TABLE A.1.5.1.8. Adjusted Street Sweeping Figures from Cal-Trans

Input	Cost (1982 $)
Salaries	398,934
Equipment	1,913,494
Materials	46,388
Other	46,388
Total	2,405,204

This total cost figure yields a cost per sq meter of $0.0054. Making the further adjustment to labor costs to account for radiation control by multiplying by 8/7 yields the costs shown in Table A.1.5.1.9.

TABLE A.1.5.1.9. Adjusted Street Sweeping Costs by Input for Cal-Trans, State of California

Input	Cost (1982 $)		Percent of Total
	$/yr	$/m^2	
Labor	455,925	0.0010	18.5
Equipment	1,913,494	0.0043	77.7
Materials	46,388	0.0001	1.9
Other	46,388	0.0001	1.9
Total	2,462,195	0.0055	100.0

T.. costs per sq meter in Table A.1.5.1.9 are calculated by dividing the cost per year by the area covered per year, which is:

$$114{,}432 \text{ mi/yr} \times 5{,}280 \text{ ft/mi} \times 8 \text{ ft wide} \times 0.093 \text{ m}^2/\text{ft}^2$$

$$= 449{,}525{,}514 \text{ m}^2/\text{yr}$$

These calculations produce a total cost per sq meter of $0.0055.

Despite these adjustments, these figures are still considerably higher than those reported by other sources. In particular, the figure of 77.7 percent of total cost for equipment is quite high compared with other sweeping operations in which figures of 40-60 percent are more common. Another question results from Cal-Trans' estimate of an average sweeping speed of 7.5 miles per hour. In general, high sweeping speeds will lead to low costs per unit surface area, and this speed is the highest speed reported from the sources contacted. Using this speed and adjusting for one hour per shift in which no vacuuming is done, we get:

$$7.5 \text{ mi/hr} \times 5280 \text{ ft/mi} \times 8 \text{ ft wide} \times 0.093 \text{ m}^2/\text{ft}^2 \times 7/8 \text{ adj}$$

$$= 25,780 \text{ m}^2/\text{hr}$$

McGraw-Hill publishes a document called PIN or Product Information Network which is compiled by the International City Management Association and the McGraw-Hill Information Systems Company. The September, 1982 volume revision concerning street sweepers contains a general discussion of street sweeping equipment as well as providing information on prices and performance of various types of equipment.

On page 17, PIN reports an annual cost of $350 per curb mile per year for vacuumized sweeping with one pass every five days. If "one pass every five days" is interpreted to mean once a week or 50 times per year, then the cost per curb mile per pass is $350/50 = $7.00. The cost per sq meter, based on an 8-foot width, is $0.0018. Multiplying by 8/7 to adjust for time for radiation control brings the cost to $0.0020 per sq meter.

PIN does not provide information on the average operating speed corresponding to the cost estimate of $350 per curb mile per year. Elsewhere in the text (p.11), a speed of 2 miles per hour is cribed as producing "very good" results and a speed of 4 to 5 miles per hour as resulting in a good compromise between productivity and cost. If we assume an average operating speed of 2.5 miles per hour, including time for dumping collected debris, then the average decontamination coverage per shift-hour would be:

$$2.5 \text{ mi/hr} \times 5280 \text{ ft/mi} \times 8 \text{ ft wide} \times 0.093 \text{ m}^2/\text{ft}^2 \times 7/8 \text{ shift-hr/hr}$$

$$= 8593 \text{ m}^2/\text{hr}$$

While PIN discusses some aspects of sweeping costs in detail, nothing is provided which would permit calculation of the respective cost shares of the various inputs into street sweeping operations.

