

## **Socio-economic aspects on applying measures to reduce infiltration and exfiltration**

Aspects socio-économiques de la gestion des infiltrations/exfiltrations dans les réseaux d'assainissement

Philipp Stauffer, Hermann Stepkes, Marko Siekmann,  
Johannes Pinnekamp

Institute of Environmental Engineering, RWTH Aachen University,  
Mies-van-der-Rohe-Str. 1, 52074 Aachen, [isa@isa.rwth-aachen.de](mailto:isa@isa.rwth-aachen.de)

### **RESUME**

Les infiltrations et les exfiltrations mettent en péril la qualité des eaux de surface et souterraines. A ce titre, les réseaux d'égout de la région de la Rhénanie-Westphalie (RFA) doivent être inspectés d'ici à la fin 2015. Dans les zones de protection de l'eau, ces inspections ont été effectuées pour la fin 2005 pour tous les bâtiments construits avant 1965. Sachant qu'il y a un grand nombre de conduites à inspecter, des études ont été entreprises sur l'organisation de l'inspection et, suivant les cas, sur leur restauration. De plus, des mesures incitatives et des programmes d'aide financière ont dû être testés pour améliorer l'acceptabilité par l'opinion publique. Ensuite, il est essentiel de déterminer la période de temps pendant laquelle les travaux d'inspection et de restauration doivent être effectués. Cet article présente les résultats de deux études - l'une concerne les zones rurales et l'autre une zone urbaine – ainsi que des mesures incitatives, des coûts et des recommandations.

### **ABSTRACT**

Infiltration and exfiltration endanger water quality of groundwater and surface water. Therefore in the German state of North Rhine-Westphalia private drains have to be inspected by the end of 2015. In water protection areas this had to be carried through by the end of 2005, if the building is built before 1965. Since the number of drains that need inspection is very large, studies were undertaken how to organize the inspection and where necessary restoration. Also, meditative measures and programs for financial aids had to be tested in order to increase acceptance within public opinion. Latter is very important if inspection and rehabilitation needs to be fulfilled within an certain time. This paper presents results from two studies. One is located in rural areas and the second is part of a city. Besides meditative measures, costs and recommendations are presented.

### **KEYWORDS**

Exfiltration; financial support; infiltration; private owner; private service connection pipe; public acceptance.

## 1 INTRODUCTION

Both infiltration and exfiltration cause significant danger to the environment. Exfiltration of sewage, and, especially in areas where drinking water is gathered (DESILVA et al., 2005, CARDOSO et al., 2006, BERTRAND-KRAJEWSKI et al., 2006). Also, infiltration is connected to a variety of negative impacts on the environment such as rising loads from combined sewer overflows (cso) or waste water treatment plants (wwtp).

### Exfiltration

Bound to the EUs framework directive, in Germany both issues are regulated competitively by federal and state law. Germany's federal law, for example, giving the framework for regional regulation assumes the necessity of action, if a contamination of groundwater or any other source is possible. This, combined with large amounts of infiltrated water in the sewer systems in some regions is reason in North Rhine-Westphalia to pursue the goal of tight sewers and drains. In order to achieve this, regulations demand proof of tightness for private drains following DIN-EN 1610 and self-control programs for public networks. The continuous monitoring of the condition of private drains has to be repeated in intervals of 20 years. However, there are existing different deadlines for first inspection depending on age and catchment area. If buildings were established before 1965 and were located within a water protection area, the proof of tightness had to be fulfilled until the end of 2005. By the end of 2015 all private drains have to be inspected. This will lead to a large amount of cases, therefore tools to increase public acceptance are necessary.

### Infiltration in rural areas

In connection with large problems due to infiltration, a systematic approach was developed taking the whole system as a single unit into account. It was fit to rural areas in low mountain regions with settlements on small overlying strata with impermeable rock beneath it. Since large areas of higher lying grounds cause peaks of groundwater flow after storm water events a strategy

- rehabilitating public networks and private drains as well as
- by-passing groundwater flows around settlements

was applied. The unifying approach needed the support of the private owners for a successful reduction of infiltration. Therefore means to increase acceptance were needed.

