APPENDIX B ENVIRONMENTAL IMPACTS

B.1 Identification of Environmental Impacts by Sector

The following aspects have been developed as part of the environmental analysis of P/D projects.

- Identification of all possible environmental *impacts* derived from the different transport sectors: highway/road, railway, air and waterborne;
- Enumeration of the *environmental problems* that those impacts are contributing to; and,
- Description of the *effects* that those problems might generate.

For each transport sector, impacts resulting from infrastructure use are listed separately from impacts due to construction and maintenance. Environmental problems are categorised according to the receptor media of the impacts that generate them. Five receptor media are identified: air, water, land, natural habitat and built or urban habitat. Effects can have a local or non-local (regional or global) nature. The following tables show the information in the format defined above:

Table index	Environmental impacts from
B1	Road/highway sector (vehicle travel)
B2	Road/highway sector (road/highway construction and maintenance)
B3	Railway sector (rail travel)
B4	Railway sector (rail construction and maintenance)
B5	Air sector (airport construction and maintenance)
B6	Air sector (air travel)
B7	Waterborne sector (construction and maintenance)
B8	Waterborne sector (maritime travel)

Table B1: Environmental impacts from the road/highway sector (vehicle travel)

IMPACTS	RECEPTOR MEDIA	ENVIRONM. PROBLEMS	LOCAL EFFECTS	GLOBAL EFFECTS
1. Exhaust and evaporative emissions: CO, SOx, NOx, VOCs, HCs, PM, CO_2, CH_4, N_2O, Pb, Benzene, Butadiene, Formaldehyde	Air	Local air pollution Global warming (CO_2, CH_4, N_2O) and Acid rain (SOx, NOx)	Health, ecological and welfare effects: respiratory and other illness (headache, cancer, premature deaths); visibility degradation; soiling and corrosion of materials; damage to crops, forests and territorial and aquatic animals and plants;	Effects from global warming and acid rain
2. Fugitive dust emissions: PM from tyre contact with road	Air	Local air pollution (increase the total suspended PMs in air)	Health, ecological and welfare effects: respiratory illness (chronic respiratory illness, asthma attacks, premature deaths); damage to crops, forests and other ecosystems; visibility degradation; soiling of building;	
3. Refrigerant agents emissions: CFCs	Air	Global warming Ozone layer depletion		Effects from global warming Effects from ozone layer depletion
4. Noise emissions/ vibration	Air	Noise pollution	Health and welfare effects: annoyance, communication interference, muscle/gland reaction, changed motor co-ordination; Economic effects	
5. Hazardous material/ commodities releases	Air Water Land Natural Habitat	Air pollution Water pollution Land contamination Habitat disruption	Effects to the different media depends on the type of the material/ commodity released and the characteristics of the media	Effects might also have global character

Table B2: Environmental impacts from the road/highway sector (road/highway construction and maintenance)

IMPACTS	RECEPTOR MEDIA	ENVIRONM. PROBLEMS	LOCAL EFFECTS	NON-LOCAL/ GLOBAL EFFECTS
1. Exhaust and dust emissions	Air	Local air pollution	Health and ecological effects	
2. Noise emissions/ vibration	Air	Local noise pollution	Health and welfare effects: annoyance, communication interference, muscle/gland reaction, changed motor co-ordination.	
3. Dust emissions	Water	Reduction in surface / ground water quality	Ecological and health effects	
4. Road salt deposition	Water Land	Surface / ground water contamination Land/soil contamination	Ecological and health effects Ecological and economic effects	
5. Road runoff	Water	Surface /ground water contamination	Ecological and health effects	
6. Land take	Land	Natural / agricultural land reduction (change in land use)	Economic, ecological effects (depends on the type of land)	
7. Solid (hazardous) waste disposal	Land	Land contamination, degradation	Ecological, economic effects	
8. Natural habitat fragmentation	Natural Habitat	Habitat disruption / destruction	Ecological and welfare effects: decrease in habitat size; decrease the interaction between species; interfered wildlife crossing; damaged vegetation and displacement of animals communities; loss/ alteration of aesthetic or recreational sites	Potential loss of ecological interest sites

IMPACTS	RECEPTOR MEDIA	ENVIRONM. PROBLEMS	LOCAL EFFECTS	NON-LOCAL/ GLOBAL EFFECTS
9. Water flow patterns modification	Natural Habitat	Habitat disruption/ destruction (hydrological alterations)	Ecological and welfare effects: damage/loss to/of vegetation and animal species; loss/ alteration of aesthetic or recreational sites; etc.	
10. Built habitat fragmentation/ alteration	Built Habitat	Severance Visual intrusion Damage/loss of archaeological sites/cultural heritage	Local Welfare effects	Potential non-local welfare effects

Table B3: Environmental impacts from the rail sector (rail travel)

IMPACTS	RECEPTOR MEDIA	ENVIRONM. PROBLEMS	LOCAL EFFECTS	NON-LOCAL/ GLOBAL EFFECTS
1. Exhaust emissions from fuel combustion: CO, SO_2, NOx, VOCs, PM-10, ammonia, CO_2, N_2O, CH_4 (not applicable to electric rail)	Air	Local air pollution Global warming (CO_2, N_2O, CH_4) and Acid rain (SO_2, NOx)	Health, ecological, welfare effects (respiratory and other illness; visibility degradation; soiling and corrosion of materials; damage to crops, forests and territorial and aquatic animals and plants)	Effects from global warming and acid rain
2. Emissions from coal/other fossil fuel power plants supplying the electricity used as fuel in electric rail: CO, NOx, PM, SOx, VOCs, Pb	Air	Local air pollution Acid rain	Health, ecological, welfare effects from reducing the local air quality	Effects from acid rain
3. Noise emissions/ vibration	Air	Local noise pollution	Health and welfare effects: annoyance, communication interference, muscle/gland reaction, changed motor co-ordination; Economic effects	
4. Hazardous material/commodities releases/spills	Water Land Natural Habitat	Water pollution Land contamination Habitat disruption/destruction	Effects to the different media depends on the type and quantity of the material/ commodity released and the characteristics of the surrounding area (climate conditions, topography, diversity and density of species: flora and fauna)	

Table B4: Environmental impacts from the rail sector (rail construction and maintenance)