While the Radiological Reclamation Performance Summary, Vol. II (Owen et al. 1967) does not report any cost figures, sweeping coverage rates are listed. Actual rates are adjusted downward by the authors by 15 percent to compensate for the ideal test conditions. Further, this source lists the net rates incorporating the effects of necessary overlap of successive sweeping swaths. This has the effect of reducing the effective sweeping width to about 3.5 to 4.0 feet. The actual sweeping width of the machines used is reported. Separate results for a variety of test results for different conditions are listed. These alternate conditions include sweeper type, pavement texture, initial mass loading of contaminant, particle size, and sweeper speed. Results from test conditions that most closely replicate the conditions likely to occur in the event of a reactor accident are reproduced here in Table A.1.5.1.10. Coverage rates in terms of sq meters per hour range from 3,962 to 18,972.

TABLE A.1.5.1.10. Selected Street Sweeping Data

Sweeper Types	Pavement Texture	Particle Size (μ)	Gear	Speed (mph)	Rate (ft^2/min)	Rate (m^2/hr)	Effective Width (ft)	Pass and Marginal Removal Efficiency (%) 1	2	3	4	5
Mechanical	Rough	74-177	1	2.5	1,060	5,915	4.8	64	67	67	45	18
			2	6.0	2,130	11,885	4.0	62	64	41	10	--
			3	9.5	3,400	18,972	4.1	62	63	60	44	22
Vacuumized	Rough	44-74	1	2.5	710	3,962	3.2	64	17	--	--	--
			2	5.0	1,550	8,649	3.5	38	32	19	12	--
			3	8.0	2,430	13,559	3.5	30	26	19	14	6
Vacuumized	Smooth	44-74	2	4.5	1,420	7,924	3.6	82	64	21	--	--

Note: Initial mass loading of contaminant was five grams per square foot. Tests were performed under temperate weather conditions.

Source: Radiological Reclamation Performance Summary, Vol. II.

This wide range encompassed all the rates reported by other sources except that for Cal-Trans. It is clear that the operating rate is not fixed by the vehicle's capabilities so much as by other factors. A major criterion might be the associated removal efficiency, but here, too, a representative rate is not immediately apparent. The conventional mechanical street sweeper achieved a first-pass removal efficiency of 62 percent for 74-177 micron-sized particles on rough pavement at the very high coverage rate of 18,972 sq meters per hour. This is only nominally better than the removal efficiency reported at 5915 sq meters per hour for the same conditions. We calculate a representative rate for these tests by averaging the coverage rates for all tests for which the first-pass removal efficiency is greater than 50 percent. This calculation yields a figure of 9732 sq meters per hour.

However, the nature of the test procedures requires some further adjustments. In particular, no time was allotted for radiation control measures. Also, the production rates given by this source do not include any time for dumping collected materials. Assuming that one hour per shift would account for radiation control measures and that half an hour per shift would be necessary for dumping, we get an adjusted coverage rate of:

$$\frac{9732\ m^2/hr \times 6.5\ hr}{8\ hr} = 7907\ m^2/hr$$

Table A.1.5.1.11 summarizes the data on vacuumized sweeping costs. Also shown are representative rate and cost data.

The average hourly production rates from the various sources are reasonably close, except for the Cal-Trans figure. In averaging the rates to arrive at a representative hourly figure, the Cal-Trans value is excluded.

The cost data cover a broader span. While the PIN figure is quite low, it supposedly represents an average taken from several municipalities. For this reason it was included in computing the average, which is the basis for the representative cost figure.

All sources that disaggregated their costs by input groups listed labor as a separate category. However, there was considerable variation in the way that nonlabor costs were categorized, making input costs hard to synthesize. The approach used here is to add all the nonlabor costs together into a composite input called equipment. Representative input costs are calculated as simple averages, excluding the Cal-Trans figures. The input cost proportions reported by the San Francisco Department of Public Works could be used as a rough guide for further input cost disaggregation, if necessary.

A.1.5.2 Low-Pressure Water Wash

Using mobile street flushers to apply a low-pressure water wash to paved surfaces is the least costly decontamination operation per sq meter.

