Estimation of the unit costs of decontamination techniques
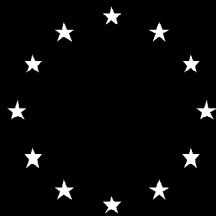
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RODOS REPORT

DECISION SUPPORT FOR NUCLEAR EMERGENCIES

RODOS(WG3)-TN (99)-32

Estimation of the unit cost of decontamination techniques
RODOS(WG3)-TN(99)-32

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Management Summary

This report presents an evaluation of the unit costs of the 13 decontamination techniques considered within the LCMT Module of RODOS. It presents into details the estimation of the various costs obtained using a RISØ (1995) and an NRPB (1996) report concerning decontamination techniques. It also presents the values obtained by NRPB in 1999, which will be inserted in ECONOM data base as default values.

The unit costs of decontamination techniques obtained by these three reports are sometimes very different. However, it appeared to be important for RODOS users to be aware that, depending on the hypothesis or on the countries, the data could vary a lot. The aim of this report is to give as much details as possible on the different assumptions made in the evaluation of costs, so as to provide a guide for users to adapt the default data base to their own data.

Contents

1 Introduction

This report presents an evaluation of the unit costs of the 13 decontamination techniques considered within the LCMT Module of RODOS.

Two major sources of information have been used for this evaluation and will be described in detail:

- A RISØ report of 1995 describing the "Practical Means for Decontamination 9 Years after a Nuclear Accident" [1],

- A NRPB report of 1996 concerning a "Review of Decontamination and Clean-up Techniques for Use in the UK following Accident Releases of Radioactivity to the Environment" [2].

Moreover, a table of data from NRPB extracted from a 1999 report on "Review of data on decontamination and remediation techniques for Plutonium and application for CONDO" [3], is also presented in the synthesis section.

The unit costs of decontamination techniques obtained by these three reports are sometimes very different. It has then been proposed to use the last table provided by NRPB [3] to fulfil the data base for the ECONOM module. However, it appeared to be important for RODOS users to be aware that, depending on the hypothesis or on the countries, the data could vary a lot. The aim of this report is to give as much details as possible on the different assumptions made in the evaluation of costs, so as to provide a guide for users to adapt the default data base to their own data.

2 The main hypothesis

The RISØ Report [1] presents the main features of around 60 decontamination techniques. The main elements presented for each technique and used for the cost evaluation are:

- Name of Tool

- Target surface

- Design (productivity)

- Mode of operation

- Costs : Manpower (days/unit area), tool investment cost (EURO), discount cost (EURO/year), consumables (unit), scale of application.

The NRPB report of 1996 [2] presents the total cost of several decontamination techniques to be used in urban areas. As pointed out in this report, *"the costs include: labour costs, costs to hire or depreciation costs for plant and vehicles, cost of consumables, running costs including maintenance, and costs to reinstate buildings, roads, etc, after decontamination. Costs for replacement of plant are not included in the overall costs. The costs of waste disposal, including the transport of waste, have not been included"*. Moreover, in the Appendix of this report, the detailed cost of some techniques are presented, with the scale of application, the labour cost, the consumables and cost of plant hire per day. These data have been used when available.

For the evaluations, the following assumption have been made:
- Daily working time: 8 hours
- Weight of petro-diesel: 1 kg = 1.1976 litre

The costs parameters used for the evaluation are:
- Average Hourly Cost of manpower in industry: 21.59 EURO/h [4, p.300, France, 1995]

- Purchase Price of Diesel oil: 0.2952 EURO/l [5, p.281, Germany, 1995]

- Purchase price of water: 15.5 FF/m^3 = 2.36 EURO/m^3 [6]

- Purchase price of sand: 0.16 FF/kg = 0.024 EURO/kg [7]

- Purchase Price of electricity: 0.2 FF/kWh = 0.03 EURO/kWh [8]

For the values given in the NRPB report, the conversion in EURO was made using the average value per calendar year of the ECU published in the EUROSTAT report on Agricultural price [5] for 1996: 1 EURO = 0.813798 UK£

For the discount price of tools given in the RISØ report in ECU, the only "conversion" made was to change ECU to EURO.

This document presents the detailed calculation in EURO/ha.

However, for all the technique, LCMT provides the surface which is assumed to be decontaminated in km^2. Within the data base, the unit cost of the various techniques will be given in EURO/km^2 to fit with the LCMT units.

The total cost of each technique is evaluated on the basis of the following five parameters which will be integrated separately in the data base, in order to facilitate its update:

- Unit cost of manpower (EURO/man-hour)

- Manpower (man-hour/km^2)

- Unit cost of consumable (EURO/km^2)

- Unit cost of equipment (or investment) (EURO/km^2)

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3 Skim and burial ploughing

3.1 Available Data

The RISØ report presents 2 techniques [1, p.50, 51]:

- Skim and burial plough and tractor: this technique allows to bury only a very thin layer (5 cm) of topsoil at 45 cm, and to have the 5-45 cm layer not inverted.

- Skim and burial ploughing allowing an upper 5 cm layer cut off and put under ploughed horizon of soil.

The following data are provided which will be used for the cost evaluation:

Table 3.1. Unit parameters for skim and burial ploughing techniques

	Skim and burial plough and tractor	Skim and burial ploughing
Daily Manpower	$4.16 \ 10^{-5}$ man-days/m^2 = 0.416 man-days/ha	0.6 man-day/ha
Discount Investment Cost	10 000 EURO/year (tractor) 825 EURO/year (plough)	2500 EURO/year
Scale of application (surface which can be decontaminated with one tool)	3 000 m^2/h x 720 h/year = 216 ha/year	2 000 m^2/h x 720 h/year = 144 ha/year
Consumables	10 l/h of petrol	20 kg/h of petro-diesel

3.2 Cost Calculation

The following Table provides the detailed calculation of manpower, investment, consumable and total cost for the two techniques. These costs are given in EURO/ha.

Table 3.2. Unit cost of skim and burial ploughing techniques

	Skim and burial plough and tractor	Skim and burial ploughing
Manpower cost: Daily manpower x Daily working time x Average hourly cost of manpower	0.416 man-day/ha x 8 h/day x 21.59 EURO/h **= 71.85 EURO/ha**	0.6 man-day/ha x 8 h/day x 21.59 EURO/h **= 103.63 EURO/ha**
Investment cost: Tool discount cost / Scale of application	(10 825 EURO/year) / (216 ha/year) **= 50.12 EURO/ha**	(2 500 EURO/year) / (144 ha/year) **= 17.36 EURO/ha**
Consumable cost: ((Petro-diesel x weight of petro-diesel) / scale of application) x purchase price of diesel oil	(10l/h / 0.3 ha/h) x 0.2952 EURO/l **= 9.84 EURO/ha**	((20 kg/h x 1.1976 l/kg) / 0.2 ha/h) x 0.2952 EURO/l **= 35.35 EURO/ha**
Total cost: Manpower + investment + consumable:	**131.81 EURO/ha**	**156.34 EURO/ha**

4 Standard Ploughing

4.1 Available data

4.1.1 RISØ Report

The RISØ report [1, p.47] gives the following data for an ordinary ploughing to a depth of 25 cm with tractor-driven Bovlund single-furrow 24" plough:

- Daily Manpower: $1.4 \ 10^{-5}$ man-day/m^2 = 0.14 man-day/ha

- Discount Investment Cost: 400 EURO/year (plough) and 10 000 EURO/year (tractor) = 10 400 EURO/year

- Scale of application (surface which can be decontaminated with one tool): 9 000 m^2/h x 720 h/year = 0.9 ha/h x 720 h/year = 648 ha/year

- Consumables (petro-diesel): 6 l/h of petrol

4.1.2 NRPB Report

The NRPB report [2, p.19] provides the cost of ploughing for large areas. The total cost is evaluated at 0.004 £/m^2. The detailed data concerning the plant hire cost, consumables or labour costs are not available. The application rate is indicated at 7 000 m^2/h.

