A RESEARCH PROJECT SUPPORTED BY THE EUROPEAN COMMISSION UNDER THE FIFTH FRAMEWORK PROGRAMME
AND CONTRIBUTING TO THE IMPLEMENT OF THE KEY ACTION "SUSTAINABLE MANAGEMENT AND QUALITY OF WATER"
WITHIN THE ENERGY, ENVIRONMENT AND SUSTAINABLE DEVELOPMENT

EVK1-CT-2002-00106

REPORT

September 2005

WP5 - SOCIO-ECONOMIC IMPACTS OF REHABILITATION STRATEGIES

D13 report: Rehabilitation impacts on socio-economic costs

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CARE-S - Computer Aided REhabilitation of Sewer networks

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Computer Aided REhabilitation of Sewer networks.

WP5 – Socio-economic impacts of rehabilitation strategies
Task 5.1 – Rehabilitation impacts on socio-economic costs

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ANNEXES:

1.1 The CARE-S project

The Computer Aided REhabilitation of Sewers network (CARE-S) project is funded by the European Community, under the fifth framework program and contributing to the implementation of the key action "sustainable management and quality of water". This project aims to establish a rational framework for sewer network rehabilitation decision-making and to develop a suite of tools, designed to assist sewer networks asset managers.

This project is organized in the following Working Packages (WP):

WP 1: Construction of a control panel of performance indicators (PI) for rehabilitation

WP 2: Description and validation of structural condition

WP 3: Description and validation of hydraulic performance

WP 4: Rehabilitation technology information system

WP 5: Socio-economic consequences

WP 6: Multi-criteria decision support

WP 7: Wastewater network rehabilitation manager

WP 8: Testing and validation

WP 9: Result presentation and dissemination

WP 10: Project management

1.2 Work Package 5: Socio-economic impacts of rehabilitation strategies

Knowledge and assessment of social and economic external costs can be useful for assisting decision-making in sewer network rehabilitation. External impacts of both failures and rehabilitation works are relevant criteria. Understanding of public perception and tolerance towards failures or works are needed for external communication and public participation. These are the topics addressed by WP5, which includes three tasks.

Task 5.1 Rehabilitation impact on socio-economic costs

The aim of task 5.1 is to help addressing the socio-economic ("indirect", or "external") costs linked to rehabilitation decision, i.e impacts of failures and impacts of rehabilitation works to third parties, by providing guidance and methods for assessing criteria representing these social costs:

- criteria for comparing a limited set of technologies when considering a given single pipe,
- criteria for comparing various rehabilitation projects, defined each at pipe level, given the related failures or failures hazards.

This task bases on both synthesis of literature (methods, results of studies) and analysis of real world data (claims, compensations, failure events…), and is very strongly linked to work packages 2, 3, 4 and 6. This report is, together with an Excel-sheet support for criteria assessment, the deliverable of task 5.1.

Task 5.2 Rehabilitation impact on social life quality

This task aims to achieve a systematisation of:

- what the different users perceive as being the costs, e.g economic, social or personal, of rehabilitation works;

- what are the public levels of awareness to the importance of maintenance actions, repair and rehabilitation of sewer and storm water networks; this identifies a need to evaluate the extent to which individuals are aware of non-intervention possible risks and consequences related to network failures;
- what are the levels of public tolerance to a set of interventions in their work or residential area.

Analysis of these topics is developed through the use of public inquiry methodologies (exploratory interviews, focus groups and questionnaire) in areas previously selected (case studies).

Task 5.3 Public acceptance and communication with public

Based on the interviews, focus groups and questionnaire surveys within task 5.2, this task aims to provide decision makers with a better understanding of public perception and acceptance concerning sewer systems failures and rehabilitation (needs and impacts). This is meant to enable better communication with the public: prior explanations on projects, public participation …

1.3 Task 5.1: Rehabilitation impacts on socio-economic costs

The aim of WP5.1 is to assist the user of the CARE-S decision support system in defining criteria which allow to take into account, directly or through coherent indicators, socio-economic costs of external impacts of either network failures (WP5.1b) or rehabilitation works (WP5.1a). These criteria can be used for decision making within WP6, as explained below, and uses results from WPs 2, 3 and 4. Deliverables of WP5.1 are this report, which delivers information about the external impacts and their possible valuation or representation within the CARE-S context, and two Excel spread-sheets (WP5.1a and 5.1b) which manage the information needed and assist the decision maker in assigning values to the criteria to be used by the WP6 procedure.

WP5.1 generic inputs/outputs and the way WP6 and WP5 procedures combine are explained below.

Selection of priorities among rehabilitation projects (around WP6.2)

Module WP6.2 acts in two different phases:

- WP6.21 identification of possible rehabilitation projects (1 rehabilitation project = 1 pipe)
- WP6.22 multi-criteria ranking for defining priorities on rehabilitation projects / pipes.

The sequence is the following.

- the rehab manager delivers to 6.21 data at pipe level from WP2/WP3
- WP6.21 returns to the rehabilitation manager a list of possible rehabilitation projects, defined as a list of pipe ID
- The rehab manager delivers input data to WP5.1b for each of the pipes chosen by WP6.21; the data needed are pipe characteristics and pipe environment data (the latter can be modified or completed by the end-user), results from WP2 and from WP3 all considered at pipe level
- module WP5.1b returns values for criteria on socio-economic impacts from failures
- WP6.22 gets from the rehab manager WP5.1b outputs and other needed inputs for the list of possible rehabilitation projects, and delivers a list of rehabilitation projects with priority ranks

As mentioned above, WP5.1b criteria are meant to help ranking pipes candidate for rehabilitation, considering their potential failures. These criteria, representing socio-economic costs of external impacts (definitions given in the next section) must hence take into account the potential effects a failure can generate, and the vulnerability of the concerned pipe environment to such effects. If an area shows no vulnerability to a given effect, in other words if there are no impacts, the criteria must show “no cost”.

As will be explained later, the occurrence of some failures are of probabilistic nature, such as wet weather flooding or blockages. This probabilistic nature must be taken into account, in a risk assessment approach for the criteria.

WP2 and WP3 will allow to consider the evolution of pipe condition and of potential failures. What about assessing future socio-economic costs through WP5.1b criteria? The decision met was to consider only the present situation, for the following reasons:

- though the socio-economic environment of a pipe may change, in average, slower that pipe condition, when changes occur they can be quite drastic (replacing an old industrial area by collective housing, having a 4 lanes connexion road created instead of a small street…); in any case, forecasting pipe environment changes needs case by case investigations and is less deterministic than the random evolution of pipes condition;
- rehabilitation planning considers time horizons for which land uses, population densities, road characteristics … are stable out of focused drastic changes like mentioned above.

Selection of a rehabilitation technique for one pipe (around WP6.1)

Module WP6.1 acts in two different phases:

- WP6.11: pre-elimination of non relevant rehabilitation techniques
- WP6.12: choice of one technique through multi-criteria ranking.

The sequence is the following.

- the rehab manager delivers to WP6.11 data for a given pipe (pipe and environment characteristics); 6.11 will also consider WP4 information on rehabilitation techniques
- WP6.11 returns to the rehab manager a list of possible rehabilitation techniques for the considered pipe
- the rehab manager delivers input to WP5.1a with necessary parameters for each of the techniques chosen by WP6.11; the data needed are pipe data and pipe environment data (the latter can be modified or completed by the end-user) and characteristics of the rehabilitation techniques chosen (data from the WP4 table)
- module WP5.1a returns values for criteria on socio-economic impacts from the pre-selected techniques, on the concerned pipe
- WP6.22 gets from the rehab manager WP4 and WP5.1a outputs for the list of possible rehabilitation techniques, and concludes on choosing a rehabilitation technique.

As mentioned above, WP5.1a criteria are meant to help ranking rehabilitation techniques which could be applied to a given pipe. These criteria, representing socio-economic costs of external impacts (definitions given in the next section) must hence take into account the potential effects a technique can generate, and the vulnerability of the concerned pipe environment to such effects. If an area shows no vulnerability to a given effect, for instance noise, in other words if there are no impacts (for instance area with no population and no established labour force), the criteria must show “no cost", and hence no difference to be made between two technologies whatever the noise created. If two technologies generate different levels of effects and consequently of impacts, for instance road surface neutralised, this must make a difference on the "traffic disturbance" criteria.

2 FRAMEWORK AND DEFINITIONS

2.1 What are social costs and why considering them

Sewer networks, whatever their physical level of tightness is, are open systems, much more open ones than most network infrastructures. Their inputs (from domestic and non domestic customers, infiltration, surface runoff…), their outputs (exfiltration, overflows, treated water outlet, slums…), but also their location mostly under public spaces (with consequences in case of failures, repairs and rehabilitation, maintenance…) determine this openness.

Hence, different failures and works will have consequences on persons, belongings, activities… which are external to the wastewater utility, and for which this utility may be liable (in legal, financial or moral grounds), even if these consequences may have no or limited counterparts in the utility budget and expenses. To whatever extend it may be, the utility cannot overlook external consequences of its actions or of the network operations.

The public nature of wastewater utilities, whatever runned and managed by public or by private structures, is a general fact due probably to the importance of sanitary and environmental stakes, but also due to the natural monopoly of such networks. External consequences are the more a stake for the utility, either managed or controlled by local, regional and/or national government bodies.

In practice, the surveys done (the general CARE-S initial survey, with results presented in annex 1, or WP3 survey done by TU Dresden) show that either regulation or management concerns address to some extend external consequences of failures or of works. This may be not or poorly formalised. These consequences may not be assessed or represented as such, but they are underlying to decision criteria or standards.

Inside the CARE-S decision support system, the decision was met to address explicitly at least part of the social costs, which could in a first approach be defined as the value given to external consequences to third parties. The definitions below will be considered further in WP5. Examples are given in the following sections.

DEFECT or FAULT

established condition of the pipe which does not comply with the nominal design and has a lower potential for functionality or use

(definition inspired by RERAU – French national project on rehabilitation of sewer networks)

PERFORMANCE DEFICIENCY

temporary operation or behaviour of the pipe or of the network which does not comply with the general or basic objective; this deficiency is linked to a *defect* and can be linked to an external trigger event such as rain

(definition inspired by RERAU – French national project on rehabilitation of sewer networks)

FAILURE

termination of the ability of a pipe or of a network to perform a required function; a failure is a *defect* or a *performance deficiency* and is defined in reference to a required level of performance

(definition inspired by French AFNOR standard on maintenance terminology NF EN 13306)

EXTERNAL EFFECTS (due to *defects/performance deficiencies*) physical changes, due to the *defect* or *performance deficiency*, which impact the “world outside” the undertaking (example: presence of rainwater on a street because the condition of the pipe has decreased the hydraulic capacity, which would otherwise have been sufficient to avoid flooding for this rain event); the “undertaking” is the public or private company or organisation which is in charge of the sewerage service and of the corresponding assets

EXTERNAL EFFECTS (due to rehabilitation works)

physical changes, due to rehabilitation works, which impact the “world outside” the undertaking (example: presence of work areas in the street); the “undertaking” is the public or private company or organisation which is in charge of the sewerage service and of the corresponding assets

EXTERNAL IMPACTS (due to *defects/performance deficiencies* or to rehabilitation works)

consequences of *external effects* on persons, on activities, on private and public properties and items or on the environment (example: traffic disturbance due to street flooding or to works)

SOCIAL COSTS (due to *defects/performance deficiencies* or to rehabilitation works)

assessment / valuation of *external impacts* ; social costs represent costs incurred by society (including sewerage service customers) as a result of sewerage works or of failures, and for which utilities or companies have no direct responsibility apart from possible compensation; if there is a compensation, the net social costs are the social costs minus the compensation amount

(definition inspired by AWWARF)

2.2 Impacts of sewer pipes failures

2.2.1 Defining risk, vulnerability

Literature on risk issues is full of risk definitions. Minimalist risk concepts coexist with broader risk views.

The most common concept of risk still is the one sponsored by technical risk analysis, where risk is defined as the product of probability of the occurrence of a specific hazard by the expected value of hazard consequences. Underlying causes tend to be circumscribed to physical phenomena and consequences to tangible damages (number of fatalities, injuries and, in some cases, material damages).

Nevertheless important, technical approaches reveal some limitations. These ones tend to disconsider risk parameters that cannot be easily transformed into a numerical value. Besides, as refers Renn (1992), they assume a mirror relationship between observation and reality and do not consider that causes of harm and its consequences are both mediated by society and human action.

Although behindhand on the study of risk issues, social sciences had the merit of calling attention to human action interference on the magnitude of, at least, some risks.

But, the existence of a plurality of approaches[1] weakens social sciences contribution for a better understanding of risk. Anyway, it should be emphasised that what unifies social sciences diverse approaches is the assumption that the way humans perceive, transform and manage environment and human activity has an influence on risk severity. The recognition of an environmental hazard as a source of risk is largely dependent of human perception. But, public risk awareness does not generate *per si* risk mitigation. Several societal factors may function as blockade. These ones can range from societies economic incapacity to devote resources for risk mitigation to the political or individual prioritisation of other sectors or stakes than the risk one.

Given this, risk configuration depends, a great deal, from the web of relations that link *society* with (built or non-built) *environment,* in time and space. This web of relations dictates the degree of vulnerability of a society towards a certain risk.

2.2.2 Wastewater and storm water risks

Sewer and storm water networks are open systems. Their inputs (from domestic and non domestic customers, surface runoff…), their outputs (overflow, treated water outlets…), but also their location mostly under public spaces (with consequences in case of failures), determine this openness.

In general terms, two major types of risk endanger wastewater systems and their immediate environment: *silent* or *slow manifestation* risks and *sudden* or *abrupt* hazards. Exfiltration and infiltration phenomena are examples of the first mentioned type of risk. Sewer collapses and blockages are examples of the second ones. But, in what conditions does these phenomena turn into failure events?

Not every sewer abnormality gains the form of failure. By failure, we mean the inability of a pipe or network to perform the required function, impeding sewer system of accomplishing the level of performance to which he was designed. Besides sewer performance, the difference between failure events and other minor abnormalities (which can be called as defects or faults) depends on "world outside" characteristics and extent of damages.

Above, it was mentioned that vulnerability towards risk varies according to the type of relationship between environment and society. Trying to concretise this assumption to our specific object, we would say that consequences of sewer hazards are on the one hand, dependent of event characteristics and, on the other, of built environment and societal characteristics. They can be synthesised as follows:

— *Characteristics of the event*: *magnitude*, *intensity*, *timing and duration*

  Magnitude refers to the amount of disruption that an event (such as a structural collapse, sewer blockage, etc) provokes on the sewer system. *Intensity* refers to the rate of change the event provokes on the normal system functioning. *Timing* refers to the period of the day that the event occurs. *Duration* refers to the length of time associated to the event, from its detection and manifestation to its resolution.

— *Environment and network characteristics*: *Climate and its contingencies, built environment characteristics, wastewater and storm water type of infra-structures and management*

[1] Almost one per social scientist.

Climate contingencies, expressed on sudden heavy rain events, are known environmental conditions, which introduce some degree of vulnerability to sewer and storm water systems. Lower or higher levels of vulnerability are, in turn, dependent on those systems characteristics (type of network, discharge and drainage capacity…), amount of impermeable surfaces, type of building structure and related uses. Concerning sewerage modes of management, we emphasise that reactive approaches tend to higher vulnerability, by comparison with pro-active ones, where prevention is a priority.

— *Population characteristics*: *demographic and socio-economic population characteristics*, *risk perceptions and protective behaviours*

Demographic and socio-economic population characteristics are especially important in relation to sewer flooding. Several studies (Green and Penning-Rowsell, 1986; Parker, 2000) have demonstrated that these two dimensions influence the intensity of impact and time of recover induced by floods.

To summarise, we would say that *consequences of a hazard* result from the combination of agents related with specific characteristics of the event (i.e. magnitude of collapse, depth of the flood, volume and duration of effluent discharge to a river channel), network conditions and type of land-use and social group.

2.2.3 conceptual scheme

The scheme below displays the concepts introduced with the above definitions. Vulnerability has not been introduced in the definitions: we will define it as the quantity of "stakes" which can be exposed to external effects (population, goods, activities, natural patrimony and resources…) and the fragility of it towards the effects.

Let us consider three examples.

1° the pipe is not tight, and there is exfiltration

We will consider this exfiltration as a continuous phenomena, even if during rains the increased water level inside the pipe may increase exfiltration. The defect is non tightness, and the misfunction which exists without an external trigger is exfiltration. The external effect will be wastewater released in the soil and possibly in the groundwater. The pollutant transfer effect will depend on exfiltration discharge, soil type (permeability…) and distance to groundwater. The initial quality of the groundwater, the global volume and dynamics (flow speed, renewal period…) and the present or future water uses (which may be sensitive to this pollution) will be the parameters accounting for vulnerability. The consequences on present and future water uses will be the external impacts, and the valuation of these impacts are the social costs.

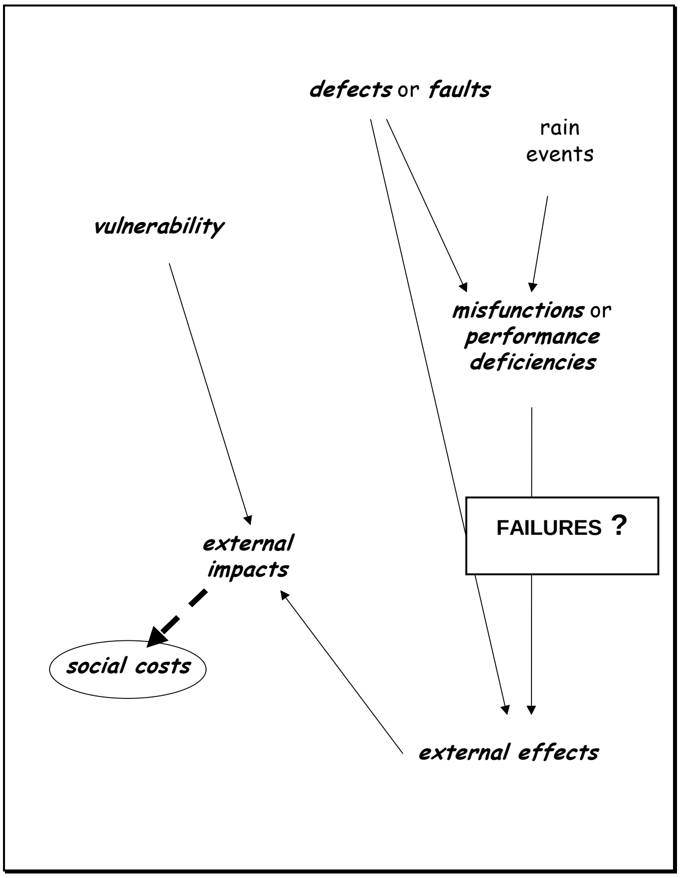
2° the pipe has a reduced hydraulic capacity

This means that during any rain, the water level inside (or outside) the pipe will be higher upstream from that pipe, and that there will be overflows, in basements or on the surface, more that if the condition of the pipe was good; the differential in hydraulics as soon as it shows outside the network will be the effect of the misfunction. People, goods, activities, traffic… in the area or in the buildings which will be more flooded than "normally", together with their sensitivity to flooding, will constitue the vulnerability. All types of damage or disruption will constitute the external impacts.

3° the pipe has a structural collapse

This defect may have several consequences, for instance in terms of flooding, odours… Let us consider the case where this collapse leads to surface soil depression: the defect "collapse" has a direct external effect, soil depression. The vulnerability of the pipe environment will depend on soil use, traffic if it is a road… And external impacts may, according to the situation, be damage to road structure, traffic disruption or at least (increased) traffic jams…

One crucial point is that we should logically only take into account those defects and misfunctions which are to be considered as failures. Minor blockages in separated wastewater pipes may not be failures, though they are defects. A flooding event due to a rain which exceeds the network design and the regulation or standards, and which is not increased by the hydraulic operation and condition of the network, is not a failure of the network.



2.2.4 definition of failures

Let us recall the definition proposed for "failure": *termination of the ability of a pipe or of a network to perform a required function; a failure is a defect or a performance deficiency and is defined in reference to a required level of performance*.

A defect or a misfunction would be a failure if they do not comply with either:

- the regulation and compulsory standards ?
- voluntary standards ?
- the initial design and foreseen operation conditions ?

- the will of the utility manager / utility owner ?

In work done for CSIRO, the concept of "externalities" introduced could be defined in reference to our framework as "consequences of a failure": these externalities occur when regulatory limits are violated, or when the situation changes from an accepted status quo (Speers et al 2000, Young 2000).

The non compliance can be defined, measured, characterised through:

1. the existence or occurrence of the defect or misfunction (for instance a structural pipe collapse)
2. the frequency of the defect / misfunction[2] (for instance a combined overflow exceeding the permitted frequency)
3. the intensity of the defect / misfunction (for instance non tightness leading to infiltration exceeding a given percentage of dry weather flow)
4. the occurrence of the misfunction given the frequency of the trigger event (for instance flooding occurring for a rain of small return period); it would be probably accepted that a network overts with a 100 years storm if the network is designed for a 10 years storm, and provided the condition of the network does not make this flooding significantly worse
5. the consequences of the defect / misfunction (for instance odours due to small blockages).

Annex 1 shows the results of the internal CARE-S survey concerning regulations on performance, standards … regarding failures. There is a major diversity of situations. Defining the boundaries of failures is a local issue, at undertaking and local government levels. Even if there are national standards, the wastewater service may decide to "do better" and to be more self-demanding towards failures.

2.2.5 who bares the external impacts, where are the social costs ?

External impacts are consequences of failures effects on third parties. But this does not mean that these third parties bare all the impacts. If the wastewater service pays for compensations, this reduces the social cost suffered by these third parties (hence the "net social costs" representing the "remaining part"), and increases the internal cost for the undertaking. If compensations are covered by the undertaking's insurance, it will also reduce the net social costs and increase indirectly the internal costs as the undertaking has to pay for the insurance contract (on a "permanent basis", and not for each failure).

For exceeding pollution discharge, the undertaking may also pay for pollution taxes (according to the polluter pays principle), this money being used to enhance the aquatic environment. In that case, we should consider that the net social costs of the pollution are reduced by the amount of pollution taxes, and that these taxes are part of the undertaking internal costs. In case of a "fine", which would not be used for the sake of water resources, the net social costs would not be reduced (as the pollution is not made for), but the internal costs increased.

Annex 1 gives an idea of the diversity of situations among countries and CARE-S end-users, as far as compensations are concerned. The difference between social costs and net social costs will depend on each local regulation or policy. We should therefore

[2] The Middlesex University Flood Hazard Research Centre (Green et al 1993, Tunstall et al 1993) performed a survey for OFWAT on the perception of water and sewerage customers: the majority of people ask for being exposed to less than 2 network flooding every 10 years. Flooding is generally considered worse than having a car stolen, and as serious as a fire in the kitchen with the fire brigade being obliged to intervene.

address “whole social costs”. But on the basic principle, net social costs excluding direct or indirect compensations should be taken into account. If these compensations where fair and comprehensive, they could be a good assessment for social costs.

2.2.6 failures, effects and impacts considered

Possible defects, misfunctions and external effects are numerous and varied. So are failures. We can only address defects and misfunctions for which there is information available about their possible occurrence, intensity, and/or probability, and which are to be considered as failures. Moreover, the question is then to link the external effects with their occurrence / characteristics / intensity / probability to the failure events, and the impacts to vulnerability and to effects. Failures can only be taken into account as far as they are addressed and described, to whatever extend, in “technical” terms in WP2 and WP3 outputs.

For the effects which are of probabilistic nature, we have to consider the notion of risk: probability times consequences, the latter being the crossing of effects intensity (water height…) and vulnerability. Effects can also be, to some extend, “random” towards defects or misfunctions:

- blockages may or may not generate dry weather wastewater flooding in basements or on the soil surface
- blockages and collapses (and more generally structural failures) may or may not induce problems of odours, insects, rodents
- structural pipe collapses may or may not induce soil depression.

In that case, it is not possible to address the chain [defect or misfunction → external effects → impacts], in a deterministic or even full probabilistic way. As will be seen later, the choice was met to consider “threat factors”, combining the probability of the “trigger failure” (blockage, collapse, structural failure) with a vulnerability indicator to the possible external effects (dry weather flooding, odours and soil depression) : for instance, this would mean combining probability of pipe collapse with road traffic. This must in no way be considered as a “risk”, as we miss the probability of the damaging effects. But such a “threat factor” combines the “best available” information accounting for the potential risk situation.

The table below displays the failures, effects and impacts taken into account in WP5, and described in more detail in the next chapters. The numbers relate to the types of impacts addressed in WP5 and for which criteria are considered.

		DEFECTS AND MISFUNCTIONS				
		wet weather floodings (with probability)	blockages (with probability) in dry weather situation	structural pipe collapses (with probability)	combined sewer overflows	exfiltration
	are they considered as failures ?	choice of end-user according to probabilities of reaching given levels	all of them	all of them	choice of end-user according to a set of parameters	any
	through outputs from	WP3 (hydraulics) considering structural condition (WP2)	WP2	WP2	WP3 considering structural condition (WP2)	WP2
E	presence of water in basements	1, 2	8			
F	presence of water on soil surface	1, 2, 3	9			
F	presence of water on buildings ground floor	1, 2				
E	pollution discharge to surface receiving waters				4	
C	pollution of groundwater (defined through "groundwater vulnerability" WP3)					5
T	no discharge possible to sewer		6			
S	soil depression			7		
	odours, insects, rodents		10	10		

1: flooding damage to buildings and their contents, and business losses

2: flooding intangible damage

3: traffic disruption and trouble due to flooding

4: degradation of surface water quality and consequences on present or future water uses

5: degradation of groundwater quality and consequences on present or future water uses

6: wastewater service interruption

7: traffic disruption and trouble, annoyances to life quality, due to soil depression

8: annoyances and damage from dry weather flooding in basements

9: annoyances and damage from dry weather flooding on the street

10: annoyances due to odours, insects, rodents.

Among the failures not considered for socio-economic impacts, we should mention wastewater treatment plant performance reductions due to clean water infiltration. Two reasons account for not considering it:

- this phenomenon, more than any other considered here, is a cumulative one over the whole network upstream from a wastewater treatment plant; identifying and quantifying the contribution of a single pipe is quite cumbersome;
- the effect on the receiving water is due to the operation of the whole sanitation and treatment system, which can be assessed, but makes it the more difficult to identify a quantitative or ranking criteria.

2.3 Impacts of rehabilitation works

2.3.1 effects and impacts considered

These situations are quite simpler than failure ones, as we consider rehabilitation works with different techniques (as described and characterised by WP4) which will happen in a given location (a pipe with its socio-economic and physical / biological site environment). The possible effects are those addressed in the WP4 database, directly or indirectly:

- noise
- dust
- groundwater pollution hazards
- service interruption
- external surface neutralisation (digging, working areas) leading to traffic disturbance and annoyances, and losses of business independently from traffic consequences (smaller attractiveness of shops…).

The same conceptual description in terms of external effects, vulnerability and external impacts can be done as for failures, but in a more usual and simple way. The works are a certain event, and we can consider that all (or the major part) of the effects are quite deterministic.

The consequences to people (inhabitants, service customers, non residents like labour force and by-passers), to activities and traffic, to groundwater resources and uses are addressed in terms of external impacts.

The duration of works will have an obvious influence on the external impacts. Inside the WP5 procedure, based on information available on pipe (length) and techniques, the DSS user will be able to assess the duration for each technology, by considering among others the linear performance of the rehabilitation technology.

2.3.2 who bares the external impacts, where are the social costs ?

The same comments apply here, as for the impacts of failures, as far as compensations are concerned, either directly or through insurance (see 2.2.4). And, with the same idea, we will consider complete social costs instead of net social costs (see also annex 1 for compensation practices among “CARE-S countries and end-users”).

2.4 Typologies considered for describing the pipe environment

For describing and possibly quantifying various components of vulnerability, we may consider an endless detailed description of population, buildings, river quality and morphology… Not only is there a limitation in available and manageable information, but moreover the decision maker has to be proposed a “reasonable” trade-off between detailed description and quantification on one hand, time and resources for processing on the other hand. This is true for hydraulic modelling as well as for socio-economic parameters. The paragraphs below show the way we chose to describe various dimensions of the pipe and network environment.

2.4.1 land uses

Dealing with vulnerability leads to taking into account different land use types, as they include for instance different population densities, different commercial activities… A CARE-S common typology for various tasks and WPs has been chosen, corresponding to the typology addressed by standard EN752 for recommending levels of flood protection :

- rural
- urban housing
- city centre
- industrial area
- shopping area.

The decision-maker must also be able to define “special areas or buildings”, in a case-by-case way, for especially sensitive or special places (hospitals…)..

2.4.2 roads and traffic

Roads and the corresponding traffic are described by several parameters:

daily traffic flow: number of vehicles per day

number of lanes: absolut number for a street section

public transport through 5 classes

0 No public transport

1 Bus traffic with low frequency

2 Bus traffic with heavy frequency

3 Tram traffic

4 Tram + bus traffic

heavy vehicles traffic: presence or not.

2.4.3 groundwater types and uses

These are classified according to potential vulnerability:

- protected area for drinkable water production
- drinkable water production
- private domestic wells
- other sensitive water uses
- other water uses
- no water use
- no groundwater

2.4.4 receiving surface water types and uses

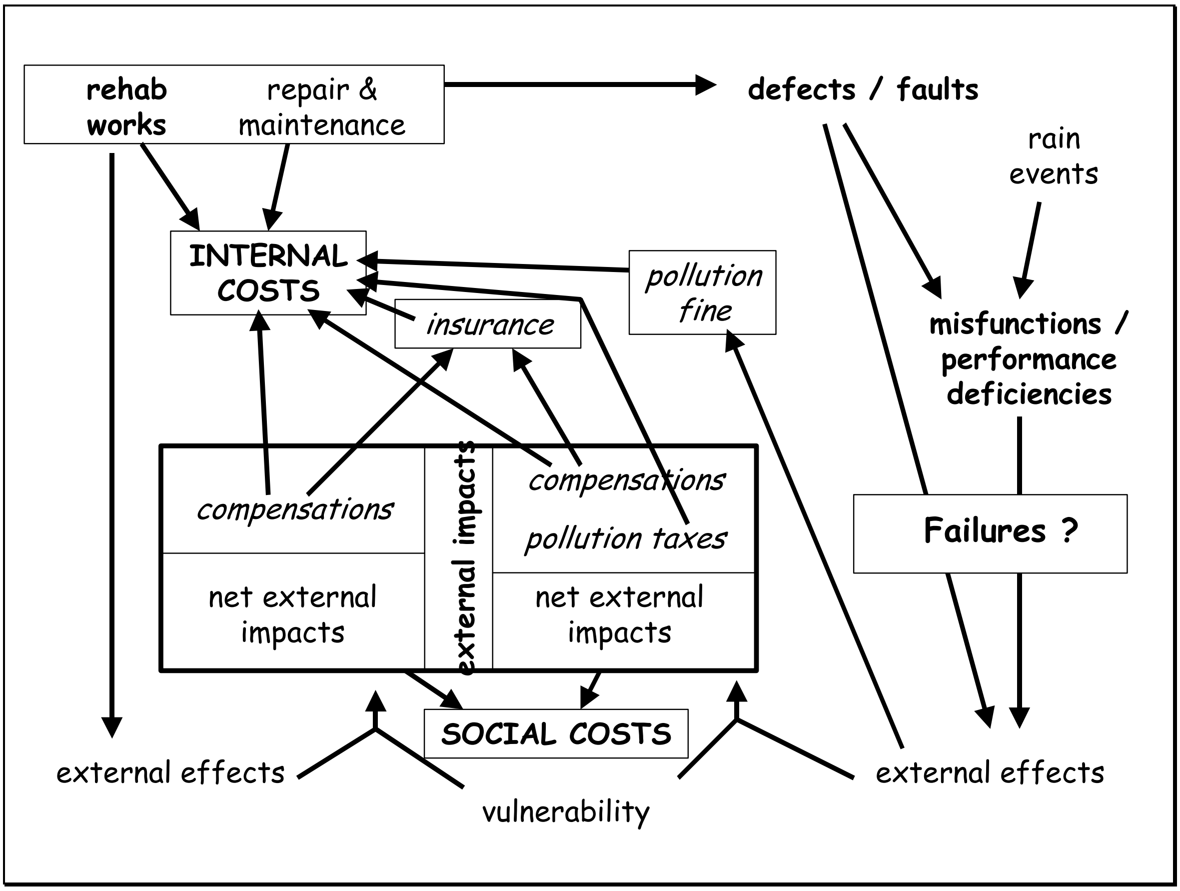
These are classified according to potential vulnerability:

- protected area for drinkable water production
- bathing area
- shell fisheries
- drinkable water production downstream
- fishing
- ecological area (protected / non protected)
- other sensitive water uses
- other water uses

2.5 Global conceptual scheme

The following scheme displays on the right side defects, misfunctions, external effects, on the left side rehabilitation works, effects. In the lower centre are external impacts with teh costs. In order to close the scheme, repair and maintenance were also displayed, and the various types of internal operation and investment costs which are linked to either rehabilitation or failures.

Social accompaniment and claims management are not displayed here: obviously, rehabilitation works necessitate preliminary information to the population through various means, as well as preventive measures for reducing possible external impacts. During and after works, as well as during and after failures, there may be claims management tasks, and other social accompaniment measures and actions in order to reduce social impacts and costs. All these tasks, which can be performed to varying extends, will of course generate operation costs on their own, as a trade-off to bigger social costs.


rehab works
repair & maintenance
defects / faults
rain events
INTERNAL COSTS
insurance
pollution fine
misfunctions / performance deficiencies
compensations
external impacts
compensations
pollution taxes
net external impacts
net external impacts
Failures ?
SOCIAL COSTS
external effects
vulnerability
external effects

3 DEFINING CRITERIA ON IMPACTS OF REHABILITATION WORKS

The criteria worked out in the frame of WP 5.1.a module are provided for the multi-criteria approach developed in WP 6.1, for choosing the best rehabilitation technique.

Besides the technical criteria such as the type of defects existing on the pipe, the soil quality, the technical durability, we focus here on the impact of rehabilitation works on the socio-economic environment.

The specificity of rehabilitation works compared with potential failure impacts is that information on the environment of the pipe and the present vulnerability can be known but in the opposite, duration of works may be longer and the impact zone larger than for a failure.

Some impacts can be reduced by choosing the most accurate time for doing works and by choosing a technique reducing impacts, for example a trenchless technique, or by making the works step by step and not all a street long at once.

(AÏT-AÏSSA 1997) gives a detailed list of direct and indirect potential impacts, external impacts in our terminology. Direct impacts come from physical action due to works on goods, activities, persons, indirect impacts are resulting from direct impacts. Both can be immediate or delayed and indirect impacts will be located either on the direct impact area or out of the works zone.

Direct impacts	on city environment	On residents
bus stations suppression		X
taxi stations suppression		X
Parking places reduction	X	X
Reduction of land space	X	X
Damage on road cover	X	X
Security of elderly people	X	X
Security of children	X	X
Security of public	X	X
Workers open to fall	X	X
Air pollution	X	X
Noise and vibrations	X	X
Dust and dirt		X
Contact with mud		X
Odours and water sinking	X	X
Works installation	X	X
Deterioration of the urban landscape	X	X
Signalling		X

Damages in parks	X	X
Material stocking	X	
Water pollution	X	X
Landslide	X	X

External impacts	**on city environment**	**On residents**
Car traffic disturbance	X	X
Emergency vehicles accessibility	X	
service vehicles accessibility	X	X
Pedestrians and handicapped accessibility	X	X
Bicycles accessibility		X
Delivery vehicles accessibility	X	X
Risk of car accidents	X	X
Works machines circulation		X
Completions after works (embakment)	X	X
Visual disturbances	X	X
Deterioration of existing networks	X	
Damages to buildings	X	X
Household refuse collecting	X	X
Reduction of commercial activity	X	X
Deviations and delays		X
Deviation or interruption of bus lines		X
Traffic of lorries		X

So disturbances are varied in type and in intensity.

The criteria considered here, for external socio-economic impacts, are meant for representing the severity of these impacts and for being able to compare and rank alternative rehabilitation technologies, for a given pipe located in a given place.

The list of criteria has been designed in order to:

- consider impacts which have an influence on decision making
- take into account the characteristics known for the different rehabilitation technologies, which make differences among the alternatives in a given city area

- group the impacts which are more or less homogenous for a given technology

Concerning quality of life:

NOISE – DUST – SERVICE INTERRUPTION – ROAD/TRAFFIC DISTURBANCE – LOSS OF TRADE

Concerning environmental damages:

POLLUTION OF GROUNDWATER

3.1 WORKS CRITERIA – calculation principles

All the following criteria can be calculated with the SOCIOWORKS tool developed on an excel sheet, within the CARE-S software environment.

3.1.1 Duration of the works

Most of criteria will take into account the **duration** of the works, considering that the impact does only exist during the effective time of the works (all criteria except the ground water pollution). Either this duration is known in days either (it is the case in the socio-works tool) it is calculated by performance data given for each technology.

3.1.2 Day or night works

The general situation is that works are done by day, but in some cases essentially to reduce the socio economic impacts, it can be decided to do works by night. This will reduce the impacts on one hand ,expect for noise, but will, on the other hand, increase the direct costs of rehabilitation essentially concerning labour force costs.

To take into account the effect of night works we introduce a coefficient N, multiplying the “day works criteria” to obtain a “night works criteria”, with the following values:

criteria	Value proposed for N
Noise	10,00
Dust	0,50
Service interruption	0,25
Traffic disturbance	0,30
Loss of trade	0,30

3.2 WORKS CRITERIA - IMPACT OF NOISE

3.2.1 What we know about

3.2.1.1 Noise effects

Considering noise and designing a criteria for mitigating it, raise a set of questions that should get an answer. They can be synthesised as follows: when does noise, that is to say an unwanted sound, become a source of annoyance and induce on a decrease of well being of those who are exposed to it? What type of impacts does noise provoke on individuals and communities?

Noise annoyance or degree of unwantedness of a particular sound is essentially a property of the noise source (type, intensity, duration or frequency), but is also rather influenced by the characteristics of the individual receiver as well as the listening situation and environmental context (FLINDELL and in FAHY 1996). This means that, as (BURGLIARELLO 1976) poses, the difference that may exist between loudness of an unwanted sound and the annoyance it causes isn't totally explained by acoustic variables. A variety of sociological, psychosocial and physiological parameters generally interfere in individual and community reaction to noise[3]. Concerning this, it is worth to mention that individual-related parameters usually viewed as potentially more interfering are the sociographic ones, such as age, gender, occupation and social class; personality dimensions, namely neuroticism, and general attitudinal positions towards the source of noise, environment, quality of life, etc [SOCZKA, 1980 #69].

Noise can have a wide range of impacts on people. Hearing loss is probably among the worst health consequences of noise pollution. Indeed, this particular impact appears as a real risk especially on situations where individuals are exposed to high-level sounds (i.e. workers on heavy industry or similar activities). Lower level sounds tend to cause other type of impacts than the above-mentioned. We refer specifically to psychological and social consequences, such as irritability, speech communication interference in work and domestic contexts, and in some situations, disturbance of economic activity (i.e. trade) (see Table below).

TABLE. Main impacts of noise pollution on individuals

Physiological impacts*	Hearing loss
	Cardiovascular effects
	Gastric effects
	Fatigue
	Sleep disturbance
Psychological impacts*	Irritability
	Tenseness
Social impacts	Speech communication interference
	Interpersonal relations disturbances
	Disturbance on trade (loss of clients)

*Source: (BURGLIARELLO 1976)

3.2.1.2 Construction noise

In general, people tolerate noise more easily **if they are causing it**, **if they feel it is necessary**, if they **know where it is coming from** [BURGLIARELLO, 1976 #67]. Concerning construction noise, at least the first condition for tolerance is not met. Apart from workers, noise induced by construction — be it a building, a bridge or a sewer — may generate major impacts for those who live or work nearby. Indeed, being aware of the importance of works, knowing from where it comes from and for how long the noise will occur contributes actively to avoiding public intolerance and annoyance.

Construction noise is fundamentally the product of machines and processes involved in construction. As can be seen through Figure 1, equipment used on public works can reach sound levels considered as high (compare data from Figure 1 with data from Table below).

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[3] This is based on a significant amount of surveys that have been made along the past decades, with the general aim of defining noise annoyance standards. These surveys show that equivalent sound stimulus may be perceived as absolutely unbearable and totally tolerable by the same individuals under different situations, and by different individuals under the same situations [SOCZKA, 1980 #69].

