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Summary of Sandia Canyon Phase 1 Sediment Investigations

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NATIONAL LABORATORY
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1.0 INTRODUCTION AND PURPOSE

In 2007, Los Alamos National Laboratory (LANL, or the Laboratory) conducted Phase 1 field investigations of potentially contaminated sediment deposits in Sandia Canyon. This work was performed as proposed in the "Work Plan for Sandia Canyon and Cañada del Buey" (the work plan) (LANL 1999, 064617), as modified by several subsequent documents and approved by the New Mexico Environment Department (NMED) (LANL 2003, 081597; LANL 2005, 091542; NMED 2005, 091689).

This status report summarizes the analytical results from all Phase 1 sediment samples plus the analytical results from additional sediment samples collected in 1998 following the "Sampling and Analysis Plan for Upper Sandia Canyon" (LANL 1998, 062340) and in 2000 after the May 2000 Cerro Grande fire. Attachment 1 is an accompanying electronic data file on compact disk (CD) that includes all analytical results from these samples. These analytical results are used to identify chemicals of potential concern (COPCs), to provide an estimated inventory of chromium in Sandia Canyon sediment deposits, and to develop a sampling plan for Phase 2 sediment investigations. The Phase 2 sample design is planned to address remaining uncertainties in the sources and extent of COPCs and to improve estimates of representative concentrations of COPCs important for assessing potential human health risk. Information on radioactive materials and radionuclides, including the results of sampling and analysis of radioactive constituents, is voluntarily provided to NMED in accordance with U.S. Department of Energy (DOE) policy.

2.0 FIELD INVESTIGATIONS AND SEDIMENT SAMPLING

In 2007, sediment samples were collected in six reaches in Sandia Canyon, as specified in the work plan (LANL 1999, 064617) and in the "Addendum to the Work Plan for Sandia Canyon and Cañada del Buey" (LANL 2007, 095060). Prior to sampling, field investigations included detailed geomorphic mapping and associated geomorphic characterization in these six reaches. One of these reaches, S-2, had been mapped previously in 1998 (Katzman (2000, 064349) but was remapped in 2007 because of geomorphic changes that had occurred as a result of flooding. One additional reach (S-1, now subdivided into S-1 North and S-1 South) had been mapped previously and characterized in 1998 (Katzman 2000, 064349) but was not remapped because only small sediment deposits occur here. Table 1 presents a summary of sediment samples collected in Sandia Canyon and reported here. Locations of reaches, geomorphic units, and sampling locations are shown on Plates 1 to 4.

The geomorphic characterization in 2007 included field x-ray fluorescence (XRF) measurements to help in the selection of samples submitted for off-site analysis and to enhance the robustness of the nature and extent of chromium in sediments. A hand-held Innov-X XRF instrument measured chromium concentration in sediment deposits in each reach prior to sampling. Measurements were made at each stratigraphic interval at each geomorphic characterization location (stream banks or hand-dug holes) and were used to help guide sampling. Samples selected for off-site analysis included the location in each reach with the highest XRF chromium concentration and also a range in concentration to provide representative average concentrations for each reach, as specified in the "Addendum to the Work Plan for Sandia Canyon and Cañada del Buey" (LANL 2007, 095060). These XRF chromium data will be included in the Sandia Canyon investigation report.

The characterization in 2007 included hand augering 21 holes in reach S-2 to improve estimates of total sediment thickness and average chromium concentration beneath the wetland and adjacent geomorphic surfaces. The auger holes ranged from 1.67 to 4.66 m in depth and revealed the thickest deposits of post-1942 sediment that have been identified at the Laboratory (exotic materials such as quartzite gravel

were found at the bottom of some holes, indicating the thickness of post-1942 sediment). At each auger hole, the entire thickness of recovered sediment was homogenized in a plastic tub, and a split was submitted for target analyte list metal analysis. After the odor of diesel was noticed in some of the holes, the analytical suite for the remaining auger samples was expanded to include organic chemicals. The site with the strongest diesel odor was also reaugered to sample and analyze the layer with the strongest odor. These analyses confirmed the presence of total petroleum hydrocarbons–diesel range organics (TPH-DRO) at depth. Sample CASA-07-3948, collected between 1.54 and 1.98 m deep, had a concentration of 470 mg/kg. This was the highest TPH-DRO result in this data set but below NMED's residential soil screening level (SSL) of 520 mg/kg (NMED 2006, 094614).

A subset of the Phase 1 samples included a geochemical characterization suite to help evaluate the presence of trivalent chromium (Cr[III]) and hexavalent chromium (Cr[VI]) in the sediment deposits. These analyses are included on Attachment 1 on the accompanying CD but have not yet been evaluated in the context of chromium stability. In addition, collocated samples of sediment and cattail leaves and rhizomes were collected from four locations in reach S-2 to evaluate chromium uptake in cattails, but the biota data have not yet been received from the analytical laboratory.

