A.5.2.3 Remove Contents, Clean, and Replace

This extensive operation provides a more thorough cleaning than detailed cleaning. The costs and rate for this operation are based on data supplied by Terry's Automotive Appearance. This source charges about $300 for the service. Of this amount, $240 is for labor, $30 for equipment, and $30 for materials.

A.5.2.4 Re-Upholstery

Re-upholstery is the most effective and most costly operation for automobile interiors. Table A.5.2.4.1 summarizes the information on this operation and shows the representative costs and rates.

TABLE A.5.2.4.1. Summary of Data for Re-Upholstering Automobile Interiors

Source	Rate (autos/hr)	Cost (1982 $/auto) Total	Labor	Equipment	Materials
Crawford's Custom Upholstering	--	600	--	--	--
Dean's Upholstery and Glass	--	600	210	180	210
Representative	0.14	600	210	180	210

A.5.3 Auto Tires

The operations for decontaminating tires are water wash, wash and scrub, sandblast, and remove and replace. The cost for washing is based on the hourly cost for a common laborer ($17.45) plus equipment ($1.00). The wash and scrub cost figures are based on the hourly wash and scrub cost figures used for walls and floors (see Section A.3.2.2). The sandblast cost is based on the hourly cost of roof sandblasting (see Section A.3.1.4). The data for removal and replacement are based on information supplied by Les Schwab Tire Center and Ivan's American Tire Service. The data summarizing the decontaminating of tires are presented in Table A.5.3.1.

TABLE A.5.3.1. Summary of Data for Different Tire Decontamination Operations

Operation	Rate (autos/hr)	Cost (1982 $/auto) Total	Labor	Equipment	Materials
Wash	10	1.85	1.75	0.10	--
Wash and Scrub	3	5.83	3.83	2.00	--
Sandblast	8	12.71	5.54	7.17	--
Remove and Replace	1	225	22.50	24.75	177.75

A.5.4 Auto Engine/Drive Train

Two techniques for decontaminating automobile engines and drive trains are steam cleaning and cleaning with an organic solvent. The data for these operations are presented in Table A.5.4.1.

TABLE A.5.4.1. Summary of Data for Decontaminating Automobile Engines and Drive Trains

Operation and Source	Rate (autos/hr)	Cost (1982 $/auto) Total	Labor	Equipment	Materials
Steam cleaning Terry's Automotive Appearance	--	24.00	17.28	2.40	4.32
L.A. Hand Car Wash	--	28.00	--	--	--
Representative	1	26.00	18.72	2.60	4.68
Clean with solvent U.S. Ecology	--	37.00	35.15	0.35	1.40
Representative	1	37.00	35.15	0.35	1.40

A.5.5 Vehicle Transport

Vehicles left in a contaminated area will need to be removed to a place where they can be decontaminated. Three ways to accomplish this are considered here. The first involves towing the vehicle out using a standard automobile tow truck. The cost of this procedure is estimated at $50 per hour, with $20 for labor, $25 for equipment, and $5 for fuel. The rate, in terms of vehicles removed per hour, is estimated at one. Therefore, costs per vehicle are the same as costs per hour. However, if the towing distance is particularly long, then the rate and costs per vehicle will have to be adjusted. Towing vehicles rather than driving them has the advantage of avoiding possible contamination of the interior of the engine, though it is not clear to what extent this poses a serious hazard.

The second means of vehicle transport involves using a vehicle transport truck such as is used to deliver new cars. The cost per vehicle is estimated at $40. Labor, comprising 40% of cost of the operation, costs $16 per vehicle. Equipment is estimated at $20 per vehicle, and fuel $4.00. The rate, in terms of vehicles per hour, is four.

The third means of vehicle transport is to drive the car out. This would involve transporting a driver to the vehicle using a van or bus. The driver would then drive the vehicle out. This method requires sufficient organizational coordination such that the driver will have the proper keys to operate the vehicle. Most of the cost of this operation is for labor. This accounts for $13.50 per vehicle, out of a total of $15.00. Fuel and equipment are for the bus or van and amount to $0.75 each per vehicle. The rate is two vehicles per hour.