IMPACTS	RECEPTOR MEDIA	ENVIRONM. PROBLEMS	LOCAL EFFECTS	NON-LOCAL/ GLOBAL EFFECTS
1. Exhaust, dust and fumes emissions	Air	Local air pollution	Health and ecological effects	
2. Noise emissions	Air	Local noise pollution	Health and welfare effects: annoyance, communication interference, muscle/gland reaction, changed motor co-ordination.	
3. Land take	Land	Natural/ agricultural land reduction (change in land use)	Economic, ecological effects (depends on the type of land)	
4. Natural habitat fragmentation	Natural Habitat	Habitat disruption / destruction	Ecological and welfare effects: decrease in habitat size; decrease the interaction between species; interfered wildlife crossing; damaged vegetation and displacement of animals communities; loss/ alteration of recreational sites	Potential loss of ecological interest sites
5. Water flow patterns modification	Habitat	Habitat disruption/ destruction (hydrological alterations)	Ecological and welfare effects: damage/loss to/of vegetation and animal species; loss/ alteration of recreational sites; etc.	
6. Built habitat fragmentation/ alteration	Built Habitat	Severance Visual intrusion Damage/loss of archaeological sites/cultural heritage	Local Welfare effects	Potential non-local welfare effects

Table B5: Environmental impacts from the air sector (airport construction and maintenance)

IMPACTS	RECEPTOR MEDIA	ENVIRONM. PROBLEMS	LOCAL EFFECTS	NON-LOCAL/ GLOBAL EFFECTS
Exhaust, dust and fumes emissions	Air	Local air pollution	Health and ecological effects	
1. Noise emissions/ vibration	Air	Local noise pollution	Health and welfare effects: annoyance, communication interference, muscle/gland reaction, changed motor co-ordination.	
2. Dust emissions	Water	Reduction surface/ground water quality	Ecological and health effects	
3. De-icing compounds releases	Water	Surface/ ground water contamination	Ecological and health effects	
4. Airport runoff	Water	Surface/ ground water contamination	Ecological and health effects	
5. Land take	Land	6.1. Natural/ agricultural land reduction (change in land use)	Economic, ecological effects (depends on the type of land)	
6. Solid (hazardous) waste disposal	Land	Land contamination, degradation	Ecological, economic effects	
7. Natural habitat fragmentation	Natural Habitat	Habitat disruption/ destruction	Ecological and welfare effects: decrease in habitat size; decrease the interaction between species; interfered wildlife crossing; displacement of animals communities; damage to or elimination of vegetation; loss/ alteration of recreational sites;	Potential damage to endangered and threatened species Potential loss of ecological interest sites

IMPACTS	RECEPTOR MEDIA	ENVIRONM. PROBLEMS	LOCAL EFFECTS	NON-LOCAL/ GLOBAL EFFECTS
8. Water flow patterns modification	Natural Habitat	Habitat alteration (hydrological alterations)	Ecological and welfare effects: damage/loss to/of vegetation and animal species; loss/alteration of recreational sites; etc.	
9. Built habitat fragmentation/ alteration	Built Habitat	Severance Visual intrusion Damage/loss of archaeological sites/cultural heritage	Local Welfare effects	Potential non-local welfare effects

Table B6: Environmental impacts from the air sector (air travel)

IMPACTS	RECEPTOR MEDIA	ENVIRONM. PROBLEMS	LOCAL EFFECTS	NON-LOCAL/ GLOBAL EFFECTS
1. Exhaust and evaporative emissions: NOx, CO_2, N_2O, CH_4, CO, SO_2, VOCs, PM, Butadiene	Air	Global warming (CO_2 , N_2O, CH_4 and NOx emitted at high altitude) Ozone layer depletion (NOx) Acid rain (NOx, SO_2) Air pollution (from low altitude emissions of CO, SO_2, VOCs, PM, NOx)	Health, ecological, welfare effects (respiratory and other illness; visibility degradation; soiling and corrosion of materials; damage to crops, forests and territorial and aquatic animals and plants)	Effects from global warming Effects from stratospheric ozone loss Effects from acid rain
2. Noise emissions/ vibration	Air	Local noise pollution	Health and welfare effects: annoyance, communication/sleep interference, muscle/gland reaction, changed motor co-ordination; Economic effects	
3. Hazardous material/commodities releases/spills	Air Water Land Habitat	Air pollution Water pollution Land contamination Habitat disruption / destruction	Effects to the different media depends on the type and quantity of the material/ commodity released and the characteristics of the surrounding area (climate conditions, topography, diversity and density of species)	

Table B7: Environmental impacts from the waterborne sector (construction and maintenance)

IMPACTS	RECEPTOR MEDIA	ENVIRONM. PROBLEMS	LOCAL EFFECTS	NON-LOCAL/ GLOBAL EFFECTS
1. Land take for ports and marinas	Land Habitat	Land reduction Habitat destruction/loss	Economic, ecological, welfare effects (depends on the type of land)	Potential loss of high ecological interest sites
2. Displacement/ removal of natural sediments (bottom material) for dredging purposes	Natural Habitat	Habitat disruption	Ecological effects: damage to vegetation and animals communities	
3. Disposal of dredged (contaminated) material	Land Water Natural Habitat	Land contamination Water pollution Territorial and aquatic habitats disruption	Ecological and health effects: damage/loss to/of vegetation and animal species;	
4. Water flow patterns modification (from dredging and channalization projects)	Natural Habitat	Habitat alteration/disruption (hydrological alterations)	Ecological effects: damage/loss to/of vegetation and animal species;	
5. Built habitat fragmentation/ alteration	Built Habitat	Visual intrusion Damage/loss of archaeological sites/cultural heritage	Local Welfare effects	Potential non-local welfare effects

Table B8: Environmental impacts from the waterborne sector (maritime travel)

IMPACTS	RECEPTOR MEDIA	ENVIRONM. PROBLEMS	LOCAL EFFECTS	NON-LOCAL/ GLOBAL EFFECTS
1. Exhaust and evaporative emissions: NOx, CO_2, N_2O, CH_4, CO, SO_2, VOCs, PM	Air	Local air pollution Global warming (CO_2, N_2O, CH_4)	Health, ecological, welfare effects (respiratory and other illness; visibility degradation; soiling and corrosion of materials; damage to crops, forests and territorial and aquatic animals and plants)	Effects from global warming
2. Impacts from wakes and anchors	Habitat	Habitat disruption (erosion and sedimentation processes)	Ecological effects: damage to vegetation and corals; other species affected;	
3. Wildlife collisions	Habitat	Habitat disruption	Ecological effects: animals kills	Potential kill of endangered and threatened species
4. Hazardous material releases/spills; effluent discharges; solid waste disposal	Water Habitat	Water contamination Habitat disruption/ destruction	Ecological, potential health human (through contaminated sea food), welfare effects: animals deaths; damage to other life organisms; loss of recreational, swimmable fishable sites;	Potential damage/kill to/of endangered and threatened species

The implementation of pilot/demonstration projects can generate environmental consequences. The environmental impacts generated by pilot / demonstration projects are identified in the preceding tables.