TABLE A.1.5.1.11. Summary of Vacuumized Street Sweeping Cost Data

Source	Rate (m^2/hr)	Cost (1982 \$/m^2) Total	Labor	Equipment[(a)]
Kennewick Street Dept.	10,000	0.0030	0.0019	0.0011
Pasco Pub. Works	7,177	0.0057	0.0023	0.0034
San Francisco Pub. Works	10,742	0.0038	0.0023	0.0015
Washington Dept. of Trans.	7,373	0.0056	0.0019	0.0020
California Cal-Trans	29,462	0.0055	0.0010	0.0045
PIN	8,593	0.0020	--	--
Owen et al.	7,907	--	--	--
Representative	8,632	0.0043	0.0021	0.0022

(a) Equipment includes all nonlabor costs.

Further, the decontamination efficiency of this operation is fairly high--95 percent on the first pass for pavement on which there has been no rain. However, this procedure results in a byproduct of a certain amount of contaminated water, which leads to the important question of what, if anything, to do with this water. In this section the flushing operation and the calculation of the costs of flushing per unit area will be discussed.

The City of Los Angeles calculates the average cost of mobile street flushing at \$9.08 per mile for all inputs, including labor, equipment, maintenance, fuel, and so forth, and assuming an average ten percent down time for the flushers. This cost varies with factors such as terrain, they estimate the cost per mile over flat areas at \$5.68 per mile and \$23.00 per mile in hilly areas. Despite this cost detail by terrain, they have no data on the costs of the different inputs.

According to this same source, the average net speed is five miles per hour. Therefore, in an average eight-hour shift the flusher will cover 40 miles. If we adjust this rate by a factor of 7/8 to account for radiation control measures, the mileage per shift is 35.

The flushers average 10 percent down time. That means for an average 8-hour shift, the flusher is available for 7.2 hours. During operation, the average speed is 5 miles per hour. Therefore, in an average 8-hour shift the flusher will cover 7.2 hours x 5 mi/hr = 36 miles. If we adjust this rate by a factor of 7/8 to account for one hour per shift for special radiation control operations, the mileage per shift is 31.5.

Flushers may be configured to flush one or both sides of the street at a time. The normal practice seems to be to flush one side at a time. That is the practice adopted by Los Angeles, and it on this basis that most flushing costs are calculated in this report. While street widths vary, a reasonable average width according to this source is 40 feet. That makes the width of a flush 20 feet. The coverage per shift hour is, then:

$$35 \text{ mi/shift} \times 5280 \text{ ft/mi} \times 20 \text{ ft wide} \times 0.093 \text{ m}^2/\text{ft}^2$$

$$\div\ 8 \text{ hr/shift} = 42{,}966 \text{ m}^2/\text{shift-hr}$$

Assuming that the cost per shift will not fall in direct proportion to the drop in output due to seven rather than eight hours of production, the cost per sq meter is calculated on the basis of an unchanged total cost per shift, even with only seven production hours out of eight. Therefore, the cost per shift hour is:

$$\frac{9.08/\text{mi} \times 40 \text{ mi/shift}}{8 \text{ hr/shift}} = \$45.40 \text{ per hour}$$

The cost per sq meter is, then

$$\$45.40/\text{hr} \div 42{,}966 \text{ m}^2/\text{hr} = \$.0011/\text{m}^2$$

The Public Works Department of the City of San Francisco provided its costs per mile for flushing, broken down by input as shown in Table A.1.5.2.1. The production rate is 40 lane-miles per 8-hour shift for an average 5 miles per hour. This figure includes time for refilling and breakdowns. Reducing the productivity rate by an hour per shift to account for radiation control brings the average hourly speed down to 5 x 7/8 = 4.375. The average hourly production, then, is:

$$4.375 \text{ mi/hr} \times 5280 \text{ ft/mi} \times 20 \text{ ft wide} \times 0.093 \text{ m}^2/\text{ft}^2 = 42{,}966 \text{ m}^2/\text{hr}$$

TABLE A.1.5.2.1. Flushing Costs by Input From the Public Works Department, City of San Francisco

Input	Cost (1982 $/mi)
Fuel	0.80
Maintenance and Equipment	1.20
Equipment	1.00
Labor	5.07
Total	8.07

As with the Los Angeles flushing data, we again assume that per shift costs would not be reduced by the hour per shift spent on radiation control measures. The cost per sq meter is therefore calculated in the following manner:

$$\frac{\$8.07/\text{mi} \times 40\ \text{mi/shift}}{(42{,}966\ \text{m}^2/\text{shift-hr}) \times 8} = \frac{\$322.8/\text{shift}}{343{,}728\ \text{m}^2/\text{shift}} = \$0.0009/\text{m}^2$$

Input costs per sq meter are calculated on the basis of the over shares for the different inputs as reported by the City of San Francisco. Therefore, the estimated costs per sq meter are as shown in Table A.1.5.2.2.

