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CONTRIBUTION TO THE ECONOMIC MODULE OF RODOS

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SUMMARY

This CEPN report groups together three reports produced in the framework of the European RODOS project, and dedicated to the economic evaluation of the countermeasures:

Calculation of early economic costs in ECONOM *(RODOS(WG3)-TN(99)-31)*

This report explains how the early economic costs are calculated in the ECONOM Module of RODOS. It also provides an update of the default data considered in the program, using French data of 1998 - 1999. The aim of this report is to give an explanation of the major elements taken into account in the coding of ECONOM to facilitate the understanding of the values obtained and the updating of default data. It doesn't present precisely all the calculation steps of the code. Three types of cost are presented: evacuation costs, early health effects costs, late health effects costs.

Unit costs to be used for the evaluation of the long term agricultural countermeasures *(RODOS(WG3)-TN(99)-30)*

This report presents the methodology adopted to evaluate the costs of the agricultural countermeasures considered in LCMT. This evaluation was made on the basis of French data. Whenever it was possible, these data have been collected via European Statistical databases published by EUROSTAT, in order to facilitate the updating by each country. However, in numerous cases, the relevant data were not available in European or French official publications. In those cases, it has been necessary to contact directly private firms which accepted to communicate their own data. The following unit costs are presented for: food production lost, food disposal, food processing, food storage, feed required, feed replaced, sorbent, ameliorant, decontamination.

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

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) report and an NRPB (1996) report concerning decontamination techniques. It also presents the values obtained by NRPB in 1999, which will be inserted in ECONOM database 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 database to their own data.

Calculation of early economic costs in ECONOM

RODOS REPORT

DECISION SUPPORT FOR NUCLEAR EMERGENCIES

RODOS(WG3)-TN(99)-31

Contents

1 Introduction

This report explains how the early economic costs are calculated in the ECONOM Module of RODOS. It also provides an update of the default data considered in the program, using French data of 1998 - 1999.

The module of early economic costs provides three types of cost:

- evacuation cost,
- early health effects cost,
- late health effects cost.

Five unit costs are used for this evaluation:

- the unit cost of transport per capita,
- the unit cost of accommodation per capita-day,
- the unit cost of loss of income due to evacuation per capita-day,
- the unit cost of loss to economy due to illness per capita-year,
- the unit cost of medical treatments per capita for early and late health effects.

The aim of the following description is to give an explanation of the major elements taken into account in the coding of ECONOM to facilitate the understanding of the values obtained and the updating of default data. It doesn't present precisely all the calculation steps of the code.

2 The calculation of evacuation costs

The evaluation of the total evacuation cost (CEVTOT) is made by adding the three following costs:

- Cost of transport (CEVTRT),
- Cost of accommodation (CEVACT),
- Cost due to loss of income (CEVLIT),

2.1 The cost of transport

Transport cost includes the direct expenditures due to the movement of people away from and back to the relocation area [1]. The assumption is made that two kinds of transports can be used for the evacuation of persons: either private transport (i.e. private car or motorbike), either public transport by bus. It is assumed that 80% of the population will use a private transport (20% a public transport) and that the average distance between the evacuation area and the destination is 50 km. For private transport, the average number of people per vehicle is assumed to be equal to 2.5.

The total transport cost (CEVTRT) is obtained by multiplying the number of people evacuated (RBEV) by a unit cost of transport per capita (UEVTRA) and by 2 (in order to take into account the return travel).

$$CEVTRT = RBEV \times UEVTRA \times 2$$

The unit cost of transport per capita is given as a default value. Using 1999 data, this value is equal to: 9.5 EURO/cap. It is calculated as following:

UEVTRA = 80% x Private transport cost per capita + 20% x Public transport cost per capita

- Private transport cost per capita for 50 km:

  (Cost/km x 50 km) / 2.5 persons = 10 EURO/cap, using a unit cost per km of 0.5 EURO/km [2].

  This cost includes costs of petrol, depreciation, insurance premium, tyres expenditures, repair and replacement and VAT.

- Public transport cost per capita for 50 km: 7.5 EURO/cap [3]

2.2 The cost of accommodation

The cost of accommodation includes the cost incurred when people cannot use their own dwellings or houses during the period of evacuation.

The total accommodation cost (CEVACT) is obtained by multiplying the number of people evacuated (RBEV) by a unit cost of accommodation per capita per day (UEVACC) and by the duration of evacuation (DUREV).

$$CEVACT = RBEV \times UEVACC \times DUREV$$

The unit cost of accommodation per capita and per day is given as a default value. It is based on the real expenditures for accommodation (mean value of hotel, plus meals). The proposed default value for UEVACC is 55 EURO per capita per day, based on the cost of an overnight stay in a hotel of about 46 EURO for two persons (i.e. 26 EURO/cap) [4] plus about 32 EURO/cap for three meals a day.

2.3 The cost due to loss of income

Loss of income cost is a loss of benefit for the economy due to the fact that production facilities cannot be operated in the evacuated area.

The total loss of income cost (CEVLIT) is obtained by multiplying the number of people evacuated (RBEV) by a unit cost of loss of income per capita per day (UEVLOI) and by the duration of evacuation (DUREV).

$$CEVLIT = RBEV \times UEVLOI \times DUREV$$

The unit cost for loss of income (in EURO/cap-day) is derived from the Gross Domestic Product (GDP, at factor costs). GDP is a measure of the economic productivity in terms of the value added of goods and services produced in an area in a certain period of time. Because accommodation costs are already calculated in the evacuation countermeasure, the housing component is subtracted in order to avoid double counting.

In France, the GDP was about 1306 billions of EURO and the housing component was 116 billions of EURO (in 1998) [4]. There are about 59 millions inhabitants. The resulting rounded default value for the unit cost of loss of income UEVLOI is 55 EURO/cap-day.

3 The early health effect cost

The evaluation of the total early health effect cost (CEHTOT) is made using the human capital approach [1, 5] which assumes that two cost categories contribute to health effect costs, namely:

- the cost of medical treatment for early health effects (CEHMTT)
- the losses of an individual's contribution to the economy (CEHLET)

3.1 The cost of medical treatment for early health effects

Two types of effects are considered:

- The non-fatal effects (morbidity):
  - lung function impairment
  - hypothyroidism
  - mental retardation
- The fatal effects (mortality):
  - pulmonary syndrome
  - hematopoietic syndrome
  - pre/neonatal death

In order to obtain a total cost of medical treatment (CEHMTT), the unit cost of each type of effect (UEHMT) is multiplied by the rounded value of the number of effects expected (IEAPOP), given the individual risk for deterministic health effects and the number of people affected.

$$CEHMTT = IEAPOP \times UEHMT$$

The proposed default values of the medical treatment costs are the following:

Table 3.1. Unit cost of medical treatment (early health effects)

Type of effect	Unit cost of medical treatment UEHMT (EURO/cap) (1998) *
Morbidity	
• lung function impairment**	2150
• hypothyroidism**	4250
• mental retardation	687700
Mortality	
• pulmonary syndrome**	7590
• hemotopoietic syndrome**	371300
• prenatal/neonatal death	2425

* These values are those of the NRPB report [6] converted in EURO using a conversion factor of 1 EURO = 0.6644 UK£ in 1988 [7], and updated to 1998 currency by applying a 3% inflation rate between 1988 and 1998.

