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Date: August 20, 2001
Refer to: ER2001-0677

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Mr. John Young, Corrective Action Project Leader
Permits Management Program
NMED – Hazardous Waste Bureau
2905 Rodeo Park Drive East
Building 1
Santa Fe, NM 87505-6303

SUBJECT: INTERIM ACTION PLAN FOR SOUTH FORK OF ACID CANYON

Dear Mr. Young:

Enclosed are two copies of the *Interim Action Plan for the South Fork of Acid Canyon*. The interim action is being proposed in the South Fork of Acid Canyon because the New Mexico Environment Department (NMED) and others have expressed concerns about the levels of radionuclides that are present in a public area close to the Los Alamos townsite. This plan presents a proposed interim action (IA) by the Los Alamos National Laboratory's Environmental Restoration (ER) Project to reduce potential radiation dose to recreational users of the South Fork of Acid Canyon following "as low as reasonably achievable" (ALARA) guidelines. ALARA guidelines allow for actions to reduce potential radiation dose below that indicated by standards, incorporating cost-benefit analyses and social and political considerations in addition to dose assessments. This plan includes a corrective action analysis (CAA) of remedial alternatives that identified sediment removal utilizing a vacuum method as the desired remedial action.

This proposed action has been presented to, and accepted by the Northern New Mexico Citizen's Advisory Board. In addition, the landowner (Los Alamos County) has also expressed support.

The ER Project is planning to perform this Interim Action in Acid Canyon on or about August 27, 2001, through approximately September 30, 2001. This plan is being provided to your office for information purposes; however, any comments on the planned actions that may ultimately lead to a final remedy will be considered. Please contact Dave McInroy at (505) 667-0819 if you have any questions.

Sincerely,

Julie A. Canepa, Program Manager
Environmental Restoration Project
Los Alamos National Laboratory

Sincerely,

Mat Johansen, Project Manager
Department of Energy
Los Alamos Area Office

JC/MJ/RB/ev

Enclosure: Interim Action Plan for the South Fork of Acid Canyon (ER2001-0648)

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environmental restoration project

A Department of Energy
Environmental Cleanup Program

LA-UR-01-4538
August 2001
ER2001-0648

Interim Action Plan for the South Fork of Acid Canyon

Los Alamos
NATIONAL LABORATORY
Los Alamos, NM 87545

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1.0 INTRODUCTION

Acid Canyon received both treated and untreated radioactive liquid waste from Los Alamos National Laboratory (the Laboratory) operations between 1944 and 1964 (Stoker et al. 1981, 06059.2; LANL 1992, 07668.1; LANL 1992, 43454.1). From 1944 to 1951, untreated radioactive effluent from former Technical Area (TA) 1 was discharged into the head of a short tributary to Acid Canyon that is referred to as the "South Fork of Acid Canyon" (reach ACS). From 1951 to 1964, effluent from a radioactive liquid waste treatment plant at former TA-45 was discharged into reach ACS. In 1966, structures at TA-45 were demolished and contaminated soils on the mesa top were excavated. The area was transferred to Los Alamos County in 1967. The site of TA-45 is now the location the County Skateboard Park. Acid Canyon currently contains several trails and is used for outdoor recreation (Figure 1). Radionuclides are present in sediment deposits in and adjacent to the stream channel in Acid Canyon at concentrations above background levels, with the highest concentrations occurring in reach ACS. However, radiation dose assessments have indicated that dose standards are not exceeded (Stoker et al. 1981, 06059; LANL 1996, 54468.3; Reneau et al. 2000, 66867.2).

1.1 Purpose and Scope

This plan presents a proposed interim action (IA) by the Canyons Focus Area (CFA) of the Laboratory's Environmental Restoration (ER) Project to reduce potential radiation doses to recreational users of reach ACS following "as low as reasonably achievable" (ALARA) guidelines. ALARA guidelines allow for actions to reduce potential radiation doses below that indicated by standards, incorporating cost-benefit analyses and social and political considerations in addition to dose assessments. This plan includes a corrective action analysis (CAA) of remedial alternatives, presented in Appendix D, which identifies sediment removal utilizing a vacuum method as the desired option. The vacuum technology would be used to remove sediment that exceeds average concentrations of plutonium-239/240 of 280 pCi/g, which is currently estimated at approximately 228 yd^3.

1.2 Rationale for Proposed Corrective Action

The Department of Energy (DOE) has directed that an IA be planned in reach ACS. This direction is based on the results of the ALARA analysis and the "Interim Report on Sediment Contamination in the South Fork of Acid Canyon," as well as guidance from the Northern New Mexico Citizen's Advisory Board (NNMCAB). Concerns about residual levels of contaminants present in a public recreational use area created the initiative to re-characterize reach ACS and perform a detailed dose assessment relative to sediments in reach ACS. Although a dose assessment indicated that the cleanup guideline of 15 mrem/yr is not exceeded in reach ACS (Reneau et al. 2000, 66867.2), and an ALARA analysis indicated that corrective action was not supported purely from a cost-benefit standpoint (Ryti and Reneau 2000, 68728.3), ALARA guidelines specify that social and political factors should also be considered in cleanup decisions (DOE 1997, 7006). An option that involves removal of areas where average concentrations of plutonium-239/240 exceed the single radionuclide soil guideline (SRSG) of 280 pCi/g has been supported by the NNMCAB (NNMCAB 2001, 70065), and the DOE has concurred with this recommendation (DOE 2001, 70070). In addition, the landowner (Los Alamos County) has also expressed support for this action (County of Los Alamos 2001, 70069)

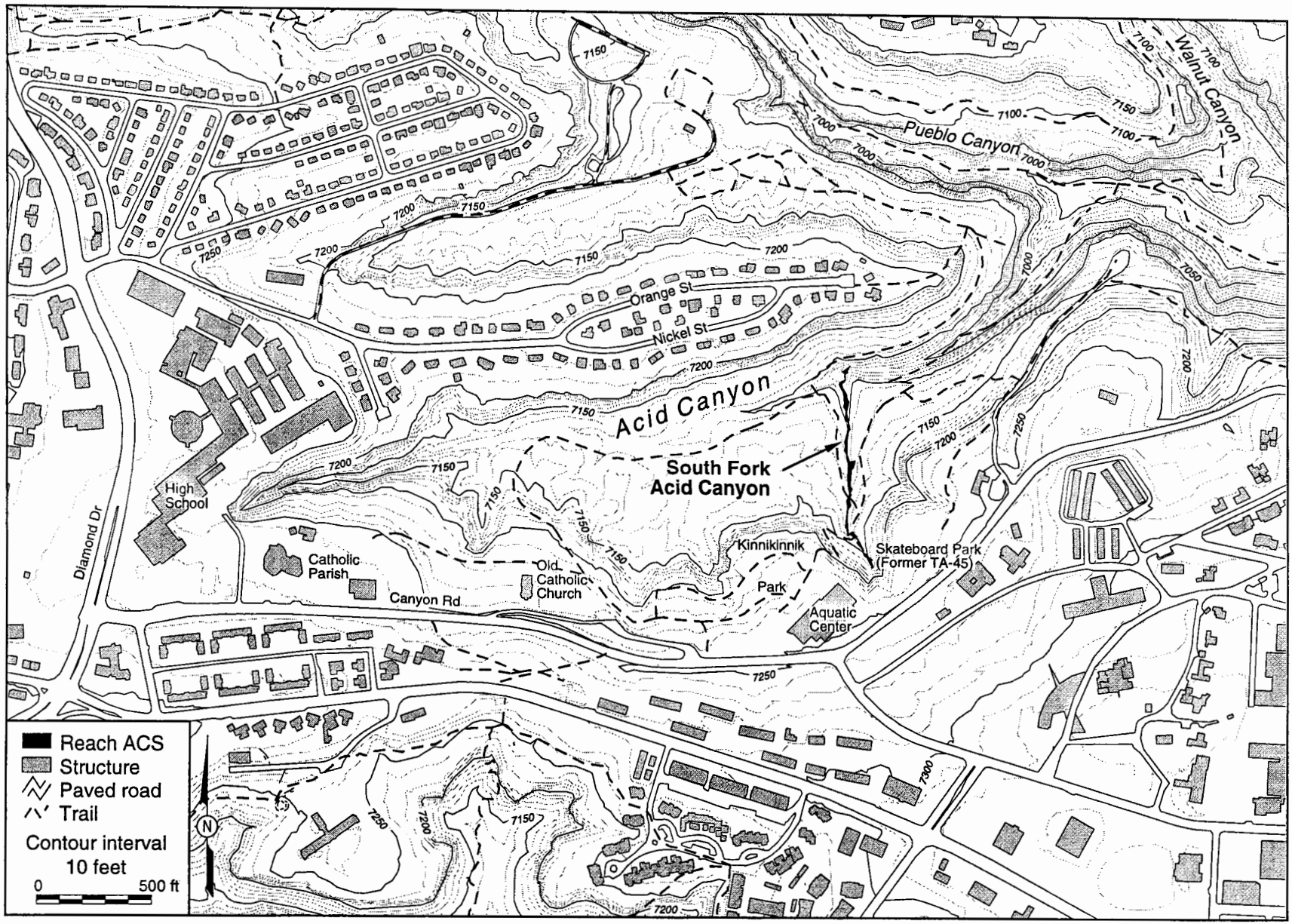

Figure 1. Acid Canyon Area

Source: FIMAD G108455 4/10/00
Modified by: cARTography by A. Kron 6/27/01

2.0 PREVIOUS SITE CHARACTERIZATION

2.1 Site Description

Reach ACS is located along a short tributary drainage to Acid Canyon, north of Canyon Road in the Los Alamos townsite (Figure 1). A dirt maintenance road and hiking trails are present in the immediate area. The County Skateboard Park and the Larry Walkup Aquatic Center are located on the mesa top south and southeast of reach ACS.

The floor of the canyon has an elevation of approximately 7070 to 7160 ft, and lies about 150 ft below the mesa top. The canyon walls adjacent to the mesa top consist of alternating steep slopes and cliffs. There is no perennial surface water within the canyon, although there is ephemeral surface water runoff in response to rain or melting snow and discharge from the Larry Walkup Aquatic Center pool which is located a short distance south of reach ACS. The aquatic center discharges pool water and water used to back flush the pool filters to reach ACS.

The north-facing slopes support a mixed conifer forest community. Douglas fir, ponderosa pine, white fir, and limber pine are the predominant tree species. Bearberry and Gambel's oak are the major shrub species. Junegrass and pine dropseed are the major grass species. Threatened and endangered species that regionally nest or forage in this mixed conifer forest include the Mexican spotted owl. Characteristic fauna found in mixed conifer forests include the elk, mule deer, red squirrel, and mountain cottontail. The only aquatic community consists of algae covering rocks in the stream channel.

2.2 Previous Field Investigations

Sediment samples were collected for radionuclide analyses from reach ACS in several investigations between 1946 and 1993 (Kingsley 1947, 04186.2; Stoker et al. 1981, 06059.2; Hakonson et al. 1973, 04974.2; Hakonson and Bostick 1976, 08914.1; Nyhan et al. 1976, 11747.1; Nyhan et al. 1975, 11746.1; LANL 1995, 54468.3). Although these studies identified the types of radionuclide contaminants present in reach ACS, characterization of these contaminants was not as thorough as current geomorphology studies and subsequent investigations in other canyons at the Laboratory, and they did not sample the areas with highest levels of radionuclides.