4.2 Cost Calculation

4.2.1 RISØ Report

The following Table provides the detailed calculation of manpower, investment, consumable and total cost. These costs are given in EURO/ha.

Table 4.1 : Unit cost of ordinary ploughing (RISØ Report)

	Ordinary ploughing (RISØ)
Manpower cost Daily manpower x Daily working time x Average hourly cost of manpower	0.14 man-day/ha x 8 h/day x 21.59 EURO/h **= 24.18 EURO/ha**
Investment cost: Tool discount cost / Scale of application	(10 400 EURO/year) / (648 ha/year) **= 16.05 EURO/ha**
Consumable cost: (Petro-diesel / scale of application) x purchase price of diesel oil	(6 l/h. / 0.9 ha/h) x 0.2952 EURO/l **= 1.97 EURO/ha**
Total cost: Manpower + investment + consumable	24.18 + 16.05 + 1.97 **= 42.20 EURO/ha**

4.2.2 NRPB Report

Total cost of ploughing:

$0.004 \text{ £/m}^2 = 40 \text{ £/ha} =$ **49.15 EURO/ha**

4.2.3 Comparison of the two results

In this case, the costs do not differ a lot from RISØ or NRPB reports.

Table 4.2. Comparison between RISØ and NRPB cost for standard ploughing

	Labour cost (EURO/ha)	Investment cost (EURO/ha)	Consumable (EURO/ha)	Total cost (EURO/ha)
RISØ	24.18	16.05	1.97	**42.20**
NRPB - Large areas	-	-	-	**49.15**

5 Plant and Shrub Removal

5.1 Available Data

The cost of this technique is described in the NRPB report [2, p.19] for decontaminating a unit area of urban surface with the plant/shrub removal technique. The total cost is the same for 'large areas' and 'small areas'. The detailed costs of manpower, investment or consumable are not indicated:

- Large and small areas: 0.4 £/m^2

5.2 Cost calculation

Total cost of plant and shrub removal:

0.4 £/m^2 = 4000 £/ha = **4 915.22 EURO/ha (for large and small areas)**

6 Grass Cutting

6.1 Available Data

6.1.1 RISØ report

The RISØ report [1, p.38] gives the following data for grass cutting with a municipal petrol driven lawn mower with seat, collecting grass in a vessel. It seems then to be applied to small areas:

- Daily Manpower: $1.3 \ 10^{-4}$ man-day/m^2 = 1.3 man-day/ha

- Discount Investment Cost: 3 000 EURO/year

- Scale of application (surface which can be decontaminated with one tool): 1 000 m^2/h x 720 h/year = 0.1 ha/h x 720 h/year = 72 ha/year

- Consumables (petro-diesel): 6 l/h of petrol

6.1.2 NRPB report

The NRPB report [2, p.19] gives the total cost for grass cutting and collection technique applied to a unit of urban area surface for small and large areas. The total costs summarised in the main table [2, Table 8, p.19] are the following:

- Large areas: 0.008 £/m^2 = 80 £/ha for grass cutting with grass collection box.

- Small areas: 0.4 £/m^2 = 4 000 £/ha for grass cutting with grass collection box.

Some other indications concerning the scale of application are given in the Appendix of the report [2, p.74, 78]

Table 6.1. Unit parameters for grass cutting technique (NRPB)

	Large areas	Small areas (gardens)
Scale of application	up to 10 000 m^2/h	- 50 m^2/h - 4 gardens per day
Labour cost	£128 per 8 h day $\Rightarrow 1.6 \ 10^{-3}$ £/m^2	£32 per garden
Other costs (plant hire per day plus consumable services, maintenance, spare)	$5.9 \ 10^{-3}$ £/m^2	Plant hire per day: £10 per day Consumable: £5 per day
Total cost	0.0075 £/m^2	0.36 £/m^2 ; 36 £/garden (this implicitly means an average size of 100 m^2 per garden)

For the small areas, if we assume that 4 gardens can be decontaminated per day, and that the average size of a garden is 100 m^2, we obtain an

average of 400 m^2 per day. The cost can then be expressed in £ per m^2 (or per ha):

- Cost of plant hire : £10 per day => 0.025 £/m^2 = 250 £/ha

- Consumable: £5 per day => 0.0125 £/m^2 = 125 £/ha

- Labour per garden: £32 per garden => 0.32 £/m^2 = 3200 £/ha

(note: Summing all these costs gives approximately the same total cost per m^2 than the one presented in the main table, i.e., 0.4 £/m^2).

6.2 Cost calculation

6.2.1 RISØ report

Table 6.2: Unit costs of grass cutting technique (RISØ)

	Grass cutting (RISØ)
Manpower cost Daily manpower x Daily working time x Average hourly cost of manpower	1.3 man-day/ha x 8 h/day x 21.59 EURO/h **= 224.54 EURO/ha**
Investment cost: Tool discount cost / Scale of application	(3 000 EURO/year) / (72 ha/year) **= 41.67 EURO/ha**
Consumable cost: (Petro-diesel / scale of application) x purchase price of diesel oil	(6 l/h / 0.1 ha/h) x 0.2952 EURO/l **= 17.71 EURO/ha**
Total cost: Manpower + investment + consumable:	224.54 + 41.67 + 17.71 **= 283.92 EURO/ha**

6.2.2 NRPB report

1. Direct conversion of the total cost:

- for large areas: 0.008 £/m^2 = 80 £/ha = 98.30 EURO/ha

- for small areas: 0.4 £/m^2 = 4000 £/ha = 4915.22 EURO/ha

The assumption is made that for 'grass cutting' the cost is an average between small and large areas (50%-50%). So the total cost is: (98.30 x 0,5 + 4915.22 x 0.5) = **2506.76 EURO/ha**

2. Estimation of the total cost using the detailed data and assuming a labour cost of 21.59 EURO per hour (instead of the assumption of 16 £/h, i.e. 19.66 EURO/h)

Table 6.3: Unit cost of grass cutting technique (NRPB)

	Large areas	Small areas (gardens)
Labour cost	0.125 man-day/ha x 8 h/day x 21.59 EURO/h **= 21.59 EURO/ha**	25 man-day/ha x 8 h/day x 21.59 EURO/h **= 4 318 EURO/ha**
Other costs (plant hire per day plus consumable services, maintenance, spare)	$5.9 \ 10^{-3}$ £/m² – 59 £/ha **= 72.50 EURO/ha**	Plant hire per day: 250 £/ha **= 307.2 EURO/ha** Consumable: 125 £/ha **= 153.6 EURO/ha**
Total cost	21.59 + 72.50 **= 94.09 EURO/ha**	4 318 + 307.20 + 153.60 **= 4 778.8 EURO/ha**

The assumption is made that for 'grass cutting' the cost is an average between small and large areas (50%-50%). So the total cost is: (94.09x0,5 + 4778.8x0.5) = **2436.45 EURO/ha**

6.2.3 Comparison between RISØ and NRPB

There is a very large difference between the three estimated cost as shown in the Table below.

