Event Duration Monitoring: Towards a level playing field for spill monitoring

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Abstract

Event Duration Monitoring (EDM) is extending significantly during AMP6. Numerous EDM equipment installations already exist in the UK, driven by UWWTD infraction proceedings issued by the EU in recent years, and by EDM reporting requirements that have applied to some companies since 2003.

Configuration of equipment installed to date has been variable, resulting in inconsistent or ineffective EDM. This has given rise to difficulties in comparing sewer / CSO spill performance between locations and across time, making it harder for the industry to substantiate that directives (including the UWWTD) have been complied with.

The existing CIWEM Event Duration Monitoring Good Practice Guide [1] gives advice on EDM technology selection and physical deployment, but not on configuration once installed. Furthermore the Guide does not advise on how to correct for biases in measurement that may result from different configurations.

This paper describes the findings of a recent UK Water Industry Research project aimed at providing a more level playing field for spill monitoring and reporting. The research quantifies the effect that differences in EDM configuration can have on spill counting, and proposes an approach to data post-processing that will provide for consistency across the industry without reconfiguration of equipment.

Guidance is also provided on how to define spill counting from hydraulic model outputs, to align with the proposed approach for use with monitoring data.

Objective

The primary project objective was to provide guidance to companies on EDM data collection and analysis configuration and on use of EDM outputs, so that performance assessments can be made that are comparable across the industry. EDM equipment selection and physical configuration (e.g. location) were not considered.

Discussion and conclusions

From consultation with companies (via surveys and discussions with Steering Group representatives) the issues which gave rise to this project were confirmed to be substantial; in particular, differences in EDM configuration setup (including monitoring frequency) were confirmed to be widespread.

An investigation of the effect of EDM configuration parameters was undertaken by applying the EA 12/24 spill counting approach [2] to a large quantity of EDM data, including:

- approximately 1 year of level data on average from each of 172 storm overflow monitors
- approximately 3.5 years of overflow start/stop times on average from each of 605 storm overflow monitors.

The investigation confirmed EDM configuration parameters can significantly influence the 12/24 spill count at a storm overflow. For example, use of 2-minute polled instantaneous values (i.e. recording every 2 minutes whether a storm overflow is discharging or not) was found on average to give rise to a 12/24 spill count that is 4.6% lower than if 1-minute polled instantaneous values were used. For 5-minute polling and 15-minute polling, the respective figures were 13.7% and 24.6% (shown graphically in Figure 1). The implication is that use of lower polling frequencies (15-minute frequency data being common across the industry) might on average lead to a company's 12/24 spill count being nearly a quarter lower than if higher frequency polling was used.