More detailed field investigations in reach ACS were conducted by the CFA in November 1999 (Reneau et al. 2000, 66867.2). Field work included detailed geomorphic mapping of the entire 290 m long canyon between the base of the hillslope and the confluence with main Acid Canyon, collecting field radiological data for alpha, beta, and gamma radiation at 48 locations, and collecting 31 Phase I sediment samples for analysis. These analyses were combined with analyses of 9 samples collected by the New Mexico Environment Department (NMED) (Yanicak et al. 1999, 70670) and 11 samples collected by the U.S. Environmental Protection Agency (EPA) (EPA 2001, 70669), to provide a revised dose assessment for reach ACS (Reneau et al. 2000, 66867.2). Figure 2 shows the reach ACS geomorphology.

Later work in reach ACS included the collection of 20 Phase II sediment samples in August and September 2000. These consisted of re-sampling previously sampled layers to expand the database of chemicals of potential concern (COPCs) other than plutonium.

Twelve additional sediment samples were collected in reach ACS in June 2001 as part of Phase III investigations. These samples were obtained from sites that had average concentrations of plutonium-239/240 less than 280 pCi/g, as determined from field alpha radiation measurements or previous analyses. The purpose of collecting these samples was to obtain additional data from areas that would remain following the IA, as input into post-IA risk assessments.

In July 2001, during preparation of this IA plan, 42 additional sediment samples were collected to provide data required for plan implementation. The 42 samples were collected for plutonium and gross alpha radiation measurements to help refine those areas that had average concentrations of plutonium-239/240 exceeding 280 pCi/g.

In August 2001, six samples were collected for volatile organic compound (VOC) and semivolatile organic compound (SVOC) toxicity characteristic leaching procedure (TCLP) analyses to aid in waste characterization.

2.3 Results of Previous Investigations

Analytical data from sediment samples collected in 1999 identified nine radionuclide COPCs in reach ACS: americium-241, cesium-137, plutonium-238, plutonium-239/240, strontium-90, tritium, uranium-234, uranium-235, and uranium-238 (Reneau et al. 2000, 66867.2). These radionuclides were evaluated in a preliminary radiation dose assessment that included three exposure scenarios: extended backyard, jogger, and hiker (Reneau et al. 2000, 66867.2). Only the extended backyard scenario is discussed here because it results in the largest potential dose. The estimated potential incremental radiation dose for this scenario was 12.7 mrem/yr, with approximately 89% of the dose from plutonium-239/240. Approximately 90% of the dose was from the soil ingestion pathway, 5% from external gamma radiation, and 5% from the inhalation pathway. The estimated potential dose is less than the EPA guideline of 15 mrem/yr (EPA 1997, 48639) and is more protective of potential human health effects than the dose limit of 100 mrem/yr in DOE Order 5400.5, *Radiation Protection of the Public and the Environment.*

The field investigations and analytical data revealed that approximately 60% of the plutonium-239/240 is contained in several discontinuous patches that constitute about 5% of the contaminated sediments area in reach ACS, or an area of approximately 50 m^2 (Reneau et al. 2000, 66867.2). All samples with results greater than 1000 pCi/g were obtained from these areas. These small areas contribute about 65% of the estimated potential incremental dose. Comparison of field alpha radiation measurements and the analytical results indicate that the field instruments were successful in identifying the areas with highest levels of plutonium-239/240. In guiding sampling, field measurements should similarly be useful in selecting areas for remediation.

No new data for plutonium was obtained in the August and September 2000 sampling event. Maximum Phase II results for all COPCs in all samples were less than results obtained in Phase I. At the request of NMED, seven samples were analyzed for perchlorate. No perchlorate was detected in these samples, so it was not identified as a COPC. A sampled layer that had previously yielded anomalously high levels of lead and other metals was resampled for TCLP analysis. All results were below regulatory limits.

Results from the June and July 2001 sampling events are not yet available.

3.0 BASIS FOR CLEANUP LEVELS

The cleanup level proposed in this IA plan is based on a dose assessment performed for reach ACS (Reneau et al. 2000, 66867.2), and an ALARA analysis that considers the effects of choosing different cleanup options on both cost and reduction of potential radiation doses (Ryti and Reneau 2000, 68728.3). These options focused on different possible cleanup levels for plutonium-239/240 because this analyte contributes about 89% of the potential incremental dose in reach ACS. The ALARA analysis evaluated four cleanup options: no sediment removal; removal of the most contaminated sediment deposits where plutonium-239/240 concentrations average greater than 2000 pCi/g (approximately 65 yd^3); removal of sediment deposits that exceed the single radionuclide screening guideline (SRSG) of 280 pCi/g

(approximately 228 yd^3); and removal of all deposits that include fine-grained plutonium-bearing sediment (approximately 880 yd^3). Upon review of the assessment report and the ALARA analysis, the NNMCAB recommended removal of sediment with an average concentration of plutonium-239/240 exceeding 280 pCi/g (NNMCAB 2001, 70065). They concluded that the additional reduction in potential dose resulting from lower cleanup levels was not sufficient to justify the additional cost in cleanup money, use of waste repository space, environmental damage caused by the cleanup itself, or stress to local residents during an extended cleanup time. DOE subsequently concurred with this recommendation (DOE 2001, 70070), and Los Alamos County has also expressed support for this cleanup option (County of Los Alamos 2001, 70069).

4.0 PROPOSED INTERIM ACTION

4.1 Conceptual Model

Plutonium and other contaminants in reach ACS were largely derived from discharges of liquid effluent from former TA-1 and TA-45 outfalls. These contaminants were generally bound to sediment particles, and were subsequently redistributed by surface water runoff. The present variations in contaminant concentration and contaminant inventory reflect both the discharge history and the 50+ year history of surface water runoff in reach ACS and downstream in main Acid Canyon, Pueblo Canyon, and Los Alamos Canyon.

The highest concentrations and most of the inventory of plutonium-239/240 in reach ACS occurs in relatively small, discontinuous sediment deposits that occupy about 5% of the total area that has experienced surface water runoff since historical discharges began. Because effluent discharges ceased in 1964, younger sediment deposits in reach ACS have lower concentrations of plutonium-239/240, and any plutonium that is remobilized by erosion is mixed with unaffected sediment during periods of surface water runoff.

Concentrations of plutonium-239/240 vary vertically within individual stratigraphic sections related to the combined effects of variations in sediment age and particle size. Typically, the highest concentrations of plutonium-239/240 at a site occur in fine-grained sediment layers, and these fine-grained layers often overlie coarse-grained layers with lower concentrations. The highest concentrations of plutonium-239/240 also typically occur in older subsurface layers that are overlain by younger layers with lower concentrations, although at some sites the highest concentrations occur in surface layers. The thickness of sediment exceeding an average concentration of 280 pCi/g plutonium-239/240 varies from about 0.2 to 1.1 m, with this sediment either overlying sediment with lower concentrations of plutonium-239/240 or overlying bedrock.

Data from Acid Canyon and Pueblo Canyon (Reneau et al. 1998, 65406.5 and subsequent data) indicate that about 15% of the plutonium in the Pueblo Canyon watershed remains in reach ACS, with the remainder redistributed downstream. Concentrations of plutonium decrease downstream and over time due to mixing, and no unacceptable dose to human health or ecosystems has been identified downstream resulting from this redistribution.

Humans potentially can receive a radiation dose above that received naturally in the environment by exposure to radioactively-contaminated sediments. To receive a radiation dose from plutonium-239/240, a person must inhale or ingest material containing plutonium, and the higher the amount of plutonium inhalation or ingestion, the higher the dose. An external radiation dose can be received from gamma-emitting radionuclides such as cesium-137, with the dose increasing with the increasing amount of time a person spent in the contaminated area. Because the highest concentrations of plutonium-239/240 occur

in relatively small areas of reach ACS, these small areas have the largest potential to impact human health.

4.2 Supplemental Data Collection

Supplemental data collection was required to refine the horizontal and vertical extent of sediment that has an average concentration of plutonium-239/240 exceeding 280 pCi/g. The most effective means to accomplish this collection was to include a combination of field alpha measurements and sediment sampling for additional plutonium analyses. As discussed in Appendix C, a correlation between field measurements of alpha radiation and the concentration of plutonium-239/240 has been developed using data collected in 1999. Within a 95% confidence interval, 280 pCi/g is equivalent to a measurement of alpha radiation of about 55 to 81 counts per minute (cpm). We used field alpha measurements to revise the previous geomorphic map for reach ACS (Reneau et al. 2000, 66867.2), subdividing the reach into areas where the average concentration of plutonium-239/240 is predicted to exceed 280 pCi/g (alpha > ~81 cpm), where it is predicted to be less than 280 pCi/g (< ~55 cpm), and where concentrations are indeterminate (~55 to 81 cpm). We then collected additional sediment samples for isotopic plutonium analyses to refine the geomorphic map further and to improve the correlation between alpha radiation and plutonium concentration. We focused these analyses in areas with average alpha radiation between about 40 and 80 cpm. The revised correlation between alpha radiation and plutonium concentration can in turn be used to refine the geomorphic map further and to assist real-time decisions during remediation.

It was necessary to obtain gross alpha radiation measurements for all samples prior to shipping to meet Department of Transportation (DOT) requirements, and these data can be used to refine the existing correlation between gross alpha radiation and plutonium-239/240 concentrations. It is anticipated that similar gross alpha measurements during remediation can provide data sufficient to confirm that cleanup levels have been met.

The supplemental data collection for plutonium and alpha radiation followed the same procedures used for previous samples in reach ACS. Isotopic plutonium analyses utilized alpha spectroscopy at an off-site laboratory. Field alpha radiation and fixed-laboratory gross alpha radiation measurements followed the procedures described in Appendix C.

Also, supplemental data collection was required for waste characterization purposes. Specifically, samples were collected for analysis of VOCs and SVOCs from areas to be remediated prior to waste disposal. Six samples were collected for these analyses, distributed between the areas targeted for sediment removal.

4.3 Cleanup Activities

In preparation for the implementation of an IA in reach ACS, an evaluation of the possible remedial alternatives was prepared (Appendix D). The purpose of this CAA was to identify the possible actions that can be taken to achieve the cleanup goals for the IA. The CAA discusses the criteria to be used to evaluate various methods, the possible actions and/or methods that could be used to achieve the cleanup goals, evaluations of each action and/or method against the defined criteria, and the results of the evaluations.

The criteria used to evaluate possible actions and/or methods were environmental impacts caused by remedial alternatives, effectiveness of technique for accomplishing cleanup goals, disruptions to adjoining neighborhoods during remedial actions (i.e., noise), restrictions on recreational access, and worker and public health.

The remedial action alternatives evaluated for the reach ACS IA were no action (for purposes of comparison), administrative controls (e.g., fencing), cover/barrier (e.g., riprap), mechanical excavation with large machinery, mechanical excavation with small machinery, hand removal (small tools and manual removal from channel), and sediment vacuuming.

The evaluation of the remedial alternatives resulted in four alternatives being rated unsatisfactory (no action, administrative controls, cover/barrier, and mechanical excavation with large machinery), two alternatives rated satisfactory (mechanical excavation with small machinery and hand removal), and one alternative rated good (soil vacuuming). Based on this analysis, soil vacuuming is determined as the best cleanup option.

Site preparation for the IA will include improvements to the access road into the canyon and setup of fenced staging areas. The access road improvements include some minor clearing, grading, and fence rollback near the entry point from the aquatic center parking lot; filling of ruts and road smoothing at the point of steepest descent into the canyon; and the possible installation of a culvert at one drainage crossing in the canyon bottom. Setup of staging areas will include minor clearing and grading, setup of fencing, and staging of cargo containers for equipment storage inside the fenced area. The work area will be closed off with barrier tape, and signs will be posted including detour routes for the portion of the road/trail closed during work hours. During remediation activities, temporary erosion controls will be installed, maintained, and inspected as required in the approved Storm Water Pollution Prevention Plan (SWPPP).