The City of Seattle Public Works Department reported that over fiscal year 1981-82 the cost of street flushing operations was $139,601. There were a total of 10,169 production miles, so the cost per mile averaged $13.72. The flusher is leased interdepartmentally from the city's Department of Administrative Services at $20.38 per hour. This covers fuel, maintenance, depreciation, interest, capital, and so forth. The cost of the driver, including benefits and administrative overhead, is $22.50 per hour. The cost of flusher and driver together come to $340 per shift. Output per shift is 25 miles.

TABLE A.1.5.2.2. Estimated Flushing Costs from the City of San Francisco

Input	Percent of Total	Cost (1982 $/m^2)
Fuel	10	0.0001
Maintenance and Repair	15	0.0001
Equipment	12	0.0001
Labor	63	0.0006
Total	100	0.0009

Adjusting output by 7/8, we get a per-shift output of 21.875 miles. With a flush width of 20 feet, this amounts to 214,830 sq meters per shift or 26,854 sq meters per hour. Dividing the cost per shift by the output per shift yields a cost per sq meter of $0.0016. The Seattle figures indicate that equipment, maintenance and repairs, depreciation and so forth comprise 47 percent of sweeping costs while labor comprises the remaining 53 percent. Converting these percentages to cost per sq meter gives $0.0008 for equipment (nonlabor inputs) and $0.0008 for labor.

The City of Portland Bureau of Maintenance operates three mobile flushers, each a part of a street cleaning crew. Because the operations of flushing and sweeping are combined and because other operations such as traffic control are also included, the separate costs of street flushing are difficult to infer.

Total curb mileage for all three crews for the 1981-82 fiscal year is 28,097 miles. Dividing by 3, since there are 3 crews, gives 9,366 miles per flusher per year. The cost per flusher per year is given as $140,000, but it is not clear if this is the cost for the flusher alone, or for flusher, labor, and so forth. The assumption made here is that $140,000 represents all costs for flusher, labor, etc. to cover 9,366 miles in one year.

The following calculates the cost per sq meter and adjusts for seven hours production in an eight-hour shift:

$$\frac{\$140{,}000 \text{ per year}}{9366 \text{ mi/yr} \times 5280 \text{ ft/mi} \times 20 \text{ ft wide} \times 0.093 \text{ m}^2/\text{ft} \times 7/8} = \$0.0017/\text{m}^2$$

The average hourly rate of a flusher is easier to calculate. The total 28,097 curb miles for one year took a total of 819 shifts. This works out to an average of 34.3 miles per shift. The adjusted average hourly rate is:

$$\begin{aligned} &34.3 \text{ mi/shift} \times 5280 \text{ ft/mi} \times 20 \text{ wide} \times 0.093\text{m}^2/\text{ft}^2 \\ &\quad \times 7/8 \text{ production hr/shift} \times 1/8 \\ &\quad = 36{,}843 \text{ m}^2/\text{hr} \end{aligned}$$

The Portland data also include some useful figures regarding the costs for the different inputs. They have three street maintenance crews consisting of five people. Each crew consists of the items shown in Table A.1.5.2.3. Costs are provided by input for the combined operations of all three crews. Also provided are the costs by input for some of the flushing operations alone (see Table A.1.5.2.4). More specifically, these are the costs of flushing the core (business) area and arterials. Excluded are the costs of flushing residential area. While the mileage corresponding to the limited flushing figures is not available, the data are useful in showing that the cost shares of the various inputs are fairly constant, so that even with incomplete information on