Figure 1. Noise ranges of a sample of construction equipment (United States, Environment Protection Agency)

Source:(BURGLIARELLO 1976)

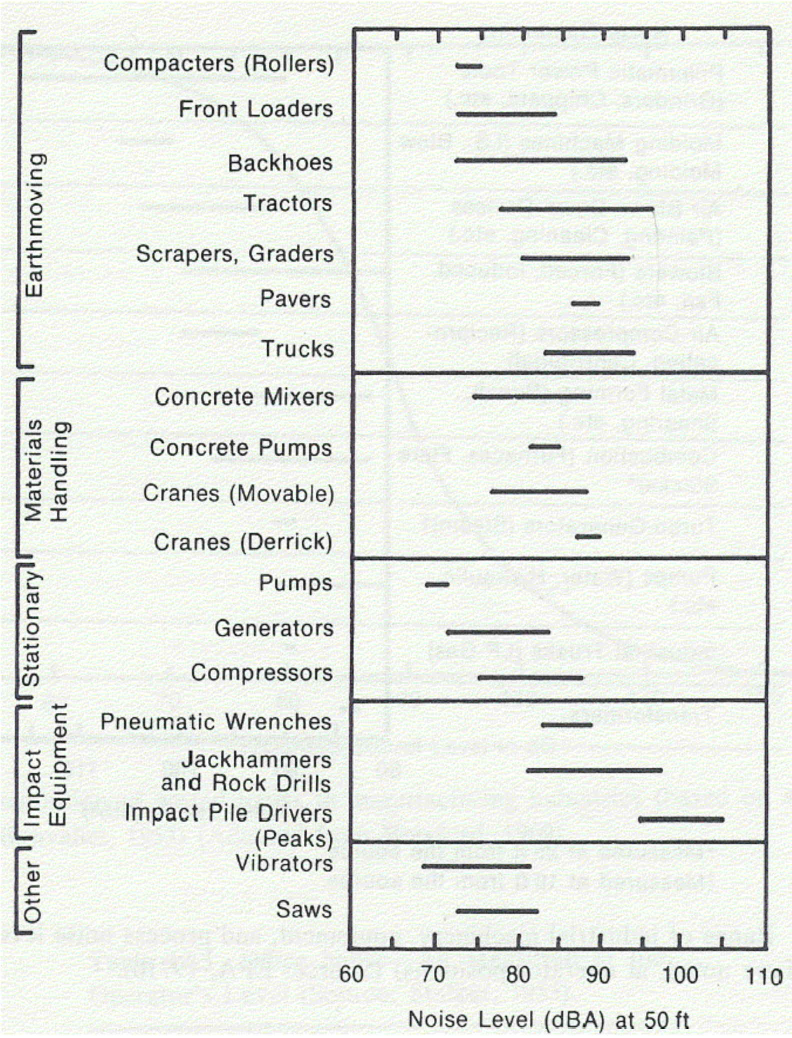

Table. Classification in terms of background noise of urban and suburban detached residential areas (United States, Environment Protection Agency)

Description	Approximate daytime residual noise level	
	Typical range dBA	Average dBA
Quiet suburban residential	36-40 inclusive	38
Normal suburban residential	41-45 inclusive	43
Urban residential	46-50 inclusive	48
Noisy urban residential	51-55 inclusive	53
Very noisy urban residential	56-60 inclusive	58

Source: (BURGLIARELLO 1976)

As can be seen through the above-mentioned Figure, potential noise of construction equipment may range from the 60 decibel, weighted A(dBA), to the 100 dBA.

One of the specificities of construction related noise is its temporary character. Given this, psychological and social impacts, such as irritability, speech and trade disturbances, appear as the most probable types of impacts. Nevertheless, physiological effects should not be disregarded, especially in what concerns tiredness and sleep disturbances. Interference with sleep is usually not a problem as long as construction is carried out during daytime. However, we should not disregard the fact that there is an amount of people who hold night jobs and sleep during daytime. Consequently, this specific social group may be affected by construction noise (BURGLIARELLO 1976).

Special attention must be taken towards the type of *background environment* of construction-target area. There are areas, such as those that have schools[4] and hospitals, where construction noise can become particularly disturbing.

Anyway, we emphasise once again the importance of contextual and circumstantial variables, when approaching to the construction noise related impacts. An equivalent sound level can be a source of disturbance for some individuals and insignificant for others. Contextual variables, such as the sociographic ones and attitudinal ones mentioned above, won't enter on CARE-S criteria definition for noise impacts. Its extreme variability doesn't allow it.

Finally, concerning circumstantial variables, we emphasise the factor *duration of works* and *time of exposure to the source of noise.* These two aspects may also influence the degree of potential annoyance. Long-term public works have characteristics for being more annoying, than short term works. One day of noise exposure is potentially more annoying than a couple of hours.

3.2.2 What we propose for CARE-S criteria calculation

CARE-S criteria for noise pollution impacts considers works scenarii as compared to a non-rehabilitation scenario, so-called as *reference situation*. Both scenarii have attached the maximum values of acceptable background noise, considering that values of *reference situation* correspond to a scenario where background noise does not induce on any kind of noise pollution hazard or annoyance.

3.2.2.1 Detailed valuation

Values of background noise for both scenarios correspond to the sound level continuous equivalent (L_{Aeq}), expressed on decibels (dB), weighted according to "A" scale (dBA)[5]. It should be emphasised that the descriptor for sound level ($L_{Aeq,}$ dBA) give us the sound pressure of a uniform noise, integrating the fluctuant sound levels and its variations [DOMINGUES, 2001 #71].

For the construction of above-mentioned scenarios and related background noise criteria we privileged the following variables:

- Land-use type

  CARE-S land-use typology was adopted, with slight modifications. We considered the categories *urban housing, city centre*, *industrial area* and *shopping area* and eliminated *rural area* category. Rural areas comprehend housing specialized spaces as well as some shopping or industry activities. In such cases, the type of land-use must be identified in detail and criteria for noise impact assessment should follow the ones defined for *urban housing*, *shopping* area or other. Besides, it should be emphasised that a *special area* category was added, with the aim of defining noise criteria for areas composed by specific infra-structures or buildings, i.e. schools, day-nurseries, hospitals, etc.

- Day period

[4] There is an amount of research on aircraft noise effects that suggest the influence of such noise pollution type on scholar achievement. Besides, as far as construction noise is concerned, this type of noise pollution can induce on temporary teacher-students speech interferences and cause fatigue.

[5] Human ear is efficient at blocking out very low and very high-frequency sound. Given this, for a more accurate representation, units of sound measurement (dB) are usually weighted, according "A" scale [Edina, 1998 #70].

This variable follows the 24h-day period typology of UE Directive (2002/49/CE) on assessment and management of background noise. This one is composed by three periods, as follows: *day* 07h-19h; *evening* 19:00-23:00; *night* 23:00-07:00. For rehabilitation works background noise, it was taken into account the *day* and *evening* period, on the assumption that, if noisy, these types of construction works tend to be programmed for day periods, especially when happening in residential areas.

- Exposure to noise (in hours)

As mentioned in the above section, noise annoyance tends to increase with the degree of human exposure to the source of noise. In other words, over shorter periods, one can tolerate higher level of noise. Given this, works scenario and criteria definition stand on a variable *time* (*T*), composed by five categories: (a) $T \leq 1$ *hour*; (b) 1 *hour* $\leq T \leq 2$ *hours*; (b) 2 *hours* $\leq T \leq 4$ *hours*; (c) 4 *hours* $\leq T \leq 8$ *hours*; (d) $T \geq 8$ *hours.* This typology follows what is stabilised in Portuguese legislation, for temporary noise events such as public works construction.

Once presented the variables underlying noise criteria definition, criteria for noise pollution assessment will be described, having the non-works scenario as a reference.

As can be seen through the next table, areas considered as non-noisy are the ones in which the *maximum sound level* or pressure (L_{Aeq} R) standard dBA varies between 55dBA (for housing and special areas) and 65 dBA (for city centre, industrial area and shopping area), during the day. In the evening and night periods, standard values for L_{Aeq} R go from 5 dBA (for housing and special areas) to a maximum of 55dBA (for city centre, industrial area and shopping area).

Threshold criteria for controlling the noise induced pollution and annoyance, in case of temporary public works, such as sewer works are the following:

A. For *housing* and *special areas*

Day period ($L_{Aeq}\,W = L_{Aeq}\,R + 5$ dBA) ($L_{Aeq}\,W, T = (L_{Aeq}\,R + 5$ dBA$) + Y)$)

The sound level L_{Aeq} *W* should not globally exceed 60 dBA.

When considering the variable Time (*T*), a weighting value Y should be introduced (see two tables below), correcting $L_{Aeq}\,W$ values, for example, when works inducing noise don't exceed one hour $L_{Aeq}\,W$ rises to 64 dBA. If works occur during a period of 8 hours or more, $L_{Aeq}\,W$ of 60 dBA should be taken as the standard value.

Evening period ($L_{Aeq}\,W = L_{Aeq}\,R + 3$ dBA) ($L_{Aeq}\,W, T = (L_{Aeq}\,R + 3$ dBA$) + Y)$)

The sound level L_{Aeq} *W* should not globally exceed 48 dBA.

When considering the variable Time (*T*), a weighting value Y should be introduced (see two tables below), correcting $L_{Aeq}\,W$ values.

Table. Sound Level equivalent, in dBA, for *Reference Situation* and Rehabilitation Works Situation

			L_{Aeq} *R*		L_{Aeq} *W*		L_{Aeq} *W, T*	
		factor Time *T*	day	evening	day	evening	day	evening
land-use type	housing area		55	45	60	48		
		T ≤ 1 hour					64	52
		1 hour ≤ *T* ≤ 2 hours					63	51
		2 hours ≤ *T* ≤ 4 hours					62	50
		4 hours ≤ *T* ≤ 8 hours					61	49
		T ≥ 8 hours					60	48
	city centre		65	55	70	58		
		T < 1 hour					74	62
		1 hour ≤ *T* ≤ 2 hours					73	61
		2 hours ≤ *T* ≤ 4 hours					72	60
		4 hours ≤ *T* ≤ 8 hours					71	59
		T ≥ 8 hours					70	58
	industrial area		65	55	70	58		
		T ≤ 1 hour					74	62
		1 hour ≤ *T* ≤ 2 hours					73	61
		2 hours < *T* < 4 hours					72	60
		4 hours < *T* < 8 hours					71	59
		T ≥ 8 hours					70	58
	shopping area		65	55	70	58		
		T ≤ 1 hour					74	62
		1 hour ≤ *T* ≤ 2 hours					73	61
		2 hours < *T* < 4 hours					72	60
		4 hours < *T* < 8 hours					71	59
		T ≥ 8 hours					70	58
	special area		55	45	60	48		
		T ≤ 1 hour					64	52
		1 hour ≤ *T* ≤ 2 hours					63	51
		2 hours < *T* < 4 hours					62	50
		4 hours < *T* < 8 hours					61	49
		T ≥ 8 hours					60	48

Table. Duration of exposure to noise and weighting values (*Y*)

Exposure to noise (in hours)	***Y* values in dBA**
T ≤ 1 hour	4
1 hour ≤ T ≤ 2 hours	3
2 hours ≤ T ≤ 4 hours	2
4 hours ≤ T ≤ 8 hours	1
T ≥ 8 hours	0

B. For *city centre*, *shopping* and *industrial* areas

Day period

The sound level L_{Aeq} *W* should not globally exceed 70 dBA.

When considering the variable Time (*T*), a weighting value *Y* should be introduced (see two tables above), correcting L_{Aeq} *W* values.

Evening period

The sound level L_{Aeq} *W* should not globally exceed the 58 dBA.

When considering the variable Time (*T*), a weighting value *Y* should be introduced (see two tables above), correcting L_{Aeq} *W* values.

It should be emphasised that L_{Aeq} standard values follow what is established in Portuguese legislation. The user of this methodshould feel at ease to introduce adjustments, according to what is established in his country.

Concerning works scenario, the option was for not making distinction between dig techniques and trenchless techniques, but only to distinguish between "noisy" and "not noisy" techniques. Nevertheless, we should not ignore the fact that dig techniques induce on more susceptibility towards noise pollution, than the non-dig ones.

As mentioned in the above-section, it is difficult to determine when a particular noise induces on annoyance for who is exposed to it. Characteristics of the receiver, jointly with the listening situation and environmental context, do influence the degree of annoyance. In spite of this, it was found pertinent to propose the construction of a typology of *potential annoyance*, with the aim of helping CARE-S users to rank rehabilitation technologies. In the cases where noisy techniques are an inevitability, the typology of potential annoyance may help to the (re)-organization of sewer works' processes in order to minimize noise impacts.

Proposal of *potential annoyance* typology is composed of three levels, as follows:

A. *Low level of potential annoyance*

Standard L_{Aeq} *W* (dBA) values that confer *low potential annoyance* correspond to the ones of *works scenario* presented above (see two tables above and next table).

B. *Medium level of potential annoyance*

Standard L_{Aeq} *W* (dBA) values for *medium level of potential annoyance* for *day period* were made having into consideration the criteria of maximum noise daily exposure of a worker, which is of 90 dBA[6]. Concerning the *evening period*, the option was of respecting the difference, in dBA, that exists between the minimum and the maximum value of *low potential annoyance* category, which is of 4 dBA (see two tables above). Given this, it should be expected that:

- In *day period*

L_{Aeq} *W* values between 75 dBA and 95 dBA, in *city centre*, *industrial* and *shopping areas,* may induce on moderate levels of annoyance for those who live or work near rehabilitation works' target-area.

[6] This criterion is, once again, according to Portuguese legislation.

L_{Aeq} *W* values between 65 dBA and 85 dBA, in *housing and special areas,* may induce on moderate levels of annoyance for those who live, work or are temporally near rehabilitation works' target-area.

- In *evening period*

L_{Aeq} *W* values between 63 dBA and 67 dBA, in *city centre*, *industrial* and *shopping areas,* may induce on moderate levels of annoyance for those who live or work near rehabilitation works' target-area.

L_{Aeq} *W* values between 53 dBA and 57 dBA, in *housing and special areas,* may induce on moderate levels of annoyance for those who live, work or are temporally near rehabilitation works' target-area.

C. *High level of potential annoyance*

Standard L_{Aeq} *W* (dBA) values for *high level of annoyance* are potentially verified every time that sound level exceeds the maximum value considered for medium annoyance, in each type of area and day period (see table below).

Public works generally induce on some kind of noise related annoyance for those who live, work or have business on target-area. Anyway, such impact is, by principle, dependent of works duration. Short-tem works are potentially less annoying than long-term works.

It was found as pertinent to consider a variable *duration of works* and propose criteria for what we may consider as being the maximum expected public tolerance towards eventual feelings annoyance, induced by public works. We therefore propose to consider two situations: (a) works duration of less than 30 days; (b) works duration longer than 30 days[7].

Given this, we propose as criteria the following parameters:

For situations where rehabilitation works don't exceed 30 days

Levels corresponding to *medium-high noise related annoyance* are potentially tolerable in day-periods, for all types of areas with exception of special areas.

Levels corresponding to *low noise related annoyance* should not be exceeded, in evening periods, especially on housing and special areas.

For situations where rehabilitation works exceed 30 days

Levels corresponding to *low noise related annoyance* should not be exceeded, during day period, especially in housing and special areas.

Works induced noise levels should be inexistent, during evening periods, in housing and special areas. Concerning the other areas (city centre, shopping and industrial area) noise levels can be higher (at the medium level), if there are no habitants or open business/services.

In such situations, a *Special Works Licence* may be needed in some countries (see below)

[7] This typology is the one that is used on Portuguese legislation on noise control and management. If a temporary activity, such as public works, is expected to exceed 30 days, the responsible entity must ask public authorities for a Works Special Licence.

Table. Potential annoyance, according to type of land-use area

		level of potencial annoyance (L_{Aeq})					
		low		medium		high	
		day	evening	day	evening	day	night
land-use type	housing area	$5 < \Delta \leq 9$ $60 < L_{Aeq}\,W \leq 64$	$3 < \Delta \leq 7$ $48 < L_{Aeq}\,W \leq 52$	$10 < \Delta \leq 30$ $65 < L_{Aeq}\,W \leq 85$	$8 < \Delta \leq 12$ $53 < L_{Aeq}\,W \leq 57$	$\Delta > 30$ $L_{Aeq}\,W > 86$	$\Delta > 13$ $L_{Aeq}\,W > 58$
	city centre	$5 < \Delta \leq 9$ $70 < L_{Aeq}\,W \leq 74$	$3 < \Delta \leq 7$ $58 < L_{Aeq}\,W \leq 62$	$10 < \Delta \leq 30$ $75 < L_{Aeq}\,W \leq 95$	$8 < \Delta \leq 12$ $63 < LAeq\ W \leq 67$	$\Delta > 30$ $L_{Aeq}\,W > 95$	$\Delta > 13$ $L_{Aeq}\,W > 68$
	industrial	$5 < \Delta \leq 9$ $70 < L_{Aeq}\,W \leq 74$	$3 < \Delta \leq 7$ $58 < L_{Aeq}\,W \leq 62$	$10 < \Delta \leq 30$ $75 < L_{Aeq}\,W \leq 95$	$8 < \Delta \leq 12$ $63 < LAeq\ W \leq 67$	$\Delta > 30$ $L_{Aeq}\,W > 95$	$\Delta > 13$ $L_{Aeq}\,W > 68$
	shopping area	$5 < \Delta \leq 9$ $70 < L_{Aeq}\,W \leq 74$	$3 < \Delta \leq 7$ $58 < L_{Aeq}\,W \leq 62$	$10 < \Delta \leq 30$ $75 < L_{Aeq}\,W \leq 95$	$8 < \Delta \leq 12$ $63 < LAeq\ W \leq 67$	$\Delta > 30$ $L_{Aeq}\,W > 95$	$\Delta > 13$ $L_{Aeq}\,W > 68$
	special area	$5 < \Delta \leq 9$ $60 < L_{Aeq}\,W \leq 64$	$3 < \Delta \leq 7$ $48 < L_{Aeq}\,W \leq 52$	$10 < \Delta \leq 30$ $65 < L_{Aeq}\,W \leq 85$	$8 < \Delta \leq 12$ $53 < L_{Aeq}\,W \leq 57$	$\Delta > 30$ $L_{Aeq}\,W > 86$	$\Delta > 13$ $L_{Aeq}\,W > 58$

$\Delta = L_{Aeq}\,W - L_{Aeq}\,R$

Table. Potential annoyance, according to type of land-use area and duration of works

DIG OR TRENCHLESS DIG											
		land-use type									
		housing area		city centre		industrial		shopping area		special area	
	Works duration	≤ 30 days	> 30 days	≤ 30 days	> 30 days	≤ 30 days	> 30 days	≤ 30 days	> 30 days	≤ 30 days	> 30 days
Day period	Potencial annoyance Day	medium-high	low	medium-high	low-medium	medium-high	low-medium	medium-high	low-medium	low-medium	low
		$60 < L_{Aeq}\,W \leq 90$	$60 < L_{Aeq}\,W \leq 85$	$70 < L_{Aeq}\,W \leq 100$	$70 < L_{Aeq}\,W \leq 95$	$70 < L_{Aeq}\,W \leq 100$	$70 < L_{Aeq}\,W \leq 100$	$70 < L_{Aeq}\,W \leq 100$	$70 < L_{Aeq}\,W \leq 95$	$60 < L_{Aeq}\,W \leq 85$	$L_{Aeq}\,W > 64$
	Potencial annoyance Evening	low	no noise	low-medium	low-medium	medium-high	low-medium	low-medium	low-medium	low	no noise
		$L_{Aeq}\,W > 52$	$L_{Aeq}\,W > 45$	$58 < L_{Aeq}\,W \leq 67$	$58 < L_{Aeq}\,W \leq 67$	$63 < L_{Aeq}\,W \leq 72$	$63 < L_{Aeq}\,W \leq 72$	$58 < L_{Aeq}\,W \leq 67$	$58 < L_{Aeq}\,W \leq 67$	$L_{Aeq}\,W > 52$	$L_{Aeq}\,W > 45$

3.2.2.2 Default criteria calculation

The impact of noise will finally depend on:

- the level of noise being more or less acceptable (see above)
- the number or density of people exposed (inhabitants and/or non residents, labor force, shop clients).

The criteria proposed for default calculation is following:

$$noiseW = duration \cdot (d_i + dnr) \cdot NA$$

with:

$duration$ = duration of the works in days

d_i = density of inhabitants

d_{nr} = density of non residents

NA = noise acceptability

If the technology considered does not generate significant noise, NA=0 (cf. technology description within WP4).

Otherwise, two cases must be considered:

- 1) if the decision support user has enough information to check for the acceptability of the noise generated by works; acceptable level would be expressed by NA =1, non acceptable level by NA =5
- 2) if not, NA =3

In the absence of useful baseline information found, we propose to consider the following impact calculation criteria:

$$noiseW = duration \cdot (d_i + dnr) \cdot NI$$

with:

$duration$ = duration of the works in days

d_i = density of inhabitants

d_{nr} = density of non residents

NI = noise impact generated by the rehabilitation technologie (Yes=1, no=0)

3.3 **WORKS CRITERIA - IMPACTS OF DUST**

3.3.1 What we know about

Concerning dust problem, more or so important as establishing criteria for its assessment is the definition of mitigation measures. These ones can range from the choice of more suitable rehabilitation techniques (dig *versus* trenchless techniques) to the adoption of dust reduction measures, during works process[8].

Dust emission can be a source of impacts, both tangible and intangible. In what concerns the first type of impacts, the probability of disturbance on trade should not be disregarded. Such probability materializes on the loss of clients due to the poor air quality of external background environment. Intangible impacts may range from irritability and discomfort feelings to temporary problems of vision, allergies and respiratory problem aggravation.

Nevertheless, similarly to noise impacts, dust impacts severity is rather influenced by situational and contextual variables. Besides the ones related to the works in itself (length of working area, type and duration of works, etc), land-use characteristics as well as type of potential "victims" influence dust impacts.

As known, dust may turn into an acute problem on public works that involve dig techniques.

It is found as rather difficult to assess dust problems through specific measures of dust emissions[9]. An alternative is to determinate the amount of time (in days) that may be considered as socially acceptable to bear a decrease on air quality, due to dust, according to the type of land-use.

Given this, we propose the following:

- Housing areas/ shopping areas/ city centre/ special areas: dust for 5 days or less= bearable; dust for more than 6 days=hardly bearable, special measures must be taken.
- Industrial areas: if not populated, dust doesn't generate a problem; if populated=adoption of previous criteria.

In what concerns mitigation measures, there are several actions that may be taken. Public information when dust problem emerges as a possibility is, in our view, a basic measure to be taken whatever the duration of dust emissions and rehabilitation works. Another aspect to be taken into account concerns the transport of earth. When not adequately protected (through special truck covering), transport may turn on a source of dust pollution. Given this, it is found as advisable to promote trucks protection. Delaying street re-pavement as well as re-gardening can also be a source of dust increase. Given this, such concluding works' actions should be done as fast as possible. Finally, there is another measure, usually advised, especially in cases where high levels of dust are anticipated; we refer specifically to the use of arboreous barriers, along works area. Such barriers have the advantage of absorbing dust and, by this, avoiding air quality decrease (see Table below).

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[8] Some of these measures will be pointed out, bellow on this section. All of them come from European Union rules of Environmental Impact Assessment (EIA) for public works (Directives 85/337/CEE, 97/11/CEE).

[9] No bibliography was found around such a problematic.

3.3.2 What we propose for CARE-S criteria calculation

In the absence of useful baseline information found, we propose to consider the following impact calculation criteria:

$$dustW = duration \cdot (d_i + dnr) \cdot DI$$

with:

$duration$ = duration of the works in days

d_i = density of inhabitants

d_{nr} = density of non residents

DI = dust impact generated by the rehabilitation technologie (Yes=1, no=0)

3.4 WORKS CRITERIA - GROUND WATER POLLUTION

General comments about water resources and their pollution, including the evaluation of impacts, can be found in section 4.8.1. Inside the scope of CARE-S WP5, water quality issues are significantly more important in relation to network failures then in relation to rehabilitation works, therefore these general aspects are addressed in the "failures" section of the report. Physical, chemical and biological aspects of water pollution concerned here are addressed in the CARE-S report D9 (P. 2004).

3.4.1 What we know about

Risks of groundwater pollution during works on sewer pipes is a day-to-day concern, if not even a common place one. But we found no consolidated literature about pollution effects and impacts in the specific case of works on pipes.

This pollution can be a consequence of:

- wastewater losses,
- products used for the rehabilitation technology,
- hydrocarbons – fuels and oils - leakage (accidental or constant) from machines and vehicles used for the works,
- other incidents or accidents within the works or close to the dug areas.

Some of these pollution sources are linked to the rehabilitation technology, some are independent or almost independent from the technology: leak in fuel tank, fall of a can… We are only concerned here with the pollution sources linked to the technology, as our aim is to compare technologies for rehabilitating a given pipe. The technology database developed inside WP4 of CARE-S describes each option with several parameters, among which the fact that each technology may result in groundwater pollution or not. A "yes/no" parameter may appear rough, but going into more details would necessitate to address the way the works are organised, the professional skills of the workers… and would still include a quite important random component when trying to predict potential pollution events.

Table. Dust mitigation measures, according to type of land-use area

		land-use type									
		housing area		city centre		industrial		shopping area		special area	
	Works duration	≤ 30 days	> 30 days	≤ 30 days	> 30 days	≤ 30 days	> 30 days	≤ 30 days	> 30 days	≤ 30 days	> 30 days
Mitigation measures	Public information everytime dust peaks emission is antecipated	obligatory	obligatory	obligatory	obligatory	obligatory	obligatory	obligatory	obligatory	obligatory	obligatory
	Minimization of time-intervals between digging and total works execution	advisable		advisable		advisable		advisable		advisable	
	Earth transport with proper protection and during periods where there is no wind or similar phenomena	advisable	obligatory	advisable	advisable	advisable	advisable	advisable	advisable	obligatory	obligatory
	Fast re-pavement and re-gardening of target-area, avoiding dust re-appearance	obligatory	obligatory	obligatory	obligatory	advisable	advisable	obligatory	obligatory	obligatory	obligatory
	Enhancement of dust absorption capacity of works-target area through utilisation of arboreous barriers	optional	advisable	optional	advisable	unecessary	unecessary	optional	optional	optional	obligatory

Report D9, as already mentioned, addresses the physical, chemical and biological effects on soil and groundwater, though with a focus on exfiltration rather than on works. Works can lead to pollution events which are focused in time, and which are visible almost instantaneously (or visible in the morning if anything happened during the night, or on a Monday morning if anything happened during the end of the week leave). Moreover, for small pollution cases, the contaminated soil may be removed before groundwater is modified. Therefore, inferences based on the comparison with “chronic” exfiltration processes should not be made without great care.

For general comments about the impacts on groundwater resources and their uses, please refer to section 4.8 of the report.

3.4.2 What we propose for Care-S criteria calculation

If a technology does not induce any pollution hazard, the criteria value will be “0” (no impact, no social cost), whatever the groundwater resource, its condition and uses. If a technology induces such a hazard, then we can consider, with potential available information, the intrinsic vulnerability of the groundwater given the type of soil and distance of the works to the water table (lower level of the pipe on the concerned section minus the level of water table) on one hand, the water uses on the other hand. Ideally, the present quality of the water could be considered, but this should then be available with a small spatial grid (we consider here very local events).

The potential vulnerability of the groundwater is addressed through the parameter assessed by WP3-D9 report ((SCHULTZ N. 2004)):”PermGround” linked to groundwater level and soil permeability. The water uses are addressed through the typology introduced in section 2.4.3. the decision maker can of course define his own criteria, given the available information.

The criteria values (from 0 to 100) proposed are summarised in the following table for the case where the technology may induce water pollution. Given the weak bases of this proposition, any decision maker should feel free to adapt these values to his knowledge and experience.

	GS: Groundwater susceptibility			
Type of groundwater and water uses	**low**	**medium**	**high**	**not known**
protected area for drinkable water production	80	100	100	100
drinkable water production	70	80	100	80
private domestic wells	50	60	80	60
other sensitive water uses	20	30	50	30
other water uses	5	10	20	10
no water use	5	5	5	5
no groundwater	0	0	0	0

GroundWpollW = *0* if no threat on ground water

GroundWpollW = *1*GS* if threat on ground water

The risk of interruption will be given, in part only, by “need for digging for reconnecting ”=Y but in some cases the reconnecting is done directly from the inside of the principal sewer.

3.5 WORKS CRITERIA - SERVICE INTERRUPTION

3.5.1 What we know about

In most cases, service interruption will be avoided by putting in place a by-pass on the rehabilitated pipe in order to maintain the upper flow discharge. But people connected on the rehabilitated pipe may have interruption if the connections are also concerned by the rehabilitation project or for specific techniques, for instance slipening where the connections are blocked and reopened afterwards. Generally in this case, when there is no by-pass, residents are invited to have no use of water and of water closets. Sometimes works are done by night with minimum flows and no service interruption.

So, in case of night works or in case of a by-pass installation, internal directs costs of rehabilitation will be increased.

Economic activity will be taken into account; for instance when there is a restaurant in the street, works will be managed in order to prevent from service interruption, as far as possible, by choosing an accurate date, or working by night, or by processing with a by-pass.

3.5.2 What we propose for Care-S criteria calculation

No valuation methodology is really available, we propose to give the following valuation to the criteria:

ServIntW = *0* if no interruption risk

ServIntW = *1*(population density)*d* if interruption risk

d = duration of the works in days

The risk of interruption will be given, in part only, by the parameter “need for digging for reconnecting ”=Y, describing the technologies, but in some cases the reconnecting is done directly from the inside of the principal sewer.

3.6 WORKS CRITERIA - ROAD/TRAFFIC DISTURBANCE

3.6.1 What we know about

Depending on the duration of the works, the size of the works area, the characteristics of the road, the traffic, the economic activity and the land use category of the concerned street, traffic disturbance can occur, concerning residents, workers, clients of shops and people just passing by, either with individual vehicles or with public transportation.

Of course trenchless techniques will reduce traffic disturbance but it depends on the width of the street: for instance in a street with two-way traffic and 2x1 lane, traffic will be affected either by an open trench or by wide working areas even if the beginning and the end of the concerned pipes only are concerned. In the opposite, when considering a one-way street with 2 lanes, if only one is affected, the disturbance can be low depending on the traffic density and on its distribution during the day or the week.

The effect of traffic disturbance will be loss of time for labor force, residents or passengers and source of irritation and tiredness, due to waiting or diversion road lengthening the drive. It will also increase the operating cost of the vehicles (length of the journey and unit cost per kilometer). These impacts concern the initial traffic of the road with works, but also the roads concerned or “influenced” by the diversion.

Concerning an industry or a shop it can mean, besides the delay in the employees’ arrival, delay in goods delivery.

Road and pavement traffic disturbance affects also residents of the street under works : access to private properties, parking troubles. Of course it is difficult to give a systematic value to the disturbance, as traffic disturbance will depend on the street network, and will be spread over part of this network.

Cost of traffic disruption estimates are typically based on the amount of time wasted (e.g. the increase in travel time), the value of travel time and the increase in vehicles operating costs.

First of all, we will consider the worst situation, that is to say, dig techniques and derivation necessity.

♦The AWWA recent research on “cost of infrastructure failure” (AWWARF 2002) refers to studies expressing travel time values as a percentage of the wage rate:

- average driver wage rate for commercial traffic
- 50% of the wage rate for drivers and passengers in vehicles for local trips, including “off-the clock” travel time

The report suggests values from 20$ (low) to 50$ (high) as wage rate per vehicle operational cost per hour.

♦ (BOITEUX 2001) in a report to the French Department for Planning proposes an evaluation for the value of the time spent in transport in urban area :

Type of travelling	% wage cost	% gross salary	France (€ 1998/h)	Paris suburb (€ 1998/h)
Professional travelling	61%	85%	10,5 €	13 €
Home-work travelling	55%	77%	9,5 €	11,6 €
Other travelling (shopping , leisure, tourism…)	30%	42%	5,2 €	6,4 €
Mean value if travelling type not known	42%	59%	7,2 €	8,8 €

Table :Time value in urban area per traveller (euros 1998/h) (Boiteux, 2001)

So we get a similar information that AWWA’study: the time value of shopping, leisure, tourisme represent half of the value given to professional and home-work travelling.

♦(ANGOT 1991) proposes methods to value the traffic disturbance:

the first one is based on the cost of delay time:

with $$C_{Td} = T_d \cdot W_{HM} \cdot D$$

C_{Td} cost of delay time (€/works day)

T_d delay time due to the works on a mean travel for a vehicle (H)

W_{HM} mean hourly wage (€/H)

D mean traffic density (vehicle/day)

the second method is based on overconsumption of motor-fuel when traffic is slowed down or deviated

with:

$$S_{ocs} = R \cdot (C_c - C_n) \cdot P_u \cdot D \cdot 24$$

S_{ocs} overcost of motor-fuel when slow down (€/j)

R slow down of the mean speed because of works (km/h/vehicle)

C_c mean consumption if congestion

C_n mean normal consumption

P_u unit price of motor-fuel

D mean traffic density

with

$$S_{ocd} = d \cdot C_n \cdot P_u \cdot d_D$$

S_{ocd} overcost of motor-fuel when deviated (€/j)

d additional distance to be covered

P_u unit price of motor-fuel

d_D variation of the traffic density on the diversion road

<u>What would be the additional time travel?</u>

One proposal made in 1978 for the Parisian transportation company suggested to consider that a road work induces a delay corresponding to one wait at traffic lights estimated between 10 and 30 seconds, stretched to 60 seconds by (MONTORI 2002). That seems to be underestimated.

♦ Concerning public transportation, (MONTORI 2002) describes the valuation of the economic loss due to a bus line diversion considered in Strasbourg, as a reference, as considered by the transportation operator and the urban community. It takes into account the conductor wages and the consumption of motor-fuel. 4 types of diversions are considered as described in the following table, the cost scale resulting from the valuation is given in the last column:

Type of diversion	Accumulated distance for both ways of circulation	Cost scale
Type 1	< 500 meters	2
Type 2	500 to 1000 meters	3
Type 3	1000 to 2000 meters	4
Type 4	> 2000 meters or several bus lines to be diverted	

Table : derivation typology for public transportation (Montori, 2002)

For each or the 3 first types, an all-inclusive cost per day is defined, for the 4th type the calculation is made case by case . Two costs per day are calculated for each type: the cost for the 1st operating day concerned and the cost for an additional day (of course lower than the precedent one).

♦ Concerning traffic disturbance due to a repair of a failure on a water main, a CSIRO (Australia) report (Speers, Burn et al. 2002) presents an example of cost valuation for a road with a normal traffic flow of 1200 cars/hour (a moderately busy two-lane road), reduced by 1/3 for one hour, with traffic taking 15 minutes too clear once repairs are completed.

The valuation is presented in the following table:

	hours	Nb persons/vehicle	Time value per person ($/H)	Flow-on value to commercial business ($/vehicle)	Total cost of traffic interruption
Private vehicles	84	1,12	8.38		788
Business vehicles	5,25	1,2	16.98		107
Light commercial	11,55	1,3	16.98	0.91	265
Heavy commercial	4,2	1	18.23	17.15	149
total	105				1200

Table : example: cost of traffic interruption (Speers, 2002)

♦Disrupting traffic due to river flooding has been studied by (GREEN 1983). Results are losses of three kinds:

- consumption of petrol, oil and so on is higher if average speeds are drastically reduced or if the journey is increased in length.
- if delays are very long, some goods may lose their value in transit (fruit, news papers…)
- the occupants of the vehicles lose the opportunity cost of the extra time spent in transport.

Some elements can be considered for impacts of works:

-If car parks are flooded, but not the facilities served by them, then the net effect should be to increased congestion. A very crude approximation of this effect would be to multiply the number of vehicles normally parked there by the hourly cost of parking. If car parks are obstructed by works, the effect can be calculated in the same way than proposed before.

-Number of trips is assessed for workers and for pupils by:

Work trips per work place (walk, cycle, car, bus passenger, other) = 2.18 x *average length of trips per day per person*

Total yearly trips generated = No of working days per year **x** ***No of shifts x 2.18*** **x** ***No of workforce***

(excludes goods deliveries and visitors)

school trips generated: in average, 2.38 trips per day per pupil

Total yearly trips generated = No of school days per year **x** ***2.38*** **x** ***No of pupils + (staff travel from above)***

♦ The German research office on roads and traffic present a valuation for “out of town” roads (FGSV 1988). Traffic is divided in 4 types:

P: passenger cars, combined cars even with a trailer

B: buses

L: lorries up to 1.5 T for pay load and up to 2.8T for total weight with trailer, lorries over 1.5 T for pay load and over 2.8T for total weight without trailer, agricultural vehicles

Z: Lorries with trailers not in type L, heavy lorries.

Different abacus give a value of loss of time depending of the mean daily traffic and the part of goods transportation (L,Z,B) and the length of the works area.

When precise data are not available for distinguishing the distribution of goods transportation in the 2 types of traffic mentioned above, a theoretical distribution is used, given in the following table:

Road type	Vehicle group		
	L (%)	Z (%)	B (%)
1	39	57	4
2	62	30	8

Table : distribution of goods in the different vehicle groups (FGSV, 1988)

Two types of roads are considered: road type 1 if 2 lanes of circulation and road type 2, a single lane. We can notice that for type 1, the biggest group is Z (heavy lorries) where as for type 2, it is type L (other lorries).

An earlier study (FGSV 1986) proposes a valuation of the loss of time in DM/(hour. Vehicle group) taking into account time periods in which the traffic is the same categories called t (15 categories have been distinguished). Results are given in the following table:

Vehicle group	Costs per hour and per Vehicle group (DM 1986) (1 euro = 1,95583 DM)	
	labour day or holidays (t=1-10)	Sundays (t=11-15)
P	7,00	3,50
L	30,00	-
Z	42,00	-
B	90,00	90,00

Table : cost of loss of time (FGSV, 1986)

If we consider trenchless techniques, troubles are lower and come essentially from the works location at one or at both extremities of the works area. Often only one lane will be concerned by troubles, impacts will depend on the width of the street and on the number of lanes in each direction, some times a derivation must be put ine place, some times traffic will be alternating…

3.6.2 What we propose for Care-S criteria calculation

We propose the following valuation for trafficW criteria:

For dig techniques

We propose a detailled valuation for <u>dig technique,</u> the working area will be whole length that is to say the length of the pipe

$$trafficW_{dig,l} = T \cdot L \cdot d \cdot n_l \cdot r_l \cdot C_{dig,l}$$

with

T mean traffic density (vehicle/day) in one direction

L length of the pipe (m)

d duration of the works (days)

l number of lanes (0,1, 2)[10]

n_l trip time factor

for l=1 n_1=2, means deviation and double trip time,

for l=2 n_2=1,3 means no derivation but slowing down

r_l if "need to later reopening of laterals" or "digging for reconnecting laterals"

for l=1, r_1=1,2

for l=2, r_2=1,05

if no "need to later reopening of laterals" or "digging for reconnecting" laterals r_l=1

$C_{dig,l}$ traffic and environment factor

[10] l=0 means pedrestrian area: only pedestrians and bicycles.

for l=1, see table below,

for l=2, $C_{dig,2}$=1/2$C_{dig,1}$,

for l=0, $C_{dig,0}$=5 for land use type 1,2,4 - $C_{dig,0}$=10 for land use type 3,5

For building the table with C values, we put the 6 values for land type use=CITY CENTER and type road=LOCAL" and traffic truck=Y and we calculate the others values of the line with multiplying factors. This line and another set of multiplying factors were used to fill in the rest of the table, vertically.

We used the following rules:

Traffic truck load: Y=1 – N=1/2

Type of road: 1"local" = 1 – 2"transit"= 2 – 3"shopping" =1,5

Land use type: 1"rural" = 1/5, 2"urban housing" = 1/3 - ,3"city center" = 1 – 4"industrial" = 2/3 – 5"shopping area" =1/2, for 6"special area" it must be a case by case valuation.