The soil vacuuming will be performed by starting at one end of the area exceeding the cleanup goal and working towards the other end. The close proximity of the road/trail along the portion of the reach to be remediated will allow the machinery and the waste containers to be moved in parallel to the work as it progresses. The machinery and waste containers will be set up so that the vacuum machinery is always south of the waste containers, which will allow the containers to be easily loaded for transport after filling. The waste containers will be in-line with the vacuum piping so that the vacuumed soil and sediments removed fall into the containers. Any fine particles not deposited in the waste containers will be collected in the vacuum system baghouses and/or in-line filters. A final sequence of high efficiency particulate aerosol (HEPA) filters will prevent any release of fine particulates from the vacuum machinery into the ambient airspace.

Vacuum hoses will extend from the waste containers into the drainage. The end of the vacuum hose will be handled by one worker while one or two other workers loosen sediment and soil with small tools such as shovels and picks. Cobble-sized or larger rocks and stones will be left in the drainage. Gravel, sand, silt, and clay-sized material from areas designated by previous radiation surveying and sampling will be vacuumed into the waste containers. Filled containers will be transported out of the canyon to TA-54 for disposal as low-level radioactive waste.

4.4 Site Restoration

Site restoration work will be completed after sediment has been removed from the selected areas, field screening results have been reviewed, a determination made that no additional sediment removal is required, and confirmatory samples have been collected and cleanup goals met. Once site restoration activities are completed, disturbed drainage banks will be covered with jute matting to stabilize soils before the establishment of vegetation. After reseeding, the matting will be unrolled in the direction of water flow and will be anchored at the toe of the slope. The matting will also be anchored at the top of the bank.

All disturbed areas, including the area disturbed during equipment staging, will be reseeded with a seed mixture and application rate as specified in Section 222.7 of the LANL Architectural Standards Manual, Volume 4, and as approved by ESH-18 and ESH-20. Following reseeding, the reseeded areas will be covered with approximately 2 in. of straw mulch. After restoration of the site is complete, the site will be inspected and maintained until the area achieves a vegetation density of greater than 70% as required by the SWPPP.

5.0 CONFIRMATORY SAMPLING

Confirmation data will be obtained during remediation by two methods: field alpha-radiation measurements and fixed-laboratory measurements for gross alpha-radiation. Following remediation, samples will be collected for off-site analyses at analytical laboratories for the full suite of COPCs identified in reach ACS to provide data for post-cleanup risk assessments.

After sediment has been removed from each area targeted for remediation, field alpha radiation measurements will be obtained from remaining sediments in the bottom and sides of the excavation (ER SOPs 10.10 R0, Radiation and Scoping Surveys and 10.11 R0, Soil Sample Field Screening to meet radioactive sample shipping requirements). The bottom will be measured at approximately 1-m intervals in areas with sediment and the sides at 15-cm depth increments. Field alpha-radiation measurements will follow the same procedure used for obtaining screening data prior to sediment removal (described in Appendix C). Excavation will then be continued if alpha radiation is found above a certain limit. This limit is assumed tentatively to be 55 cpm based on the model presented in Appendix C (Figure C-2b), although this limit may be revised following receipt of the data discussed in Section 4.2. A subset of sites with the highest levels of alpha radiation will then be collected from each area for gross alpha-radiation measurements at a fixed laboratory to provide further confirmation that the cleanup goal of 280 pCi/g has been met. Available data indicate that at a 95% confidence interval, samples with gross alpha-radiation less than 340 pCi/g meet the cleanup goal of 280 pCi/g plutonium-239/240 (Appendix C). This value may also be revised following receipt of the data discussed in Section 4.2.

Following remediation and receipt of confirmation data on gross alpha-radiation, 12 samples will be collected from the base of the excavations for the full suite of COPCs that have been identified in reach ACS. Twelve samples are considered adequate coverage for a remediation area consisting of three subareas—two areas of approximately 60 ft by 10 ft and one area of approximately 120 ft by 10 ft—based on the expected low residual concentrations of COPCs in these subareas and experience in characterizing sediment in reaches of this length. For a typical large area canyon reach , 6 to 10 full-suite samples are typically collected. The confirmation samples will be allocated roughly in proportion to the area that was remediated. For the subareas of 600 ft^2, three confirmation samples will be collected per subarea and six confirmation samples will be collected from the larger subarea of 1200 ft^2. The location of the confirmation samples will be determined by the field team after reviewing the field alpha measurements. An effort will be made to obtain representative samples of the remaining sediments for calculating an average concentration in this remediated area. The number of confirmation samples collected will be adjusted if the area being remediated changes from these initial area estimates.

The analyte suite to be used for these samples will consist of isotopic plutonium, gamma spectroscopy radionuclides, strontium-90, isotopic uranium, tritium, target analyte list metals, pesticides, PCBs, VOCs, and SVOCs. Detection limits that are less than the sediment background values will be requested to ensure the usability of the data.

The post-remediation data will be grouped into different geomorphic deposits and average concentrations will be calculated for each deposit. An overall weighted average will be calculated based on the area of

the geomorphic deposits in a manner similar to that used in the reach ACS Interim Report (Reneau et al. 2000, 66867.2). These weighted average concentrations will be compared to the SRSGs developed for reach ACS (Reneau et al. 2000, 66867.2).

6.0 WASTE MANAGEMENT

6.1 Estimated Types and Volumes of Waste

Existing analytical data from areas of planned sediment removal in reach ACS (see Appendix B) were used to determine that the excavated sediment will be characterized as low-level radioactive waste. Sediment from one location yielded relatively high concentrations of certain metals, so this location was resampled for TCLP metals analysis. This sampling effort was performed in order to ascertain whether or not there would be a mixed waste issue associated with the sediment in reach ACS. The fixed analytical laboratory results show metal concentrations below the maximum concentration of contaminants for the toxicity characteristic.

In the ALARA analysis for reach ACS (Ryti and Reneau 2000, 68728.3), it was estimated that approximately 228 yd^3 of sediment exceeds the average of 280 pCi/g plutonium-239/240 and would require removal. This volume will be revised once the data discussed in Section 4.2 are received.

The areas to be excavated can be subdivided into areas with relatively high levels of plutonium-239/240 (greater than approximately 1000 pCi/g), and areas with relatively low levels of plutonium-239/240 (less than approximately 1000 pCi/g). Because some areas are known to have plutonium-239/240 exceeding 2000 pCi/g (2 nCi/g)— thus exceeding DOT limits—it will be necessary to combine sediment from areas with relatively high levels of plutonium with sediment from areas with lower levels of plutonium to assure that material in any waste container does not exceed 2 nCi/g. The soil packages have been assigned an average plutonium concentration based on the correlation between average field alpha for each soil package and derived plutonium concentrations. Volumes of different soil packages containing different plutonium concentrations have been calculated to fill a 12 yd^3 capacity rolloff bin with a mixture containing less than 1500 pCi/g to provide a safety buffer of 500 pCi/g under the 2 nCi/g DOT limit.

Averages for all COPCs in these two groupings of sediment are presented in Appendix B, and can be used to estimate average levels of all analytes in each container based on the percentage of each container derived from relatively high- versus relatively low-plutonium areas.

6.2 Method of Management and Disposal

During soil removal, soil packages (a land area that represents a specific level of contamination) of varying contamination levels will be combined in a single rolloff bin. The mixing of soil packages will be done to ensure that the specific activity for each waste container will fall below the DOT regulatory limit of 2 nCi/g. Radioactively-contaminated soil characterization will be based on existing analytical data, existing field radiological measurements, additional analytical data on VOCs and SVOCs (TCLP analyses), and field radiological measurements obtained during IA sediment removal activities.

Waste will be vacuumed into sealed 12 yd^3 rolloff bins. All waste will be labeled as radioactive waste and each waste container will be transported to TA-54 for disposal the same day it is filled. In the event the waste cannot be transported the same day the container is filled, the container will essentially become a radioactive waste storage area that will be properly cordoned off, posted, and managed in a protective manner within the boundary of the work area as described in LANL-ER-SOP-1.06, R1, Management of Environmental Restoration Project Wastes. Based on existing analytical data, field radiological

measurements, and the waste packaging strategy, the radioactively-contaminated soil will be managed as low-level waste, suitable for disposal at TA-54.

7.0 PROPOSED SCHEDULE AND UNCERTAINTIES

The proposed field activities are expected to have a duration of approximately 25 working days, including mobilization, sediment removal, and demobilization. The actual duration could be affected by several factors, including the exact amount of sediment to be removed, weather conditions during field activities, and functioning of the equipment. The duration could be adversely affected by the need to remove a larger volume of sediment than anticipated, by the occurrence of unexpectedly wet weather during field operations, or by mechanical difficulties. The actual start date will be dependent on the timing of plan approval and completion of a readiness review, which in turn depends on obtaining an access agreement with the county, getting an approved modification to the existing site-specific health and safety plan (SSHASP), obtaining an excavation permit and a dredge and fill permit, and other factors. It is also possible that budgetary constraints could affect the start date.

It is anticipated that the plan could be approved and the readiness review completed by Monday, August 20, 2001, at the earliest. This would allow mobilization to the field to begin on Tuesday, August 21, 2001, and allow sediment removal activities to begin by Wednesday, August 27, 2001. The sediment removal is expected to take approximately 20 working days, with a 6-day work week. The Labor Day holiday falls within this time frame, and the earliest date to complete sediment removal would be Saturday, September 8, 2001. Demobilization could then be completed by Tuesday, September 11, 2001. As discussed above, several factors could either delay the start of field work or increase its duration. Therefore, mobilization and demobilization may occur sometime after August 13 and September 11, 2001, respectively.

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Appendix A

Acronyms and Glossary

APPENDIX A LIST OF ACRONYMS AND GLOSSARY

A-1.0 LIST OF ACRONYMS

ACS	Acid Canyon South
ALARA	as low as reasonably achievable
AOC	area of concern
ARS	American Radiation Services
CAA	corrective action analysis
CFA	Canyons Focus Area (ER Project)
COPC	chemical of potential concern
cpm	counts per minute
DOE	US Department of Energy
DOT	US Department of Transportation
EPA	US Environmental Protection Agency
ER	environmental restoration
HEPA	high efficiency particle aerosol
IA	interim action
ID	identification
LANL	Los Alamos National Laboratory ("the Laboratory" is preferred)
NMED	New Mexico Environment Department (New Mexico Environmental Improvement Division before January 1, 1991)
NNMCAB	Northern New Mexico Citizen's Advisory Board
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PPE	personal protective equipment
PRS	potential release site
SOP	standard operating procedure
SRSG	single radionuclide screening guideline
SSHASP	site-specific health and safety plan
SVOC	semivolatile organic compound
SWMU	solid waste management unit
SWPPP	storm water pollution prevention plan
TA	technical area
TAL	target analyte list
TCLP	toxicity characteristic leaching procedure
VOC	volatile organic compound

A-2.0 GLOSSARY

chemical of potential concern (COPC) — A chemical, detected at a site, that has the potential to adversely affect human receptors due to its concentration, distribution, and mechanism of toxicity. A COPC remains a concern until exposure pathways and receptors are evaluated in a site-specific human health risk assessment.

ephemeral — A stream or spring that flows only during and immediately after periods of rainfall or snowmelt.

polychlorinated biphenyls (PCBs) — Any chemical substance that is limited to the biphenyl molecule that has been chlorinated to varying degrees or any combination of substances which contains such substances. PCBs are colorless, odorless compounds that are chemically, electrically, and thermally stable and have proven to be toxic to both humans and animals.

potential release site (PRS) — Refers to potentially contaminated sites at the Laboratory that are identified either as solid waste management units (SWMUs) or areas of concern (AOCs). PRS refers to SWMUs and AOCs collectively.

radionuclide — A nuclide (species of atom) that exhibits radioactivity.

receptor — A person, plant, animal, or geographical location that is exposed to a chemical or physical agent released to the environment by human activities.

release — Any spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, *leaching*, dumping, or disposing of hazardous waste or hazardous constituents into the environment (including the abandonment or discarding of barrels, containers, and other closed receptacles that contain any hazardous wastes or hazardous constituents).

sample — A portion of a material (e.g., rock, soil, water, air), which, alone or in combination with other samples, is expected to be representative of the material or area from which it is taken. Samples are typically sent to a laboratory for analysis or inspection or are analyzed in the field. When referring to samples of environmental media, the term field sample may be used.

sediment — (1) A mass of fragmented inorganic solid that comes from the weathering of rock and is carried or dropped by air, water, gravity, or ice; or a mass that is accumulated by any other natural agent and that forms in layers on the earth's surface such as sand, gravel, silt, mud, fill, or loess. (2) A solid material that is not in solution and either is distributed through the liquid or has settled out of the liquid.

standard operating procedure (SOP) — A document that details the method for an operation, analysis, or action with thoroughly prescribed techniques and steps, and is officially approved as the method for performing certain routine or repetitive tasks.

technical area (TA) — The Laboratory established technical areas as administrative units for all its operations. There are currently 49 active TAs spread over 43 square miles.