Table 6.4: Comparison between RISØ and NRPB for grass cutting technique

	Labour cost (EURO/ha)	Investment cost (EURO/ha)	Consumable (EURO/ha)	Total cost (EURO/ha)
RISØ	224.54	41.67	17.71	283.92
NRPB - Large and Small	4 318 21.59	307.2 72.50	153.60 -	2 436.45

a. Costs estimated using the data provided in the Appendix of the report (Table B7, p.74, 78) (with labour cost updated).

b. Costs estimated using the 'total cost' data (Table 8, p.19)

The major difference comes from the estimated manpower.

- In RISØ report, the manpower is estimated to 1.3 man-day per ha.

- In the NRPB report, it is mentioned that the labour costs are calculated using a value of £16 per hour (i.e. 19.66 EURO/h, which is a little less than our assumption of 21.59 EURO/h). Using this value and an estimation of 8 hours of work per day, we obtain the following amount of manpower:

  - for large areas :

    labour cost : 16 £/ha => (16/16)/8 = 0.125 man-day/ha

- for small areas:

Labour cost: £32 per garden

=> if we retain the implicit assumption made in the report to calculate the total cost, i.e. 100 m^2 per garden, we have a total cost of 3 200 £/ha

=> 25 man-day/ha

Other remarks:

In another note of the report concerning the same detailed data it is mentioned that garden are assessed as 340 m^2 [2, Table B7, p.77]. With this hypothesis, it would mean that the manpower is equal to 7.35 man-day/ha.

The total cost of the technique would be, assuming that 5 gardens can be decontaminated per day, and that the average size of a garden is 340 m^2 (i.e. 1700 m^2 per day):

- Cost of plant hire : £10 per day =>0.005882 £/m^2 = 58.82 £/ha

- Consumable: £5 per day => 0.0029411 £/m^2 = 29.41 £/ha

- Labour per garden: £32 per garden => 0.0941176 £/m^2 = 941.18 £/ha

Summing all these costs gives a total cost equal to 1029.38 £/ha => 1 264.94 EURO/ha

7 Soil Removal

7.1 Available data

7.1.1 RISØ report

The RISØ report presents three types of soil removal techniques [1, p.32,34]:

- Scrapping off the top soil with a front loader: cutting of contaminated soil layer
- Scrapping off the top soil with a Bulldozer (10-30 cm)
- Scrapping off the top soil with a grader

The following data are provided in the report:

Table 7.1: Unit parameters for soil removal techniques (RISØ)

	Front Loader	Bulldozer	Grader
Daily Manpower	0.0002 man-day/m^2 = 2 man-day/ha	4 man-day/ha	0.00036 man-day/m^2 = 3.6 man-day/ha
Discount investment cost	2 000 EURO/year	2 000 EURO/year	rent cost: 100 EURO/day
Scale of application	700 m^2/h x 900h/year = 630 000 m^2/year = 63 ha/year	300 m^2/h x 800 h/year = 240 000 m^2/year = 24 ha/year	1000 m^2/h x 720 h/year = 720 000 m^2/year = 72 ha/year
Consumable	0.03 kg/m^2 of diesel oil	12 kg/h of petro-diesel	24 kg/h

7.1.2 NRPB report

The report on decontamination and clean-up techniques [2, p.19] presents the total cost associated with the 'turf removal and top soil removal (50 mm)' technique for large and small areas.

- Total cost for large areas: 0.8 £/m^2
- Total cost for small areas: 2 £/m^2

Some detailed data can be found in the Appendix [2, p.74, 78]:

For large areas:

- Scale of application: 100 m^2/h (if we assume 8 h/day, we obtain an average of 800 m^2/day) with 3 workers.
- Plant hire per day: £100 (=> with 800 m^2 per day: 0.125 £/m^2)

- Consumable per day: £118 (=> with 800 m^2 per day: 0.148 £/m^2)

- Labour per 8h day: £384 (=> with 800 m^2 per day: 0.48 £/m^2)

- Total per m^2: £0.75 (Which corresponds to the sum of above estimates per m^2).

For small areas:

- Scale of application: between 5 m^2/h (or 8 days per garden of 340 m^2) and 10 m^2/h (or 4 days per garden of 340 m^2) with 1 worker

- Plant hire per day : £40 (part-time use)

- Consumable per day: £32 (part-time use)

- Labour per garden: £512

- Total per m^2: £1.95 - Total per garden: £584 (This corresponds to a garden of 300 m^2!).

Given the fact that the tools are used only part-time, it is not possible to express the various costs of plant hire and consumable, into £ per m^2. We will then only consider the total cost.

7.2 Cost calculation

7.2.1 RISØ report

- **Manpower cost (EURO/ha):**

Daily manpower x Daily working time x Average hourly cost of manpower:

Table 7.2. Unit cost of manpower for soil removal techniques (RISØ)

Front Loader	Bulldozer	Grader
2 man-day/ha x 8 h/day x 21.59 = **345.44 EURO/ha**	4 man-day/ha x 8 h/day x 21.59 = **690.88 EURO/ha**	3.6 man-day/ha x 8 h/day x 21.59 = **621.79 EURO/ha**

- **Investment cost (EURO/ha):**

Tool discount cost / Scale of application:

Table 7.3. Unit investment cost for soil removal techniques (RISØ)

Front Loader	Bulldozer	Grader

(2 000 EURO/year) / (63 ha/year) = **31.75 EURO/ha**	(2 000 EURO/year) / (24 ha/year) = **83.33 EURO/ha**	• 720 h/year => 90 days/year
		• rent cost: 100 EURO per day => 9 000 EURO per year
		• (9 000 EURO/year) / (72 ha/year) = **125 EURO/ha**

- **Consumable cost (EURO/ha):**

((Petro-diesel x weight of petro-diesel) / scale of application) x purchase price of diesel oil:

Table 7.4. Unit cost of consumables for soil removal techniques (RISØ)

Front Loader	Bulldozer	Grader
0.03 kg/m^2 x 1.1976 l/kg x 0.2952 EURO/l = 0.0106059 EURO/m^2 = **106.06 EURO/ha**	((12 kg/h x 1.1976 l/kg) / 0.03 ha/h) x 0.2952 EURO/l = **141.41 EURO/ha**	((24 kg/h x 1.1976 l/kg) / 0.1 ha/h) x 0.2952 EURO/l = **84.85 EURO/ha**

- **Total cost (EURO/ha):**

Manpower + investment + consumable:

Table 7.5. Total cost of soil removal techniques (RISØ)

Front Loader	Bulldozer	Grader
345.44 + 31.75 + 106.06 = **483.25 EURO/ha**	690.88 + 83.33 + 141.41 = **915.62 EURO/ha**	621.79 + 125 + 84.85 = **831.64 EURO/ha**

7.2.2 NRPB report

1. Direct conversion of the total cost:

- large areas: 0.8 £/m^2 = 8000 £/ha = 9 830.45 EURO/ha

- small areas: 2 £/m^2 = 20 000 £/ha = 24 576.12 EURO/ha

The assumption is made that for 'soil removal' the cost is an average between small and large areas (50%-50%). So the total cost is: (9830.45 x 0.5 + 24576.12 x 0.5) = **17203.29 EURO/ha**