B.2 EXAMPLES OF THE USE OF ENVIRONMENTAL ASSESSMENT TOOLS

B.2.1 Example of the Use Of The Descriptive Tool (from the DGXII CONVERGE Project)

An example of the use of this tool comes from the guidelines developed as part of the CONVERGE project for DGXIII [(8)]. In this, the affected groups are known as appraisal groups, and may include:

- operators of the application;
- intermediate users of the application such as providers of information;
- end-users of the application;
- individuals or groups affected indirectly from the application but who cannot be classed as either operators, end-users or intermediate users.

The expected impacts are classified in a qualitative manner using the following scale:

++	very positive impact
+	positive impact
0	neutral/ uncertain impact
-	negative impact
--	very negative impact

An example of the use of such a method is given in Table C.9.

Table B.9 Example of Use of CONVERGE Framework

Impacts expected	Target groups	Applications	Impact Magnitude
Reduced environmental pollution	shippers	A B	0 0
	combined transport operators	A B	0 0
	drivers	A B	0 0
	terminal operators	A B	0 0
	insurance companies	A B	0 0
	public authorities	A B	+ +
	society	A B	+ +

Note: "A" & "B" represent different technological solutions.

The example listed is very simple, but the descriptive tool can also be used at a very fine level of detail in terms of impact definition and target groups.

B.2.2 Example of the Use of the Ranking Tool

In the following example, the aggregation of a number of diverse impacts (not all of them environmental) is illustrated, making use of the regime method. This is taken from Nijkamp et al (1990) [9].

Table B.10 provides information about the qualitative and quantitative assessment of a number of alternatives according to 5 criteria. Attached to each of these criteria is a weight indicating the relative importance of the criteria.

Table B.10 Qualitative and quantitative assessment of a number of alternatives according to 5 criteria

Criteria	Units	Alternatives			Weights
		Highway	Road/Bus	Train	
Costs	guilder	200	250	400	++
Travel time	---/+++	+++	++	+	+
Capacity	km/year	20	30	40	+++
NO_x emissions	ton/year	1000	750	100	+++
Landscape	---/+++	---	--	-	+

Each pair of alternatives is compared, and a concordance index is derived. This is the sum of the weights for each criteria where one solution performs better than the alternative - e.g. comparing highway and train, highway performs better on cost grounds (weight = ++) and in terms of travel time (weight = +).
So, comparing highway (alternative 1) with train (alternative 3), we have a concordance index of:

$c_{13} = (++) + (+)$

Comparing train (3) with highway (1), gives:

$c_{31} = (+++)+(+++)+(+)$

The two values are then subtracted to obtain the index μ (i.e. $\mu_{13} = c_{13}-c_{31} <0$).

Table C.11 provides a summary of the comparison of the alternatives in matrix format.

Table B.11 Relative Success Indices

Scheme	Highway	Road/bus	Train
Highway	-	0.08	0.00
Road/ bus	0.92	-	0.00
Train	1.00	1.00	-

The value 1.00 in the comparison between the train alternative and the highway alternative indicates that for all the criteria, the train alternative ranks above the highway alternative. The overall score of an alternative is calculated as the row average of the relative success indices. In this example, the train is the most preferred choice, followed by the road/bus and highway.

Note that the relative simplicity of the method means that care should be taken in interpreting the outputs of the regime process. The aggregate score of any alternative is derived through the combination of two qualitative factors - a qualitative impact assessment and a qualitative weight. Thus, the limitations of such an approach should be recognised.

B.2.3 Example of the Use of The Physical Measurement Tool (from Design Manual for Roads and Bridges)

An example of the use of this tool is given in the environmental section of the UK's Design Manual for Roads and Bridges [(9)]. This has the following structure:

A. Appraisal Groups:
   1. Local People and their Communities (Table C12)
   2. Travellers (Table C13)
   3. The Cultural and Natural Environment (Table C14)
   4. Policies and Plans (Table C15)

B. Land Use Table (Table C16)

C. Mitigation Table (Table C17)

The tables are re-produced in this annex.

The manual is used to determine the impacts of road infrastructure projects. Despite this specific use, the reporting format is relevant to all forms of project, including pilot projects.

Table B12: A. Appraisal Group 1 - Local People and their Communities

Sub Group	Effects	Units	Preferred Route	Do-Minimum
Commercial buildings used by people: retail premises	Properties demolished	Number	0	0
	Noise. dB $L_{A10,}$ 18hr	Number of properties experiencing an increase of more than 1 < 3 3 < 5 5 < 10 10 < 15 >=15	 0 0 0 3 0	 12 0 0 0 0
	Visual Impact	Number of properties subject to: Substantial Moderate Slight No Change visual impact	 0 1 0 0	 No change No change No change No change
	Severance: (a) relief to existing severance; (b) imposition of new severance	- -	(a) None (b) Slight for property X	(a) None (b) None
	Disruption during construction	-	3 premises within 100m or site both slightly affected	None

Table B13: A. Appraisal Group 2 - Travellers

Sub Group	Effects	Units	Preferred Route	Do-Minimum
Traveller amenity Vehicle users amenity	Driver stress	-	Low	Eastbound high Westbound moderate
	View from the road	-	Moderate relief of severance	Agricultural upland
Pedestrians' and Equestrians Amenity	Severance (New)	Number	Moderate relief of severance	No change
	Change in Amenity	Bridleway A7	Reduction in amenity for equestrians and ramblers. Estimated usage 50 and 100 journeys/week respectively.	Existing good amenit unchanged
Traveller Safety Pedestrians' and Equestrians' Safety		-	Segregation of pedestrians and vehicles will improve safety	No improvement in r safety
All Vehicle Travellers' Safety	Reduction in casualties Fatal Serious Slight	 Number Number Number	 47 350 997	 0 0 0

Table B14: A. Appraisal Group 3 - The Cultural and Natural Environment

Sub Group	Effects	Units	Preferred Route	Do-Minimum
Heritage (a) Punchbowl Hotel (Grade II listed building)	Noise		Decrease of 1-3dB(A) at 3 facades; increase of 3 dB(A) at fourth	No change
	Severance		Substantial reduction	No change
	Visual impact		Slight increase	No change
(b) Augill House (Grade II listed building)	Visual Impact		Slight increase	No change
Nature and Landscape (a) North Pennines AONB[1]	Landtake	hectares (ha)	0.7 ha	No change
	Landscape effect		Some views of an d from the AONB will be moderately worsened, although planting will mitigate adverse effects in longer term.	
(b) Limestone Pavement				

[1] AONB - Area of Outstanding Natural Beauty.