US Department of Energy (DOE) — Federal agency that sponsors energy research and regulates nuclear materials for weapons production.

US Environmental Protection Agency (EPA) — Federal agency responsible for enforcing environmental laws. While state regulatory agencies may be authorized to administer some of this responsibility, the EPA retains oversight authority to ensure protection of human health and the environment.

Appendix B

Pre-Interim Action Data

APPENDIX B PRE-INTERIM ACTION DATA

Analytes and maximum values in the "removal" area are listed in Table B-1. The metals aluminum, antimony, beryllium, cobalt, iron, magnesium, manganese, sodium, thallium, and vanadium are not COPCs because they are not different from background values. Non-detected organic chemicals are also not considered COPCs. All other analytes are COPCs for ACS.

Table B-1
Analytes and Maximum Value in Removal Area

Analyte	Units	Maximum in Proposed Removal Area	Average in Low Plutonium Area	Average in High Plutonium Area	TCLP for Metals (mg/L)
Americium-241	pCi/g	278	7.8	278	—*
Americium-241 (g-spec)	pCi/g	228	38	73	—
Cesium-137	pCi/g	148	44	4	—
Tritium	pCi/g	1.86	1.9	0.0	—
Plutonium-238	pCi/g	37.3	2.3	8.0	—
Plutonium-239/240	pCi/g	7780	328	2119	—
Strontium-90	pCi/g	80	26	31	—
Uranium-234	pCi/g	21.5	3.9	10.5	—
Uranium-235	pCi/g	2	0.2	1.0	—
Uranium-238	pCi/g	16.6	3.1	7.1	—
Aluminum	mg/kg	8900	4040	3150	—
Antimony	mg/kg	1.7	0.5	0.4	—
Arsenic	mg/kg	7.1	3.5	2.7	0.034
Barium	mg/kg	240	85	63	**0.93**
Beryllium	mg/kg	2	0.6	1.0	—
Cadmium	mg/kg	11	5.8	2.9	**0.083**
Calcium	mg/kg	24000	12860	1490	—
Chromium	mg/kg	56	22	19	**0.0099**
Cobalt	mg/kg	4.4	2.3	2.7	—
Copper	mg/kg	190	92.8	13.1	—
Iron	mg/kg	9300	6600	7467	—
Lead	mg/kg	2300	711	87	**3.7**
Magnesium	mg/kg	1550	753	767	—
Manganese	mg/kg	330	190	198	—
Mercury	mg/kg	7.2	3.1	2.1	**0.000092**
Nickel	mg/kg	17	12	6	—
Potassium	mg/kg	2060	832	681	—
Selenium	mg/kg	1	0.4	0.6	0.026
Silver	mg/kg	29	10.3	5.5	0.0045
Sodium	mg/kg	1200	434	270	—
Thallium	mg/kg	0.52	0.41	0.39	—
Vanadium	mg/kg	17	9.9	8.4	—

Table B-1 (continued)
Analytes and Maximum Value in Removal Area

Analyte	Units	Maximum in Proposed Removal Area	Average in Low Plutonium Area	Average in High Plutonium Area	TCLP for Metals (mg/L)
Zinc	mg/kg	110	63	52	—
Aroclor-1248	mg/kg	5.1	0.9	1.2	—
Aroclor-1254	mg/kg	10.1	2.4	1.9	—
Aroclor-1260	mg/kg	3.3	1.0	1.0	—
Aldrin	mg/kg	not detected	not detected	not detected	—
BHC[alpha-]	mg/kg	not detected	not detected	not detected	—
BHC[delta-]	mg/kg	not detected	not detected	not detected	—
BHC[gamma-]	mg/kg	not detected	not detected	not detected	—
Chlordane[alpha-]	mg/kg	not detected	not detected	not detected	—
Chlordane[gamma-]	mg/kg	0.013	not detected	0.006	—
DDD[4,4']	mg/kg	not detected	not detected	not detected	—
DDE[4,4']	mg/kg	0.2	not detected	0.05	—
DDT[4,4-]	mg/kg	0.23	not detected	0.07	—
Dieldrin	mg/kg	not detected	not detected	not detected	—
Heptachlor Epoxide	mg/kg	not detected	not detected	not detected	—
Acenaphthene	mg/kg	not detected	not detected	not detected	—
Acenaphthylene	mg/kg	not detected	not detected	not detected	—
Anthracene	mg/kg	not detected	not detected	not detected	—
Benz(a)anthracene	mg/kg	not detected	not detected	not detected	—
Benzo(a)pyrene	mg/kg	0.31	0.31	not detected	—
Benzo(b)fluoranthene	mg/kg	0.66	0.66	not detected	—
Benzo(g,h,i)perylene	mg/kg	0.19	0.19	not detected	—
Benzo(k)fluoranthene	mg/kg	not detected	not detected	not detected	—
Benzoic Acid	mg/kg	not detected	not detected	not detected	—
Bis(2ethylhexyl)phthalate	mg/kg	not detected	not detected	not detected	—
Carbazole	mg/kg	not detected	not detected	not detected	—
Chrysene	mg/kg	0.3	0.3	not detected	—
Di-n-octylphthalate	mg/kg	not detected	not detected	not detected	—
Dibenz(a,h)anthracene	mg/kg	not detected	not detected	not detected	—
Dibenzofuran	mg/kg	not detected	not detected	not detected	—
Fluoranthene	mg/kg	0.64	0.64	not detected	—
Fluorene	mg/kg	not detected	not detected	not detected	—
Indeno(1,2,3-cd)pyrene	mg/kg	not detected	not detected	not detected	—
Methylnaphthalene[2-]	mg/kg	not detected	not detected	not detected	—
Naphthalene	mg/kg	not detected	not detected	not detected	—
Phenanthrene	mg/kg	0.23	0.23	not detected	—
Pyrene	mg/kg	0.72	0.72	not detected	—

*A dash indicates TCLP was not conducted for this analyte.

Appendix C

Field and Fixed Laboratory Radiation Data

APPENDIX C FIELD AND FIXED LABORATORY RADIATION DATA

Field and fixed analytical laboratory radiation data and plutonium data obtained in 1999 were evaluated to determine what kind of data may be used to establish the spatial boundaries of the sediment removal in reach ACS. If field radiation measurements (field alpha counts) provide a reliable indicator of plutonium-239/240 concentration, then the spatial boundaries of the removal can be assessed rapidly in the field and also updated as lifts of sediment are removed. The utility of the gross alpha radiation measurements from the American Radiation Services (ARS) Laboratory in Los Alamos, New Mexico were also evaluated.

The data evaluated are provided in Table C-1. The samples analyzed for gross alpha radiation by ARS were field splits of the Acid Canyon samples submitted by the CFA in 1999 for plutonium analyses. ARS Laboratory used a G542M Quad Alpha Beta Counting System instrument made by Gamma Products to count dry samples for a 60-minute time period.

Table C-1
Data Used for Statistical Analyses

Fixed Point Site	Location ID	Sample ID	Pu-239/240 (pCi/g)	ARS Gross Alpha (pCi/g)	Field Alpha on Samples (cpm)[a]	Repeat Field Alpha on Samples (cpm)	Average Field Alpha (cpm)
AC3-2	PU-10017	CAPU-99-1000	110.8	141.7	27	32	29.5
AC3-2	PU-10017	CAPU-99-1001	38.5	70.4	16	16	16
AC3-6	PU-10018	CAPU-99-1002	23.9	72.37	12	15	13.5
AC3-13	PU-10019	CAPU-99-1003	37	60.93	17	13	15
AC3-13	PU-10019	CAPU-99-1004	142.9	219.98	42	42	42
ACS-47	PU-10000	CAPU-99-1005	6780	3448.03	285	257	271
ACS-15	PU-10002	CAPU-99-1006	94.2	123.13	33	28	30.5
ACS-16	PU-10003	CAPU-99-1007	4990	6771.17	611	645	628
ACS-23	PU-10005	CAPU-99-1008	393	498.51	78	74	76
ACS-36	PU-10006	CAPU-99-1009	26	55.27	12	9	10.5
none (c1)[b]	PU-10010	CAPU-99-1010	14.74	13.34	10	19	14.5
AC1-9	00-10240	CAPU-99-1011	0.123	16.45	9	4	6.5
AC1-10	00-10241	CAPU-99-1012	0.026	20.65	18	6	12
none	PU-10013	CAPU-99-1013	0.08	13.27	5	9	7
AC2-2	PU-10014	CAPU-99-1014	0.342	10.88	9	7	8
AC2-3	PU-10015	CAPU-99-1015	0.408	23.47	6	11	8.5
AC2-6	PU-10016	CAPU-99-1016	1.25	15.24	4	12	8
AC1-9	00-10240	CAPU-99-1017	0.0107	14.35	6	7	6.5
AC1-10	00-10241	CAPU-99-1018	0.104	22.2	11	11	11
AC1-11	00-10242	CAPU-99-1019	0.027	12.53	6	6	6
ACS-47	PU-10000	CAPU-99-1023	1002	370.22	55	52	53.5
ACS-47	PU-10000	CAPU-99-1024	7780	7670.89	1051	949	1000
ACS-47	PU-10000	CAPU-99-1025	1660	3739.93	331	315	323
ACS-47	PU-10000	CAPU-99-1026	234	417.81	81	88	84.5
ACS-11	PU-10001	CAPU-99-1027	2780	4595.31	399	442	420.5
ACS-11	PU-10001	CAPU-99-1028	1620	1565.62	158	182	170