DIG or TRENCHLESS DIG | daily traffic flow= 150 | requires later reopening of laterals (Y/N)= Y

working area required sizeld= whole length | need of digging for reconnecting laterals (Y/N)= Y

length of works= 300 | pit damage (Y/N)= Y

works duration = 20

number of lanes = 1

			type of road					
			local =1		transit=2		shopping=3	
			traffic truck load					
		traffic-public transportation	Y	N	Y	N	Y	N
land use type	rural =1	no public transport =0	4	2	8	4	6	3
		bus traffic with low frequency = 1	8	4	16	8	12	6
		bus traffic with heavy frequency =2	12	6	24	12	18	9
		tram traffic =3						
		tram+bus =4						
	urban housing =2	no public transport =0	6	3	13	6	10	5
		bus traffic with low frequency = 1	13	6	26	13	20	10
		bus traffic with heavy frequency =2	20	10	40	20	30	15
		tram traffic =3	26	13	53	26	40	20
		tram+bus =4	33	16	66	33	50	25
	city center =3	no public transport =0	20	10	40	20	30	15
		bus traffic with low frequency = 1	40	20	80	40	60	30
		bus traffic with heavy frequency =2	60	30	120	60	90	45
		tram traffic =3	80	40	160	80	120	60
		tram+bus =4	100	50	200	100	150	75
	industrial	no public transport =0	13	6	26	13	20	10
		bus traffic with low frequency = 1	26	13	53	26	40	20
		bus traffic with heavy frequency =2	40	20	80	40	60	30
	area=4	tram traffic =3	53	26	106	53	80	40
		tram+bus =4	66	33	133	66	100	50
	shopping area=5	no public transport =0	10	5	20	10	15	7,5
		bus traffic with low frequency = 1	20	10	40	20	30	15
		bus traffic with heavy frequency =2	30	15	60	30	45	22,5
		tram traffic =3	40	20	80	40	60	30
		tram+bus =4	50	25	100	50	75	37,5
	special	no public transport =0						
	area	bus traffic with low frequency = 1						
		bus traffic with heavy frequency =2						
		tram traffic =3						
	buildings=6	tram+bus =4						

Table :$C_{dig,1}$ traffic and environment factor for 1 lane and DIG technique – VALUES

DIG or TRENCHLESS DIG			daily traffic flow= 150	requires later reopening of laterals (Y/N)= Y				
working area required sizeId=	whole length			need of digging for reconnecting laterals (Y/N)= Y				
			length of works= 300	pit damage (Y/N)= Y				
			works duration = 20					
number of lanes = 1			type of road					
			local =1		transit=2		shopping=3	
			traffic truck load					
		traffic-public transportation	Y	N	Y	N	Y	N
land use type	rural =1	no public transport =0						
		bus traffic with low frequency = 1						
		bus traffic with heavy frequency =2						
		tram traffic =3						
		tram+bus =4						
	urban housing =2	no public transport =0						
		bus traffic with low frequency = 1						
		bus traffic with heavy frequency =2						
		tram traffic =3						
		tram+bus =4						
	city center =3	no public transport =0						
		bus traffic with low frequency = 1						
		bus traffic with heavy frequency =2	A	A/2	A*2	A/2*2=A	A*1,5	A/2*1,5
		tram traffic =3						
		tram+bus =4						
	industrial area=4	no public transport =0						
		bus traffic with low frequency = 1						
		bus traffic with heavy frequency =2						
		tram traffic =3						
		tram+bus =4						
	shopping area=5	no public transport =0						
		bus traffic with low frequency = 1						
		bus traffic with heavy frequency =2						
		tram traffic =3						
		tram+bus =4						
	special area buildings=6	no public transport =0						
		bus traffic with low frequency = 1						
		bus traffic with heavy frequency =2						
		tram traffic =3						
		tram+bus =4						

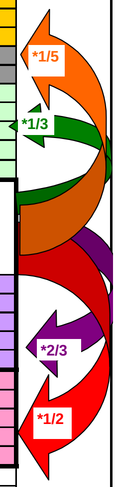


Table :$C_{dig,1}$ traffic and environment factor for 1 lane and DIG technique - RULES

For trenchless techniques

We propose the same valuation than before, the major difference will be that we consider that there is no derivation, so we will be in the case of $C_{dig,2}$ = ½ $C_{dig,1}$, but with some other information concerning the techniques, especially the length of the working area (<works length) and the number of working locations:

TRENCHLESS	daily traffic flow= 150	working area required nb location (1,2 or variable)= 1
		working area required sizeId(<100 or 100-300 or 300-80(<100
		requires later reopening of laterals (Y/N)= Y
	length of works= 300	need off digging for reconnecting lateral= Y
	works duration = 20	pit damage (Y/N)= Y
		no surface damage (Y/N)= Y

TRENCHLESS	daily traffic flow= 150	working area required nb location (1,2 or variable)= 1
		working area required sizeId(<100 or 100-300 or 300-80(<100
		requires later reopening of laterals (Y/N)= Y
	length of works= 300	need off digging for reconnecting lateral= Y
	works duration = 20	pit damage (Y/N)= Y
		no surface damage (Y/N)= Y

$$trafficW_{trenchless,l} = T \cdot d \cdot a_{l,s,n} \cdot r_l \cdot C_{trenchless,l} \cdot x$$

with

T mean traffic density (vehicle/day) in one direction

d duration of the works (days)

$a_{l,s,n}$ trip time factor

- l number of lanes (0,1, 2)
- ws location size (< 100,100-300,300-800)
- wn number of working locations coefficient (1,2) (if variable we consider=2)

			Number of lanes *l*	
	location size *ws*	location nb *wn*	*l=1*	*l=2*
trip time factor $a_{l,s,n}$	<100	1	**1,3**	**1,1**
		2	**1,5**	**1,3**
	100-300	1	**1,5**	**1,3**
		2	**1,8**	**1,5**
	300-800	1	**1,8**	**1,5**
		2	**2**	**1,8**

r_l "reopening laterals" factor

if "need to later reopening of laterals" or "digging for reconnecting" laterals

for l=1, r_1=1,2

for l=2, r_2=1,05

if no "need to later reopening of laterals" or "digging for reconnecting" laterals r_l=1

x length/location" factor

- L length of the pipe
- m max length from each location (maximum length the rehabilitation technology can reach without moving from a single location)

x=0,9 if $L<m$

x=1 otherwise

$C_{trenchless,l}$ traffic and environment factor

for l=1, $C_{trenchless,1}$ = $C_{dig,2}$=1/2$C_{dig,1}$

for l=2, $C_{trenchless,2}$ = 1/2$C_{trenchless,1}$

for l=0, $C_{trenchless,0}$ =2 for land use type 1,2,4

$C_{trenchless0\ l}$=3 for land use type 3,5

3.7 WORKS CRITERIA - LOSS OF TRADE

Loss of trade means that because of the works, trades suffer from economic losses. This is linked essentially to the duration of the works, the location of the street, its accessibility, the technique put in place…People can decide to delay their purchases to another day because the shop is in a works area and there are difficulties to access to it by car or by bus for traffic jam reasons, or because the pavement is disturbed and it is difficult to walk… People can also decide to go to another shop and come back to the "works concerned shop" once the works are finished, or maybe never come back…

Goods delivery may also be disturbed. In specific cases, if the goods are not in place at a given time of the day, they will not be sold: newspaper, bread….

Parking possibilities and public transportation facilities will of course have an importance in the consumers' attitude, we will focus here on the question of accessibility of the shop, of the industry at the street level.

In the literature, loss of trade is studied as a social cost mainly for situations of service interruptions (essentially concerning water delivery for sensitive activities) or during big public works such as new tramway laying.

3.7.1 What we know about

In the survey made around careS-partners (see annex 1), we can see that compensations for sewage works already exist in several countries such as Australia, Italy, Denmark, Norway. We got no information on the valuation practices but often it is a case by case calculation.

In the literature, we found the following information:

3.7.1.1 Concerning dig techniques

Some results concerning space consumption have been proposed by (ANGOT 1991) when using a technique with trench opening on the pavement.

He takes into account the fact that parking and access to shops can be disturbed.

One possibility for valuation is to consider the tax that shops are paying to the municipality to occupy the public area of the pavement in front of their shop or trade. An other way is to take into account the loss for the parking manager, in this case, the cost of loosing parking space can be calculated as follows:

$$C_p = C_l \cdot 10h$$

with

C_p	cost of consumption of parking place (€/m^2/day)
C_l	hourly cost of lending the parking place (€/m^2/h)
$10h$	operating duration of a ticket machine per day.

Traffic deviations or disturbances are also considered as having an impact on shops turnover.

However, these are restrictive valuations not really representative.

Enquiries by tradesmen made by ANGOT however revealed that there is an impact and that the turnover can decrease from 5 to 50% during a works period.

3.7.1.2 Concerning tramway works

Because of the duration of the works and the area of the working site, works like laying a new tramway line lead often to compensations request. The loss of trade during works is due essentially to accessibility problems of the shop itself or of the works area.

In France, several towns have decided to construct new tramway lines, and have put in place a conciliatory procedure of compensation. The compensation risk is taken into account in the project cost valuation. So more and more information is provided to trades people, craftsmen and learned profession concerning their possibility to ask for compensations, possible if they are directly concerned by the works.

The calculation of the compensation is done as following by chartered accountants (case study Strasbourg):

$$\mathrm{Compensation}_w = (\mathrm{TTO}_w - \mathrm{RTO}_w) \cdot \mathrm{CM} - \Delta SC_w$$

with

w	period concerned by the works
TTO	mean theoretical turn over during the 2 years before works for the corresponding period w
RTO	real turn over during the period w
CM	gross income ratio for the sufferer or the national mean for the economic sector concerned
ΔSC	variation of staff costs on period w

The first part represents loss of contribution margin and the second one saving of fixed costs concerning staff.

The gross income ratio is calculated on the 2 years before works and compared to the value of the national gross income ratio in the same activity sector.

Depending on the activity, seasonal factors can be introduced.

Results of data collection will be presented in appendix N°3.

3.7.1.3 Concerning road works

In the same way, concerning road works[11], two law proposals have been under discussion in Wallonie (Belgium), since beginning of 2004, concerning on one hand compensations for learned professions bordering road works, on the other hand the undertaking of this compensation.

The Commission of Finance and Economic Affairs proposed to put in place a compensation on and after the 1st day of the 2nd month of road works producing annoyances for learned professions on a minimal value ,indexable, of 27,66 Euro per day. (http://www.uvcw.be).

[11] **Road works** means repairs, maintenance, alterations, improvements or installations or any other works to, above or under a public road. (The terms "public road" and "road" in these directions have the meaning assigned to them in the Roads Act, 1993.). Road works include any works on the carriageway and footpath, where public road and footpath space is temporarily unavailable for public use. (County Council Dublin, 2003, http://www.dlrcoco.ie).
In France, we use the ancronym "V.R.D."is used, , meaning "roads and various networks".

3.7.1.4 Concerning water service interruption

We present here methods concerning water delivery interruption because they propose valuations of the economy loss due to an interruption of the activity dependent from water delivery. It this case the cut generally lasts for a short period: a couple of hours. The difference with rehabilitation works and the impact due to accessibility of the economic area will be that these works will generally take much longer: several days or weeks. The economic activity will generally not be stopped but only disturbed.

The following evaluation methods have been identified:

♦ <u>For industrial consumers</u>:

One way of giving a cost to an interruption is to evaluate the loss of turn over (BEURET 1992).

Financial ratios are established by the French Central Bank (La Banque de France) per activity sector, such as production of electronic component, production of elevators….And so the turn over P for a certain duration and for a firm in a certain activity sector (referenced by a code), is given by:

$$P = R_1 \cdot R_2 \cdot N \cdot D / 220$$

with: $R_1 = \frac{net\ operation\ result}{annual\ turn\ over}$

$R_2 = \frac{annual\ turn\ over}{manpower}$

$N = manpower$

$D = duration\ of\ the\ \text{interruption}\ in\ days$

This formula has been adapted (WEREY 2000) to present ratios and for 2 hours interruption:

$$P = R_7 \cdot R_9 \cdot R_{20} N \cdot 2/24/220$$

with: $R_7 = \frac{mean\ operation\ capital}{added\ value\ (in\ factor\ of\ production\ \cos t)}$

$R_9 = \frac{added\ value\ (in\ factor\ of\ production\ \cos t)}{mean\ manpower}$

$R_{20} = \frac{brut\ operation\ excedent}{mean\ operation\ capital}$

It is a sector approach, contrary to the valuation given for tram works which is a case by case valuation.

♦ In the case of water supply disruption from seismic events, an estimation of indirect economic losses has been proposed, which can be used at the region level or at a lower level, with the following approach (AWWARF 2002):

The percentage of value added by all activity sectors within the economy have been grouped in 36 specific categories. These 36 categories and their national averages (USA) are presented in the following table:

Number	Economic sector	Percent added value
1	Livestock	0,45%
2	Agr. Prod.	1,06%
3	AgServ.For. Fish	0,11%
4	Mining	3,89%
5	Construction	5,52%
6	Food & Tobacco	2,41%
7	Textile goods	0,37%
8	Misc. Text. Prod	0,73%
9	Lumber & Wood	0,52%
10	Furniture	0,34%
11	Pulp 1 Paper	0,87%
12	Print & Publish	1,31%
13	Chemical & drugs	1,40%
14	Petrol. Refining	0,96%
15	Rubber & Plastics	1,03%
16	Leather Prods	0,12%
17	Glass Stone Clay	0,62%
18	Prim. Metal Prod.	1,04%
19	Fab. Metal Prod.	1,64%
20	Mach. Exc. Elec.	1,56%
21	Elec. & Electron.	2,52%
22	Transport Eq	2,62%
23	Instruments	0,68%
24	Misc. Manufact.	0,69%
25	Transp & Whse.	3,46%
26	Utilities	5,89%
27	Wholesale Trade	5,63%
28	Retail trade	5,63%
29	F.I.R.E.	16,64%
30	Pers./prof. Serv.	8,03%
31	Eating drinking	2,12%
32	Auto serv.	1,09%
33	Amuse and Rec.	0,70%
34	Health Ed. Soc.	6,30%
35	Govt. & Govt ind.	11,79%
36	Houselholds	0,25%
	TOTAL	100,00%

Table :national US economic sectors – percent value added (AWWARF, 2002)

The percent distribution can vary from region to region.

The loss of function LOF, residual or remaining capacity of the system at any given point in time following the earthquake event must be evaluated. The LOF estimates are weighted to calculate the average estimates at the monthly level. Then by exploiting the monthly LOFs with the values for " Percent Value-Added Lost Due to Specific Percent of Loss of water Supply System" incremental LOF levels for each of the 36 economic sectors can be established. The " Percent Value-Added Lost Due to Specific Percent of Loss of water Supply System" is a table containing the percent indirect economic losses estimates (PIEL) for each of the 36 economic categories associated with incremental LOF levels between 10 and 100 percent. By multiplying the appropriate PIEL estimates with the percent contribution of each economic sector in the affected regional economy and the monthly gross production of the regional economy, the estimate of indirect economic loss at the monthly level can be calculated at the specific sector level.

The link has been made with water interruptions due to failures: the method is considered to be applicable by reducing the area and the time from a month to the couple of hours concerned by a water main break.

♦CSIRO report (Speers, Burn et al. 2002) presents results of a survey made in Perth. The business have been divided in five categories, as presented in the following table, depending on their sensitivity to water interruption, excluding major shopping malls:

impact	Effect on net business income in the first 2 hours	Effect on net business income for next 2 hours	examples
Negligible impact	**<1%**	**<1%**	**Newsagent, hardware, bike shop, pharmacy, liquor store, boutique, craft shop, pool shop, cemetery, real estate, telecommunications, solicitors…**
Minor impact	**1-20%**	**1-20%**	**Physiotherapy, plant nursery, milk bar, grocery, tattoo shop, service station**
Significant impact	**20-40%**	**20-60%**	**Medical surgery, café, bakery…**
Major impact	**40-60%**	**60-80%**	**Veterinary surgery, sea food store, butcher, hair salon, hotel…**
Extreme impact	**60-80%**	**80-100%**	**Dentist, radiologist, restaurant, fast food beauty salon, laundry, photo developer…**

Table : categories of impact on business customers (Speers, 2002)

Assumption is made that a decline of net income due to an interruption represents a reduction in the value added by that business. The approach assumes a certain value added per employee, so :

$$bu\sin nes\,loss = nber\,of\;employees \cdot average\,hourly\,rate\;for\,wages \cdot value\,added\,by\,each\,employee$$

Results of a worked example are presented in the following table:

	No of connection	Estimated No of employees at peak time	Assumed value (proportion added)	effect on added of value	Effect per value added interruption	hour on for a 4 hour
			1st 2-hour period	2nd 2-hour period	total	$ connection per hour
Negligible impact	135	512	0,01	0,01	461	3,41
Minor impact	6	27	0,10	0,10	189	31,50
Significant impact	8	44	0,30	0,340	1134	141,75
Major impact also outside Business hours	3	12	0,50	0,70	648	216,00
Major impact in business hours	15	75	0,50	0,70	3240	216,00
Extreme impact in business hours only	7	25	0,70	0,90	2016	288,00
Extreme impact restaurant	17	89	0,70	0,90	7344	432,00
Not applicable – private residence	5	0	0,00	0,00		
Not applicable – vacant	19	0	0,00	0,00		
TOTAL		784			15 031,80	69.62

Table : valuation of impact on business customers (Speers, 2002)

These results are interesting for the typology and for the scale of the valued added. So we can see, if we put a note of 1 for negligible effect we get the following classification:

effect	Negligible impact	Minor impact	Significant impact	Major impact also outside Business hours	Major impact in business hours	Extreme impact in business hours only	Extreme impact restaurant

Scale on 4 hours interruption added value	1	10	50	70	70	100	140

3.7.1.5 Results on tramway compensation survey made in Strasbourg

The results of this survey are presented in annex 3.

For works corresponding to one tramway line, 93 requests have been examined and we focused on the valuation of 28 of them.

With this reduced sample we defined for each activity sector the ratio (mean loss of trade/theoretical turn over) on the works period with loss of trade given by (loss of contribution margin – economy on staff costs), that gives an idea of the relative loss of each activity sector and by this way on the sensitivity of the economic activities.

The mean duration of the works was 15 months.

On the global sample we looked at the relative mean compensation cost per activity sector, that gives an idea on the cost scale for the utility, showing for instance that for a supermarket the ratio presented previously can be low but that the compensation amount will be high because of the size of the activity.

These results are presented in the following tables.

We considered the following typology:

categories	detail
FOOD PRODUCTS	Butchery, Bakery, coffee, tea, chocolates sales dietetic products
HEALTH CARE	Doctor Dentist
FUEL DELIVERY	wholesaler to service station
CULTURE & LEISURE	Travel agency Music and instruments shop Gymnastic centre Cinema
EQUIPMENT FOR THE HOUSE	Furniture shop
EQUIPMENT FOR THE PERSON	Florist Sport wear shop Clothing shop Shoes shop Jewellery
MEDICAL EQUIPMENT	Pharmacy

	Optician Biological products
BOOKSHOP	
RESTAURANT	Restaurant Fast food Cake-shop Tea-room
HEALTH, BEAUTY and HYGIENE	Hairdresser Beauty centre
SERVICES TO PERSONS	School of motoring Insurance office Dry cleaning
SERVICE STATION	
SUPERMARKET	
TOBACCONIST	

Table : activities typology in the sample

Analysis of the reduced sample:

Activity categories	Number of requests	%(Loss of trade)/theoritical turn over
ALIMENTARY PRODUCTS	**4**	**14**
HEALTH CARE	1	4
FUEL DELIVERY	1	2
CULTURE & LEISURE	1	2
EQUIPMENT FOR THE HOUSE	1	4
EQUIPMENT FOR THE PERSON	3	**26**
MEDICAL EQUIPMENT	3	1
BOOKSHOP	0	/
RESTAURANT	**6**	**22**
HEALTH, BEAUTY and HYGIENE	1	19
SERVICES TO PERSONS	0	/
SERVICE STATION	1	**28**
SUPERMARKET	2	4
TOBACCONIST	**4**	7
total	28	

Table : reduced sample – loss trade/turn over

We can see that the most sensitive activities concern food products, equipment for the persons, restaurant and service station.

Analysis of the global sample:

Activity categories	Number of requests	Loss of trade scale
FOOD PRODUCTS	6	30
CONSULTING	5	13
FUEL DELIVERY	1	37
CULTURE & LEISURE	4	**71**
EQUIPMENT FOR THE HOUSE	2	**64**
EQUIPMENT FOR THE PERSON	**20**	40
MEDICAL EQUIPMENT	5	47
BOOKSHOP	4	55
RESTAURANT	**24**	31
HEALTH, BEAUTY and HYGIENE	6	53
SERVICES TO PERSONS	4	39
SERVICE STATION	1	31
SUPERMARKET	3	**100**
TOBACCONIST	8	30
total	93	

Table : global sample – compensation scale

Here we can see that the activities culture-leisure, equipment for the house, supermarket represent the highest compensations.

3.7.2 What we propose for Care-S criteria calculation

We use these different elements for proposing a criteria LossOfTradeW, considering the different land use types. Precise valuation method can be implemented to improve values in the following table and especially for the land use type “special area building” needing a case by case valuation.

For dig techniques

In this case the working area is whole length of intervention

$$LossOfTrad\ eW_{dig} = L \cdot d \cdot r \cdot p \cdot E_{dig}$$

with

L length of the works (m)

d duration of the works (days)

r if “need to later reopening of laterals” or “digging for reconnecting laterals”

r=1,2

if no “need to later reopening of laterals” or “digging for reconnecting” laterals r=1

p in case of “digging requirements: pit damage”,

p=1,1

if no pit damage $p_=$1

E_{dig} loss of trade factor presented in the table below

We built this table by giving values to the case city centre and afterwards to the other lines of the table.

DIG or TRENCHLESS	DIG	requires later reopening of laterals (Y/N)=	Y
working area required sizeld=	whole length	need of digging for reconnecting	Y
length of works=	300	pit damage (Y/N)=	Y
works duration =	20		

			NOISE Y		NOISE N	
			DUST			
		number of lanes	Y	N	Y	N
land use type	rural =1	pedestrian street=0	50	40	40	30
		1	50	40	40	30
		2	20	15	15	10
	urban housing =2	pedestrian street=0	30	20	20	10
		1	30	20	20	10
		2	15	10	10	5
	city center =3	pedestrian street=0	120	110	110	100
		1	120	110	110	100
		2	70	60	60	50
	industrial	pedestrian street=0				
		1	130	120	120	110
		2	130	120	120	110
	shopping area=5	pedestrian street=0	120	110	110	100
		1	150	130	130	120
		2	80	70	70	60
	special area	pedestrian street=0				
		1				
		2				

Table: E_{dig} loss of trade factor for dig technique

For trenchless techniques

We propose the following valuation taking into account the former table and the following data:

DIG or TRENCHLESS	TRENCHLESS	working area required nb location (1,2 ou variable)=	1
		working area required sizeld(<100 ou 100-300 ou 300-800)=	<100
length of works=	300	requires later reopening of laterals (Y/N)=	Y
works duration =	20	need off digging for reconnecting lateral=	Y
		pit damage (Y/N)=	Y

$$LossOfTradeW_{trenchless} = a_{l,s,n} \cdot d \cdot (p + s) \cdot r \cdot E_{trenchless}$$

with

$a_{l,s,n}$ trip time factor

l number of lanes (0,1, 2)

ws location size (< 100,100-300,300-800)

wn number of working locations coefficient (1,2) (if variable we consider=2)

		Number of lanes *l*	
Location size *ws*	location nb *wn*	*l=1*	*l=2*

trip time factor $a_{l,s,n}$	<100	1	**1,3**	**1,1**
		2	**1,5**	**1,3**
	100-300	1	**1,5**	**1,3**
		2	**1,8**	**1,5**
	300-800	1	**1,8**	**1,5**
		2	**2**	**1,8**

r if "need to later reopening of laterals" or "digging for reconnecting" laterals

r=1,2

if no "need to later reopening of laterals" or "digging for reconnecting" laterals r=1

p in case of pit damage,

p=1,1

if no pit damage p=1

s in case of surface damage s=0,05

if not s=0

$E_{trenchless}$ loss of trade factor

$E_{trenchless} = 1/3.E_{dig}$

4 DEFINING CRITERIA ON IMPACTS OF FAILURES

The criteria worked out in the frame of WP 5.1.b module are provided for the multi-criteria approach developed in WP 6.2, for choosing the pipes to be rehabilitated.

All criteria can be calculated with the SOCIOFAIL tool developed on an excel sheet, within the CARE-S software environment.

Besides the technical criteria such as the type of defects existing on the pipe, the age of the pipe, the technical characteristics, we focus here on the impact of failures on the socio-economic environment.

The question here is to compare a set of pipes and classify them considering different criteria, that means that here we will have to give criteria allowing a discrimination between the pipes (where as in the former part concerning works we had to compare several techniques for a same pipe).

4.1 FAILURES CRITERIA: wet weather flooding (material damage and loss of trade)

4.1.1 What we know about

4.1.1.1 Urban flooding causes

The urban sewer system has two main tasks to fulfil, the collection and hygienic transport of wastewater out of urban areas and the drainage and safe removal of storm water. A well designed and functional drainage system prevents urban areas from flooding up to a certain storm event. In reality, flooding will also occur locally during precipitation with lower intensities. This might be due to wrong design, deteriorating network or blockages. Urban flooding in general can have several causes and the flooded area is not necessary identical with the location of its origin. For example, a can flood relate to an up- or downstream deficiency. The following listing is grouped regarding the trigger sources for flooding:

1 Construction flaws (long term problems)

- pipes partially blocked due to construction faults
- gates partially closed
- backwater into basements from combined sewer (no backwater valve or siphon)
- wrong slope or uphill slope
- street inlets higher than surrounding area
- cross connection storm to sanitary sewer (overload of sanitary sewer)
- high infiltration into sanitary sewer (overload of sanitary sewer)
- overland flow directly into basement (wrong surface slope)

2 Operational problems (short term problems)

- pipes partially blocked due to deterioration (broken, roots, displaced joints etc.)
- inlets clogged by leaves
- large bottom sediments
- pipe clogged with debris
- screens clogged
- pump out of order
- inlets frozen or clogged by snow (winter)
- inlets clogged by hail (summer)

3 Overloading ("act of god")

- "catastrophic" short term rainfall
- long duration rainfall with high intensity at the end
- unfavourable combination of snowmelt/rainfall
- backwater caused by high receiving water (backwater into sewers)
- surcharging of receiving water (overtopping of banks, storm surge)
- obstructions due to exceptional events (landslides, uprooted trees, etc.)

4 Underdesign (human fault)

- surcharging due to hydraulic bottleneck (pipe too small)
- backwater due to hydraulic bottleneck in combined sewer (and no back valves in basements)
- wrong design loading (design storm too small)
- confuse recurrence interval of rainfall with recurrence interval of flooding
- under-dimensioned inlet capacity / surface drainage
- computational errors
- uncertainty and lack of data (design storm; connected area)

5 Urbanisation (long term)

- increasing degree of imperviousness (no increase of total area)
- total connected areas increasing
- general urbanisation upstream (more frequent river flooding)
- buildings inside the floodplain or lower areas

6 Groundwater (flooding events types not addressed further)

- flooded basement due to high groundwater level

- high groundwater levels cause wetting of basement walls
- wrongly designed stormwater infiltration system
- blocked soil drainage pipes

7 Flooding due to break of water supply pipes (flooding events types not addressed further)

- break of public water mains
- break of private in-house installations

The European Standard EN 752 defines flooding as a *"condition where wastewater and/or surface water escapes from or cannot enter a drain or sewer system and either remains on the surface or enters buildings"*. Consequences and damages are not explicitly included in this definition of flooding, but are mentioned at other places in the EN 752. It must be assumed that damage occurs under the condition of flooding. Additionally, damage can occur under a surcharge situation without flooding. This is especially valid for countries that do not request backwater valves in their service pipes. Surcharge is defined as a *"condition in which wastewater and/or surface water is held under pressure within a gravity drain or sewer system, but does not escape to the surface to cause flooding"*. Not every surcharge is leading automatically to damage. It is therefore necessary to consider local circumstances when evaluating the potential of flood damage in a surcharge and/or flooding situation.

Three different scenarios can be distinguished where flood damage occurs:

1. Surface runoff from precipitation and snowmelt enters the sewer system and is drained under <u>surcharge condition</u>. The pressure level is between the minimal accepted basement level and surface level. Damage occurs only in form of basement flooding in case of non existent or malfunctioning backwater valves.

2. The <u>transport capacity</u> of the sewer system is not sufficient for the amount of precipitation and/or snowmelt. Surface runoff cannot enter or escapes the sewer system. In addition to basement flooding through the sewer system, damage can appear on the surface and water can enter a building from there.

3. The <u>drainage capacity</u> of the intakes to the sewer system is not sufficient or the design for surface drainage is wrong. In the first case, clogging by leaves, gravel, ice and snow is more common than insufficient dimensions. Damage is only caused by surface water. This is a typical flooding situation in cold climate regions or with extreme precipitation intensities.

Flooding is also often caused by rivers leaving their borders. This situation is not connected to the dimension criteria for urban sewer systems and therefore not included in this description. Nevertheless, river water levels are constraints to the urban sewer system and should be taken into account as a downstream border condition.

4.1.1.2 Consequences of urban flooding

Urban flooding in European cities as defined in chapter 1.1 tend to have a short duration and limited spatial extent. Their causes and effects vary from flooded basements caused by blockages in the sewer system to pure surface flooding during snow smelt events. The impacts of urban flooding are equally varied and minor damages are quite regular as figure 1 illustrates. The example from Norway shows sorted flood damage amounts for a ten year period. 75 % of the damages lie below the average. Dramatic events with comprehensive damages and possible loss of human lives are often related to river flooding that is not the subject of this research.

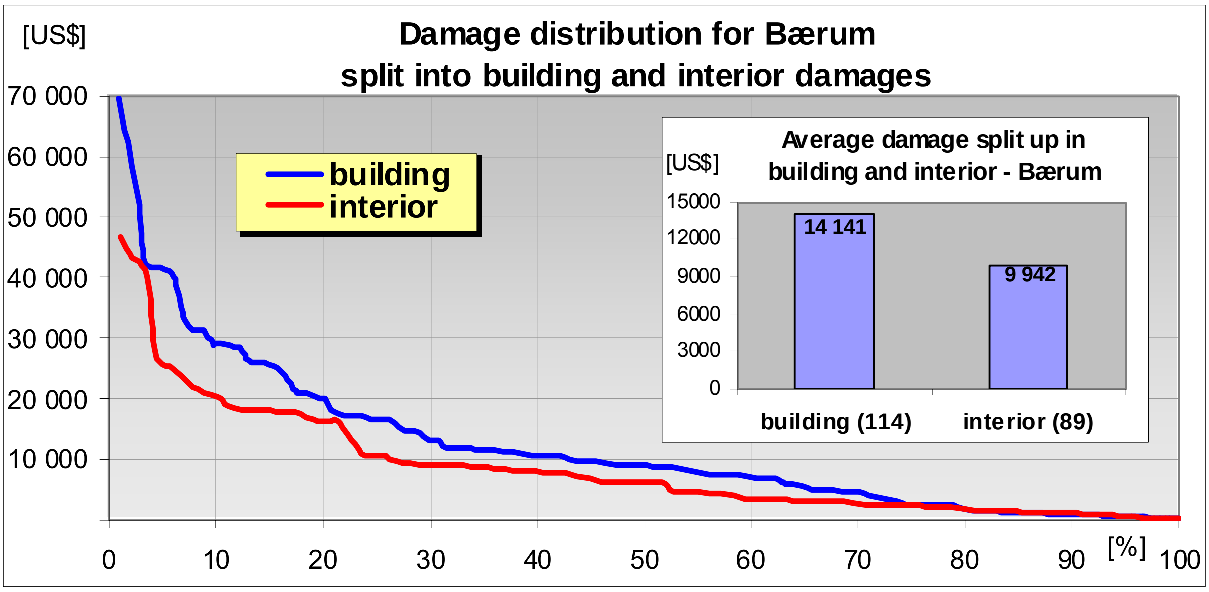


Figure 1: Damage distribution for urban flooding for a Norwegian town (1990-2000)

In the chain of causes, urban flooding originates in a *defect* or *misfunction* of the urban drainage system. Combined with a load on the system (precipitation) a defect will cause an *effect*, a physical change. An effect that is not in accordance with the respective regulations or exceeds a level of acceptance can be defined as a *failure*. Effects can be distinguished into ex- and internal effects. *Internal effects* generate consequences on the urban drainage system itself, internal to the network manager or owner. *External effects* have an *impact* on a second party, in a physical, economic and social way. The magnitude of an impact or damage depends on the intensity of the effect and the *vulnerability* of the impacted area, population and activities.

External impacts, also called consequences or damages can be further subdivided into several groups. There exist varying definitions of those groups in literature, depending on the point of view and the context they are embedded into. The following definition is taken from a Norwegian study on urban damages (König, 2002).

Direct damages

Direct damages have a physical link between the effect and the impact. The damage can be caused by water level, flow velocity, flooding duration or a combination of it. Under normal circumstances all damages can be repaired or replaced. Exceptions are personal effects like irreplaceable collections or historical values. The damage can be monetary quantified by evaluation of repair or replacement costs.

The following listing gives an overview over the most common damages that are included in this category:

- Buildings: The structure of the building, its foundation, installations and permanent interior work is damaged. That includes cracks in the walls or floors, damage on technical installations like water supply, drainage system, electricity or heating system. Wall papers, painting and floor covering are included just as structural damage on walls, floors and ceiling. The damage consists often of moisture damage and in the long run of mildew and mould. Outside the building, damage is mostly caused by erosion around foundations. Pollution plays an additional role for the extent of damage. There is a significant difference between damage caused by sewage or only by surface runoff: Cleaning is more costly, and more interiors must be removed when sewage is mixed in the floodwater. The damage costs include the building materials as well as the labour costs, for replacement, repair and cleaning. If a building is severely damaged, the question may be of replacement instead of repair.

- Interior: Every item inside a building that is movable is included in this point. Typical examples for flood damage are furniture, books, clothes and electrical devices. For a commercial building or manufacture further damages can appear like on production equipment, storage goods and machinery. The damage costs include only the replacement costs for the damaged items (valued at the remaining value or second hand cost, if this makes sense for the type of good damaged), repair and/or cleaning.

- Vehicles: Damage consists mostly of interior damage or technical malfunction.

- Road structures: Damage on roads is mostly caused by erosion of road foundations. Floodwater velocity is the main factor here. Also erosion on bridge foundations and railway lines is included under this point.

- Landscape: Erosion and floodwater velocity are the main factors. Damages can include everything from small erosion furrows in parks or gravel parking lots to extensive landslides. Uprooted trees and damage on vegetation in general are further examples for landscape damage.

- Urban infrastructure: Besides damages on road constructions, which are listed separately, damage can also appear on water supply and drainage systems, gas pipes and electricity lines, collective heating, phone lines…. A structural damage is most likely only when erosion is extensive. Consecutive damages following a failure of e.g. the electricity supply is not included under direct damage but under the next category, indirect damage.

Direct damages are quite numerous, but are relatively straightforward to categorise, to assess and to quantify, even it is problematic to generalise a survey. Compensation payments are mainly made by insurance companies for building, car and interior damage. Damage on urban infrastructure is also often covered by insurance. There are nevertheless huge differences between countries and insurance regulations and urban flooding damages are often a burden for individuals or the municipality.

Indirect damages

This category includes consequential damages and side-effects, caused by exceptional conditions due to the flooding (state of emergency), for example administrative and labour costs. Typical indirect damages are business losses. They can occur in- and outside the impacted area, as a consequence of traffic detours and sub-supplier hindrances. Indirect damages outside the flooded area are also called secondary impacts. They are very difficult to identify and assess, even more since the impact can be positive in the case of business shift to outside areas.

Indirect damages are not constant, but last only for the duration of the flood or short time after. Some of them can be "made up for" in the mid-term if activities (or purchases by clients) are delayed. They are not as obvious as direct ones and consecutive effects can have many links. In other terminology (AWWARF) these kind of impacts are defined as social costs. The most important examples are listed here:

- Traffic detours: In addition to buildings, flooding in urban areas affects mainly the road system. Shallow flooding will slow down traffic and causes traffic jams. When areas are blocked by floodwater, the traffic must be led around it. This causes longer travel distances and therewith increased driving duration, more traffic density and finally more pollution. The additional driving time results in reduced working or spare time. All types of public transports can suffer from impacts of same kind.

- Turnover and production losses: Business and industrial places that are directly affected by flooding suffer additional losses by reduced or terminated production and turnover. This can be caused by flooding of the production site itself or indirectly, when employers and supply parts cannot arrive and products not be delivered in time. This second cause can also affect localities, which are outside the flooded area and is defined as secondary impact.

- Clearing work: Cleaning and clearing work, which is not connected to direct repairs, belongs to indirect damage as well. Dirt and mud must be removed from roads, basements must be pumped and dried and damaged interior must be removed. Generally, this point includes all labour that is needed to re-establish the conditions before flooding occurred, excluding the repair work for direct damages.

- Administrative expenses: Flooding causes extensive organisational work. The municipality must organise the clearing and cleaning work and co-ordinate traffic detours and emergency actions like fire brigade operations. All direct damages and turnover losses result in additional paper work for the damage regulation between the affected persons and insurance companies. Finally, there is an increasing number of court trials between private persons, insurance companies and the responsible institution for the urban drainage system. This creates costs in addition to the compensation payment.

The burden of indirect flooding costs is mostly carried by the local authorities and partly by insurance companies. But also individual persons, tradesmen or manufacturers are affected by the costs if no insurance is signed for these losses.

Social consequences

The third category is the most difficult to define. The damage related to it is not directly connected to a single flood event but more to the frequency and severity of urban floods, or to the time series of floods. Nevertheless, effects on health, worry, fear, stress… combine consequences of the real-time time and of the immediate aftermath, with mid to long term consequences. The social consequences are continuous and cannot be repaired immediately after a single flood event. Besides the definition of the third category, its monetary quantification is difficult to obtain. Nevertheless, in the long run social consequences might be more costly than direct flood damages and are therefore important to include:

- Regional development: The exposure of a city to frequent floods will affect its development in several ways. It will be difficult to attract new business to an area and the expansion of existing ones is restrained. In the worst case, business, industry and inhabitants are moving out of the exposed area. It might be that the insurance premium against flood damages is set higher in these areas, which will certainly not attract new establishments. The flood frequency in an urban area is not so much of a meteorological nature, but the matter of political decisions and urban drainage management. This will affect the confidence in a region in general and consequently its development. But since regional development is connected to numerous aspects, it will not be easy to determine the effect of frequent urban floods separately.

- Social acceptance: Close connected to the regional development is the social acceptance. In the end it is a political decision where to set the protection level against floods. If this level is not accepted by the public opinion, it will finally affect elections. Media plays an important role in opinion building, pointing out the responsible which is to blame for any nuisance. Urban flood events are especially well suited for drawing the public attention.

- Quality of life: Frequent urban flooding reduces live quality for each inhabitant and severe flooding is even live threatening. Flooding regulations, preventive actions, repair works and traffic hindrances are annoying. Even if people get used to frequent flooding, so is their behaviour affected by it. For example is the usage of basements or ground floors that are regularly flooded restricted. Finally, this will reduce the value of a property.

- Health impacts, stress… (cf intangible damages presented below).

Social consequences are not covered by any insurance, but will have its effect on the community. A possible quantification can be made by comparing similar areas with each other, but it will be difficult to isolate the effect of urban floods.

Further on, damages can divided into tangible and intangible costs. Material and economic losses where it is possible to put a monetary value on it are defined as tangible damage. Most direct and indirect damages belong to this category. Intangible damage is unfeasible or impractical to assess directly in monetary terms. It corresponds to the category social consequences above and paraphrases disruption of daily life and feelings of anxiety, stress, insecurity and irritation.

In the CARE-S context, the socio economic consequences of urban flooding that are included are divided into the following groups:

1. *Material damage and loss of trade*: That group includes both direct and indirect damages that are tangible, with the exception of consequences on traffic disruption that are described in a separate group. Secondary damages outside the flooded area are not included.

2. *Intangible damage to population*: Intangible damages refer to a variety of disruption costs upon which it is not currently possible (or worthless) to objectify or to attribute a monetary

value. They are mainly of psychological nature and can be grouped into disruption of daily life and routines, anxiety, stress and irritation, worry with recover and future flooding, feelings of insecurity, health damages and so forth.

3. *Road and traffic disturbance*: These are indirect consequences on traffic flow caused by urban flooding.

The three categories are analysed in the respective following chapters. There, the nature of impact is described further and possible assessment methods are described and evaluated.

4.1.2 Impact of wet weather flooding in the framework of CARE-S

In CARE-S, socio-economic consequences are taken into account in setting up a rehabilitation plan for sewer networks. The social costs are an assessment of the external impacts on society due to failures. A failure appears when an element in the sewer network has a defect or a misfunction. That is when the element does not comply with the nominal design and is therefore not working as expected. A defect will together with a system load result in an external effect that can be defined in a physical change of the environment outside the undertaking. The social consequences of those effects are the issue of this report.

A necessary input to evaluate social costs, is the quantitative description of the external effects that should be considered. The contents of this report have therefore to be based on the deliverables from other tasks in Care-S. Consequently, the quality and quantity of impact criteria included in this investigation are limited to number of external effects and the amount of data coming from those sources.

Flooding in urban areas is modelled in CARE-S as sewer systems drained under surcharge conditions. The real hydraulic conditions, based on observed and predicted deteriorated networks are taken into account. Two types of floods can occur: Local flooding caused by local obstructions in the network during dry weather and wet weather flooding due to overloaded systems. Dry weather flooding is addressed elsewhere in this report.