Table B15: A. Appraisal Group 4 - Policies and Plans

Policy	Authority	Interest	Preferred Route	Do-Minimum
1. Structure Plan Policy number 17(a)	Coombeshire CC	To regenerate the town centre of Coombetown	Removes estimated 50% of through traffic, will enable the introduction of parking and traffic calming measures	The existing poor conditions will deteriorate
2. Structure Plan Policy number 23(c): 3. Local Plan: To resist the loss of recreational land to other uses	Coombeshire CC Warbury DC	Playing field Cedar Park	Route requires 10% of field, but re-orientation of soccer pitches will enable all to be retained.	No change
4. Structure Plan Policy number 4(a): 5. Local Plan Policy number 5: to preserve and enhance potential for the Medan Canal for leisure.	Coombeshire CC Woodleigh DC	Old Wharf side and locks	Two new bridges across canal will maintain navigation clearances	No change

Table B16: B. Land Use Table

Existing Land Use	Area Required Permanently			Area required temporarily Durin[g] Construction (ha)
	Area for Carriageway, Footways & Other Hard Surfaces (ha)	Area for Verges, Embankments, Cuttings & Other Landscaping (ha)	Total Area (ha)	
Derelict land	-	4.0 (4.0)	4.0 (4.0)	-
Agricultural land Grade 2 Grade 3 Grade 4	 2.0 8.0[1] -	 8.0 19.0 (7.0) 1.5	 10.0 27.0 (7.0) 1.5	 2.0[2]
Community land - Public open space	 1.0	 2.0	 3.0	 -
Other - industrial	 1.0	 3.0	 4.0	 -
Total	12.0	37.5	49.5	2.0

Table B17: C. Mitigation Table

Mitigation Measure	Location, Purpose and Forecast of Benefit	Capital Cost	Forecast Maintenance Requirement, Method and Cost
Noise bund	CH 100-160 Westbound Noise reduction of 2-3dB(A) for 20 residential properties	£10,000	No specific maintenance requirement
Noise barrier	CH 500-700 Eastbound Noise reduction of 2-3dB(A) for 50 residential properties	£30,000	Regular maintenance required for painting & replacing panels. Maintenance from verges. Estimated cost £1,500/ year.
Over deepening of balancing pond	Junction 15. Ecological enhancement will allow introduction of wetland species	£5,000	Additional maintenance required to preserve developed wetland species whilst maintaining primary function of balancing pond. Maintenance from pond side. Additional cost estimate of £2,000/ year.
Provision of interceptors	All outfalls to river to meet requirement of NRA for run-off quality. Permit draining to river.	£100,000	Routine maintenance cleaning required. Maintenance from highway land. Estimate cost £4,000/ year.
Revised horizontal alignment	East of Fox Wood Nature Conservation. Avoid SSSI.	£200,000	No specific extra maintenance requirement.

B.3 TECHNIQUES FOR ESTABLISHING MONETARY VALUES FOR ENVIRONMENTAL IMPACTS

B.3.1 Economic Valuation Techniques

From the economic point of view environmental problems constitute *negative externalities* or (*external*) *costs* which, in principle, cannot be taken into account during the decision process. This is due to the fact that there are no markets for the different environmental assets and services. Market prices, then, are not generated for them. This means that a direct monetary value cannot not be attached to changes in environmental quality brought about by transport activities/projects, for instance.

A number of methodologies, however, have been developed to provide (indirect) money values to environmental assets, services and changes in the environmental quality from hypothetical or related markets. Valuation methods are generally classified into two categories: direct methods and indirect methods. Direct methods value environmental quality by inferring individuals' preferences for it. Individuals are asked directly to state their preferences for the environment. The Contingent Valuation method and other stated preference methods will be discussed. The indirect methods use surrogate or related markets to infer values for the environment. The travel cost method, the hedonic price method, the dose-response approach, the averting expenditure/avoided cost approaches, the replacement cost method and shadow prices will be examined subsequently. First, however, a discussion about appropriateness of using direct market values for some of the impacts derived from transport projects will be presented.

- **Direct market values**

Market values are used to value some environmental impacts derived from the transport sector. These impacts are those derived from the use of natural resources: land, fuel and other non-renewable resources. Market prices exist for these natural resources and, then, impacts can be valued using the corresponding prices. Land take and the consumption of fuel and other non-renewable resources can be accounted for at market prices. This approach presents, however, a significant limitation: market prices generally do not reflect the relative scarcity of resources. Therefore, the valuation of resource consumption at market prices will understate the real cost of this use to society.

The valuation of land take at market prices presents an additional problem. Even if market prices are not subject to distortions, they might not adequately reflect some values, for example, in the case of land uses for recreational purposes. Additionally, the use value might not reflect the total social value of the land because of some non-use values attached to it. In these cases, the use of market values will understate the true environmental cost.

- **Indirect money values: Quasi-market values and surrogate prices**

Indirect money values for environmental impacts can be estimated by direct or indirect methods of valuation.

Direct methods of valuation

Contingent valuation method (CVM)

The contingent valuation method uses questionnaires ask people to state their maximum willingness to pay (WTP) for an increase in environmental quality or for avoiding a loss of environmental quality. People might instead be asked about the minimum willingness to accept compensation (WTAC) to forgo an increase in environmental quality or to accept a reduction in environmental quality. WTP and WTAC measures can be used to represent both use values and non-use values (option and existence values).

Since environmental quality, or whatever the specific good is to be valued, is not a marketed good, a hypothetical market must be set up in the questionnaire. The questionnaire should provide clear information on the good subject to valuation, the reasons for the payment being asked, the vehicle through which the payment is to be made (the bid vehicle) and the decision about whether to proceed or not with the project (the provision rule). Questions asked should relate to a well-perceived situation or experience. The survey can be done by face-to-face interviews, telephone interviews or mail. Face-to-face interviews are preferred over the others.

There are two basic formats that a CVM survey can adopt. In the *open ended* format, no initial value is suggested when people are asked to state their maximum WTP (or minimum in the case of WTAC). The main problem with this format is that the range of responses might be very high, including no responses at all since people find very difficult to answer those kind of questions. In the *closed-ended* format, on the contrary, people are asked in relation to an initial payment (the offer price). Such questions are called *dichotomous choice* questions. Those who are indifferent to the offer price are explicitly considered using *trichotomous choice* questions. The process continues in the *double-bounded* format, by presenting to those who accepted the offer price a higher bid and to those who did not accept it a lower one. The main problem with these CVM variants is that responses can be highly affected by the initial bid.

Estimates for environmental benefits or costs from CVM are influenced by the following factors:

- First, WTP measures differ from WTAC measures when in theory they should be identical. Several application of the CVM have shown that WTP measures are lower that WTAC measures. This means a different value will be attached to an environmental change depending on how the environmental change is presented.

