APPENDIX B
COMPOST BIOREACTOR GROUNDWATER TREATMENT AREA DESIGN CALCULATIONS

MEDEP Data 8/10/2011
Total Metals
Callahan Mine Superfund Site

Metal		Units	602-S	602-D	605-S	605-D	SB1142-S	SB1142-D	SB1123	604-S	Average*
Aluminum	Al	mg/L	0.000	0.000	0.000	0.087	277	3.92	26.85	0.000	4.41
Antimony	Sb	mg/L	0.014	0.006	0.015	0.007	0.045	0.035	0.053	0.034	0.023
Arsenic	As	mg/L	0.004	0.001	0.007	0.005	0.376	0.015	0.048	0.030	0.016
Barium	Ba	mg/L	0.009	0.007	0.112	0.007	0.639	0.052	0.088	0.009	0.041
Cadmium	Cd	mg/L	0.002	0.000	0.001	0.000	0.124	0.009	0.021	0.002	0.005
Calcium	Ca	mg/L	179	90.7	19.0	2.59	946	242	588	624	249
Chromium	Cr	mg/L	0.008	0.009	0.009	0.010	0.101	0.015	0.042	0.008	0.014
Cobalt	Co	mg/L	0.000	0.000	0.000	0.000	0.100	0.001	0.027	0.019	0.007
Copper	Cu	mg/L	0.002	0.001	0.003	0.004	5.26	0.324	0.703	0.002	0.148
Iron	Fe	mg/L	0.073	0.101	0.057	0.035	247	5.02	30.63	21.33	8.18
Lead	Pb	mg/L	0.000	0.000	0.000	0.000	4.99	0.283	0.885	0.026	0.171
Magnesium	Mg	mg/L	71.2	88.0	77.9	3.02	272	341	67.9	23.4	96.0
Manganese	Mn	mg/L	0.18	0.08	0.01	0.01	25.0	1.11	6.51	7.51	2.20
Molybdenum	Mo	mg/L	0.017	0.060	0.047	0.146	0.170	0.085	0.040	0.026	0.060
Nickel	Ni	mg/L	0.001	0.001	0.002	0.001	0.209	0.004	0.045	0.108	0.023
Potassium	K	mg/L	16.3	61.7	65.7	10.4	26.7	131	18.8	4.91	44.1
Selenium	Se	mg/L	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.011	0.002
Silver	Ag	mg/L	0.000	0.000	0.000	0.001	0.026	0.002	0.003	0.003	0.001
Sodium	Na	mg/L	23.7	154	45.56	235	10.9	3274	116	6.28	551
Vanadium	V	mg/L	0.000	0.000	0.000	0.001	0.121	0.002	0.020	0.000	0.003
Zinc	Zn	mg/L	0.398	0.032	0.062	0.030	69.13	2.08	6.62	3.74	1.85
	SO4	mg/L	654	798	109	96	1967	1872	1339	1345	888
	pH	s.u.	7.41	7.15	8.05	7.95	7.74	7.77	7.19	7.01	7.50

Concentrations less than the reporting limit shown as the reporting limit.

*Average calculated without SB1142-S as those data are considered anomalously high and non-representative compared to historical data.