Table C-1 (continued)
Data Used for Statistical Analyses

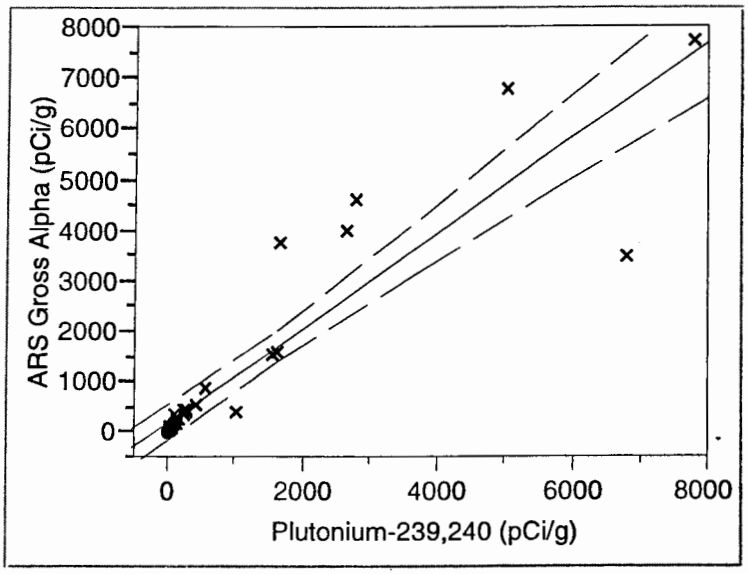
Fixed Point Site	Location ID	Sample ID	Pu-239/240 (pCi/g)	ARS Gross Alpha (pCi/g)	Field Alpha on Samples (cpm)[a]	Repeat Field Alpha on Samples (cpm)	Average Field Alpha (cpm)
ACS-11	PU-10001	CAPU-99-1029	134.4	255.39	41	31	36
ACS-15	PU-10002	CAPU-99-1030	9.57	25.13	11	10	10.5
ACS-15	PU-10002	CAPU-99-1031	37.4	99.76	12	9	10.5
ACS-16	PU-10003	CAPU-99-1032	114.5	156.3	28	33	30.5
ACS-16	PU-10003	CAPU-99-1033	267	360.29	89	78	83.5
ACS-16	PU-10003	CAPU-99-1034	112.1	231.32	28	18	23
ACS-37	PU-10004	CAPU-99-1035	23.9	80.45	13	12	12.5
ACS-37	PU-10004	CAPU-99-1036	9.51	35.26	8	10	9
ACS-23	PU-10005	CAPU-99-1037	218	341.89	49	45	47
ACS-23	PU-10005	CAPU-99-1038	82.9	339.74	46	50	48
ACS-23	PU-10005	CAPU-99-1039	548	850.5	199	219	209
ACS-23	PU-10005	CAPU-99-1040	277	397.46	94	81	87.5
ACS-41	PU-10007	CAPU-99-1041	13.5	31.99	7	11	9
ACS-46	PU-10008	CAPU-99-1042	17.4	90.45	15	12	13.5
ACS-46	PU-10008	CAPU-99-1043	46.1	48.66	12	11	11.5
ACS-33	PU-10009	CAPU-99-1044	129.7	156.83	18	25	21.5
ACS-33	PU-10009	CAPU-99-1045	20.6	47.28	17	25	21
trail	PU-10011	CAPU-99-1046	0.123	35.61	6	6	6
trail	PU-10012	CAPU-99-1047	0.096	12.61	8	7	7.5
ACS-11	PU-10001	CAPU-99-1048 (duplicate)	2640	3960	399	442	420.5
ACS-11	PU-10001	CAPU-99-1049 (duplicate)	1540	1501	158	182	170

[a] cpm = counts per minute.
[b] (c1) = active channel.

Following analysis by ARS, these sample splits were measured for alpha radiation using the same instruments and methods used during field characterization. These measurements utilized a Model 2221 Ratemeter with a 43-1 Alpha Scintillator probe. A sample was evenly spread over the bottom of a 6-in.-diameter aluminum pie tin and the alpha probe was placed on the sediment for a one-minute count. Each sample was then stirred to mix the material and then remeasured to evaluate variability.

To evaluate correlation of radiation data, scatter plots were prepared showing the concentration of plutonium-239/240 on the x-axis and the field radiation measurements (or laboratory gross measurements) on the y-axis (Figures C-1, C-2, and C-3). Data relating to one variable (y-axis) are plotted against data from a second variable (x-axis). Each point represents the values of the two variables. In Figures C-1 and C-2, individual sample results from Table C-1 are plotted, and in Figure C-3 the average value from a location is plotted. An association or correlation between the two variables is indicated if the points on the scatter plot follow (approximately) a sloped straight line. Figures C-1, C-2, and C-3 demonstrate that there is a positive correlation between the radiation measurements and the concentration of plutonium-239/240.

a)



b)

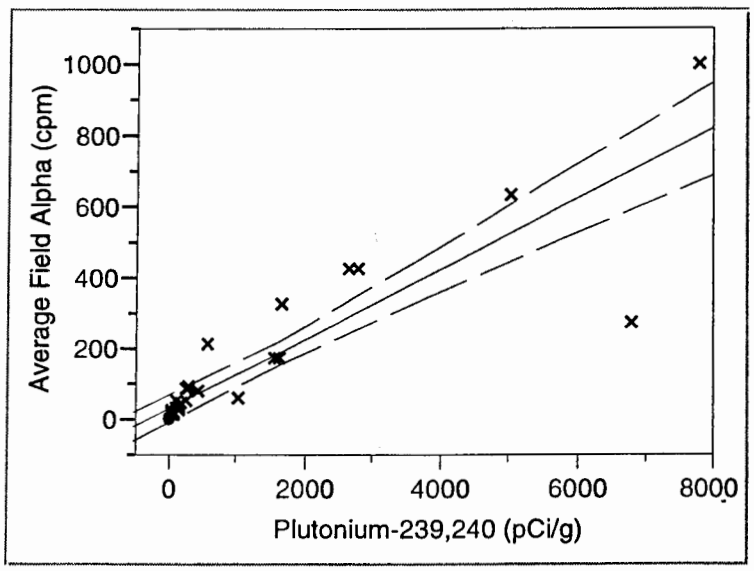
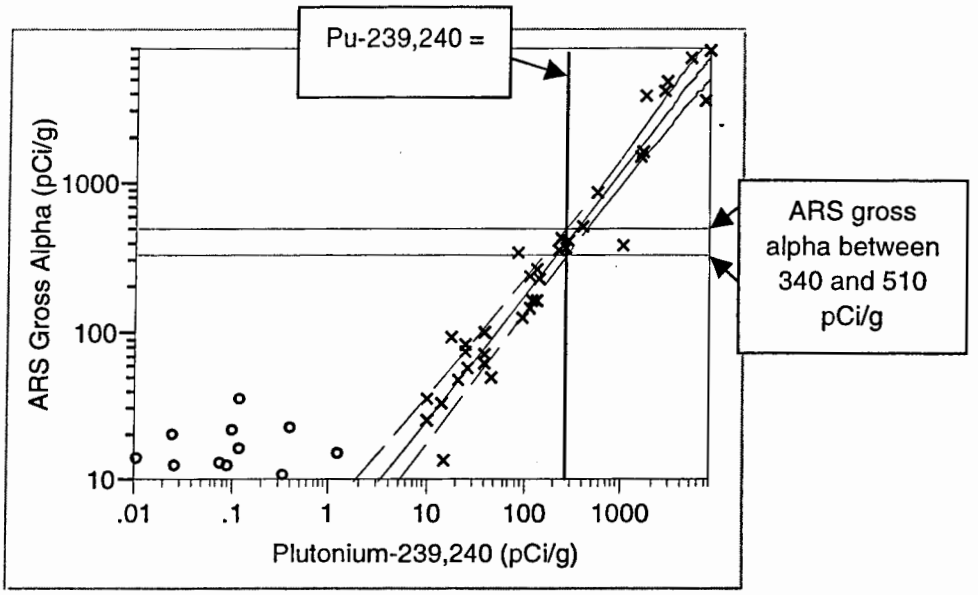


Figure C-1. Scatter plot showing the correlation between plutonium-239/240 results from the analytical laboratory versus gross alpha-radiation (a) and average field alpha-radiation (b). Line shows the linear regression between these variables and the dashed lines around the line are the linear model 95% confidence interval. Open circles (circles are difficult to see on this plot because of the cluster of points at the origin) indicate samples with plutonium-239/240 <2 pCi/g. These values were excluded from the regression. The regression models are:

(a) ARS Gross Alpha (pCi/g) = 193 + 0.939 Pu-239/240 (pCi/g); r^2=0.82; n=36; p<0.0001

(b) Average Field Alpha (cpm) = 31.2 + 0.0986 (cpm/pCi/g) Pu-239/240 (pCi/g); r^2=0.79; n=36; p<0.0001

a)



b)

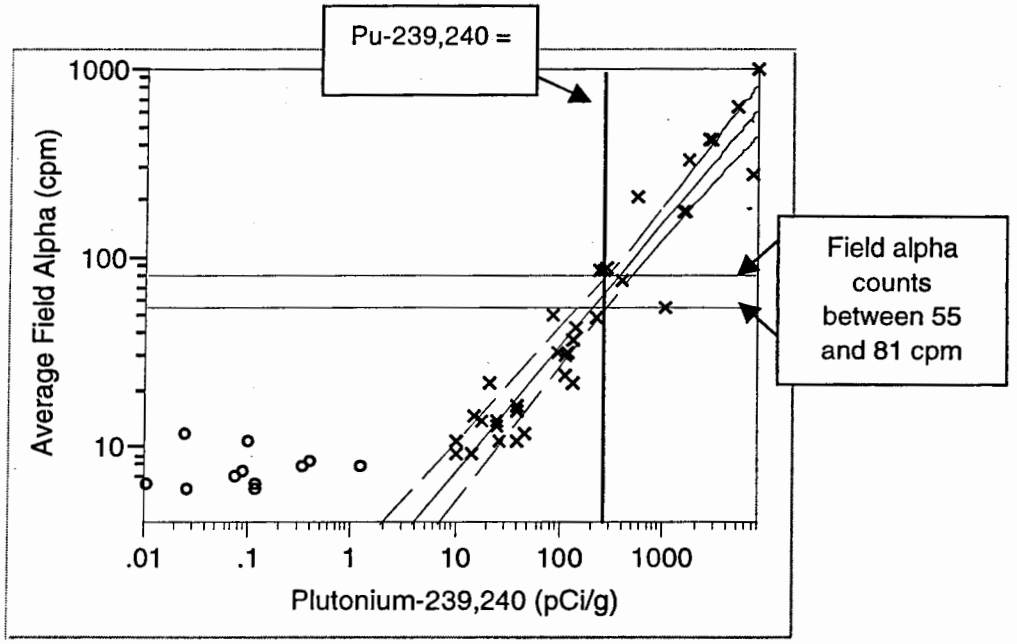
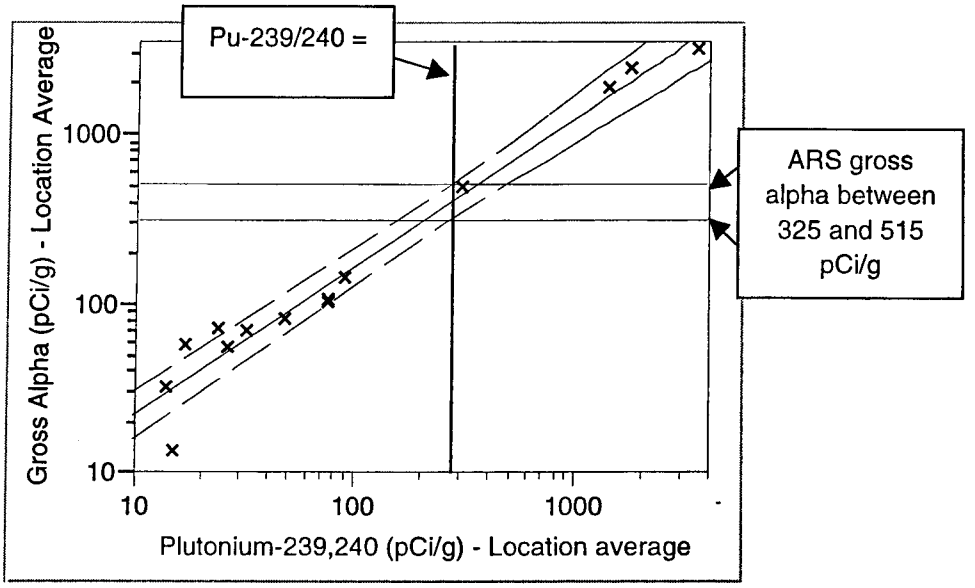


