

ATTACHMENT 1

LOCKHEED MARTIN**Lockheed Martin Idaho Technologies Company****INTERDEPARTMENTAL COMMUNICATION**

Date: September 15, 1997

To: M. V. Carpenter MS 2107 6-8467

From: C.P. Oertel ^{apocrypha} MS 5202 6-3541

Subject: RESULTS OF INSITU GAMMA RAY MEASUREMENTS AT ARA 23 -
CPO-04-97

We have completed insitu gamma ray analyses of 88 points located in the rockpile area of ARA 23. These measurements were performed using a 30% efficient p-type germanium detector held at a distance of one meter above ground. Each count duration was 600 seconds live time and all spectra were checked for gain stability in the field using the Cs-137 gamma ray at 661 keV and the K-40 gamma ray at 1460 keV. Spectra were analyzed using the USDOE Environmental Measurements Laboratory M1 protocol and software. Results are shown on the attached Excel spreadsheet.

The target isotope of interest for this work is Cs-137. During our recent meeting with Bob Gehrke and Dick Helmer, we agreed to assume a uniform distribution of Cs-137 with soil depth to four inches. In order to use M1 properly and report the Cs-137 values in pCi/g I assumed a relaxation length or depth (depth for the activity to decrease to 1/e) of four inches and a soil density of 1.6 g/cm³. M1 uses the inverse of the relaxation length and the density in its calculations. The M1 protocol states that if a relaxation length of less than 4 inches is assumed, the software assumes a planar distribution and reports the Cs-137 in units of pCi/m². I mention this in the event that you are considering recalculation of the Cs-137 with different depth distributions. I can perform those calculations or I can calculate simple counts/sec for any of the spectra. It would also be interesting and useful to perform some measurements with an n-type extended energy range detector as suggested by Bob. This might allow inferences of the depth distributions which we currently do not have.

Finally, we are available to perform the additional background measurements suggested by Dick Helmer and yourself. Please contact me if you still want this work performed.

CPO/gjf

cc: R. J. Gehrke, MS 2114
R. L. Hand, MS 5210 (w/o Attach)
R. G. Helmer, MS 2114
C. M. Haring, MS 3953
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ARA 23 RESULTS: Cs-137 (pCi/g) by location

 $\alpha/p=0.059$, $\rho(\text{soil})=1.6 \text{ g/cm}^3$

RELAXATION LENGTH= 4.2 INCHES

CPP RADIOCHEMISTRY GROUP 9/97

FIELD MEASUREMENTS: SJ HILL, BK HARRIS,

KJ OLTMANN, CP OERTEL

DATA ANALYSIS: CP OERTEL

Point ID	North	East	Elevation	Descriptor	Cs-137 (pCi/g)	Error (1 σ)
43	675744.69	327157.65	5062.84	1409		
45	675519.6797	326807.6821	5048.761211	1820		
46	675244.701	326507.7292	5048.190371	2290		
50	675303.737	326856.3668	5044.37718	1009	2.27	0.07
51	675328.7173	326855.7158	5044.865007	1010		
52	675353.742	326855.0312	5045.785916	1011	2.28	0.07
53	675378.0687	326829.4661	5045.689839	1012	2.85	0.07
54	675352.9932	326829.9899	5046.732685	1013		
55	675328.0392	326830.7276	5048.46982	1014		
56	675303.0546	326831.3398	5044.429285	1015	2.96	0.07
57	675277.4055	326807.0023	5044.049412	1025		
58	675302.4133	326806.3045	5044.854863	1026	1.87	0.06
59	675327.4592	326805.7545	5044.596126	1027		
60	675352.6674	326805.3328	5047.831542	1028	1.37	0.06
61	675377.433	326804.4346	5046.556864	1029	3.43	0.08
62	675402.335	326803.7368	5048.002064	1030		
63	675401.6833	326778.7488	5045.907501	1031		
64	675376.6885	326779.3859	5047.490977	1032	1.82	0.06
65	675351.6612	326780.0584	5048.081828	1033	1.24	0.05
66	675326.7149	326780.7079	5045.259991	1034		
67	675301.5998	326781.3086	5043.727492	1035	1.59	0.06
68	675276.8133	326782.0105	5043.461811	1036		
69	675276.1472	326757.0416	5043.507705	1050		
70	675301.2179	326756.5073	5044.447854	1051		
71	675326.1296	326755.7322	5047.014996	1052	1.28	0.05
72	675351.1436	326755.1421	5045.622707	1053		
73	675376.0818	326754.3842	5047.968021	1054		
74	675401.1055	326753.8079	5046.313219	1055	1.86	0.06
75	675426.0899	326753.1818	5046.250684	1056		
76	675425.4659	326728.2734	5046.967459	1058		
77	675400.3911	326728.7804	5048.180975	1059		
78	675375.29	326729.2733	5048.090687	1060	1.66	0.06
79	675350.4003	326730.0992	5047.361644	1061		
80	675325.4817	326730.6747	5047.025283	1062		
81	675300.444	326731.3422	5045.428173	1063	1.56	0.06
82	675275.5435	326732.0383	5044.062974	1064		
83	675274.8408	326707.0309	5044.413949	1078		
84	675299.791	326706.392	5047.198912	1079		
85	675324.786	326705.6797	5046.4961	1080	1.32	0.05
86	675349.7831	326705.0688	5045.807912	1081		
87	675374.7714	326704.4601	5047.413038	1082	1.44	0.05
88	675399.7944	326703.7889	5048.852351	1083		
89	675424.7644	326703.136	5047.293443	1084	4.18	0.09