3.0 IDENTIFICATION OF COPCs

COPCs were identified in each reach based on a comparison to sediment background values (BVs) where available or on detection status. The BVs are presented in LANL (1998, 059730) and McDonald et al. (2003, 076084) and include values for fallout radionuclides as well as naturally occurring radionuclides and inorganic chemicals. An inorganic chemical was identified as a COPC in a reach if the maximum detected or nondetected result exceeded the BV or if it was detected but has no BV. Organic chemicals, for which no BVs have been determined, were identified as COPCs in a reach whenever they were detected. A radionuclide was identified as a COPC in a reach if the maximum detected result exceeded the BV or if it was detected but has no BV. Tables 2 through 4 present maximum concentrations in each reach for all COPCs in sediment samples from Sandia Canyon. Maximum concentrations are shown for the purpose of identifying COPCs and indicating general spatial trends in concentrations. Values that exceed residential screening action levels (SALs) for radionuclides or SSLs for inorganic or organic chemicals are highlighted in gray in these tables and are discussed in Section 5.0. Screening levels were obtained from U.S. Environmental Protection Agency (EPA), Laboratory, or NMED documents (LANL 2005, 088493; EPA 2006, 094321; NMED 2006, 092513; NMED 2006, 094614).

The sampling and analyses identified 29 inorganic COPCs, 39 organic COPCs, and 11 radionuclide COPCs in sediment samples from Sandia Canyon. All reaches had multiple COPCs identified. In addition to sources from solid waste management units (SWMUs) or areas of concern (AOCs), some of the COPCs may also represent naturally elevated background concentrations as seen elsewhere on the Pajarito Plateau (e.g., Drakos et al. 2000, 068739) or may result from runoff from roads and parking lots and not from releases from SWMUs or AOCs (e.g., LANL 2004, 087390). Potential sources of COPCs are discussed further in Sections 4.0 and 5.0.

Box-and-whisker plots presenting data for all COPCs by reach are included in Attachment 1 on the accompanying CD to show variations in COPC concentrations between reaches and the relationship to sediment BVs. In the plots, the reaches are ordered from upcanyon (reach S-1S) to downcanyon (reach S-5E). The ends of the boxes represent the 25^{th} and 75^{th} percentiles of the data in each reach; the horizontal lines in the boxes represent the median value in each reach; the vertical dotted lines (the whiskers) extend up to 1.5 times the interquartile range, terminating at the largest and smallest sampling results contained within this range. Values that plot beyond the whiskers are possible outliers in the data.

Where available, sediment BVs are shown as dotted horizontal lines on the plots. The plots use separate symbols for detected (filled symbol) and nondetected (open symbol) results. The plots also include comparisons with the sediment background data set used in LANL (2004, 087390) and McDonald et al. (2003, 076084).

4.0 POTENTIAL SOURCES AND EXTENT OF COPCS

The spatial distribution of COPCs allows a preliminary evaluation of the primary sources and extent of COPCs in Sandia Canyon sediment deposits. Most COPCs have maximum concentrations in reach S-2, and additional COPCs have maximum concentrations in reaches S-1N or S-1S, indicating sources in the uppermost part of the watershed (Technical Areas [TAs] 03, 60, and/or 61). Specific sources for some of these COPCs have been identified, including chromium and molybdenum from releases of cooling water from the power plant at TA-03 (LANL 1999, 064617; LANL 2006, 094431) and polychlorinated biphenyls (PCBs) from SWMU 03-056(c), a former transformer storage area (LANL 1999, 064617; LANL 2006, 094431). Sources for some other COPCs, such as TPH-DRO, are uncertain. Only nine COPCs have maximum concentrations in downcanyon reaches, and examination of box plots indicate that these results do not clearly indicate additional sources of contaminants, although contributions from SWMUs or AOCs at downcanyon TAs cannot be ruled out.

The spatial distribution of COPCs indicates that contaminants have been transported along the full length of Sandia Canyon from TA-03 at least as far east as New Mexico State Road (SR) 4. For example, chromium is present above the sediment BV in all reaches, including reach S-5E immediately west of SR 4. The downcanyon extent of chromium and other COPCs has not been determined because no characterization has been conducted east of SR 4.

5.0 COMPARISON TO HUMAN HEALTH SCREENING LEVELS

Maximum concentrations for each COPC in each reach were compared with residential SALs and SSLs to help identify which COPCs are most important for assessing potential human health risk and which reaches have the highest potential risk. Three inorganic COPCs (arsenic, chromium, and lead), three organic COPCs (Aroclor-1254, Aroclor-1260, and benzo[a]pyrene), and one radionuclide COPC (thorium-228) have maximum concentrations exceeding residential SALs or SSLs in one or more reaches. They are highlighted in Tables 2 through 4. Following the process used in the “Mortandad Canyon Investigation Report” (LANL 2006, 094161), Table 5 identifies other COPCs that potentially influence risk, specifically those that have ratios of maximum concentrations to screening levels >0.1 for reaches and risk endpoints where the sum of these ratios is >1. Endpoints are carcinogenic risk, noncarcinogenic hazard, and radionuclide dose. In addition to the analytes exceeding SALs and SSLs that are discussed above, nine inorganic COPCs (aluminum, cadmium, iron, manganese, mercury, molybdenum, silver, thallium, and vanadium), five organic COPCs (benzo[a]anthracene, benzo[b]fluoranthene, dieldrin, indeno[1,2,3-cd]pyrene, and Aroclor-1242), and one radionuclide (thorium-232) are also identified as potentially influencing risk.

