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# The role of open data in regulating Combined Sewer Overflows

A. Schellart<sup>1\*</sup>, L. Sharp<sup>2</sup>, J.L. Bertrand-Krajewski<sup>3</sup>, J. Rieckermann<sup>4</sup>

<sup>1</sup>Department of Civil and Structural Engineering, University of Sheffield, Mappin Street, Sheffield, S1 3JD, United Kingdom

<sup>2</sup>Department of Urban Studies and Planning, University of Sheffield, Winter Street, Sheffield, S3 7ND, United Kingdom

<sup>3</sup> Université de Lyon, INSA Lyon, Laboratory DEEP EA 7429, F-69621 Villeurbanne cedex, France

<sup>4</sup> Department of Urban Water Management, Eawag, 8600 Dübendorf, Switzerland

\*Corresponding author email: [a.schellart@sheffield.ac.uk](mailto:a.schellart@sheffield.ac.uk)

## Highlights

- Comparison of CSO regulation and compliance assessment in several European countries
- Increasing complexity of CSO regulations and its downsides
- Emerging experience with open CSO data and its potential for transparency in regulation

## Introduction

How a society deals with their wastewater system, its operation and regulation is a continuously evolving field. There is a paradigm shift in several countries to move away from regulation of 'end-of-pipe' emissions from Waste Water Treatment Works (WWTWs) only, to looking at the performance of the entire urban drainage systems, with increasing concern about emissions from combined sewer overflows and their impacts. This abstract focuses on European countries, where there is increasing scrutiny of combined sewer overflows (CSOs) through the revision of the Urban Wastewater Treatment Directive (UWWTD), as well as the general public. Combined Sewer Overflows (CSOs) provide an interesting challenge for contemporary engineering. In the middle of the 19th century, CSO structures were included in a combined sewer system for economical purposes, to keep the dimensions and the cost of the pipe network reasonable, while avoiding urban flooding. With the development of WWTWs from the beginning of the 20th century, CSOs were used and designed to avoid overloading WWTWs. Currently, many CSOs operate regularly in most European countries, often in an order of magnitude of several 10s of spills per CSO structure per year (e.g. Botturi et al., 2021). While 'occasionally spilling diluted wastewater into the receiving water' may have once been a reasonable practice in the case of 'gross' pollutants (BOD/COD/un-ionised ammonia), there is increasing concern about the amount of CSO spills, as well as micropollutants and pathogens in CSO spills (e.g. Mutzner et al., 2022).

There is limited consensus among technical experts about what would characterise an 'appropriate' level of CSO use. There are a plethora of different standards of drainage design and of regulation across Europe. Blumensaat et al. (2012) distinguish between two main types of regulation, based on emissions (e.g. limiting frequency or volume or pollutant loads of CSO spills themselves), or on receiving water impact (e.g. duration and frequency of exceedance of certain pollutant concentrations in the receiving water). However, both types of regulation have considerable limitations. The emissions from CSO spills alone do not inform on receiving water impact. Receiving water impact-based standards, for example the UK's Fundamental Intermittent Standards (FIS), which are concentration, duration and frequency standards of dissolved oxygen and un-ionised ammonia (FWR, 2018), are held up as a more scientifically sound reflection of acute toxicity to aquatic life. However, checking against such standards is costly and complex, due to the need for extensive data collection and sewer system and river impact modelling. For example, during the 2025-2030 planning period, only two catchments in Yorkshire (England) have been required to have FIS investigation, estimated to cost £572,000 and £1,188,000 respectively, for a river length of 19.4 km and 9.4 km (Yorkshire Water, 2023). Hence, a more pragmatic way of measuring the impact of CSOs is needed to inform realistic future regulatory standards. In addition to this technical debate, CSOs also enter into the realm of public scrutiny. The growing popularity of outdoor water sports, citizen scientists, cheaper sensors and the ease of sharing data means that CSO spills are starting to be brought into the public awareness, and publics are

increasingly demanding action to achieve cleaner rivers. Where CSO data is released more openly, citizens can hold water operators accountable for the management of their assets. To address the issues of appropriate CSO standards and the role of public scrutiny, we ask the question: ‘what type of CSO data would be most useful to collect and release to the public?’ The paper will start to address this question through reviewing the development of CSO-related regulations in Europe, alongside the experiences of monitoring CSOs and different levels of openness in CSO related data.

## Methodology

The novelty from this work comes from reviewing and comparing CSO-related regulations, specifically focusing on: historic development of the regulations, shifts in the aims of these regulations, practicalities around implementation and testing of compliance, as well as the openness and availability of data. The initial step involved a group of researchers (see also acknowledgement) comparing practice by answering the questions in Table 1 for their respective localities. While the result is far from exhaustive, it serves as a starting point for discussion on the management of CSO spills and the role open data could play in this.