ARA 23 RESULTS: Cs-137 (pCi/g) by location $\alpha/\rho=0.059$, $\rho(\text{soil})=1.6 \text{ g/cm}^3$ RELAXATION LENGTH= 4.2 INCHES	CPP RADIOCHEMISTRY GROUP 9/97 FIELD MEASUREMENTS: SJ HILL, BK HARRIS, KJ OLTMANN'S, CP OERTEL DATA ANALYSIS: CP OERTEL
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Point ID	North	East	Elevation	Descriptor	Cs-137 (pCi/g)	Error (1 σ)
90	675449.0307	326677.3913	5049.183857	1088		
91	675424.0846	326678.1759	5049.85674	1089		
92	675399.073	326678.7622	5049.120006	1090	1.82	0.06
93	675374.0451	326679.4294	5047.847177	1091		
94	675340.2005	326680.0984	5048.022364	1092	1.16	0.05
95	675324.2016	326680.6934	5048.867026	1093		
96	675299.1723	326681.3733	5045.799852	1094		
97	675274.2148	326682.0154	5045.01986	1095		
98	675273.471	326656.9678	5045.449784	1105		
99	675298.5016	326656.3915	5047.65857	1106	2.03	0.06
10	675323.47212589	326655.75794233	5048.0275415763	1107	1.22	0.05
10	675348.53459248	326655.14628146	5049.2200849635	1108		
10	675373.47510419	326654.35838146	5050.6363822356	1109	1.97	0.06
10	675398.50202330	326653.80678188	5050.6556185105	1110		
10	675423.45339175	326653.12023734	5050.2044122380	1111	2.66	0.07
10	675448.46751783	326652.45192801	5049.5026743373	1112		
10	675473.48193858	326651.85261599	5050.9206965857	1113		
10	675472.77886238	326626.85708505	5051.2591544447	1117		
10	675447.73515775	326627.47793927	5051.0436214498	1118	4.47	0.09
10	675422.87444791	326628.15573702	5051.5531850309	1119		
11	675397.90343888	326628.78974187	5050.0153111299	1120	2.15	0.06
11	675372.87714152	326629.47101010	5048.8571386334	1121		
11	675347.90326831	326630.10398013	5047.7589065021	1122	0.93	0.04
11	675322.92347636	326630.83766795	5049.9855441914	1123		
11	675297.91337941	326631.40954894	5048.9303300981	1124		
11	675272.95778094	326632.18541610	5046.1923707427	1125		
11	675272.34511423	326607.15215687	5046.5921586133	1133		
11	675297.30964278	326606.39659851	5048.8285225107	1134		
11	675322.18879097	326605.78004788	5049.7116179093	1135	3.12	0.08
12	675347.22814336	326605.14524807	5050.0668325708	1136		
12	675371.68665247	326603.58962285	5048.5855042052	1137	1.63	0.06
12	675397.20408023	326603.79886400	5050.3023454455	1138		
12	675422.15869481	326603.11218779	5052.0045905713	1139	2.55	0.07
12	675447.18797548	326602.56144211	5051.5661022571	1140		
12	675472.20082170	326601.89770834	5051.2519281951	1141		
12	675497.17137283	326601.19346286	5052.3008951477	1142		
12	675496.47252809	326576.23094119	5053.1431419916	1146		
12	675471.58561460	326578.84851385	5049.8369680293	1147		
12	675448.63172663	326577.66340020	5051.5657956913	1148	6.00	0.01
13	675421.59231015	326578.18320251	5049.1269360859	1149		
13	675396.60894411	326578.90902814	5048.7446198667	1150		
13	675371.63527903	326579.57000695	5049.5156071210	1151		
13	675346.61972258	326580.13238115	5049.5523302528	1152	1.77	0.06