## 2 OBJECTIVE

In both cases it was essential for a successful rehabilitation to include private owners into the decision making progress as well as to give incentives to increase participation rates. The resulted costs differ strongly embracing the whole spectrum of damages, catchments sizes and problems. However, costs are the major concern of abutters and need to be clarified in an early stage of the project. Especially if state authorities decided to establish a fund to support, the owner of drainage systems, policy maker request reliable estimates of cost in advance. The costs however depend strongly on the participation of the private owner. To avoid ordered actions by administrative law and to achieve an unsolicited assistance, appropriate actions have to take place, e.g. an information bureau or public hearings. The paper presents the conducted technical measures and attending activities in respect to the estimated and realized costs. The expenses for attending private owners are displayed by local

authorities. Also, potentials are shown that were realized from additional cost benefits when combining several submissions to a single. An evaluation of the different methods as well as rules of application will be driven from this. Also, the established public systems giving aid to private owners and its acceptance will be discussed.

### 3 METHODS

Two catchments are presented, one from the large city of Cologne and one lying in a rural region nearby the city of Monschau. The first area covers a total area of about 80 ha within a water protection area (see fig. 1). It consists of 530 built-up realties. About 70 % were built before 1965 which lead with knowledge of previous studies to an estimation of 75 % of damaged drains in that area. The housing consists predominantly of single and double occupancy housing. The average length of a drain connected to the public combined sewer is 26 m. The focus was to inspect and if necessary to renovate private drains of all 530 lines within 2 years. Supported by a large municipality that seemed possible.



Figure 1: Overview of the project area Cologne-Höhenhaus

The latter catchment is part of a town with about 2,000 inhabitants and located at an inclination of a low mountain. Previous studies from DOHMANN et al. (2002) determined that large parts of the infiltration water originate from non-canalized pervious areas on higher ground above the settlement. It was estimated that about 500 ha, that is three times the canalized surface, contribute to infiltration, compare Figure 2. Since the overlying strata is only a few meters deep, precipitation falling on higher grounds do not form deep groundwater. Instead it is flowing downhill and contributes to high

infiltration rates. Measurements document monthly infiltration surcharges of up to 900 %.