TABLE A.1.5.2.3. Typical Street Maintenance Crew, City of Portland

Labor	Capital
2 Sweeper Drivers	2 Mobile Sweepers
1 Flusher Driver	1 Mobile Flusher
1 Utility Worker	1 Pickup Truck
1 Laborer	--

TABLE A.1.5.2.4. Portland Street Flushing Cost Data

	Cost of All Operations		Cost of Flushing Limited Area	
Input	1982 Dollars	Percent	1982 Dollars	Percent
Labor	457,000	55	108,000	55
Materials	13,000	2	4,000	2
Fleet	364,000	44	82,000	42
Unspecified	2,000	0	1,000	1
Total	836,000	100[(a)]	195,000	100

(a) Parts do not add to total due to rounding.

flushing we can be reasonably confident that the proportions calculated for the limited area are likely to be very close to the proportions of total sweeping costs. Applying these proportions to the estimated cost per sq meter, we can estimate the input costs per sq meter, as shown in Table A.1.5.2.5.

The September, 1982 version of PIN's (Product Information Network) report on street sweepers includes information on the cost of mobile street flushing. They report (p. 17) that the annual cost of flushing is $150 per curb mile per year with one flush every five days. Interpreting this to mean one pass per week or 50 passes per year, the cost per curb mile per pass is $3.00. Note that this figure is substantially less than any other reported.

TABLE A.1.5.2.5. Street Flushing Input Costs, City of Portland

Input	Percent of Total	Cost ($\$/m^2$)
Labor	55	0.0009
Materials	2	0.0000
Fleet	42	0.0007
Unspecified	1	0.0000
Total	100	0.0017

The cost per sq meter (adjusted for production in only seven of eight shift hours) is calculated as follows:

$$\frac{\$3/\text{mi}}{(5280\ \text{ft/mi} \times 20\ \text{ft wide} \times 0.093\ \text{m}^2/\text{ft}^2)} \times \frac{8}{7}\ \text{adj} = \$0.0003/\text{m}^2$$

The document indicates that the flusher is operated at the same speed as a street sweeper (about 8593 sq meters per hour). This is problematical for two reasons. The first is that the other sources providing flushing data indicated that flushers normally operate at about twice the forward speed of street sweepers. The second reason to suspect a faster forward speed is that procedures such as these, which are capital- and labor-intensive rather than materials-intensive, will tend to have lower costs at faster rates. Since the cost given here is quite low, one would expect a corresponding faster than average speed. The result of these considerations is to conclude that the information in PIN is not appropriate for estimating production rates. The information in PIN also provides no basis for calculating the shares of total costs by input.

The Maintenance and Operations Division of the State of Washington Department of Transportation estimates its cost of street flushing at $11.71 per lane mile. Its performance standard for flushing is 1.667 lane miles per hour, a much lower rate than reported by other sources. The area flushed in one hour, adjusted for time for radiation control, is:

$$1.667\ \text{mi/hr} \times 5280\ \text{ft/mi} \times 20\ \text{ft wide} \times 0.093\ \text{m}^2/\text{ft}^2 \times 7/8\ \text{adj}$$

$$= 14{,}325\ \text{m}^2/\text{hr}$$

At 1.667 miles per hour, Washington's cost per hour is:

$$1.667\ \text{mi/hr} \times \$11.71/\text{mi} = \$19.52/\text{hr}$$

Dividing the cost per hour by the average hourly production yields the cost per sq meter:

$$\frac{\$19.52}{14{,}325} = \$0.0014/\text{m}^2$$

According to this source, the cost of street flushing can be broken down as shown in Table A.1.5.2.6. Input costs per sq meter are estimated by applying the same input cost shares already reported to the (adjusted) cost per sq meter.