The hydraulic simulations in CARE-S will not take into account surface flooding as described in chapter 1.1, pure surface flooding where the network is not overloaded or a combination of surcharge and surface flooding. River flooding that affects cities will neither be the subject of CARE-S and therewith not be included in the socio-economic analysis.

The evaluation of impacts from wet weather flooding relies on the output from work package 3, hydraulic performance. Expected parameters from this work package that are used for those impacts are frequencies for certain flood levels and flood duration for each pipe. The flood levels are defined for 4 classes: full pipe, up to a critical level (user defined), up to the ground level, above ground level. Besides those hydraulic effects, parameters on vulnerability are needed to assess the impact costs for wet weather flooding. This data is expected from the user of CARE-S and closer defined in chapter 1.4.2 (assessment of criteria).

The impact of flooding has to be assessed at pipe level since the failure consequences for each pipe are considered as rehabilitation criteria. The more sever the consequences that a pipe causes, the higher is the priority for rehabilitation. Therefore, material damages at buildings, cars and infrastructure, loss of trade and traffic disruptions must be connected to a single pipe. A main obstacle for the damage assessment is the fact that the pipe(s) where flooding occurs is not necessarily the pipe(s) that causes the flood. Those are most likely localised further downstreams and act as a bottleneck. The responsible pipe can only be identified in the hydraulic analysis in CARE-S. Work package 3, the hydraulic analysis, delivers a criterion that is called "weight of the link" and represents the responsibility of a pipe for a flooding event. To obtain this information a simple comparison of the theoretical flow capacity and the actual flow during an event is made. The responsible pipe has to be related to the aggregation of flooding consequences in the flooded area. Work package 5 in CARE-S, socio-economic consequences, only assesses the consequences related to the single flooded pipe. The aggregation needed for decision making of the rehabilitation scheme is not part of WP5.

4.1.3 Material damage and loss of trade

4.1.3.1 Impact assessment

Flood damages have been assessed in literature on a case to case basis. In most cases, river flooding and its consequences have been investigated. There are some significant differences between urban and river flooding and the conclusions drawn in those studies can only be transferred with limitations. River flooding (with medium-size to large catchments, or in flat areas) occurs usually within a sufficient warning period, giving time to move interiors into upper floors or evacuate the area. On the other hand, the duration is longer in average and damage types differ from short term urban flooding. Flow velocity and water levels are also generally higher with river flooding and damages are therefore often more sever.

All studies of urban flood damage reveal a very high deviation around average values and local variations are substantial. Continuous functions for damage cost prediction that have been established in several studies must be applied with care. The results are better suited to make a comparative, qualitative analysis than to predict the actual cost that a flood event will generate. The prediction of single building damages is almost impossible and the reliability increases for larger flood areas.

Information on urban flooding can be gained from different sources, but are seldom complete:

1. Municipalities or sewage system operator: Records of major and minor events, mostly only location and number of damages. Detailed damage costs only in case of recourse against the network operator.
2. Insurance companies: Detailed damage information of single cases, including costs. Often difficult to identify a cause. All insurance companies must be included to get the overall damage.
3. Fire brigade and other emergency service: No complete overview available, but precise records of time and location.
4. House owners: Interview directly with flood victims. Detailed, but incomplete information, influenced by individual perception.

Flood victim regulations differ from country to country and the insurance practice is not consistent. Urban flooding belongs in some cases to natural disasters and is therewith regulated differently to normal house and interior insurance cases. The responsibility of the network operator varies from case to case. A major differentiation regarding responsibility is often made between surface flooding and backwater flow from sewer systems into the basement. Backwater valves are only obligatory in some countries for example.

Due to variations in appearance, responsibility, severity and regulations of urban flooding it is not possible to make a consistent impact assessment, based on recorded events. In the

CARE-S context, consequences of urban flooding is one of many factors leading to a list of prioritised rehabilitation projects. It is therefore important to choose an applicable approach, offering at the same time a flexibility regarding varying conditions and a qualitative differentiation between pipes and areas. That means that the criteria of flooding impact should be possible to include for the user without extensive and costly studies on flooding consequences, but influences the process of rehabilitation planning nevertheless.

The user will be able to make a qualitative assessment of flooding consequences with the data already available in the CARE-S database and improve the assessment with own data and experience. The definition of the criteria "material damage and loss of trade" is made in the next chapter. As a help to the user, main results from flood damage assessments from literature that seem to be most relevant for the chosen approach, are described briefly in the following paragraphs.

The European projects EUROFLOOD 1 and 2 (Hubert et al 1996, Picheral et al 1995, Torterotot 1993-1) had the objective of flood hazard assessment, modelling and management in a broad perspective. The first project addressed river flooding, the second also considered urban storm flooding. One of the project reports aims at a simplified model of rainfall flood damage. The basis was the answers of detailed questionnaires from three different parts of France. The survey analysed flood characteristics and damage to buildings, interior, trade and industry. The investigated parameters were amongst others type of building, construction year, area, existence of basements, interior, prevention measures, trading activities and water depth. The statistical analysis was the basis to a simplified model with the goal to produce cost damage functions.

A unitary damage, the relation between actual and potential damage, has been introduced in this study with several varying definitions for the potential damage, for example the total real estate value, the floor related real estate value and interior value. Cases with and without basements are distinguished as well as fast and slow oncoming flooding. For each case a figure with unitary damage against water depths is shown in the report.

Additionally, explicit individual building damage functions are developed from the unitary damages in the EUROFLOOD projects. For all cases, an absolute damage can be calculated from a linear equation, dependent on the water depth.

Another European project, called RISURSIM (Milina et al 2003), had two main objectives. The first one was to develop a hydraulic dual drainage model that simulates the real flow and water depth on the surface and the interaction between sewer system, surface flow and basements. The second objective was to develop a consequence model with the goal to establish water level – damage relations, in a first step for buildings only. The combined models are able to forecast flood damage on buildings for one event or the overall damage costs for a long term simulation.

The data source for the consequence model was the database of an insurance company in Norway which covers about one third of all households. Detailed damage information for about 400 cases could be retrieved from that database about the location, source and reason of the damage, building details, how and where the flood water entered the building, water levels inside the building and a detailed damage description. Backwater valves are not common in Norway and most damages happened therefore in the basements.

Water level – damage relations were developed, dependent on basement standard, source of flood water type of building and combinations of several parameters. Based on the findings, a factor model has been established, with the overall average damage as a basic number and corrective factors for the investigated parameters, see table below.

Table: Damage factor model on buildings from RISURSIM project

Mean total damage	136 400 NOK
Corrective factors:	
Basement furnished	1,4
Basement partly furnished	0,7
Basement not furnished	0,5
Surface water into building	0,7
Sewage into building	1,4
Detached house	1,2
Semi detached house	0,7
Apartment building	0,7
Industrial building	1,8
Other building / unknown	1,0
Water level 0-5 cm	0,5
Water level 6-25 cm	1,0
Water level > 25 cm	2,1

Other studies are also aimed at finding vulnerability factors for types of buildings and different activities. In the CARE-S related project CARE-W (Torterotot 2001) the flooding consequences of a pipe burst have been studied. An intensive literature study integrated findings from investigations on river flooding, urban runoff flooding and pipe burst flooding. Flood damage factors have been established for housing and retail shops, industry and public buildings and traffic disruptions.

For housing and retail shop damages, vulnerability factors were taken from IIBRBS (1994), see table below.

Table: Results from a flood damage study around Paris (IIBRBS, 1994)

The values are transformed to be made non dimensional, factor value 1 corresponding to estate and furniture value of ground floors in an individual housing area, without retail shops.

type of land use	**vulnerable values factor**	**number of flats and individual houses on ground floor per hectare**	**number of retail shops per hectare**
individual housing with retail shops	1.05	13	0.5
individual housing without retail shops, allotments	1	13	0
rural housing	1	13	0
attached houses of small height	1.53	20	2
attached collective buildings of small height	1.53	20	2
collective buildings with numerous flats	0.85	15	2

Studies on river flooding from DREIF (1986), Debizet and Claude (1986) and Torterotot (1993) were synthesized into table below, distinguishing basement and surface flooding and soil slope.

This table compares damage calculated (from various damage curves) when water level is:

- 1 meter below the ground (significant basement flooding without surface flooding),
- 0.05 meter above the ground ("standard" level considered by Green et al 1987 for representing typical flooding from sewers),
- 0.20 above the ground, which we propose to consider for representing flooding when the soil has a significant slope and water level climbs against upstream walls of the buildings.

On the other hand, we had to consider buildings where the ground floor is elevated above the outside soil level : basing on surveys performed in several cities in floodplains (Torterotot 1993), we considered a standard average value of 0.30 meter for the elevation of such ground floors above the soil.

Damage costs were made non dimensional by dividing them, for any of the four damage curve sources, by the cost with 0.05 meter water above the ground when a house has a basement and a ground floor flush with the soil.

Table: Intensity factors for buildings (Torterotot, 2001)

buildings with basement ? buildings with ground floor above soil ?	yes yes	yes no	no yes	no no
flooding of basement only	0.49	0.59	0	0
surface flooding without significant soil slope	0.86	1	0	0.36
surface flooding with significant soil slope	0.92	1.1	0.17	0.48

For industrial and public buildings vulnerability factors from IIBRBS (1994) are used again:

- industrial plant	1,7
- wide industrial site	0,93
- industrial allotment	0,66
- open air storage	0,14
- big stores	1,0
- offices	4,3
- sports halls	0,87
- education buildings	0,65

Several further studies have been reviewed for this report (see references), mostly on river flooding and all of them based on real cases. Their results vary widely, as well within the studies as between the studies. Often, the amount of investigated and damaged assets is statistically not significant enough. Even if it is the case, the transferability to other cases is doubtful, because most studies depend on one or very few special events.

Business losses (as well as other indirect damage) are even more difficult to address than direct physical damage. First they depend on the characteristics and on the behaviour of activities concerned (shops, factories, offices…) facing a flooding event and on the duration of recovery (repairs, cleaning…), second they depend on possible transfers of activities in time and/or in space: for instance some types of sales can be postponed, some are “transfered” to competitors… In any case they should not be neglected as they can be important. To give an example, the ratio between indirect losses on one hand and building and content material damage on the other hand, when considering 20 centimeters water above the floor for fast rising river floods, have been given following values (SAGERI 1988, Torterotot 1993): for city centre about 0.5, for other urban areas and village 0.2, for industrial area 0.9, for handcraft and professional shops area 0.6.

For future research on urban flooding, the inclusion of all types of flooding events over a longer period is desirable. It can be expected that in the future, detailed asset data will be available in an electronic format and hydraulic analysis will be capable of modelling surface water levels in a more accurate way.

4.1.4 What we propose for Care-S criteria calculation

4.1.4.1 Criteria definition

Criteria values in the socio-economic work package in Care-S are defined as non-unit numbers with an abstract qualitative relation to the real monetary or social value of the damage. For each criterion, values can be compared within the same impact type, but not between two different impact types. This approach has been chosen instead of a monetary assessment because of its universal applicability and to avoid the complications of assessing some types of social costs. The benefit of monetary values in the context of rehabilitation planning, if there is any at all, would stand in no relation to the difficulties of their assessment. The multi-criteria decision procedures considered in CARE-S allow to use such criteria.

In the consequence, average damage costs, gained from various investigations will not be considered in the damage model of CARE-S. The qualitative distinction of potential damages due to urban flooding is the core of the approach.

The following basic data is available in the database of the Rehab Manager in CARE-S and can be utilised for the damage assessment (vulnerability):

Pipe based data:

1. Pipe identification (Identification, street name)

Catchment based data:

2. Land use type of a subcatchment (typology from EN752)
3. Area of a subcatchment [m^2]
4. Impervious urban area [m^2]
5. Existence of basements (yes or no)
6. Existence of backwater valves (yes or no)

The calculation of flooding frequencies (effect) on pipe scale is made in the hydraulic analysis of CARE-S. For water levels exceeding the surface level, the real runoff situation is not simulated and therefore, water depths on the street are not calculated. Out of practicality reasons, 3 water levels are distinguished in the hydraulic analysis and the frequency of exceeding those levels is determined in long-term simulations. The first level is the top of a pipe (level B), the second a user defined average level of basements (level C) and the third the surface (level D). Thus, further input for the impact assessment of flood damage is coming from work package 3 (effect):

Pipe based data:

1. Frequency of exceeding a certain water level [#/year]

Other flooding information like duration can only be included in the damage assessment when analysing certain events. An average duration for each water level is not reasonable to include. For the chosen approach, it has to be assumed that flood water is always contaminated with sewage since the hydraulic surface runoff is not modelled in CARE-S.

The driving factor for the determination of vulnerability is the land use type of a subcatchment. Based on available research, a more detailed flood damage model could include information about single types of buildings, their ground floor area, usage and construction of the building, basement standards, potential estate value and more. It would also be possible to include water level – damage relations in a more sophisticated model. In CARE-S, this level of detail is not appropriate in relation to the project goal, unless the user is focusing on urban flooding driven rehabilitation of the network. In that case, a more detailed model could be applied in its place.

In the typology of EN752 are 5 types of land use defined:

2. rural
3. urban housing
4. city centre
5. industrial area
6. shopping area

All subcatchments in the hydraulic analysis will be related to one of those area types. In the chosen factor based approach each of the area type receives a basic value, representing the potential material damage and loss of trade for an area type. Additionally, the impervious area can be used to derive the building density of an area. It is included as a corrective factor to the land use type. Alternatively, the population density could be derived from the population number and area size that is both stored in the Rehab Manager. It was decided that including this information would not necessarily result in a better flood damage assessment and is therefore left outside, apart of the intangible damage part.

Another subcatchment related factor is the combination of the existence of basements and backwater valves. In case of no basements or existing backwater valves, damage is assumed to occur first after reaching hydraulic level 3, the surface. Otherwise, a factor represents the potential damage of basements for water levels above 2, the user defined average level for basements above the sewer.

In the CARE-S WP5 procedure, parameters describing and characterising the pipe environment, and hence various components of vulnerability to failures, can be validated – changed by the DSS user at pipe level. This is meant in order to take into account particular areas at street level, and of course streets of building blocks which show a specific vulnerability.

Loss of trade is considered to happen first when the water level reaches the surface. It is assumed that trade is situated in the ground floor and the accessibility to shops is blocked when the flood water rises above the surface level. Physical damage to shops and retailers is included in material damage.

The impact assessment has to be pipe related in CARE-S as described previously. So far, the vulnerability factors have been catchment related, with a possibility to specify pipe related values for pipe environment parameters. For actual damage calculations with a monetary value, the individual pipe has to be linked to a part of this area. In that case, the information about average pipe length per area unit has to be included. Multiplied with the actual pipe length would result in the absolute damage cost linked to a pipe. However, the impact assessment in CARE-S has been chosen to be a factorial approach, with number values not estimating the actual costs but representing an order of magnitude. Including the pipe length as an additional factor would be misleading in the result since for example a factor for the land use type could hardly be related to the length of a pipe. If two neighbouring pipes with a length of 10 and 100 meter have the same damage factor, for example 5, the multiplication would lead to a huge difference that can not be justified. The weight of the length would result in misleading criteria values. The length of a pipe is therefore not included in the calculation.

The calculation of the criteria value for the impact 'material damage and loss of trade' for an individual pipe is proposed as follows:

$$MDLD(pipe\ ID) = (P(WLC) - P(WLD)) * 10 * (D_{mat1} + D_{spec1}) + (P(WLD)) * 10 * (D_{mat2} + D_{trade} + D_{spec2})$$

with: MDLD = Material damage and loss of trade

P(WLC) = Probability of reaching water level C (basement level = critical level see D10 report)

P(WLD) = Probability of reaching water level D (surface level see D10 report)

D_{mat1} = Material damage factor for basements (building + interior)

D_{mat2} = Material damage factor for ground floor and basements (building + interior)

D_{trade} = Loss of trade factor

D_{spec1} = Specific damage factor for basements (user defined additional weight)

D_{spec2} = Specific damage factor for ground floor and basements (user defined additional weight)

Obviously, if a flooding situation should not be considered as a failure for a given pipe or sub-catchment (for instance if flooding is due to a rare rain event, for which the network is not supposed to collect significantly the flow), than the impact criteria considered for decision making would be 0, as there would be no priority addressing a non failing situation as long as there are failing ones left.

The factor '10' has the purpose to increase the probability to a number that is better to handle in relation to the D-factors.

D_{mat} is a function of land use type, existence of basements, existence of backwater valves and building density. D_{trade} is independent from basements as described above and therewith a function of land use type and building density. D_{spec} is an additional factor, defined by the user to give higher values to more vulnerable areas, e.g. around a hospital. The default value of D_{spec} is 0.

The damage factors D_{mat} and D_{trade} are established from a basic factor for the land use type and corrective factors for building density, basements and backwater valves:

$D_{mat1} = F_{LUTmat} * F_{BD} * F_{Bas1}$

$D_{mat2} = F_{LUTmat} * F_{BD} * F_{Bas2}$

$D_{trade} = F_{LUTtrade} * F_{BD}$

with: F_{LUTmat} = Basic factor for material damage of ground floor and calculation of basement damage regarding land use type

$F_{LUTtrade}$ = Basic factor for loss of trade regarding land use type

F_{BD} = Corrective factor for building density

F_{Bas1} = Corrective factor for basement damage with water level below surface

F_{Bas2} = Corrective factor for basement damage with water level above surface

Basic and corrective factor values for D_{mat} and D_{trade} are derived from the existing research by comparing average damages for the different categories. Values that could not be supported by research are defined in relation to the derived values. The basic values F_{LUTmat} and $F_{LUTtrade}$ are placed within a range between 1 and 5.

The corrective factor for building density (F_{BD}) is derived from the percentage of impervious area minus a percentage for traffic areas. The traffic area is individual for each land use type. The percentage of traffic area given in the following tables is related to the total area of a subcatchment, not the impervious one. The values are taken from a surface run-off study in Trondheim, Norway (Schilling et al 1998). There are high individual deviations from the proposed average values and the user might change the percentage. Traffic area includes streets, pavements and parking lots and all other impervious area without roofs.

The corrective values for basements F_{Bas1} and F_{Bas2} have several functions. First of all, F_{Bas1} sets D_{mat1} to zero if there are no basements or if there are existing backwater valves. In that case, there will be no material damages and loss of trade for water levels below the surface. In case of basements and no backwater valves, F_{Bas1} reduces the basic factor for material damage (F_{LUTmat}) and therewith D_{mat1} to basement damages only. Here, only lower water levels within the basement are assumed.

For the calculation of D_{mat2} (Material damage factor for ground floor and basements) three cases are distinguished for the value of F_{Bas2}. If there are no basements, F_{Bas2} is 1 and does not influence the basic factor F_{LUTmat}. If there are basements and no backwater valves, the flood water will enter the basement through the ground floor as well as the basement connection to the sewer system. High flood water levels in the basement are assumed in that case and the damage is higher as in the case of only basement flooding (D_{mat1}). In the third case, backwater valves exist and the flood water enters the basement only via the ground floor. It can be assumed that the damage in the basement is then lower than in the previous case.

In summary, F_{Bas2} can increase the basic damage factor, while F_{Bas1} reduces the basic damage factor to basement damage only. The relation between basement damage and ground floor plus basement damage is represented by the relation between F_{Bas1} and F_{Bas2}.

Table: Basic and corrective factors for rural areas

<table>
<tr><td colspan="6">Land use type: rural</td></tr>
<tr><td>Basic factor:</td><td>F_{LUTmat} =</td><td>1,0</td><td>$F_{LUTtrade}$ =</td><td colspan="2">1,0</td></tr>
<tr><td colspan="6">Corrective factors:</td></tr>
<tr><td colspan="6">Assumed percentage of traffic area = 10 %</td></tr>
<tr><td>Building density</td><td>low</td><td colspan="2">medium</td><td colspan="2">high</td></tr>
<tr><td>F_{BD}</td><td>0,8</td><td colspan="2">1,0</td><td colspan="2">1,2</td></tr>
<tr><td colspan="6">Existence of basements</td></tr>
<tr><td colspan="4">yes</td><td colspan="2" rowspan="3">no</td></tr>
<tr><td colspan="4">Existence of backwater valves</td></tr>
<tr><td colspan="2">yes</td><td colspan="2">no</td></tr>
<tr><td>F_{Bas1}</td><td>F_{Bas2}</td><td>F_{Bas1}</td><td>F_{Bas2}</td><td>F_{Bas1}</td><td>F_{Bas2}</td></tr>
<tr><td>0</td><td>1,2</td><td>0,2</td><td>1,4</td><td>0</td><td>1,0</td></tr>
</table>

Table: Basic and corrective factors for urban housing areas

<table>
<tr><td colspan="6">Land use type: urban housing</td></tr>
<tr><td>Basic factor:</td><td>F_{LUTmat} =</td><td>2,0</td><td>$F_{LUTtrade}$ =</td><td colspan="2">1,0</td></tr>
<tr><td colspan="6">Corrective factors:</td></tr>
<tr><td colspan="6">Assumed percentage of traffic area = 20 %</td></tr>
<tr><td>Building density</td><td>low</td><td colspan="2">medium</td><td colspan="2">high</td></tr>
<tr><td>F_{BD}</td><td>0,8</td><td colspan="2">1,0</td><td colspan="2">1,2</td></tr>
<tr><td colspan="6">Existence of basements</td></tr>
<tr><td colspan="4">yes</td><td colspan="2" rowspan="3">no</td></tr>
<tr><td colspan="4">Existence of backwater valves</td></tr>
<tr><td colspan="2">yes</td><td colspan="2">no</td></tr>
<tr><td>F_{Bas1}</td><td>F_{Bas2}</td><td>F_{Bas1}</td><td>F_{Bas2}</td><td>F_{Bas1}</td><td>F_{Bas2}</td></tr>
</table>

0	1,2	0,3	1,4	0	1,0

Table: Basic and corrective factors for city centres

Land use type: city centre					
Basic factor:	F_{LUTmat} =	4,0		$F_{LUTtrade}$ =	4,0
Corrective factors:					
Assumed percentage of traffic area = 40 %					
Building density	low		medium		high
F_{BD}	0,7		1,0		1,3
Existence of basements					
yes				no	
Existence of backwater valves					
yes		no			
F_{Bas1}	F_{Bas2}	F_{Bas1}	F_{Bas2}	F_{Bas1}	F_{Bas2}
0	1,4	0,4	1,6	0	1,0

Table: Basic and corrective factors for industrial areas

Land use type: industrial area					
Basic factor:	F_{LUTmat} =	5,0		$F_{LUTtrade}$ =	1,0
Corrective factors:					
Assumed percentage of traffic area = 50 %					
Building density	low		medium		high
F_{BD}	0,5		1,0		1,5
Existence of basements					
yes				no	
Existence of backwater valves					
yes		no			
F_{Bas1}	F_{Bas2}	F_{Bas1}	F_{Bas2}	F_{Bas1}	F_{Bas2}
0	1,6	0,6	1,8	0	1,0

Table: Basic and corrective factors for shopping areas

Land use type: shopping area				
Basic factor:	F_{LUTmat} =	4,0	$F_{LUTtrade}$ =	5,0
Corrective factors:				
Assumed percentage of traffic area = 40 %				
Building density	low	medium	high	
F_{BD}	0,7	1,0	1,3	

Existence of basements					
yes				no	
Existence of backwater valves					
yes		no			
F_{Bas1}	F_{Bas2}	F_{Bas1}	F_{Bas2}	F_{Bas1}	F_{Bas2}
0	1,6	0,6	1,8	0	1,0

The calculation of the criteria value for material damage and loss of trade (MDLD) is then in detail:

$$MDLD(\text{pipe ID}) = (P(WLC) – P(WLD)) * 10 * (F_{LUTmat} * F_{BD} * F_{Bas1} + D_{spec1})$$
$$+ (P(WLD)) * 10 * (F_{LUTmat} * F_{BD} * F_{Bas2} + F_{LUTtrade} * F_{BD} + D_{spec2})$$

Examples:

1. A pipe in city centre with an average building density and a probability of 0,3 to reach water levels between basement and surface and a probability of 0,1 to reach water levels above the surface. D_{spec} is zero (no especially critical area)
   a. with no basements:

      MDLD = 0,3*10*(4,0*1,0*0,0)+0,1*10*(4,0*1,0*1,0+4,0*1,0) = 8,0

   b. with basements but no backwater valves:

      MDLD = 0,3*10*(4,0*1,0*0,4)+0,1*10*(4,0*1,0*1,6+4,0*1,0) = 15,2

   c. with basements and backwater valves:

      MDLD = 0,3*10*(4,0*1,0*0,0)+0,1*10*(4,0*1,0*1,4+4,0*1,0) = 9,6

2. A pipe in urban housing area with a high building density and a probability of 0,2 to reach water levels between basement and surface and a probability of 0,05 to reach water levels above the surface. D_{spec2} is set to 2,0 but D_{spec1} remains zero.
   a. with no basements:

      MDLD = 0,2*10*(2,0*1,2*0,0)+0,05*10*(2,0*1,2*1,0+1,0*1,2+2,0) = 2,8

   b. with basements but no backwater valves:

      MDLD = 0,2*10*(2,0*1,2*0,3)+0,05*10*(2,0*1,2*1,4+1,0*1,2+2,0) = 4,72

   c. with basements and backwater valves:

      MDLD = 0,2*10*(2,0*1,2*0,0)+0,05*10*(2,0*1,2*1,2+1,0*1,2+2,0) = 3,04

Without the special factor D_{spec2} the results are reduced by 1,0.

The software for the calculation of the MDLD is therewith based on one equation, containing parameters that are defined in look-up tables. The criteria value for material damage and loss of trade is per default common to all pipes in a subcatchment, since all parameters are expected on a catchment level. However, the user will have the possibility to make individual changes to all parameters on a pipe level. All impact criteria in WP5 are assessed on pipe level and the software has to calculate criteria values pipe by pipe. This option has to be incorporated during the software development.

4.1.4.2 Restrictions of the chosen approach

The main restrictions of the chosen approach, already mentioned in previous chapters, shall be summed up again in this chapter.

The criteria values are factors representing qualitatively the actual monetary damage costs. This unitless approach makes it difficult to relate damage to a pipe length or area unit. A long pipe will therefore get the same risk as a neighbouring short pipe.

Information on buildings and trade is very limited in the CARE-S approach. The parameters that are included in the impact calculation are therefore also limited. Individual building types and estate values can not be considered.

The hydraulic information is restricted to the probability of occurrence of flood ranges. Distinctive water levels and existing research on water level – damage curves can be taken into account only very roughly. The grade of information is especially low for damage events where the water level reaches the surface. We don't know how much water leaves the sewer system, how it behaves on the surface, what levels are reached on the street and if the flood water enters the buildings at all.

However, the assessment of the exact cost of material damage and loss of trade is not necessary in the CARE-S approach. A qualitative statement about the risk and magnitude of an impact is sufficient to rank sewer rehabilitation projects. Additionally, literature research on flooding damage revealed very high deviations from average values and a reliable calculation of material damage and loss of trade can therefore not be realised. In any case, an end-user facing high stakes related to flooding risks, and having experienced significant events, should consider criteria defined on its own, either inspired by the above proposal, or specific to his knowledge.

4.2 FAILURES CRITERIA: wet weather flooding (intangible damage to population)

As mentioned above, flooding *external effects* may exceed the so-called tangible damages and provoke intangible impacts. These ones aggregate a set of personal and social consequences to which is impracticable or difficult to attribute a monetary value. Nevertheless, the intangible nature of any impact is not an *a priori* reason to presume its triviality or to exclude it from decision-making processes about flood alleviation schemes. In fact, there is presently empirical evidence that, under certain conditions, intangibles, such as health problems or disruption of daily life are felt, by flood victims, as equally or more significative than tangible losses (Green and Penning-Rowsel 1986; Doizy, 1990/1991).

4.2.1 What we know about

Most common (and studied) floods intangible damages are of psychological nature and intrinsically related with households and individuals. Besides these, there are other non-monetary social consequences that, although less studied, should not be disregarded.

Given this, in the CARE-S context, the intangible damages of urban flooding that will be considered are the following:

1. *Households:* disruption of daily life and routines due to home/business material damages; health problems; worry with recovery and future flooding; loss of sense of security in home; loss of memorabilia or irreplaceable objects.
2. *Relation with authorities and water services*: decrease of degree of satisfaction with water services; loss of confidence in authorities, due to perceptions of ineffectiveness or inaction before, during and after floods occurrence.

The above-mentioned three categories will be described and discussed in the following sections.

4.2.1.1 Households' intangibles

As mentioned above, health problems, disruption of daily life, loss of sense of security in home, worry and loss of memorabilia are the most common intangible impacts of floods on households.

It should be emphasised that these kinds of impacts may be more acute in river flooding events, by comparison with urban flooding events. Nevertheless, we should not disregard the possibility of significative damages to population, namely the intangibles ones, induced by small-scale and short-lived floods, as typically is urban flooding. In average, urban flooding is more sudden than river flooding, with a quicker rise of water level.

Hazards such as floods are regarded as potentially multi-strike stressors made up of a number of different components. The health impacts from flooding are therefore complex and cannot be viewed as merely circumscribed to the absence or existence of a physical disease or infirmity (Tapsell, 1999). By health we mean a state of physical, mental and social well being and floods can, under certain conditions, induce on disturbances at the second and third levels of well-being. Stress and anxiety are the most common psychological effects of floods[12], which are mentioned by victims as having affected their quality of life.

Besides the event of flood in itself, there are, as mentioned above, other recovery related factors, which can induce on stress and anxiety. There are the following: having to leave home or having to live in a damaged house; the confrontation with the loss of beloved or irreplaceable objects; lack of emotional support or of advice on what to do, immediately after the experience of flood; the dealing with insurers and builders; worry with extra-financial re-building expenses and with the possibility of flood re-occurrence.

Besides issues related with property re-building, worry experienced by individuals and households, is usually related with a possible increase of risk awareness, materialised on the fear of flood re-occurrence in the future. Related to this, worry can also elapse from the perception of home as a place, which is no longer secure to live.

According to Green and Penning-Roswell, such intangibles and consequential behavioural adjustments can induce on what they name as *opportunity cost*. By this term, they mean the individuals and households' loss of opportunity of making the best use of their own home.

Besides caution related with the generalization of empirical results, most of mentioned household impacts require caution when developing a methodology for their evaluation and

[12] Feeling lethargy, tiredness, lack of energy and depression are examples of other psychological effects, induced by flood events, which can affect individuals and households well being.

quantification. This is especially true for health and worry impacts. Unlike loss of memorabilia, those impacts cannot be directly observed.

In what concerns to health impacts, there are two general ways of evaluation. We refer, on the one hand, to the observation of impacts through statistical analysis of changes in health-care demands, following a flood. There is, on the other hand, the possibility of assessment through comparative empirical studies between flooded groups and non-flooded groups (control group). Both of them guard, as we shall see, their own limitations.

Green and Penning-Rowsell state that the measurement of health impacts through health-care demands changes presents limitations, for several reasons. Firstly, analysis of statistical trends concerning medical-care services is not a direct measure of health impacts, once they only indicate that there are changes. Secondly, there is empirical evidence that the proportion of people who seek help due to symptoms tends to be low, especially psychological symptoms, such as stress, anxiety, sense of loss and depression, which are particularly common following a flood. Given this, any analysis of social costing through this method would be necessarily limited because fundamentally based on cases of more drastic ill health circumstances, notifiable diseases or death. Those who did not seek for help but actually felt a health state decrease are, under these circumstances, irremediably out.

Flood Hazard Research Centre (FHRC) explored the second above-mentioned way of assessment of health impacts. Founded on public inquiry methodologies, FHRC studies on this issue use clinically validated scales of Subjective Health Status to assess health status of pre-selected flooded populations. This scale is composed by a set of components. Each component is operationalised into statements, to which the respondents must indicate their agreement or disagreement. If a respondent agrees with the statements related with a specific component, a score of 100 will be attributed to that component. The gauging of impacts on health status elapses from comparative analysis between flood victims and non-victims, taken as a control group (residents living in the periphery of flooded area and individuals without any experience of floods, either direct or indirect).

Comparing the sate of health on flood victims with the one of control populations should not be viewed as a complete test of the hypothesis that flooding results on poorer health status. The main reason of this relates with the lack of knowledge on the state of health of respondents, before the flood event. A way of mitigating such limitation would be through the adoption of longitudinal approaches, but these have the disadvantage of being extremely costly, if not impossible.

As said, measurement of worry presents similar difficulties as health impacts issue. The adoption of public inquiry methodologies is the most suitable way of assessment such impact of flood events. Green and Penning-Rowsell (1985; 1986) state that worry, when existent, has an impact on behaviour[13]. Given this, they proposed to operationalize worry through a set of possible behavioural adjustments. These are, in turn, transformed into statements to which respondents are invited to express their agreement or disagreement (see Table below).

[13] Or individuals' behavioural intentions.

Table. Examples of statements to assess households' behavioural intentions, due to worry

— "We stay up all night when it rains heavily"
— "If we go away we arrange with neighbours how they can contact us in case of a flood"
— "We are afraid of going out when it rains heavily"
— "We have given up trying with the garden"´
— "We would move to another house if we could"
— "We have spent money trying to stop the floodwater getting into the house"

(Green and Penning-Rowsel, 1986)

Similarly to tangible damages, intangibles can assume the form of direct or indirect damages. Health problems are conventionally classified as direct damages, once they are directly caused by the flood event. Disruption of life routines are usually viewed as indirect intangibles, induced by consequential effects of floods. Nevertheless, the frontier between direct and indirect impacts is not always clear, once some of them can assume both forms. Anxiety and stress impacts on individuals or households exemplify the hybrid character of some intangibles. The flood event on itself can be a source of anxiety, but the aftermath or recover period can also be a source of anxiety and stress. At the origin of such feelings are a variety of factors, such as the circumstance of having to live in damp or damaged proprieties, the cleaning up task, house or business repair and related financial expenses.

4.2.1.2 Relation with authorities and water services

Trust erosion and decrease in customers' degree of satisfaction with authorities/services are two other intangible impacts that should not be disregarded. Nevertheless, these two types of impacts seem to be less explored and tested, by comparison with the above discussed.

By trust we mean the belief, on the part of lay population, on the fiability of systems such as sewerage and organizations that represent them. It is, in other words, a form of faith, disembodied of expert knowledge, on systems and its professionals that they will operate as usually and as it is expected. Abnormal events such as floods fall outside the boundaries of normality and may originate a lay trust breakdown.

Tapsell (1999), in an exploratory research on health effects of Easter 1998 floods in England, reports the loss of confidence of residents in authorities and institutions associated with flood protection and recovery support. This decrease of lay confidence explained, on great part, the manifestation of other intangibles, such as worry and anxiety associated with the possibility of future flooding. Explanations of floods as being the result of "natural forces" was not believed by flood victims. Consequently, there was a kind of fear that authorities would, in the future, fail to protect or warn residents.

Similarly, trust erosion can originate a decline on the degree of satisfaction of customers with the quality of service delivered. An OFWAT research (2001)' on customers' views about water and sewerage services in England and Wales, reports a strong relationship between customer level of satisfaction and personal experience with services. Bad experiences, namely those related with sewerage flooding, tend to unchain dissatisfaction with water and sewerage companies.

4.2.1.3 Context variables underlying floods' impacts

Although exceedingly reported on research literature, floods intangibles require caution when thinking on generalizing results. The main reason underlying this is the permeability of floods impacts, namely the intangible ones, to the *type of flood* factor and *type of impacted population*.

Different types of floods originate different types of damages, namely the intangibles ones. Green and Penning-Rowsell (in ibid) list a set of flood related factors, which may influence the magnitude of its impacts. They are respectively: *depth of flooding*, *rate of rise of water*, *water velocity*, *duration of flooding*, *time of the year* and *day* and *the degree of contaminants*.

Nevertheless, it should be emphasised that flood event magnitude does not have a linear correspondence with perceived magnitude. In other words, we can have a low magnitude event, which is lived and perceived by individuals as a high magnitude event. Tezer and Rubin (1987) have shown empirically the importance of perceived risk: a natural disaster has an influence on estate value as far as it changes the previous prevailing risk perception.

Similarly, damages, namely the intangible ones, can be evaluated diversely from individual to individual. The elderly might value the loss of irreplaceable objects more highly than would the young, and suffer more severely its loss. Green and Penning-Roswell include *household size, social class, prior experience of flooding*[14] *and dwelling type* as other items of *type of impacted population* factor that may influence the degree of flood losses as well as its perceived severity (see table below).

Table. Population and flood event characteristics that may influence severity and impacts of flooding

Household characteristics	Flood event characteristics
Age	Depth of flooding
Household size	Degree of warning
Income and wealth	Duration of flooding
Social class	Time of the year
Dwelling type	Time of the day
Personality	Contaminants in water
Degree of social community support	Water velocity
Prior experience of flooding	Rate of rise of water

(Green and Penning-Rowsel, 1986)

Besides the above-mentioned factors, it is found as pertinent to add another one. We refer to the *length of time to recover*. It is rather consensual that longer periods of recover can worsen intangible impacts (i.e. stress, anxiety and worry). Poor social groups are particularly vulnerable to these kinds of situations (Mileti and Sorensen, 1987; Parker, 2000).

Most suitable way of assessment of flood intangibles damages on populations — as well as its weight by comparison other damages, namely the tangible ones — implies the adoption of methodologies based on public inquiry techniques. Even though, this methodology presents its limitations, some of them already mentioned. They are the following: (i) difficulty of generalization from on population to another; (ii) difficulty of direct observation of damages; (iii) impracticability of attributing a cost in economic terms.

[14] Green and Suleman (1987) refer several studies on flood impacts where prior experience of flooding influences the degree of damages. Households who have more experience of flooding (i.e. once a year) tend to suffer fewer damages, either tangible or intangible. Flood experience may induce on home structural modifications as well as on protective behavioural adjustments, which can have an effect on impacts.

It should be mentioned that, in what concerns to the economic value problem above referred, Flood Hazard research Centre (FHRC) proposes a procedure that, although exploratory, should be taken into account. This procedure is based on several steps: a) selection of a set of impacts of flooding (see table below for the typology of damages tested by FHRC); b) knowledge through survey techniques of perceived severity attributed to each damage; and c) inference about monetary equivalent to intangibles.

Table

— Health effects
— Loss of memorabilia and other irreplaceable contents
— Stress of experience a flood
— Worry about future flooding
— Disruption to life: the problems of discomfort whilst trying to get the house back to normal after the flood
— Replaceable contents loss
— Physical damage to house

Exploratory study conducted by FHRC researchers gauged perceived severity of flood impacts through a 11 point category ranging from ‘0’ for ‘no effect’ and ‘10’ for ‘most severe’, inviting respondents to score each impact they felt, in a comparative basis. In what concerns to tangible damage categories, respondents were invited to give also a value in £ for damage experienced. Inference about monetary equivalent for intangible losses was made through the relationship between subjective severity and monetary magnitude attributed to tangible damages. Taken as an example, a household that states to have suffered £500 worth of structural damage will report a score for subjective severity of 3. If the household also gives a score of 3 for subjective severity underlying loss of memorabilia, it can be inferred that both impacts were felt as essentially equivalent in terms of severity. In this case, we can assume that the monetary equivalent for loss of memorabilia (which resulted from a subjective severity of 3) is also of £500. If that same household judges, for example, health effects as quite most severe, that is with a score of 9, then it would mean that they consider this impact as considerably more severe than either the one of structural impact or memorabilia. In the specific case, the monetary equivalent would be necessarily higher than £500 (Green and Penning-Roswell 1986; Doizy, 1990/1991).

4.2.2 What we propose for Care-S criteria calculation

The permeability of floods’ intangible impacts to the so-called contextual variables makes it difficult (and risky) to create a general criteria framework. Health problems, i.e. stress and anxiety, are not always a reality whenever a flood happens. Contextual dimensions, related with physical characteristics of flood event and type of population, intervene on type of damages and intensity.

Given this, our proposal for criteria bases on inference reasoning, considering the following parameters:

- The bigger the population density of vulnerable areas towards sewer flooding, the greater the possibility of potential victims suffering from intangible impacts;
- Flood related tangible damages turn households and individuals more prone to intangible damages.

Proposal for intangible criteria is composed by values that range from 0 (no impact, no social cost) towards 100 (high impact, high social cost).

Departing from Eurostat proposal of population density classification, we postulate that areas classified as "high density" present an increased vulnerability towards intangible type of damages. Such vulnerability augments if associated with tangible damages.

Table

Population density	
High	A set of local unities (district) that have a population density higher than 500 inhabitants *per* km^2 and have a total population volume of at least 50.000 inhabitants.
Medium	A set of local unities that have a population density between 100 inhabitants *per* km^2 and 500 inhabitants *per* km^{2,} being contiguous to a highly dense area or having a total population volume of at least 50.000 inhabitants.
Low	A set of local unities that, not making part of a highly/medium dense area, have a population density of less than 100 inhabitants *per* km^2 .