2. Estimation of the total cost using the detailed data and assuming a labour cost of 21.59 EURO per hour (instead of the assumption of 16 £/h, i.e. 19.66 EURO/h), only for large areas:

Table 7.6. Unit cost of soil removal for large areas (NRPB)

	soil removal (large areas)
Manpower cost: Manpower x Average hourly cost of manpower	37.5 man-day/ha x 8 h/day x 21.59EURO/h **= 6 477 EURO/ha**
Plant hire cost	0.125 £/m^2 = 1 250 £/ha **= 1 536.01 EURO/ha**
Consumable cost	0.148 £/m^2 = 1 480 £/ha **= 1 818.63 EURO/ha**
Total cost	6 477 + 1 536.01 +1 818.63 **= 9 831.64 EURO/ha**

7.2.3 Comparison between RISØ and NRPB

The next Table presents the different costs obtained for the decontamination by soil removal. Here again, there is a very large difference coming mainly from the estimated labour cost.

Table 7.7. Comparison between RISØ and NRPB costs for soil removal techniques

	Labour cost (EURO/ha)	Investment cost (EURO/ha)	Consumable (EURO/ha)	Total cost (EURO/ha)
RISØ - Front Loader	345.44	31.75	106.06	483.25
RISØ - Bulldozer	690.88	83.33	141.41	915.62
RISØ - Grader	621.79	125	84.85	831.64
NRPB - Small and large areas (average)	-	-	-	17 203.29
NRPB large areas	6 477	1 536	1818	9 831.64

The labour cost in the NRPB report is estimated with a value of 16 £/h.

For large areas, as the given cost is 0.48 £/m^2, we can calculate the global manpower required: 0.03 man-hour/m^2 = 300 man-hour/ha = 37.5 man-day/ha. This value is much different from the values given in the RISØ report : between 2 and 4 man-day/ha. The techniques defer also by the number of workers needed. In the NRPB report, it is mentioned that the turf and top soil removal requires 3 workers. In the RISØ report, the 3 techniques (Front loader, bulldozer or grader) require only one worker.

For small areas, it is mentioned in the NRPB report that the process allows to perform between $5m^2/h$ and $10 m^2/h$ and requires 1 worker. This implicitly means that the global manpower required is between 125 man-day/ha and 250 man-day/ha (on a basis of 8 hours per day).

8 Double Digging Gardens

8.1 Available data

8.1.1 RISØ report

The data provided in the RISØ report concern the technique of triple digging of gardens soil using an ordinary shovel [1, p.39].

- Daily Manpower: 0.068 man-day/m^2 = 680 man-day/ha

- Discount Investment Cost: 24 EURO/year

- Scale of application (surface which can be decontaminated with one tool): unlimited

- Productivity: 2 m^2/h

- Consumables (petro-diesel): none

8.1.2 NRPB report

The total cost of double digging is provided for small areas [2, p.19] : 1.6 £/m^2.

The detailed data provided in appendix are the following [2, p.77, 78]:

- Personnel: 1 worker

- Scale of application: between 2.5 m^2/h (by owner) and 10 m^2/h (by professional) (this gives a total manpower between 125 man-day/ha and 500 man-day/ha).

- Cost of plant hire : 10 £/day

- Consumable: none

- Labour per garden: £320 (assuming a labour cost of 16 £/h, 200 m^2 of garden and a professional cleaning-up of the garden) (note: the total cost of 1.6 £/m^2 does not take into account the plant hire cost).

8.2 Cost calculation

8.2.1 RISØ report

Table 8.1. Unit costs of triple digging garden (RISØ)

	Triple digging garden (RISØ)
Manpower cost Daily manpower x Daily working time x Average hourly cost of manpower	680 man-day/ha x 8 h x 21.59 EURO/h **= 117 449.6 EURO/ha**
Investment cost: Tool discount cost / Scale of application	The report notes that there is an unlimited scale of application, that means that there is no restriction on the use of the tool per year. The investment cost is equal to 24 EURO/year. Assuming 240 working days per year, and 680 man-day per ha, we have a global cost of investment equal to: 680/240 x 24 **= 68 EURO/ha**
Total cost: Manpower + investment	117 449.6 + 67.2 **= 117 517.60 EURO/ha**

8.2.2 NRPB report

1. Direct conversion of the total cost for small areas:

Total cost : 1.6 £/m^2 = 16 000 £/ha = **19 660.90 EURO/ha**

2. Estimation of the total cost using the detailed data and assuming a labour cost of 21.59 EURO per hour (instead of the assumption of 16 £/h, i.e. 19.66 EURO/h)

Table 8.2. Unit cost for double digging small areas (NRPB)

	Small areas
Manpower cost: Manpower x Average hourly cost of manpower	500 man-day/ha x 8 h x 21.59 EURO/h **= 86 360 EURO/ha**
Plant hire cost	0.5 £/m^2 = 5000 £/ha **= 6 144.03 EURO/ha**
Total cost	86 360 + 6 144.03 **= 92 504.03 EURO/ha**

8.2.3 Comparison between RISØ and NRPB

Table 8.3 : Comparison between NRPB and RISØ costs for digging technique

	Labour cost (EURO/ha)	Investment cost (EURO/ha)	Total cost (EURO/ha)
RISØ -triple digging	117 449.60	68	117 517.60
NRPB - Small areas	86 360	6 144.03	92 504.03

The cost of this technique relies only on the assumption made for the global manpower needed to its implementation. Three hypotheses are provided by RISØ or NRPB:

- 500 man-day/ha => cost of 86 360 EURO/ha (NRPB) => small areas

- 680 man-day/ha => cost of 117 449.6 EURO/ha (RISØ)

9 Rotovating / Digging Gardens

9.1 Available data

The only data available concerning this technique come from the NRPB report which gives the total cost of 'rotovating cultivated areas'. [2, p.19] : £0.2 per m^2.

The detailed data provided in the Appendix are the following [2, p.77, 78]:

- Personnel: 1 worker

- Rate of application: 100 m^2 per hour ; 4 gardens per day

- Plant hire per day: £7 (i.e. 0.009 £/m^2 assuming 100 m^2/h and 8 h per day)

- Consumable per day: £8 (estimate) (i.e. 0.01 £/m^2 assuming 100 m^2/h and 8 h per day)

- Labour per garden: £64 (using a hourly salary rate of £16, => implicitly around 400 m^2 per garden)

- Total cost: £0.18 per m^2; £36 per garden (=> implicitly 200 m^2 per garden)

9.2 Cost calculation

1. Direct conversion of the total cost:

0.2 £/m^2 = 2 000 £/ha = **2 457.61 EURO/ha**

2. Estimation of the total cost using the detailed data and assuming a labour cost of 21.59 EURO per hour (instead of the assumption of 16 £/h, i.e. 19.66 EURO/h)

Table 9.1. Unit costs of rotovating cultivated areas (NRPB)