ARA 23 RESULTS: Cs-137 (pCi/g) by location $\alpha/p=0.059, \rho(\text{soil})=1.6 \text{ g/cm}^3$ RELAXATION LENGTH= 4.2 INCHES	CPP RADIOCHEMISTRY GROUP 9/97 FIELD MEASUREMENTS: SJ HILL, BK HARRIS, KJ OLTMANN, CP OERTEL DATA ANALYSIS: CP OERTEL
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Point ID	North	East	Elevation	Descriptor	Cs-137 (pCi/g)	Error (1s)
13	,675321.63372270	,326580.84183304	,5049.8340339905	,1153.		
13	,675296.62330215	,326581.43951789	,5049.8402083335	,1154.	4.14	0.09
13	,675271.61848025	,326582.12836207	,5047.6585568295	,1155.		
13	,675246.61643507	,326582.70691054	,5047.1908316699	,1156.		
13	,675248.07646141	,326557.80494055	,5047.9580207826	,1160.		
13	,675270.97976385	,326557.05527701	,5049.3755515124	,1161.		
14	,675298.00558985	,326556.40141633	,5050.6074057213	,1162.		
14	,675320.98827505	,326555.78756336	,5050.1481783853	,1163.	3.41	0.08
14	,675345.99931228	,326555.09939887	,5050.7880006257	,1164.		
14	,675370.92053093	,326554.52473262	,5050.8446166507	,1165.	2.18	0.06
14	,675395.88762587	,326553.76224502	,5050.4867238120	,1166.		
14	,675420.88876175	,326553.18198011	,5052.2274785168	,1167.	4.23	0.09
14	,675445.91972943	,326552.65840301	,5052.8685763742	,1168.		
14	,675470.90247548	,326551.89284400	,5051.5464924017	,1169.		
14	,675495.89599596	,326551.26599521	,5052.3343082597	,1170.		
14	,675520.91249350	,326550.63610814	,5053.1156155327	,1172.		
15	,675245.34623456	,326532.77419368	,5048.2508665579	,1188.		
15	,675270.35892566	,326532.19749167	,5049.1548213734	,1187.		
15	,675295.33228990	,326531.44671922	,5050.4865643351	,1188.	14.01	0.15
15	,675320.30872510	,326530.82665972	,5050.8066348444	,1185.		
15	,675345.25133216	,326530.12319122	,5051.7461460707	,1184.	4.65	0.09
15	,675370.34548998	,326529.57977657	,5051.3278820931	,1183.		
15	,675395.29106350	,326528.86807924	,5049.5264841783	,1182.	2.82	0.07
15	,675420.30579114	,326528.20755352	,5052.7183528769	,1181.		
15	,675445.28284227	,326527.54937198	,5053.2310615335	,1180.	3.83	0.08
15	,675470.27486111	,326526.81385109	,5053.9428345368	,1179.		
16	,675495.27709692	,326526.23137849	,5052.7748579446	,1178.	19.50	0.20
16	,675520.31042662	,326525.71869270	,5053.4744370173	,1177.		
16	,675544.58345778	,326499.94913309	,5053.0607094143	,1200.		
16	,675519.61914621	,326500.74562787	,5055.5377074817	,1199.	24.80	0.21
16	,675494.60988733	,326501.29891445	,5054.7725207284	,1198.		
16	,675469.58900360	,326501.88378439	,5054.3674159370	,1197.	7.45	0.11
16	,675444.61853281	,326502.64389387	,5052.4940224265	,1196.		
16	,675419.61362456	,326503.20749081	,5051.7180282858	,1195.	5.09	0.09
16	,675394.85698830	,326503.84818135	,5051.7198225451	,1194.		
17	,675369.71039663	,326504.51487917	,5052.3748874916	,1193.	4.89	0.09
17	,675344.71882578	,326505.23186074	,5053.8277912446	,1192.		
17	,675319.71841619	,326505.84172477	,5052.9764276946	,1191.	12.20	0.14
17	,675294.68102057	,326506.36596598	,5050.7318852955	,1190.		
17	,675269.68342645	,326507.12018647	,5048.3040555563	,1189.		
17	,675568.99983322	,326474.32904206	,5054.6663105595	,1205.		
17	,675618.91105021	,326473.10121727	,5055.0140217950	,1203.		
17	,675593.89878745	,326473.79700912	,5055.6303279355	,1204.	86.80	0.40