The inorganic and organic COPCs that exceed SSLs all have maximum concentrations in reaches S-1N, S-1S, or S-2 (Tables 2 and 3), indicating sources and the highest potential human health risk in the upper watershed. The only other reach with a maximum concentration for an inorganic or organic COPC exceeding the SSL is reach S-3W for arsenic. The risk ratio for the carcinogenic endpoint exceeds 1 only in these four reaches (Table 5). The hazard index (HI) for the noncarcinogenic endpoint exceeds 1 in reaches S-1S, S-2, S-4E, and S-5C. In S-4E and S-5C, the main contributor to potential noncarcinogenic hazard is iron, accounting for over half of the total HI. However, iron is only a COPC in these reaches

based on single results 1%–6% above the BV in each reach, and examination of box plots indicates that these iron results appear to represent outliers in the data set. The HIs are also low in these reaches (1.08 and 1.16).

The only radionuclide COPC that exceeds the SAL, thorium-228, has a maximum concentration in reach S-4W, and it also exceeds the SAL in reach S-5E. Radionuclide dose ratios exceed 1 only in these reaches (Table 5). Only single thorium-228 results exceed the BV of 2.28 pCi/g in each reach, and the maximum concentration (2.47 pCi/g) is <10% greater than the BV. Reaches S-4W and S-5E are incised into Bandelier Tuff units Qbt 1g or Qbo, which have a relatively high BV for thorium-228 (4.90 pCi/g) (LANL 1998, 059730). These results suggest that the highest thorium-228 results in S-4W and S-5E represent outliers in the data set associated with a locally elevated background and not releases from Laboratory operations.

6.0 CHROMIUM INVENTORY

The inventory of chromium in sediment deposits was estimated in each sampled reach in Sandia Canyon and was interpolated between reaches to provide a canyon-scale estimate. The estimates in each reach followed the same process used in previous canyon investigations at the Laboratory, combining data on the area and average thickness, COPC concentration, gravel content, and density in different geomorphic units and sediment facies (e.g., LANL 2006, 094161, pp. D-4, D-5, D-8). The average background concentration of chromium (5.6 mg/kg, McDonald et al. 2003, 076084, Table 10, p. 47) was subtracted from the average chromium concentration in Sandia Canyon sediment samples to provide an estimate of the amount of anthropogenic chromium, as was done previously in Mortandad Canyon (LANL 2006, 094161, p. D-8). Figure 1 shows this estimated inventory both as a normalized inventory in each sampled reach in units of kg/km (chromium mass divided by reach length; Figure 1a) and as a cumulative inventory along the length of the canyon above SR 4 (Figure 1b). The inventory calculations indicate that the majority of the chromium in Sandia Canyon sediment deposits is contained in the large sediment deposits in reach S-2 where the highest concentrations of chromium have been measured, estimated as about 84% of the total inventory. A minor, secondary increase in the chromium inventory occurs ~5 km downcanyon between reaches S-4W and S-5C where sediment deposits are also large but chromium concentrations are much lower.

Paired total chromium and Cr(VI) analyses indicate that the chromium in Sandia Canyon sediment deposits is dominated by Cr(III). In reach S-2, where the majority of the chromium is located, the percentage of Cr(VI) to total chromium in individual Phase 1 samples varies from <0.05% to 3.7%, and an estimated 0.2% of the S-2 chromium inventory is Cr(VI). Five sets of paired total chromium and Cr(VI) analyses obtained from S-1S and S-2 in 1998 yielded nondetect results for Cr(VI) and support a low percentage of Cr(VI) in these reaches.

The accuracy of the canyon-scale chromium inventory estimate is limited by uncertainties in S-2 where measured chromium concentrations vary by over 2 orders of magnitude (12 to 3740 mg/kg) and where relatively few exposures (e.g., bank cuts) exist. The uncertainty in the S-2 chromium inventory was evaluated using Monte Carlo simulations, following a process previously applied in Los Alamos and Pueblo Canyons investigations and presented in Ryti et al. (2005, 093019). The Monte Carlo simulations indicate a median estimate of ~11,000 kg and a mean estimate of ~15,000 kg of chromium in S-2, with a range of 5700 to 27,000 kg provided by the 10^{th} and 90^{th} percentiles, respectively. Combined with data from the other reaches (Figure 1), these simulations indicate that ~65% to 90% of the total chromium inventory in Sandia Canyon sediment deposits is in S-2. The simulations also indicate that increasing the number of samples in S-2 would not have a significant effect on reducing this uncertainty.

7.0 PROPOSED PHASE 2 SEDIMENT INVESTIGATIONS

Proposed Phase 2 sediment investigations in Sandia Canyon are focused on evaluating the source and extent of COPCs and on improving estimates of average concentrations of COPCs that are important for evaluating potential human health risk. Proposed Phase 2 reaches, sample numbers, and analytical suites are shown in Table 6 and are discussed below. Sampling in each Phase 2 reach is expected to include both surface and subsurface sediment layers, depending the thickness of historical (post-1942) sediment in each reach.