	Rotovating cultivated areas (NRPB)
Manpower cost: Manpower x Average hourly cost of manpower	100h/ha x 21.59 EURO/h **= 2 159 EURO/ha**
Investment cost	0.009 £/m^2 = 90 £/ha **= 110.59 EURO/ha**
Consumable cost	0.01 £/m^2 = 100 £/ha **= 122.88 EURO/ha**
Total cost	2 159 + 110.59 + 122.88 **= 2 392.47 EURO/ha**

10 Road Planing

10.1 Available Data

The RISØ report [1, p.21] gives the following data for large areas, using a rotating 'drum' which grinds off the asphalt top layer which must be removed:

- Daily Manpower: 0.0019 man-day/m^2 = 19 man-day/ha

- Discount Investment Cost: 12 500 EURO/year

- Scale of application (surface which can be decontaminated with one tool): 500 m^2/h x 720 h/year = 360 000 m^2/year = 36 ha/year

- Consumables: 8 l/h of petro-diesel

10.2 Cost calculation

Table 10.1. Unit costs of road planning (RISØ)

	Road planning (RISØ)
Manpower cost Daily manpower x Daily working time x Average hourly cost of manpower	19 man-day/ha x 8 h/day x 21.59 EURO/h **= 3 291.68 EURO/ha**
Investment cost: Tool discount cost / Scale of application	(12 500 EURO/year) / (36 ha/year) **= 347.22 EURO/ha**
Consumable cost: (Petro-diesel / scale of application) x purchase price of diesel oil	(8 litre/h / 0.05 ha/h) x 0.2952 EURO/l **= 47.23 EURO/ha**
Total cost: Manpower + investment + consumable:	3 291.68 + 347.22 + 47.23 **= 3 686.13 EURO/ha**

11 Fire Hosing

11.1 Available data

11.1.1 RISØ report

The RISØ report [1, p.11] gives the following data for fire hosing using a pump and 2 jet pipes:

- Daily Manpower: 0.0013 man-day/m^2 = 13 man-day/ha

- Discount Investment Cost: 600 EURO/year

- Productivity: 100 m^2/h

- Scale of application (surface which can be decontaminated with one tool): 72 000 m^2/year = 7.2 ha/year

- Consumables (petro-diesel): 10 l/h of petro-diesel + 24 m^3 of water per hour

11.1.2 NRPB report

The NRPB report presents the cost of firehosing at low pressure using fire-engines, pumping units and water coming directly from hydrants. The total cost is the same for large and small areas: £0.01 per m^2 [2, p.19].

Some detailed data are also provided in the Appendix of the report [2, p.71, 72]:

- Personnel: 2 workers

- Application rate: 32 000 m^2 per 8 hours-day

- Plant hire per day: Fire-engines: £48; Pumps: £10; Hosing from hydrants: £4 (=> total of £62 per day, equivalent to 19.38 £/ha using the application rate of 32 000 m^2 per day)

- Consumables, per day: Fire-engines: £32; Pumps: £20; Hand Hosing: £4 (=> total of £56 per day equivalent to 17.5 £/ha using the application rate of 32 000 m^2 per day)

- Labour: £256 per 8 hours day (using a labour cost of £16 per hour) (=> 80 £/ha using the application rate of 32 000 m^2 per day)

- Total per m^2: £0.01 (or 100 £/ha)

11.2 Cost calculation

11.2.1 RISØ report

Table 11.1. Unit costs of fire hosing (RISØ)

	Fire Hosing (RISØ)
Manpower cost Daily manpower x Daily working time x Average hourly cost of manpower	13 man-day/ha x 8 h/day x 21.59 EURO/h **= 2 245.36 EURO/ha**
Investment cost: Tool discount cost / Scale of application	(600 EURO/year) / (7.2 ha/year) **= 83.33 EURO/ha**
Consumable cost: (Petro-diesel / scale of application) x purchase price of diesel oil	(10 l/h / 0.01 ha/h). x 0.2952 EURO/l **= 295.20 EURO/ha**
(Water / scale of application) x purchase price of water	(24 m^3/h / 0.01 ha/h) x 2.36 EURO/m^3 **= 5 664 EURO/ha**
Total cost: Manpower + investment + consumable:	2 245.36 + 83.33 + 295.20 + 5 664 **= 8 287.89 EURO/ha**

11.2.2 NRPB report

1. Direct conversion of the total cost:

0.01 £/m^2 = 100 £/ha = **122.88 EURO/ha**

2. Estimation of the total cost using the detailed data and assuming a labour cost of 21.59 EURO per hour (instead of the assumption of 16 £/h, i.e. 19.66 EURO/h)

Table 11.2 : Unit costs of fire hosing (NRPB)

	Fire Hosing (NRPB)
Manpower cost Daily manpower x Daily working time x Average hourly cost of manpower	5 man-hour/ha x 21.59 EURO/h **= 107.95 EURO/ha**
Investment cost	19.375 £/ha **= 23.80 EURO/ha**
Consumable cost	17.5 £/ha **= 21.50 EURO/ha**
Total cost: Manpower + investment + consumable:	107.95 + 23.8 + 21.5 **= 153.25 EURO/ha**

11.2.3 Comparison between RISØ and NRPB

There is a very large difference between the two estimated costs as shown in the Table below.

Table 11.3. Comparison of NRPB and RISØ estimated costs for fire hosing technique

	Labour cost (EURO/ha)	Investment cost (EURO/ha)	Consumable (EURO/ha)	Total cost (EURO/ha)
RISØ	2 245.36	83.33	5 959.2	8 287.89
NRPB	107.95	23.80	21.50	153.25

The major differences come from:

- the estimated manpower:

- in RISØ report, the manpower is estimated to 13 man-day/ha,

- in NRPB report, the manpower is estimated to 5 man-hour/ha.

- the use of water:

- in RISØ report, the use of water represents the major part of the total cost.

12 Vacuum Sweeping Roads

12.1 Available data

12.1.1 RISØ report

The RISØ report [1, p.27] gives the following data for a vacuum sweeping with a municipal seated Schöling street machine with a water nozzle to spray a fine mist of water onto the road prior to brushing with 3 rotating brushes and finally application of a vacuuming attachment:

- Daily Manpower: $3.6 \ 10^{-5}$ man-day/m^2 = 0.36 man-day/ha

- Discount Investment Cost: 18 000 EURO/year

- Scale of application (surface which can be decontaminated with one tool): 3500 m^2/h x 720 h/y = 2 520 000 m^2/year = 252 ha/year

- Consumables: 5 l/h of petrol

12.1.2 NRPB report

The NRPB report presents the cost of a mechanical road sweeping (dry or wet) and a cost of mechanical sweeping of pavements [2, p.19]. In order to compare to the same technique as the RISØ report, we will here consider only the wet mechanical road sweeping. The total cost is equal to: 0.003 £/m^2.