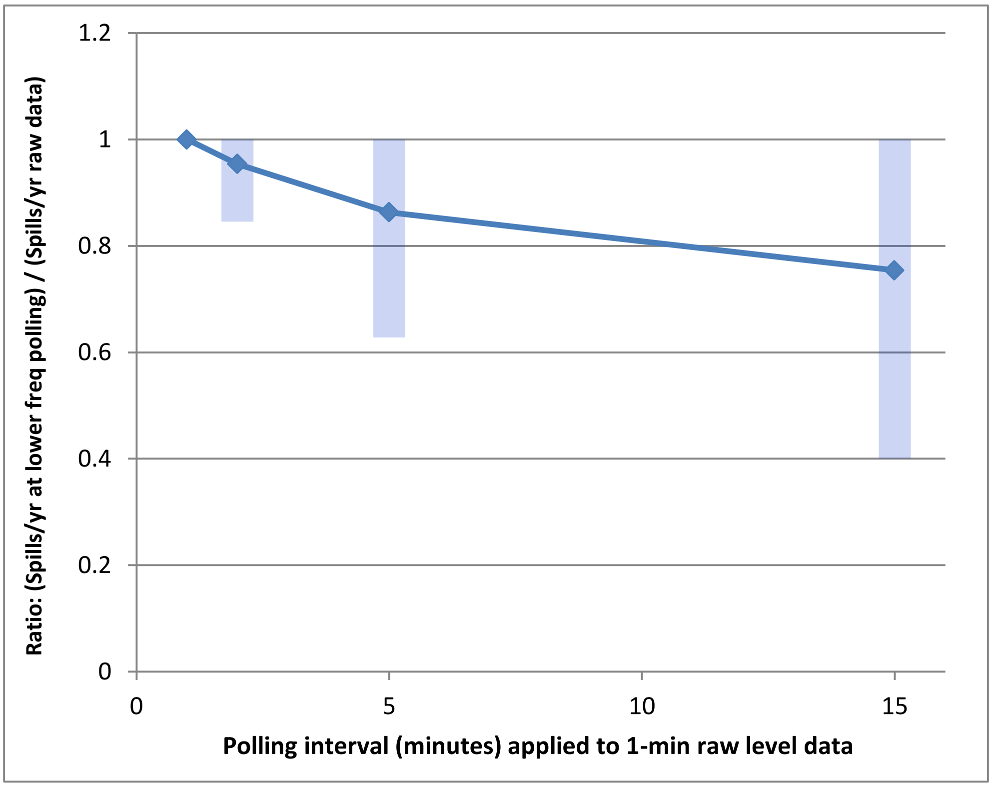

Figure 1: Mean effect of reducing polling frequency, with 80% confidence intervals

There is a wide degree of variation between individual storm overflows in terms of the effects of EDM configuration on 12/24 spill count. For example, although use of 15-minute polled data was found to result in a *mean* reduction of 24.6% in the 12/24 spill count compared to 1-minute data (Figure 1), there might be no effect at all on some storm overflows (namely those where all overflow events last longer than 15 minutes), whereas for other storm overflows the 12/24 spill count would be reduced by much more than 24.6%. This variability could not be explained by differences in catchment or storm overflow attributes.

Use of different averaging periods can also have a large effect on spill counts as shown in Figure 2. Each symbol shows a different CSO and compares the number of spills counted using 1-minute level data (plotted on the x-axis) with those counted if the data are first averaged to 15-minute or 5-minute values (plotted on the y-axis in red and blue respectively). Again there is significant variability between CSOs.