Average selected for design purposes

MEDEP Data 8/10/2011
Dissolved Metals
Callahan Mine Superfund Site

Metal		Units	602-S	602-D	605-S	605-D	SB1142-S	SB1142-D	SB1123	604-S	Average*
Aluminum	Al	mg/L	0.000	0.000	0.000	0.076	0.000	0.000	0.000	0.000	0.011
Antimony	Sb	mg/L	0.011	0.005	0.009	0.008	0.055	0.014	0.017	0.022	0.012
Arsenic	As	mg/L	0.007	0.008	0.009	0.014	0.009	0.009	0.009	0.006	0.009
Barium	Ba	mg/L	0.213	0.180	0.307	0.239	0.076	0.275	0.064	0.092	0.196
Cadmium	Cd	mg/L	0.002	0.000	0.001	0.000	0.004	0.001	0.004	0.001	0.001
Calcium	Ca	mg/L	172	90.2	19.0	2.74	649	225	543	587	234
Chromium	Cr	mg/L	0.004	0.007	0.006	0.007	0.007	0.008	0.005	0.008	0.006
Cobalt	Co	mg/L	0.001	0.002	0.004	0.002	0.073	0.001	0.021	0.016	0.007
Copper	Cu	mg/L	0.001	0.000	0.002	0.000	0.000	0.003	0.003	0.000	0.001
Iron	Fe	mg/L	0.106	0.055	0.061	0.054	44.2	0.164	0.061	0.018	0.074
Lead	Pb	mg/L	0.005	0.000	0.000	0.002	0.007	0.000	0.000	0.000	0.001
Magnesium	Mg	mg/L	69.8	86.8	79.1	2.85	127	327	37.7	21.9	89.3
Manganese	Mn	mg/L	0.171	0.048	0.005	0.015	19.57	0.85	5.62	7.20	1.99
Molybdenum	Mo	mg/L	0.011	0.046	0.036	0.110	0.01	0.06	0.01	0.02	0.041
Nickel	Ni	mg/L	0.001	0.001	0.000	0.001	0.16	0.00	0.03	0.10	0.019
Potassium	K	mg/L	15.2	59.7	64.1	9.74	3.88	125	14.8	5.26	42.0
Selenium	Se	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.001
Silver	Ag	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
Sodium	Na	mg/L	20.5	146	39.0	220	6.46	3220	113	5.23	538
Vanadium	V	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.002
Zinc	Zn	mg/L	0.56	0.19	0.19	0.22	43.9	0.28	3.01	3.14	1.08

Concentrations less than the reporting limit shown as the reporting limit.
*Average calculated without SB1142-S as those data are considered anomalously high and non-representative compared to historical data.

Comparison of RI Seep Data, RI Well data, and MEDEP Well Data
Callahan Mine Superfund Site

Metal		Units	RI Seeps Total	RI Seeps Diss	RI Wells Total	RI Wells Diss	DEP Wells Total	DEP Wells Diss	
Aluminum	Al	mg/L	1.45		0.445	0.482	4.41	0.011	
Antimony	Sb	mg/L	0.006		0.001	0.001	0.023	0.012	
Arsenic	As	mg/L	0.004		0.006	0.006	0.016	0.009	
Barium	Ba	mg/L	0.012	0.011	0.035	0.031	0.041	0.196	
Cadmium	Cd	mg/L	0.024	0.023	0.000	0.000	0.005	0.001	
Calcium	Ca	mg/L	231	234	155	135	249	234	
Chromium	Cr	mg/L			0.002	0.001	0.014	0.006	
Cobalt	Co	mg/L	0.004	0.003	0.003	0.002	0.007	0.007	
Copper	Cu	mg/L	0.125	0.044	0.015	0.003	0.148	0.001	
Iron	Fe	mg/L	1.47	0.181	6.08	5.27	8.18	0.074	
Lead	Pb	mg/L	0.031	0.001	0.010	0.003	0.171	0.001	
Magnesium	Mg	mg/L	28.3	27.8	72.2	67.2	96.0	89.3	
Manganese	Mn	mg/L	0.675	0.656	1.29	1.03	2.20	1.99	
Molybdenum	Mo	mg/L	0.000				0.060	0.041	
Nickel	Ni	mg/L	0.013	0.012	0.005	0.004	0.023	0.019	
Potassium	K	mg/L	5.99	6.14	34.3	35.1	44.1	42.0	
Selenium	Se	mg/L	0.002	0.002	0.003	0.003	0.002	0.001	
Silver	Ag	mg/L	0.001		0.002	0.002	0.001	0.000	
Sodium	Na	mg/L	41.1	41.5	439	422	551	538	
Vanadium	V	mg/L	0.004		0.002	0.002	0.003	0.002	
Zinc	Zn	mg/L	7.12	6.73	0.429	0.26	1.85	1.08	
sulfate	SO4	mg/L	453	-			888	-	
	pH	s.u.	6.8				7.5		(pH = arith. ave.)

RI seep data summary based on RI Tables 4.4.2 and 4.4.1: SP-510, -511, -512, -513, SP-614
RI wells data summary based on RI Table 4.5-3 and wells MW-601, -602 S/D, -603 S/D, -604 S/D, -605 S/D, -722, and PZ-601
ME DEP data summary based on wells MW-602 S/D, -604S, -605 S/D, SB1142D, and SB1123

DEP Wells total selected for design.