Source: National Institute of Statistics/Eurostat

Table

Population density	*Material damages*	
	Y	N
High=city center	100	70
Medium	90	60
Low= rural	70	40

Valuing intangible flood damage raises questions about methodology and existing knowledge, but also about the spirit in which they can be taken into account for decision making.

The CARE-S software does no propose.

4.3 FAILURES CRITERIA: wet weather flooding (road/traffic disturbance)

4.3.1 What we know about

Traffic disturbance due to flooding will be different that traffic disturbance due to works:

- no organisation of derivation will exist when the flood happens so car drivers will have to find a solution on their own
- the whole street can be flooded : so derivation will be the common solution

The phenomena may be progressive or brutal and then cars can remain bound. Once the alert is given, traffic derivation will be organised and will last during the trouble, which generally will be linked whith the duration and the intensity of the rain event (see elements given by (GREEN 1983) for river flooding in §3.6.1).

4.3.2 What we propose for Care-S criteria calculation

We take into account the traffic and environment factor proposed for traffic disturbance due to works (see §3.6.2)for dig techniques and when there is only one lane in the street. This factor depends on the type of road, the traffic truck load, the traffic of public transportation and the land use.

$$trafficF_{flooding} = T \cdot p_f \cdot E$$

T mean traffic density (vehicle/day)

P_f annual probability of surface flooding

$E = \boldsymbol{C}_{dig,1}$

(for $C_{dig,1}$ see §3.6.2 for criteria $trafficW$ valuation)

4.4 FAILURES CRITERIA: pollution of receiving waters by overflow

4.4.1 What we know about

Failing sewer networks, due to pipes in bad condition, can increase surface waters pollution in different ways. As mentioned above, the only type of situation considered here, in connection with surface water pollution, is the increase of combined sewer overflows (increase in frequency and/or volume and/or pollution load, provided this increase is considered as a failure).

4.4.1.1 General comments on water and aquatic resources

Water and aquatic resources, whether surface water, groundwater, aquatic and wetland environments, all “provide” environmental goods/services in various aspects which we could summarise in:

- raw materials (water in quantity and quality) for a high diversity of consumptive and non consumptive uses (hydroelectricity is an example of non consumptive use),
- amenities (landscape, biological patrimony…),
- capacity of transport and biodegradation of liquid and solid wastes.

A degradation or change in water and aquatic resources will have an impact, and hence create social costs, as soon as there is a loss in one or several of these aspects, in general and economic words a loss of “utility”. An increase of pollution discharge to a river, lake or groundwater may have consequences on all of these aspects, for instance when preventing a given water consumption, when making preliminary water treatment necessary, when reducing the ecological quality and value, when reducing the biodegradation capacity of a river…

The effects of an additional pollution will hence depend on the initial condition of the resource, on the polluting discharge (flow, pollution load for different components..., duration, time of the year…), on the biochemical processes changed or induced downstream from the discharge. The impacts, as a consequence of these effects, will then depend on the present and future potential utility of the resources: uses in the usual meaning, recreational activities, patrimonial value… Social costs of pollution events are very case dependent, and are related to several aspects.

Assigning an economic (negative) value to an additional pollution means hence assessing losses in use value (“use” meant in a broad meaning), in option value (linked to potential future uses) and in non-use value or intrinsic value (the value which has no link with a present or potential use of the resource). These different values concern respectively the users of the water or aquatic resource, the future / potential users, and finally all the population when considering non-use value. Green et al (1988) and Kontogiani et al (2003) develop this question of the importance of non-use value and of the corresponding motivations: water and aquatic resources have a utility even for people who have no present or future use of it, for instance for altruistic or ethical reasons. Therefore, the collective value is not at all limited to use and option values. This has been recently shown on the specific issue of reducing sewage overflows (Ozdemiroglu et all, 2004).

We won’t develop here and now the questions of economic valuation methodologies for environmental goods. The literature is abundant in general, though for water quality there are less quantitative results than could be expected. Annex 4 displays references and very synthetic results of direct economic assessment approaches. The methodological developments underway for the implementation of the European Water Framework Directive have to face the same “relative shortage” and diversity of results concerning water and aquatic environment quality.

We might also consider indirect assessment approaches, by taking into account:

- pollution taxes if there is a full implementation of the polluter-pays principle,
- compensations decided upon by courts if all harmed parties and interests have successfully sued the “polluter”,
- full costs of technical pollution prevention options as a minimal value (if these options are implemented, there is an underlying assumption that their costs are smaller than the benefits of avoiding the corresponding pollution…).

Here again, not only do the validity of such methods depend on specific assumptions and conditions, but also results are quite scattered, and insufficient at a general level to propose standard social cost values.

4.4.1.2 some information on impacts of water pollution due to failing sewer networks

Physical, chemical and biological aspects of water pollution concerned here are addressed in the CARE-S report D9 (Schulz and Krebs, 2004). Concerning impacts, a French survey was done in order to find real case cost data, economic studies, and among other things compensations decided upon by courts, for cases of failing sewer systems (Clementel 2002, 2003). Hereafter some results and data are displayed.

In France, one third of accidental potable water contamination cases are due to water resource quality problems: among these latter cases a majority is related to sewer systems. From 1986 to 1988 in France, 10 microbiologic pollution accidents occurred in water distribution networks due to wastewater: the consequences were 6680 ill persons and 240 days of stay in hospitals. Economic assessments in France and in the USA show close results: a day of gastro-enteritis or diarrhoea has a social cost of about 1200 euros (French estimate: 5% of GDP per head).

Sewer network failures also lead to 40% of the French cases of bathing areas downgrading situations (this concerns 2% of bathing sites, with average closure duration of 15 days).

Several compensations decided upon in courts can give ideas about orders of magnitudes of costs to third parties:

- 8 pollution cases of fish farms with average compensation of 100 000 euros,
- 3 contamination cases of cattle with average compensation of 20 000 euros,
- 1 pollution of a thermal spa with a compensation of 285 000 euros,
- 1 pollution of a mineral water production with a compensation of 200 000 euros.

Of course, these amounts could not be transposed to other situations.

4.4.1.3 Impact assessment

The two preceding sections and annex 4 give an insight of the state of the art, in terms of economic valuation of social costs of the impacts we consider. We should be aware that an economic assessment is always an explicit or implicit comparison between two options or two situations: in fact, the results shown in annex 4 relate either to preservation of present conditions (as compared to an existing continuing degradation of water quality), or to improvement / re-conquer (as compared to present situation).

The only generally applicable method, which can consider all the components of economic value and all types of situations, is contingent valuation. This method is quite heavy in terms of costs and required means (population survey, with specific precautions, preliminary qualitative analysis…). Annex 4 gives on insight of conditions which should be regarded for transposing quantitative results from one case study to another case. Considering present knowledge (and the relative “shortage” of results), these conditions are quite drastic in operational terms. Investing in a case-specific contingent valuation can be justified if water quality issues carry important stakes. It would probably be less or not justified at all for more current and usual situations, with limited and well-known stakes, provided water quality can be taken into account in the decision, in a way or another.

Annex 4 proposes a first set of information and references for a decision maker who would consider the opportunity of an economic assessment and wonder about the way to have such a study done. The default approach proposed hereafter, in order to “feed” a multi-criteria decision support, is based on “non-economic” criteria values aiming at representing different levels of vulnerability to water pollution.

4.4.2 What we propose for Care-S criteria calculation

As mentioned already, impacts depend on effects and on vulnerability, but first of all the impacts considered should be limited to what is attributable to failures. The quantitative outputs of WP3 concerning overflows may be very loosely correlated with the “failing part” of the overflow. If an important CSO exceeds the allowed discharge by 10%, only 10% of the polluting effect should be considered here, whereas a much smaller CSO may exceed the allowed discharge by 300%. Inside the WP3 procedures there is one which allows to identify whether an overflow, in the present situation, is a failure, but it has not bee possible to include a procedure identifying whether a given pipe is a potential contributor / cause to this failure. This can only be determined on a case by case approach, relying on expertise, technical diagnosis of part of the network…, and we propose to consider basically only a “yes / no” answer. It is a rough approach. But given the strong diversity of regulation frameworks and of cases, it is the one which offers the best level of realism, if we want to stick to two principles when dealing with impacts: considering failures only and accounting for the responsibility of a given pipe.

If a pipe is not suspected to contribute to failing overflows, the criteria value will be 0. If pipe is a potential contributor / cause, then the criteria can represent water resources and uses vulnerability with the proposed following values:

Types of surface water resources and uses	Criteria value
protected area for drinkable water production	100
bathing area	80
shell fisheries	70
drinkable water production downstream	70
fishing	50
ecological area (protected / non protected)	50
other sensitive water uses	30
other water uses	10

Given the weak bases of this proposition, any decision maker should feel free to adapt these values to his knowledge and experience.

4.5 Failures – pollution of groundwater resources by exfiltration

Physical, chemical and biological aspects of water pollution concerned here are addressed in the CARE-S report D9 (Schulz and Krebs, 2004). For general comments about water pollution from failing sewer networks, please refer to sections 4.8.1 and 4.8.2.

4.5.1 What we know about

The comments to be made here are identical to those of section 4.8.3. The types of activities / services which can be harmed are more restricted than for surface waters. On the other hand, the knowledge of effects is usually poorer, and the duration of remaining consequences much longer.

4.5.2 What we propose for Care-S criteria calculation

If a pipe does not leak, the criteria value will be "0" (no impact, no social cost), whatever the groundwater resource, its condition and uses. In the opposite case, we can consider, with potential available information, the intrinsic vulnerability of the groundwater to the leaks, given the type of soil and distance of the pipe to the water table, the wastewater discharged through exfiltration, and finally the water uses. Ideally, the present quality of the groundwater could be considered, but this should then be available with a small spatial grid (we consider here very local events).

The "groundwater vulnerability" is addressed through the parameters assessed by WP3 (see D9 report) when available, the water uses are addressed through the typology introduced in section 2.4.3.

"Groundwater vulnerability" aims at considering both the importance of exfiltration and the "protection" of the groundwater given distance of the water table and soil types. Two "full effect" criteria can be assessed as an output of WP3; "groundwater vulnerability" defined in three classes (low, medium, high), or "groundwater vulnerability" defined in a quantitative value. The latter necessitates more information and time from the user of the decision support system.

With rougher information on soil materials and characteristics, "potential groundwater vulnerability" is defined in three classes (low, medium, high), as well as "potential groundwater contamination" by combining ground water level and permeability(PermGround parameter of WP3) and exfiltration defined in three classes (ExGround parameter of WP3).

To summarise, WP3 possible outputs are either a quite demanding quantitative index on one hand, and/or three "3 classes HML" indices which incorporate more or less information and expertise. We propose to consider, for a default criteria calculation, the 3-classes "groundwater vulnerability" (low, medium, high), if not available "potential groundwater contamination", if not available "potential groundwater vulnerability".

The criteria values (from 0 to 100) proposed are summarised in the following table for the case where there is exfiltration attributable to a pipe. Given the weak bases of this proposition, any decision maker should feel free to adapt these values to his knowledge and experience.

type of groundwater and water uses	"groundwater vulnerability" or " potential groundwater contamination" or "potential groundwater vulnerability"			
	low	medium	high	none available
protected area for drinkable water production	80	100	100	100
drinkable water production	70	80	100	80
private domestic wells	50	60	80	60
other sensitive water uses	20	30	50	30
other water uses	5	10	20	10
no water use	5	5	5	5
no groundwater	0	0	0	0

Of course, these criteria values cannot be compared to the criteria values proposed for surface water pollution (4.8) or for groundwater pollution due to rehabilitation works (3.3), as the types of effects are quite different in average (type of water resources, duration of pollution discharge …).

4.6 FAILURES CRITERIA: service interruption due to blockages/chokes (quality of life)

4.6.1 What we know about

This failure concerns the impacts to inhabitants whose connection cannot evacuate wastewater, and may even overflow in the house because of the blockage on the sewer in the street. Once the blockage know the inhabitant may be informed and pleased not to use water (in order to have no flow to the sewer) during a certain time.

We found no information about assessments of possible impacts of unforecasted sewage service inteeruptions.

4.6.2 What we propose for Care-S criteria calculation

$$SerIntF_{blokage} = P \cdot L \cdot p_b \cdot u_t$$

P population density (nb/m2)

L length of the pipe

p_c annual probability of blokage

$u_t$land use factor

	Land use Type *t*					
	Rural=1	Urban Housing=2	City Center=3	Industrial Area=4	Shopping area=5	Special area=6
Land use factor u_t	5	5	10	10	5	10

4.7 FAILURES CRITERIA: soil depression due to sewer collapses ("threat factor")

4.7.1 What we know about it

Sewer collapes can lead to surface soil depression, most often on streets, but there is no feasible way (given available knowledge and data) to forecast the phenomena generating soil depression as a consequence of sewer collapses. There is not even a sensible way to give a probability of soil depressions following sewer collapses: the former is usually known and may be reported in utility documents, whereas only part of the latter are identified.

Soil depression is a risk event, and its social consequences would be usefully taken into account by a risk criteria "probability x impacts". This probability cannot be assessed, we only get information and forecasts on sewer collapses probability.

Instead of considering a "risk'" criteria, we propose to consider a "threat" criteria, combining probability of sewer collapse with impacts of a possible soil depression, restricted to traffic disturbance.

4.7.2 What we propose for CARE-S criteria calculation

Here again, we take into account the traffic and environment factor proposed for traffic disturbance due to works (see §3.6.2) for dig techniques and when there is only one lane in the street. This factor depends on the type of road, the traffic truck load, the traffic of public transportation and the land use.

$$trafficF_{collapse} = T \cdot 2 \cdot n_l \cdot p_c \cdot E$$

T mean traffic density (vehicle/day) in one direction

2 for here and back journey

Pc annual probability of sewer collapses

n_l trip time factor

for l=1 n_1=2, means deviation and double trip time,

for l=2 n_2=1,3 means no derivation but slowing down

$E = C_{dig,1}$

(for $C_{dig,1}$ see §3.6.2 for criteria *trafficW* valuation)

4.8 FAILURES CRITERIA: dry weather flooding in the basements

4.8.1 What we know about it

In cases of blockages or chokes reducing significantly the discharge capacity of a pipe as compared to dry weather discharge, there may be flooding of basements. Of course this failure is a real stake if two conditions are fulfilled:

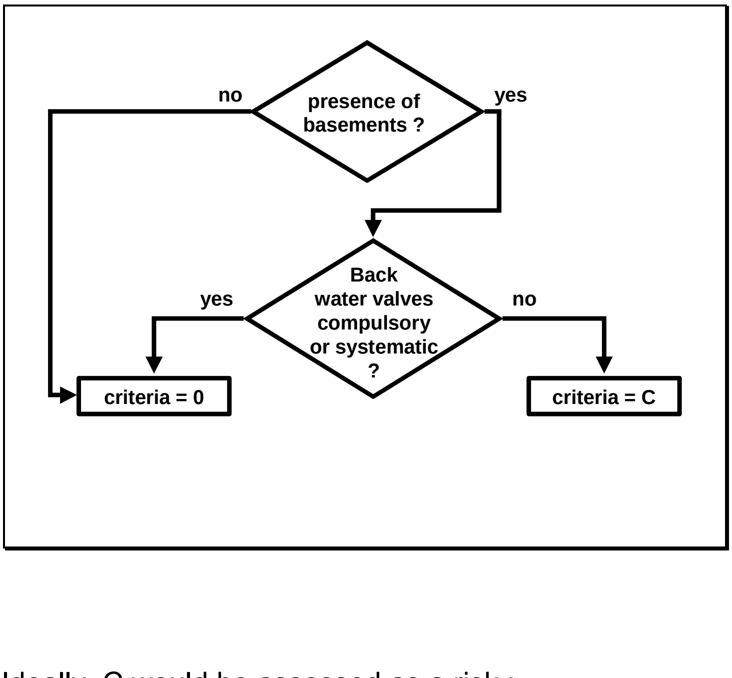
- there are basements in the buildings connected to the failing pipe and to near upstream pipes,
- these basements are not protected by backwater valves.

It is not possible to know, at connection level, if there is or not a backwater valve. We therefore considered this question at global scale: either if backwater valves are compulsory or if their implementation is very widespread and considered as natural, possible dry weather flooding of basement will not be considered as a failure impact.

In case of a dry weather flooding of a basement, the impacts may be close to those of a wet weather flooding, apart from the fact that the flooding is due to "pure" sewerage, and not to a mixture of sewerage and rainwater. No representative data of these impacts could be found.

4.8.2 What we propose for CARE-S criteria calculation

The figure bellow summarizes the basic framewok for defining the criteria.



Ideally, C would be assessed as a risk :

C = P(b) x P(o,b) x S x DBS x UC

P(b) probab. of sewer blockage

P(o,b) probab. of overtopping in case of a blockage

DBS density of basement surface

UC unit cost of damage (to estate and basement content) per m2

S surface of area concerned (m2)

Limitations in available information and knowledge lead to proposing a default assessment in terms of a “threat factor” criteria. As for soil depression, we only have data on blockage probability, not on subsequent basement flooding. The default calculation criteria proposed is therefore using results of criteria 1 on wet weather flooding (material damage due to flooding, taking into account only the part of result for basement flooding):

$$C= P(b) \times [F_{LUTmat} \times F_{BD} \times F_{bas1} + D_{spec1}]$$

4.9 FAILURES CRITERIA: dry weather flooding on street surface

4.9.1 What we know about it

Similarly to odours effect, criteria for dry weather flooding on street surface stands on empirical findings, gathered through Amadora-Oeiras claims' analysis. Literature review was unsuccessful on finding references on this specific issue.

Impacts of dry weather flooding in street surface may range from the unfeasibility of public space for social uses to more tangible consequences, such as business' loss of clients[15]. Besides, there were some cases, in Amadora-Oeiras claims' analysis, of personal injury caused by dry weather flooding situations. We assume that such events would not have any significant impact on road traffic

4.9.2 What we propose for CARE-S criteria calculation

We define a sensitivity index DS depending of the land use types.

dry weather flooding in street surface criteria	
Land-use type	**DS**
Rural	70
Urban housing	70
City centre	150
Shopping area	
Industrial area	

The decision maker should feel free to adapt such criteria values to his knowledge and context.
As the two precedent criteria (see §4.7 and §4.8), this impact should be adressed through a risk quantification, but the probability of a failure inducing a surface flooding could not be

[15] Unfeasibility of public space for social uses can induce on negative consequences to trade. Besides, as can be seen through Table 1 (section 4.8), wastewater overtopping on street surface may provoke effects, such as odours, which worsens impacts' intensity.

known. We therefore refer to a threat criteria, concerning both the density of population and the sensitivity of different land use types.

The proposed criteria is:

$$DwfloodingS/F = P(b) \times DS \times population\ density$$

P(b) probab. of sewer blockage

4.10 FAILURES CRITERIA: odours due to collapses or blockages

4.10.1 What we know about it

Literature revision revealed scarceness in what concerns to impacts of odours due to sewer or similar type of failures. Given this, it should be emphasised that approach to this specific type of effect stands fundamentally on the study of 2002 Amadora and Oeiras (Lisbon end-user) written claims (see Annex 2)[16].

Sewer odours seem to be frequently associated with other type of external effects. In fact, odours' effect never appears alone in 2002 claims, but associated with other abnormalities. As can be seen through the Table bellow, flooding appears as the type of event where there is more reference to odours and related disturbances.

As far as it is possible to determinate with the existent data, odours impacts seem to be more of intangible nature, than tangible. Concerning intangibles, the most common ones seem to be the feeling of diffuse annoyance jointly with the statement that odours induce on disturbances to the good usufruct of individuals' home. Such impacts relate to what Green *et al.* (June 1986) name as an *opportunity cost,* that is, the loss of opportunity, induced by some kind of event, of residents to make the best use of their own home. In our view, such type of intangible cost extends to public space. In fact, odours effect may contribute to transform public space in an unpleasant place to pass by, to rest or play.

There was no empirical evidence of tangible impacts induced by odours in Amadora-Oeiras 2002 claims analysis. Nevertheless, such possibility should not be excluded. As far as it possible to postulate, an impact that should not be disregarded is disturbance on business activity due to odours. If such disturbance gains the form of decrease of clients or decrease of work force productivity, due this type of effect, we are in presence of a tangible impact.

4.10.2 What we propose for CARE-S criteria calculation

We propose a framework for odours criteria calculation composed by values that range from 0 (no impact, no social cost) to 100 (high impact, high social cost). Given the weak basis of this proposition, the decision maker should feel free to adapt such framework and values to his knowledge and context.

Odours framework privileges the following variables:

— Type of impacted area

Variable composed by three items or categories, as follows: a) private housing, whenever sewer related odours induce on impacts inside houses; b) business premices, whenever odours induce

[16] Statistical analysis of the universe of 2002 written claims of Amadora and Oeiras (Lisbon metropolis) municipalities aimed at :

(i) contributing to the construction of a typology of failures, where social and economic impacts would enter and
(ii) preparing 5.2 Task. Given this, approximately 140 written claims, concerning sewer failure problems, were object of analysis.

on induce on trade and business disturbances; c) public spaces, for situations where odours produce impacts on streets or other exterior public spaces; d) special area/buildings, for situations where odours produce impacts on schools, hospitals, health centre and similar installations[17].

Table Failures and related external effects, according to claims registred in Amadora an Oeiras (2002)

External effects		Type of failure								TOTAL	
		Sewer colapses	Wrong and illegal connexions	Public sewer blockages	Inside building blockages	Pits deficiencies	Manhole covers damages	Other situations	Unknown failures	n	%
House flooding			2	7	5			2	2	18	
	and WC overtoping		1	1	1					3	
	and wastewater open drainage							1		1	
	and odours	1		1	2					4	
	Other effects			1						1	
	Sub-total	1	3	10	8	0	0	3	2	27	19,6
Retail flooding				2					1	3	
	and WC overtoping			2				1		3	
	and odours			2						2	
	Sub-total	0	0	6	0	0	0	1	1	8	5,8
Soil sinking in									5	5	
	and rodents & insects	1								1	
	Sub-total	1	0	0	0	0	0	0	5	6	4,3
Wastewater open drainage			1	5	3	1	2	1	5	18	
	and odours	1			1				1	3	
										0	
	Sub-total	1	1	5	4	1	2	1	6	21	15,2
Other external effects	Exfiltration and infiltration	2		1						3	
	Pollution of receiving waters		1			1			2	4	
	Public space flooding			1			1			2	
	Noise						7			7	
	Odours	1	2	2	2			3	1	11	
	Sub-total	3	3	4	2	1	8	3	3	27	19,6
Effects non-knowledge		1		7	2	2	29	7	1	49	35,5
Sub-Total		1	0	7	2	2	29	7	1	49	
TOTAL of claims		7	7	32	16	4	39	15	18	138	
Row general total (%)		5,1	5,1	23,2	11,6	2,9	28,3	10,9	13,0		100

[17] CARE-S land-use typology revealed some inadequacy to this specific effect. It was found as pertinent to do a distinction between more detailed aspects of impacted area, such as inside & outside buildings that CARE-S typology did not allow.

<u>Factor *time*</u> (duration in days of odour effect)

We postulate that odours impacts worsen as far as it delays in time. Given this, it was found as pertinent to introduce a variable *time* composed by the following items: a) *T* ≤ 2 days*; b)* 2 ≤ *T* ≤ 5 days; c) *T ≥ 5 days*.

Table. Criteria index Od framework for odours effect

odours effect criteria			
		factor Time	OD index
Type of impacted area	Private housing		80
		T ≤ 2 days	80
		2 ≤ T ≤ 5 days	85
		T ≥ 5 days	90
	Business infra-structures		70
		T ≤ 2 days	70
		2 ≤ T ≤ 5 days	75
		T ≥ 5 days	80
	Public spaces		60
		T ≤ 2 days	60
		2 ≤ T ≤ 5 days	65
		T ≥ 5 days	70
	Special area/buildings		90
		T ≤ 2 days	90
		2 ≤ T ≤ 5 days	95
		T ≥ 5 days	100

As can be seen through the table above, situations where odours induce on impacts to inhabitations and special area/buildings are classified as the most serious type of situation. Such seriousness worsens as it delays in time. A lower value was attributed to "business infrastructure" and "public spaces" type of area. Nevertheless, such value increases as it increases the time of exposure to odours.

And so the criteria proposed is :

OdoursF= Od x *(population density + density of non resident) x max (P(b), P(c), P(f))*

P(b) probab. of sewer blockage

P(b) probab. of sewer collapse

P(b) probab. of sewer structural failure

5 SOCIAL ACCOMPANIMENT OF FAILURES AND WORKS

5.1 Managing claims: criteria for a procedure definition

Water and wastewater suppliers, either public or private, are fundamentally providers of a service to the community. Given this, relationship with users or customers appears as an important component of suppliers' activity. Their pattern of relationship with customers, namely in what concerns to claims management, is a feature of quality of service which any assessment of water and wastewater performance should have in consideration.

This section has as main aim to present some key elements that should prevail when managing the relationship to costumers and their claims. Afterwards, a brief description of Lisbon end-user claims' handling will be pursued.

An efficient claims procedure is the one that ensures an easy way of customer approaching to the utility and make a claim; a fully investigation of the problem underlying the claim, at a reasonable time; a satisfactory explanation as well as a satisfactory outcome to the costumer, which may include compensation (OFWAT, 2001).

Approach to the sewerage utility sends us to the **accessibility** component. For efficacy reasons, utilities should guarantee that they are accessible to the costumers. Accessibility concerns not only the existence of stabilized ways of approaching to the utility[18], but also the guaranteeing of a direct and fluid channel of communication between the customer and the appropriate person/department. Related to this, an efficient costumer service procedure is the one that ensures previous **information** to the costumer, in what concerns *to how to claim*, when necessary, and *what to expect from the utility* in the sequence of a claim. Knowledge component can be insured through billing (back of the bill) or through leaflets, periodically annexed on billing correspondence[19].

Costumers will only claim if they believe that their claim will be listened and acted upon. Given this, another key element of an efficient claim management is utility expressed **commitment** on solving costumer claimed problem. Problem solving may require service operational intervention in a reasonable time, but there are cases where response implies nothing more than to provide a satisfactory explanation to the customer. Satisfactory explanation implies delivery of information, in a customer friendly language, about what has happened, why it happened and how the utility solved or intends to solve the problem (OFWAT, in ibid).

Claiming is a way of public participation, which should be valued and stimulated by sewerage utilities. Through costumers' claims utilities can improve their service, by correcting routines and management procedures. Through costumers' claims utilities can identify problems that, for some reason, escaped the attention of operational staff. Nevertheless, the vision of claims as an opportunity of *"doing better"* is, in many cases, shadowed by an organization culture that renders subaltern the role of claims and customer participation. Besides, it is not unusual to view claims as something that questions utility and staff competence. Both attitudes are misleading, once they lead to inefficacy.

[18] There are usually two general methods of costumer approaching to the companies: a written one (through mail letter, fax or email) and an oral one (telephone, personal visit)

[19] Internet can be another way of information delivery. The important issue, here, is the guarantee that customers have access to information.

Table . Key elements of sewerage utility claims procedures

Accessibility	*How to approach the company and make a claim?* Companies should guarantee a direct and accessible channel of communication with costumers-users. In turn, costumers-users should know that they can complain if they want and how to make the claim.
Information	*What to expect from the company, in the sequence of a claim?* Companies should assure that the costumer knows the procedure inherent to the act of claiming to the company, respectively in what concerns to *whom*, *how* and *when* the problem underlying the claim will be solved.
Commitment	*How to deal with claims and claimers?* Companies should guarantee a response to the compliant, by ensuring a solution to the "claimed" problem as well as by providing a satisfactory explanation to the costumer-user.
Staff training	What is the correct / adequate attitude and behaviour of staff in the face of claims and claimers? Companies, specially the bigger ones, should assure periodic training to Costumer Service staff in order to guarantee a efficient and fluid management of the relation with the costumer, its expectations and claims.
Assessment	Are claims being correctly handled? *Companies should have a system of periodic auditing of claims procedures in order to evaluate its efficacy. This auditing should be viewed as an opportunity to improve service performance.*

When claims are viewed as an opportunity of *"doing better"*, **assessment** and **staff training** appear as important components. Assessment concerns with periodical review of claims management procedures in order to assess its efficacy and correct irregularities. Parameters such as accessibility to customer service, speed and quality of responses to customers, type of claims received and underlying problems can be reviewed and improved through periodical assessment sessions. Besides, assessment is also an opportunity of staff training. Nevertheless, utilities, when concerned on having an efficient customer service or department, should invest on specific staff training programs. This component becomes particularly important in bigger utilities where claims must be handled by a significant number and diversity of staff. In small sewerage utilities claims tend to be handled by small teams whereas change of information and control of tasks are easier.

5.2 Amadora-Oeiras claims handling: a brief description

Before a description of procedures underlying Lisbon end-user (SMAS Oeiras-Amadora) claims' management, it is found as pertinent to do a brief presentation of Lisbon end-user.

This utility is responsible for water and wastewater management of two Lisbon municipalities — Amadora and Oeiras[20]. Amadora territory was, in the past, part of Oeiras municipality. Its

[20] The circumstance of having one public utility responsible for water and wastewater management of two municipalities is rather unique in the context of Lisbon metropolis. The common pattern in Lisbon is the existence of one water and wastewater utility per municipality.

institutionalisation as a municipality did not have repercussions, in terms of water and wastewater administration. Amadora is, by comparison with Oeiras territory, smaller in terms of total area, but concentrates more population as well as higher density of buildings[21] (cf. Appendix II).

Description of Amadora-Oeiras claims management procedure relies on the analysis of 2002 written claims, pursued under Task 5.1. (cf.Annex 2), as well as on exploratory meetings taken with Lisbon end-user. Given this, it should be emphasised that this description serves only exploratory aims. A more accurate knowledge of this issue will be pursued, under Task 5.2, either through a more directed gathering of data close by the end-user[22] and through public inquiry to customers-users[23].

Lisbon claims' analysis comprehends 138 written claims related with sewer failure problems or with rehabilitation problems[24]. Residents are, as expected, the main claimers. Nevertheless, there are claims, for which the senders are the local districts, enterprises and other municipality services.

Oeiras and Amadora costumers may approach to their sewerage utility through two general ways or methods: an oral one, by telephone or personal visit, and a written one, through mail letter.

In what concerns to the claim circuit, analysis of 2002 written claims showed that approximately half of the claimers' letters were sent directly to the utility, either in Amadora or in Oeiras. Nevertheless, there is an amount of customer written claims that arrive to sewerage utility through other municipality departments or organisms. As can be seen through the table below, approximately half of 2002 claims arrive to sewerage utility through one or two intermediaries. In other words, many costumers, when felt disturbed by a certain problem, apply to other public organisms, which can be the local district, a municipality department, police and, in some cases, the local Health Center. Then, these organisms redirect the claim to the sewerage utility, asking for the problem solution.

This data on claim entrance circuit indicates that many customers, when faced with some kind of sewer problem, ignore who is the appropriate person/department to which they should ask for support. Besides, claim entrance through other department than sewerage utility may delay problem solution or response to the costumer.

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[21] The circumstance of having more population and higher building' density, and consequently more users and costumers, does not seem to have a correspondence in organizational terms. In fact, Amadora water and wastewater services are much smaller, when compared with Oeiras. They have fewer personnel, either technical staff or operational staff.

[22] More specifically in what concerns to the component above mentioned — *accessibility, information*, *commitment, staff training and assessment.*

[23] We intend that an accurate knowledge of social accompaniment methods and routines cannot be done without an analysis of public-customers side, its perceptions, level of satisfactions, expectancies and preferences. For reasons of accuracy, both costumers and utility must be auscultated.

[24] It should be emphasised the mentioned volume of claims does not correspond to the total of claims of 2002. As we shall see, Amadora-Oeiras municipality has other methods of claim entrance, namely through telephone. This way of approaching was not object of analysis once the utility does not make registration.

Table. Patterns of written claim entrance circuit

	nº	%
Claims sent directly to sewerage utility	66	47,8
Claims arrived to sewerage utility, through one intermediary organism[1]	58	42,0
Claims arrived to sewerage utility, through two intermediate organisms[1]	9	6,5
Non-knowledge	5	3,6
TOTAL	138	100

[1]Local districts, other municipality services, police department and Health Center are the intermediaries of

claims' final destiny, which is sewerage utility

Table. Patterns of written claim entrance circuit, according to the municipality

	Oeiras		Amadora	
	nº	%	nº	%
Claims sent directly to sewerage utility	34	43	32	54,2
Claims arrived to sewerage utility, through one intermediary organism[1]	33	41,8	25	42,4
Claims arrived to sewerage utility, through two intermediate organisms[1]	7	8,9	2	4,7
Non-knowledge	5	6,3		
TOTAL	79	100	59	100

As said, one of important aspects of claim management system is to assure the problem solution/response to customer-user in a reasonable time. But, what do we intend as a reasonable time, in the face of claimed failures? The response to this questioning will certainly vary according to the type of failure. There are certainly cases where intervention must be a prompt one (i.e. sewer blockage with flooding as external effect) while others can wait.

An analysis of the duration of time that Amadora wastewater department spends to solve the claimed problem and responds to the claimer allows us to have some conclusions[25]. As can be seen through the table below, slightly more than a half of the claims are "solved" within one month, at the maximum. Around 36,7 of the claims have a resolution in fifteen days. Failures underlying these cases are fundamentally sewer blockages and damaged manholes.

[25] Due to information scarcity, it was impossible to analyse this specific data for Oeiras municipality. Although part of the same utility, Amadora and Oeiras services have different ways of archiving claims. In Amadora service, the claim has annexed other information than the claimer letter (i.e. type of solution, response circuit, etc). In Oeiras the information necessary to reconstitute the whole circuit of claim (since its arrival to its response and solution) is dispersed in several archives/services. This circumstance made a more profound analysis impracticable.

Table. Duration of time for claimed problem resolution and answer to the claimer, in Amadora municipality

	nº	%	Cumulative %
1-15 days	18	36,7	36,7
16-30 days	13	26,5	63,3
31-60 days	9	18,4	81,6
61-120 days	7	14,3	95,9
More than 121 days	2	4,1	100
TOTAL	49	100	

Amadora-Oeiras utility previews financial compensation for cases whereas the causes of tangible damages of customers-users are proved to be due to some kind of wastewater public system irregularity. In these cases, the claim is sent to the municipality juridical department for analysis and financial compensation delivery.

Amadora sewerage department answered to almost every written claim received, during the year of 2002[26]. Nevertheless, data analysis showed uncertainty in what concerns to whether the claimer actually received a personal answer to its claim or not. As can be seen through the table below, from a total of 17 residents that claimed in 2002, only 5 received a written answer from the utility. These are the ones that wrote directly to the utility. The remaining are customers who claimed through other services. In these cases Amadora sewerage department writes to the intermediary organization[27].

To synthesise, Amadora sewerage department pattern of response is to direct the answer to the person/organisation that writes to the department, either claimer or intermediary of the claim. In the cases where the claimer writes directly to the department he usually receives a response to its claim. In the cases where there is an intermediary of claimer the Amadora sewerage department sends the response to the intermediary.

In the face of this pattern of response management to claims, the questioning that rises is if it actually guarantees that every claimer receives an explanation to its claim.

[26] On a total of 59 received claims on sewer problems, Amadora answered to 46 claims.

[27] Which can be the local district, a municipality department, the police or Health Center.

Table. Response to claims, according their entrance (Amadora)

		written response receivers						
	claim entrance circuit	local district	residents	police	municipality	others	TOTAL	
resident	directly to sewerage utility		5				5	
	indirectly, trough other services	4		1	7		12	
	total	4 23,5%	5 29,4%	1 5,9%	7 41,2%	0 0,0%	17 100%	37,0%
l.district	directly to sewerage utility	7					7	
	indirectly, trough other services	3		1	2		6	
	total	10 76,9%	0 0,0%	1 7,7%	2 15,4%	0 0,0%	13 100%	28,3%
others services	directly to sewerage utility	1			2	2	5	
	indirectly, trough other services	1			2		3	
	total	2 25,0%	0 0,0%	0 0,0%	4 50,0%	2 25,0%	8 100%	17,4%
municipality	directly to sewerage utility				8		8	
	total	0 0,0%	0 0,0%	0 0,0%	8 100,0%	0 0,0%	8 100%	17,4%
	TOTAL	16 34,8%	5 10,9%	2 4,3%	21 45,7%	2 4,3%	46 100%	100%

In what concerns to written answer contents, analysis showed that answers generally inform that the problem is solved. Some of them inform about the reasons underlying the claimed problem and the type of solution encountered to it.

5.3 Proposal of criteria to Quality of Service assessment

It is found as pertinent to end this section with a systematisation of a first proposal of criteria or performance indicators to assess quality of service, namely in what concerns to claims management. These criteria intend to be re-worked and tested under 5.2 Task. Besides, we intend they can become a contribution to Performance Indicators framework (dimension quality of service), which is being developed under Workpackage 1.

As mentioned above, an exhaustive quality of service assessment should be based on an approach directed to the utility procedures analysis as well as to the analysis of public side, its experience, perception and personal evaluation.

Given this, the next table presents a list of indicators for the analysis of the components above mentioned – *accessibility, information, commitment, staff training and assessment.*

Table. Components and related indicators, for analysis of sewerage performance, in what concerns to claim management procedures

Accessibility		Personal visit
	Ways of approaching to the sewerage utility	email
		Telephone
		Letter
	Circuit of claim entrance	Directly to sewerage utility
		Indirectly, through other services
		Both
Information	Information delivery to customers about claiming procedures	Non-delivery
		Delivery on the back of bills
		Delivery through leaflets
	Type of information delivered	Utility ways of approaching to claim
		Utility procedure to solve claimed problem
Commitment	nº of days to solve claim underlying problem	Nº / interval scale
	Sending of response letter to customer	No
		Yes
	Content of response letter to customer	"Problem solved"
		Explanation of what happened
		Explanation of why happened
		Explanation of how was problem solved
		Apology, when appropriate
		Compensation, when appropriate
Staff training	Existence of staff training routines	Yes
		No
	Frequency	Nº of hours per year
Assessment	Claims management procedure subject of review	Never
		Once a year
		Once in two years
		Once in more than three years

According to the choice of targets and level of social accompaniment, and to some extend to the way these tasks are organised, the internal cost for the wastewater utility can vary to a significant extend. A cost estimate should base on the explicit setting of targets, and on the definition of task organisation and corresponding workloads. It is a case by case matter.

6 CONCLUDING COMMENTS

Decision making about sewer rehabilitation involves many aspects, among which the socio-economic impacts of both possible failures and rehabilitation works. In order to propose criteria in regard to these aspects, the basic principle of the work presented here was to use and summarize as much existing knowledge and available data as possible. As can be seen, both knowledge and data availability are very diverse, according to the type of impact. Generally, they are quite limited in representativity, in accuracy, in completeness…

Therefore, users of the CARE-S Rehab manager should consider all knowledge and information available locally, and should not hesitate to tailor criteria calculations to their legitimate decision making framework, as well as to the local geographical, technical, hydrological, economic and social context.

Whatever the decision support system which may be considered, whatever the decision making paradigm, information and data on failures, on works, on their "physical" effects and on socio-economic impacts are very precious. Reporting, monitoring and assessment of such events, and systematic storage of the related data must be strongly promoted. This would allow, locally as well as through synthesis work, to go further in the description and quantification of socio-economic impacts.

For defining the possible criteria, and especially the default calculation criteria within the CARE-S Rehab manager, it was necessary to "accommodate" the conceptual framework defining impacts and social costs with available inputs (external data, results from other components of the CARE-S DSS). Two important but difficult issues would especially deserve further methodological work:

- the identification, according to the decision maker stakes (regulations, objectives…), of the events (defects, misfunctions, deficiencies) which must be considered as failures, and hence of their consequences; this point may strongly depend on national regulations, which showed being very diversified,
- the link between a "faulty pipe" and the failures induced, when these failures show up at another place, at sub-catchment level… or when they combine with consequences of bad conditions of other parts of a network.

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ANNEXES

Annex 1: Analysis of partner and end-user survey

Just after launching the project, during the first half-year, a general survey was done with all end-users and partners of CARE-S, in order to design a detailed state-of-the-art on various topics relevant for the project. Inside, a specific part was devoted to sewer networks failures on one hand, to rehabilitation works on the other hand: regulations, standards, compensations, management, available data… The answers summarised here address either national situations or specific end-user situations. Only those related to impacts of failures or of works on third parties are considered here. The points dealing with public information and participation are taken into account elsewhere.

REGULATION, STANDARDS, DUTIES … CONCERNING MISFUNCTIONS AND FAILURES

The report addresses the issue of defining what a failure is: when is a defect or a misfunction a failure ? As mentioned, if there is a regulatory limit or target about what is or is not acceptable, this may be taken explicitly as a definition of failures, or at least be considered as a default and implicit definition of failures. It was hence interesting to know about the national and local situations in connection with the project.