** These effects are those considered for the moment in ECONOM.

3.2 The cost of loss to the economy due to illness

The unit cost of loss of an individual's contribution to the economy, resulting from a radiation-induced health effect (UHELE), is based on the Net National Product at factor costs per inhabitant per year of the country. This value (22000 EURO/Cap-year in France, 1998) is multiplied by the number of lost life years per type of health effect (DUREH). For morbidity effects, it is assumed that, on an average, 0.1 year is lost due to the illness. For mortality, the value is based on the average life expectancy calculated over the whole distribution of population of a country, i.e. 39 years (for Germany). Moreover, in order to take into account the decreasing of cost due to time, the number of lost life years is discounted using a discount factor (DFEH) based on a discount rate (DISHE) of 4.0% (default value).

The total cost of loss to economy due to illness is calculated by multiplying the number of expected cases of each category of effect (IEAPOP) by the unit cost of one year lost (UEHLE) and by the discounted number of years of life lost per type of effect (DFEH)

$$CEHLE = IEAPOP \times UHELE \times DFEH$$

4 The late health effect cost

The evaluation of the total late health effect cost (CLHTOT) is made using the human capital approach [1, 5] which assumes that two cost categories contribute to health effect costs, namely:

- the cost of medical treatment for late health effects (CLHMTT)
- the losses of an individual's contribution to the economy (CLHLET)

4.1 The cost of medical treatment for late health effects

The late health effects are the stochastic ones and include all the types of radiation induced cancers. The total number of stochastic health effects (PNUM) comes from the HEALTH module, and are evaluated with or without emergency actions.

The ECONOM program considers ten time periods (IOBS) after the accident for the appearance of one effect, between 5 and 200 years (including hereditary effects). For each time period is given the percentage of total number of health effects which will appear: (TIMFCT). The number of lost years of life in each period due to the cancer is given by (DURLH). Table 4.1 summarises the default data included in the code.

Table 4.1. Default data used to evaluate the number of health effects per time period and the number of year of life lost

Time period (IOBS)	Percentage of total number of health effects (TIMFCT)	Number of lost years of life (DURLH)
5	0.32	31
10	2.24	29
20	5.53	24
30	6.73	19
40	8.93	14
50	12.07	10
70	30.0	6
90	20.23	2
150	12.71	0
200	1.24	0

The unit cost of the medical treatment (ULHMT) corresponds to the weighted average value of cancer treatment (86 %) and hereditary effect treatment (14 %). The following table indicates the various treatment costs presented in a 1988 NRPB report [6]. The values have been converted into EURO using a conversion factor of 1 EURO = 0.6644 UK£ (in 1988) [7] and an inflation rate factor of 3% per year between 1988 and 1998.

Table 4.2. Costs of treating radiation-induced cancer

Desease	Cost of medical treatment (EURO/cap) (1998)
Cancers	
leukaemia	52600
bone cancer	38450
lung cancer	42500
gastrointestinal cancer	42500
breast cancer	6100
thyroid cancer	6100
skin cancer	4050
other cancers	52600
leukeamia in utero	52600
other cancer in utero	52600
benign thyroid nodules	2030
Average value for cancer	**40450**
Hereditary effects	
Single-gene dominant	30350
X-linked mutation	30350
Numerical chromosome aberrations	810000
Structural chromosome aberrations	810000
Multifactorial diseases	610000
Recessive effects	1000000
Average value for hereditary effect	**607000**
Weighted value for all types of effects (86 % of cancer + 14 % of hereditary effects) (ULHMT)	**120000**

The total cost of medical treatment (CLHMTT) is obtained by multiplying the number of effects per period (PNUM x TIMFCT(N)) by the unit cost of medical treatment (ULHMT), the later being discounted using a discount

factor (DFLH1(N)) calculated for each period on the basis of a discount rate (DISHE) of 4%.

$$CLHMTT = PNUM \times TIMFCT(N) \times ULHMT \times DFLH1(N)$$

4.2 The cost of loss to the economy due to illness

The unit cost of loss of an individual's contribution to the economy, resulting from a radiation-induced health effect (UHELE), is based on the Net National Product at factor costs per inhabitant per year of the country. This value (22000 EURO/Cap-year in France, 1998) is multiplied by the number of lost life years per type of health effect (DURLH) (See Table 4.1 above). Moreover, in order to take into account the decreasing of cost due to discounting, the number of lost life years is discounted using a discount factor (DFLH2(N)) based on a discount rate (DISHE) of 4.0% (default value).

The total cost of loss to economy due to illness is calculated by multiplying the number of expected cases per period (PNUM x TIMFCT(N)) by the unit cost of one year lost (UEHLE), by the discounted number of years of life lost per period (DFLH2(N)), and by the discount factor DFLH1(N) (See 4.1)

$$CLHLETT = PNUM \times TIMFCT(N) \times UHELE \times DFLH2(N) \times DFLH1(N)$$

5 Summary of default values used in ECONOM for the calculation of early economic costs

The following table presents all the default cost values used in the different stages of the evaluation.

Table 5.1. Default unit costs for the evaluation of early economic costs

Type of cost	Unit cost
Cost of evacuation	
• unit cost of transport per capita (UEVTRA)	• 9.5 EURO/cap
• unit cost of accommodation per capita and per day (UEVACC)	• 55 EURO/cap-day
• unit cost of loss of income per capita per day (UEVLOI)	• 55 EURO/cap-day
Cost of early heath effect	
• Unit cost of medical treatment (UEHMT(NOG, MOR))	
- Morbidity (MOR = 1)	
• lung function impairment (NOG=1)	• 2150 EURO/cap
• hypothyroidism (NOG =2)	• 4250 EURO/cap
- Mortality (MOR = 2)	
• pulmonary syndrome (NOG=1)	• 7590 EURO/cap
• hemotopoetic syndrome (NOG =2)	• 371300 EURO/cap
• Unit cost of loss of economy due to illness for early and late health effects (UHELE)	• 22000 EURO/cap-year
Cost of late health effects	
• Unit cost of medical treatment (ULHMT)	• 120000 EURO/cap
Discount rate (DISHE)	• 4.0 %

6 References

[1] Faude, D. *COSYMA - Modelling of Economic Consequences,* KFK report 4336 Forschungszentrum Karlsruhe (1992).