As discussed in Section 4.0, the easternmost investigated reach, S-5E, contains Laboratory-derived COPCs, and the downcanyon extent of these COPCs has not been determined. Reaches S-6 West (S-6W) and S-6 East (S-6E) were proposed in Section 7.1.2.3 of the work plan as contingency reaches, to be investigated contingent on results in S-5E (LANL 1999, 064617, pp. 7-13 and 7-14). Reaches S-6W and S-6E are proposed for investigation in Phase 2 to determine the downcanyon extent of COPCs in Sandia Canyon sediment deposits. The proposed analytical suites include all COPCs identified in S-5E and are shown in Table 6. Because S-6W and S-6E are on San Ildefonso Pueblo land, investigation of these reaches is contingent on approval from the Pueblo.

Relatively few samples were collected from well-defined geomorphic contexts in reaches S-1N and S-1S, and uncertainties exist concerning sources of some COPCs found in S-2, such as TPH-DRO and representative concentrations of COPCs. Proposed Phase 2 sampling includes enlarging the data set in these reaches for all COPCs identified in reaches S-1N, S-1S, or S-2. The proposed number of samples and the analytical suites are shown in Table 6.

Phase 1 sampling in reach S-3W only included metals and PCBs, which had been previously identified as including the most important COPCs upcanyon in S-2, and additional analyses will be required from S-3W to provide data for a human health risk assessment. Specifically, in addition to metals and PCBs, data on pesticides and polycyclic aromatic hydrocarbons are needed to evaluate the carcinogenic risk endpoint. Proposed sample numbers and analytical suites are shown in Table 6.

8.0 REFERENCES

The following list includes all documents cited in this report. Parenthetical information following each reference provides the author(s), publication date, and ER ID number. This information is also included in text citations. ER ID numbers are assigned by the Environmental Programs Directorate's Records Processing Facility (RPF) and are used to locate the document at the RPF and, where applicable, in the master reference set.

Copies of the master reference set are maintained at the NMED Hazardous Waste Bureau; the U.S. Department of Energy–Los Alamos Site Office; the U.S. Environmental Protection Agency, Region 6; and the Directorate. The set was developed to ensure that the administrative authority has all material needed to review this document, and it is updated with every document submitted to the administrative authority. Documents previously submitted to the administrative authority are not included.

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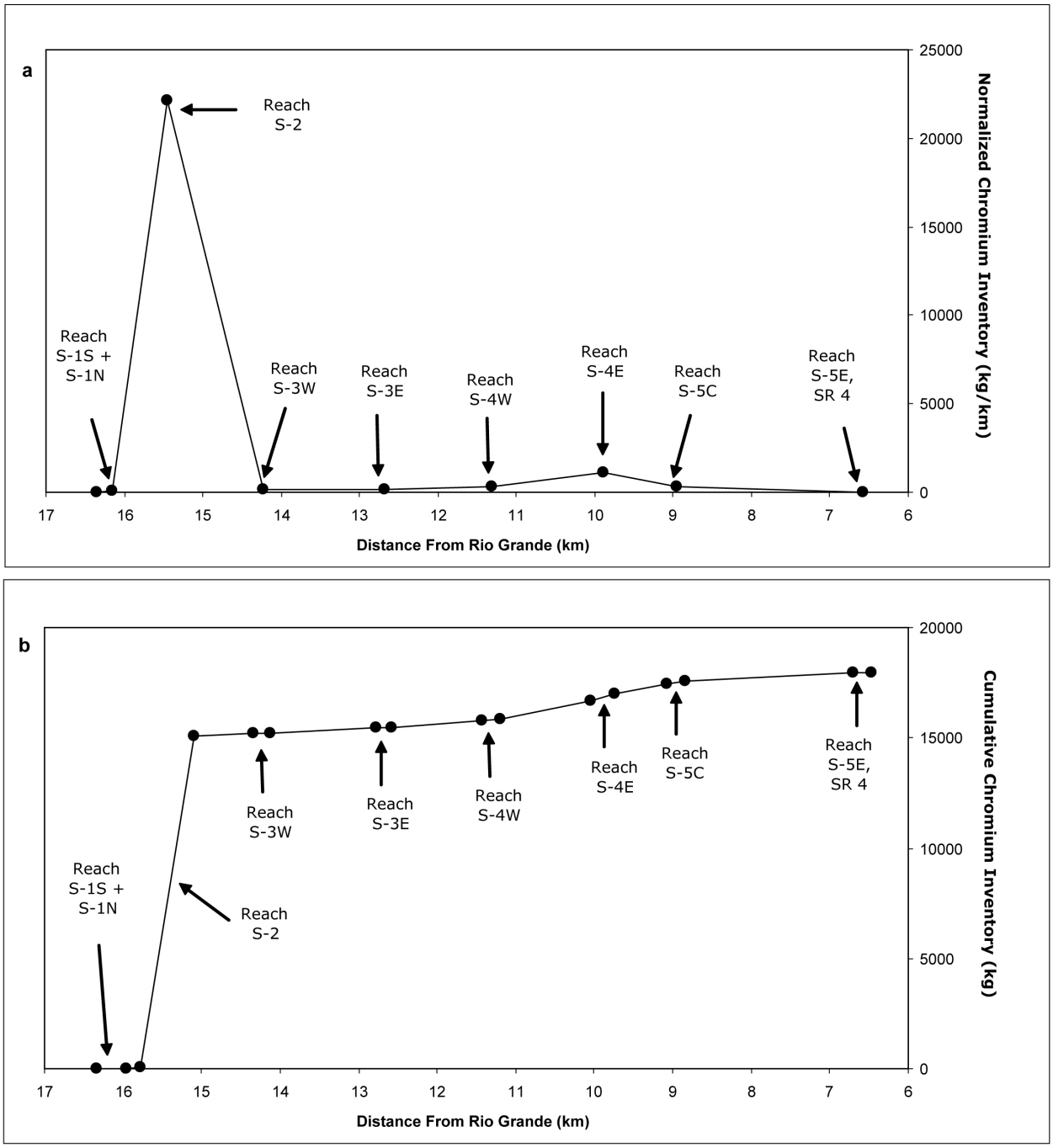