Figure C-2. Scatter plot showing the correlation between plutonium-239/240 results from the analytical laboratory versus gross alpha-radiation (a) and average field alpha-radiation (b). Line shows the linear regression between these variables and the dashed lines around the line are the linear model 95% confidence interval. Open circles indicate samples with plutonium-239/240 <2 pCi/g., These values were excluded from the regression. The regression models are:

(a) Ln (ARS Gross Alpha (pCi/g)) = 1.32 + 0.837 Ln (Pu-239/240 (pCi/g)); r^2=0.94; n=36; p<0.0001

(b) Ln (Average Field Alpha (cpm)) = 0.487 + 0.659 (ln(cpm)/ln(pCi/g)) Ln (Pu-239/240 (pCi/g)); r^2=0.91; n=36; p<0.0001

a)



b)

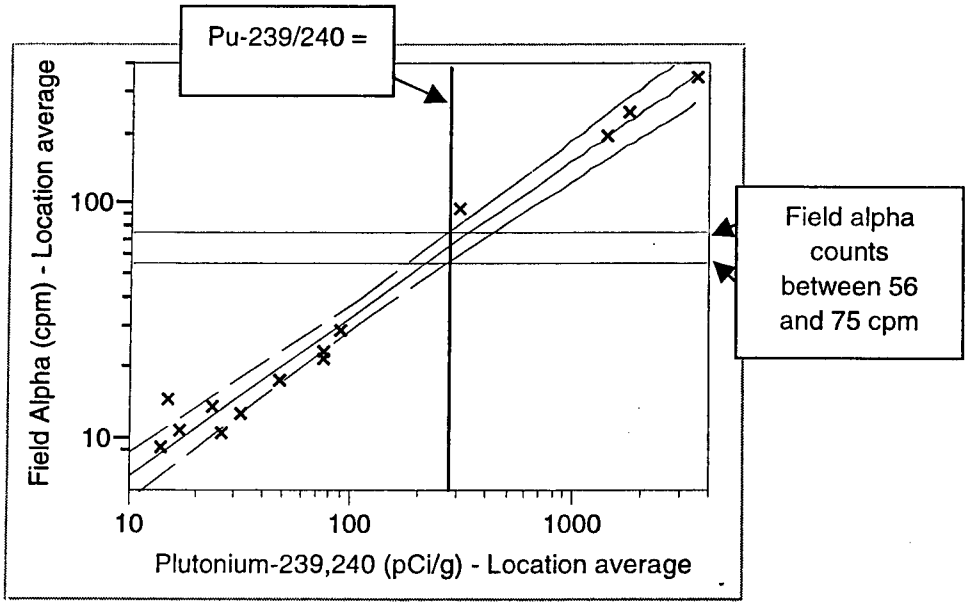


Figure C-3. Scatter plot showing the correlation between location averaged plutonium-239/240 results from the analytical laboratory versus location averaged gross alpha-radiation (a), and average field alpha-radiation (b). Line shows the linear regression between these variables and the dashed lines around the line are the linear model 95% confidence interval. The regression models are:

(a) Ln (Mean(ARS Gross Alpha (pCi/g))) = 1.078 + 0.877 Ln (Mean(Pu-239/240 (pCi/g))); r^2=0.96; n=14; p<0.0001

(b) Ln (Mean(Average Field Alpha (cpm))) = 0.397 + 0.672 Ln (Mean(Pu-239/240 (pCi/g)))r^2=0.97; n=14; p<0.0001

Linear regression was used to fit a model between the plutonium-239/240 concentrations and the radiation measurements. Regression models require selecting an independent variable (by convention the variable plotted on the x-axis) and a dependent variable (by convention plotted on the y-axis). The assumption is that the variable plotted on the y-axis depends on the variable plotted on the x-axis. Field or fixed-lab radiation measurements functionally depend on plutonium-239/240 concentrations (and perhaps concentrations of other radionuclides). So plutonium-239/240 concentrations were selected for the x-axis and the variability in this measure and the concentrations of other alpha emitting radionuclides were ignored for simplicity of statistical modeling.

The regression model generates a best-fit line and confidence interval on the model. The regression models for the sample results are shown on Figure C-1, and the models for the natural logarithm transformed data are shown in Figure C-2. Samples with plutonium-239/240 concentrations less than 2 pCi/g were excluded from the linear regression analysis. On the natural logarithm scale seen in Figure C-2, it is clear that these samples were excluded because field and fixed-lab alpha measurements are at a consistent instrument background level for plutonium-239/240 concentrations less than 2 pCi/g. Instrument background levels include other alpha emitting radionuclides that interfere with detecting lower plutonium concentrations (<10 pCi/g plutonium-239/240). However, the log-transformed data show that variability of field and fixed-lab radiation measurements at the SRSG of 280 pCi/g is low, and field or fixed-lab radiation measurements will be useful in detecting concentrations of plutonium-239/240 in the hundreds of pCi/g range.

Linear regression yields a model with a slope and intercept. The fit of the data to the model is calculated as the coefficient of determination (also known as r^2 or the explained variance of the model). A coefficient of determination of 1 occurs when there is a perfect fit (the errors are all zero). A coefficient of determination of 0 means that the model fit predicts the radiation measurements no better than the overall response mean (the regression would have a slope of zero in this case). The models fit between the individual sample points on the natural logarithm transformed data have r^2 values greater than 0.9, which are good fits and suggest that field or fixed-lab radiation measurements could be used for inverse prediction of plutonium-239/240 concentrations (Figure C-2). The natural logarithm-transformed models are more useful for prediction of concentrations around the plutonium-239/240 SRSG of 280 pCi/g, because of the relatively narrow confidence interval for the models in Figure C-2 at this concentration compared to Figure C-1. The 95% confidence intervals for the models shown in Figure C-2 are used to develop categories or field alpha measurements and ARS gross alpha measurements. Regression models were also developed for the average values for a sampling location, and these average measurements by location (or field section) are planned to be used in the field decision to remove sediment or leave it in place. The regression models for the location average data are provided in Figure C-3 and show models similar to the individual point models. However, the r^2-values for the location average models are marginally greater than the individual point model. This observation suggests that some of the scatter in Figure C-2 is random error and the pooling of additional field measurements more precisely relates to plutonium concentration in the section. Additional data will be collected to test this observation. Figure C-3 shows the confidence intervals for the location average models, and these confidence intervals were used to define three radiation measurement bins. First are the low radiation measurements (less than 56 cpm field alpha), which also correlate to low plutonium-239/240 concentrations. Second are intermediate radiation measurements with commensurately higher plutonium-239/240 concentrations (between 56 and 75 cpm field alpha). Lastly, there are high radiation measurements that also have the highest plutonium-239/240 concentrations (greater than 75 cpm field alpha).

To provide more information on the specific volume of sediment to be removed, it is necessary to collect additional radiation measurements and isotopic plutonium concentrations from sediments with

intermediate radiation measurements (between 40 and 80 cpm field alpha or 250 to 500 pCi/g gross alpha). This information will be collected as a part of the IA implementation, and the resulting data will be used in a revised statistical model with plutonium-239/240 as the independent variable and the radiation measurements as the dependent variable. Using this updated model and understanding the cost consequences for selecting an overly protective radiation measurement threshold, inverse prediction techniques will be used to select a field alpha or ARS gross alpha threshold for the sediment removal decision. The updated regression model will be useful for prediction if the r^2 value is greater than 0.5, and based on the data analyzed to date the r^2 value should be much larger (between 0.8 and 1), providing excellent information for the IA Plan objectives of removing most of the sediments containing plutonium-239/240 with concentrations greater the SRSG.

All sample locations were grouped into geomorphological soil packages. The soil packages have been assigned a specific activity (pCi/g) based on field alpha measurements collected at sample locations within their boundaries. The correlation of average field alpha to calculated plutonium is presented in Table C-2 Average Field Alpha Radiation Measurements and Calculated Plutonium Concentrations. Pu-239/240 was derived from average field alpha measurements using the following equation; Derived Pu-239/240(pCi/g) = exp((Ln Av.Field Alpha(cpm) - 0.397)/0.672).

Table C-2
Average Field Alpha Radiation Measurements and Calculated Plutonium Concentrations

Sample Location	Average Field Alpha (cpm)	Calculated Pu-239/240 (pCi/g)*	Remove (R) or Stay (S)
ACS 1	12	22	S
ACS 2	37	119	S
ACS 3	49	181	S
ACS 4	32	96	S
ACS 5	115	646	R
ACS 6	27	75	S
ACS 7	83	397	R
ACS 8	62	257	R
ACS 9	212	1604	R
ACS 10	116	654	R
ACS 11	161	1065	R
ACS 12	39	129	S
ACS 13	75	342	R
ACS 14	27	75	S
ACS 15	10	17	S
ACS 16	126	740	R
ACS 17	121	696	R
ACS 18	19	44	S
ACS 19	14	28	S
ACS 20	26	71	S
ACS 21	59	239	S
ACS 22	17	38	S

Table C-2 (continued)
Average Field Alpha Radiation Measurements and Calculated Plutonium Concentrations

Sample Location	Average Field Alpha (cpm)	Calculated Pu-239/240 (pCi/g)*	Remove (R) or Stay (S)
ACS 23	77	355	R
ACS 24	41	139	S
ACS 25	13	25	S
ACS 26	14	28	S
ACS 27	12	22	S
ACS 28	22	55	S
ACS 29	5	6	S
ACS 30	20	48	S
ACS 31	19	44	S
ACS 32	16	34	S
ACS 33	41	139	S
ACS 34	23	59	S
ACS 35	2	2	S
ACS 36	9	15	S
ACS 37	9	15	S
ACS 38	33	101	S
ACS 39	15	31	S
ACS 40	10	17	S
ACS 41	11	20	S
ACS 42	40	134	S
ACS 43	49	181	S
ACS 44	15	31	S
ACS 45	14	28	S
ACS 46	4	4	S
ACS 47	251	2062	R
ACS 48	161	1065	R
ACS 49	414	4343	R
ACS 50	134	811	R
ACS 51	87	426	R
ACS 52	65	276	R
ACS 53	29	83	S
ACS 54	44	155	S
ACS 55	110	604	R
ACS 56	62	257	R
ACS 57	32	96	S
ACS 58	72	322	R
ACS 59	115	646	R

Table C-2 (continued)
Average Field Alpha Radiation Measurements and Calculated Plutonium Concentrations

Sample Location	Average Field Alpha (cpm)	Calculated Pu-239/240 (pCi/g)*	Remove (R) or Stay (S)
ACS 60	62	257	R
ACS 61	101	532	R
ACS 62	88	434	R
ACS 63	27	75	S
ACS 64	11	20	S
ACS 65	96	493	R
ACS 66	56	221	S
ACS 67	52	198	S
ACS 68	13	25	S
ACS 69	86	419	R
ACS 70	46	165	S
ACS 71	44	155	S
ACS 72	428	4563	R
ACS 73	16	34	S
ACS 74	71	315	R
ACS 75	111	612	R
ACS 76	16	34	S
ACS 77	202	1493	R
ACS 78	220	1695	R
ACS 79	199	1460	R
ACS 80	27	75	S
ACS 81	20	48	S
ACS 82	13	25	S

A preliminary volume estimate based on land area and depth of soil removal was calculated in order to determine the volume of a soil package to be placed in a particular waste container (20yd^3 roll-off bin). This information is displayed in Table C-3, Soil Package Information.