[2] *L'argus de l'automobile et des locomotions,* French Magazine,1999.

[3] Communication of a private transport company.

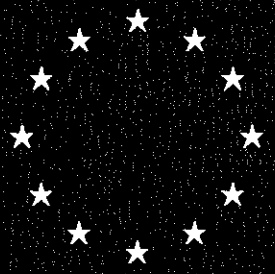
[4] *Annuaire Statistique de la France,* 1998

[5] Päsler-Sauer, J. *Model Description of the Early Countermeasure Module ECM-EMERSIM,* RODOS(WG3) -TN(98)-13

[6] Haywood, S.M., Robinson, C.A., Heady C., *COCO-1: Model for assessing the cost of offsite consequences of accidental releases of radioactivity,* NRPB-R243, 1991.

[7] EUROSTAT, *Agricultural Prices, Price indices and absolute prices, 1987-1996.*

Unit costs to be used for the evaluation of the long term agricultural countermeasures



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The following unit costs are presented:

- unit cost of food production lost (EURO/kg),
- unit cost of food disposal (EURO/kg),
- unit cost of food processing (EURO/kg),
- unit cost of food storage (EURO/kg),
- unit cost of feed required (EURO/kg),
- unit cost of feed replaced (EURO/kg),
- unit cost of sorbent (EURO/kg),
- unit cost of ameliorant (EURO/kg),
- unit cost of decontamination (EURO/km^2).

The food stuff concerned by those costs are those included in LCMT. A summary table is provided at the end of this report.

2 Unit cost of food production lost

The cost of food production lost has to be evaluated for all the countermeasures considered in LCMT, as all of them are applied when a banning of food is necessary.

One indicator of the cost of losing any food production is the loss for the producer due to the non selling of the products. Therefore, the unit cost (EURO/kg) of the food production lost can be evaluated through the average selling price of the food under concern.

The following table presents for each food stuff concerned by the countermeasures the proposed default value for a unit cost of food production lost, as well as the assumptions made for the evaluation.

Nearly all the indicated prices concern France in 1995. When the price was not available for France or for this year, it is noticed into bracket.

Table 2.1. Unit cost of food production lost

Food Stuff [Reference]	**Methodology of evaluation of the unit cost of food production lost**
Spring wheat (whole) [1], p 171	Estimation based on soft wheat and durum wheat: (selling price of soft wheat + selling price of durum wheat) / 2: (0.131 + 0.163) / 2 = 0.147 EURO/kg
Spring wheat (flour) [2], p 104 (1997)	Selling price, 0.803 EURO/kg.
Spring wheat (bran) [1], p 263	The price indicated is the purchase price of animals feedingstuff, 0.213 EURO/kg.
Winter wheat (whole) [1], p 171	Estimation based on soft wheat and durum wheat: (selling price of soft wheat + selling price of durum wheat) / 2 (0.131 + 0.163) / 2 = 0.147 EURO/kg
Winter wheat (flour) [2], p 104 (1997)	Selling price, 0.803 EURO/kg.
Winter wheat (bran) [1], p 263	The price indicated is the purchase price of animals feedingstuff, 0,213 EURO/kg.
Rye (whole) [1], p 171	Selling price, 0.134 EURO/kg.
Rye (flour) [3], (1999)	Selling price, 0.686 EURO/kg.
Rye (bran) [4], (1999)	Selling price, 0.122 EURO/kg.
Oats [1], p 171	Selling price, 0.112 EURO/kg.
Potatoes [1], p 171	Selling price of 'main crop food potatoes', 0.171 EURO/kg.

Table 2.1. Unit cost of food production lost (cont.)

Food Stuff [Reference]	**Methodology of evaluation of the unit cost of food production lost**
Leafy vegetables [1], p 158, [5], p 61, (d)	This denomination mainly regroups: globe artichokes, asparagus, leaf celery, cabbages, endives, spinach, leeks, salads, beets and chard [6]. The evaluation of the mean selling price is based on a balance between the selling prices of the most representative elements of this family (for the considered country) and the production. In Germany, the most cultivated leafy vegetables are cauliflowers and lettuces. Cauliflowers: in 1995 the production was about 156 000 tonnes and its selling price was 0.3438 EURO per kg. Lettuces: in 1995 the production was about 124 000 tonnes (assumption: 50% under glass and 50 % in the open air) and the selling prices were 0.98 EURO per kg for lettuces under glass and 0.5957 EURO per kg for lettuces in the open air. The resulting weighted selling price for leafy vegetables is: [(156/(156+124)) x 0.3438] + [(124/(156+124)) x 0.5 x 0.5957] +[(124/(156+124)) x 0.5 x 0.98] = 0.541 EURO/kg
Root vegetables [6], p 159 [1], p 172	This denomination includes mainly: garlic, beets roots, carrots, celeris-raves, shallots, turnips, onions, radishes, salsifies and scorzoneras [6]. The evaluation of the mean selling price is based on a balance between the selling prices of the most representative elements of this family (for the considered country) and the production. In France, the most cultivated root vegetables are carrots and onions. Carrots: in 1995 the production was about 637 851 tonnes and the selling price was 0.259 EURO per kg (only the selling price of 'quality I' is available). Onions: in 1995 the production was about 288 963 tonnes and its selling prices was 0.3954 EURO per kg ('all qualities'). The resulting weighted selling price for root vegetables is: [(637 851/(637 851+288 963)) x 0.259] + [(288 963/(637 851+288 963)) x 0.3954] = 0.306 EURO/kg.

Table 2.1. Unit cost of food production lost (cont.)