A.6 OTHER ACTIVITIES

A.6.1 Surveying and Monitoring Operations

In this section we derive estimates for the costs of radiological surveying and monitoring activities. The cost estimates are structured so that they can be applied in a variety of circumstances. Data are developed for a varying mix of surface types, and schedules are devised, depending on the time at which the surfaces are decontaminated.

By radiological survey operations we mean those activities intended to measure the nature and extent of radiation contamination, but preceding any cleanup operations. In general, the measurements are not specific to any particular surface type.

Radiological monitoring operations are generally intended to gauge the effectiveness of decontamination activities and, as such, would normally be performed following decontamination actions; they also tend to be surface specific.

In the discussion below, we consider several major types of radiological surveying and monitoring activities that would likely be undertaken in the event of a severe radiological release. Specific surveying and monitoring operations are identified as applying to certain types of surfaces. For example, an aerial radiological survey measures contamination over all horizontal exterior surfaces. In addition to describing the operations, cost estimates measured in 1982 dollars and rates of coverage are developed. Several of the operations discussed below would be repeated over the months and years following initial contamination. Section A.6.1.10 presents the schedule for these operations.

A.6.1.1 Aerial Radiological Survey

The initial assessment of radiation contamination can be done most effectively with an aerial radiological survey. Cost data for this operation were supplied by EG&G, Inc., which serves as the Department of Energy's contractor to perform aerial surveys. For an area of 30 by 100 miles, with overflight tracks spaced at one-mile intervals, the cost would be $125,000. This is equivalent to $\$1.61 \times 10^{-5}$ per sq meter of land area.

Flight speed is 135 knots. This means that the survey would take about 19 hours. With allowances for refueling and maneuvering, we assume a total task time of 24 hours. This is equivalent to 3.24×10^{8} sq meters per hour. It should be clear that these cost and rate figures are based on the specified survey intensity. Should a tighter grid be specified, the unit cost would be higher and the coverage rate would be lower. Note that these cost estimates already allow for radiation control measures. Therefore, no additional adjustment is necessary.

A.6.1.2 Mobile Air and Soil Sampling

Following an aerial survey, additional information on the extent and nature of the contamination can be achieved with two-person teams taking air and soil samples at specified points. The unit cost of this activity depends on such things as the spacing of the sample points, whether vegetation and water are also sampled, and how extensive the sample analyses are. Because it is assumed that the contamination will be spread uniformly over wide areas, adequate information can be obtained by sampling in a grid pattern having a unit linear dimension of five miles. Thus, there would be one sample location for every 25 sq miles (6.47×10^7 m^2). A tighter grid pattern would require adjustment to cost estimates by raising both the number of samples taken as well as the total transportation costs.

The sampling crew would drive a pickup truck with the necessary equipment to the designated sample locations. If the area has paved roads, the time between locations may be less than ten minutes. In rural areas, however, off-road travel may be required with an associated increase in travel time. We assume an average of 20 minutes between locations.

Once at the proper location, the crew would set up portable air sampling equipment. The motor for the sampler would be powered by the vehicle's electrical system. During the 10 to 15 minutes that the air sampler is in operation, a soil sample and any optional plant or water samples would be taken. When the air sampling and documentation are completed, equipment would then be returned to the truck, and the crew would move to the next sample location.

A number of sources provided information useful for estimating the cost of this operation. All sources emphasized that their cost and rate estimates were dependent on a number of unspecified variables and, therefore, their figures could only be considered as approximate. Costs may be divided into four categories: labor, equipment including operation, sample analyses, and administration, reporting and overhead.

The hourly labor costs reported varied from a little over \$10 to over \$40 per hour. It appears that a major reason for this variation is that some sources included such expenses as fringe benefits, administrative overhead, sample analysis and documentation in the labor charge, while other sources reported unburdened labor costs. The lowest of these labor costs appeared in Witherspoon (1982), who listed a base labor rate of \$10 per hour for the year 1980. Converting to 1982 price levels using the GNP implicit price deflator, the labor cost was \$11.60 per hour. The report added that fringe benefits raised the labor charge 25 percent, bringing the total to \$14.50. Administration and overhead were expressed separately, but also in terms of the wage rate, at 15 percent and 31 percent, respectively.

