contain wastes of interest within the scope of our study.

Three major criteria were used in selecting those waste streams most amenable to bioremediation process development. First, there must be a need (or an anticipated need) for present or future treatment of the waste. Second, streams without radioisotopes are best suited to process development, with those containing low level contamination being less suitable and those with high level contamination being unsuited to experimental purposes. Third, the

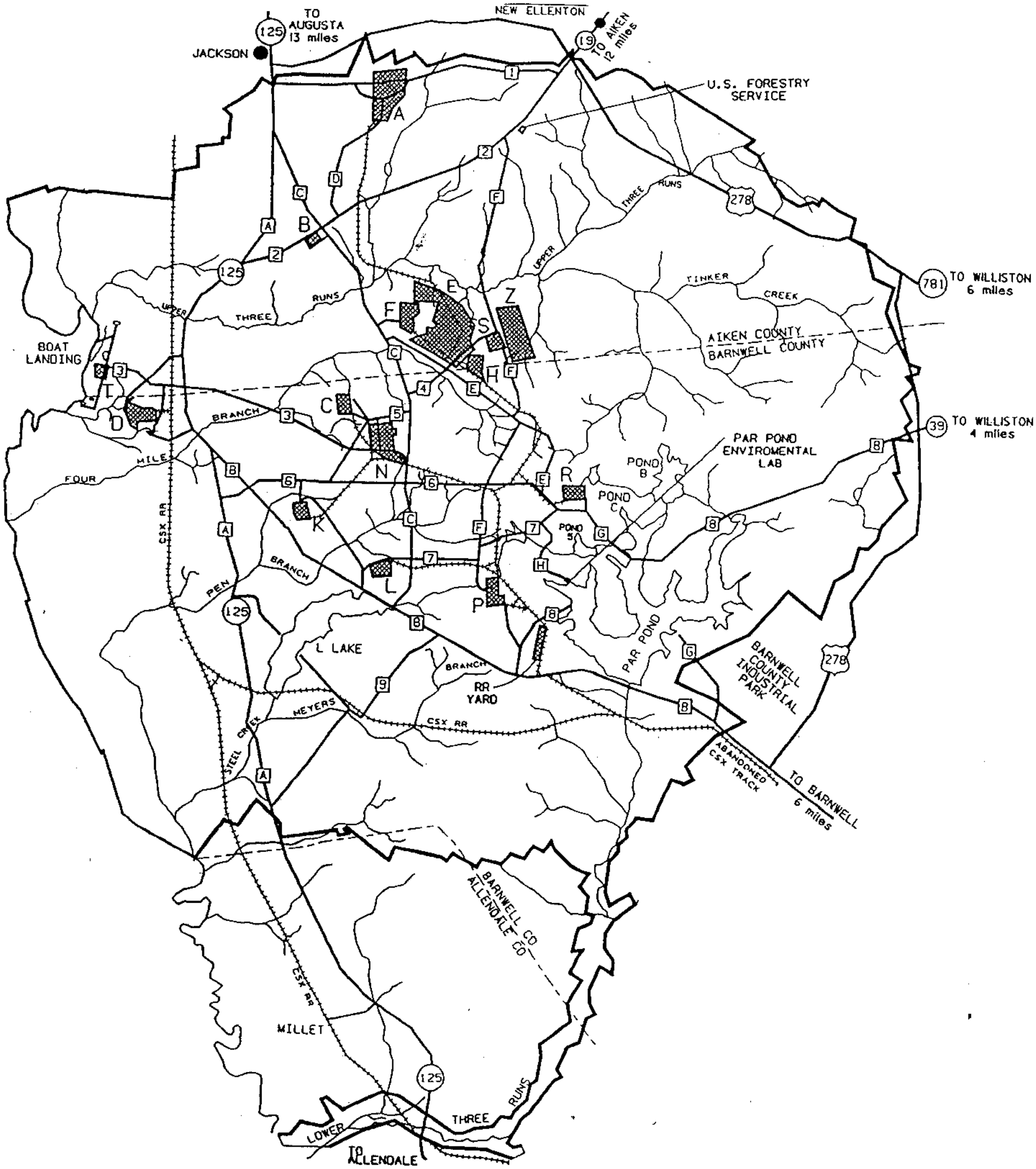

Figure 1. Map of SRS Showing Principal Site Areas

Table 6. Past and Present Activities Within Principal Areas of SRS

Area	R	S	FF	RW	SW	L
A	-	-	-	X	X	X
B	-	-	-	-	X	X
C	X	-	-	-	X	-
D	-	-	-	X	X	X
E	-	-	-	X	-	-
F	-	X	-	X	X	X
G*	-	-	-	X	X	X
H	-	X	XT	X	X	X
K	X	-	-	-	X	-
L	X	-	-	-	X	-
M	-	-	XR	X	X	X
N	-	-	-	X	X	-
P	X	-	-	-	X	-
R	X	-	-	-	-	-
S	-	-	-	X	X	X
TNX	-	-	-	-	X	X
Y	-	-	-	-	-	-
Z	-	-	-	X	-	-

Activities Code:

R	Reactor
S	Separations
FF	Fuel Fabrication (R=reactor fuels; T=tritium)
RW	Radioactive or mixed waste management
SW	Sanitary waste treatment
L	Laboratory activities

*Facilities not confined to any of the other specific areas are collectively considered to exist in G-Area.

Table 7. Metal-Containing Wastes at SRS

Area	Description	Radioactive?	Metals	Volume	Currently Generated?	Analysis Available?	Current Treatment	Additional Treatment Needed?
A	Photo lab waste	No	Ag	1200-1600 gal/yr	Yes	Sampled post-treatment	Ion exchange (A-Area Ag Recovery Unit)	No
A	Medical Dept. photo waste	No	Ag	350 gal/yr	Yes	Sampled post-treatment	Ion exchange (N-Area Ag Recovery Unit)	No
A	SRTC lab wastes	Yes (low level)	Hg, Cr, U, Pu	52,000 gal on hand	Yes	Yes	Ion exchange, storage	Eventual disposal via LLW (haz.) and landfill (nonhaz.)