Some detailed data are also provided in the Appendix of the report [2, p.71, 72]:

- Personnel: 1 worker

- Application rate: 27 000 m^2 per 8 h. day per vehicle (=> 0.37 man-day/ha)

- Depreciation cost per day : £48

- Consumables, per day: £40 - £48

- Labour per 8 hour day (hourly salary cost: £16): £128

- Total per m^2: £0.003 (or 30 £/ha)

Remark:

If we consider the application rate of 27 000 m^2 per 8 hours day, the labour cost of £128 per day, as well as the consumable (£40/day) and depreciation costs (£48/day) can be expressed in £ per m^2, which gives:

- Labour cost: £128 for 27 000 m^2 => 0.005 £/m^2

- Consumables: £40 for 27 000 m^2 => 0.002 £/m^2

- Depreciation cost: £48 per 27000 m^2 => 0.002 £/m^2

The total is then equal to 0.009 £/m^2 (and not 0.003 £/m^2 as indicated)

12.2 Cost calculation

12.2.1 RISØ report

Table 12.1. Unit costs of vacuum sweeping road (RISØ)

	Vacuum sweeping road (RISØ)
Manpower cost Daily manpower x Daily working time x Average hourly cost of manpower	0.36 man-day/ha x 8 h/day x 21.59 EURO/h **= 62.18 EURO/ha**
Investment cost: Tool discount cost / Scale of application	(18 000 EURO/year)/ (252 ha/year) **= 71.43 EURO/ha**
Consumable cost: (Petro-diesel / scale of application) x purchase price of diesel oil	(5 l/h / 0.35 ha/h) x 0.2952 EURO/l **= 4.22 EURO/ha**
Total cost: Manpower + investment + consumable	62.18 + 71.43 + 4.22 **= 137.83 EURO/ha**

1. Direct conversion of the total cost:

$0.003 \ \text{\pounds/m}^2 = 30 \ \text{\pounds/ha} = \textbf{36.86 EURO/ha}$

2. Estimation of the total cost using the detailed data (i.e. total cost of 0.009 £/ha as mentioned above) and assuming a labour cost of 21.59 EURO per hour (instead of the assumption of 16 £/h, i.e. 19.66 EURO/h)

Table 12.2. Unit costs of vacuum sweeping road (NRPB)

	Vacuum sweeping road (NRPB)
Manpower cost Daily manpower x Daily working time x Average hourly cost of manpower	0.37 man-day/ha x 8 h x 21.59 EURO/h **= 63.90 EURO/ha**
Investment cost	20 £/ha = **24.58 EURO/ha**
Consumable cost	20 £/ha = **24.58 EURO/ha**
Total cost: Manpower + investment + consumable:	63.9 + 24.58 + 24.58 = **113.06 EURO/ha**

12.2.3 Comparison between RISØ and NRPB

Those two estimations are quite similar.

Table 12.3. Comparison between unit costs of NRPB and RISØ for vacuum sweeping technique

	Labour cost **(EURO/ha)**	**Investment cost** **(EURO/ha)**	**Consumable** **(EURO/ha)**	**Total cost** **(EURO/ha)**
RISØ	62.18	71.43	4.22	137.83
NRPB -large areas	63.90	24.58	24.58	113.06

13 Sandblasting External Walls

13.1 Available data

13.1.1 RISØ report

The RISØ report [1, p.14, 15] presents the cost of two techniques :

- Dry sandblasting (using a high-pressure air compressor with sandblasting equipment and sand container)

- Wet sandblasting (using a high-pressure water cleaning equipment supplied with a sandblasting device which injects sand in the water jet stream)

The detailed data of each technique are the following:

Table 13.1. Unit parameters for sandblasting techniques (RISØ)

	Dry sandblasting	Wet sandblasting
Daily Manpower	0.012 man-day per m^2 (120 man-day/ha)	0.0083 man-day per m^2 (83 man-day/ha)
Discount Investment Cost	900 EURO/year	480 EURO/year
Scale of application (surface which can be decontaminated with one tool)	20 m^2/h x 720 year = 14 400 m^2/year = 1.44 ha/year	30 m^2/h x 720 year = 21 600 m^2/year = 2.16 ha/year
Consumables	5 l. petro-diesel /h 2 kg sand per m^2	4 l petro-diesel /h 2.25 kg sand per m^2 55 l water per m^2

13.1.2 NRPB Report

The NRPB report provides the unit cost of wall sandblasting technique [2, p.19] : 15 £ per m^2. It is mentioned that the wet sandblasting may be worthwhile if the waste can be contained. The detailed costs data are not presented in the report.

13.2 Cost calculation

13.2.1 RISØ report

Table 13.2. Unit costs of sandblasting techniques (RISØ)

	Dry sandblasting	Wet sandblasting
Manpower cost: Daily manpower x Daily working time x Average hourly cost of manpower	120 man-day/ha x 8 h/day x 21.59 EURO/h = **20 726.4 EURO/ha**	83 man-day/ha x 8 h/day x 21.59 EURO/h = **14 335.76 EURO/ha**
Investment cost: Tool discount cost / Scale of application	900 EURO/year / 1.44 ha/year = **625 EURO/ha**	480 EURO/year / 2.16 ha/year = **222.22 EURO/ha**
Consumable cost: (Petro-diesel / scale of application) x purchase price of diesel oil	(5 l/h / 0.002 ha/h) x 0.2952 EURO/l. = **738 EURO/ha**	(4 l/h / 0.003 ha/h) x 0.2952 EURO/l = **393.6 EURO/ha**
Sand/ha x purchase price of sand	20 000 kg/ha x 0.024 EURO/kg = **480 EURO/ha**	22 500 kg/ha x 0.024 EURO/kg = **540 EURO/ha**
Water/ha x purchase price of water	-	550 m^3/ha x 2.36 EURO/m^3 = **1 298 EURO/ha**
Total cost: Manpower + investment + consumable	**22 569.4 EURO/ha**	**16 789.58 EURO/ha**

13.2.2 NRPB Report

Conversion of the total cost:

15 £/m^2 = 150 000 £/ha = **184 320.92 EURO/ha**

13.2.3 Comparison between RISØ and NRPB

There is a very large difference between the estimated costs as shown in the Table below. The fact that the calculation is not detailed in the NRPB report makes difficult the identification of the reasons of this difference.

Table 13.3. Comparison between RISØ and NRPB costs for sandblasting techniques

	Labour cost (EURO/ha)	Investment cost (EURO/ha)	Consumable (EURO/ha)	Total cost (EURO/ha)
RISØ -dry sandblasting	20 726.40	625	1 218	22 569.40
RISØ -wet sandblasting	14 335.76	222.22	2 231.60	16 789.58
NRPB	-	-	-	184 320.92

14 Roof Brushing

14.1 Available data

14.1.1 RISØ report

The RISØ report [1, p.18] provides the costs of roof cleaning using rotating brush mounted on extendible rod (to allow operation from ground). An air compressor provides pressure for rotating the brush and tap water at ordinary pressure is needed for rinsing. A filter system can enable recycling. The following data are presented:

- Daily Manpower: 0.014 man-day/m^2 = 140 man-day/ha

- Discount Investment Cost: 1 200 EURO/year

- Scale of application (surface which can be decontaminated with one tool): 18 m^2/h x 720 h/y = 12 960 m^2/year = 1.296 ha/year

- Consumables: 5 l/h of petrol and 13 l/m^2 of water.