N.U.S., Inc. quoted a labor cost of $20 per hour, including administration. Quadrex, Inc. listed labor charges of $40 per hour for a technician and $50 per hour for an engineer, plus $100 per day for living expenses away from home, plus a single charge of $300 to $400 for flying the person to and from the accident site. This comes to about $54 per hour. These costs apparently include basic monitoring equipment. Nuclear Support Services, Inc. quoted a labor cost of $17.18 per hour for a junior technician and $26.00 per hour for a senior technician. Keith Price, in the Pacific Northwest Laboratory's (PNL) Environmental Evaluations Section, estimated labor costs, including benefits and administrative overhead, at around $40 per hour. This was close to the $300 to $350 per day figure given by AWC, Inc.

Based on this information, we take $25 per hour as the labor cost per person, including fringe benefits, but excluding administrative and other overhead costs. Applying this cost to air and soil sampling, it is necessary to estimate the time required for the different steps. As mentioned earlier, we estimate time to the sample site to be 20 minutes. Equipment setup would, according to several sources and our own estimate, take about 5 to 10 minutes. It would take another 15 minutes to take the air sample and during this time the soil sample would be collected. About 5 to 10 minutes would be necessary to replace the equipment in the truck and to complete the documentation. These steps add up to 40 to 55 minutes per sample. If 7 hours of an 8-hour shift are devoted to sampling and it takes 45 minutes per sample, 9.33 samples per shift will be taken. This is 1.17 samples per shift-hour. The labor cost per sample is

$$\frac{\text{8 hr per shift} \times \text{\$25 per hr} \times \text{2 people}}{\text{9.33 samples per shift}} = \text{\$42.87 per sample}$$

With one sample per 25 sq miles, the rate of coverage for this operation is 233 sq miles per 8-hour shift, or 7.54×10^7 sq meters per hour.

Next to be considered are equipment costs. Equipment would include a pickup truck or similar vehicle. Four-wheel-drive capability would be required for difficult unpaved terrain. One or two air samplers would be carried. According to PNL's Environmental Evaluations Section, these samplers cost roughly $1500 each. In addition, the crew would carry two portable radiation detectors, primarily as a precautionary measure for the safety of the crew. These cost about $800 each. Other equipment would include air filters, miscellaneous tools, protective clothing, and materials for recording information. This equipment, if new, would cost somewhere in the range of $12,000 to $17,000, depending primarily on the size of the vehicle and whether it is equipped with four-wheel drive. In Means (1982) the rental rate for a 3/4-ton two-wheel-drive pickup is $275 per month. A four-wheel-drive truck is $395 per month.

Estimating a cost-per-month or cost-per-sample for the remaining equipment is not as straightforward. However, if we assume that the truck comprises two-thirds of total equipment lease costs, then the monthly equipment cost is between $412.50 and $592.50, again depending on whether the truck has four-wheel-drive capability. We take $500 as the monthly equipment cost, implying that about half the trucks are four-wheel drive. At 9.33 samples per shift, 10 shifts per week, and 4.2 weeks per month, this comes to about $1.30 per sample.

Almost all of the equipment operation costs are associated with the vehicle. Means lists hourly operation costs for the two types of trucks at $4.42 and $4.54, though it is not clear what mileage is assumed in the Means calculations. If the truck is in essentially continuous operation for the whole shift, the cost per sample is about

$$\frac{\text{8 hr per shift x \$4.50 per hr}}{\text{9.33 samples per shift}} = \text{\$3.86 per sample}$$

The source at PNL's Environmental Evaluations Section indicated that the operating cost of a pickup truck is estimated at about $0.30 per mile plus gas. Assuming 12 miles per gallon and a gas price of $1.30 per gallon, the gas cost amounts to about $0.11 per mile. If total distance comes to, say, 100 miles per shift, then the total equipment operating cost estimated this way is

100 mi x $0.41 per mi = $41.00 per shift

The equivalent cost per sample is $4.39. Based on these two estimates of $3.86 and $4.39 per sample, we take $4.00 as representative. Total equipment costs expressed on a per-sample basis are, therefore, $5.30.