- Second, the method suffers from several *biases* that might also affect the WTP and WTAC estimates: the *strategic bias*, derived when interviewees respond strategically to affect the result of the questionnaire; the *design bias*, which refers to the fact that answers might be influenced by how the information about the problem has been given; the *instrument bias* that arises when respondents react differently to different payment vehicles; and the *starting point bias*, which refers to the influence of the initial bids on the range of answers obtained.

- Third, in the process of grossing up the monetary value estimated from the sample (mean WTP/WTAC) to adequately represent the total value attached by the whole population, the magnitude of the total value is conditioned by the choice of the relevant population (for non-user values) and the way/technique used to extrapolate the estimated value. The influence of the latest factor diminishes when a bid curve can be estimated.

In principle, the CVM can be applied to value changes in environmental quality due to the implementation of transport pilot projects. However, given that its use is highly time and resource consuming, its application should be conditioned to the size/scale of the project.

Stated preference methods

With stated preference (SP) methods individuals state their preferences for a set of different options and individuals' utility functions are estimated on the basis of those statements. The specific technique might ask to the individuals to rank a list of environmental options (the contingent ranking method), to rate the options on response scales or to choose one option between pairs or group of options.

In SP methods, all possible/relevant attributes of the environmental good or service to be valued and ways of measuring them are identified. Possible values for all the attributes identified are set. From the set of all attributes and their corresponding possible values, a subset is selected through the use of statistical techniques. Alternative scenarios are then defined from this subset according to the attribute(s) of interest.

The most popular and reliable method of SP relies on responses to questions about which options an individual prefers from a set of hypothetical alternatives. These contain combinations of goods or attributes and the options are rated or ranked by respondents [(10)].

As in the CVM the design of the questionnaire is very important. Different alternatives or scenarios should be described to the interviewees in a meaningful and comprehensive way, so that choices are made as easy as possible. To this purpose some technical data might be presented, with the risk, however, of giving rise to an information bias. Strategic responses are not so likely in stated preference methods since the alternatives presented incorporate trade-offs. Given that attributes are specifically considered, SP techniques directly value the characteristics of the environmental goods.

Indirect methods of valuation

Indirect methods to value in monetary terms changes in environmental quality might aim at revealing individuals' preferences for the environment through observing actual behaviours in related markets. *Revealed preference* methods are the Travel Cost Method (TCM) and the Hedonic Price Method (HP). These methods should be distinguished from those that, although also using surrogate or related markets, do not aim to reveal individual preferences.

This second class of methods refer to actual costs or expenditure generated by environmental impacts to place monetary value on them. Costs or expenses take place in related or surrogate markets to the environmental impact under evaluation. The dose-response method, the averting expenditure/avoided cost method, the replacement cost method and the shadow price approach provide *surrogate prices*. The averting expenditure/avoided cost method might aim to reveal individual preferences when actual behaviour is accounted for or when surveys are carried out to determine how much people are willing to spend for protection against the impact.

Travel Costs Method

Used mainly to infer the value of recreational sites, the method uses the travel costs incurred to reach a particular site to infer the value of the site itself. Travel costs are used then as a *proxy* of the price paid for visiting the site. A surrogate demand function for the site is estimated by relating the number of visits and the visit costs.

There are two variants of the TCM:

- In the first, data on the number of visits and travel costs are recorded for different zones. The number of visits per capita in each zone is then explained as a function of the travel costs and some socio-economic variables. Travel costs for each zone vary according to the distance from the origin to the site and the time spent in travelling. A demand function can then be obtained by estimating the rate at which the number of visits per capita decreases as travel costs increase. This is the Zonal TCM.

- In the second variant, data on number of visits in a given period of time and travel costs (and some socio-economic variables) are recorded for each specific individual. In this case a demand function is estimated by relating the number of visits of each individual to his/her travel costs. This is the Individual TCM.

From the estimated (surrogate) demand function, the consumer surplus for a visitor from each zone or for a particular individual can be calculated providing information, together with the actual travel costs, about the maximum willingness to pay for the benefits obtained from the recreational site. The sum across zones or individuals can give an indication of the costs of losing the recreational site.

The application of one variant or the other might be determined according to the case at hand. No suggestion is given by the literature on the theoretical superiority of one approach over the other.

This methodology presents a number of problems:

1. Only use-values are estimated. Since the estimated value is based on the consumption expenditure necessary to reach and then *use* the site, when no direct use is made of the site, i.e. no trips take place, then no value can be attached to the site. This means that the social cost of a decrease in its quality or the social costs of its loss would be zero. The methodology can only be used for recreational/amenity sites with high attendance.

2. The value of the travel/leisure time. Should the travel time be distinguished from the time being at the site? Does the travel time represent just a pure cost? Which value should be used to estimate that cost? What about the opportunity cost of time in terms of forgone earnings or in terms of forgone recreational opportunities?

3. No uniqueness of consumer surplus estimates. Consumer surplus estimates may vary significantly according to the approach chosen and the functional form selected. The estimation might also be highly dependent on the value used for the cost of travel time.

4. Multi-purpose trips are excluded. It is assumed that trips have only the purpose of visiting the site in question and therefore no other benefits are derived from it. Some options have been suggested to avoid this problem.

The method is only relevant for valuing benefits derived from public goods. In the context of transport projects, the method is relevant for valuing the recreational or amenity function of habitats that might be somehow altered or damaged by projects implementation. Some alterations of the original models allow one to value the effects of changes in the initial characteristics of the sites.

Hedonic Price Method

The hedonic price method aims to value environmental characteristics by observing individuals' behaviour in markets for goods which prices are assumed to depend on a set of attributes. Among them are the environmental characteristics to be valued. Individuals' preferences for the environmental characteristics can then be revealed from consumption decisions on the marketed good.

The method has been applied mainly to the housing market. Monetary valuations have been derived for the costs of a reduction in the environmental quality of the surrounding area provoked by noise and air pollution. House prices depend on a number of variables: physical, neighbourhood and environmental attributes (e.g. environmental quality). Should the two first be kept constant, then changes in prices would reflect changes in the environmental characteristics and the differences could be regarded as monetary values of environmental quality improvements or worsens.

In this methodology, a (non-linear) *hedonic price function* for the marketed good is first estimated by relating the level of the different attributes to the price. From this function, *implicit prices* can be calculated for the environmental characteristics by differentiating the hedonic function with respect to the environmental variable in question. Implicit prices represent the marginal cost of improving the environmental quality and, only under certain conditions, the marginal benefit derived from that improvement and, thus, the willingness to pay for it. An *inverse demand function* for the environmental quality might be, finally, estimated by relating implicit prices to the corresponding environmental quality levels and some socio-economic variables.