ARA 23 RESULTS: Cs-137 (pCi/g) by location $\alpha/\rho=0.059$, $\rho(\text{soil})=1.8 \text{ g/cm}^3$ RELAXATION LENGTH= 4.2 INCHES	CPP RADIOCHEMISTRY GROUP 9/97 FIELD MEASUREMENTS: SJ HILL, BK HARRIS, KJ OLTMANN, CP OERTEL DATA ANALYSIS: CP OERTEL
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Point ID	North	East	Elevation	Descriptor	Cs-137 (pCi/g)	Error (1 σ)
17	,675594.80036231	,326498.74853153	,5053.8550141410	,1202.		
17	,675544.00662600	,326475.01825319	,5055.1662147778	,1206.	50.90	0.29
18	,675519.00415936	,326475.88162081	,5055.0288325951	,1207.		
18	,675493.98517873	,326476.23954341	,5055.3161727796	,1208.	14.10	0.15
18	,675469.02335489	,326477.07677518	,5055.3797125590	,1209.		
18	,675443.98815825	,326477.58038793	,5054.7784476422	,1210.	12.60	0.15
18	,675419.03013131	,326478.22661386	,5052.6928616559	,1211.		
18	,675393.96280503	,326478.85950446	,5053.0179955476	,1212.	12.20	0.14
18	,675369.01337724	,326479.59550284	,5053.9237771720	,1213.		
18	,675344.07374974	,326480.32909523	,5054.2243248823	,1214.	17.50	0.17
18	,675318.94744429	,326480.70996594	,5050.8779969670	,1215.		
18	,675294.04743241	,326481.55499547	,5048.5930883808	,1216.		
19	,675318.38685407	,326455.80344187	,5049.5455857091	,1219.		
19	,675343.40598143	,326455.22787228	,5054.0145666783	,1220.		
19	,675368.39529640	,326454.53275452	,5053.7773799700	,1221.	21.60	0.19
19	,675393.42913731	,326453.94425445	,5054.1716232773	,1222.		
19	,675418.38429987	,326453.28685597	,5053.5548731838	,1223.	15.40	0.16
19	,675443.39538111	,326452.58209773	,5051.6134947024	,1224.		
19	,675468.30372915	,326452.05423004	,5056.2871548079	,1225.	14.40	0.16
19	,675493.26610863	,326451.20777797	,5055.1974158688	,1226.		
19	,675518.30382510	,326450.68682723	,5056.7815616255	,1227.	22.50	0.20
19	,675543.31181637	,326450.05727605	,5057.6087019945	,1228.		
20	,675588.29998159	,326449.33760071	,5057.8241522162	,1229.	67.20	0.36
20	,675593.30084791	,326448.80232823	,5055.9820398948	,1230.		
20	,675618.33084896	,326448.22875366	,5058.2789387630	,1231.	74.40	0.38
20	,675643.29303804	,326447.58854016	,5058.1251354899	,1232.		
20	,675642.60841113	,326422.54993456	,5059.2616816495	,1233.	64.60	0.35
20	,675617.67850251	,326423.09449619	,5059.8913156411	,1234.		
20	,675592.70239779	,326423.83050955	,5057.5335970441	,1235.	95.60	0.43
20	,675567.67310802	,326424.48930063	,5056.5831517012	,1236.		
20	,675542.69878261	,326425.08783679	,5055.9016647451	,1237.	41.60	0.30
20	,675517.74592541	,326425.79373831	,5056.1457855478	,1238.		
21	,675492.69950259	,326428.28702995	,5053.4042946175	,1239.	18.30	0.18
21	,675467.72327007	,326428.93477985	,5055.2763983651	,1240.		
21	,675442.67393367	,326427.54221181	,5055.2197331073	,1241.	21.30	0.19
21	,675417.71158398	,326428.33597626	,5054.8200323596	,1242.		
21	,675392.68336629	,326428.87335493	,5054.7897642387	,1243.	24.10	0.20
21	,675387.74565778	,326429.60560360	,5054.3846562609	,1244.		
21	,675342.74281804	,326430.29530399	,5052.1606532526	,1245.	33.70	0.24
21	,675342.11497728	,326405.24346882	,5051.6360608757	,1248.		
21	,675367.14554007	,326404.64711269	,5055.1291033242	,1249.	31.70	0.23
22	,675392.11492218	,326403.91884481	,5056.0086755696	,1250.		
22	,675417.13452692	,326403.39427871	,5054.9281250883	,1251.	29.50	0.22