Calculation of m-mols/L Sulfate Required for Preciptation
Callahan Mine Superfund Site

Metal	Mol Wt	S:Me	RI Seeps Total m-mols/L	RI Seeps Diss m-mols/L	RI Wells Total m-mols/L	RI Wells Diss m-mols/L	DEP Wells Total m-mols/L	DEP Wells Diss m-mols/L		MeS	ksp
Cadmium 2+	112.40	1	0.00021	0.00020	0.00000	0.00000	0.00004	0.00001		CdS	8.00E-27
Cobalt 2+	58.90	1	0.00006	0.00005	0.00005	0.00004	0.00012	0.00011		CoS	4.00E-21
Copper 2+	63.50	1	0.00196	0.00069	0.00024	0.00005	0.00234	0.00002		CuS	6.00E-37
Iron 2+	55.80	1.5	0.03965	0.00488	0.16339	0.14158	0.21985	0.00199		FeS	6.00E-19
Lead 2+	106.40	1	0.00029	0.00001	0.00009	0.00002	0.00160	0.00001		PbS	3.00E-29
Manganese 2+*	54.90	1	0.01230	0.01195	0.02346	0.01881	0.04007	0.03619		MnS	2.50E-13
Nickel 2+	58.70	1	0.00022	0.00021	0.00009	0.00007	0.00040	0.00032		NiS	3.00E-19
Silver 2+	107.90	1	0.00000	0.00000	0.00002	0.00001	0.00001	0.00000		AgS	6.00E-51
Zinc 2+	65.40	1	0.10889	0.10294	0.00656	0.00393	0.02830	0.01657		ZnS	2.00E-25
Total m-mole/L metal			0.16	0.12	0.19	0.16	0.29	0.06	milli-moles metal/ liter		
Sulfate	96			0.0			9.2	milli-moles sulfate/ liter			

* sulfate demand by manganese reduced by 50% because of high MnS solubility product
ksp from http://www.csudh.edu/oliver/chemdata/data-ksp.htm

DEP Wells total selected for design.

Bioreactor Area and Volume Calculation for Given Flow and Sulfide Production
Callahan Mine Superfund Site

Surface Area Calculation				
Assumed flow =	8.00	gpm	(Input variables are highlighted)	
=	30.28	L/min	3.785411	L/gal
L /d =	43607.93	L/day	1440	min/day
milli-mols metal / L =	0.29			
milli-mols metal /d =	12646	milli-mols/d		
Assume sulfide production =	0.15	mol/d/m3		
=	150	milli-moles/d /m3		
Media requirement =	84.3	m3		
	110.3	cy	1.3079029	cy/m3
Assumed thickness =	3.0	feet		
	0.91	meters	3.2808	ft/m
Surface Area =	992	sq ft	(if vertical sidewalls)	
Surface Area =	92	sq m		
Retention Time Calculation				
Media thickness =	3.0	feet		
	0.91	meters	3.2808	ft/m
Media bulk volume =	2977	cf		
=	110	cy	27	cf/cy
	84	m3	1.3079029	cy/m3
Porosity =	0.32			
Liquid volume =	953	cf		
=	26978	L	28.31685	L/cf
Calculated retention time =	0.62	days		

Reactor Volume for Given Flow and Retention Time
Callahan Mine Superfund Site

Assumed flow =	8.00	gpm	(Input variables are highlighted)	
Assumed liters /min =	30.3	L/min	3.785411	L/gal
=	11520.0	gal/day	1440	min/day
Assumed retention time =	2.00	days		
Porosity =	0.32			
Liquid volumn retained =	23040.0	gal		
Reactor / media volume =	72000.0	gal		
=	9625	cf	7.4805	gal/cf
=	356	cy	27	cf/cy
=	273	m3	1.3079029	cy/m3
Media thickness =	3.0	feet		
Media thickness =	0.91	meter	3.2808	ft/m
Calculated reactor surface arrea =	3208	sq ft	(if vertical sidewalls)	
=	298	sq m	10.76365	sq ft /sq m