Food Stuff [Reference]	Methodology of evaluation of the unit cost of food production lost
Fruit vegetables [6], p 160 [1], p 172	This denomination includes mainly: strawberries, aubergines, cucumber, gherkins, marrow, melons, water melons, sweet pepper, pumpkins, gourds, tomatoes [6]. The evaluation of the mean selling price is based on a balance between the selling prices of the most representative elements of this family (for the considered country) and the production. In France, the most cultivated fruit vegetables are tomatoes, melons, cucumbers and strawberries. Tomatoes: in 1995 the production was about 800 179 tonnes (including 382 707 under glass) and the selling price was 0.6667 EURO per kg for tomatoes in the open air. Cucumbers: in 1995 the production was about 128 214 tonnes (including 119 226 under glass) and the selling price of cucumber under glass -quality I- was 0.8536 (the price of cucumber in the open air is not available). Melons: the selling price is not available. Strawberries: in 1995, the production was about 80 735 tonnes and its selling price was, for all types of production, 2.6437 EURO/kg. The resulting weighted selling price for fruit vegetables is: [(800179 /(800179+128214+80735)) x 0.6667] + [(128214/(800179+128214+80735)) x 0.8536] + [(80735 /(800179+128214+80735)) x 2.6437] = 0.849 EURO/kg.
Fruits [6], p 162 [1], p 172	This denomination included mainly: apricots, cherries, peaches, nectarines, plums, olives, apples, pears, chestnuts, walnuts, hazel nuts, clementines, oranges, grapefruits... [6] The evaluation of the mean selling price is based on a balance between the selling prices of the most representative elements of this family (for the considered country) and the production. In France, the most cultivated fruit are apples, pears, peaches, apricots, sweet cherries. Apples: in 1995 the production was about 2 088 785 tonnes and the selling price 'all varieties' was 0.4383 EURO/kg. Pears: in 1995 the production was about 320 694 tonnes and the selling price 'all varieties' was 0.5042 EURO/kg. Peaches: in 1995 the production was about 312 809 tonnes and the selling price 'all varieties' was 0.9578 EURO/kg. Apricots: in 1995, the production was about 100 642 tonnes and the selling price 'all varieties' was 1.2873 EURO/kg. Sweet cherries: in 1995 the production was about 56 797 tonnes and the selling price was 2.141 EURO/kg. The resulting weighted selling price for fruit vegetables is: [(2088785 / (2088785 + 320694 + 312809 + 100642 + 56797)) x 0.4383] + [(320694 / (2088785 + 320694 + 312809 + 100642 + 56797) x 0.5042] + [(312809 / (2088785 + 320694 + 312809 + 100642 + 56797)) x 0.9578] + [(100642 / (2088785 + 320694 + 312809 + 100642 + 56797)) x 1.2873] + [(56797 / (2088785 + 320694 + 312809 + 100642 + 56797)) x 2.141] = 0.565 EURO/kg.

Table 2.1. Unit cost of food production lost (cont.)

Food Stuff [Reference]	Methodology of evaluation of the unit cost of food production lost
Berries [6], p 163 [1], p 172 (uk)	This denomination includes mainly: kiwis, blackcurrants, raspberries, redcurrants [6]. The evaluation of the mean selling price is based on a balance between the selling prices of the most representative elements of this family (for the considered country) and the production. In France, the most cultivated berries are blackcurrents and raspberries. Blackcurrants: in 1995 the production was about 7 467 tonnes. Its selling price is not available in [1] for France: by default selling prices in United Kingdom have been considered (the United Kingdom production is not available), 7.2085 EURO/kg. Raspberries: in 1995 the production was about 9 600 tonnes. Its selling price is not available in [1] for France: by default selling prices in United Kingdom have been considered (the United Kingdom production is not available), 4.6689 EURO/kg. The resulting weighted selling price for fruit vegetables is: [(7467/(7467+9600)) x 7.2085] + [(9600/(7464+9600)) x 4.6689] = 5.78 EURO/kg .
Cow's milk [1], p 237	Selling price, 0.296 EURO/kg.
Condensed milk [1], p 246 (d)	Selling price, 1.713 EURO/kg.
Cream [1], p 257 (uk) (1994)	Selling price, 5.397 EURO/kg.
Butter [1], p 249	Selling price, 4.273 EURO/kg.
Cheese (rennet) [1], p 249 [7], (1993)	This denomination regroups all varieties of cheese. Cheeses are very different from a country to another. The evaluation of the mean selling price is based on a balance between the selling prices of the most representative cheeses of the considered country, and the production. In France, the most produced cheeses are: emmenthal, cantal, roquefort and camembert normand. Emmenthal: in 1993 the production was about 13 000 tonnes and the selling price was 4.3777 EURO/kg. Cantal: in 1993 the production was about 16 083 tonnes, and the selling price was 4.2586 EURO/kg. Roquefort: in 1993 the production was about 19 048 tonnes and the selling price was 11.1552 EURO/kg . Camembert normand: in 1993 the production was 11 322 tonnes and the selling price was 3.3104 EURO/kg. The resulting weighted selling price for cheese rennet is: [(130000 / (13000 + 16083 + 19048 + 11322)) x 4.3777] + [(16083 / (13000 + 16083 + 19048 + 11322)) x 4.2586] + [(19048 / (13000 + 16083 + 19048 + 11322)) x 11.1552] + [(11322 / (13000 + 16083 + 19048 + 11322)) x 3.3104] = 6.312 EURO/kg.

Table 2.1. Unit cost of food production lost (end)

Food Stuff [Reference]	**Methodology of evaluation of the unit cost of food production lost**
Cheese (acid) [2], p 105 [8], p 54	This denomination regroups all varieties of fermented milk products. The evaluation of the mean selling price is based on a balance between the selling prices of the most representative fermented milk products of the considered country, and the production. Are available: - the production of flavoured (676 098 tonnes) and no flavoured (476 115 tonnes) fermented milk products, - the selling prices of flavoured yoghurts (1.21 EURO/kg) and no flavoured yoghurts (1.45 EURO/kg). Assumption: the two prices are respectively associated with each production. The resulting weighted selling price for cheese acid is: [(676098/(676098 + 476115)) x 1.21] + [(476115 / (676098 + 476115)) x 1.45] = 1.309 EURO/kg.
Goat's milk [1], p 237 (s)	Selling price, 0.386 EURO/kg.
Sheep's milk [1], p 237 (s)	Selling price, 0.803 EURO/kg.
Beef (cow) [1], p 225	Selling price (unit values), 2.703 EURO/kg.
Beef (bull) [1], p 225	Selling price (unit values), 3.248 EURO/kg.
Veal [1], p 213	Selling price (carcasses), 4.466 EURO/kg.
Pork [1], p 229	Selling price (pigs carcasses - class I), 1.364 EURO/kg.
Lamb [1], p 231	(selling price of suckling lambs + selling price of fattening lambs) / 2 (2.352 + 2.270) / 2 = 2.311 EURO/kg
Chicken [1], p 233	Selling price (class A - slaughtered), 1.179 EURO/kg.
Roe deer [9]	Selling price, 6.860 EURO/kg.
Eggs [1], p 239	The selling price is given per 100 items. There are about 18 eggs in 1 kg [7], Selling price of 100 eggs: 3.99 EURO in 1995 => selling price of 1 kg cost: 3.99/100 x 18 = 0.718 EURO/kg
Beer [1], p 106	Selling price, 1.277 EURO/litre.

3 Unit cost of food disposal

This cost is used for all countermeasures, as it will be necessary to dispose the amount of produced food which has to be banned.

It is rather difficult to find out what would be the cost of disposal for contaminated food. The only estimation which could be found was 60 EURO/kg for liable to putrefy waste. But this price should be considered as an overestimation in the future (notably in France where a facility for burning radiological waste will be available in the near future, which will allow to decrease significantly the cost of disposal).

4 Unit cost of food processing

The second countermeasure considered in LCMT consists in processing the contaminated food, in order to provide a decrease of the concentration of radioactivity. The only food considered are cows milk, whole wheat and rye.