Soil packages were assigned to waste containers based on the total volume of sediment available, and the specific activity (pCi/g) of the soil package. Each waste container must stay below the Department of Transportation (DOT) regulatory limit of 2 nCi/g. In order to achieve this, soil packages of varying activity levels were mixed so that the specific activity of each waste container would be approximately 1.5 nCi/g, incorporating a safety factor of 25%. Pu-239/240 (pCi/g) was found using a weighted average. For example, if 1.7 yd^3 of soil package 8 was being placed in the waste container number 1, the activity level for soil package 8 was 257 pCi/g (Table C-3), and the total volume of soil being placed in the container was 10 yd^3, then Pu-239/240 = 257 pCi/g * (1.7 yd^3/10 yd^3) = 43.69 pCi/g.

A fluff factor of 30% was applied to the total volume of sediment in the waste container to account for the increase in volume expected during vacuum removal of sediment. This information is displayed in Table C-4, Waste Container Information for Chemical Waste Disposal Requests.

Table C-3
Soil Package Information

Soil Package	Derived Pu-239/240 (pCi/g)	Land Area to Remove (ft^2)	Depth of Soil to Remove (ft)	Volume Estimate (yd^3)
75/74	464	193.30	2.46	17.61
4	96	71.66	3.28	8.71
5	646	103.20	1.64	6.27
6	75	51.94	3.28	6.31
7	397	52.48	1.97	3.83
49	4343	171.44	1.97	12.51
47/72	3313	141.95	2.62	13.77
8	257	27.88	1.64	1.69
71/42	145	92.16	2.71	9.25
43/70	173	47.82	3.03	5.37
9/11/78/79	1456	229.55	2.30	19.55
48	1065	98.46	0.98	3.57
12	129	41.88	3.28	5.09
13	342	18.01	1.97	1.31
69	419	44.28	1.97	3.23
10	654	44.18	2.30	3.76
50	811	59.95	2.95	6.55
65/66/67	304	212.97	2.13	16.80
16	740	36.29	1.97	2.65
17	696	77.30	2.30	6.58
21	239	16.18	2.62	1.57
52/58/59/60/61/62	411	450.08	2.93	48.84
23/51/55/56	411	198.37	2.34	17.19
Totals	17584			222.03
Average Activity	765			
Number of Containers				22

Table C-4
Preliminary Waste Container Information for Chemical Waste Disposal Requests

Waste Container	First Soil Package Number	Soil Package Volume to be Removed (yd^3)	Pu-239/240 in Soil Package Volume to be Removed (pCi/g)	Second Soil Package Number	Soil Package Volume (yd^3)	Pu-239/240 (pCi/g)	Third Soil Package Number	Soil Package Volume (yd^3)	Pu-239/240 (pCi/g)	Fourth Soil Package Number	Soil Package Volume (yd^3)	Pu-239/240 (pCi/g)	Total Volume of Soil in Waste Container (yd^3)	Total Pu-239/240 (pCi/g) in Waste Container
1	8	1.70	43.69	7	3.83	150.86	49	2.50	1085.75	43/70	2.00	34.60	13.04	1314.90
2	43/70	3.37	58.30	49	3.37	1463.59	6	3.26	24.45				13.00	1546.34
3	6	6.31	47.25	49	3.37	1463.59							12.58	1510.84
4	49	3.26	1415.82	71/42	6.74	97.73							13.00	1513.55
5	47/72	4.20	1391.46	71/42	2.50	36.25	75/74	3.30	153.12				13.00	1580.83
6	47/72	4.20	1391.46	4	5.80	55.68							13.00	1447.14
7	47/72	4.20	1391.46	4	2.91	27.84	5	2.90	187.34				13.01	1606.64
8	47/72	1.17	387.62	5	3.37	217.70	75/74	5.46	253.34				13.00	858.66
9	75/74	10.00	464.00										13.00	464.00
10	75/74	2.15	99.76	9/11/78/79	7.85	1142.96							13.00	1242.72
11	9/11/78/79	11.70	1456.00										15.21	1456.00
12	48	3.57	380.20	12	5.09	65.66	13	1.31	44.80				12.96	490.66
13	10	3.76	245.90	50	6.55	531.21							13.40	777.11
14	69	3.23	135.34	65/66/67	6.77	205.81							13.00	341.15
15	65/66/67	10.03	304.00										13.04	304.00
16	16	2.65	196.10	17	6.58	457.97							12.00	654.07
17	21	1.57	37.52	52/58/59/60/61/62	8.43	346.47							13.00	383.99
18	52/58/59/60/61/62	10.00	411.00										13.00	411.00
19	52/58/59/60/61/62	10.00	411.00										13.00	411.00
20	52/58/59/60/61/62	10.00	411.00										13.00	411.00
21	52/58/59/60/61/62	10.41	411.00										13.53	411.00
22	23/51/55/56	10.00	411.00										13.00	411.00
23	23/51/55/56	7.19	411.00										9.35	411.00

Appendix D

Corrective Action Analysis

APPENDIX D CORRECTIVE ACTION ANALYSIS

In preparation for the implementation of an IA in reach ACS, an evaluation of the possible remedial alternatives was prepared. The purpose of this CAA was to identify the possible actions that can be taken to achieve the cleanup goals for the IA. The CAA discusses the criteria to be used to evaluate various methods, the possible actions and/or methods that could be used to achieve the cleanup goals, evaluations of each action and/or method against the defined criteria, and the results of the evaluations.

D-1.0 EVALUATION CRITERIA

The criteria to be used to evaluate possible actions and/or methods are discussed in this section. The evaluation criteria are as follows:

- environmental impacts caused by the remedial alternative
- effectiveness of technique for accomplishing cleanup goals
- disruptions to adjoining neighborhoods during remedial action (i.e., noise)
- restrictions on recreational access
- worker and public health

Each of these criteria will be discussed in detail in the following subsections.

D-1.1 Environmental Impacts Caused by Remedial Alternative

Reach ACS is located on Los Alamos County land in an area designated as protected "wilderness" and is traversed by trails used by hikers, joggers, and bicyclists. It is important to the county and the public that environmental damage be kept to a minimum so as to preserve the natural environment as much as possible. This preservation will include minimizing disturbance, to the extent possible, to the stream channel, its banks, slopes, and areas adjacent to the channel.

D-1.2 Effectiveness of Technique for Accomplishing Cleanup Goals

The IA is intended to remove sediment deposits with average plutonium-239/240 concentrations exceeding 280 pCi/g. It is estimated that approximately 228 yd^3 of sediment removal will allow this goal to be met (Ryti and Reneau, 2000, 68728.3). The final volume will depend on the additional definition of areas along reach ACS exceeding this cleanup goal. The sediment to be removed is located in several discontinuous areas in abandoned channel and floodplain deposits adjacent to the active channel. The channel is incised such that the vertical difference between the channel bottom and the top of the sideslopes along the channel varies from a few feet to as much as 20 ft. In addition, the sideslopes along the channel are very steep to nearly vertical. These conditions will make access to the channel by both personnel and machinery difficult.

The sediment packages to be removed will be defined by flagging along each location's perimeter. Detailed maps and spreadsheets of the sediment packages define the excavation depths necessary to remove sediment with concentrations above the cleanup goal. Figure 2 shows sediment packages and geomorphology and Table C-3 shows sediment package volumes to be removed. During removal of the sediment, precision will be needed to minimize environmental impact and the amount of material being sent for disposal at TA-54.

D-1.3 Disruptions to Adjoining Neighborhoods During Remedial Action

During the IA, disruptions to the adjoining neighborhoods will be minimized to the extent possible. The major anticipated disruption to the adjoining neighborhoods from the cleanup activities will be noise. The distance to the closest houses on the north side of Acid Canyon is a few hundred feet from the closest point of the remedial activities (just above the confluence of the south fork with the main channel in Acid Canyon).

D-1.4 Restrictions on Recreational Access

The restrictions to recreational access in Acid Canyon during the implementation of the IA will be minimized to the extent possible by minimizing both the area of restriction with the goal of allowing bypass or detour routes for the affected trails, and the amount of time that the restrictions will be in effect.

D-1.5 Worker and Public Health

During the implementation of the IA, the health and safety of both the workers performing the remedial activities and the public will be protected. Protection of worker health and safety will involve the minimization of natural hazards, mechanical hazards, radiation exposure, noise levels, heat stress (or conversely, hypothermia), and physio-mechanical stresses that could produce physical injury. Public health protection will include protecting the public from the mechanical hazards and noise during the IA through exclusion zones, avoiding exposures to the contaminated sediments through the minimization of dusts generated during cleanup activities, and preventing exposure during nonoperational periods (nights and weekends) by storing potentially contaminated equipment and/or contaminated sediments within signed, fenced, and locked areas.

D-2.0 REMEDIAL ACTION ALTERNATIVES

This section presents and discusses the remedial action alternatives to be evaluated for the reach ACS IA. The alternatives to be considered for evaluation are as follows:

- no action (for purposes of comparison)
- administrative controls (e.g., fencing)
- cover/barrier (e.g., rip-rap)
- mechanical excavation with large machinery
- mechanical excavation with small machinery
- hand removal (small tools and manual removal from channel)
- sediment vacuuming

The following subsections discuss each of the remedial action alternatives in detail.

D-2.1 No Action

The no-action alternative is intended as a baseline for comparison purposes. No action would involve leaving reach ACS in its current condition with no administrative controls and no sediment removal.

D-2.2 Administrative Controls

Administrative controls would involve changing the use and access to reach ACS. It could include signage, fencing, or closing of trails. This alternative does not include any sediment removal. However, no trees would be cut and only minimal noise would be generated.

D-2.3 Cover/Barrier

The cover/barrier methodology involves the use of some kind of physical barrier to prevent direct exposure by the public to the contaminated sediments. This alternative does not result in any sediment being removed. A simple method of providing a barrier could involve the use of rip-rap (cobble- to boulder-sized rock fragments) to cover the entire channel bottom and sides. Alternative barrier or cover methods could involve gabions, reno mattresses, or shotcrete.

For installation of a cover or barrier, the channel and its slopes would need to be prepared by cutting all trees and all but the smallest shrubs. Additional trees might have to be cut for access points for end-dumping of rip-rap into the channel or for stockpiling stone on top of slopes for use in gabions or reno mattresses. For rip-rap installation, access points would also be needed for bulldozers or similar equipment that would spread and work the rip-rap into a more uniform surface covering and stabilizing all affected areas. This method could create a substantial amount of dust and engineering controls would be necessary to minimize it. This alternative would also create a substantial amount of noise.

D-2.4 Mechanical Excavation with Large Machinery

Mechanical excavation with large machinery would involve the use of bulldozers, backhoes, and front end loaders to construct access points to the channel, widen the channel at points too narrow for the machinery to work, and remove the contaminated sediments. This method of excavation would involve clearing of trees at access points along the channel and extensive earth moving. This method could create a lot of dust and engineering controls would be necessary to minimize it. This alternative would also create a substantial amount of noise.

D-2.5 Mechanical Excavation with Small Machinery

Mechanical excavation with small machinery would involve the use of bobcat loaders or similar small machinery to remove sediment from the channel and banks without widening the channel for access or creating large access points to the channel. However, creation of several narrow access routes would be required. Tree clearing and earth moving would be involved, but to a lesser extent than with the large machinery. Less dust and noise would be created than from using larger machinery.