The next cost category is that of sample analysis. Since there are several laboratories which do this on a commercial basis, reliable cost estimates are easy to obtain. The costs of these tests vary with respect to how detailed an analysis is desired. The prices for air (filter) sample analysis supplied by United States Testing, Inc., are given in Table A.6.1.1 and illustrate the charges for different analyses. The charges for soil sample analysis are almost identical to those for corresponding air sample analysis. The only two differences are that the plutonium test is $225 for a soil sample versus $140 for an air sample; and the strontium test is $155 for a soil sample versus $140 for an air sample.

The final cost category is for survey administration, management and overhead. Means (1982) gives these costs as 46 percent of labor costs. Using this relationship, the administration and overhead cost comes to $19.72 per sample.

Combining the cost estimates for each category, the total cost per sample is as shown in Table A.6.1.2. Since one sample is taken for every 25 sq miles, the respective costs per sq meter are calculated by dividing the per sample costs by 6.47×10^7 m^2, giving the amounts shown in the table.

TABLE A.6.1.1. Air Sample Test Costs by Type ($1982)

Test	Cost
Gross alpha	$ 17.00
Gross beta	17.00
Gamma scan	56.00
Plutonium	140.00
Americium	165.00
Strontium	140.00
Uranium	70.00
Krypton-85	395.00
Tritium	30.00
Carbon-14	395.00

Source: Pacific Northwest Laboratory.

TABLE A.6.1.2. Mobile Sampling Costs by Category ($1982)

Category	Cost	
	Per Sample	Per sq Meter
Labor	$ 42.87	66.2×10^{-8}
Equipment	5.30	8.2×10^{-8}
Sample analysis	141.50	218.5×10^{-8}
Administration	19.72	30.5×10^{-8}
Total	$209.39	323.4×10^{-8}

Source: Pacific Northwest Laboratory.

It is clear that sample analysis accounts for the largest part of the cost. If there are any economies of scale in this area, the total cost savings could be substantial. This is evident when comparing these cost calculations with information supplied by Dr. Barry Bermin of Radiation Survey Activities Group at Oak Ridge National Laboratory. He supplied an unverified quick estimate of $100,000 to $150,000 for the total cost of air sampling for an area of 3000 sq miles on a one-mile grid. Of this amount, $50,000 was for sample analysis, including strontium and gross gamma for all samples. While he was not able to quote a per-analysis cost, his figures imply a cost per sample site of $33 to $50. This is considerably less than the $209.39 per sample estimated here. The total cost estimated here, exclusive of sample analysis, is about $70,000, which is within the $50,000 to $100,000 range estimated by the Oak Ridge source. This emphasizes the fact that the differences in cost estimates lie primarily with the cost of sample analysis. Whether this difference is due to gains from scale effects or misestimation is unclear.

Water and Plant Samples. Water and plant sampling are considered here as activities that would be carried out as an adjunct to the air and soil sampling just described. Therefore, the costs for water and plant samples do not include any additional transportation costs. Further, equipment and operation costs are negligible. It seems likely that plant and water samples can be taken in conjunction with the soil sample, while the air sampler is in operation, and at no increase in time or labor cost. As a result, costs of taking these samples are merely the cost of sample analysis. It is convenient that costs of plant and water samples are essentially equal to each other.

The cost of sample analysis is based on the soil sample charges by United States Testing, Inc. For each plant or water sample, it is likely that the tests performed will be a gamma scan and a strontium test, which have respective costs of $56 and $155, for a total of $211. With sample points set out on a five-mile grid arrangement, the cost per sq meter is $\$3.26 \times 10^{-6}$.

Since this activity requires no time in addition to the mobile air and soil sampling, the rate is the same as the rate of the air and soil sampling; namely, 7.55×10^{7} sq meters per hour.

A.6.1.3 Mobile Gamma Scanning

Where necessary, gross gamma measurements can be taken from a vehicle fitted with gamma scanning instruments. These can be aimed to take measurements up to 60 meters on either side of the vehicle. The Radiation Survey Activities Group at Oak Ridge operates a number of vans, each fitted with three or more scanning units and associated recording devices.