Flooding and surcharge

The table below summarises the answers: existence or not of legal or standard limits, nature / origin of them, and references or values (in terms of thresholds expressed in return periods).

country	end-user	flooding			surcharge		
		standard	from ?	comment	standard	from ?	comment
AUS	Melbourne	Yes	State govern. regulator	5 years return period	No		
D	Dresden	Yes	national + legal	EN752 ATV 118 (1)	Yes		standard ATV 128
DK	Aalborg	No			Yes	best practice accepted by courts	combined 2 years separate 1 year
F	Nantes	Yes	national « guide », best pract	10	Yes	id	
GB		Yes	national + internal	OFWAT= when due to company 5 years or 10 years + internal rules of company	Yes	national	standards of water industry
H	Budapest	No			Yes	national	depend. on region ; here 2 years

I	Ferrara	No			No		
	Palermo	No			Yes	national + internal	5, 10, 20 years depending on local authorities
	Reggio Emilia	Yes	internal	urbanis 5 years spec.urb 10 spec.road 20	No		
	Bergen	Yes	national guidelines	TA-550 according to area types	No		
	Oslo	Yes	national and now internatio n	soon EN752	Yes	internation	EN752-4
	Stavanger	Yes	nation + internatio + legal	EN752 top pipe 10 or 20	No		
	Trondheim	Yes	internal	10	No		
	(SINTEF)	Yes guideline	EN752 + national	10 when conseq serious, 2 else	Yes	idem	
P	Oeiras Amadora	No		EN752-2; not yet current practice	No		idem
SP	Barcelona	Yes	national + internal	(2)	No		
TCH	Brno	Yes	national + EU	standard CSN756110 = EN752 no obligation	Yes	national + EU	standard CSN 756110 and 756101 no obligat.

Concerning flooding, for a majority of utilities there is a standard, from various origins including internal rules, and concerning surcharge for half of the cases. For several cases the quantitative targets (return periods / frequencies) are taken from or influenced by standard EN752, but there is a significant influence of best practice, which may be recognised by courts.

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(1)

See eurocode EN 752 and ATV (Abwassertechnische Vereinigung, German association for water pollution control) standard A 118 (1999): “Standards for the hydraulic calculation of wastewater, stormwater and combined wastewater sewers”.

location	***design flooding frequency*** ***(once in “n” years)***
rural	10
housing	20

City centre, industrial	30
Subterranean traffic facilities, underpass	50

Due to the difficulties in modelling flooding frequencies, ATV A 118 recommends submerging frequencies for new design and rehabilitation of sewers:

location	***design submerging frequency (once in "n" years)***
rural	2
housing	3
City centre, industrial	less than 1 in 5
Subterranean traffic facilities, underpass	less than 1 in 10

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(2)

Regional Basin Agency

Structure	Road category	T
Bridges over rivers	all	500
River channelling	all	500

Instrucción de carreteras 5.1 - IC drenaje (roads national standard - drainage)

Structure	Road category	T
Bridges over rivers that can have serious consequences	all	50-100-500
Rest of bridges	1	50-100
	2	25
Sewers and channel under road	1	25
	2	10
longitudinal drainage and ditch	1	10
	2	5
Urban road	all	10
gutters	all	2-5

PECLAB (Barcelona's Master Drainage Plan - Local standard)

Concept	T
Streets	10 (*)
Urbans tunnels	25-50

* Other cities have taken different values: i.e. The city of Valencia has T = 25 years

But the most commonly used is T = 10.

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The table below displays the content of the *Eurocode EN752-2*, as far as flooding or surcharge frequencies are concerned, and compares them to other standards / targets considered amongst the CARE-S end-user services. The standard proposes to consider surcharge as a substitute to considering flooding, when it is too difficult to consider flooding frequencies in terms of available knowledge and in the following conditions :

- when no obligation is defined,
- for small projects,
- when no hydraulic model available

The return period thresholds are explicitly ***recommendations***.

Land use type, infra or superstructure	**threshold recommendations on flooding frequencies (1 in « n » years)**	other values also considered amongst CARE-S end-users	**threshold recommendations on surcharge frequencies (1 in « n » years)**	other values also considered amongst CARE-S end-users
rural	**10**	5	**1**	2
housing	**20**	5, 10	**2**	3
city centre, industrial area, shopping area	**30**		**2 if flooding hazard checked, 5 else**	5
underground traffic facilities, underpass … (roads and rails)	**50**	20, 25	**10**	
general (not in Eurocode)		2, 5, 10, 25 or else according to consequences		2, 5, 10, 20 combined 2 separate 1
urban roads (idem)		10		
special roads (idem)		20		

Combined sewer overflows

The table below summarises the answers: existence or not of legal or standard limits, nature / origin of them, and references or values. We have made the distinction about quantity (water volume discharged or flow) and quality (amount or concentration of pollutants discharged).

country	end-user	overflow quantity / frequency			overflow quality		
		standard	from ?	comment	standard	from ?	comment
D	Dresden				Yes		ATV 128
DK	Aalborg	No			Yes	best practice accepted by courts	
F	Nantes	Yes	water police regulation	case by case	Yes	water police regulation	case by case
GB		Yes	national	bathing waters 3 per season ; shell fisheries 10 per year ; rivers cf Envt Agency	Yes		number of spills or water quality impact
I	Ferrara	No			Yes		effluent standards
	Palermo	No			Yes	Italian law 152/99	
	(SINTEF)	Yes recommen -dation	national + internal	capacity = 4 times average flow	Yes		some cities consider global pollution budgets for sewer system
P	Oeiras Amadora	No			Yes	urban wastew. treatment	
SP	Barcelona	Yes	(3)		Yes	(3)	
TCH	Brno	No			Yes		treatment plants + overflows (pay if exceed)

The cases with a defined standard on quantity are a minority, whatever these standards are defined by regulation or are recommended, case by case or nationally. Overflow quality is more often standardised, but a standard may be fixed globally for the wastewater system, on the basis of a global pollution budget.

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(3)

There's, in Spain, a limit on total spill duration to sea waters < 450h per year and 3% bathing hours

In Barcelona a new Master Drainage Plan limits the CSOs number to 20 in a year (nowadays there are 63 in a year). Tanks against CSO are presently designed and built with the goal to reduce to 1.5% the total number of non compliance hours in a bathing season

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COMPENSATIONS OF IMPACTS TO THIRD PARTIES

In financial terms, the costs of failures impacts or of work impacts on third parties are the possible compensations paid, either directly or through an insurance, which is paid by the sewerage undertaking on a "permanent" coverage contract basis. In economic terms, the corresponding social costs are difficult to assess. Compensations might be considered as a first proxy assessment for the types of impacts covered by a compensation system, in spite of numerous potential shortcomings of such an approach. More generally, we might assume that compensations, which are a real expense, are a lower limit assessment for the social costs.

Compensation of failures impacts

The question was asked about possible compensations in case of sewer network failures, and about the principle used for calculation of these compensations.

country	end-user	compensation for:	calculation rules / modes:
AUS	Melbourne	flooding, collapse, pollution	direct + insurance
DK	Aalborg	if responsible for damage caused directly or indirectly	No
F	Nantes	no case up to now	
GB		internal flooding	typically 50% of yearly wastewater charge (more if company decides)
H	Budapest	flooding, collapse	direct through insurance
I	Ferrara	collapse	insurance
	Palermo	if legal process recognises responsibility : flooding collapse	direct
	Reggion Emilia	flooding + collapse + pollution	
Lt	Siauliai		insurance

	Bergen	flooding	direct + insurance
	Oslo	flooding, collapse	direct + insurance
	Stavanger	flooding when discharge capacity smaller than required	insurance
	Trondheim	flooding, collapse	direct + insurance
P	Oeiras Amadora	flooding, collapse when complaint	insurance
SP	Barcelona	if legal actions by user	No
TCH	Brno	collapse, pollution	insurance

Flooding and collapse are the failures types which can be compensated in a majority of cases, with a predominance of insurance systems, of mixed systems combining insurance and direct compensation. In England and Wales a compensation procedure exists based on a reduction of wastewater charge.

Compensation of works impacts

The question was asked about possible compensations in case of sewer network rehabilitation works (or more generally works with the same kind of potential external effects), and about the principle used for calculation of these compensations.

country	**end-user**	**compensation ?**	**calculation rules / modes:**
AUS	Melbourne	Yes	case by case
DK	Aalborg	if responsible for damage caused directly or indirectly	No
F	Nantes	No	
H	Budapest	No	
I	Ferrara	No	
	Palermo	permanent or temporal use of properties	No
	Reggio Emilia	for damage caused by works	No
	Bergen	No	
	Oslo	for damage caused	case by case
	Stavanger	Yes ?	
	Trondheim	No	

P	Oeiras Amadora	Yes	case by case
SP	Barcelona	Yes	No
TCH	Brno	easement, permanent exemption	No

The undertakings vs national situations considering compensation for work impacts, and the types of impacts covered, are less important than in the case of failures. Moreover, no one reported about compensation calculation rules or principles.

A question was also asked about possible compensation procedures and principles in general for public works. Given the wide scope of this question, the results should be considered with care.

country	**compensation**
DK	compulsary if loss induced
F	if damage or property rights restrictions (direct agreement or court)
GB	No
H	No
I	when acquisition of private properties
N	No (mandatory private insurance)
P	for expropriation
TCH	Yes (compulsory)

Annex 2: Analysis of claims data from SMAS Oeiras Amadora

Delta Sousa e Silva (LNEC LISBOA)

1. INTRODUCTION

Wastewater and storm water systems, combined with its treatment and reuse, appear as fundamental components of *urban water cycle*. Its performance and management dictates, in great part, whether environmental sustainability and urban quality of life are or not achieved.

Sewer and storm water systems of modern industrialized societies suffer from a wearing out induced by the combination of **ageing infrastructure**, **population growth** and **increased urbanization** in peri-urban areas. This wearing out process has as consequence the increased vulnerability towards risk such as sewer structural collapse, pollution of receiving waters, soil and ground water pollution, sewer blockage, flooding and overflow. This general scenario has repercussions at environmental as well as at social and economic levels. Sewer misfunctions and failures endanger environmental sustainability as well as it troubles citizens' safety and quality of life.

Mitigation of such sewer problems implies a reorientation of urban wastewater policy. Reactive patterns of management, directed to fixing acute problems, must be gradually abandoned, in favour of pro-active approaches. The "*lemma*" here is to prevent problems before their manifestation in the form of failures, which may imply to give priority to sewer rehabilitation.

European cities are not an exception in what concerns to wastewater systems. Old cities have, in general, old sewer and storm water systems. This scenario turns sewer rehabilitation an imperative, at medium and long-term. One of the difficulties underlying rehabilitation is its high cost. European cities spend in the order of five billion euro per year for wastewater network rehabilitation. According to estimations, costs tend to increase over the coming decades, due to network ageing (CARE-S, Description of Work, EESD-ENV-3.Call). This scenario turns even more pertinent the investment on pro-active wastewater policies, whereas decision-making about rehabilitation stands on previous analysis and assessments.

CARE-S project departs from the assertion that sustainable deliberative processes around sewer networks must be knowledge-based. Given this, its main goal is to develop a suite of tools, directed to facilitate cost-efficient and informed rehabilitation processes. Multidisciplinary analysis around sewer and storm water systems[28] is in course and intends to be the basis for a *Decision Support System* (DSS) construction. This system intends, in short, to support network owners and operating companies in their decision about *when* to rehabilitate, *where* and *how* to rehabilitate *at a minimum total cost* and *before serious failures do occur*.

One of CARE-S specific objectives is the integration of social and economic costs of malfunctioning sewer system in the rational framework for sewer rehabilitation decision-making[29]. This specific objective intends to be achieved through workpackage 5 (WP5).

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[28] Wastewater and storm water performance indicators, socio-economic and environmental impacts of malfunctioning sewer systems and rehabilitation technology.

[29] Indeed, network misfunctions and failures induce, at times, on direct damages to individuals simultaneously with an amount of other hidden costs conventionally called intangible. This variety of costs goes from the negative effects on citizens of streets temporary blockages to the stress and worry caused by sewer flooding, passing by

Knowledge of social and economic costs raises a set of questions to which research must answer. They can be synthesised as follows: What type of risks and failures may occur in urban wastewater and storm water systems? What impacts do they provoke? To what extent do these impacts represent social and economic cost to costumers and citizens?

Approach to social costing — and questions it raises — stands on a methodology, which comprehends four general components. They are the following: (i) literature revision and construction of theoretical approach to social costing; (ii) collection and analysis of empirical data about failures and costumer claims and (iii) public inquiry on social impacts of network failures and rehabilitation works; (iv) definition of criteria representing the social impacts of failures on one hand, of sewer rehabilitation works on the other hand.

APPENDIX II intends to synthesise the main results of a first approach to failures and associated impacts, developed under WP5, Task 5.1. This first approach was done through the empirical analysis of Lisbon end-user (SMAS: Amadora-Oeiras) written claims, concerning the year of 2002[30]. It aimed to contribute for the construction of a typology: claimed failures→expressed effects→expressed impacts.

2. APPROACH TO LISBON CLAIMED FAILURES

Before a description of procedure and objectives underlying claims' analysis, it is found as pertinent to do a brief presentation of Lisbon end-user and target-territory (Amadora and Oeiras Municipality).

2.1. Lisbon end-user and its target-territory

Lisbon end-user (SMAS Oeiras-Amadora) has the responsibility of wastewater and storm water management of two munipalities — Amadora and Oeiras. The circumstance of having one public company responsible for two municipalities is rather unique in the context of Lisbon metropolis[31]. Amadora territory was part of Oeiras municipality. Its institutionalisation as a municipality, in the seventies, did not have repercussions, in terms of water and wastewater administration. The creation of an independent company in Amadora municipality is previewed, although not rendered concrete, yet.

Amadora and Oeiras are two rather different municipalities. The first one has in its History a confused process of urbanization and population growth. Along decades a receiving territory of immigrants[32], this municipality is today composed by a mixture of old buildings, shantytowns and recent buildings. This confused urbanism seems to have effects on wastewater and storm water system of Amadora. We emphasise here two types of effects, sometimes interrelated: (i) difficulties of drainage of wastewater and storm water networks, due to a discrepancy between sewers capabilities and the volume of buildings they serve; (ii)

the non-usufruct for recreational aims of public spaces. Once existing, they can and should play an important role in decision making about *when*, *where* and *how* to repair or rehabilitate sewers.

[30] The team thanks Water and Wastewater Services of Oeiras and Amadora Municipality (particularly engs. Julieta and Maria Helena) for the support and availability of data on claims.

[31] The common pattern in Portugal is the existence of a water or wastewater company, private or public, by municipality.

[32] Amadora territory was, in the fifties, a rural area, sited at the periphery of the city of Lisbon. The low cost of land, associated with the lack of land-use planning, is at the origin of uncontrolled private initiatives of building construction. Urban expansion was not, at least in a few sites (i.e. district of Brandoa, known in the decade of 60 as the bigger illegal neighbourhood of Europe) accompanied by a re -adaptation of sanitation infrastructures.

incidence[33], at least in some sites, of wastewater open drainage in streets due to existence of shanty houses without any kind of connexion to sewer network.

Oeiras municipality scenario appears as quite different, when compared with Amadora. Wastewater problems are apparently lower. A more controlled and planned process of urbanization and growth had an important role on preventing such problems.

Table 1. Brief social and territorial overview

	AMADORA	OEIRAS	LISBON* city or urban area ?		
	Value	Value	Value	Unity	Year of reference
Total area	23,8	45,8	1090,04	Km^2	2001
Density of population	7371,1	3508,8	1765,6	$Inhab/km^2$	2001
Total of inhabitants	175431	160702	1924565	Inhabitants	2001
Total of buildings	13445	16052	227445	nº	2001
Density of buildings	564,9	350,5	208,7	$Buid/km^2$	2001
Total of dwellings	65284	60923	723319	nº	2001
Total of dwellings – classical	63846	60428	713916	nº	2001
Total of dwellings – others	1438	495	9403	nº	2001
Total of dwellings – others	2,2	0,8	1,3	%	2001
Population comfortableness (dwellings) [1]	68,8	77,9	72,8	%	2001
Population served by water public network	98,7	99,1	97,8	%	2001
Population served by sewer public network	95,3	96,8	92,3	%	2001

[1] Population living in dwellings with electricity, water closet, water, house heating and bath.

Font: National Institute of Statistics.

As can be seen through Table I, Amadora municipality is, by comparison with Oeiras and Lisbon, the one that has the smallest total area (km^2) and simultaneously the highest density of population as well as of buildings. Besides, it is in Amadora where we find higher percentages of non-classical dwellings.

2.2 Approach to Amadora-Oeiras claims

Lisbon end-user claims analysis aimed (i) to contribute to the construction of a typology of failures, where the social and economical impacts would enter and (iii) to assure a first-approach to the terrain where fieldwork under 5.2 task would be developed[34].

This analysis concerns only the year of 2002. The inexistence of a computer-based method of claims' archive made impracticable the option for a longitudinal analysis of claims. Besides, it should be emphasised that the data that will be presented bellow does not correspond to the total of claims and failure events occurred in 2002. Costumers can claim to

[33] Evident in some citizens' claims.

[34] Data collected through claims analysis appears as important for 5.2 Task in, at least, two aspects: (i) first approach to failures social impacts and (ii) "mapping" of vulnerability points where Lisbon field work under 5.2 can fall upon.

Lisbon end-user through, at least, two modes: by letter or by phone. The data analysed corresponds to written claims.

Costumers' letters were subject of a content analysis. Almost every claim had annexed notes of the service, which were also object of analysis. A database was conceived regarding information about "**who and what claims**", "**claim entrance circuit**", "**service resolution and response to claimer**", jointly with **site identification**.

The item "what claims" concerns information about the type of network failure underlying the citizen claim, its expressed external effects as well as felt impacts. It should be emphasised that the typology of claimed failures, to be presented bellow, should be viewed as a typology of "trigger events". Analysis showed that, in many cases, failures had inherent a set of other "hidden and anomalous events or associated abnormalities". This complexity turned difficult the exercise of typification of many failures.

External failure effects and impacts were not explicit in all claims. Some costumers expressed effects and impacts whereas others did not. Nevertheless, lack of explicit mentioning impacts does not mean that there were not any. Although non-explicit in words, the act of writing a claim has, in our view, inherent some kind of disturbance on the part of who claims.

3. Amadora and Oeiras claimed failures

3.1. Who claims?

Lisbon end-user database is composed by 138 written claims[35], 59 of which are from Oeiras municipality and 79 from Amadora. Residents are, as expected, the main claimers. Nevertheless, there were cases, especially in Amadora, where local districts and other municipality services were intermediaries of citizens' claims. Most of claims from residential building condominiums and enterprises are from Oeiras municipality (see Figure 1 and 2).

Figure 1. Total of Lisbon end-user claims (year 2002)

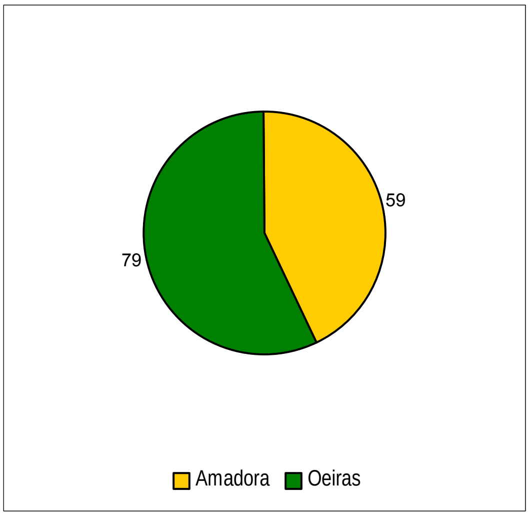
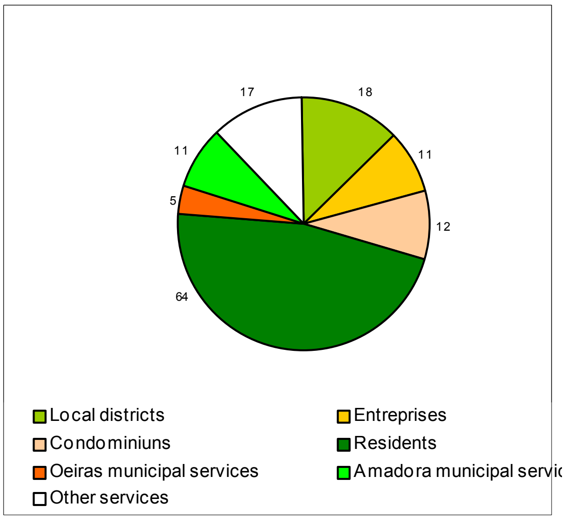


Figure 2. Claimers

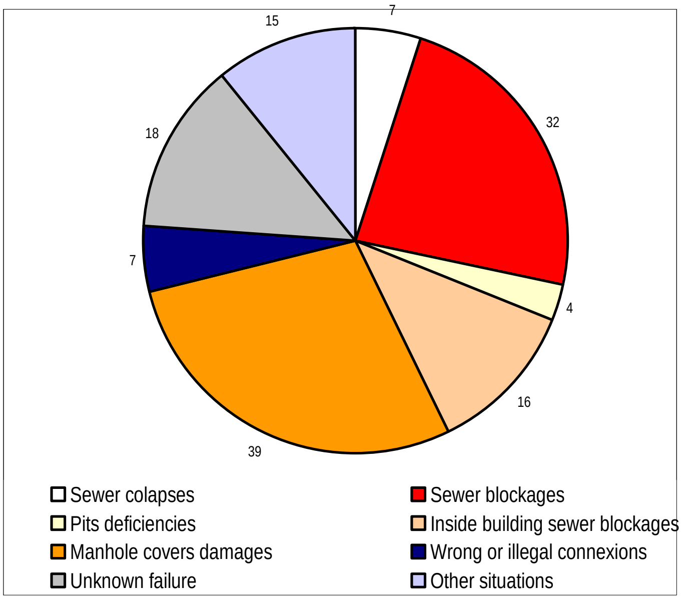


3.2. What type of failures or trigger events are claimed?

Claims fall upon a rather high diversity of failures. Nevertheless, the most common are **sewer blockages**, some of them due to internal building pipes malfunction and others due to public network fragilities. There are other claims that fall upon **sewer collapses**, **disposal wells blockages/functioning deficiencies** and **damaged manholes**[36]. Besides these, there is an amount of other expressed abnormalities due to **faulty**[37] **or furtive network connections** that provoke sewer surcharge. Claims also denounce **other situations** or abnormalities. We refer to situations caused by problems induced by the lack of sewer infrastructures[38] as well as problems induced by inappropriate uses of the network[39]. Although not strictly related with rehabilitation matters, it was not to exclude from the present analysis these **other situations** due to the degree of disturbance that they seem to cause on some claimers.

As can be seen through the Figure 3, most of the claims are due to sewer network blockages and damaged manholes[40]. There is an amount of claimed blockages, especially in Oeiras municipality (15%), attributed by wastewater services to internal building network. In these cases, services do not intervene, leaving to private owner the responsibility of solving the problem.

Figure 3. Failures underlying claims



[35] There were initially 168 claims. Database was object of a more refined analysis, excluding all cases that were not related with failure or rehabilitation problems.

36 This last type of failure is usually a consequence of maintenance handicaps, more than structural network fragilities. Its preponderance as well as its impacts, both in Amadora and Oeiras territory, justified the inclusion of this specific type of failure.

[37] By this, we mean situations where storm water network is irregularly connected with wastewater network. In these cases the trigger event was not a blockage or a collapse, so we opted by classifying it separately.

[38] These problems concerns specifically: (i) lack of street gutters/stormwater network that obliges residents to open sewer manholes in order to facilitate storm water drainage; (ii) cases of wastwewater open drainage on streets due to the existence of a shanty town where the is no connexion of houses to public sewer network; (iii) building infiltrations due to the non-existence of a storm water network and (iv) exfiltration cases.

[39] Residual number of claims about odours, due to private discharges of illegal pollutants.

[40] Oeiras and Amadora municipalities have similar patterns in what concerns these two specific failures. Claimed sewer blockages represent 27% of the whole failures claimed in Amadora and 20% of the total failures claimed in Oeiras. Similarly, Manholes damages represent 27% of the whole failures claims in Amadora and 29% of claims in Oeiras.

There is an amount of abnormalities where it turned impossible to determine the failure underlying. In these cases, external effects or impacts are mentioned but scantiness of services paperback notes makes impracticable the identification of the trigger event.

4.3. What type of failure external effects are mentioned ?

Most external effects of collapses and blockages are similar qualitatively. With exception of **soil deperssion** and **exfiltration** effects[41], referred effects concern to **inside & outside[42] houses flooding (during dry weather)** and **retail** flooding[43] [44], **WC overflowing**, **wastewater open drainage** along streets, “nauseous” **odours and rodents & insects propagation**. As can be seen through Table 2, some of these external effects appear associated. In other words, dry weather flooding cases, fundamentally caused by blockages, have inherent situations of WC overflowing and provoke odours.

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[41] Which are associated to sewer collapses.

[42] By outside houses flooding, we mean building gardens.

[43] Flooding was, in this context, treated as an external effect, instead of a failure, because it appeared related with sewer blockages or collapses.

[44] The team had doubts in the categorization of this specific effect. Lack of knowledge of water depths impeded the classification of these phenomena as (minor) inundations or a more severe flooding. Anyway, as far as claims could allow, an amount of these phenomena caused material damages to individuals.

Table 2. Expressed external effects, according to failures

External effects		Type of failure: Sewer colapses	Wrong and illegal connexions	Public sewer blockages	Inside building blockages	Pits deficiencies	Manhole covers damages	Other situations	Unknown failures	TOTAL n	TOTAL %
House flooding			2	7	5			2	2	18	
	and WC overtoping		1	1	1					3	
	and wastewater open drainage							1		1	
	and odours (rodents & insects)	1		1	2					4	
	Other effects			1						1	
	Total	1	3	10	8	0	0	3	2	27	19,6
Retail flooding				2					1	3	
	and WC overtoping			2				1		3	
	and odours			2						2	
	Total	0	0	6	0	0	0	1	1	8	5,8
Soil sinking in									5	5	
	and rodents & insects	1								1	
	Total	1	0	0	0	0	0	0	5	6	4,3
Wastewater open drainage			1	5	3	1	2	1	5	18	
	and odours (rodents & insects)	1			1				1	3	
										0	
	Total	1	1	5	4	1	2	1	6	21	15,2
Other external effects	Exfiltration and infiltration	2		1						3	
	Pollution of receiving waters		1			1			2	4	
	Public space flooding			1			1			2	
	Noise						7			7	
	Odours, rodents and insects	1	2	2	2			3	1	11	
	Total	3	3	4	2	1	8	3	3	27	19,6
Effects non-knowledge		1		7	2	2	29	7	1	49	35,5
Total		1	0	7	2	2	29	7	1	49	
TOTAL of claims		7	7	32	16	4	39	15	18	138	
Row general total (%)		5,1	5,1	23,2	11,6	2,9	28,3	10,9	13,0		100

Damaged manholes most referred external effect is **noise**, caused by car traffic. There are also a few claimers that refer to problems of **wastewater open drainage** and public space **flooding**. Faulty of furtive connections are the abnormalities attributed to a few claimed cases of house flooding, wastewater open drainage and **pollution of receiving waters**.

An analysis of expressed external effects, independently of associated trigger events, shows that flooding is the most expressed external effect. Approximately 41,5 of claimers who mentioned external effects, caused by some kind of failure or abnormality, claim of having suffered from flooding in their house or in public space nearby.

3.4. What are the social impacts of failures?

Explicit reference to social impacts due to failures was not a reality on all the claims. In fact, only 41% of 2002 claimers refer explicitly to consequences bared by some kind of abnormality or failure. However, this non-mentioning should not be viewed as inexistence of impacts. As said above, the act of writing a claim implies some kind of disturbance for the person who claims. This assumption as well as the present stage of the research advises to the consideration of all mentioned social impacts, even if they appear only once.

Table 3. Verbatim comments of failure claimers

Failure expressed external effects	Expressed social Impacts
Dry weather flooding ?	"A situation that affects not only the life quality of my client and his family, but also the one of other residents and citizens passing by 25 de Abril street, in Brandoa. We are in presence, it urges to emphasise, of a serious public health problem, which eternalises for almost two years" (claiming letter from a resident lawyer).
Wastewater overflows ?	"Stagnant waters propitiate insects and rodents propagation, for that residents feel revolt, without being able to open windows or usufruct the place. Insects bites have obliged some medical assistance (…)" (Claiming letter of an Amadora local District).
Odours	"(…) A nauseous odour in my building entrance (…) As this situation can not perpetuate, once it is affecting public health namely the one from residents, we ask you intervention (…)" (Enterprise owner of Amadora).
Noise	"it turns impossible to rest and sleep due to the constant passage of cars in the damaged manhole" (Amadora resident)
Wastewater open drainage in public spaces/landscape	"(…) a wastewater open drainage at the beach [Oeiras] near a place where people use to usufruct the beach and its waters. I manifest my surprise for this unpleasant situation (…)" (Oeiras resident and user of Paço d'Arcos beach)

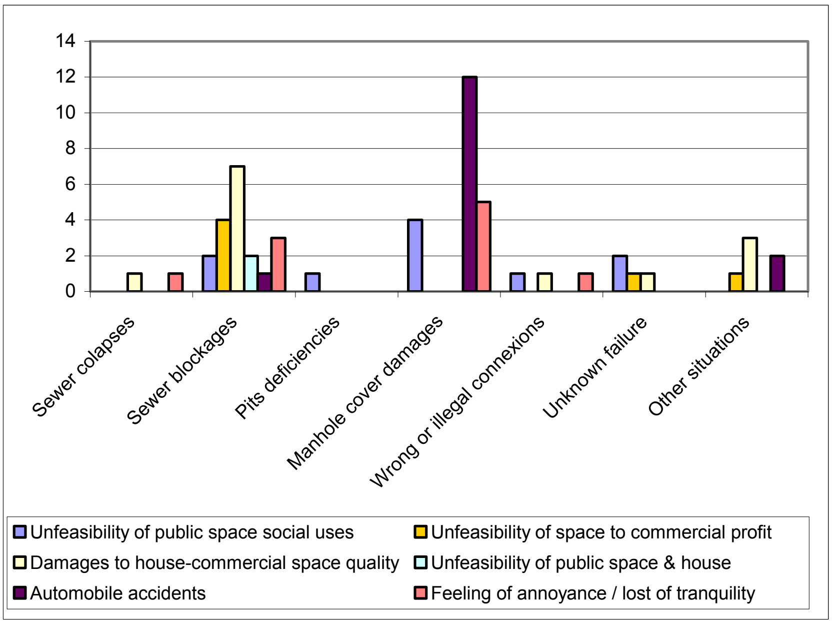
Car accidents, especially due to damaged manholes[45], are the most referred impacts, to which the claimer asks for compensation. **Damages to houses and retail spaces**, either tangible (material damages) or intangible (ei. impossibility of house usufruct due to odours or noise induced by damaged manholes) are the second most referred impacts. Related to this, there were cases of **temporary unfeasibility of space to commercial profit**. This last impacts concern situations of temporary closure of retail or clients running away. Besides these impacts, there are others, classified as **temporary unfeasibility of public space for social uses**. The category includes a diversity of situations such us the reference to disturbances, caused by abnormalities, to public health, environment and personal safety. It also includes cases where claimers refer the inappropriateness of public space for recreation

[45] It should be noted that there is a case of car accident caused by wastewater open drainage, due to a case of blockage.

(ei. children play, beach usufruct). Finally, there are an amount of claimers revealing **personal annoyance** and **irritation** due to the effects of several failures.

As can be seen through Figure 6, those claimers who suffer from effects of sewer blockages fundamentally refer **damages to houses and retail spaces** as well as **temporary unfeasibility of space to commercial profit**. These effects are fundamentally flooding and, in some cases, odours. Although not so salient as others, **temporary unfeasibility of public space for social uses** is an expressed impact, which is present in almost mentioned failures (sewer blockages, disposable well deficiencies, manhole damages, irregular connections and other unknown failures). The mentioned underlying external effects of such failures are once again flooding, associated or not with odours, rodents & insects propagation and wastewater open drainage. Similarly, an annoyance and irritation feeling is present in almost the claims where impacts are described by claimers.

Figure 4. Expressed social impacts, according to type of claimed failure



4. FINAL REMARKS

Analysis of Amadora-Oeiras written claims fits on a first empirical approach to social impacts of sewer failures, to be deepened under Task 5.2. The main results of this first approach — and the questioning they rouse — will be briefly synthetized in this section.

Residents are the main claimers. The circuit of claim entrance is diverse. Some residents write directly to Oeiras-Amadora sewerage service while others claim through their local district or through a municipality department. It is not clear, at this stage of the research, if all claimers received a written answer to their problem.

Citizens complaints play, theoretically, an important role in helping companies on the delivery of a better service. Nevertheless, their vision as an opportunity of *'doing better'* seems to be shadowed by the subalternity of Costumer Service within a company or by the missleading idea that claims question company competence.

Most common claimed failures are *sewer blockages* and *damaged manholes*. In what concerns manholes, they seem to be related with maintenance problems. Nevertheless, at the origin of such failure may be problems of sewer surcharge, due to structural incapacity.

Flooding and *wastewater overflowing* are the most referred external effects of claimed failures.

In what concerns impacts, Amadora-Oeiras claimers mentionned tangible and intangible impacts. Damages to houses and retail and car accidents are examples of tangible impacts. Unfeasibility of public space for social uses as well as annoyance and irritation are examples of intangible damages.

Figure 5. First typology of claimed failures, expressed effects and impacts (according to Lisbon 2002 claims' analysis)

[1]Provoking sewer surcharge.

Claimed failures	Expressed effects	Expressed impacts
Public sewer blockages	Flooding	Damages to houses & retail
Inside Building blockages	Wastewater open drainage	Car accident
Manhole cover damages	WC overtoping	Unfeasibility of public spaces
Sewer collapses	Odours	Personal annoyance
Wrong or illegal connexions[1]	Soil depression	Irritation
Pit deficiencies	Rodents & insects	
	Noise	
	Pollution of receiving waters	
	Exfiltration phenomena	

Intangibles seem to induce on what Green et. al. (June 1986) define as *opportunity costs*, that is in the temporary *loss of opportunity* of making the best use of residents' own home or public space. The questions that these kinds of impacts raise are similar to the ones raised by Green and Penning Rowsell (op.cit) in relation to floods' intangibles. How to translate these damages into quantifiable social costs in sewer networks assessments? An answer to this question implies, in our view, the answer to another one, which is the following: what weight do residents give to sewer failure intangible damages, by comparison with the tangible ones? What are the limits of personal and social acceptability and tolerance towards these phenomena and their effects?

In fact, cases of failures inducing on low economic costs and high intangible social impacts are a possibility. If individuals' weight of these last ones is higher, together with relevant levels of social unacceptability, we found as pertinent to ponder this when decision making about *where*, *when* and *how* to rehabilitate is to be taken.

Content analysis revealed that unacceptability or intolerance seems to rise due to failure repeated experience or/and services inaction. There were some claims where it is possible to note that it is not the first time the costumer claims to wastewater services. Similarly, persistence of the problem, even after services intervention, tends to originate higher levels of unacceptability.

Although not completely evident through the empirical data analysed at this stage of research, analysis rouse the hypothesis that levels of social acceptability vary according to socio-economic status and environment related social values. The higher the social status, the lower the levels of acceptability towards certain circumstances or phenomena.

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Annex 3: Analysis of compensation data from Strasbourg Urban Community (may 2004)

Caty WEREY (Cemagref-ENGEES Strasbourg)

In this data collection we investigated three utilities of the Strasbourg Urban Community and we met also people from the department of legal matters in charge of the whole Urban Community records. These utilities are responsible for:

- the sewerage network

- the water network

transportation concerning new tramway lines construction.

We asked for failure data and for compensation data or indemnisation data following damages of works or of failures on the different networks.

In France compensation is not common in sewer networks operation.

Concerning failures:

- Flooding risks have to be known by the residents: it is considered as a "public cause " and so flooding does not lead to a juridical procedure towards the sewer utility. It must be noticed that in France backwater valves are compulsory.

- Concerning blockages, most of them concern the private part of connections and so aren't the responsibility of the utility .

However, concerning flooding of cellars and goods due to water pipes breaks (failures) are considered as damages and taken into account by the utility insurance.

- Contentious matters most often are linked with problems during or after works and so it lies within the responsibility of the company concerned with the works.

Concerning works:

Nothing is foreseen for compensating trade losses during works, generally works duration is not too long and arrangements are found in other to reduce annoyance.

However, impacts of flooding of cellars and goods due to water pipes breaks (failures) are considered as damages and taken into account by the utility insurance.

As for sewer networks no compensation is foreseen during works on the network, effort is made on the communication with users and on the time schedule of water delivery cuts.

In Strasbourg as welle as in other French towns, for tramway works a preliminary and amiable compensation procedure has been put in place for tradesmen on the lay-out of new tram lines.

1 - Data on sewers[46]:

The sewerage utility of the Urban Community of Strasbourg (CUS) gathers all the 27 municipalities of the Urban Community representing 557 122 inhabitants (1999). The total network represents 1 556 km of pipes distributed as follows:

municipalities	Network length (ml)
BISCHHEIM	38 258
ECKBOLSHEIM	33 124
ECKWERSHEIM	8 389
ENTZHEIM	18 559
ESCHAU	40 367
FEGERSHEIM	36 593
GEISPOLSHEIM	47 380
HOENHEIM	42 591
HOLTZHEIM	10 182
ILLKIRCH-GRAFFENSTADEN	120 475
LAMPERTHEIM	19 649
LINGOLSHEIM	64 085
LIPSHEIM	15 184
MITTELHAUSBERGEN	10 279
MUNDOLSHEIM	37 132
NIEDERHAUSBERGEN	8 648
OBERHAUSBERGEN	21 214
OBERSCHAEFFOLSHEIM	9 293
OSTWALD	47 447
PLOBSHEIM	20 167
REICHSTETT	45 284
SCHILTIGHEIM	73 877
SOUFFELWEYERSHEIM	35 017
VENDENHEIM	44 996
WANTZENAU	48 550
WOLFISHEIM	20 322

[46] It is necessary to notice that in our analysis of flooding events we took into account all the rain events. Rains events in 1994 and 1996 should be considered more as “catastrophic” and not presented at the same level that usual rains for which the networks is dimensionned.