D-2.6 Hand Removal

Hand removal would involve the use of small tools (shovels and picks) and manual removal from the canyon bottom by carrying the material in bags or buckets to the top of the sideslopes for containerization. A variation of this method could be to use all terrain vehicles with trailers to load bags or buckets of contaminated sediment for transfer to larger containers. Minimal tree clearing or earthwork would need to be done to access the channel since only the workers and small tools would be needed in the channel. Little dust and noise generation would occur from this method. Significant physical stress to workers would require increased monitoring, increased break periods, and possible shorter work days to reduce physical impacts such as muscle and joint strains, sprains, and heat stress.

D-2.7 Sediment Vacuuming

Sediment vacuuming would involve the use of machinery to vacuum sediment from the channel bottom and sides. Vacuumed sediment would then be transported via hoses to an in-line container such as a drum or larger container. The vacuum system would need to include HEPA filters to reduce dust. The material collected by this method would be limited to large gravel sized pieces (approximately 2 in.) or smaller because of hose size. The vacuum machinery could have noise levels higher than other types of machinery that would be used in other methods. It is possible that these noise levels could be mitigated through the use of baffles and other noise reducing techniques. Little tree clearing or earthwork would be necessary to access the channel since only the workers, small tools and hoses would be needed in that area.

D-3.0 EVALUATION OF REMEDIAL ACTION ALTERNATIVES

This section will evaluate each of the potential remedial action alternatives presented in Section 3 against the criteria discussed in Section 2.

D-3.1 No-Action

The no action alternative will be evaluated against the criteria to provide a baseline. The no action alternative would not cause any environmental impacts but would not accomplish the cleanup goals. There would be no disruptions to the neighborhoods, restrictions to recreational access, nor concerns related to worker or public health from the alternative. Because the cleanup goals are not accomplished by this alternative, it is rated unsatisfactory.

D-3.2 Administrative Controls

Administrative controls that could be implemented as a remedial action alternative include signage, fencing, and/or closing of trails. The environmental impacts of these actions would be minimal (minor disturbance to vegetation during the installation of fencing). The cleanup goals would not be accomplished by this technique. There would be little disturbance to neighborhoods during the remedial action (minor noise levels from fence installation) but the restrictions on recreational access would be the most severe of all alternatives being evaluated and would continue indefinitely. Administrative controls would limit potential exposure to human receptors. Worker health would be a relatively minor concern relating to installation of fencing. Exposures should be minimal because the fencing would be installed along the perimeter where contamination levels are negligible. There would be little public health concern from the implementation of this alternative. Because the cleanup goals are not accomplished by this alternative and because the restrictions on recreational access are the most severe of all alternatives, this alternative is rated unsatisfactory.

D-3.3 Cover/Barrier

Rip-rap or other types of covers or physical barriers could be constructed to prevent contact with the contaminated sediments. The environmental impacts caused by the implementation of this alternative would be significant since most trees and larger shrubs would be cut in preparation for cover/barrier placement and additional trees and vegetation would be cut to provide access points and rock stockpile locations at the top of the stream side slopes. In addition, this alternative would result in a permanent alteration of the visual character of the canyon bottom, inconsistent with the goal of keeping the area as natural as possible. The technique would not accomplish the removal of sediment for cleanup goal but would prevent physical contact with contaminated sediments. The disruption to adjoining neighborhoods

would be moderate to significant because of the use of heavy machinery such as dump trucks, bulldozers, and front-end loaders and from the use of chain saws to fell trees. Restrictions to public access would be necessary during the implementation of this remedial alternative, but there would be no restrictions once the action was completed. Concerns for worker and public health from the implementation of this remedial alternative would be significant to moderate since the method would involve significant use of heavy machinery and could create a lot of dust. The impacts to worker health would need to be mitigated through the use of appropriate personal protective equipment (PPE). Impacts to worker and public health would also need to be mitigated through the use of engineering controls such as spraying water to control dust. This method would generate the most heavy machinery traffic (dump trucks for hauling rip-rap or stone and concrete trucks for shotcrete) and would need significant traffic control measures to protect the health and safety of both workers and the public. Because the environmental impacts from this method are high, cleanup goals are not accomplished, disruptions to adjoining neighborhoods are significant, and impacts on worker and public health are potentially significant, this alternative is rated unsatisfactory.

D-3.4 Mechanical Excavation with Large Machinery

Mechanical excavation with large machinery would involve the use of bulldozers, backhoes, and front-end loaders to both construct access points to the channel, widen the channel at points too narrow for the machinery to work, and remove the contaminated sediments. The environmental impacts caused by this remedial alternative would be significant because of a combination of clearing of vegetation with a significant amount of excavation and earth moving in and along the channel to allow access of heavy machinery along the entire reach. The method would achieve the cleanup goals but would have lower precision for minimizing the removal of adjacent soils that are below the cleanup level. The disruption to adjoining neighborhoods would be moderate to significant because of the use of heavy machinery such as dump trucks, bulldozers, and front-end loaders and from the use of chain saws to fell trees. Restrictions to public access would be necessary during the implementation of this remedial alternative but there would be no restrictions once the action was completed. Concerns for worker and public health from the implementation of this remedial alternative would be significant to moderate since the method would involve significant use of heavy machinery and could create a lot of dust. The impacts to worker health would need to be mitigated through the use of appropriate PPE. Impacts to worker and public health would also need to be mitigated through the use of engineering controls such as spraying water to control dust. Because the environmental impacts from this method are high and impacts on worker and public health are potentially significant, this alternative is rated unsatisfactory.

D-3.5 Mechanical Excavation with Small Machinery

Mechanical excavation with small machinery would involve the use of bobcat loaders or similar small machinery to remove the sediment from the canyon bottom without widening the channel for access or creating large access points to the channel. The environmental impacts from this remedial alternative would be low to moderate because the access points to the stream channel would be smaller and the channel would not have to be widened to allow access by machinery to all parts of the reach. The method would achieve the cleanup goals and allow a higher precision of removal of contaminated sediment, and, therefore, better waste minimization. The disruption to the adjoining neighborhoods would be low to moderate because of use of small machinery, some use of heavy machinery (trucks to haul waste containers), and chain saws for a low to moderate amount of clearing. Restrictions to public access would be necessary during the implementation of this remedial alternative but there would be no restrictions once the action was completed. Concerns for worker and public health from the implementation of this remedial alternative would be moderate since the method would involve use of small machinery and

some heavy machinery and could create a moderate amount of dust. The impacts to worker health would need to be mitigated through the use of appropriate PPE. Impacts to worker and public health would also need to be mitigated through the use of engineering controls such as spraying water to control dust. Because this alternative achieves the cleanup goals with a higher degree of precision, environmental impacts and disruption to neighborhoods is low to moderate, and recreational restrictions and impacts to worker and public health are moderate, this alternative is rated satisfactory.

D-3.6 Hand Removal

Hand removal would involve the use of small tools (shovels and picks) and manual removal from the channel by carrying the material in bags or buckets to the top of the sideslopes for containerization. The environmental impacts from this remedial alternative would be low because there would be little or no clearing or excavation to create access points for workers and tree clearing along the channel and sideslopes would be minimized. The method would achieve the cleanup goals and allow a high-precision removal of contaminated sediment and, therefore, better waste minimization. The disruption to the adjoining neighborhoods would be low because of the use of hand tools—although some use of heavy machinery (trucks to haul waste containers) and chain saws for a small amount of clearing would be necessary. The length of the period for restrictions to public access would be significant since the use of hand tools would take longer than any of the removal actions being considered. However, there would be no restrictions to recreational access once the action was completed. Concerns for worker health from the implementation of this remedial alternative would be significant since the method involves significant physical stress to the workers with possible physical impacts such as muscle and joint strains and sprains and increased chance of heat stress. Workers would also have increased physical contact with the contaminated sediments, but only minimal amounts of dust should be generated because of the use of hand tools. Significant physical stress to workers would require increased monitoring, increased break periods, and possible shorter work days to reduce physical impacts. Impacts to public health from the implementation of this remedial alternative would be low since the amount of dust generation from the use of hand tools would be low to very low. Although the environmental impacts and disruptions to neighborhoods are low, the cleanup goals are achieved with a high degree of precision, and the impacts to public health are low from this method. The restrictions on recreational access are high as well as the potential impacts to worker health. Therefore, this alternative is rated satisfactory.

D-3.7 Sediment Vacuuming

Sediment vacuuming would involve the use of machinery to vacuum sediment from the channel bottom and sides that would then be transported via hoses to an in-line container such as a drum or larger container. The environmental impacts from this remedial alternative would be low because there would be little to no clearing or excavation to create access points for workers and vacuum hoses, and tree clearing along the channel and sideslopes would be minimized. The method would achieve the cleanup goals and allow a high-precision of removal of contaminated sediment, and, therefore, better waste minimization. The disruption to the adjoining neighborhoods would be high because of the noise levels produced by the vacuum machinery, although some mitigation methods such as sound reduction baffles could be used to reduce the noise levels. Restrictions to public access would be necessary during the implementation of this remedial alternative but there would be no restrictions once the action was completed. Although workers would have increased physical contact with the contaminated sediments for this method, only minimal amounts of dust should be generated because of some use of hand tools to loosen sediment, and that dust should be captured by the vacuum hose. Because noise levels around the vacuum machinery are expected to be high, workers will be required to wear hearing protection. The use of hand tools to loosen the sediment for vacuuming will cause some physical stress to the workers, but this stress

would be much less than that from the hand removal method because the sediment would not have to be lifted, bagged (or placed in buckets), and carried up the slope for containerization. As a result, the impacts to worker health and safety from the implementation of this remedial alternative are low to moderate. The impacts to public health would also be low because the use of HEPA filters will prevent the release of any dust from the vacuum machinery. Although the disruptions to adjoining neighborhoods from this method are potentially high, this alternative achieves the cleanup goals with a high degree of precision, environmental impacts and impacts on worker and public health are low, and restrictions on recreational access are moderate. This alternative is therefore rated good.

D-4.0 RESULTS OF EVALUATION

The results of the evaluation of the remedial alternatives against the evaluation criteria are presented on Table D-1. As indicated by Table D-1, four alternatives are rated unsatisfactory (no action, administrative controls, cover/barrier, and mechanical excavation with large machinery), two alternatives are rated satisfactory (mechanical excavation with small machinery and hand removal), and one alternative is rated good (soil vacuuming). Based on this analysis, soil vacuuming is therefore recommended as the best cleanup option.

Table D-1
Results of Evaluation of Remedial Methods

Evaluation Criteria	No Action	Administrative Controls	Cover/Barrier	Mechanical Excavation with Large Machinery	Mechanical Excavation with Small Machinery	Hand Removal	Soil Vacuuming
Environmental Impacts	None	Low	High	High	Low to Moderate	Low	Low
Effectiveness of Technique for Accomplishing Cleanup Goals	Ineffective	Ineffective	Ineffective	Satisfactory	Good	Superior	Superior
Disruptions to Adjoining Neighborhoods During Remedial Action	None	Low	Moderate to High	Moderate to High	Low to Moderate	Low	Moderate to High
Restrictions on Recreational Access	None	Very High	Moderate	Moderate	Moderate	High	Moderate
Impact on Worker Health	No impact	Low	High	High	Moderate	High	Moderate
Impact on Public Health	No impact	Low	Moderate	Moderate	Low	Low	Low
Overall Evaluation	Unsatisfactory	Unsatisfactory	Unsatisfactory	Unsatisfactory	Satisfactory	Satisfactory	Good