14.1.2 NRPB report

The report gives some cost indications for 9 different techniques to be applied for decontaminating the roofs [2, p.83, 84]. We will here select the technique which is closed to the one presented in the RISØ report, i.e. a mechanical wet brushing and waste collection/filtering. Two costs are provided:

- For a roof originally clean: £3.70 per m^2

- For a roof covered with moss, algae, etc.: £8.93 per m^2

The detailed data are the following:

Table 14.1. Unit parameters for roof brushing technique (NRPB)

	Roof originally clean	Roof covered with moss, etc.
Application rate (m^2 per 8 h day)	137 m^2 per 8 h/day with 3 operators	67 m^2 per 8 h/ day with 3 operators
Cost of plant hire per day	£80 => 0.58 £/m^2	£140 => 2.09 £/m^2
Consumable cost, per day	£40 incl. brush and compressor =>0.29 £/m^2	£80 => 1.19 £/m^2
Labour per roof (132 m^2)	£372.7 => 2.82 £/ m^2	£739 =>5.6 £/m^2
Total cost	£3.69 per m^2 £492.7 per roof (=>134 m^2 per roof)	£8.88 per m^2 £1 696 per roof (=>190 m^2 per roof)

14.2 Cost calculation

14.2.1 RISØ report

Table 14.2. Unit costs of roof cleaning (RISØ)

	Roof cleaning (RISØ)
Manpower cost Daily manpower x Daily working time x Average hourly cost of manpower	140 man-day/ha x 8 h/day x 21.59 EURO/h **= 24 180.8 EURO/ha**
Investment cost: Tool discount cost / Scale of application	(1 200 EURO/year) / (1.296 ha/year) **= 925.93 EURO/ha**
Consumable cost: (Petro-diesel / scale of application) x purchase price of diesel oil water/ha x purchase price of water	(5 litre/h / 0.0018 ha/h) x 0.2952 EURO/l **= 820 EURO/ha** 130 m^3/ha x 2.36 EURO/m^3 **= 306.8 EURO/ha**
Total cost: Manpower + investment + consumable	24 180.8 + 923.93 + 820 + 306.8 **= 26 233.53 EURO/ha**

14.2.2 NRPB report

1. Direct conversion of the total cost:

Table 14.3. Total cost of roof brushing techniques (NRPB)

Roof originally clean	Roof covered with moss, etc.
£3.69 per m^2 = 36 900£/ha **= 45 342.95 EURO/ha**	£8.88 per m^2 = 88 800 £/ha **= 109 117.99 EURO/ha**

2. Estimation of the total cost using the detailed data and assuming a labour cost of 21.59 EURO per hour (instead of the assumption of 16 £/h, i.e. 19.66 EURO/h)

Table 14.4. Unit costs of roof brushing techniques (NRPB)

NRPB	Roof originally clean	Roof covered with moss, etc.
Manpower cost: Manpower x Average hourly cost of manpower:	1 752 man-hour/ha x 21.59 EURO/h **= 37 825.68 EURO/ha**	3 582 man-hour/ha x 21.59 EURO/h **= 77 337.31 EURO/ha**
Investment cost	0.58 £/m^2 = 5 800 £/ha. **= 7 127.08 EURO/ha**	2.1 £/m^2 = 21 000 £/ha. **= 25 804.93 EURO/ha**
Consumable cost	0.29 £/m^2 = 2 900 £/ha. **= 3 563.54 EURO/ha**	1.2 £/m^2 = 12 000 £/ha. **= 14 745.67 EURO/ha**
Total cost	38 862 + 7 127.08 + 3 563.54 = **48 516.30 EURO/ha**	75 565 + 25 804.93 + 14 745.7 = **117 887.91 EURO/ha**

14.2.3 Comparison between RISØ and NRPB

Here again, the cost evaluations of RISØ and NRPB are quite different:

Table 14.5. Comparison between NRPB and RISØ costs for roof brushing techniques

	Labour cost (EURO/ha)	Investment cost (EURO/ha)	Consumable (EURO/ha)	Total cost (EURO/ha)
RISØ	24 180.8	925.93	306.8	**26 233.53**
NRPB - clean roof	37 825.68	7 127.08	3 563.54	**48 516.30**
NRPB - non clean roof	77 337.31	25 804.93	14 745.67	**117 887.91**

If we compare the RISØ technique with the NRPB one for clean roof, it appears that the major difference comes from the investment and consumable costs. It is difficult to know the explanation of this difference, as the NRPB report does not provide the detailed investment and consumable costs.

15 Vacuuming Indoors

15.1 Available data

15.1.1 RISØ report

The RISØ report presents one indoor decontamination technique consisting in replacing wallpapers, using vacuum cleaner, razors, manual scrapper and brush [1, p.24].

The following data are presented:

- Daily Manpower: 0.03 man-day/m^2 = 300 man-day/ha

- Discount Investment Cost: 18 EURO/year

- Scale of application (surface which can be decontaminated with one tool): 7.5 m^2/h x 8 h/day x 200 days/year = 12 000 m^2/year = 1.2 ha/year

- Consumables: 0.0005 kWh/ m^2 => 5 kWh/ha.

15.1.2 NRPB report

This report presents in Appendix the costs of 9 techniques to be used for decontamination of internal surface [2, p.89-90]. In a first approach (before determining exactly which decontamination technique is used in RODOS), we propose here to evaluate the cost following techniques (the latest one consists in removing the soft furnishings - its cost can only be given per house, and therefore does not seem relevant for RODOS):

- Vacuuming - hand : £0.88 per m^2

- Washing: £1.67 per m^2

- Vigorous washing/scrubbing: £3.33 per m^2

- Chemical cleaning - degreasing, paint removal : £4.08 per m^2

- Strippable coating: £9.15 per m^2

- Surface removal including scabbling, water jetting: £12.13 per m^2

- Surface covering - painting: £6.5 per m^2

- Steam cleaning and vacuuming: £9.15 per m^2

15.2 Cost evaluation

15.2.1 RISØ report

Table 15.1. Unit costs of indoor decontamination (RISØ)

	Indoor decontamination (RISØ)
Manpower cost Daily manpower x Daily working time x Average hourly cost of manpower	300 man-day/ha x 8 h/day x 21.59 EURO/h **= 51 816 EURO/ha**
Investment cost: Tool discount cost / Scale of application	(18 EURO/year) / (1.2 ha/year) **= 15 EURO/ha**
Consumable cost: Electricity per m^2 x purchase price of electricity	5 kWh/ha x 0.03 EURO/kWh **= 0.15 EURO/ha**
Total cost: Manpower + investment + consumable	51 816 + 15 + 0.15 **= 51 831.15 EURO/ha**

15.2.2 NRPB report

Table 15.2. Unit cost of 8 indoor decontamination techniques (NRPB)

Technique	Unit cost (£ per m^2)	Unit cost (EURO/ha)
Vacuuming - hand	0.88	**10 813.49**
Washing	1.67	**20 521.06**
Vigorous washing/scrubbing	3.33	**40 919.25**
Chemical cleaning - degreasing, paint removal	4.08	**50 135.29**
Strippable coating	9.15	**112 435.76**
Surface removal including scabbling, water jetting	12.13	**149 054.19**
Surface covering - painting	6.5	**79 872.40**
Steam cleaning and vacuuming	9.15	**112 435.76**

16 Decontamination costs provided by NRPB in 1999

As mentioned in the introduction, the NRPB has made, with the UK Ministry of Defence, a recent review of decontamination and remediation techniques for Plutonium [3].

The following assumptions are made:

- Conversion into EURO: 1 EURO = 0.66876 UK£ (1999 rate)

- Cost of labour for all countermeasures: 25 £/man.hour

  = 38 EURO/man.hour

  This cost is for personnel working in active areas. It is taken as a factor of 3 higher than commercial rates in non-radioactive areas.

- Costs of equipment include capital costs, depreciation, interest, taxes, insurance, storage and maintenance & repair.