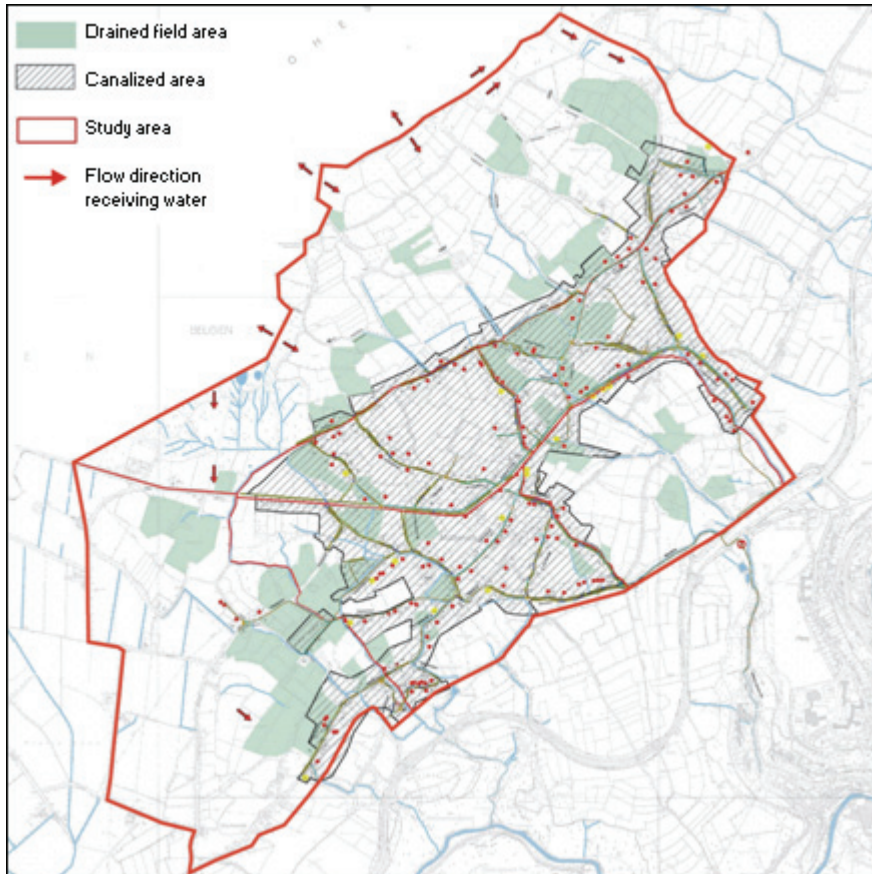


Figure 2: Map of developed "rehabilitation measures to reduce infiltration"  
(Dohmann et al., 2002)

The investigated catchment area being part of the case study amounts up to 5.2 ha with 27 % impervious area. Thirty-two households are located evenly spread along two roads dividing the area into two parts. The sanitary sewer of its separate system is loaded with 300 % infiltration water on average over a year. In order to reduce infiltration rates following measures were applied:

- Renovation of public sewers,
- establishing and reactivating of trenches,
- Disconnection of cross-connections and
- Rehabilitation of private drains.

In both cases activities and information campaigns were undertaken to ease opposition of private ownership. Since high costs usually arise by restoring drainages, it was assumed that owners will oppose plans and will take actions to postpone the inspection. Therefore the following meditative measures were applied:

- Thorough information of owners,
- Financial aid,
- Local contact persons,
- Technical assistance by local authorities and
- Support at the commissioning of the executing companies.

In the case of the large catchment there were also further services by the local authorities to support the decision making for the restoration counseling in the offering procedure.

The chosen information policy included several meetings with affected citizen and brochures and leaflets explaining the events coming up. Besides technical issues, further education of the involved parties was necessary to explain current regulations and the need to comply with them. However, in the beginning anticipated costs have been a mayor concern of the owners. Therefore systems giving financial aid were of great interest. The following table gives an overview of specific funding for each household which applied for a financial support. In order to be able to monitor the condition of the private drains and to be able to check progress, the owner were asked to participate in a monitoring program. Actually the participation at the specific monitoring program wasn't the premise to be eligible to apply to public funding. The participation also granted several rights for the local authority to enter the private drain. However, by participating in the monitoring program the inspection and if applicable the proof of tightness were assigned by the assisting local authority.

	Monschau	Cologne
TV – Inspection	80 % of total costs	150 EUR
Proof of tightness	80 % of total costs	
planning of restoring private drains, consulting, mediation	n.s.	300 EUR
Restoring/ rehabilitation	none	30 % (max. 2,000 EUR)
disconnection of cross-connections	80 % of total costs	-

Table 1: Financial support

On basis of the results from 15 % of the total number of TV-inspections in the case-study of Cologne, specifications and a framework contract with 12 reliable companies were negotiated in order to simplify planning and restoration efforts.

In rural areas it is more common that owners substitute their drains as personal contribution. Therefore cost estimations are less reliable. Also in this specific case beginning of winter resulted in a delay.

#### 4 RESULTS

Due to the thorough information policy the majority of owners were taking part in the monitoring program, see Table 2. The acceptance of the applied measures even increased when abutters were confronted with videos or images from their damaged drains.

The results from inspecting the drains were in both cases devastating. In Cologne in almost 98 % of private drains leaks were found by visual inspection. In Monschau visual inspection and proof of tightness conducted that 64 % of private drains are leaky or need rehabilitation.

	Monschau	Cologne
condition of private drains [% leaky]	64	98
rate of return [%]	88	95
participation rate [%]	88	87

Table 2: Results of the visual inspection and proof of tightness

The results show the considerable rehabilitation needs in the area of the private service connection pipes.

#### 5 COSTS

The costs are significant that have to be paid by owners of drains. Consulting, meditative measures, inspection as well as its analysis generated expenditures of about 480 EUR. However, it has to be considered that in many cases the calculated price of 265 EUR for inspection and proof of tightness was not sufficient. In rural regions, where usually further distances need to be covered, costs for inspection lie above these figures. In Monschau respectively 400 EUR were necessary to spent for a single TV-inspection and additionally 450 EUR for a proof of tightness.