In cases in which the deposition of radioactive particles is relatively uniform, as would be the case from a reactor plume, this scanning can be done quite rapidly. Vehicle speeds of 30 to 40 miles per hour would be practical.

In residential areas, a scanning width of about 15 meters on each side of the vehicle would allow simultaneous measurements on the road surface and lawns on both sides of the street. In addition, if we assume an average vehicle speed of 20 miles per hour, then the surface coverage is about 294,300 sq meters per hour. With seven production hours per eight-hour shift, output per shift-hour would be 257,500 sq meters.

The cost of operating this equipment, including wages for two 3-person crews, transportation to the site, reports, and administrative overhead, is about $15,000 per week. About half the cost is for labor. Assuming operation for two shifts per day for five days, the cost per sq meter would be $\$7.28 \times 10^{-4}$.

A.6.1.4 Manual Survey of Building Surfaces

Surveying of building surfaces would normally be done with two-person crews. They would use hand-held instruments such as a Geiger-Mueller meter and a scintillation survey instrument to determine whether the surfaces had been sufficiently decontaminated. In addition, they would also take some smear samples for a determination of the amount of remaining contamination that was removable. The crew would also place five-chip dosimeters (TLDs) in main rooms throughout the structure.

Sources contacted were unable to provide estimates of unit cost per surface for surveying. They were, however, able to estimate the time necessary to survey a typical 1600 sq foot home. Estimates from Nuclear Support Services, Inc., Pacific Northwest Laboratory, and the Radiation Survey Activities Group ranged from 0.375 to 1.0 man-days per house. We take 0.75 man-days (6 man-hours) as a representative estimate. At $25 per hour for a technician, this come to $150. Adjusting for one hour per shift for radiation control measures gives an adjusted labor cost of $171.43.

Equipment for this operation would not be extensive. The portable instruments mentioned would cost less than $2000. The estimated hourly equipment cost is $2.00. The cost per house is

$$\$2.00/\text{hr} \times 6\ \text{hr/house} \times 8/7\ \text{adj} = \$13.71.$$

Sample analysis for smear tests costs about $17.00 for both gross alpha and gross beta per sample, according to United States Testing, Inc. Assuming 5 of these samples tested for alpha and beta for each 1600 sq feet of building interior, the cost comes to $170. In addition, the five-chip dosimeters cost $17.50, according to United States Testing. This cost includes laboratory analysis of the exposed dosimeter. The total cost for the dosimeters per 1600 sq feet is $52.50, based on placement of three dosimeters. The estimated total cost for sample analysis and dosimeters is $222.50.

Finally, administration and overhead--calculated at 46 percent of labor costs, as in Means (1982)--come to 0.46 x $171.43 = $78.58. The costs for a 1600 sq foot home are given in Table A.6.1.3.

Apportioning this cost to surfaces making up a house requires some simplifying assumptions. The first of these is that all the structure surfaces can be surveyed at the same rate and cost. The second is that 25 percent of the surveying costs are expended on furnishings and other items that are not part of the structure. Therefore, to estimate the cost per unit of surface, it is necessary to estimate total structure surface area. We use the factors for

TABLE A.6.1.3. Building Surveying Costs by Category

Category	Cost ($1982) Per House	Per sq Meter
Labor	$171.43	0.1622
Equipment	13.71	0.0130
Sample analysis and dosimeter	222.50	0.2104
Administration and overhead	78.85	0.0746
Total	$486.40	0.4602

Source: Pacific Northwest Laboratory.

residential property to estimate total surface area for a 1600 sq foot home (see Section E.3). The resulting areas are as follows.

Interior floor area = 1600 sq feet

Projected Roof area = 1200 sq feet

Exterior wall area = 1900 sq feet

Interior wall area = 2890 sq feet

Basement floor area = 400 sq feet

Basement wall area = 550 sq feet

Total surface area = 8540 sq feet
= 793 sq meters

Noting that the 793 sq meters account for 75 percent of the cost of all surfaces surveyed, we can calculate how much structure surface alone could be surveyed in six hours:

$$793\ m^2 \div 0.75 = 1057\ m^2$$

Dividing the costs per house in Table A.6.1.3 by this total area gives the costs per sq meter shown in this table.