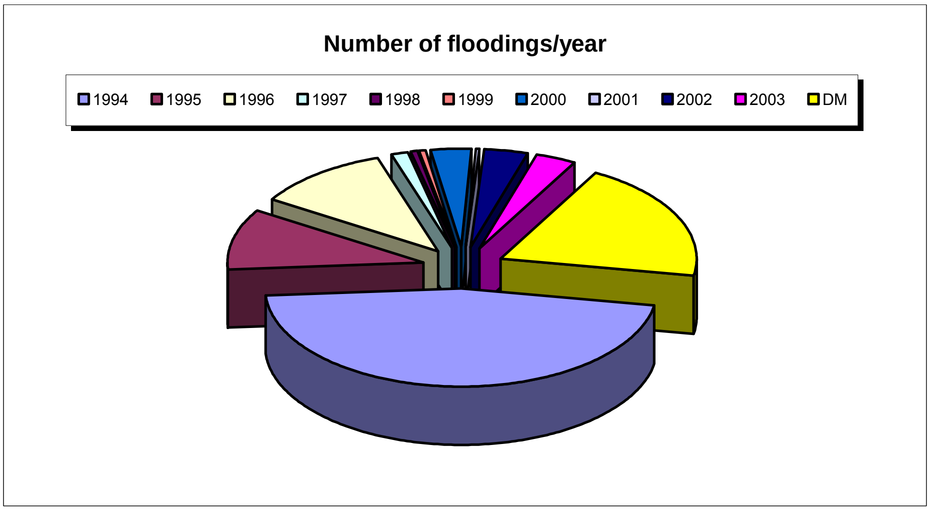
STRASBOURG	638 938
TOTAL	1 556 000

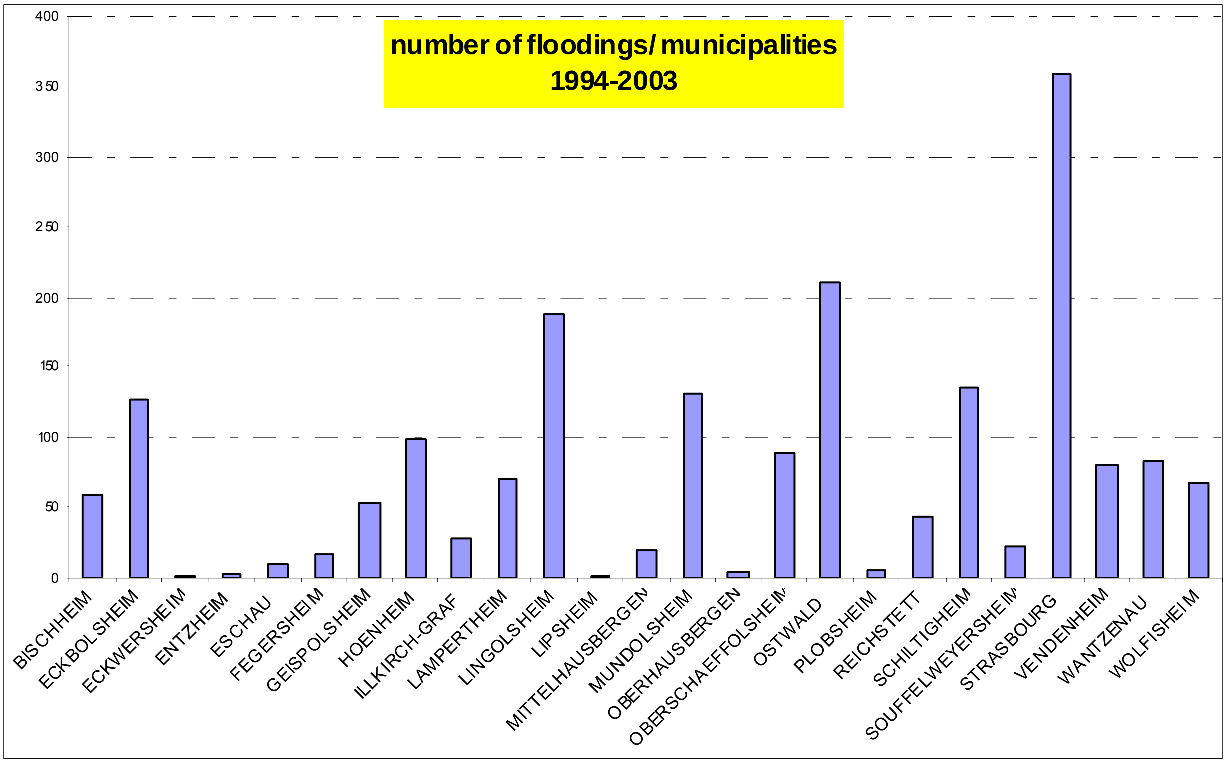
Cellars flooding

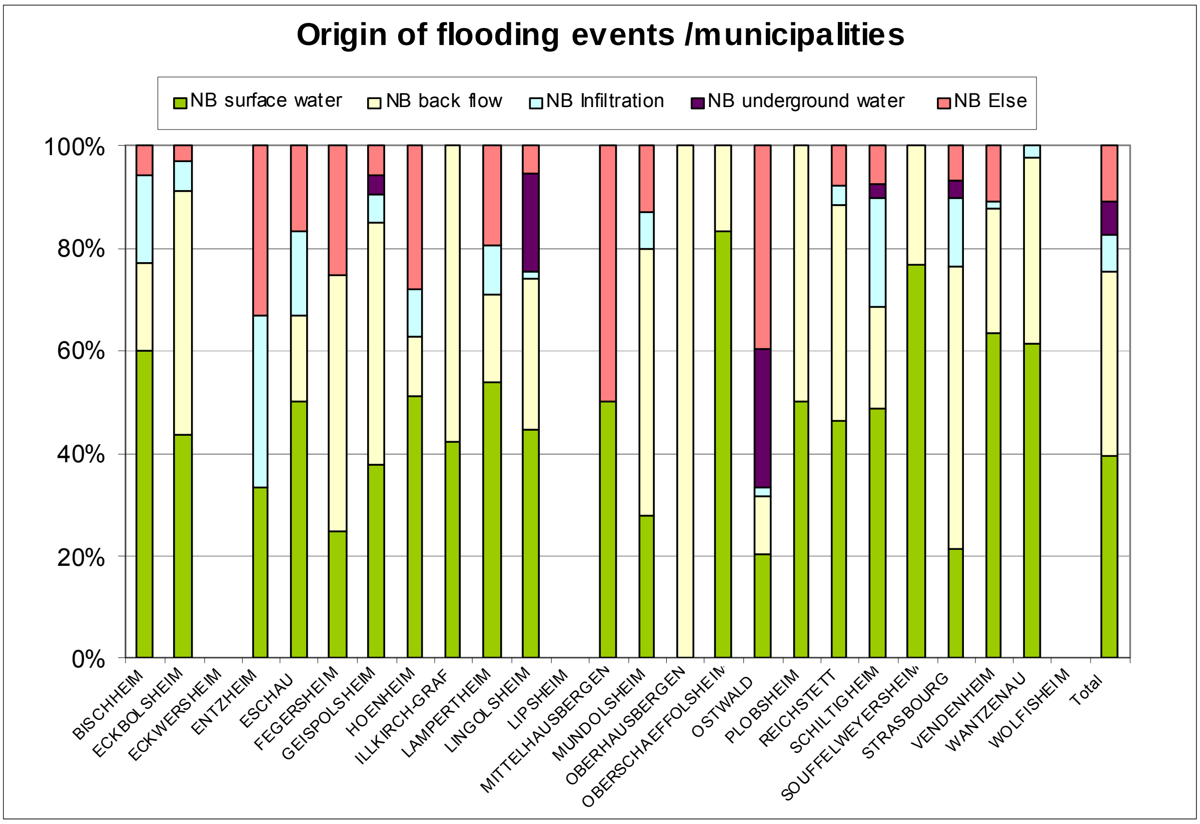
The data collection concerns the period [1994-2003] on 25 municipalities.

These data were collected by the sewerage utility.

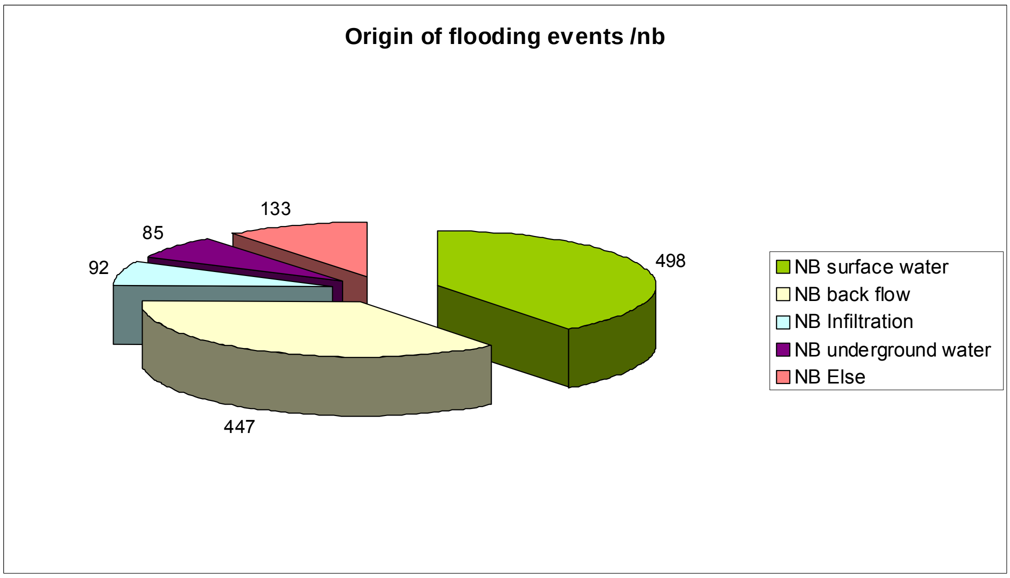
The following graphs show the distribution between municipalities, the distribution between years and the different origins of the cellar flooding events.




number of floodings/ municipalities
1994-2003
400
350
300
250
200
150
100
50
0
BISCHHEIM
ECKBOLSHEIM
ECKWERSHEIM
ENTZHEIM
ESCHAU
FEGERSHEIM
GEISPOLSHEIM
HOENHEIM
ILLKIRCH-GRAF
LAMPERTHEIM
LINGOLSHEIM
LIPSHEIM
MITTELHAUSBERGEN
MUNDOLSHEIM
OBERHAUSBERGEN
OBERSCHAEFFOLSHEIM
OSTWALD
PLOBSHEIM
REICHSTETT
SCHILTIGHEIM
SOUFFELWEYERSHEIM
STRASBOURG
VENDENHEIM
WANTZENAU
WOLFISHEIM

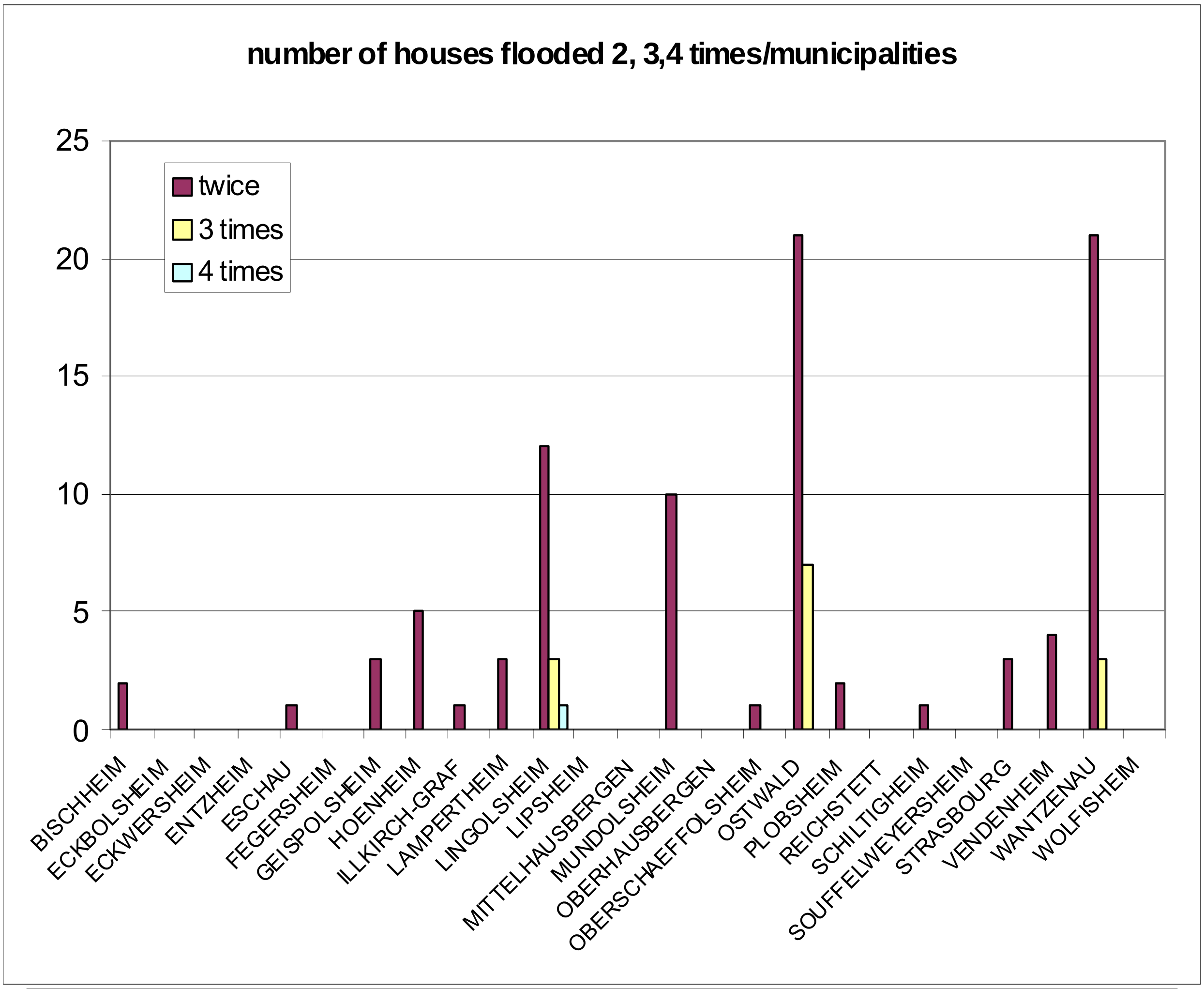


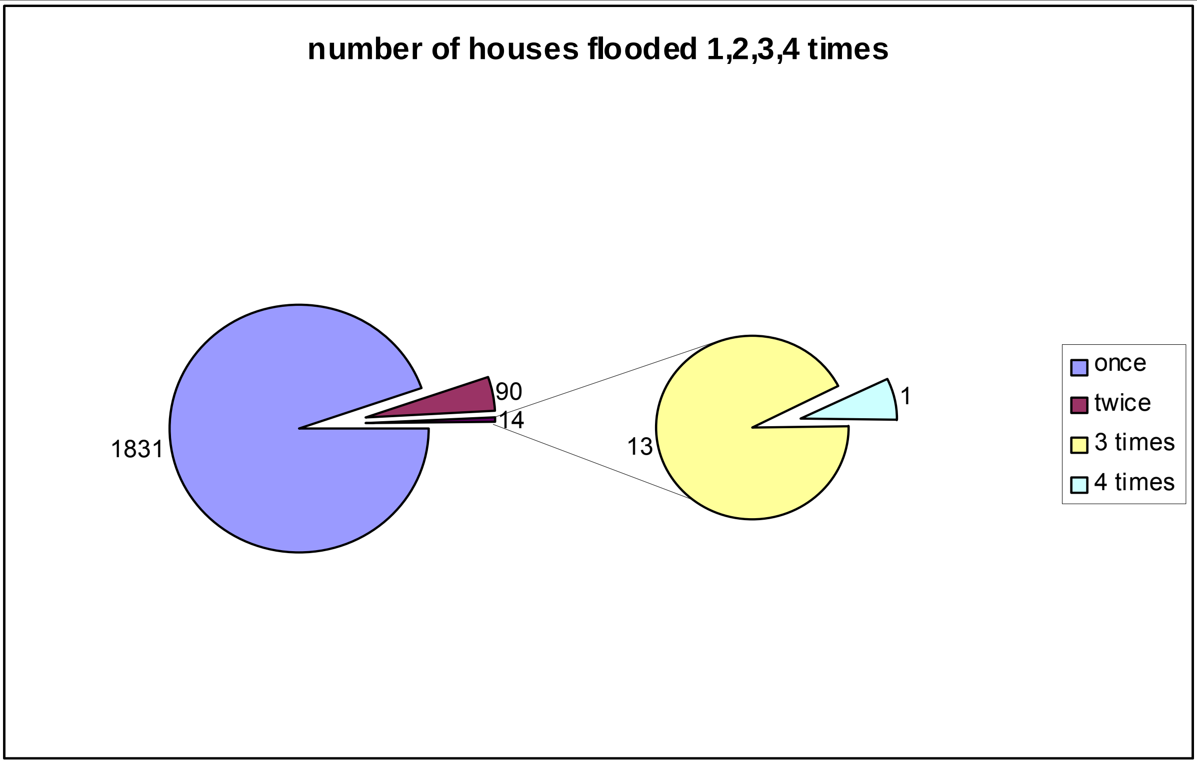
Origin of flooding events /municipalities
NB surface water
NB back flow
NB Infiltration
NB underground water
NB Else
100%
80%
60%
40%
20%
0%
BISCHHEIM
ECKBOLSHEIM
ECKWERSHEIM
ENTZHEIM
ESCHAU
FEGERSHEIM
GEISPOLSHEIM
HOENHEIM
ILLKIRCH-GRAF
LAMPERTHEIM
LINGOLSHEIM
LIPSHEIM
MITTELHAUSBERGEN
MUNDOLSHEIM
OBERHAUSBERGEN
OBERSCHAEFFOLSHEIM
OSTWALD
PLOBSHEIM
REICHSTETT
SCHILTIGHEIM
SOUFFELWEYERSHEIM
STRASBOURG
VENDENHEIM
WANTZENAU
WOLFISHEIM
Total



Origin of flooding events /nb
133
85
92
498
447
NB surface water
NB back flow
NB Infiltration
NB underground water
NB Else

The following graphs show the distribution of the number of houses flooded (once or several times) by street and by municipalities.





__Damages / compensations__

These data come in part from the sewerage utility and in part from the department of legal matters of the whole Urban Community of Strasbourg from 1994 to 2003.

Most of the damages are linked with works on the network.

We collected data on 24 compensation cases within 55 damage cases,

Origin of the damage:

works on sewers

leakage on sewer

back flow

emptying of fat-box

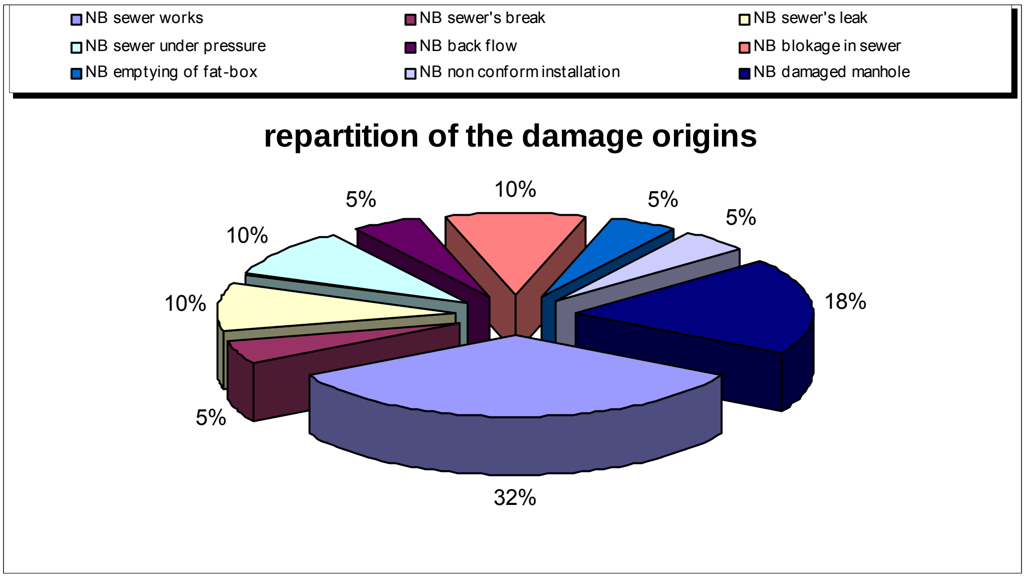
sewer manhole

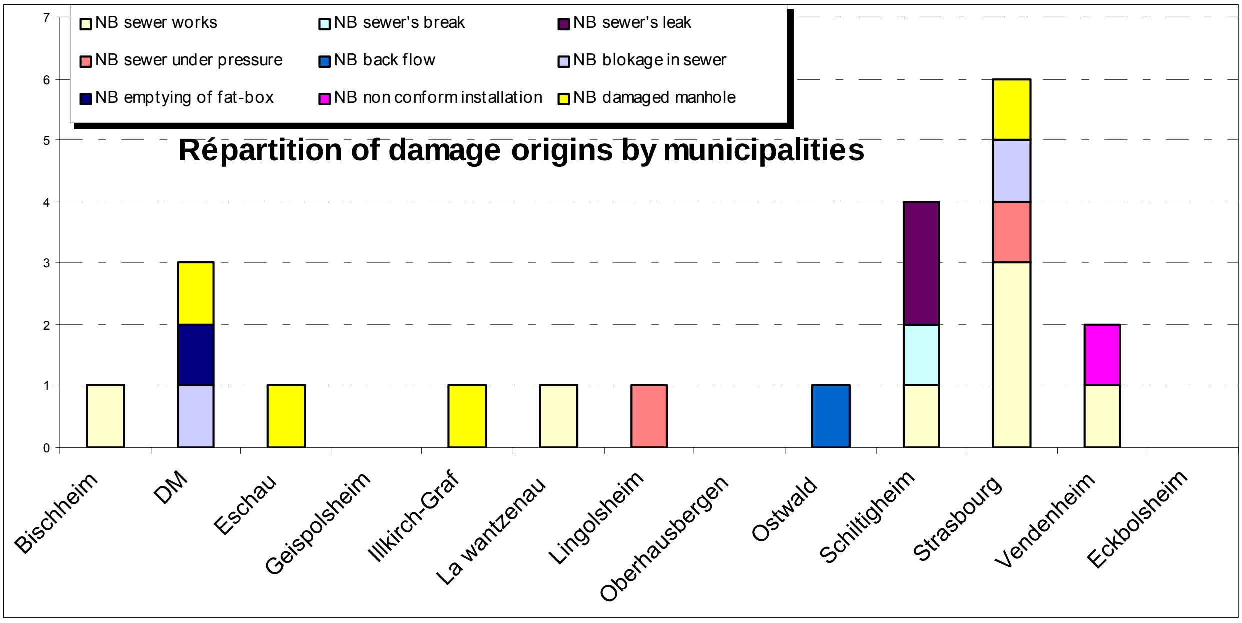
break in a sewer

sewer under pressure

blockage in sewer

non conform installation





<u>Damages</u>

Flooding

Damage on other networks

Damage on buildings

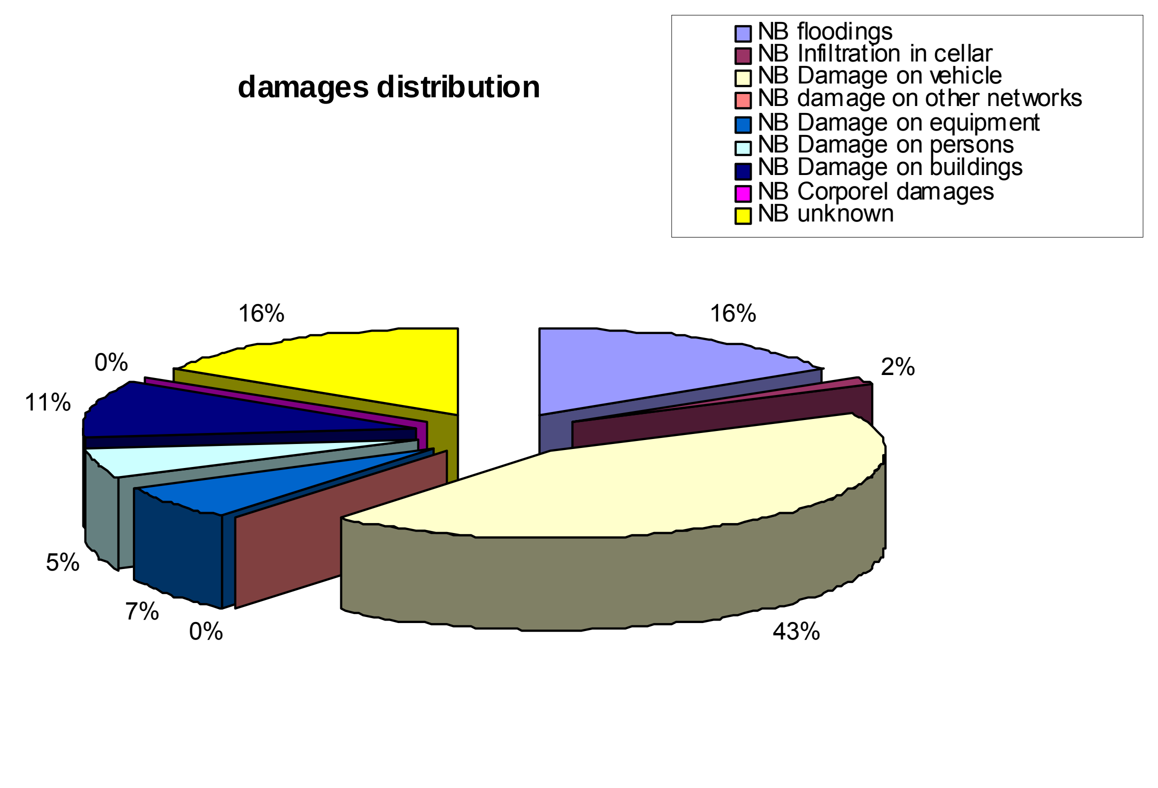
Infiltration in cellars

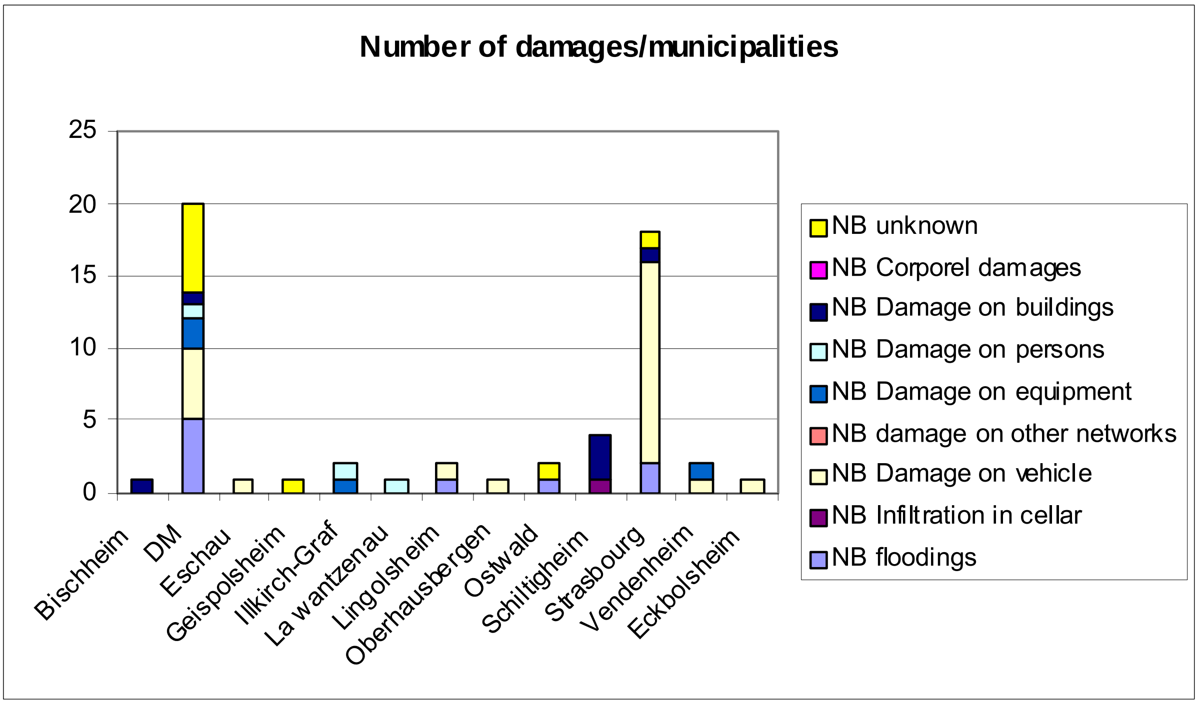
Damage on equipment

Corporel damages

Damage to the person

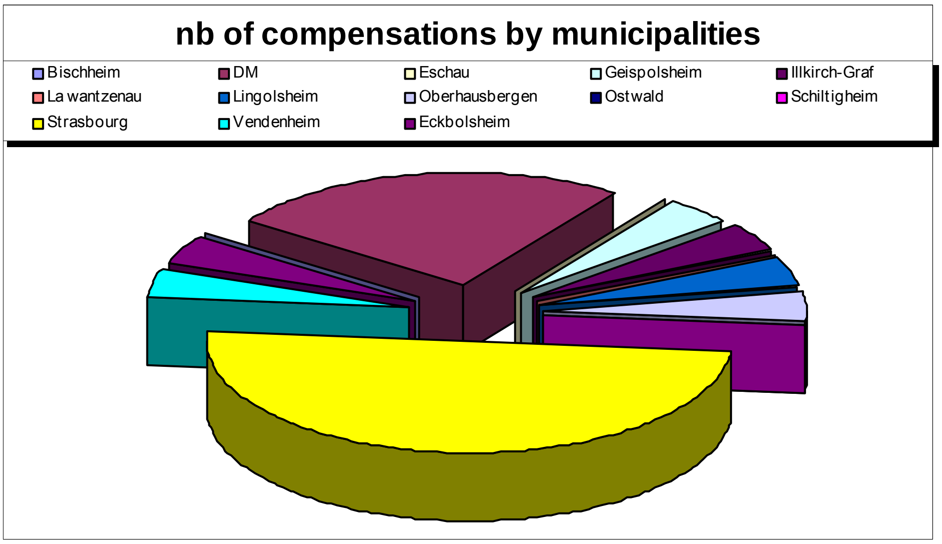
Damage on vehicule





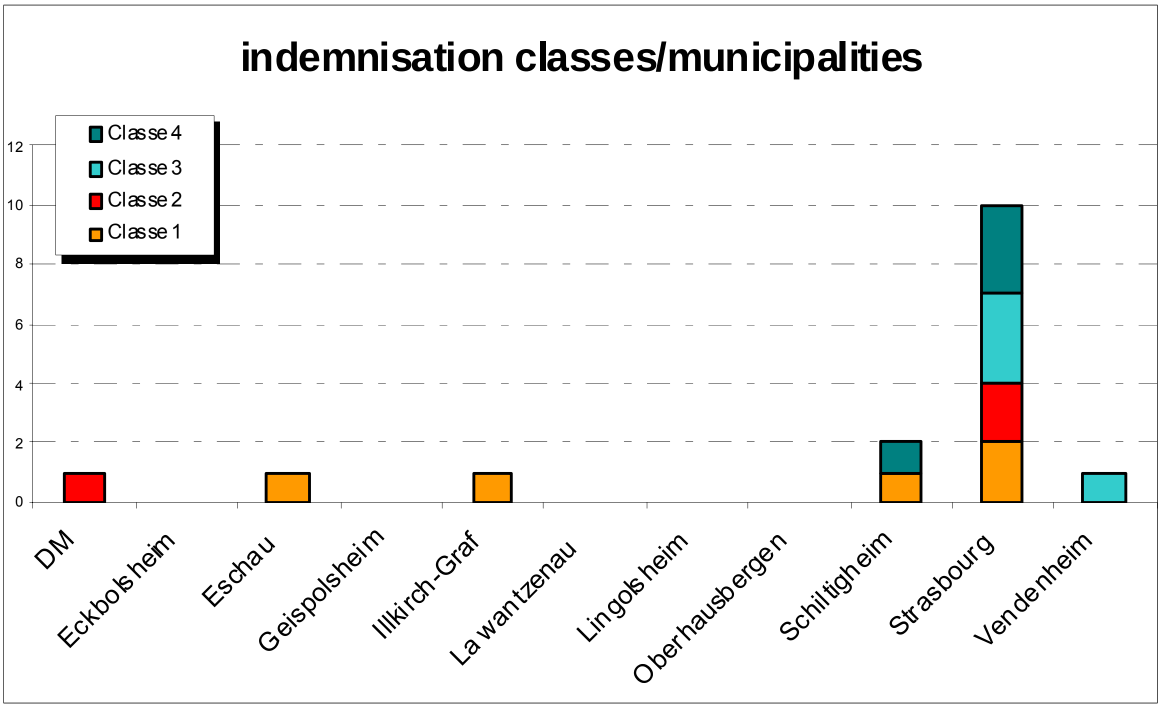
DM=missing data

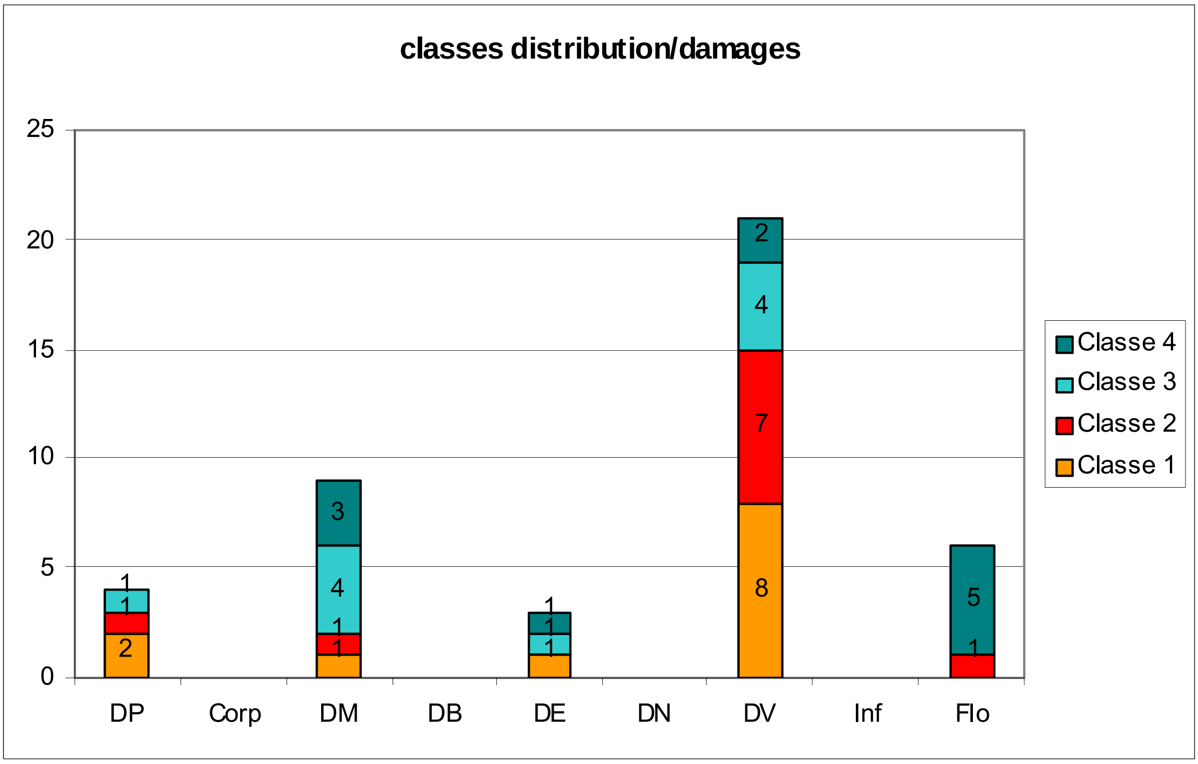
Nb damages/nb compensations



compensationclasses and type of damages

	Damage to person DPs	**Missing data** DM	Damage on building DB	Damage on equipment DE	Damage on other networks DN	Damage to vehicle DV	Infiltration in cellar Inf	Flooding Flo	Icompensation
Classe 1	2	1		1		8			40 F – 165 F
Classe 2	1	1	1			7		1	165 F - 45 F
Classe 3	1	4	1	1		4			450F –1 250 F
Classe 4		3		1		2		5	1 250 F – 3 000 F
Mean value	381,81 F	920,37 F	330,61 F	1 309,82 F		500,84 F		1 698,80 F	
Standard derivation	533,74 F	634,72 F	202,37 F	895,40 F		632,81 F		1 004,43 F	


indemnisation classes/municipalities
Classe 4
Classe 3
Classe 2
Classe 1
12
10
8
6
4
2
0
DM
Eckbolsheim
Eschau
Geispolsheim
Illkirch-Graf
Lawantzenau
Lingolsheim
Oberhausbergen
Schiltigheim
Strasbourg
Vendenheim


classes distribution/damages
25
20
15
10
5
0
DP
Corp
DM
DB
DE
DN
DV
Inf
Flo
Classe 4
Classe 3
Classe 2
Classe 1

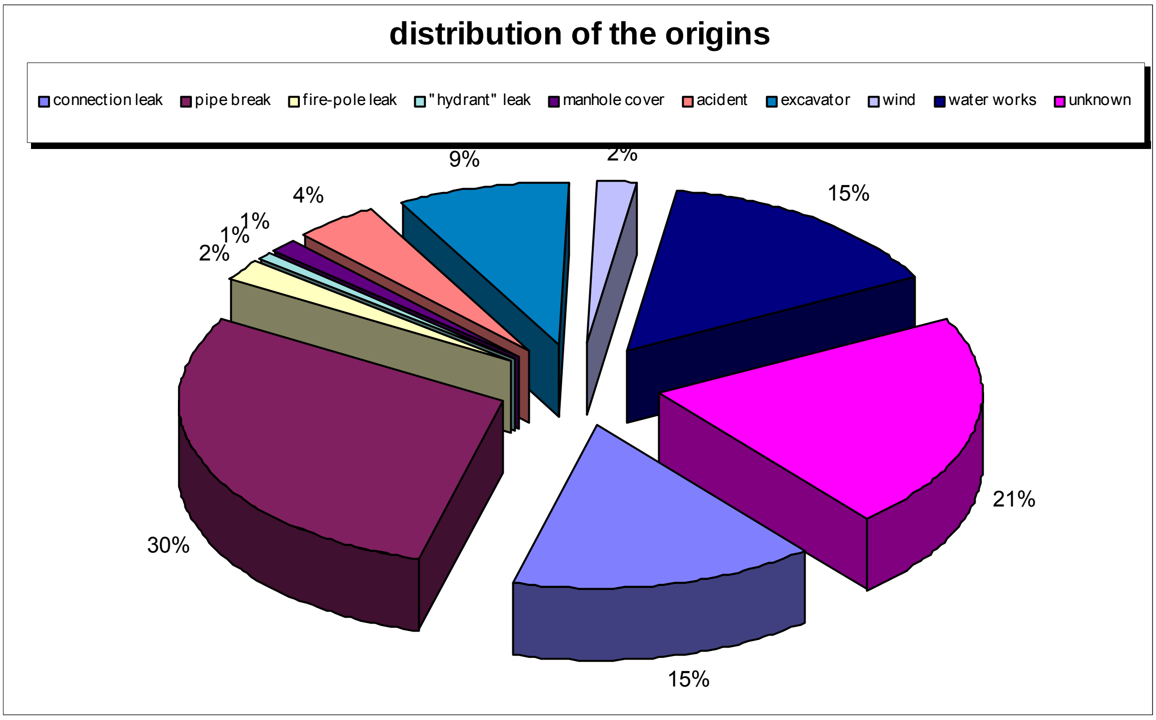
2 - DATA on water pipes:

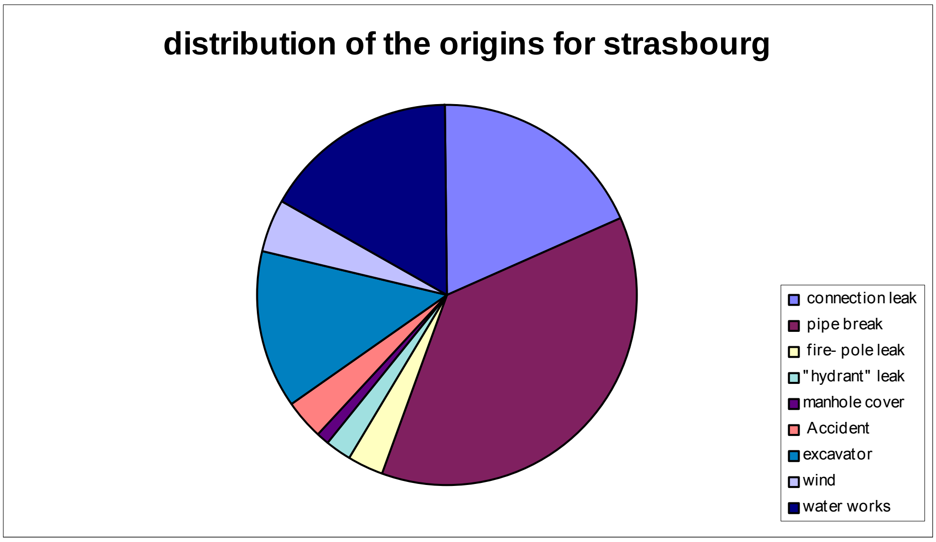
data from 1994 to 2003

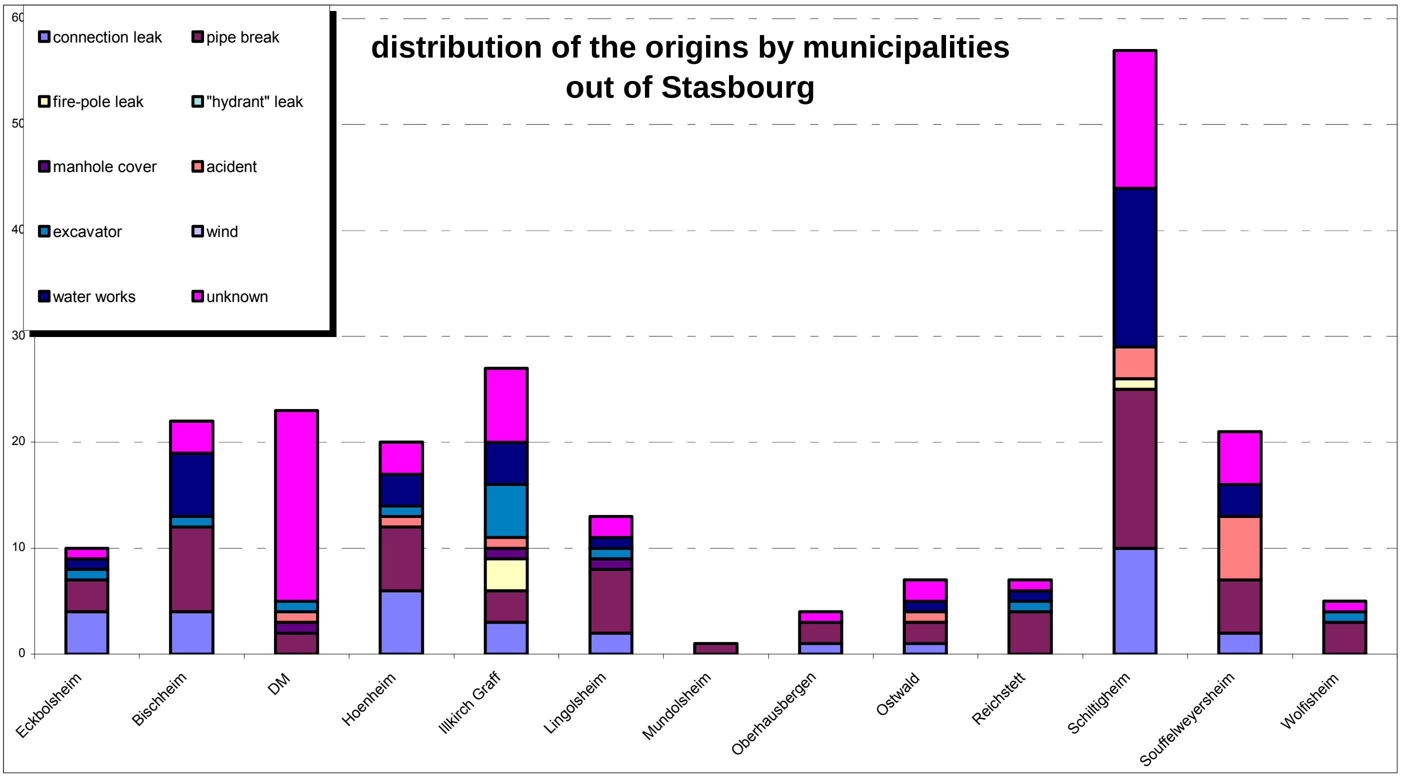
8 municipalities are managed by the urban community water utility:

