Preliminary Radiological Results of Samples from Potential Pathways from the Los Alamos National Laboratory (LANL) into the Rio Grande --Part 2

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Introduction and Purposes

Responding to public concerns, Concerned Citizens for Nuclear Safety (CCNS) and The RadioActivist Campaign (TRAC) began technical explorations of LANL's possible radiological effects on public lands in June 2002. Based on that introduction, TRAC and CCNS collaborated on a raft trip, sampling down the Rio Grande, past LANL, in October 2002. Those first preliminary results have already been reported at this website.

TRAC, CCNS, and other stakeholders conducted a follow-up raft trip between April 30 and May 02, 2003. This trip had three purposes: to confirm or refute evidence of radioactive seepage from LANL into the Rio Grande; to obtain a vegetation sample of consistent medium from CCNS Spring; and to test for artificial radioactivity there. The third purpose was to collect a first reference sample from Sanchez Canyon mouth to screen for artificial radioactivity.

Methods Summary

Samples were collected and analyzed for radionuclides in an integrated "survey" procedure, previously described in Part 1 of this report. During the initial survey, radioactivities close to detection levels are reported without uncertainties and only if results are positive. (This allows low detection levels while avoiding false positive reports.) After an artificial radionuclide is detected in the system, counts for that radionuclide are reported, whether positive or negative. Uncertainties are reported as "±" one standard deviation counting error, as generated by Canberra G2K software.

Results previously presented in Part 1 of this report were reviewed later. That review of sample results revealed substantial decays and ingrowths of several short-lived beta-emitting radionuclides in the natural uranium and thorium decay chains. Unconfirmed "[ ]" reports of strontium-90 close to detection level were determined to be unreliable and are retracted. The spectral subtraction methodology was modified for the present report to preclude such false positive reports. The modification involves separate subtraction of short-lived and of long-lived reference spectra for the uranium and thorium decay chains.

Several samples were recounted to reduce counting uncertainty.

Results

Table 4, below, is arranged in a geographical order, progressing down the Rio Grande past LANL.

Table 4. Preliminary Radiological Results

Sample			picocuries/kilogram (wet)		Wet/
Location	Setting	Medium	Be-7	Cs-137	Dry
CCNS	spring	willow leaves	326.±40.	–0.7±2.6	4.0
“	spring	Russian olive leaves	561.±60.	[4.8±4.7]	3.9
#4A	spring	washed aquatic moss	216.±25.	2.4±1.2	6.9
“	“	moss wash solids	157.±31.	3.5±1.9	8.5
“	“	fine sediment	1557.±475.	–3.7±14.9	1.0
“	“	water, **d**issolved	0.08±0.16	0.005±0.008	--
“	“	water, **p**articulates	0.02±0.16	0.004±0.008	--
“	“	**water, total (d+p)**	**0.10±0.23**	**0.009±0.011**	--
below #4A	stream	washed aquatic moss	1200.*	5.8±2.5	6.7
“	“	water, **d**issolved	0.48*	0.015±0.009	--
“	“	water, **p**articulates	0.56*	–0.003±0.011	--
“	“	**water, total (d+p)**	**1.04***	**0.012±0.014**	--
Ancho Canyon	stream	washed aquatic moss	431.±33.	10.3±1.8	7.4
Frijoles Canyon	shore	willow leaves	367.±52.	2.5±4.5	3.7
Sanchez Canyon	shore	sorrel**	85.±30.	–0.7±1.9	7.2

Radioactivities corrected to date of sample collection.

[ ] - reportable result fails one or more quality assurance criterion.

± - one standard deviation counting uncertainty, propagated.

* - Be-7 results reported in Part 1, without uncertainty.

** - Sanchez Canyon sorrel: Sr-90 = [180. pCi/kg(wet)]. This report invites future follow-up.

Wet/Dry - Wet weight / dry weight of samples, to allow dry-weight calculations.