One way of evaluating the cost of food processing is to subtract from the selling price of one unit (kg) of the processed food (for example flour), the selling price of the raw food (for example wheat) needed to produce this unit of food. The resulting cost is then given for one unit of the raw food.

- **The cost of processing whole wheat into wheat flour:**

- 1.333 kg of whole wheat is needed to produce 1 kg of wheat flour
- The selling price of whole wheat is 0.147 EURO/kg [1, P.171]
- The selling price of wheat flour is 0.803 EURO/kg [2, p.104]
- The cost of processing 1 kg of wheat flour is then:

  0.803 - (1.333 x 0.147) = 0.607 EURO/kg
- The cost of processing 1 kg of whole wheat into wheat flour is:

  0.607 / 1.333 = 0.455 EURO/kg of whole wheat

- **The cost of processing whole rye into rye flour:**

- 1.333 kg of whole rye is needed to produce 1 kg of rye flour
- The selling price of whole rye is 0.134 EURO/kg [1, P.171]
- The selling price of rye flour is 0.686 EURO/kg [3]
- The cost of processing 1 kg of rye flour is then:

  0.686 - (1.333 x 0.134) = 0.507 EURO/kg
- The cost of processing 1 kg of whole rye into rye flour is:

  0.507 / 1.333 = 0.380 EURO/kg of whole rye

- **The cost of processing cow's milk into cheese**

For the moment, it is not possible to select in LCMT which type of cheese will be processed. The proposed default value of processing is the mean of the processing costs of cheese rennet (emmenthal and camembert) and cheese acid (yoghurt).

- Cost of processing emmenthal:
- 12.9 kg of milk is needed to produce 1 kg of emmenthal
- The selling price of milk is 0.296 EURO/kg [1, p.237]
- The selling price of emmenthal is 4.378 EURO/kg [1, p.249]
- The cost of processing 1 kg of emmenthal is then:
  4.378 - (12.9 x 0.296) = 0.56 EURO/kg
- The cost of processing 1 kg of milk into emmenthal is:
  0.56 / 12.9 = 0.043 EURO/kg of milk

- Cost of processing camembert:
- 8.256 kg of milk is needed to produce 1 kg of camembert
- The selling price of milk is 0.296 EURO/kg [1, p.237]
- The selling price of camembert is 3.310 EURO/kg [1, p.249]
- The cost of processing 1 kg of camembert is then:
  3.310 - (8.256 x 0.296) = 0.866 EURO/kg
- The cost of processing 1 kg of milk into camembert is:
  0.866 / 8.256 = 0.105 EURO/kg of milk

- Cost of processing yoghurt:
- 1 kg of milk is needed to produce 1 kg of yoghurt
- The selling price of milk is 0.296 EURO/kg [1, p.237]
- The selling price of yoghurt is 1.309 EURO/kg [8, p.54]
- The cost of processing 1 kg of yoghurt is then:
  1.309 - (1 x 0.296) = 1.013 EURO/kg
- The cost of processing 1 kg of milk into yoghurt is:
  1.013 / 1 = 1.013 EURO/kg of milk

- Mean cost of processing 1 kg of milk :
  (0.043 + 0.105 + 1.013) / 3 = 0.387 EURO/kg of milk

5 Unit cost of food storage

Food storage is the third countermeasure included in LCMT.

There are four different ways of storing food:

- Loose storage, at ambient temperature,
- Pallet storage, at ambient temperature,
- Refrigerated storage,
- Freezing storage.

The cost of storage includes two costs (France, 1999):

- a set cost (entrance and exit of goods),

- a cost per kg or m^2 and per day or month.

As the unit cost of storage has to be given per kg of food stored, it is assumed that the duration of storage will be 6 months. However, some types of food cannot be stored for such a long period. In this case, the cost of storage is given for the maximum possible duration of storage.

Table 5.1. Unit cost of storage

Food **Kind of storage** **[Reference]**	**Methodology for estimating the unit cost of storage**
Spring wheat (whole) Winter wheat (whole) Ambient temperature, in loose, 6 months [10], [11]	Assumption: 3600 kg of whole wheat fill 1 m^2 at ground level. • Set cost (entrance and exit of goods): 22 FF/m^2 => 22/3600 = 0.006 FF/kg • Cost per month: 22.1 FF/m^2 => (22.1/3600) x 6 = 0.037 FF/kg for 6 months • Total cost: 0.043 FF/kg = 0.007 EURO/kg.
Spring wheat (flour) Winter wheat (flour) Rye (flour) Ambient temperature, on pallets, 6 months [10], [11]	Assumptions : • One pallet supports a maximum of 1000 kg and fills 1 m^3; several pallets can be stacked • The density of packed flour is approximately d = 0.65. The weight of one pallet is 0.65 x 1000 = 650 kg. We assume that 3 pallets can be superposed, which give a total weight stored per m^2 of 1950 kg/m^2 • Set cost (entrance and exit of goods): 22 FF/m^2 => 22/1950 = 0.011 FF/kg • Cost per month: 28.6 FF/m^2 => (28,6/1950) x 6 = 0.088 FF/kg for 6 months • Total cost: 0.099 FF/kg = 0.015 EURO/kg

Table 5.1. Unit cost of storage (cont.)