ARA 23 RESULTS: Cs-137 (pCi/g) by location $\alpha/\rho=0.059$, $\rho(\text{soil})=1.6 \text{ g/cm}^3$ **RELAXATION LENGTH= 4.2 INCHES****CPP RADIOCHEMISTRY GROUP 8/87****FIELD MEASUREMENTS: SJ HILL, BK HARRIS,
KJ OLTMANN, CP OERTEL****DATA ANALYSIS: CP OERTEL**

Point ID	North	East	Elevation	Descriptor	Cs-137 (pCi/g)	Error (1s)
22	,675442.09325536	,326402.62896610	,5055.1558321353	,1252.		
22	,675467.12558160	,326402.08851787	,5055.2946224880	,1253.	26.70	0.21
22	,675492.13183967	,326401.42357265	,5053.9546957149	,1254.		
22	,675517.00252964	,326400.63709175	,5054.9602862377	,1255.	49.20	0.25
22	,675541.98928978	,326400.12112875	,5056.8377964545	,1256.		
22	,675567.02300528	,326399.50687471	,5056.8685589152	,1257.	119.00	0.50
22	,675592.01684913	,326398.80834694	,5058.7824372220	,1258.		
22	,675617.00982224	,326398.10495189	,5057.4461315254	,1259.	84.50	0.40
23	,675591.40438548	,326373.77257408	,5057.8325782203	,1260.	95.20	0.40
23	,675586.41070206	,326374.40641982	,5058.0192223955	,1261.		
23	,675541.40871578	,326375.14501733	,5055.8006802743	,1262.	102.00	0.40
23	,675516.40641895	,326375.76213354	,5055.9893627334	,1263.		
23	,675490.79071226	,326375.52185369	,5054.8820617258	,1264.	49.10	0.29
23	,675466.40545698	,326377.07011896	,5054.9145750105	,1265.		
23	,675441.42737328	,326377.65533927	,5054.5550894568	,1266.	28.10	0.22
23	,675416.42176822	,326378.39001580	,5054.8417569213	,1267.		
23	,675391.37365580	,326378.83321827	,5056.0073108143	,1268.	29.10	0.22
23	,675366.50480269	,326379.62281346	,5055.0088901969	,1269.		
24	,675341.49533642	,326380.18860317	,5052.2419355181	,1270.		
24	,675365.80721231	,326354.60005378	,5053.8382503551	,1271.		
24	,675390.82037842	,326353.94185781	,5054.7073986156	,1272.		
24	,675415.78133181	,326353.24754456	,5055.5178795442	,1273.	31.10	0.23
24	,675440.78588142	,326352.53156681	,5054.0587489828	,1274.		
24	,675465.83731883	,326352.13212351	,5054.3585791678	,1275.	50.40	0.30
24	,675490.79216100	,326351.35841186	,5056.0891045871	,1276.		
24	,675515.81633123	,326350.94297300	,5057.6630526217	,1277.	88.70	0.38
24	,675540.78623740	,326350.10602358	,5057.4973917227	,1278.		
24	,675515.11731511	,326325.75919459	,5057.7843214729	,1279.		
25	,675490.10657358	,326326.38406258	,5056.8162735724	,1280.	75.60	0.40
25	,675465.09069247	,326326.99626439	,5054.8573286648	,1281.		
25	,675440.11575066	,326327.77519704	,5055.3060039284	,1282.	42.90	0.30
25	,675415.23245618	,326328.35659088	,5054.7819978545	,1283.		
25	,675390.21736946	,326328.90513771	,5053.9323410250	,1284.		
25	,675414.50150548	,326303.33324060	,5053.9682969309	,1286.		
25	,675439.50461441	,326302.78924931	,5054.5566272439	,1287.		
25	,675464.49202803	,326301.97878581	,5057.2632633446	,1288.	81.70	0.40
25	,675463.75917934	,326276.94620972	,5055.6444636932	,1291.		
25	,675489.66739419	,326276.28598355	,5056.1837669202	,1292.		
26	,675489.93558223	,326301.09775791	,5056.7961898780	,1293.		
28	,675514.35372843	,326300.75022314	,5057.4334808366	,1294.	174.00	0.50
26	,675513.57599280	,326275.75765997	,5056.8832566567	,1295.		
26	,675539.99515154	,326275.04975866	,5057.0284477912	,1296.		
26	,675540.16996712	,326299.86792296	,5059.1882511072	,1297.		