A	Wastewater Neutralization Facility	No	Hg	5000 gal on hand	No	Yes	Ion exchange upon demand	No
A	Met Lab wastes	No	Ni, Cr, Fe, Al, Cu, others?	4 gal/yr now, up to 20 gal/mo future	Yes	In progress	Neutralization, storage	Procedure being estab. to ppt. Cr, allowing discharge to sanitary sewer
A, B, C, D, F, G, H, K, L, P, S, TNX	Sanitary wastewater treatment plants	No	Pb, Zn, Cu, Al	Up to 4,000,000 gal/day (H Area)	Yes, but some will shut down in March '95	Yes	Conventional wastewater treatment , land application	Not at present. Metal levels occas. near land application limits
C	Disassembly basin	Yes	Cs, Pu, Al, Fe, others	3,550,000 gal present	No	Partial	None	Yes

Table 7 (Cont'd).

Area	Description	Radioactive?	Metals	Volume	Currently Generated?	Analysis Available?	Current Treatment	Additional Treatment Needed?
D, N	Hg thiocyanate lab waste	Yes	Hg	146 drums on hand	No	Yes	Ion exchange (Duolite GT-73)	Columns tend to plug
D	Water Quality Lab waste	Yes	Hg	?	yes	yes	Heavy water recovery	No
F	Separations wastes	Yes	Similar to H-Area separations waste	Current: 5000 gal/mo. Future: 20,000 gal/mo.	On small scale	Yes	ITP, ETF, immobilization	No
F	Separations-FB-Line Waste (from chillers)	Yes	Pu, Cr	27 gal. on hand	Intermittently	In prep.- NMPSB 0930009	Recycled or sent to Mixed Waste Storage Facility	No
F	Cooling maintenance shop	No	Pb	<1 drum/yr	Yes	In prep.	Recycling & reuse	No
F	Separations-Evaporator overhead	Yes	Similar to other separations wastes, but lower conc.	formerly 160,000 gal/d, very little currently	Yes	Yes	ETF	No
H	CIF blowdown water	Yes	Pb, Sr, Cs, Hg, poss. others	75,000 gal/yr projected	Projected for 1996	Predicted, WSRC TR 93623	Solidification @ Saltstone	Volume reduction desirable

Table 7 (Cont'd).