Figure 1 Estimated anthropogenic chromium inventory in Sandia Canyon sediment deposits upcanyon of SR 4: (a) normalized inventory (kg/km); (b) cumulative inventory (kg)

Table 1
Summary of Sediment Samples in Sandia Canyon

Reach	Reach Abbreviation	Reach Length (km)[b]	Approximate Distance from Rio Grande to Midpoint of Reach (km)	Year of Sediment Sampling	Number of Samples Collected Per Suite[a]																			
					Target Analyte List Metals	Hexavalent Chromium	Total Cyanide	Molybdenum	Perchlorate	Explosive Compounds (NMED Explosives List)	Pesticides	Polychlorinated Biphenyls	Polycyclic Aromatic Hydrocarbons	Semivolatile Organic Compounds	Total Petroleum Hydrocarbons–Diesel Range Organics	Volatile Organic Compounds	Americium-241 by Alpha Spectroscopy	Gamma Spectroscopy Radionuclides	Plutonium 238,239/240	Strontium-90	Thorium-228, -230, -232	Tritium	Uranium-234, -235, -238	Geochemical Characterization Suite[c]
S-1 North	S-1N	0.16	16.04	1998	3	—[d]	—	—	—	—	1	8	—	1	1	—	1	1	1	1	—	1	1	—
S-1 South	S-1S	0.38	16.15	1998	5	1	—	—	—	—	2	13	—	2	2	—	2	2	2	2	—	2	2	—
S-2	S-2	0.68	15.44	1998	26	4	—	—	—	—	10	47	—	10	10	—	10	10	10	10	—	10	10	—
				2007	36	36	10	10	10	10	10	20	20	20	20	20	10	10	10	10	10	10	10	14
S-3 West	S-3W	0.21	14.24	2007	10	10	—	10	—	—	—	10	—	—	—	—	—	—	—	—	—	—	—	2
S-3 East	S-3E	0.20	12.68	2000	8	—	8	—	—	—	8	8	—	8	—	—	8	8	8	—	—	—	8	—
				2007	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	2
S-4 West	S-4W	0.23	11.31	2007	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	2
S-4 East	S-4E	0.31	9.89	2007	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	2
S-5 Central	S-5C	0.24	8.96	2000	7	—	7	—	—	—	7	7	—	7	—	—	7	7	7	—	—	—	7	—
				2007	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	2
S-5 East	S-5E	0.23	6.59	2007	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	2

[a] Sample numbers exclude field duplicates, rinsate blanks, trip blanks, and resamples resulting in duplicate analyses.

[b] Length refers to area mapped and characterized.

[c] Geochemical characterization suite includes iron(II), manganese(IV), phosphorous, nitrate, sulfate, and sulfide.

[d] — = No samples were collected for suite in reach.

Table 2
Maximum Concentrations for Inorganic COPCs in Sandia Canyon Sediment Samples