Food **Kind of storage** **[Reference]**	**Methodology for estimating the unit cost of storage**
Spring wheat (bran) Winter wheat (bran) Rye (bran) Ambient temperature, on pallets, 15 days at a maximum [10], [11]	Assumptions: • one pallet supports a maximum of 1000 kg and fills 1 m^3; several pallets can be stacked. • The density of packed bran is approximately d = 0.25. The weight of one pallet is 0.25 x 1000 = 250 kg. We assume that 7 pallets can be superposed, which gives a total weight per m^2 of 250 x 7 = 1750 kg/m^2 • Set cost (entrance and exit of goods): 22 FF/m^2 => 22/1750 = 0.013 FF/kg • Cost per month: 28.6 FF/m^2 => (28.6/1750) x 0.5 = 0.008 FF/kg for 15 days • Total cost : 0.021 FF/kg = 0.0003 EURO/kg (for 15 days)
Rye (whole) Ambient temperature, in loose, 6 months [10], [11]	Assumption: 3789 kg of whole rye fill 1 m^2 at ground level. • Set cost (entrance and exit of goods): 22 FF/m^2 => 22/3789 = 0.006 FF/kg • Cost per month: 22.1 FF/m^2 => (22.1/3789) x 6 = 0.035 FF/kg for 6 months • Total cost: 0.041 FF/kg = 0.006 EURO/kg
Oats Ambient temperature, in loose, 6 months [10], [11]	Assumption: 2937 kg of oats fill 1 m^2 at ground level. • Set cost (entrance and exit of goods): 22 FF/m^2 => 22/2937 = 0.007 FF/kg • Cost per month: 22.1 FF/m^2 => (22.1 2937) x 6 = 0.045 FF/kg for 6 months • Total cost: 0.053 FF/kg = 0.008 EURO/kg.
Potatoes Refrigerated temperature, 6 months [12]	• Set cost (entrance and exit of goods): 0.20 FF/kg • Cost per day: 0.006 FF/kg => 0.006 x 182 = 1.092 FF/kg for 6 months • Total cost: 1.292 FF/kg = 0,197 EURO/kg
Leafy vegetables Root vegetables Fruit vegetables Fruits Freezing temperature, 6 months [13]	• Set cost (entrance and exit of goods): 0.15 FF/kg • Cost per day: 0.002 FF/kg => 0.002 x 182 = 0.364 FF/kg for 6 months • Total cost: 0.514 FF/kg = 0.078 EURO/kg
Cow's milk Condensed milk Cream Goat's milk Sheep's milk Ambient temperature, on pallets, 6 months [10], [11]	Assumptions: • one pallet supports a maximum of 1000 kg and fills 1 m^3; several pallets can be stacked • The density of the packed milk products is approximately d = 1.05. The weight of one pallet is 1.05 x 1000 = 1050 kg. We assume that 2 pallets can be superposed 1050 x 2 = 2100 kg/m^2 • Set cost (entrance and exit of goods): 22 FF/m^2 => 22 / 2100 = 0.0105 FF/kg • Cost per month: 28.6 FF/m^2 => (28.6 / 2100) x 6 = 0.0817 FF/kg for 6 months • Total cost: 0.092 FF/kg = 0.014 EURO/kg

Table 5.1. Unit cost of storage (end)

Food **Kind of storage** **[Reference]**	**Methodology for estimating the unit cost of storage**
Butter Eggs Refrigerated temperature, 6 months [12]	• Set cost (entrance and exit of goods): 0.35 FF/kg, • Cost per day: 0.006 FF/kg => 0.006 x 182 = 1.092 FF/kg for 6 months. • Total cost: 1.442 FF/kg = 0.220 EURO/kg
Cheese (rennet) Cheese (acid) Refrigerated temperature, 3 months [12]	• Set cost (entrance and exit of goods): 0.35 FF/kg, • Cost per day: 0.006 FF/kg => 0.006 x 91 = 0.546 FF/kg for 3 months. • Total cost: 0.896 FF/kg = 0.014 EURO/kg for 3 months
Beef (cow) Beef (bull) Veal Pork Lamb Chicken Roe deer Berries Freezing temperature, 6 months [13]	• Set cost (entrance and exit of goods): 0.15 FF/kg • Cost per day: 0.0035 FF/kg => 0.0035 x 182 = 0.637 FF/kg for 6 months • Total cost: 0.787 FF/kg = 0.120 EURO/kg.
Beer Ambient temperature, on pallets, 6 months [10], [11]	Assumptions: • one pallet supports a maximum of 1000 kg and fills 1 m^3; several pallets can be stacked • The density of packed beer is approximately d = 1.10. The weight of one pallet is 1.10 x 1000 = 1100 kg. We assume that 2 pallets can be superposed 1100 x 2 = 2200 kg/m^2 • Set cost (entrance and exit of goods): 22 FF/m^2 => 22/2200 = 0.010 FF/kg • Cost per month: 28.6 FF/m^2 => (28.6/ 200) x 6 = 0.078 FF/kg for 6 months • Total cost: 0.088 FF/kg = 0.013 EURO/kg.

6 Unit cost of feed required

This cost is necessary for the agricultural countermeasures 4 to 7 which consider that the animals are removed from contaminated pasture or that there is a substitution of their contaminated feed with uncontaminated one.

The evaluation of the cost of feed required is based on the price of the feedstuff which will have to be purchased, given in EURO per kg.

The following table gives, for each "food product" considered within LCMT, the animals which may require an addition of feedstuff, and the purchase price of the feedstuff (French price in 1995 for the data found in EUROSTAT, and 1999 prices for the data communicated by a private firm).

Table 6.1. Unit costs of feedstuff required when applying removal of animals from contaminated pasture or substituting contaminated feed.

Food	Animal	Feedstuff	Unit cost of feedstuff
Cow's milk	Lactating cow	Grass, meadow hay	0.137 EURO/kg, [14] (1999)
Goat's milk	Goat	Grass, meadow hay	0.137 EURO/kg, [14] (1999)
Sheep's milk	Sheep	Grass, meadow hay	0.137 EURO/kg, [14] (1999)
Beef (cow)	Beef cow	Grass, meadow hay	0.137 EURO/kg, [14] (1999)
Beef (bull)	Beef bull	Maize	0.225 EURO/kg, [1] p 263
Pork	Pig	Barley, potatoes	0.189 EURO/kg, [1] p 263
Lamb	Lamb	Grass, meadow hay	0.137 EURO/kg, [14] (1999)
Chicken	Hen, chicken	Fodder wheat	0.193 EURO/kg, [1] p 299
Eggs	Hen	Fodder wheat	0.193 EURO/kg, [1] p 299
Veal	Veal	Grass, meadow hay	0.137 EURO/kg, [14] (1999)
Roe deer	Roe deer	Grass, meadow hay	0.137 EURO/kg, [14] (1999)

7 Unit cost of sorbent

This cost applies to countermeasure 8 which assumes that sorbents can be added to animal feedstuff or directly to the animal's gut in form of boli.

The default sorbent considered in LCMT is the bentonite given as feed additive. Its selling price is evaluated at 0.582 EURO/kg [15].

The prices of other sorbents are presented for information in the Table below.

Table 7.1. Unit cost of sorbents

Sorbent	Unit cost
Bentonite as feed additive	0.582 Euro/kg [15]
Hexacyanoferrates (AFCF - Prussian blue) as boli	19.2/head/year [16]
Hexacyanoferrates (AFCF - Prussian blue) as feed additive	136 Euro/kg [19]
Calcium as feed additive	0.046 Euro/kg [20]

8 Unit cost of feed replaced

This cost is to be applied for countermeasure 9 (substituting different feedstuff in animal diets) which assumes that up to 50 % of the animal diet can be substituted with one of the default list of feedstuffs. (These feedstuff are slightly different from those considered in countermeasures 4 to 7).

The evaluation of the cost of feed required is based on the price of the feedstuff which will have to be purchased, given in EURO per kg.

The following Table gives, for each food product considered within LCMT, the animals which may require an addition of feedstuff, and the purchase price of the feedstuff (French price in 1995 for the data found in EUROSTAT, and 1999 prices for the data communicated by a private firm).