Area	Description	Radioactive?	Metals	Volume	Currently Generated?	Analysis Available?	Current Treatment	Additional Treatment Needed?
H	Separations wastes	Yes	Current: Pu, Fe. During normal operation: Pu, Sr, Cs, Hg, Cr, U, Fe, Al, Ag, Ba, Tc, Pm, Ni, Th	Current: 5000 gal/mo. Previous : 30,000 gal/mo.	On small scale	Partial	ITP, ETF, DWPF (vitrification),Salt stone (concrete)	No
H	Separations-Filter backwash water, resin regeneration water	Yes	Al, Zn, Cs, Se, Co	29,000-45,000 gal/mo.	Yes	Yes	pH adjustment, sent to tank farm (hi level) or GP evaporator (lower level)	No
K	Disassembly basin	Yes	Cs, Pu, Al, Fe, others	3,400,000 gal present	Yes (contam. continues due to presence of fuel)	Yes	ion exchange sludge vacuumed	Disposal of eluted contaminants, resin, sludge
L	Disassembly basin	Yes	U, Th (sludge), Cs, Zn (water)	3,400,000 gal present	Yes (contam continues due to presence of fuel)	Yes SRTC-ADS-93-0411	ion exchange, sludge vacuumed	Disposal of eluted contaminants, resin, sludge
M	Analytical and Metallurgy Lab effluents	No	As, Ba, Cu, Ag, Pb	260 gal/wk.	Yes, but will move soon	Yes	DETF (metal ppt. then pressure filt.	No

Table 7. (Cont'd).

Area	Description	Radioactive?	Metals	Volume	Currently Generated?	Analysis Available?	Current Treatment	Additional Treatment Needed?
N	Photographic wastes: EBASCO Svcs., Medical Dept., Paint Shop, Document Ctrl.	No	Ag	350 gal on hand	Yes	Sampled post-treatment	Ion exchange (N Area Ag Recovery Unit)	No
N	Wash water-bubble tower and gas tank cleanup	No	Hg, Cr	4 drums on hand	No	Yes	offsite vendor	No
P	Disassembly basin	Yes	Cs, Pu, Al, Fe, others	4,800,000 gal present	Yes (contam. continues due to presence of fuel)	Yes	Ion exchange, sludge vacuumed	Disposal of eluted contaminants, resin, sludge
R	Disassembly basin	Yes	Cs, Pu, Al, Fe, others	4,500,000 gal. present	No	Yes	None	Yes
S	Lab & process wastewater (from waste immobilization activities)	Yes	Hg (current), various radionuclides (future)	200,000 gal present	Cold runs only	Yes- DHEC permit proposal, CPES document	Vitrification/storage. Steam stripping/reduction of Hg	No
TNX	Lab waste from IDMS sample analyses	No	Hg	2320 gal/yr	Yes	Yes	Offsite vendor	No

Table 7. (Cont'd)

Area	Description	Radioactive?	Metals	Volume	Currently Generated?	Analysis Available?	Current Treatment	Additional Treatment Needed?
Z	Saltstone facility wastes (from waste immobilization activities)	Yes (low leve/mixed waste)	Cs^{137}, misc. beta/gamma, Cr(VI)	Current: 15,000 gal/mo, future: 3-6 X 10^6 gal/yr	Yes	WSRCTR94-0364 (in prep)	Immobilization/ storage	No

streams should be generated or stored in sufficient quantities to make the cleanup effort worthwhile.

In this manner, the streams catalogued in Table 7 can rather quickly be reduced to a handful of candidates. Among these are the CIF (Consolidated Incineration Facility) blowdown water and a D Area lab waste containing Hg thiocyanate. These contain low level radiation, requiring the use of an RCA or of simulated wastes. It is also possible that algal biosorbents might provide a useful alternative or adjunct to the present ion exchange resin used to remove Hg from various lab wastes and Wastewater Neutralization Facility wastes. Future candidates are sanitary wastewater treatment facilities in which metals may eventually pose a sludge disposal problem. Bioreme-diation processes might also find application in the ongoing cleanup of reactor disassembly basins, but these wastes are not suitable for the initial development of such processes due to their high radiation levels.