Reach	Aluminum	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chloride	Chromium	Chromium Hexavalent Ion	Cobalt	Copper	Cyanide (Total)	Fluoride	Iron	Lead
Sediment BV	**15400**	**3.98**	**127**	**1.31**	**0.4**	**4420**	**17.1**	**10.5**	**na**[a]	**4.73**	**11.2**	**0.82**	**na**	**13800**	**19.7**
Residential SSL[b]	**77800**	**3.9**	**15600**	**156**	**39**	**na**	**na**	**2100**[c]	**234**	**1520**	**3130**	**1220**	**3670**	**23500**	**400**
S-1S	—[d]	—	—	—	0.6 (U)	—	—	160 (J-)	—	—	48 (J-)	—	—	—	77 (J-)
S-1N	—	4	—	—	0.63 (U)	—	—	—	—	—	—	—	—	—	690
S-2	20000	15.6	297	3.97	8.69	6080	66 (J-)	3740	2.01 (J+)	8.2	223	11.6	3.31 (J-)	21000	74.4
S-3W	—	4.77	128 (J-)	—	0.79	—	—	217 (J-)	0.548 (J+)	—	28.7	—	—	—	24.4 (J)
S-3E	—	—	—	1.6	0.64 (U)	—	79.4	439	1.96	—	26	0.86 (U)	4.87 (J-)	—	34
S-4W	—	—	—	—	0.665 (U)	—	43.6 (J-)	112	—	—	16.2	—	1.88 (J-)	—	30.1
S-4E	—	—	—	—	0.559 (U)	—	—	113	2.53	5.24	18.4	—	4.56 (J-)	13900 (J+)	28.5
S-5C	—	—	—	—	0.55 (U)	—	—	73.9	—	—	15.2	—	1.89 (J-)	14600	63.2
S-5E	—	—	—	—	0.535 (U)	—	—	22.5	0.587 (J)	—	—	—	2.44 (J-)	—	25.1

Table 2 (continued)

Reach	Magnesium	Manganese	Mercury	Molybdenum	Nickel	Nitrate	Perchlorate	Potassium	Selenium	Silver	Sulfate	Thallium	Vanadium	Zinc
Sediment BV	**2370**	**543**	**0.1**	**na**	**9.38**	**na**	**na**	**2690**	**0.3**	**1**	**58.2**	**0.73**	**19.7**	**60.2**
Residential SSL[b]	**na**	**3590**	**23**[c]	**391**	**1560**	**100000**	**55**[c]	**na**	**391**	**391**	**na**	**5.16**	**78.2**	**23500**
S-1S	—	—	1.2	—	—	—	—	—	0.6 (U)	14 (J-)	—	—	—	110 (J-)
S-1N	—	—	0.13 (U)	—	11	—	—	—	0.63 (U)	2.5 (U)	—	—	—	—
S-2	2800	582	5.57	44.4	69.3 (J+)	13 (J-)	0.000997 (J)	3500	4.43 (U)	87.3 (J+)	1340 (J-)	1.06	40	1140
S-3W	—	996	0.26	3.4	10.2	1.43	—	—	1.7 (U)	6.35	—	—	—	—
S-3E	—	—	0.17 (U)	1.6	—	3.75	0.00141 (J)	—	1.92 (U)	4.2	59.5	—	—	100
S-4W	—	636	—	1.12	—	4.72 (J-)	0.00123 (J)	—	1.99 (U)	2.29	—	—	—	158
S-4E	—	629	0.239	1.6	—	5.87 (J-)	0.00101 (J)	—	1.68 (U)	3	—	—	—	102
S-5C	—	597	0.106	1.54	—	1.65 (J-)	0.00221 (J-)	—	1.76	2.4	—	—	—	89.9
S-5E	—	—	—	0.394	—	1.37 (J-)	0.00113 (J)	—	1.6 (U)	—	—	—	—	—

Note: Units are mg/kg. Qualifiers are shown in ( ). Results shown only for analytes that are COPCs in a reach. Values highlighted in gray exceed the residential SSL.

[a] na = Not available.

[b] Residential SSLs are from NMED (2006, 092513), unless otherwise noted.

[c] U.S. Environmental Protection Agency (EPA) Region 6 residential screening level (EPA 2006, 094321); for chromium, EPA value multiplied by 10 to match NMED target risk level; for mercury, value is for mercury and compounds.

[d] — = Not a COPC in reach.

Table 3
Maximum Concentrations for Organic COPCs in Sandia Canyon Sediment Samples

Reach	Acenaphthene	Acenaphthylene	Acetone	Anthracene	Aroclor-1016	Aroclor-1242	Aroclor-1248	Aroclor-1254	Aroclor-1260	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(g,h,i)perylene
Residential SSL[a]	**3730**	**2290[b]**	**28100**	**22000**	**3.93**	**1.12**	**1.12**	**1.12**	**1.12**	**6.21**	**0.621**	**6.21**	**2290[b]**
S-1S	—[c]	—	—	1.9 (J)	—	—	—	—	11	3.6	3.3	3	—
S-1N	—	—	—	—	—	—	0.076	—	0.045	—	—	—	—
S-2	1.39	0.0608 (J)	0.207 (J+)	2.04	0.024	0.366	—	2.53	2.08	3.3	2.36 (J)	3.54 (J)	0.914 (J)
S-3W	—	—	—	—	—	—	—	0.258	0.282	—	—	—	—
S-3E	—	—	—	—	—	—	—	0.06	0.3 (J-)	0.0286 (J)	—	0.225 (J)	—
S-4W	—	0.0631	—	—	—	—	—	0.112	0.12	0.0565	—	0.0792	—
S-4E	0.279	—	—	0.00888 (J)	—	—	—	0.17	0.219	0.0473	0.0981	0.132	0.0174 (J)
S-5C	0.0777	—	—	—	—	0.043	—	0.0979	0.157	0.0524	0.0438	0.0575	—
S-5E	0.0252 (J)	—	—	0.00731 (J)	—	0.0414	—	0.0259	0.0527	—	—	—	—