Table 8.1. Unit cost of feedstuff replaced in animal diet

Food	Animal	Feedstuff	Unit cost of feedstuff replaced
Cow's milk	Lactating cow	Intensive grassland	0.137 EURO/kg, [14], (1999)
Goat's milk	Goat	Intensive grassland	0.137 EURO/kg, [14], (1999)
Sheep's milk	Sheep	Intensive grassland	0.137 EURO/kg, [14], (1999)
Beef (cow)	Beef cow	Intensive grassland	0.137 EURO/kg, [14], (1999)
Beef (bull)	Beef bull	Intensive grassland	0.137 EURO/kg, [14] (1999)
Pork	Pig	Winter barley	0.189 EURO/kg, [1] p 263
Lamb	Lamb	Intensive grassland	0.137 EURO/kg, [14] (1999)
Chicken	Hen, chicken	Maize	0.225 EURO/kg, [1] p 263
Eggs	Hen	Maize	0.225 EURO/kg, [1] p 263
Veal	Veal	Intensive grassland	0.137 EURO/kg, [14] (1999)
Roe deer	Roe deer	Intensive grassland	0.137 EURO/kg, [14] (1999)

9 Unit cost of ameliorant

The cost of ameliorant is needed for countermeasure 8 which considers a treatment of soils to improve their quality and reduce the uptake of radionuclides by plants. The default technique considered in LCMT is the liming of acid soil.

The cost parameters of this technique are described in a RISØ report concerning decontamination techniques [16, p.54]. The following assumption are made:

- Manpower cost: 0.6 man-day/ha

Assuming 8 hours a day, and an average hourly salary cost in the industry of 21.59 EURO/hour [21, p.300, France, 1995], the amount of the manpower cost is: 103.632 EURO/ha

- Investment cost: 1200 EURO/year

As the technique allows to treat 288 ha/year, this gives an investment cost of 4.167 EURO/ha

- Consumable cost: 10 kg of petro-diesel/ha - 800 kg of lime/ha

Assuming a selling price of gazole of 0.2952 EURO/l [1, p.281, France, 1995], 1.1976 litre of gazole per kg, and a selling price of lime of 0.107 EURO/kg [17, France, 1999], the total consumable cost is equal to 85.6 EURO./ha

- Total cost of the liming technique: 196.934 EURO/ha

Assuming that the technique requires 800 kg of lime per ha, the cost of liming acid soil is 0.246 EURO/kg of ameliorant

10 Unit cost of decontamination techniques

The techniques which can be used for the decontamination of pasture are described in a RISØ report concerning decontamination techniques [16]:

- ordinary ploughing [16, p47],
- deep ploughing [16, p48-49] (2 types),
- skim and burial ploughing, [16, p50-51] (2 types).

The evaluation of the cost of these techniques is presented in the Table below. It is based on the data provided by RISØ, and on the following assumptions:

- average hourly salary cost in the industry of 21.59 EURO/hour [21, p.300, France, 1995]
- selling price of gazole of 0.2952 EURO/l [1, p.281, France, 1995]

Table 10.1. Estimation of the costs of decontamination techniques

	Manpower cost	Investment cost	Consumable cost	Total cost
Ordinary ploughing	0.14 man.day/ha x 8 hour/day x 21.59 EURO/hour = 24.181 EURO/ha	(10400 EURO / year) / (648 ha/year) = 16.049 EURO/ha	6.667 l/ha of petro-diesel/ha x 0.2952 EURO/l = 1.968 EURO/ha	42.198 EURO/ha 4219.8 EURO/km^2
Deep ploughing (1)	0.18 man.day/ha x 8 hour/day x 21.59 EURO/hour = 31.0896 EURO/ha	(10400 EURO / year) / (504 ha/year) = 20.6349 EURO/ha	14.2857 l/ha of petro-diesel/ha x 0.2952 EURO/l = 4.217 EURO/ha	55.942 EURO/ha 5594.2 EURO/km^2
Deep ploughing (2)	0.6 man.day/ha x 8 hour/day x 21.59 EURO/hour = 103.632 EURO/ha	(2000 EURO / year) / (144 ha/year) = 13.888 EURO/ha	89.82 l/ha of petro-diesel/ha x 0.2952 EURO/l = 26.515 EURO/ha	114.04 EURO/ha 11404 EURO/km^2
Skim and burial ploughing (1)	0.416 man.day/ha x 8 hour/day x 21.59 EURO/hour = 71.852 EURO/ha	(10825 EURO / year) / (216 ha/year) = 50.115 EURO/ha	33.333 l/ha of petro-diesel/ha x 0.2952 EURO/l = 9.84 EURO/ha	131.81 EURO/ha 13181 EURO/km^2
Skim and burial ploughing (2)	0.6 man.day/ha x 8 hour/day x 21.59 EURO/hour =103.632 EURO/ha	(2500 EURO / year) / (144 ha/year) = 17.361 EURO/ha	119.76 l/ha of petro-diesel/ha x 0.2952 EURO/l = 35.353 EURO/ha	156.35 EURO/ha 15635 EURO/km^2

As the default technique is not known, it is suggested to consider a default cost equal to the average cost of these 4 techniques, which gives: 10 006.8 EURO/km^2.

11 Some data concerning the change of crop species or variety

For the moment, the cost of the countermeasure considering a change of crop species or variety is not evaluated, because it is not planned to enter the initial crop and the new one. However, it was possible to find some indications concerning the cost of growing crops (see table 11.1). These costs are given per ha for 1999 and include investment, manpower, consumables (oil, fertilising, seeds,...), insurance and taxes. They have been provided by a French agriculture expert [18].

If a specie of crop is changed, only the cost of the new seed should be taken into account.

If the variety of crop is changed, then the cost is given by the difference between the production cost of the new crop and the previous variety.

Example: a change from spring wheat to root vegetables would cost: 1730 - 540 = 1190 EURO/ha

Table 11.1. Total production cost of some foodstuff

Food	Production cost (EURO/ha)
Spring wheat	540
Winter wheat	580
Rye	520
Oats	482
Root vegetables	1730

12 Summary of unit costs

The following Table gives the default unit costs to be used for the agricultural countermeasures of LCMT, and the food concerned by the countermeasures.