The above-listed waste streams are described in more detail as follows:

3.1 Consolidated Incineration Facility (CIF) Blowdown Water (H-Area)

The CIF is slated for completion in 1996. It is expected to produce about 75,000 gal/yr of blowdown water, containing Pb, Hg, ^{90}Sr, ^{137}Cs, and possibly other metals. Evaluation of a treatment scheme, involving pH adjustment and coprecipitation of metals with iron followed by sulfide treatment to remove Hg, indicated that Cs and Sr were not affected by the treatment, and that the use of sulfide presented a disposal problem (WSRC-RP-92-457). Current plans are to solidify the blowdown waste (in cement) in the same manner as solid CIF wastes in order to minimize permitting requirements and avoid delays in startup of the facility. However, a cost-effective means of reducing the volume of blowdown waste requiring solidification and permanent storage would be of value.

3.2 Hg Thiocyanate Lab Waste (D, N Areas)

A lab waste containing Hg thiocyanate, heavy water, permanganate, and a variety of organics was formerly generated in D-Area. 100 drums (classified as nonhazardous) remain in storage at D Area, and 46 drums (classified as hazardous) are stored in N Area. These require cleanup before their heavy water can be recycled. The current treatment option consists of ion exchange using Duolite GT-73 resin, which reduces Hg content to acceptable levels. Resin performance is sometimes impaired due to clogging of the columns, and the system is currently undergoing modification to overcome this problem.

3.3 SRTC Laboratory Wastes (A-Area)

Wastes collected via low level (high and low activity) drains in SRTC labs are stored in tanks in A Area, along with lab wastewater generated during tests associated with the development of vitrification processes in S Area. The waste is periodically treated with Duolite GT-73 resin to remove mercury introduced by a contaminated drain, and will eventually be sent to the tank farm when tanks are full.

3.4 Wastewater Neutralization Facility (A-Area)

The 735-11A Neutralization Facility has about 5000 gal of wastewater contaminated with mercury, urine, and nitric acid. This material is classified as a RCRA waste. Current treatment is by passage through Duolite GT-73 ion exchange resin.

3.5 Sanitary Wastewater Treatment Plants (A, B, C, D, F, G, H, K, L, P, S, T Areas)

Domestic wastewater, which sometimes contains significant amounts of Pb, Zn, Cu, and/or Al, is processed by a system of sanitary waste water treatment plants located in various areas. The treated liquid meets water quality standards, but it has been noted that the sludge sometimes contains metals at levels approaching allowable limits for land application. It is conceivable that additional treatment might be needed if metal levels should rise or regulatory limits should change. Several waste water treatment units are expected to close soon because of the transition to a centralized facility, but the treatment method (and hence the sludge composition) is not expected to change.

3.6 Disassembly Basins (C, K, L, P, R Areas)

Although no reactors are operating at the present time, disassembly basins at C, K, L, P, and R Reactors contain water and sludge contaminated with radionuclides and metals (e.g. Cs, Pu, Al, Fe). In K, L and P disassembly basins, a mixed bed ion exchange resin is used intermittently to reduce cation and anion levels in standing water. This is not done at C and R basins because little or no fuel is present and hence contamination levels are much lower. Resin is regenerated by the RBOF facility in H Area and the eluted contaminants are sent to a waste tank for storage. Spent resin is also stored pending the selection of a disposal method. An upgrade of the deionizing system is planned and may involve reverse osmosis carried out by an outside vendor. Sludge is periodically vacuumed from disassembly basins and is currently being stored in the absence of a disposal method.

4.0 CONCLUSIONS

The purpose of this endeavor was to identify potential SRS wastewaters that are amenable to clean-up by a novel bioremediation process being developed at SRS, and to select three sites for experimentation while the process is in the development stage. The three wastewaters selected for study in the short term were the CPRBs, the TNX Burying Grounds and the Road A Chemical Basin. These sites all have significant heavy metal contamination, are not radioactive, and may be readily sampled. The CPRBs contain standing water and all three wastewater sources have monitoring wells where contaminated groundwater samples can be obtained. All of these sites are in need of remediation and no formal remediation plan is available.

Numerous other sources of SRS wastewater amenable to clean-up by the process under development were identified. These were discussed in Sections 2 and 3 of this report. While less suitable than the aforementioned sites for immediate experimental work, several of the wastewaters identified in the survey have considerable potential for cleanup in the future by bioremediation.

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