Federal guidelines for surface water quality

Be-7	6000. pCi/Kg	(EPA-570/9-76-003)
Sr-90	8. “	(40 CFR 141)
Cs-137	200. “	(EPA-570/9-76-003)

Locations and rationale for samples in Table 4 are listed in Table 5, below.

Table 5 Sample Locations and Rationale (for Table 4)

Location	Medium	North 35°	West 106°	Number*	Rationale
CCNS Spring	willow leaves	49.351’	10.656’	343013	Obtain sample of medium consistent with set.
“	Russian olive leaves	49.358’	10.650’	343012	Alternative sample medium.
#4A Spring	aquatic moss	48.243’	11.829’	350109	Follow-up: differentiate between seepage and blown dust. Moss washed in stream.
“	moss wash solids	“	“	350111	Differentiate moss, above, from wash solids.
“	water	“	“	350108	40-liter sample to compare to stream water sampled below Spr. 4A.
“	fine sediment	“	“	350110	Compare to other media at Spring 4A.
below #4A	aquatic moss	48.143’	11.725’	2x1015	Prior reference for #4A samples; see above.
“	water	“	“	2x1017	“
Ancho Canyon	aquatic moss	46.287’	13.212’	350113	Reference for Spring 4A Sample 350109.
Frijoles Can.	willow leaves	45.188’	15.210’	350118	Reference for CCNS Spring Sample 343013.
Sanchez Can.	sorrel	40.994’	19.057’	350213	Recon for Sanchez Can.

* Sample Number digits are: Year Month Day Day Hour Hour. Month is numeric, with October as “x”, November as “y”, and December as “z”. Hours count to 24, as military time. “343013” is 2003, April 30, 1:00 PM.

Analysis

Source fractions of the Spring 4A system by Be-7 analysis.

Activity of Be-7 provides one indication of the sources of water in either environmental water samples or vegetation containing water, as described in Part 1 of this report. In the simplest case, Be-7 activity allows an estimation of the fraction of water in a sample that is recent rainwater and the fraction that is old groundwater.

Be-7 has a halflife of 53.3 days. Regional groundwater resides in the ground for years and so has a Be-7 activity nearly zero. For a simple case in which a water sample (S) can be considered a mixture of a fraction (x) of rainwater (R) and a fraction (1-x) of groundwater (G), where

S, R, and G are respective Be-7 activities.

The mixing equation is

$$S = xR + (1-x)G .$$

Recalling that $G \ll R$, in cases where $S \ll R$,

$$x = S/R ; \qquad (1-x) = (1 - S/R)$$

For the purposes of the present study, Be-7 in rainwater around Los Alamos is estimated as the average of surface water samples collected by LANL from Pueblo Canyon on 4/30/02 (see <http://wqdbworld.lanl.gov>):

$$R = 3.8 \pm 1.4 \text{ pCi/L} .$$

The mixture of water in Sample 2x1017 (Table 4), collected from the stream below Spring 4A, is estimated as follows:

$$x = 1.04 / 3.8 = 27\% \text{ rainwater, and } 73\% \text{ groundwater.}$$

This result suggests that most of the water added to the stream below Spring 4A originates from old groundwater rather than recent rainwater.

If the Cs-137 (0.012±0.014) reported for this water sample is correct and if this Cs-137 originates in the groundwater seeping from LANL, then the activity of Cs-137 in groundwater sampled directly from Spring 4A is estimated to be

Cs-137 in Spring 4A water = (0.012±0.014) / 0.73 = 0.016±0.019 pCi/Kg

This compares to the measured value of Sample 350108:

Cs-137 in Spring 4A water = 0.009±0.011.

Preliminary Bioaccumulation Factors and Their Application:

Bioaccumulation Factors (BFs) are the ratio of activity of a radionuclide in aquatic biota to the corresponding radioactivity in the water from which the biota was collected. Radioactivities are reported here on a wet weight basis: BF is the ratio of reported activity in vegetation divided by the activity in the water from which the sample was collected.