Table 3 (continued)

Reach	Benzo(k)fluoranthene	Benzoic Acid	Bis(2-ethylhexyl)phthalate	Butanone[2-]	Butylbenzene[n-]	Butylbenzene[sec-]	Carbon Disulfide	Chlordane[gamma-]	Chloroaniline[4-]	Chloroform	Chrysene	DDD[4,4'-]
Residential SSL[a]	**62.1**	**100,000[d]**	**347**	**31,800**	**62.1[e]**	**60.6**	**460[e]**	**16.2[f]**	**240**	**4**	**615**	**24.4**
S-1S	2.8	—	—	—	—	—	—	—	—	—	3.7	—
S-1N	—	—	—	—	—	—	—	—	—	—	—	—
S-2	1.57 (J)	0.466 (J)	1.35	0.0339 (J+)	0.000847 (J)	0.000877 (J)	0.012 (J+)	0.047	0.342 (J)	0.000383 (J)	3.3	0.036
S-3W	—	—	—	—	—	—	—	—	—	—	—	—
S-3E	0.0146 (J)	—	0.111 (J)	—	—	—	—	—	—	0.0003 (J)	0.0279 (J)	—
S-4W	—	—	—	—	—	—	—	—	—	0.000344 (J)	0.0512	—
S-4E	0.052 (J)	—	—	—	—	—	—	—	—	—	0.067	—
S-5C	0.0146 (J)	—	—	—	—	—	—	—	—	—	0.0394	—
S-5E	—	—	0.0932 (J)	—	—	—	—	—	—	0.00024 (J)	0.00861	—

Table 3 (continued)

Reach	Dibenzofuran	Dieldrin	Di-n-butylphthalate	Ethylbenzene	Fluoranthene	Fluorene	Indeno(1,2,3-cd)pyrene	Isopropyltoluene[4-]	Methylnaphthalene[2-]	Naphthalene	Phenanthrene	Pyrene	Toluene	Total Petroleum Hydrocarbons Diesel Range Organics
Residential SSL[a]	**142**	**0.304**	**6110**	**128**[e]	**2290**	**2660**	**6.21**	**271**[g]	**79.5**[h]	**79.5**	**2290**[b]	**2290**	**252**	**520**[i]
S-1S	—	—	—	—	9	—	1.2 (J)	—	—	—	6.8	6.3	—	69
S-1N	—	—	—	—	—	—	—	—	—	—	—	—	—	—
S-2	1.22	0.037	0.106 (J)	0.001 (J)	13	1.88	1.03 (J)	0.0798	0.456	0.854	16	9.78	0.00651	470 (J)
S-3W	—	—	—	—	—	—	—	—	—	—	—	—	—	—
S-3E	—	—	—	—	0.046	—	—	—	—	—	0.0277 (J)	0.0557	—	81.9
S-4W	—	—	—	—	0.164	—	—	—	—	—	0.0515	0.108	—	28.8 (J)
S-4E	—	—	—	—	0.105	0.00976 (J)	0.0639 (J)	0.00543	—	—	0.0486	0.0909	0.00613	52.5
S-5C	—	—	—	—	0.0851	—	—	—	—	—	0.0387	0.0833	0.00223 (J+)	120 (J)
S-5E	—	0.00274	—	—	0.0133	—	—	—	—	—	0.00791 (J)	0.0129	0.000887 (J)	69.6

Note: Units are mg/kg. Qualifiers are shown in (). Results shown only for analytes that are COPCs in a reach. Values highlighted in gray exceed the residential SSL.

[a] Residential SSLs are from NMED (2006, 092513), unless otherwise noted.

[b] Pyrene residential SSL is used as a surrogate.

[c] — = Not a COPC in reach.

[d] EPA Region 6 screening level (EPA 2006, 094321).

[e] SSL based on the soil saturation concentration; not a risk-based value.

[f] Chlordane residential SSL is used as a surrogate.

[g] Isopropylbenzene residential SSL is used as a surrogate.

[h] Naphthalene residential SSL is used as a surrogate.

[i] Screening guidelines for diesel #2/crankcase oil (NMED 2006, 094614).

Table 4
Maximum Concentrations for Radionuclide COPCs in Sandia Canyon Sediment Samples

Reach	Americium-241	Cesium-137	Plutonium-238	Plutonium-239/ Plutonium-240	Strontium-90	Thorium-228	Thorium-232	Tritium	Uranium-234	Uranium-235	Uranium-238
Sediment BV	**0.04**	**0.9**	**0.006**	**0.068**	**1.04**	**2.28**	**2.33**	**0.093**	**2.59**	**0.2**	**2.29**
Residential SAL[a]	**30**	**5.6**	**37**	**33**	**5.7**	**2.3**	**5**	**750**	**170**	**17**	**86**
S-2	0.05	1.1	0.125	0.391	1.9	—[b]	—	4.46	4.29	0.228	4.04
S-4W	—	—	0.0251	—	—	2.47	2.37	—	—	—	—
S-4E	—	—	—	1.72	—	—	—	—	—	—	—
S-5C	—	0.96	—	—	—	—	—	—	—	—	—
S-5E	0.0431	—	—	—	—	2.35	—	—	—	—	—

Note: Units are pCi/g. Results shown only for analytes that are COPCs in a reach. Values highlighted in gray exceed the residential SAL.