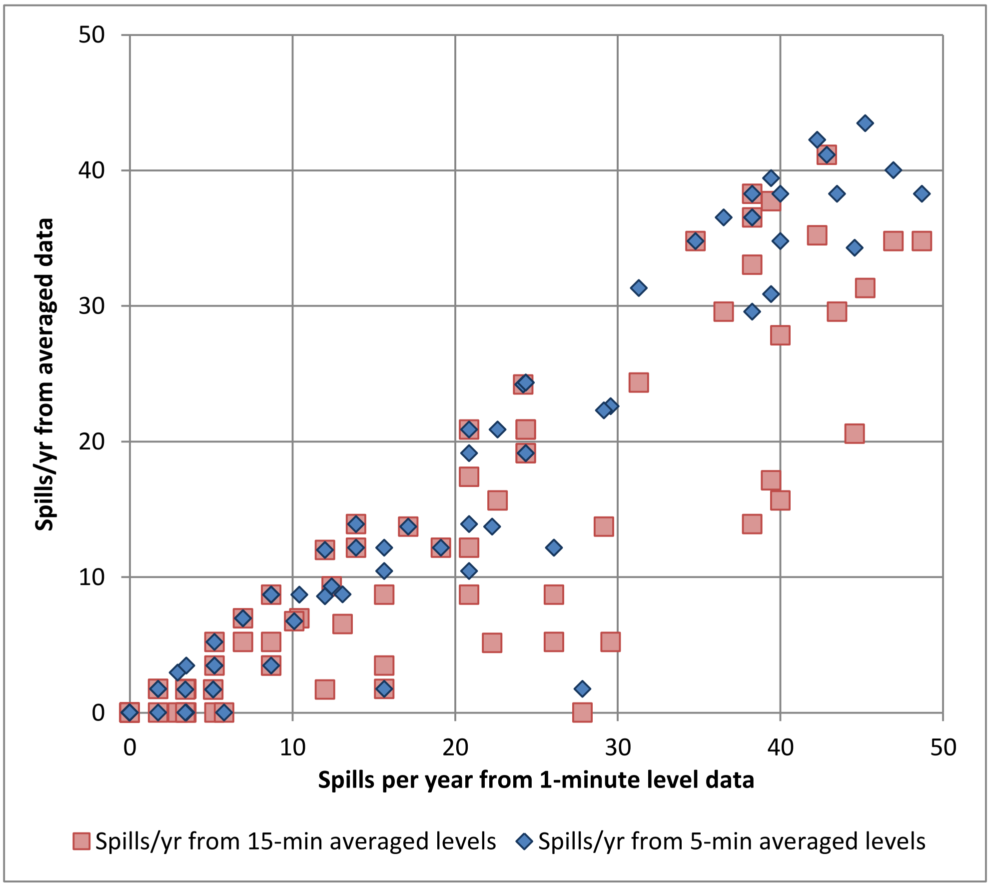

Figure 2: Annual spill counts given different averaging periods

Therefore although companies justifiably could attempt to estimate the degree to which their EDM configurations were leading to under- or over-estimation in their total spill counts, it would be misleading to extrapolate this into attempts to normalise data or apply 'correction factors' to individual storm overflows. The uncertainty spread in a 'normalised' annual spill count would likely be tens of percent – much too wide to be able to rely on for determining whether a storm overflow had exceeded its permitted number of spills.

It has been noted that there are many storm overflows for which hydraulic models are not available and there is no current understanding of a 'design' or normal spill frequency against which monitoring results can be compared by companies and the Environment Agency. In these cases it has been suggested that a statistical estimate of spill frequency range (based on catchment and storm overflow attributes) could be considered. This research found that although it is possible to produce statistical estimates with a definite correlation to hydraulic model outputs, there is a large degree of scatter / unexplained variation. I.e. when reviewing model performance for individual storm overflows the statistical estimate is usually very different from the hydraulic model output.

Guidance on hydraulic model outputs

Hydraulic models are widely used to analyse CSO spills and help understand and predict the behaviour of CSOs in reality. It is therefore important that consistency is sought regarding the hydraulic modelling undertaken, particularly where actual and modelled 12/24 spill counts are to be compared. This should include consistency in both the features of the hydraulic modelling approach and the model outputs used. In order to better understand the issues, hydraulic simulations were applied to the same catchments using the same models but with certain settings (e.g. timestep) changed.

Full details of the analysis undertaken are provided in the UKWIR report [3].

The analysis confirms that the outcomes of hydraulic simulations are dependent upon the options chosen to generate spill counts and other related statistics. Care is needed to use models effectively to generate the most accurate statistics possible.

Using a 12/24 counting method (in the way in which it can[1] be performed using ICM[2]), the duration of spill events is not represented accurately. The duration of events should not be calculated using the 12/24 method. It is recommended combining overflow events only when the gap between them is short (e.g. 1h). The volume of the spill shows some small, insignificant, differences.

Running simulations at different timesteps showed that there may be significant differences for individual links, i.e. an individual CSO's spill statistics may vary depending upon the timestep used. When considering the spills for the total catchment the differences are small. It is recommended to run simulation at a small timestep.

Use of a minimum volume of 50m^3 to define CSO spills was (as expected) found to reduce the modelled number of spills, and their total duration and volume, in comparison to when no minimum volume threshold is used. It can also be seen that using a 12/24 counting

[1] It should be noted that it is not possible in ICM to count spills as specified by the EA method; the EA method specifies that 12/24 counting resets when there is a 24 hour block with no discharges. The 12/24 counting method available in ICM will produce similar spill counts to the EA method for most realistic flows, but discrepancies are possible. Further details are given in [3].