ARA 23 RESULTS: Cs-137 (pCi/g) by location
 $\omega/p=0.059$, $\rho(\text{soil})=1.6 \text{ g/cm}^3$
RELAXATION LENGTH= 4.2 INCHES

CPP RADIOCHEMISTRY GROUP 9/97
FIELD MEASUREMENTS: SJ HILL, BK HARRIS,
KJ OLTMANN, CP OERTEL
DATA ANALYSIS: CP OERTEL

Point ID	North	East	Elevation	Descriptor	Cs-137 (pCi/g)	Error (1 σ)
26	,675541.29927698	,326324.90162447	,5058.1446619591	,1298.	169.00	0.53
26	,675565.58871057	,326349.37266433	,5058.5898463271	,1299.	126.00	0.50
26	,675585.25058899	,326324.62957063	,5058.8208850601	,1300.		
26	,675564.32204256	,326299.11255797	,5057.8614102867	,1301.		
26	,675588.31413677	,326299.02088114	,5057.7072712387	,1302.		
27	,675589.50945470	,326324.07845903	,5059.7250842258	,1303.	132.00	0.50
27	,675590.50402335	,326348.94762872	,5058.3801053608	,1304.		
27	,675614.58413872	,326323.48267049	,5056.9522972876	,1305.		
27	,675615.57873719	,326348.08228487	,5058.8661026571	,1306.	141.00	0.50
27	,675616.62033660	,326373.53779745	,5058.8318886144	,1307.		
27	,675640.35213145	,326347.22788944	,5056.8495215471	,1308.		
27	,675641.09432179	,326372.58238596	,5057.4631311187	,1309.	129.00	0.50
27	,675641.82284302	,326396.97200332	,5058.8024605272	,1310.		
27	,675667.06439947	,326396.80615269	,5058.7339624071	,1311.		
27	,675667.74898578	,326422.21793026	,5058.3275383701	,1312.		
28	,675692.71975652	,326421.12422328	,5056.6719604139	,1313.		
28	,675693.75380784	,326446.30146174	,5056.6519262633	,1314.		
28	,675668.43293205	,326448.97426835	,5059.5355243493	,1315.	64.80	0.35
28	,675668.48336591	,326471.67985242	,5058.8848630154	,1316.		
28	,675643.70157531	,326472.32720986	,5056.8829194608	,1317.		
28	,675644.61864215	,326498.16097358	,5055.6144081898	,1318.		
28	,675619.76808771	,326498.38888748	,5055.7250792041	,1319.		