As with the previous method, there are a number of problems:

1. The market for the good in question might not be in equilibrium, and therefore, prices might be also influenced by market distortions. For implicit prices to be interpreted as marginal benefits, and then as measures of the willingness to pay, individuals should be well informed about the environmental quality.

2. The method can only reveal use-values. Additionally, it cannot be applied to rented houses.

3. The value of the implicit prices may be highly influenced or biased (*i*) by the choice of the functional form of the hedonic function, (*ii*) because of some relevant variables might be omitted and (*iii*) because of the existence of multi-collinearity between variables.

4. The application of this methodology requires high data collection from an appropriate sample. It is relevant when the environmental variable can be measured, for example, noise pollution and air and water pollution, but not in other cases.

When the implementation of a transport project brings about an increase in the level of noise or in air or water pollution, the costs of these impacts are measured by the area under the inverse demand curve estimated for the corresponding environmental variable between its level prior to project implementation and the post-implementation level. Even though some applications of this methodology can be found (e.g. Kageson, 1993), its restricted theoretical assumptions and its practical problems do not recommend its use.

<u>Dose-response method</u>

Environmental impacts might alter the production conditions of a marketed good affecting the producers' surplus, as well as the consumers' surplus derived from their consumption. Environmental impacts can then be valued through estimating changes in producer' and consumer' surplus.

The logic of the method is that the production of the good depends on an environmental factor whose availability or quality changes the production level. The first step in this method is to estimate the so-called *dose-response* function or damage function which relates the level of production to the environmental factor itself or its quality, or to the impact (change in availability or quality). Therefore, the dose-response function estimates the physical effect of the environmental impact.

Dose-response or damage functions can be determined by (*i*) laboratory or field research, (*ii*) controlled experiments or (*iii*) statistical regression techniques. The effects of exogenous factors should be eliminated. (Winpenny, 1991)

Once the physical effect is determined, monetary values are assigned through valuing the changes in production at the market prices. These market prices should be, however, adjusted to account for possible market distortions. When production changes are likely to affect prices, then a new price level should be predicted and changes in consumers' surplus should be accounted for. The method can also be applied to non-market goods, using market prices from substitutive or close actual markets to the good under consideration.

This approach has been mainly applied to value the effects of air pollution on crops and water pollution on fish production. The main limitation of this method is the difficulty in estimating the dose-response function: physical relationships are not well known. As a consequence, results are highly dependent on the assumptions about the dose-response function. The presence of other factors generating the same consequences can over estate the physical effect when the effects from the environmental impact at hand cannot be properly isolated. Finally, producers and consumers might react against the adverse effects of environmental impacts. These responses should be taken into account in order to avoid over or under valuation of the effects. Different assumptions about these responses might also influence the valuation.

Averting expenditure/avoided cost method

Based on the household production function approach, in which households use a combination of inputs to produce goods or services that generate utility for them (e.g. environmental quality), the method considers the averting or defensive expenditures against an environmental impact as a measure of the welfare loss due to that impact. For intense, double glazing can be installed to reduce the indoor level of noise. The expenses of double glazing can then be use as a measure of the welfare loss due to the noise.

The method will generate an exact measure of the welfare loss if the expenditure exactly offsets the impact and does not generate additional benefits. In the case of double glazing, for example, if the measure has been taken in order to combat an increase in the noise level due to the implementation of a transport project, the expenses will constitute an exact measure of the cost of the impact if the double gazing just offsets the increase in noise due to project implementation and it does not generate additional benefits as heat insulation.

In the avoided cost version, benefits from an improvement in the environmental quality are valued as the costs one would have had to incur if the improvement had not taken place in order to reach the same quality level.

The method can be applied when substitute marketed goods for environmental impacts exists. Information can be obtained through:

- direct observation of actual expenditures,
- by asking people how much they will spend in protecting themselves against the environmental impact
- or by estimates from professionals about the cost of doing so.

In the first case, the method attempts to reveal individual preferences by observing the choice consumers have taken between incurring in the expenditure or suffering the effects of the impact. In the second case, individual preferences are directly stated. Finally, in the third case surrogate prices are provided. These prices can be used to value the physical effects estimated by dose-response functions when the effect is not marketed.

The main limitation of this methodology is that the averting expenditure might be a joint product generating additional benefits that, if not discounted, can over estimate the value of the impact.

Replacement cost method

Another type of surrogate market method is the replacement cost method. The cost of replacing environmental assets or services that have been damaged by a particular impact can be used to value the cost of the impact. The boundary between this method and the previous one is sometimes not clear. For example, double glazing can also be interpreted as the cost of replacement the initial level of noise.

A specific variant of this method is the so-called *shadow or compensating project* method. When an environmental or heritage asset/habitat is damaged or threatened by, for instance, the implementation of a transport project, the actual or potential loss or damage can be valued through the cost of the (shadow) project necessary to recreate or restore the asset/habitat.

It is assumed that full replacement of the habitat/asset damaged or loss can be done. However, this is a very unrealistic assumption since some of the effects may appear in the long term, might not be perceived or cannot be restored. It is then highly likely that the method will under estimate the cost of the environmental impact.

In this and the previous method discussed, environmental impacts susceptible to be valued are those that have a monetary implication through the inducement of an expenditure. It is not necessary, however, that it is an actual expenditure. Shadow projects, mitigation and clean-up measures might not in fact be carried out.

Shadow prices

Some of the environmental impacts that the transport sector generates might be regulated in the environmental policy through the establishment of standards or targets (e.g. emission standards or reduction targets for CO_2 emissions). When, for whatever reasons, stated or revealed preference techniques cannot be applied or are not appropriate, and the computing of the induced costs or expenditure by impacts is not tackled, then the existence of standards or targets might offer an alternative way of placing monetary values to environmental impacts.

This is the case of CO_2 emissions which are the main emission responsible of the greenhouse effect and whose emissions level should be reduced in the next years. In this case, a shadow price can be computed for the resource origin of the emissions, i.e. petrol. The shadow price would be the price at which petrol consumption would produce a level of emissions consistent with the target. The difference between the shadow price and the actual price would represent an estimation of the environmental costs associated with the emissions.

Therefore, in this shadow price approach environmental impacts are valued through the economic costs necessary to achieve the policy constraints or targets placed on them. Indeed, the method can be interpreted as a variant of the defensive/averting expenditure method, since environmental impacts are valued through the costs necessary to avoid them.