## Results and discussion

Several countries show a move to more complex regulation of CSOs. This, however, considerably increases the potential for lack of transparency and different interpretations. Working out the level of harm in receiving water involves simulating and monitoring considerably more processes. A summarised selection of comparisons is shown in Table 1. CSO monitoring is not widely done, but the number of CSO structures being monitored looks to be increasing. Compliance assessment with the regulation is mostly made based on model simulations. In some countries there is no definition of what constitutes an ‘illegal’ CSO spill, and there tends to be limited follow up of illegal or ‘unintentional’ spills. Where there is open CSO data, for example in Brussels, the Belgium citizens group ‘Canal It Up’ started making use of the open data. In order to ensure a correct use and interpretation of the Flowbru data a positive collaboration between Canal It Up and HYDRIA (the sewer operator managing the Flowbru data) has been created. An open interaction and communication has led to the CSO data already made publicly available by Flowbru being enhanced, enabling an easier understanding of the data and the negative impacts of CSO spills, but also correct from the perspective of HYDRIA. Referring to open CSO data in Massachusetts USA, Sanders (2019) describes how achieving policy agreement between policy makers, voluntary organisations and the public begins with a shared understanding of the facts. The latter, in turn, depends on the existence of robust data, but also everyone having access to that data. Sanders’ analysis of this open CSO data showed that areas with more people who are poor, non-white and/or linguistically challenged, face higher CSO discharges. There is furthermore the cost aspect of improving urban drainage systems. Gill et al. (2021) described considerable cost implications of a policy focused on achieving spill reductions, and also concluded that SuDS are more expensive and have higher carbon emissions than storage tanks, but that the cost of SuDS may be reduced with collaboration from the public. One result of the open CSO data in England is that the cost of improving urban drainage systems is now openly debated in the media.

## Conclusions and future work

In some areas, open CSO data has already helped to highlight challenges in managing urban drainage systems and open up discussions around costs of improvements, leading to somewhat more transparent governance. However, the data needs to be of good quality, and made open in a way that is easily accessible and understandable. This is especially challenging given the inherent variability and complexity of the processes involved (e.g. variability of rainfall patterns across different space and time scales). Closer and further collaboration between urban drainage engineers, social scientists, governance specialists, communication specialists and citizen science groups is urgently needed. This may help people’s understanding of why & how investments are made, as well as encouraging better management of their own contributions to urban runoff and wastewater. Future work will answer the ‘Table 1’ questions in more detail, and collate detailed references found in individual countries’ different ‘grey’ literature sources. This can be used to aid the discussion on what level and type of CSO data may be most appropriate to make public.