J-220

ATTACHMENT 2

Lockheed Martin Idaho Technologies Company

INTERDEPARTMENTAL COMMUNICATION

Date: September 4, 1997

To: N. E. Josten ^H MS 2107 6-7691

From: R. J. Gehrke/R. G. Helmer ^{RJG/RGH.} MS 2114 6-4155/6-4157

Subject: CONVERSION OF ARA-23 DATA TO CONTAMINATION LEVELS -
RJG-16-97/RGH-39-97

In response to a request, we have generated a factor to convert count rates from the TSA plastic scintillator mounted on the Vehicle Roadway Monitor, VRM, system to contamination levels. This system was used recently for a survey of the ARA-23 area, site of the 1961 SL1 accident at the INEEL. It **MUST BE EMPHASIZED** that there are several assumptions and approximations involved in creating this conversion factor and that some measurements should be made with this system on calibrated sources in order to validate these results. So that you can understand the potential limitations of these results, the various steps involved are described.

The initial step was the modeling of the response of a 12"x12"x1.5" plastic scintillation detector which has been used for other surveys of radionuclide activities. This modeling was done using the Monte Carlo electron and photon transport code CYLTRAN. Although this detector is rectangular, the limitations of CYLTRAN required that it be represented as a right circular cylinder, but for the earlier uses of the detector this was not a serious limitation. This detector is used with the 12"x12" surface facing the soil and it has a lead shield around the edges of the detector. This modeling has been done for a variety of source (i.e., area of contamination) sizes, both in horizontal direction and depth in the soil as well as for different soil-detector distances. For the cases of interest here, the modeling was done for photons with an energy of 662 keV, as obtained from ¹³⁷Cs and for a soil-detector distance of 1 meter. Each such calculation gives the detector response as a spectrum giving the number of events as a function of the amount of energy deposited in the plastic scintillator. The energy deposited is not the full energy of the photons because, when the original photon interacts with the detector, secondary photons are produced and they have a high probability of escape from the detector.

A low-level discriminator in the detector electronics cuts off, or discards, all of the events which deposit less than a particular energy. It is expected that this cutoff lies between 50 and 150 keV for the TSA detector. This range will correspond to a range of approximately 2 in the measured count.

In this work to support the ARA survey, it has been assumed that the ^{137}Cs activity is uniformly distributed down to a depth of 4 inches, 10.16 cm, and over a large area. The detector response was computed for several source depths between 0 and 4 inches and these were combined to give the desired response for a uniform distribution down to 4 inches. (Calculations were also done to give the response if the contamination is all on the surface.)

For this 12"x12"x1.5" plastic scintillator, the results can be reported in the following way. The percentage of the 662-keV γ rays emitted from a uniformly distributed source 14 meters in diameter and 10.16 cm into the soil that deposit more 50 keV of energy in the detector is 0.00954. If the electronic cutoff on the detector is 150 keV, this percentage is 0.00547 or at 100 keV, about 0.0068. If we assume the best value for this cutoff for the TSA detector is 100 keV, but allow it to be anywhere from 50 to 150 keV, this percentage is 0.0068 +0.0027-0.0013.

In order to convert these results to the TSA detector, we have compared the results from the modeling for a 12"x12"x4" detector with the 1.5" thick one discussed above. The effect of the added thickness is to absorb more of the secondary photons and thereby move some events up past the cutoff energy. The computed increases in the above percentages of events above the two cutoffs are given by the following factors:

- 2.1 for a cutoff of 50 keV and
- 2.2 for a cutoff of 150 keV.

We expect the loss of secondary photons to be somewhat larger for the TSA detector than calculated for the 12"x12"x4" detector due to it being only 4" across. Therefore, we have used a factor of 1.8 ± 0.3 in the following calculations.

The volume of the TSA scintillator is 11% larger than the 12"x12"x4" detector, so the efficiency is assumed to be larger by this amount.

In order to proceed, we must assume that the TSA plastic scintillator has no inherent differences from our 12"x12"x1.5" plastic scintillator, except those due to the difference in size. This is a very reasonable assumption, but we have no experimental information to verify it. The percentage of 662-keV photons that we might expect to produce events above a cutoff of 100 ± 50 keV in the TSA system would then be estimated as follows:

value for 12"x12"x1.5" detector	0.0068% +0.0027-0.0013,
corrected to 12"x12"x4" detector	0.0122% + 0.0053-0.0031, and
corrected for 11% added volume	0.0136% +0.0059-0.0034.