B.3.2 Assignment of Relative Weights

Instead of being valued separately, environmental impacts can be jointly considered by attaching to them a weight that reflects the relative importance of each impact with respect to all the others. Weights reflect decision maker(s) preferences. This is the approach of multi-criteria analyses, in which alternative schemes are ranked. Impacts measured are transformed into cardinal or ordinal scales or, in other words, the valuation of impacts is made through cardinal or ordinal scales. Since the approach does not present peculiarities for the environmental case, the reader is referred to the paper in which this methodology is described.

B.3.3 Which Valuation Technique?

The following sector discusses the appropriate valuation technique for each category of environmental externality.

Local air pollution

Atmospheric pollutants from the transport sector, like dust, exhaust and evaporative emissions, contribute to reducing the quality of the local air. This reduction might provoke health, welfare and ecological effects at local level. Some of the valuation techniques reviewed can be used to estimate those effects. The defensive expenditure/avoided cost method and the dose-response approach can be used to calculate surrogate prices for the different pollutants. Alternatively, revealed and stated preference methods can determine individual preferences for the quality of air and its changes.

Stated preference methods require full perception of all effects derived. However, health problems and effects on crops, for example, might not be well perceived. The hedonic price method is also likely capture only the welfare effects of the pollution. A dose-response approach to the valuation is likely to provide a more adequate value to the total cost of air pollution. Dose-response functions should be estimated in order to determine the effects of the pollutants on human health, visibility degradation, building and materials, crops, vegetation and fauna. Physical effects should be, then, translated into monetary values by applying market or surrogate prices according to the nature of the effect variable. Nonetheless, the existing uncertainties with regard to the physical relationships between pollutants and effect variables limit the application of the dose response approach. Therefore, the defensive cost method based on the costs of the measures necessary to meet policy targets or standards seems the most practicable one since surrogate markets for air pollution are not common.

Global air pollution

The main two global problems to which the transport sector contributes are the greenhouse effect and the ozone layer depletion. CO_2 is the main greenhouse gas. CFC emissions are, in contrast, the main responsible for the depletion of the ozone layer. Since the transport sector is not an important source of CFC emissions, only the global warming problem will be analysed. However, the same arguments would apply to those emissions.

Given that the effects derived from global warming have a global nature, revealed and stated preference methods are not appropriate as ways of deriving monetary values. A dose-response approach may be limited by the existing uncertainties about the effects of this process. Therefore, the *averting expenditure* method appears again as the most appropriate/practicable one, even though the value provided by it might not reflect the real cost. CO_2 emissions can be attached with a value equal to the expenses necessary in the transport sector to prevent them. Alternatively, the cost induced by CO_2 emissions can be taken into account by valuing the petrol at the (*shadow) price* that would make its consumption consistent with the target of emissions reduction.

Noise pollution

The generation of noise emissions is one of the most well recognised impacts from the transport sector. As a local problem and with a potentially well identified affected area, the costs of noise pollution can be derived from revealed and stated preference methodologies. However, full perception of the health effects induced by noise emissions is required. Otherwise, the methods will just value the welfare loss from annoyance, communication interference and so on. The application of the hedonic price method is not feasible when there is not a well developed property house market (market distortions, rented housing, business district).

Effects derived from transport noise can also be valued using the averting expenditure method (cost of the measures to attenuate or eliminate noise). This approach can capture the economic effects of noise: effects that the noise might cause in business and other working centres like schools, hospitals and so on. Noise can also be scored according to the magnitude of the impact: the number of decibels generated by the impact.

Water pollution

Water bodies can be also contaminated by the transport sector. Dust might be disposed on (surface) aquatic resources during construction phases lowering, at least temporarily, the water quality. Surface and ground water resources are polluted by road salt and by highway/airport runoff impacts in which rainwater picks up atmospheric pollutants and road deposits and takes them into the water (suspended solids or particulates, oxygen-consuming constituents, nutrients, heavy metals, trace organics and micro-organisms). Other hazardous wastes, for example from travel accidents, may also be disposed. Reduction of the water quality, eutrophication processes and other alterations can affect human health and threaten the aquatic life.

Stated preference might reveal individual preferences on clean water. This approach is likely to provide a monetary value for the human health effects (in the case of drinkable water), but not for the potential ecological effects. The potential of the dose-response approach can be limited if uncertainties surround the interrelations between pollutants and water components. The cost of the clean-up measures to "replace" the initial water quality can be used, even though it may not reflect the real cost.

Land take/Change in land use

The discussion made in the previous section about the use of direct market values can be applied here. Land take is normally evaluated at market prices. However, these prices can be distorted due to a number of reasons: subsidies, speculative effects, and so on. Land market prices should, then, be adjusted for the existing distortions and also to reflect the opportunity cost of the land.

Land/soil degradation

Hazardous wastes might be disposed/spilled on land during construction activities or from travel accidents: asbestos and other petroleum wastes, organic and inorganic compounds, pesticides, cyanides, corrosives, heavy metals and biological and radioactive wastes. Soil structure and then fertility might also be harmed by the salt used as a de-icing compound in roads. Economic and ecological effects are likely to be provoked. When the land affected is used for agricultural purposes, then the costs on the impact can be estimated by the loss on production induced (dose response function plus the production market price). In non-agricultural lands, the costs of the ecological damage induced can be estimated by the costs of the measures needed to restore the soil characteristics.

Natural Habitat disruption/destruction

Land amenity:

In addition to the adjusted market value of the land taken for construction activities, its amenity value should also be accounted for, specially in the case of a land of public access. When the amenity or recreational properties of an area are damaged/disrupted, a value can be attached to this impact by stating individuals' preferences for the area (stated preference or contingent ranking methods) or revealing users' preferences for a highly visited area (the travel cost method). Alternatively, the loss of an amenity or recreational area can be computed as the cost of the (shadow) project that would be necessary to recreate the area elsewhere. When mitigation or remedial measures are only needed, their cost would provide a value of the damage caused. In both cases the *replacement cost method* is applied. Finally, the impact on land amenity can also be scored in a cardinal or ordinal scale according to the importance of the amenity and the severance of the impact, or it might simply be described by experts' judgements.

Ecological damage-biodiversity loss:

The fragmentation of and "interference" to habitats due to transport infrastructures, and the subsequent travel activities, impose several ecological impacts that should be taken into account in the appraisal process: decrease in habitat size; decrease in the interaction between species; interfered wildlife crossing; displacement of or damage to animals communities; damage to or elimination of vegetation, etc. Any attempt to value in monetary terms these effects will face some problems:

- When ecological assets and services have a public good character, their values might not be properly captured using individual WTP measures;

- -The lack of market and surrogate values for environmental assets and services prevent the use of the dose-response and averting expenditure approaches;

- Individual effects generated are only part of the total damage that can be imposed on a habitat, since the functions of an ecosystem depends on the interaction amongst its parts. These interactions are not well known and, therefore, (long term) effects on the ecosystem itself cannot be estimated.