BFs for aquatic mosses collected from Spring 4A and from the stream below Spring 4A are calculated from the respective results for aquatic moss and total water in Table 4, as follows:

Table 6. Bioaccumulation Factors Calculated for Aquatic Moss

Location	Be-7	Cs-137
Spring 4A	2200.	270.
Stream below Spring 4A	1200.	480.
Root-Product Average	**1600.**	**360.**

--These BF calculations lack statistical significance because their divisors are more uncertain than their values. These are best estimates at the present time.

BFs are sometimes considered to be invariant properties of particular biota, under equal conditions. The consistency of BFs calculated for aquatic mosses collected from Spring 4A and from the stream below Spring 4A, Table 6, is an indication that the Be-7 and Cs-137 results reported here are consistent.

Assuming the Cs-137 content of regional groundwater is practically nil, the significantly positive result of Cs-137 = 2.4±1.2 pCi/Kg(wet) for Sample 350109 confirms Cs-137 seeping from LANL into Spring 4A.

The accompanying moss wash solids, Sample 350111 have a similar radiological signature, suggesting the moss wash might be decaying moss and particulates from the spring water. The negative Cs-137 result in fine sediments (Sample 350110) does not evidence dust blowing into the stream.

The average BFs at the bottom of Table 6 can be applied to the sample of aquatic moss (350113) collected from the stream in Ancho Canyon. The activity of a radionuclide in stream water is estimated as the ratio of that radioactivity in aquatic moss, divided by the corresponding BF:

Table 7. Estimates of Be-7 and Cs-137 in Ancho Stream Water

Location of aquatic moss	Be-7	Cs-137
Ancho Stream 350113 (pCi/Kgwet)	431.	10.3
BF for aquatic moss	1600.	360.
Stream water estimate (pCi/Kg)	**0.27**	**0.029**

--These estimates lack statistical significance because the BF values from Table 6 are more uncertain than their values. These are best estimates at the present time.

The fraction (x) of rainwater (R) in Ancho Stream is then estimated, as it was for the stream below Spring 4A:

Ancho Stream: $x = S/R = 0.27/3.8 = 7\%$ rainwater, and 93% groundwater

That is, the Be-7 BF for aquatic moss suggests that almost all the water in Ancho Stream, at the time the aquatic moss was sampled, originates as groundwater. The Cs-137 content in spring water near the head of Ancho Canyon would then predicted to be:

Cs-137 in Ancho Spring water $= (0.029) / 0.93 = 0.031$ pCi/Kg

This prediction that the spring at the head of Ancho Canyon is leaking Cs-137 into the Rio Grande can be tested by the means described here in regard to Spring 4A.

BF = 1600 for Be-7 in aquatic moss allows an estimation either (a) of minimum traveltime of groundwater contaminated with Cs-137 at LANL to Spring 4A or (b) of maximum rainwater intrusion into Spring 4A, as follows:

Be-7 in Spring 4A water, based on aquatic moss BF (pCi/Kg): 216./1600. = 0.135.

(a) groundwater traveltime from LANL to Spring 4A:
R/S = 3.8/0.135 = 2^(traveltime/53.3 days)

where: 3.8 pCi/Kg = Be-7 estimated in LANL rainwater.
0.135 pCi/Kg = Be-7 in Spring 4A, from BF = 1600.
53.3 days = Be-7 halflife.

yielding
traveltime ~ 260 days.

or

(b) fraction of recent rainwater contaminating Spring 4A moss:
S/R = 0.135/3.8 = 3.5%.

That is to say, the fraction of rainwater in Spring 4A is likely less than about 3.5%. Depending on the actual percentage of rainwater contributing to the Spring 4A moss sample, traveltime from LANL to Spring 4A might be as short as one year.

.End.