The margin of fluctuation of costs for the rehabilitation of private drains is wide. On average 3,000 EUR had to be invested to restore a broken drain, special boundary conditions can cause costs of over 9,000 EUR. On the other hand the determined costs were less than 1,000 EUR in 10 per cent of the cases. Figure 3 shows the frequency distribution of costs of restoration of a private drain. This analysis bases on 315 completed restorations in the city of Cologne.

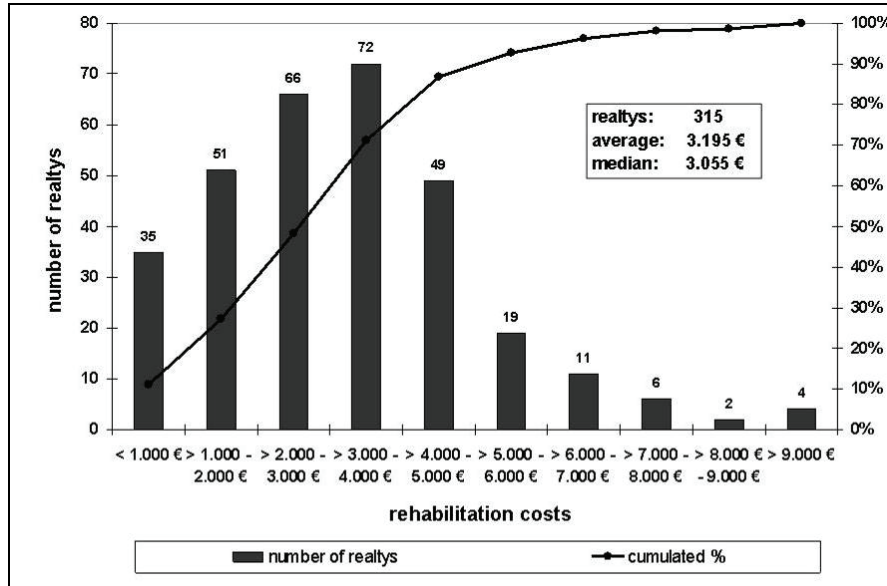


Figure 3: Rehabilitation costs as a result of the study in the city of Cologne

## 6 DISCUSSION AND RECOMMENDATIONS

Meditative measures are suitable to tighten activities for a coordinated rehabilitation of private drains and service connection pipes. Most important is a transparent information policy. The explanation why restoring these pipes is necessary is just as important as a comprehensive procedure to evaluate the most promising strategy and to find the most cost effective way to restore a damaged drain (e.g. by inlining, part-lining etc.). Also financial aid simplifies the ease of handling especially to support inspection and analyzing its data.

However, from dealing with more than 500 households quickly any meditative capacities in a city were exceeded. Therefore it is recommended to limit the number of participating private owners to a maximum, if the rehabilitation needs to be finished within the set time and number of involved employees is limited. The field study in the city of Cologne showed that up to 3 persons of the local authority got engaged with the support of the private owners. As one final result the study showed that up to 200 participants can be advised without endangering the success of the measures and without exceeding the capacity of the involved employees.

A transparent quality management model is an important part of a successful accomplishment of a coordinated rehabilitation strategy. It documents kind and extent of necessary measures; it controls as well as it checks the activities of the involved parties, especially of the executing companies and it allows combining inspection of drains with the analysis of its data and the recommendation of appropriate measures for restoration.

## 7 CONCLUSIONS

To make a successful reorganization of a sewerage system and the private service connection lines possible for reducing exfiltration and infiltration, it is required to involve the private home owners in the measurements. Therefore it is necessary to make arrangements and additional measures to increase the acceptance.

As a main result of the presented field studies it is important

- to provide for a transparent quality management model,
- to limit the participating private owners into dependence of the involved employees,
- to provide for a transparent information system and
- to provide for separate meditative measures,

to obtain a solution satisfying for all involved institutions.

## 8 ACKNOWLEDGMENTS

We like to acknowledge the support of the two case studies by the Ministry of Environment and conservation, agriculture and consumers protection (MUNLV) of North Rhine-Westphalia. Also, we like to thank the support of the local authorities of the city of Cologne and the city of Monschau.

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