- It might be possible to mitigate or remedy individual effects (e.g. replant tree species that have been cut), however it seems likely impossible to recreate an habitat with all its ecological functions. Therefore, the replacement cost method is also of limited use.

- Finally, it is difficult that the different monetary valuation techniques can capture all the values attached to environmental assets and services: direct use values, indirect use values, option values and existence use values. Only CV surveys can derive option and existence values.

Given all these problems, the valuation of ecological impacts through either ranking scores or descriptive statements seems more reasonable. Impacts can be ranked according to the magnitude of the impact and the ecological quality of the habitat. When impacts are to provoke a loss in the diversity of biological resources (loss of ecosystems or species or genes) or to damage an area of high ecological interest, the protection of the area should put a constraint to the design of the project.

Visual intrusion

Visual intrusion refers to the impact of the presence of traffic and/or transport infrastructures on an area of special beauty or of heritage or historical interest. Stated preference can be used to attached a monetary value to this visual impact. This highly subjective impact can also be ranked in an ordinal or cardinal scale or described.

Severance

Severance refers to the effects provoked on a community when its movement / mobility is obstructed by traffic or physical barriers. Stated preference methods to calculate WTP values could be applied. However, they may not be appropriated when severance in not fully perceived by the individuals. Since the impact does not imply actual payments, surrogate prices cannot be used. In contrast, the impact can be ranked in either a cardinal or ordinal scale.

Heritage/archaeological areas disruption/loss

Stated preference might be used to determine the value that individuals attach to heritage and archaeological areas. Preferences can also be revealed through the travel cost method when the site is located far from the urban centre requiring trips for visiting purposes. The use of these methods is likely to produce inaccurate values when those areas are of special global interest. In those cases, the protection of these areas should be a constraint for project design. In other case, damage provoked or to be provoked can be evaluated using the replacement cost method.

Table B18 summarises the previous discussion on the most appropriate valuation techniques for the different environmental problems.

Table B18: Proposed valuation techniques for transport environmental problems

ENVIRONMENTAL PROBLEMS	VALUATION TECHNIQUES
Local air pollution	Averting expenditure Dose-response functions Hedonic pricing/ Stated preference
Global air pollution	Averting expenditure Shadow price
Noise pollution	Averting expenditure Hedonic pricing Stated preference, Contingent Valuation Ranked scale
Water pollution	Replacement cost/averting expenditure Dose-response approach Stated preference, Contingent Valuation
Land taken	Adjusted market values/ Land opportunity cost
Land/soil degradation	Dose-response function + market prices Replacement method cost
Land amenity	Stated preference Revealed preference (TCM) Replacement cost method Ranked scales (ordinal, cardinal) Descriptive methods/experts' judgement
Ecological damage-biodiversity loss	Ranked scales (ordinal, cardinal) Descriptive methods/experts' judgement Replacement cost (for partial effects)
Visual intrusion	Stated preference Ranked scale
Severance	Stated preference Ranked scale
Heritage/archaeological areas disruption/loss	Stated preference Revealed preference (TCM) Replacement cost method

B.3.4 Example of the Use of Monetary Valuation (from the DGXII EXTERNE Project)

The following tables gives examples from the ExternE project [(11)] of the damage estimates due to vehicle use for passenger cars. These values are expressed in units of Euro/1000 vehicle kilometres (vkm).

Because the values are highly context specific, the analyst should obtain as much information as possible about the assumptions underlying the values in order that they can be determined as appropriate, or that adjustment for different circumstances in the study area can be carried out.

Table B.19 Damage estimates (vehicle use only) for diesel passenger cars in different locations, given as 'best estimate' in Euro/1000 vkm.

Diesel car	**Agglom-erations**	**Urban areas**			**Extra-urban a (motorway dr**	
	Paris (FR)	**Stuttgart (DE)**	**Amsterdam (NL)**	**Barnsley (UK)**	**Stuttgart-Mannheim (DE)**	**Tiel (NL**
Primary Pollutants						
Particles ($PM_{2.5}$)	534.09	50.43	78.60	97.40	18.77	29.5
SO_2	0.93	1.12	0.71	0.80	0.60	0.32
CO	0.02	0.003	0.003	0.005	0.001	0.00
Cancers	4.02	0.54	0.57	1.25	0.18	0.22
Secondary Pollutants						
Sulphates	0.59	0.82	1.30	0.63	0.68	1.10
Nitrates	18.18	9.14	2.70	2.82	7.24	3.80
Ozone	1.29	0.96	0.90	0.93	0.78	1.20
Global Warming	2.97	2.28	2.70	3.45	1.99	2.30
TOTAL	562.1	65.3	87.5	107.3	30.2	38.4

Note: [1] A = high confidence (a factor 2.5 to 4); B = medium confidence (factor 4 to 6); C = low confidence (factor 6 to 12); "?"=evidence is weak;
These figures should not be used without reference to the source material.
Source: EXTERNE project (11).

Table B.20 Damage estimates (vehicle use only) for 'three-way-catalyst' passenger cars in different locations, given as 'best estimate' in Euro/1000 vkm.

	Agglomerations			**Urban areas**			**Extra-u (motorw**
	Paris (FR)	**Athens (GR)**	**Milan (IT)**	**Stuttgart (DE)**	**Amsterdam (NL)**	**Barnsley (UK)**	**Stuttgart-Mannheim (DE)**
Primary Pollutants							
Particles($PM_{2.5}$)	53.41	n.q.	n.q.	3.73	1.96	4.17	1.10
SO_2	1.05	1.44	3.05	0.12	0.10	0.33	0.06
CO	0.06	0.04	0.13	0.02	0.02	0.025	0.004
Cancers	0.33	1.75	1.01	0.18	0.06	0.76	0.03
Secondary Pollutants							
Sulphates	0.66	0.22	0.43	0.09	0.21	0.26	0.07
Nitrates	16.14	1.62	2.78	4.58	1.60	2.76	5.89
Ozone	1.24	1.11	0.03	0.54	0.51	1.42	0.64
Global Warming	3.58	4.73	5.40	2.98	3.20	3.48	2.38
TOTAL	76.5	10.9[2]	12.8[2]	12.2	7.7	13.2	10.2

Note: [1] A = high confidence (a factor 2.5 to 4); B = medium confidence (factor 4 to 6); C = low confidence (factor 6 to 12); "?"=evidence is weak;
[2] Total for Athens, Milan includes no primary particles.
These figures should not be used without reference to the source material.
Source: EXTERNE project (11).