Table 12.1. Summary of all unit costs to be applied to evaluate the agricultural countermeasures of LCMT

		All counterm.	All counterm.	C02	C03	C04-07	C08	C09	C10	C13
		Unit cost of food production lost (EURO/kg)	Unit cost of food disposal (EURO/kg)	Unit cost of food processing (EURO/kg)	Unit cost of food storage (EURO/kg)	Unit cost of feed required (EURO/kg)	Unit cost of sorbent (EURO/kg)	Unit cost of feed replaced (EURO/kg)	Unit cost of ameliorant (EURO/kg)	Unit cost of deconta. (EURO/km2)
Food	code	UCFDPDLOST	UCFDDISP	UCFDPROC	UCFDSTR	UCFEEDREQ	UCSORBENT	UCFEEDREPL	UCAMELIOR	UCDECONT
Spring wheat (whole)	FSWW	0.147	60.000	0.455	0.007	-	-	-	0.246	-
Spring wheat (flour)	FSWF	0.803	60.000	-	0.015	-	-	-	-	-
Spring wheat (bran)	FSWB	0.213	60.000	-	0.017	-	-	-	-	-
Winter wheat (whole)	FWWW	0.147	60.000	0.455	0.007	-	-	-	0.246	-
Winter wheat (flour)	FWWF	0.803	60.000	-	0.015	-	-	-	-	-
Winter wheat (bran)	FWWB	0.213	60.000	-	0.017	-	-	-	-	-
Rye (whole)	FRYW	0.134	60.000	0.380	0.006	-	-	-	0.246	-
Rye (flour)	FRYF	0.686	60.000	-	0.015	-	-	-	-	-
Rye (bran)	FRYB	0.122	60.000	-	0.017	-	-	-	-	-
Oats	FOAT	0.112	60.000	-	0.008	-	-	-	0.246	-
Potatoes	FPOT	0.171	60.000	-	0.197	-	-	-	0.246	-
Leafy vegetables	FVEL	0.541	60.000	-	0.078	-	-	-	0.246	-

Table 12.1. Summary of all unit costs to be applied to evaluate the agricultural countermeasures of LCMT (end)

		All counterm.	All counterm.	C02	C03	C04-07	C08	C09	C10	C13
		Unit cost of food production lost (EURO/kg)	Unit cost of food disposal (EURO/kg)	Unit cost of food processing (EURO/kg)	Unit cost of food storage (EURO/kg)	Unit cost of feed required (EURO/kg)	Unit cost of sorbent (EURO/kg)	Unit cost of feed replaced (EURO/kg)	Unit cost of ameliorant (EURO/kg)	Unit cost of deconta. (EURO/km2)
Food	code	UCFDPDLOST	UCFDDISP	UCFDPROC	UCFDSTR	UCFEEDREQ	UCSORBENT	UCFEEDREPL	UCAMELIOR	UCDECONT
Root vegetables	FVER	0.306	60.000	-	0.078	-	-	-	0.246	-
Fruit vegetables	FVEF	0.849	60.000	-	0.078	-	-	-	0.246	-
Fruits	FFRU	0.565	60.000	-	0.078	-	-	-	-	-
Berries	FBER	5.780	60.000	-	0.120	-	-	-	-	-
Cow's milk	FMIL	0.296	60.000	0.387	0.014	0.137	0.582	0.137	-	10006.8
Condensed milk	FCOM	1.713	60.000	-	0.014	-	-	-	-	-
Cream	FCRE	5.397	60.000	-	0.014	-	-	-	-	-
Butter	FBUT	4.273	60.000	-	0.220	-	-	-	-	-
Cheese (rennet)	FCHR	6.312	60.000	-	0.220	-	-	-	-	-
Cheese (acide)	FCHA	1.309	60.000	-	0.220	-	-	-	-	-
Goat's milk	FMIG	0.386	60.000	-	0.014	0.137	0.582	0.137	-	10006.8
Sheep's milk	FMIS	0.803	60.000	-	0.014	0.137	0.582	0.137	-	10006.8
Beef (cow)	FBEC	2.703	60.000	-	0.120	0.137	0.582	0.137	-	10006.8
Beef (bull)	FBEB	3.248	60.000	-	0.120	0.225	0.582	0.137	-	10006.8
Veal	FVEA	4.466	60.000	-	0.120	0.137	0.582	0.137	-	10006.8
Pork	FPOR	1.364	60.000	-	0.120	0.189	0.582	0.189	-	10006.8
Lamb	FLAM	2.311	60.000	-	0.120	0.137	0.582	0.137	-	10006.8
Chicken	FCHI	1.179	60.000	-	0.120	0.193	0.582	0.225	-	10006.8
Roe deer	FROE	6.860	60.000	-	0.120	0.137	0.582	0.137	-	10006.8
Eggs	FEGG	0.718	60.000	-	0.220	0.193	0.582	0.225	-	10006.8
Beer	FBEE	1.277	60.000	-	0.013	-	-	-	-	10006.8

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Estimation of the unit costs of decontamination techniques

RODOS REPORT

DECISION SUPPORT FOR NUCLEAR EMERGENCIES

RODOS(WG3)-TN(99)-32

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 database 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 database 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), discounted 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 costs 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 discounted 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 techniques, LCMT provides the surface which is assumed to be decontaminated in km^2. Within the database, 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 database, 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)

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 top soil 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
Discounted 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 discounted 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
- Discounted 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 discounted 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 £/m^2 = 40 £/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 cost (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
- Discounted 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 ⇨ 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
- Consumables: £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 discounted 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} £/m^2 = 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 large difference between the three estimated costs 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 cost (EURO/ha)	Total cost (EURO/ha)
RISØ	224.54	41.67	17.71	283.92
NRPB - Large and	4 318	307.2	153.60	2 436.45
Small	21.59	72.50	-	

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
- Consumables: £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
Discounted 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
Consumables	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)

- Consumables 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)
- Consumables 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 discounted 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 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
- Discounted 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
- Consumables: 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 cost 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 discounted 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)
- Consumables 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
- Discounted 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 discounted 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
- Discounted 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 fire hosing 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 cost 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 discounted 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 (Water / scale of application) x purchase price of water	(10 l/h / 0.01 ha/h). x 0.2952 EURO/l = **295.20 EURO/ha** (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 cost 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 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 cost (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
- Discounted 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 cost 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 discounted 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**

12.2.2 NRPB Report

1. Direct conversion of the total cost:

0.003 £/m^2 = 30 £/ha = **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 cost 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 cost of NRPB and RISØ for vacuum sweeping technique

	Labour cost (EURO/ha)	**Investment cost (EURO/ha)**	**Consumable cost (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)
Discounted 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 cost 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 discounted 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 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 cost (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
- Discounted 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 cost 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 discounted 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	(5 litre/h / 0.0018 ha/h) x 0.2952 EURO/l **= 820 EURO/ha**
water/ha x purchase price of water	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 cost 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 cost (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
- Discounted 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 of the 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 cost 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 discounted 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 database 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 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 consumable 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 consumable (EURO/km^2)			Unit cost of equipment (EURO/km^2)		
	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	-	-	-	-	**0**	-	-	**18.2 10^3**
4. Grass cutting	*1.0 10^3*	*100.0 - 20.0 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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[4] "Eurostat Annuaire 1997, Vue Statistique sur l'Europe 1986-1996", Eurostat, Office Statistique des Communautés Européennes, Luxembourg, 1997.

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