The Radiological Reclamation Performance Summary, Vol.II (Owen et al. 1967) reports detailed performance data regarding mobile street flushers but provides no information about costs. The performance figures in Owen et al. are somewhat at variance with those supplied by other sources. The major difference is that the tests and subsequent calculations for coverage rates and removal efficiencies reported by Owen et al. are based on an average effective flushing width of about 5.2 feet rather than the 20 feet reported by other sources. Vehicle speed is 6 miles per hour. As mentioned earlier, the usual practice for flushing streets is for the mobile flusher to direct a spray of water from the center of the street toward the curb. In this manner, either one or both halves of an average 40-foot wide urban street can be flushed in one pass. The apparent assumption in the Radiological Reclamation Performance Summary was that greater water pressure and, hence, greater scouring action of a direct water spray was necessary to produce sufficient removal. Other available sources concerned with mobile street flushing as a method of radiation decontamination provide no details about the flushing procedure.

This low flushing width is partially offset by an average effective operating speed of 6 miles per hour, which is faster than that reported by most other sources. Even so, the reported coverage rate of 15,345 sq meters per hour in Owen et al. is still comparatively low. Adjusting for an hour per shift due to radiation control measures, we get:

$$15{,}345\ m^2/hr \times 7/8\ adj = 13{,}427\ m^2/hr$$

TABLE A.1.5.2.6. Washington State Department of Transportation Estimates of Street Flushing Costs by Input

Input	Reported Cost (1982 $/mi)	Reported Cost Percent[a]	Adjusted Cost (1982 $/m^2)
Labor	6.06	52	0.0007
Equipment	5.11	44	0.0006
Materials	0.54	5	0.0001
Total	11.71	100	0.0014

(a) Parts do not add to total due to rounding.

The previously reported flushing data from other sources results in low unit costs in large part because of the high rate of coverage. If a 20-foot flushing width per pass is unrealistic, then the previously reported costs could be converted to a 5-foot width basis by multiplying all cost figures by 4 (20 ft ÷ 5 ft = 4). This adjustment seems more appropriate than the alternative one of increasing unit costs by the ratio of the estimated coverage rates:

$$\frac{\text{est. coverage rate for source A}}{\text{est. coverage rate for Owen et al.}} \times \text{est. unit cost for source A}$$

$$= \text{adjusted unit cost for source A}$$

This adjustment, which converts all costs to an hourly coverage rate of 13,427 sq meters, suppresses the collected information on vehicle speed. In addition to assuming an effective flushing width of about five feet, it also assumes an average speed of 6 miles per hour.

An important reason for not adjusting all costs and rates to a narrower width basis is that a narrow width, direct water spray method is analyzed in the next section. Those cost and rate estimates can be used if 20-foot wide flushing proves unsatisfactory.

A final detail reported by Owen et al. is that the flusher discharged water at the rate of 370 gallons per minute, for a coverage of 0.13 gallon per sq foot. Also, nearly half of the operating time was spent in refilling the flusher.

Table A.1.5.2.7 summarizes the foregoing mobile street flushing data. While most of the figures are fairly consistent, the PIN data show an exceptionally low rate and low unit cost, and the rate reported by Owen et al. is slightly below that for the Washington Department of Transportation. All rates are averaged to produce the representative rate. The PIN unit cost was omitted in computing this cost.

Of the sources providing data for allocating input costs, all designate labor as one of the categories. Beyond that, however, the categories vary. Potential inconsistencies are resolved by lumping all nonlabor costs together. The representative input unit costs are calculated in two different ways, both of which produce the same result. In the first method, the four input costs are averaged and then proportionally adjusted to the representative total cost. The other method is to convert each source's input cost to a percentage of total unit cost and then to average these percentages. Then the average input cost shares are applied to the $0.0013 per sq meter unit cost to give the input costs.