**Table 1. Comparison of CSO monitoring, regulation and compliance assessment in several European countries**

Questions	England/ Wales	France	Switzerland	Belgium	Denmark	Spain	Netherlands	Germany	Austria
Number of CSO structures.	14,470	Unknown?	est. 5,000 (no official statistics)	<b>Flanders:</b> est. 8,000 <b>Brussels:</b> est. 100	4,257 (declared in 2021)	About 8,000 (some areas missing)	est. >15,000	25,909 simple 20,341 with storage tanks	Estimated 10,300
How are existing CSO structures regulated?	<b>Pass-forward flow.</b> Occasionally <b>receiving water impact.</b> <b>Moving to Emission based</b>	<b>Emission based.</b> (Municipality decides): spill frequency, <b>or</b> spill volume, <b>or</b> spill pollutant load	<b>Receiving water-impact based.</b> Some cantons different (e.g. spill duration in Basel)	<b>Flanders: Emission based</b> (Spill frequency)  <b>Brussels: ?</b>	<b>Emission based.</b> Nr. of CSO events, yearly volume, max discharge (l/s/ha).	<b>Emission based</b> (spill volume) and <b>receiving water impact based</b> in some cases	<b>Emission &amp; sensitivity of the receiving water based</b>	Permits based on simulation results for COD <b>emissions.</b> No additional regulation is applied.	<b>Legally binding emission based regulation planned since 1996,</b> but failed (resistance cities & municipalities)
How many CSOs are monitored, using what attributes?	13,323 CSO structures (2022), start and end time of spill monitored	Unknown at national level. Data could be obtained at municipal level or from Water Agencies	Unknown at national level. Data could be obtained at utilities. Reporting not obligatory	<b>Brussels:</b> est 50% of CSO structures (Frequency & duration, simulation of the volume via level & velocity data).	<b>Most are simulated.</b> 0.6% has monitoring of spill quality, 7% monitoring of hydraulic parameters.	<b>Upcoming:</b> all sewer systems >50000 p.e. will be monitored (spill duration, volume, some cases pollution).	In some areas monitoring is obligatory, the monitoring network is growing.	Not widely done (only for certain CSO tanks); monitoring compulsory in 2 of the 16 federal states	Currently unknown at national level
Is <b>monitored</b> or <b>simulated</b> CSO spill data used in regulation compliance assessment?	<b>Yes, monitored</b> spill duration data	<b>Depends, monitored or simulated</b> (largest CSO structures must be monitored)	<b>Not yet.</b> Permits based on <b>simulated emissions.</b> Some cantons ask for CSO attributes.	<b>Brussels:</b> A reporting of <b>monitored</b> CSO spills happened at yearly basis by 'Brussels Environment'	Each municipality <b>has to report the (mostly simulated)</b> yearly discharges	<b>Upcoming:</b> river basin authorities will be informed on <b>monitored and simulated</b> CSO data	<b>No,</b> just to get an indication of the evolution of spills	<b>No.</b> Permits are based on <b>simulated emissions</b>	<b>No.</b> Only very limited data available. Where available, mostly measured voluntarily and not made public
Does assessing compliance with data happen regularly or only in certain cases?	<b>Spill frequency regularly assessed.</b> <b>Receiving water impact only rarely</b>	Municipalities <b>must report</b> CSO performance and compliance. Evaluated yearly.	<b>No,</b> currently no legal requirements for CSO monitoring and reporting	<b>Brussels:</b> Follow-up on a yearly basis	Compliance checked by the Environmental Agency, but controls are not sufficient	<b>Just in few cases</b> and depending on the river basin authority	<b>No</b>	<b>Not regularly.</b> Only if data are far out of the expected, water authority might interfere.	<b>No,</b> currently no legal requirement for CSO monitoring and reporting existing.
What happens if illegal spills occur? Who is responsible for follow-up & preventing recurrence?	Fines for breaches of EA spill permits. Water utilities negotiate with EA & OFWAT on investment in 'solutions'.	Municipalities are responsible. If illegal spills are detected, the source is investigated (but difficult to find)	Legal action only for spills by private entities. If a municipality contaminates environment: nothing happens	<b>Brussels:</b> In case of illegal spill detection, 'Brussels Environment' tries to track its source, but often very difficult.	Theoretically the responsible entity can receive a fine. In practice this only very seldomly occurs	<b>Fines for illegal spills.</b> CSO compliance has been applied in just few cases till now, as regulation since 08/23	Theoretically the responsible organisation/ person can receive a fine. In practice this only very seldomly occurs	No standard procedure. <b>No regulations on spills. Difficult to categorize a spill during wet-weather as illegal.</b>	<b>Nothing.</b> There are currently no legal requirements for CSO monitoring and CSO reporting existing

Questions	England/ Wales	France	Switzerland	Belgium	Denmark	Spain	Netherlands	Germany	Austria
Is CSO data made public, if so, what data, through what mechanism.	Event frequency and duration by EA, through big .csv files. Visualisations by NGOs	CSO data are not public	Yearly performance report of utility (only know of 1 utility which does it regularly)	<b>Brussels:</b> data collected via FLOWBRU is Open Data	<b>Yes, public homepage.</b> NGO & journalists provide visualizations	<b>No.</b> Only some Aggregated data, not easy to understand	No. Basically all data are open, but they are not easily accessible: <b>only via a formal request</b>	No. Citizens have a legal right to information, <b>only via formal request</b>	No
Is river quality data collected, regularly, if so, what data; is it country-wide and made open to public?	<b>Yes</b> , infrequent water quality grab samples. Data openly accessible through EA	<b>Yes.</b> These data are made publicly available, e.g. on websites of Water Agencies.	<b>Yes</b> (NADUF), but not always “continuously”. Grab samples in selected rivers. Data public and country-wide.	<b>Brussels:</b> Continuous measurements of the main 2 CSO-receiving water bodies.	<b>Yes.</b> River data available online, the number of monitored rivers is small, so several data are outdated	River data at selected gauging stations used for river basin management plans. Data is openly available.	<b>Yes</b> , monitoring, water quality and warnings are issued (e.g. risk to swimmers).	<b>Yes.</b> Monitoring according to requirements of the EU WFD. Not specifically related to CSO events.	<b>Yes</b> , monitoring according to requirements of the EU WFD. Not specifically related to CSO events.
Are citizen groups or NGOs concerned with river quality? How are they utilizing data? Media impacts?	<b>Yes</b> , NGOs and river custodian groups utilising data. <b>Costs of sewer upgrades discussed in media.</b>	<b>Yes</b> , NGOs with concern about river quality. Not frequently concerned with CSOs.	<b>Yes</b> , and also national action groups. Not actively scrutinizing, but occasional media coverage	<b>Brussels: Yes.</b> ‘Canal It Up’ uses the CSO data to raise awareness on the impacts of CSO spills.	CSO data in newspapers every year. <b>Big focus on CSO from farmers association</b>	<b>Not yet.</b> Some action groups debated separate v.-combined sewer and SuDS implementation	<b>Yes</b> , e.g. the NGO ‘Natuur & Milieu’ incidently reports results of monitoring campaigns.	River quality is only in the media related to spectacular events causing large scale fish kill.	<b>Currently no</b> , since no CSO data is currently publicly available

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