ATTACHMENT 3

ARA for other Depths

<u>calc. depth</u> cm	<u>calc. uniform to</u>		^{0.79} <u>fraction of cts above 10 keV cutoff & uniform to</u>	<u>Mass of sample (g)</u>
	cm	inches		
1.3	2.6	1.0	0.0109% ⁺³⁶ ₋₁₈	5.87 × 10 ⁶
3.8	5.1	2.0	0.0091% ⁺²³ ₋₁₆	1.18 × 10 ⁷
6.4	7.7	3.0		
8.9	10.2	4.0	0.0068% ⁺²⁷ ₋₁₃	2.36 × 10 ⁷

$$\text{mass} = \pi r^2 d \rho = 1.5 \pi r^2 d = 2.309 \times 10^6 d$$

<u>unif. to</u>	<u>cts/sec.</u>	<u>γ's/sec.</u>	<u>d/s</u> 157Cs	<u>PCI</u>	<u>PCI/g</u>	<u>PCI/g * depth (in.)</u>
1"	100	9.17 × 10 ⁵	1.08 × 10 ⁶	2.92 × 10 ⁷	4.97	5.0
2"	"	1.00 × 10 ⁶	1.29 × 10 ⁶	3.49 × 10 ⁷	2.96	5.9
4"	"	1.47 × 10 ⁶	1.73 × 10 ⁶	4.68 × 10 ⁷	1.98	7.9

$1 \text{ Ci} = 3.7 \times 10^{10} \text{ d/s}$
 $1 \text{ nCi} = 37 \text{ d/s}$
 $1 \mu\text{Ci} = 0.037 \text{ d/s}$

4520 COMPENSATED AND 2-DIMENSIONAL
 45203 REPLICATED WHITE SQUARE
 MADE IN U.S.A.

ATTACHMENT 4

X-Sender: rhz@apl.inel.gov
 X-Mailer: Windows Eudora Light Version 3.0.1 (32)
 Date: Thu, 25 Sep 1997 16:19:51 -0600
 To: GSense@srv.net
 From: Richard Helmer <rhz@inel.gov>
 Subject: ARA data on source depth
 Mime-Version: 1.0
 X-UIDL: ccd32b7d87250eac9a9de166dc4117dd

Nick,

Bob Gehrke called and said that the ratio of the peak areas for the K x ray and gamma ray from ^{137}Cs was 0.20 on the average and ranged from 0.15 to 0.25. (All numbers are approximate at this point. He was still counting the last spectrum.) My previous Monte Carlo runs for this Ge detector and for large diameter (120 cm) disk sources at various depths can be interpolated and processed to give the following X/gamma ratios:

all of source at depth of (cm)	X/gamma ratio
on surface	0.58
0.3	0.43
0.9	0.22
1.5	0.117
2.1	0.061
2.7	0.032

So, the "centers" of the sources have to be near 1.0 cm.

source uniform down to (cm)	X/gamma ratio
1.2	0.32
1.8	0.26
2.4	0.21
3.0	0.17
15.2	0.077

So, a uniform distribution would need to extend down to about 2.5 cm (1").

If the radioactivity were wind blown and then washed down into the soil, one would expect more near the surface (although eventually it might all be washed down some minimum distance). So, I tried a couple of triangular distribution: of which the following is the most interesting:

9/25 at 0.3 cm
 7/25 at 0.9 cm
 5/25 at 1.5 cm
 3/25 at 2.1 cm
 1/25 at 2.7 cm

which gives an X/gamma ratio of 0.25.

A suggestion, based on Bob's comments. The X/gamma ratios near 0.15 may be in regions where the radioactivity was buried near 1.2 cm when items were dragged to the burial area. The X/gamma ratios near 0.25 are for wind blown material that has been washed down to give a distribution near the above triangular distribution. In the latter case, over 90% of the activity would be removed with the top 2.6 cm, or 1 inch, of soil.

Things are, of course, much more complex than this, but this is an idea to start any discussion.

See you,

Dick

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Lockheed Martin Idaho Technologies Co.
Idaho National Engineering and Environmental Laboratory