A.1.5.3 High Pressure Water

Using a high pressure water wash of 80 to 120 pounds per sq inch has the advantage of scouring the pavement. This results in greater removal of

TABLE A.1.5.2.7. Summary of Mobile Street Flushing Data

Source	Rate (m^2/hr)	Cost (1982 \$/m^2) Total	Labor	Nonlabor
Los Angeles Pub. Works	42,996	0.0011	---	---
San Francisco Pub. Works	42,996	0.0009	0.0006	0.0003
Seattle Pub. Works	26,854	0.0016	0.0008	0.0008
Portland Bur. of Maint.	36,843	0.0017	0.0009	0.0008
PIN	8,593	0.0003	---	---
Washington Dept. of Trans.	14,325	0.0014	0.0007	0.0007
Owen et al.	13,427	---	---	---
Representative	26,576	0.0013	0.0007	0.0006

small particles and particles that have penetrated into surface irregularities. There are three basic methods for carrying out this procedure. The first method requires a high pressure fire hydrant system. Crews of two or three workers equipped with a small amount of equipment, primarily fire hoses and nozzles, move from hydrant to hydrant hosing down the pavement by section.

The second method would be used principally in cases where there were no hydrants or where the hydrant system provided inadequate pressure. In this method, water from a hydrant or from a water tanker truck would be supplied to a pump truck which would boost the pressure and supply it to one or two hose lines.

The third method is to use a tank truck fitted with a pump and a set of spray nozzles mounted on a boom across the front of the truck. This equipment would have the capability of applying the water over the width of a lane and would be able to move forward while spraying.

Each of the three methods is discussed in detail below, and cost estimates are given for each. These estimates are weaker than some others in this study due to the fact that high pressure washing of pavement is not an activity which is commonly performed. Therefore, cost estimates are constructed from information on the factor inputs and their likely costs; the estimates are generally not based on experience.

The method using the least amount of specialized equipment requires equipping two- or three-man crews with about 500 feet of firehose (in 50-foot sections with coupling fixtures), a nozzle, a hydrant wrench, and a limited amount of miscellaneous personal equipment, such as rubber boots and other waterproof and protective clothing. The hoses would be connected to a hydrant and used to spray the pavement. Two people may be required to hold the hose if higher pressures are used. After spraying the pavement, workers would drag the hoses to the next hydrant and repeat this operation.

It is interesting that some data from a similar operation was recorded from actual experience in the cleanup of volcanic ash following the eruption of Mount St. Helens in 1980. That event created a situation not entirely unlike the one which would result from a nuclear reactor accident. While the ash did not create a radiation hazard, the sheer volume of material made a large-scale cleanup program necessary. Of course, removing a large volume of ash is not the same as removing an essentially invisible coating of radioactive fallout. However, in some cases the costs and methods of the two may be similar. For example, in the absence of better data, the cost and rate for hosing a thick coating of volcanic ash from paved surfaces might be a good proxy for the cost of hosing paved surfaces to remove a thin but tenacious coating of radioactive particles. Both operations require a degree of thoroughness--one in order to remove a high volume of material and the other to remove particles with great adhesion to the surface.

The Administrative Services Manager of Spokane Community College directed the cleanup of that campus. Of the total 200 acres, 110 acres are paved. He reports that, on average, one man can hose down a length of street a block long in one hour. Including sidewalks, he estimates the area covered in an hour at 15,000 sq feet. This estimate was the result of actually timing the operation. In addition, 15 minutes were required to move the hose from one hydrant to the next. This brings the effective rate down to 15,000 sq feet every 75 minutes. If one hour per shift is devoted to equipment and personnel decontamination activities, the coverage rate is:

$$15{,}000\ ft^2 \times 0.093\ m^2/ft^2 \times 7/8\ adj \div 1.25\ hr = 977\ m^2/hr$$

The average straight-time salary at the time of the eruption was $6.00 per hour. Here we use a burdened labor cost figure of $17.45 per hour. In addition to these costs are the costs for equipment. This same source reports that the hose and most fittings had to be replaced after two weeks of round-the-clock use. (Sources in the Seattle Fire Department indicated that they would expect a shorter life than two weeks if the hoses are regularly dragged across pavement.)

Apparently, various hose setups were tried. The one for which they reported the greatest success was a Y-setup with one 2-1/2-inch connection to a hydrant. The 2-1/2-inch hose, in (usually) six 50-foot sections led to a Y valve to which two lines of 1-1/2-inch hose were connected. The 1-1/2-inch lines were usually comprised of 50-foot sections. Each 1-1/2-inch line was