[a] Residential SALs are from LANL (2005, 088493).

[b] — = Not a COPC in reach.

Table 5
Risk and Dose Ratios, HQs, and HIs for Select COPCs in Sandia Canyon Sediment Samples

Reach	Aroclor-1254	Aroclor-1260	Arsenic	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Chromium	Dieldrin	Indeno(1,2,3-cd)pyrene	Sum of Risk Ratios for Carcinogenic (ca) Endpoint	Aluminum	Aroclor-1242	Aroclor-1254	Aroclor-1260	Cadmium	Iron	Manganese	Mercury	Molybdenum	Silver	Thallium	Vanadium	HI for Noncarcinogenic (nc) Endpoint	Thorium-228	Thorium-232	Sum of Dose Ratios for Radionuclides (rad)
Endpoint	**ca[a]**	**ca[a]**	**ca**	**ca**	**ca**	**ca**	**ca**	**ca**	**ca**	**ca sum**	**nc**	**nc**	**nc**	**nc**	**nc**	**nc**	**nc**	**nc**	**nc**	**nc**	**nc**	**nc**	**nc HI**	**rad**	**rad**	**rad sum**
S-1S	—[b]	5.00	—	0.58	5.31	0.48	—	—	0.19	**11.70**	—	—	—	9.82	—	—	—	—	—	—	—	—	**9.94**	—	—	—
S-1N	—	—	1.03	—	—	—	—	—	—	**1.05**	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
S-2	1.15	0.95	4.00	0.53	3.80	0.57	1.78	0.12	0.17	**13.10**	0.26	0.33	2.26	1.86	0.22	0.89	0.16	0.24	0.11	0.22	0.21	0.51	**7.56**	—	—	—
S-3W	0.12	0.13	1.22	—	—	—	0.10	—	—	**1.57**	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
S-3E	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
S-4W	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.07	0.47	**1.55**
S-4E	—	—	—	—	—	—	—	—	—	—	—	—	0.15	0.20	—	0.59	0.18	—	—	—	—	—	**1.16**	—	—	—
S-5C	—	—	—	—	—	—	—	—	—	—	—	—	—	0.14	—	0.62	0.17	—	—	—	—	—	**1.08**	—	—	—
S-5E	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.02	—	**1.02**

Note: Values are risk ratios (carcinogens [ca]), hazard quotients (HQs), (noncancerous effect [nc]), or dose ratios (radiological [rad]) unless otherwise specified. Values shown only for COPCs that have ratios or HQs >0.1 in a reach based on maximum results and that have the sum of ratios or HIs >1 in the reach.

[a] EPA Region 6 SSL (2.2 mg/kg) used for this endpoint at NMED target risk level.

[b] — = COPC not a contributor to potential human health risk in reach.

Table 6
Proposed Phase 2 Reaches, Analytical Suites, and Sample Numbers in Sandia Canyon

Reach	Number of Samples for Each Analytical Suite[a]																				Notes on Analytical Suites
	Target Analyte List Metals	Hexavalent Chromium	Total Cyanide	Perchlorate	Fluoride	Nitrate	Molybdenum	Pesticides	Polychlorinated Biphenyls	Polycyclic Aromatic Hydrocarbons	Semivolatile Organic Compounds	Volatile Organic Compounds	Total Petroleum Hydrocarbons, Diesel Range Organics	Americium-241 by alpha spectroscopy	Gamma Spectroscopy Radionuclides	Plutonium-238, -239/240	Strontium-90	Thorium 228, -230, -232	Tritium	Uranium-234, -235, -238	
S-1N	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	—[b]	10	10	Includes all COPCs identified in S-1N, S-1S, or S-2
S-1S	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	—	10	10	Includes all COPCs identified in S-1N, S-1S, or S-2
S-3W	10	—	—	—	—	—	—	10	10	10	—	—	—	—	—	—	—	—	—	—	Includes all COPCs identified in S-3W as potentially contributing to the carcinogenic human health risk endpoint and COPCs so identified in S-2 for which no data are available in S-3W
S-6W[c]	10	10	—	10	10	10	10	10	10	10	10	10	10	10	—	—	—	10	—	—	Includes all COPCs identified in S-5E
S-6E[c]	10	10	—	10	10	10	10	10	10	10	10	10	10	10	—	—	—	10	—	—	Includes all COPCs identified in S-5E

[a] Number of samples excludes field duplicates, rinsate blanks, and trip blanks.
[b] — = No analyses proposed for suite in reach.
[c] Phase 2 sampling in this reach will be contingent on approval of San Ildefonso Pueblo.

Attachment 1

Sediment Samples, Analytical Data, Box Plots, and Geomorphic Maps for Sandia Canyon Phase 1 Summary Report (on CD included with this document)