Municipalities	Network length (ml)
BISCHHEIM	24 655
ECKBOLSHEIM	20 245
HOENHEIM	15 680
LINGOLSHEIM	39 450
OBERHAUSBERGEN	19 230
SCHILTIGHEIM	55 468
STRASBOURG	303108
WOLFISHEIM	12 525

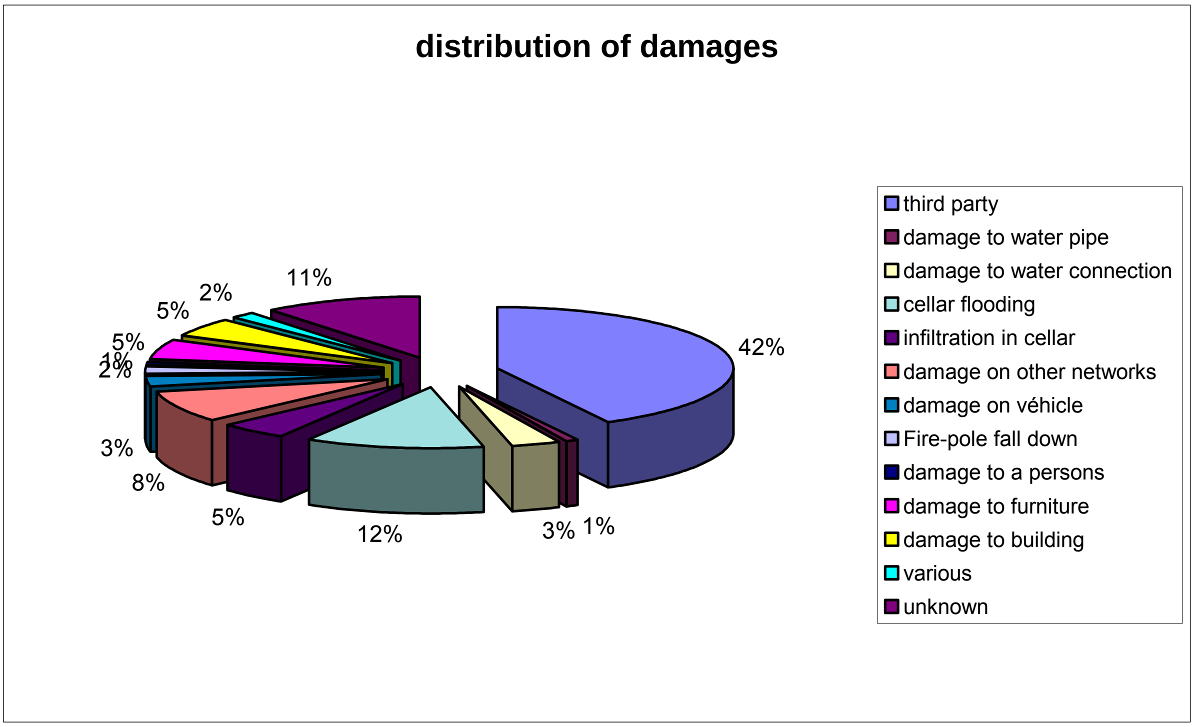
Origins of the damages



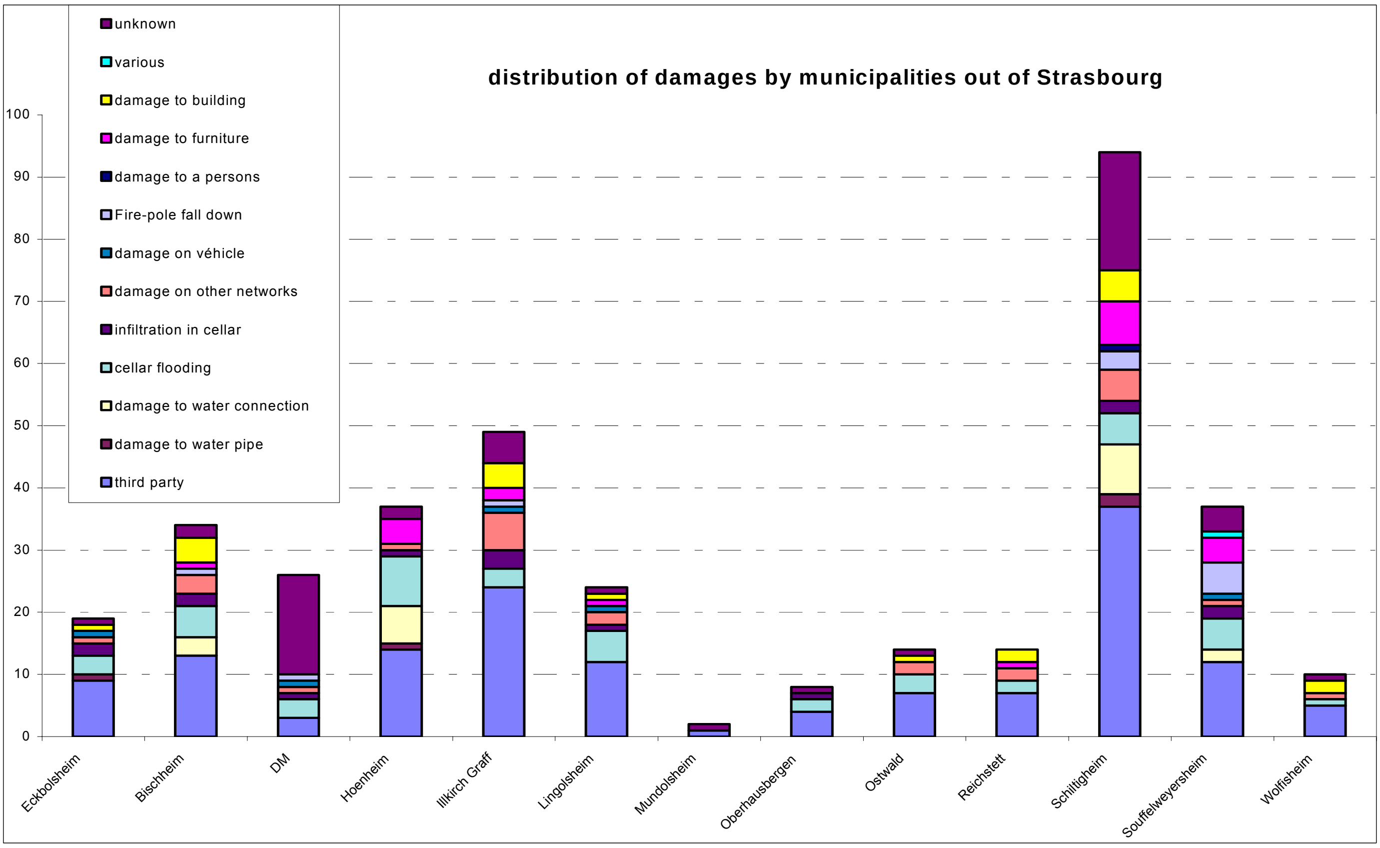

distribution of the origins for strasbourg
connection leak
pipe break
fire- pole leak
"hydrant" leak
manhole cover
Accident
excavator
wind
water works


distribution of the origins by municipalities out of Stasbourg
connection leak
pipe break
fire-pole leak
"hydrant" leak
manhole cover
acident
excavator
wind
water works
unknown
0
10
20
30
40
50
60
Eckbolsheim
Bischheim
DM
Hoenheim
Illkirch Graff
Lingolsheim
Mundolsheim
Oberhausbergen
Ostwald
Reichstett
Schiltigheim
Souffelweyersheim
Wolfisheim

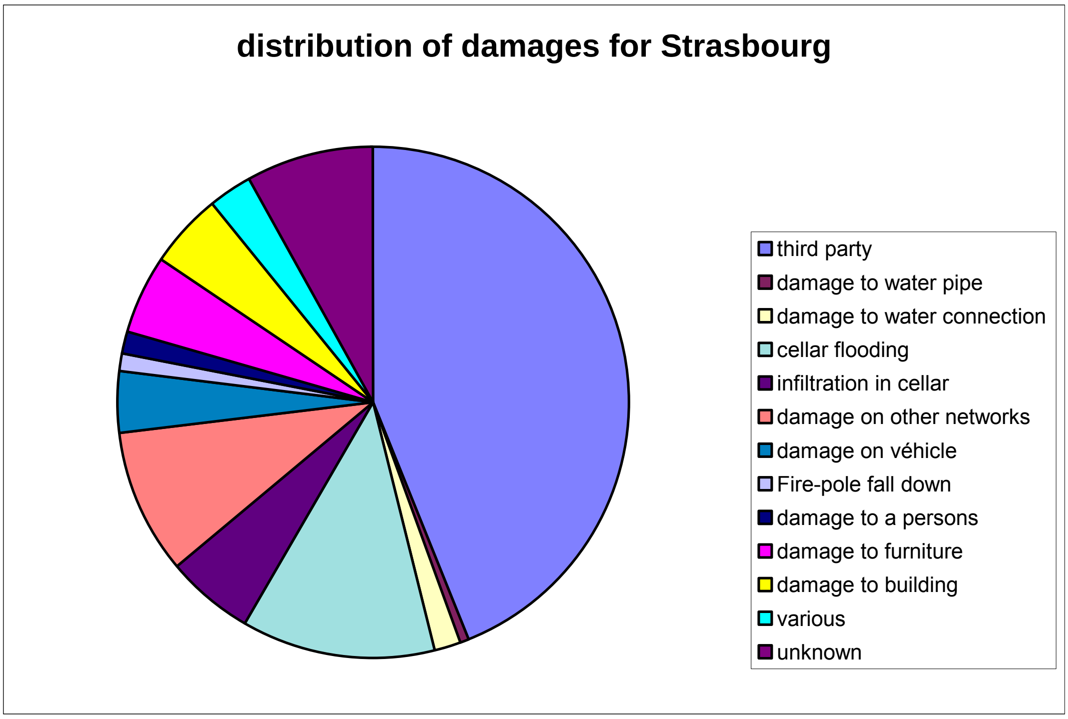
Damages



distribution of damages
42%
11%
2%
5%
5%
1%
2%
3%
8%
5%
12%
3%
1%
third party
damage to water pipe
damage to water connection
cellar flooding
infiltration in cellar
damage on other networks
damage on véhicle
Fire-pole fall down
damage to a persons
damage to furniture
damage to building
various
unknown

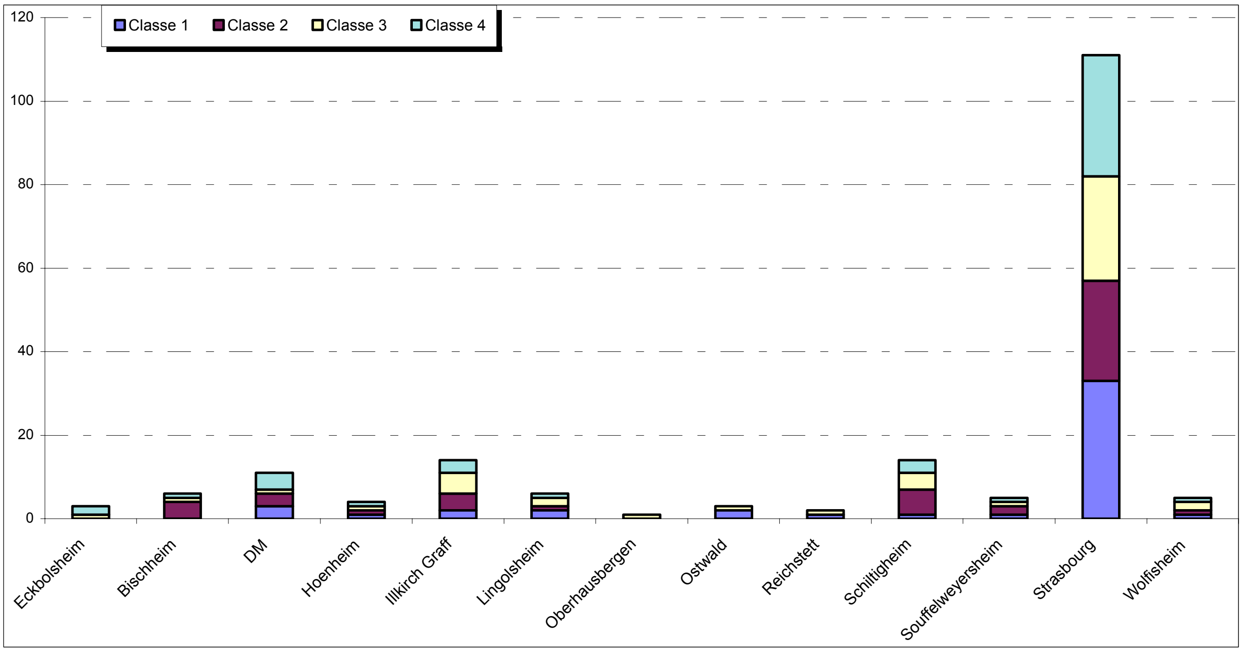


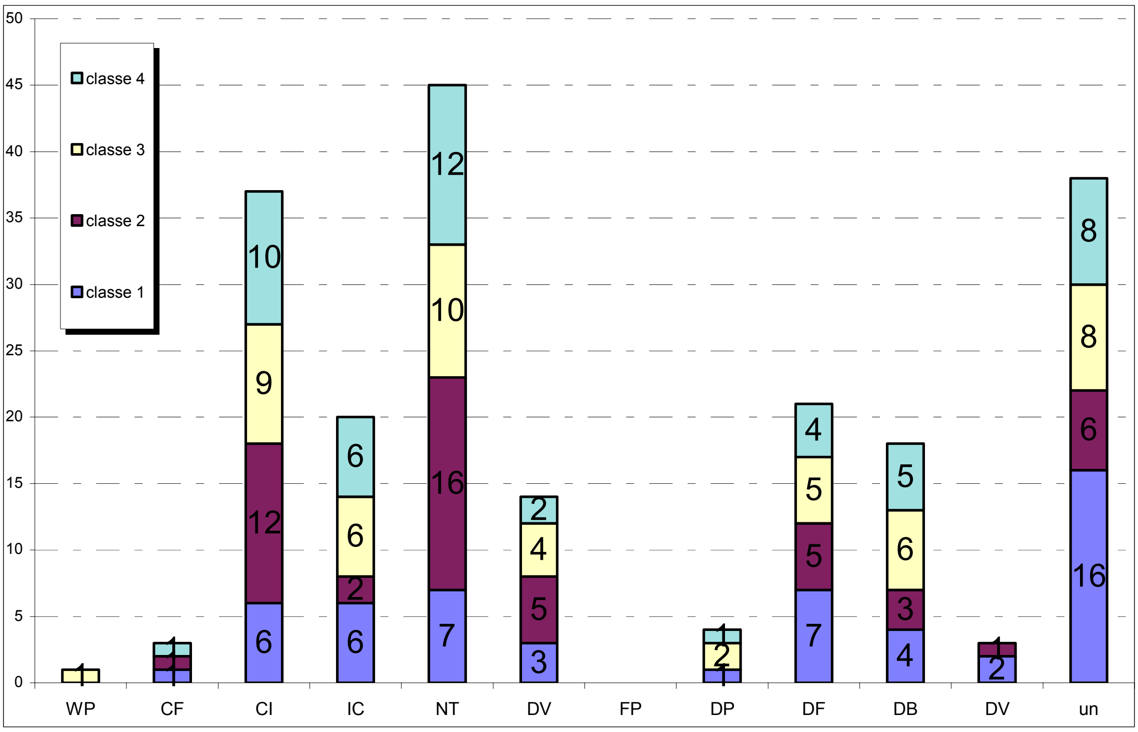
distribution of damages by municipalities out of Strasbourg
unknown
various
damage to building
damage to furniture
damage to a persons
Fire-pole fall down
damage on véhicle
damage on other networks
infiltration in cellar
cellar flooding
damage to water connection
damage to water pipe
third party
100
90
80
70
60
50
40
30
20
10
0
Eckbolsheim
Bischheim
DM
Hoenheim
Illkirch Graff
Lingolsheim
Mundolsheim
Oberhausbergen
Ostwald
Reichstett
Schiltigheim
Souffelweyersheim
Wolfisheim



Indemnisations

Damage to	water pipe WP	Water connection **WC**	Cellar flooding CF	Infiltration in cellar IC	On other networks NT	To vehicle DV	To fire-pole FP	To persones DP	To furniture DF	To building DB	Various DV	Unknown **un**	compensations
classe 1		1	6	6	7	3		1	7	4	2	16	13 F – 250 F
classe 2		1	12	2	16	5			5	3	1	6	250 F – 520 F
classe 3	1		9	6	10	4		2	5	6		8	52 F – 1 050 F
classe 4		1	10	6	12	2		1	4	5		8	1 050F – 475 000 F
Mean value	897,81 F		2 198,56 F	931,96 F	1 539,65 F	611,72 F		867,00 F	520,15 F	26 192,92 F	205,14 F	628,80 F	
Standard derivation	0		3 934,58 F	870,70 F	5 460,99 F	535,29 F		764,40 F	661,06 F	108 145,26 F	85,97 F	636,52 F	


Classe 1
Classe 2
Classe 3
Classe 4
120
100
80
60
40
20
0
Eckbolsheim
Bischheim
DM
Hoenheim
Illkirch Graff
Lingolsheim
Oberhausbergen
Ostwald
Reichstett
Schiltigheim
Souffelweyersheim
Strasbourg
Wolfisheim


classe 4
classe 3
classe 2
classe 1
50
45
40
35
30
25
20
15
10
5
0
WP
CF
CI
IC
NT
DV
FP
DP
DF
DB
DV
un

3 - DATA on TRAM works

A case in city center

Activities impacted

Restaurant
- Cake-shop
- Café
- Tea room
- Pizzeria
- Fast food

Health, beauty and hygiene
- Beauty center
- hairdresser

Food products
- Butchery
- Backery
- Chocolate, tea coffeee trade
- dietetic products

Equipment for the person
- florist
- Sport wear shop
- Clothing shop
- Shoes shop
- Hats shop
- jewellery

Health care
- dentist
- doctoc

Culture and leisurer
- Travel agencys
- Music and instruments shops
- Gymnastic center
- Cinema

Medical equipment
- Articles optique
- pharmacie
- optician
- Biological products

Equipment for the house
- Furniture shop

Services to persons
- Shool of motoring
- Insurance office
- Dry cleaning

bookshop

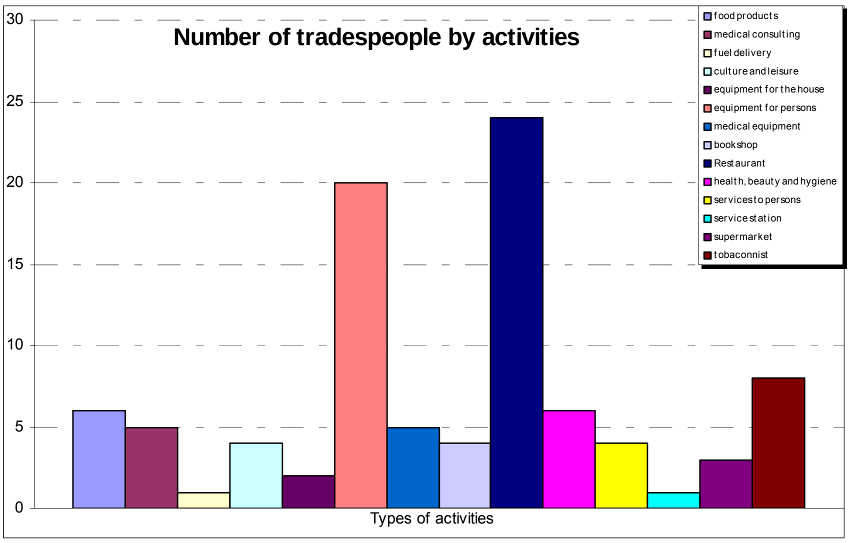
tobacconist

supermarket

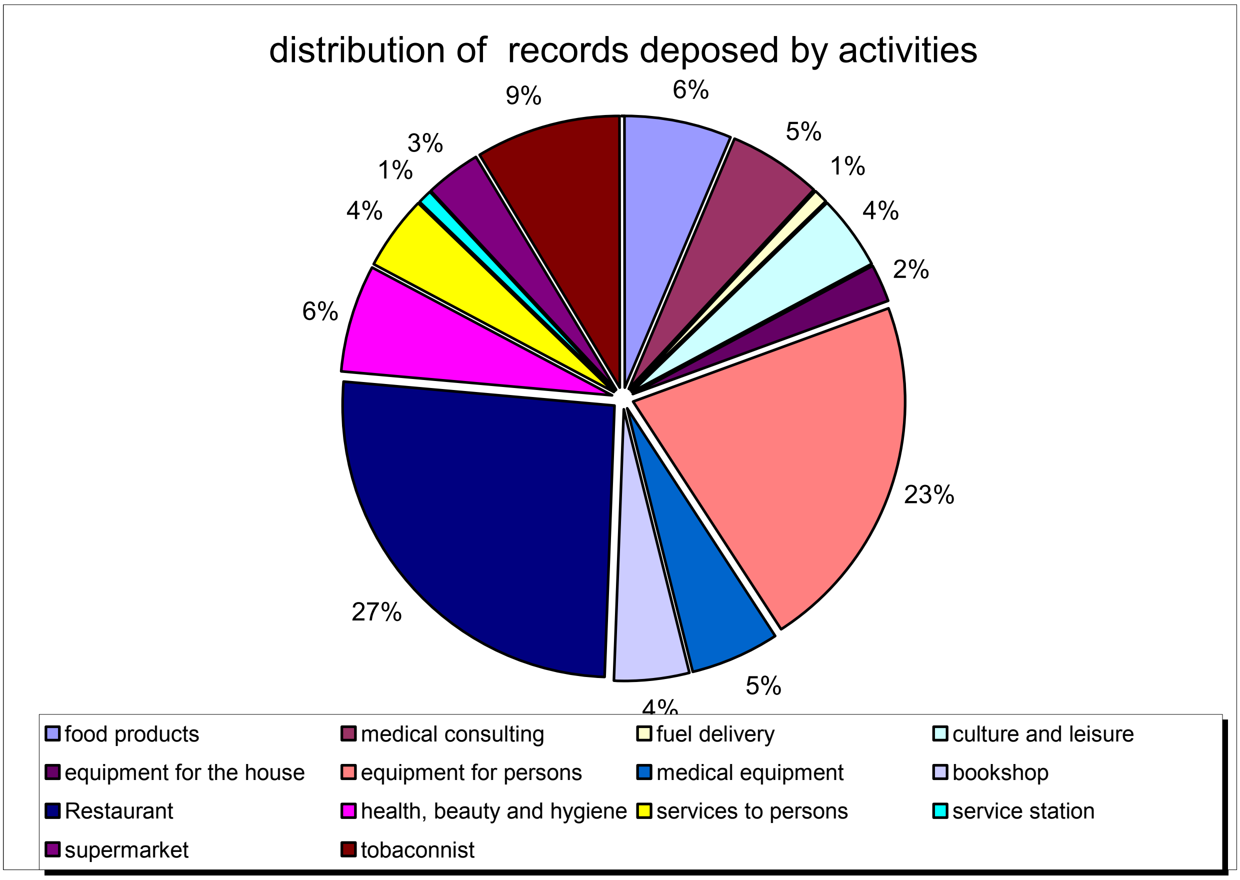
Service station

Fuel delivery

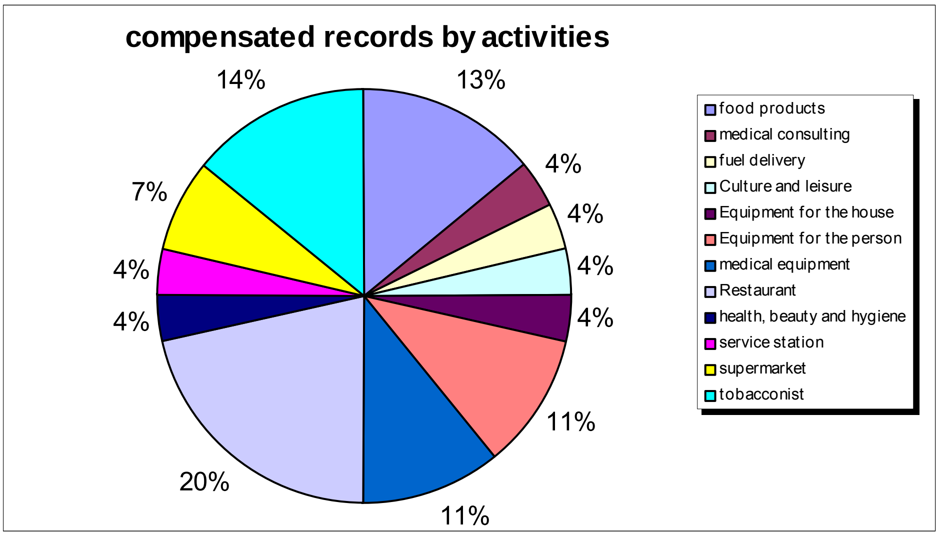
Tradespeople distribution:

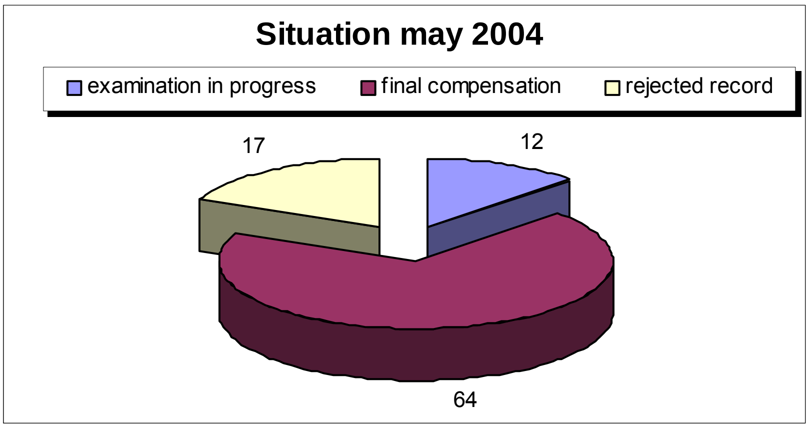


Cases of compensation claims (records):



compensations





We had access to compensation data but they are considered as confidential so we only present here ranges corresponding of the distribution of the corresponding compensations cases.

We thanks the Urban Community of Strabourg for having allowing this study and given the available data.

Annex 4: Economic assessment of water resources quality

The aim of this annex is to provide a synthesis of economic literature, concerning evaluation of water resources quality (in economic terms), in order to display economic values found. It is not a manual of economics, of course. The methods applied in the references quoted here are "traditional" approaches for environment economics, but in the same time they are rarely applied to water quality (literature revealed to be quite scarce on such a key topic). These methods may be quite cumbersome to use, and some are still under methodological refinements and checks.

The methods considered in the references quoted are:

- CV, contingent valuation, consists in having people state their preferences in equivalent economic values (WTP willingness to pay, WTA willingness to accept), by creating for the interview a "virtual" or "fictitious" market where money transfer could have an influence on water quality,
- TC, travel costs, is applied for assessing the value of recreative uses of water resources and aquatic biotopes; the total expense of a travel for recreative purposes (including time) must be at least equivalent to the utility of this recreative activity linked to water; hence, the travel expenses is considered to be a lower limit of the economic value of the water linked recrative activity;
- CBA: cost benefit analysis is meant for assessing a project or a decision, by quantifying in economic terms and comparing advantages and drawbacks of a project.

Some references quoted in the literature found have unavilable information on the valuation method (NA = not available).

For methodological support in complement to an environmental economics manual, we would point on Arrow et al (1993), Bergstrom et al (2001a), Bowers and Young (2000), Boyle et al (2001), Farber and Griner (2000), Horowitz and McConnell (2002), Johnston et al (1995), Jorgensen and Syme (2000), Loomis et al (2000).

	Estimated values	Valuation method[47]	Localisation	Survey type	Sources	Sample	Valuation
Ground water	***Preservation***	CV	**Europe**				
			France				
			Bièvre-Liers plain (Isère)	Face-to-face + mail survey	(Grappey 1999)	108 face-to-face, 173 by mail	FF 252 (face-to-face) (1997), FF 402 (mail) (1998) [42 and 67 euros 2004]
			10 sites in Alsace	Face-to-face	(Stenger and Willinger 1998)	817 (including 217 living in contamined sites)	FF 617 per household per year (1993) [110 euros 2004]
			12 sites in Alsace	Face-to-face – open-ended valuation + referendum method	(Rozan, Stenger et al. 1997)	817 users + 159 non users	FF 617 per user household per year, FF 340 for a non user (1993) [110 and 61 euros 2004]
			Sweden	NA	(Silvander 1991) cited by (Stenger and Willinger 1998)	NA	FF 239-468 per year (FF 1995) [41 and 81euros 2004]
			UK – Anglia Region	NA	(Hanley 1989) cited by (Stenger and Willinger 1998)	NA	FF 138 per year (FF 1995) [24 euros 2004]
			USA				
			12 towns (Massachusetts, Pennsylvania + New York States)	Mail survey	(van den Bergh, Ferrer-i-Carbonell et al. 2000)	617	Between $31.96 to $108.49 ($/household/year) (1989)
			12 towns across 3 northern states (New York, Massachussetts, Pennesylvania)	Mail survey – payment card	Powell (1991) cited by (Poe, Boyle et al. 2001)	1006	$83 ($ 1997)

[47] To better know valuation methods for non market goods, see Garrabé, M. (1994). Ingénierie de l'évaluation économique. Paris.
, Scherrer, S. (2002?). Méthodologie de valorisation des biens environnementaux. Paris, Ministère de l'Environnement et du Développement Durable,**:** 33 pages.
, Tietenberg, T. (1992). Environmental and natural resource economics. New York, Harper Collins.
.

			Aroostook County, Maine	Mail survey – 9 WTP values	Boyle (-) cited by (Poe, Boyle et al. 2001)		$46 ($ 1997)
			Dougherty County, Georgia	Mail survey – 9 WTP values	Bergstrom (-) cited by (Poe, Boyle et al. 2001)		$199 ($ 1997)
			Maine + Georgia	Mail survey – payment card	(Bergstrom, Boyle et al. 2001)	417 + 486	Between $34 to $312 (1996-1997)
			Michigan	Mail survey	Caudill (1992) cited by (Poe, Boyle et al. 2001)	1213	$768 ($ 1997)
		CV + experimental economic setting	Students from University of Rhode Island		(Spencer, Swallow et al. 1998)	140	Hypothetical-money survey: $42.49 Real-Money survey: $9.15
	Recon-quer	CV	**USA**				
			Cape Code, Massachussets	Mail survey	(Edwards 1988) cited by (Poe, Boyle et al. 2001)	585	$1,316 ($ 1997)
			Georgia	Mail survey	(Sun, Bergstrom et al. 1992) cited by (Poe, Boyle et al. 2001)	603	$1,126 ($ 1997)
				Mail survey – payment card	(Jordan and Elnagheeb 1993)cited by (Poe, Boyle et al. 2001)	180	$126 ($ 1997)
			Wisconsin	Mail survey	Poe stage I and II (…) cited by (Poe, Boyle et al. 2001)	244	$324-380 ($ 1997)
			4 regions	Telephone survey	(Crutchfield, Cooper et al. 1997) cited by (Poe, Boyle et al. 2001)		$691 ($ 1997)
			Dover, New Hampshire	Mail survey – no impact on household welfare specified	Schultz. (1989) cited by (Poe, Boyle et al. 2001)	346	$114 ($ 1997)
			Lancaster + Lebannon countries (south-western Pennsylvania)	Mail survey	Delavan (1997) cited by (Poe, Boyle et al. 2001)		$59 ($ 1997)
		CV+ experimental	Students from University of Rhode Island		(Spencer, Swallow et al. 1998)	140	Hypothetical-money survey: $63.23

		setting					Real-Money survey: $13.55
		CBA	France Syndicat d'Ic (Britain)	Valuation for 8300 inhabitants	(Le Roux 1999)		FF 1200 per household between 1985 and 1998 [200 euros 2004]
			Quebec – 4 communities	Telephone survey	(Traoré, Amara et al. 1999)	2,333	From $CAN 181 to 267 per household annual average averting cost
Surface water	***Recreative - steady state***	CV	**Europe**				
			Brest Rade France	NA	Le Goffe (1994) cited by (Gorin)	NA	FF 215 per household (1994?) [38 euros 2004]
				NA	(Bonnieux, Le Goffe et al. 1995)	607	218 FF (1993) [39 euros 2004]
			NA	NA	Mitchell and Carson (1980) cited by (Gorin)	NA	Per household per year: FF 1900-2200 for a no sanitary risk bath, FF 1600-1900 for fish maintenance, FF 1200-1500 for allowing navigation
				NA	Sanders and al. (1991) cited by (Gorin)		FF 135 per person and per visit
		TC	**Europe**				
			Brest Rade France	Phone survey	(Gorin)	183	FF 182.9 per year per person (1995) [32 euros 2004]
			NA		Sanders and al. (1991) cited by (Gorin)		FF 125 per person + per visit
		NA	NA	NA	Walsh and al. (1985) and (1992) cited by (Gorin)	NA	Average surplus per visit: FF 120-170 (1985), 160-250 (1992) [27-38-29-45euros 2004]
	Recreative – improvement	CV	NA	NA	Mitchell and Carson (1984) cited by (Gorin)		Per household per year: FF 660 (to be able to bath), FF 500 (to allow to fish to live), FF 560 (to be able to navigate)

			Greece	Face-to-face	(Kontogianni et al 2003)	466	45.69 euros / year
			USA	NA	(Green, Tunstall et al. 1988)	1,200 users + 300 neighbours + 300 ‘far’ neighbours	0.38 $/visit for bathing

	Ecosystem preservation	CV	**Europe**				
			Brest Rade France	NA	(Bonnieux, Le Goffe et al. 1995)	607	173 FF (1993) [31 euros 2004]
	Ecosystem improvement		USA	NA	(Green, Tunstall et al. 1988)	1,200 users + 300 neighbours + 300 'far' neighbours	0.42 $/visit for water birds, 0.48 $/visit for ecosystem
Water in general	***Increasing drinking water availability***	CV	*USA* - Adelaide	Mail consulting?	(Speers, Burn et al. 2002)	768	$2.20 - $2.35 per annum (2001)
	Improved water quality	CV	USA				
			South Platte River	In-person interviews – visual aids – question fermée	(Loomis, Kent et al. 2000)	96	$ 21 per month + per household (1998)
			National	Mail survey – payment card	McClelland and al. (1992) cited by (Poe, Boyle et al. 2001)	1983	$117 ($ 1997)
	Reduce combined sotrm overflows to reduce health effects, fish kills, sewage litter	Choice modelling and CV	Area around the lower Thames, UK	Face to face	(Ozdemiroglu et al, 2000)	2000	63 to 77 £ per year

Impact factors on "willingness to pay"

Through the different results and references, hereafter are the factors which revealed, in one or several cases, to have an impact on the stated preferences.

General

- *Type of good or service which is evaluated*: salubrity versus ecosystem preservation (Bonnieux, Le Goffe et al. 1995), drinking water protection aquifer protection (Poe, Boyle et al. 2001), etc.;
- *Type of survey*: face to face or mail (Grappey 1999), referendum or open-ended method (when using contingent valuation) (Rozan, Stenger et al. 1997), type of valuation method (contingent valuation, travel costs, etc.);
- Type of econometric modelling (Poe, Boyle et al. 2001).

Specific

- *People concerned by water degradation* (+): previous experience on groundwater contamination (van den Bergh, Ferrer-i-Carbonell et al. 2000), households living in polluted areas (Stenger and Willinger 1998; Traoré, Amara et al. 1999), frequency (consumption of tap water) (Rozan, Stenger et al. 1997; Stenger and Willinger 1998)
- *People who have observed quality problems* (+): coloured water observation (Bonnieux, Le Goffe et al. 1995),
- *Water quality perception* (bad*:* +): (Grappey 1999; van den Bergh, Ferrer-i-Carbonell et al. 2000)
- *Type of water risks and consequences* (forecasted or perceived) of a water degradation (+): (Rozan, Stenger et al. 1997; Stenger and Willinger 1998), cancer (Bonnieux, Le Goffe et al. 1995), households facing water-related nuisances (odour, staining problems, and bad taste) are less inclined to take averting actions, and on average, they spend less to solve these problems than those suffering from water pollution by bacteria and minerals (Traoré, Amara et al. 1999)
- *Impacts of measures proposed to protect / to ameliorate water quality perceived being significant* (+): (Stenger and Willinger 1998; Loomis, Kent et al. 2000; van den Bergh, Ferrer-i-Carbonell et al. 2000; Bergstrom, Boyle et al. 2001; Poe, Boyle et al. 2001)
- *Environmentalists or ecologists (+):* (Bonnieux, Le Goffe et al. 1995; Traoré, Amara et al. 1999; Loomis, Kent et al. 2000; van den Bergh, Ferrer-i-Carbonell et al. 2000)
- *Household income (+):* (Bonnieux, Le Goffe et al. 1995; Rozan, Stenger et al. 1997; Stenger and Willinger 1998; van den Bergh, Ferrer-i-Carbonell et al. 2000)

- *Education (+):* (Bonnieux, Le Goffe et al. 1995; van den Bergh, Ferrer-i-Carbonell et al. 2000)
- *Type of work / profession* (+): (Bonnieux, Le Goffe et al. 1995; Rozan, Stenger et al. 1997; Grappey 1999)
- *Bid amount (-)* (when contingent valuation with referendum method)*:* (Rozan, Stenger et al. 1997; Stenger and Willinger 1998; Loomis, Kent et al. 2000)
- *Average water bill (-):* (Grappey 1999; Loomis, Kent et al. 2000)
- *Urban (+):* (Loomis, Kent et al. 2000)

WARNING ON "ENVIRONMENTAL BENEFIT TRANSFER" TENDENCY

From (André 2002)

As in other scientific fields, the question often arises about the possibility to "transfer" results obtained on one case to another case. Value transfer can be justified for three main raisons:

1. A high cost of studies conducted to evaluate non market goods;
2. No time to conduct valuation studies before policy decision taking;
3. To have an estimated value, even rough, is preferable than to have nothing.

But there are several conditions necessary to realise a value transfer:

1. Primary studies must be robust and must present detailed technical informations in order to make value transfer in good conditions;
2. Primary and secondary studies must be similar in terms of environmental good to evaluate, of impacted population, and of possibilities of alternatives;
3. Quality variations of environmental good between study site and application site must be near in relative and absolute dimension;
4. WTP must be expressed in terms of socio-economic characteristics (income, education, …) in order to be recalibrated for the new population;
5. Price and income sensitivities must be similar;
6. A Estimated values must be regularly reevaluated.

Even when these necessary conditions are realized, it seems that value transfer do not have good results which are acceptable as a real tool to help decision making (Rozan and Stenger 2000).

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