- Consumable costs do not include fuel and water costs. However, where relevant, the quantities of water required per m^2 are indicated.

Table 16.1. Decontamination costs (NRPB, 1999)

TECHNIQUE	Cost of consumables (EURO/km^2)	Cost of equipment (EURO/km^2)
1. Skim and burial ploughing [a, b]	0	7.3 10^3
2. Standard ploughing [a]	0	1.5 10^3
3. Plant and shrub removal [a]	0	18.2 10^3
4. Grass cutting [a]	0	11.7 10^3
5. Soil removal [a]	0	89.6 10^3
6. Double digging gardens [c] [2]	0	2.0 10^3
7. Rotovating / digging gardens [c]	0	1.8 10^3
8. Road planing [a]	123 10^3	3.5 10^3
9. Fire hosing [a, d]	0 (Water: 2.0 l/m^2)	24.3 10^3
10. Vacuum sweeping roads [a, c]	1.2 10^3	4.3 10^3
11. Sandblasting external walls [f]	501.5 10^3 (Water: 9.0 l/m^2)	501.5 10^3
12. Roof brushing [c, g]	1.9 10^6 (Water: 13.0 l/m^2)	3.5 10^6
13. Vacuuming indoors [c]	0	6.0 10^3
14. Tree felling/bush removal [a, b]	0	304 10^3

Notes of Table 16.1.:

a. Costs for decontaminating large areas

b. Equipment cost estimated at 30% of total cost based on supporting information [1].

c. Techniques only applicable for small areas.

d. Assumes use of fire tender and hoses.

e. Costs for vacuum sweeping a wet surface, with waste water collection and filtration prior to disposal of water drains.

f. Costs for sandblasting with waste water collection and filtration prior to disposal of water drains. Assumes use of a fire tender and hydraulic platform

g. Assumes cleaning of moss covered roofs

h. Does not include replacement of trees.

17 Synthesis of data

The data base for evaluating costs of decontamination techniques contains three parameters per technique:

- Unit cost of manpower (EURO/man-hour)

- Unit cost of consumable (EURO/km^2)

- Unit cost of equipment (EURO/km^2)

The default data are those provided by NRPB in 1999 [3] (see section 16).

Table 17.1 presents all the data collected in RISØ and NRPB reports (rounded values). The manpower required for each technique is indicated for information, but it will not be included in ECONOM. It will be provided directly by LCMT. The default data for f manpower is 38 EURO/man.hour for each technique.

Table 17.2 presents the total cost of each technique (EURO/km^2), calculated from RISØ and NRPB (1996) reports. This cost is obtained by adding the unit cost of manpower (obtained with a cost of manpower of 21.6 EURO/man.hr), the unit cost of consumables and the unit cost of equipment.

Table 17.1. Synthesis of the unit cost of decontamination techniques

TECHNIQUE	Manpower (Man-hours/km2)		Unit cost of consummable (EURO/km²)			Unit cost of equipment (EURO/km²)		
	RISØ [1]	NRPB [2]	RISØ [1]	NRPB [2]	NRPB [3]	RISØ [1]	NRPB [2]	NRPB [3]
1. Skim and burial ploughing	330.0 - 480.0	-	$990 - 3.5\,10^3$	-	0	$5.0\,10^3 - 1.7\,10^3$	-	$7.3\,10^3$
2. Standard ploughing	110.0	-	200	-	0	$1.6\,10^3$	-	$1.5\,10^3$
3. Plant and shrub removal	-	$100.0 - 20.0\,10^3$	-	-	0	-	-	$18.2\,10^3$
4. Grass cutting	$1.0\,10^3$	-	$1.8\,10^3$	$15.3\,10^3$	0	$4.2\,10^3$	$7.3\,10^3 - 30.7\,10^3$	$11.7\,10^3$
5. Soil removal	$3.2\,10^3 - 244.8\,10^3$	$30\,10^3$	$10.6\,10^3 - 14.0\,10^3 - 8.5\,10^3$	$181.8\,10^3$	0	$3.2\,10^3 - 8.3\,10^3 - 12.5\,10^3$	$153.6\,10^3$	$89.6\,10^3$
6. Double digging gardens	$544.0\,10^3$	$400.0\,10^3$	0	0	0	$6.8\,10^3$	$614.4\,10^3$	$2.0\,10^3$
7. Rotovating / digging gardens	-	$80.0\,10^3$	-	$12.3\,10^3$	0	-	$11.0\,10^3$	$1.8\,10^3$
8. Road planing	$15.2\,10^3$	-	$4.7\,10^3$	-	$123.0\,10^3$	$34.7\,10^3$	-	$3.5\,10^3$
9. Fire hosing	$10.4\,10^3$	500.0	$596.0\,10^3$	$2.2\,10^3$	0	$8.3\,10^3$	$2.4\,10^3$	$24.3\,10^3$
10. Vacuum sweeping roads	290.0	300.0	422.0	$2.5\,10^3$	$1.2\,10^3$	$7.1\,10^3$	$2.5\,10^3$	$4.3\,10^3$
11. Sandblasting external walls	$96.0\,10^3 - 66.4\,10^3$	-	$121.8\,10^3 - 223\,10^3$	-	$501.5\,10^3$	$62.5\,10^3 - 22.2\,10^3$	-	$501.5\,10^3$
12. Roof brushing	$112.0\,10^3$	$175.0\,10^3 - 358.0\,10^3$	$112.7\,10^3$	$356.3\,10^3 - 1.50\,10^6$	$1.9\,10^6$	$92.6\,10^3$	$712.7\,10^3 - 2.6\,10^6$	$3.5\,10^6$
13. Vacuuming indoors	$240.0\,10^3$	-	15	-	0	$1.5\,10^3$	-	$6.0\,10^3$
14. Tree felling/bush removal	-	-	-	-	0	-	-	$304.0\,10^3$

Table 17.2. Synthesis of the total cost of decontamination techniques

TECHNIQUE	RISØ [1]	NRPB [2]
1. Skim and burial ploughing	$13.2 \ 10^3$ - $15.6 \ 10^3$	-
2. Standard ploughing	$4.2 \ 10^3$	$4.9 \ 10^3$
3. Plant and shrub removal	-	$491.5 \ 10^3$
4. Grass cutting	$283.4 \ 10^3$	$9.4 \ 10^3$ - $477.8 \ 10^3$
5. Soil removal	$48.3 \ 10^3$ - $91.5 \ 10^3$ - $83.1 \ 10^3$	$983.2 \ 10^3$ - $2.5 \ 10^6$
6. Double digging gardens	$11.7 \ 10^6$	$9.3 \ 10^6$
7. Rotovating / digging gardens	-	$239.2 \ 10^3$
8. Road planing	$368.6 \ 10^3$	-
9. Fire hosing	$828.7 \ 10^3$	$15.3 \ 10^3$
10. Vacuum sweeping roads	$13.7 \ 10^3$	$11.3 \ 10^3$
11. Sandblasting external walls	$2.3 \ 10^6$ - $1.7 \ 10^6$	$18.4 \ 10^6$
12. Roof brushing	$2.6 \ 10^6$	$4.8 \ 10^6$ - $11.8 \ 10^6$
13. Vacuuming indoors	$5.2 \ 10^6$	-
14. Tree felling/bush removal	-	-

18 References

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