[2] There are several software packages in use for creating hydraulic models of urban drainage systems; one of the most common is InfoWorks ICM (Integrated Catchment Modelling) developed by Innovyze, which was used in this work.

method may cause smaller (below 50m^3) spills to be combined together and so counted. It is recommended to use a zero minimum volume (0m^3) to give the most accurate representation of CSO spills.

Recommendations

Analysis of the effect of EDM configuration on 12/24 spill count showed that biases do occur under different EDM configurations.

There are three options to address these biases:

(i) To standardise the configuration of the monitoring equipment and data collection

(ii) To make adjustments to the data prior to applying the 12/24 counting approach

(iii) To make adjustment to the results of the 12/24 counting approach.

Option (i) may have its merits, but clearly has cost implications for the monitors currently in use. This research has shown that Option (iii) is not feasible.

Option (ii) is the recommended approach. It is proposed that this is achieved through an addition to the EA definition of 12/24 counting, in order that companies which collect higher resolution EDM data are not penalised for doing so.

The existing EA definition also allows for different interpretations of the "24 hour block with no discharge" following a spill event. Some readers have interpreted this statement as meaning "24 hours after the end of the last discharge"; the authors (and most other users) have interpreted this as "the first discharge-free 24 hour block based on block counting from the start of the first discharge".

The following refined definition is proposed – where steps (4) to (8) are the existing EA 12/24 counting approach (plus additional words in square brackets, to address the ambiguity in meaning of "24 hour block with no discharge"), and steps (1) to (3) are additions proposed to address the issue of biases that could otherwise result from different-resolution data.

1) *Collate 'discharge status' data (either discharge start/stop times, or level data values and whether the level exceeds the spill threshold) for the storm overflow*

2) *If data are logged more frequently than the 15 (or 2) minute monitoring interval required by the EA for the storm overflow, then select discharge status values at fixed 15 (or 2) minute intervals starting precisely on the hour. i.e. given a 15 minute monitoring interval requirement, a time series would be produced for the storm overflow indicating "discharging" or "not discharging" at precisely* 12:00, 12:15, 12:30 etc.*

   Note that the discharge status at other times becomes irrelevant e.g. if a storm overflow had discharged from 12:01 to 12:14 this would not affect the "not discharging" statuses at 12:00 or 12:15. Conversely, given a discharge lasting only from 12:29 to 12:31, the *"discharging" status at 12:30 would not be affected by the fact that there had been no discharge for most of the preceding and following 15 minutes.*

** If the discharge status is not available at the desired time (e.g. if the raw data are only for 12:14:00 and 12:16:00, and discharge status is required at 12:15:00) then use the last known discharge status prior to the time required. I.e. in this case, assume that the 12:15:00 discharge status is the same as the 12:14:00 discharge status.*

3) *12/24 spill counting should then be applied as follows, using only the 15 (or 2) minute interval discharge status values:*

4) *Spill counting starts when the first discharge occurs at a given overflow.*

   [A sequence of 'blocks' is defined as starting at this time, with the first block lasting 12 hours and subsequent blocks lasting 24 hours. The end times of the blocks are thus 12 hours, 36 hours, 60, 84 etc. (and so on every 24 hours) after the start of the first discharge.]

5) *Any discharge(s) in the first 12 hour block is counted as 1 spill.*

6) *Any discharge(s) in the next and subsequent 24 hour blocks are each counted as 1 additional spill per block.*

7) *This counting continues until there is a 24 hour block with no discharge at a given overflow.*

8) *For the next discharge after the 24 hour block with no discharge, the 12 hour and 24 hour block spill counting sequence begins again.*

   [The end times of the blocks in this new sequence will be 12, 36, 60 etc. hours after the start time of this new discharge.]

Although a clarification is proposed in steps (4) and (8) above regarding the meaning of "24 hour block with no discharge", discussion with the EA is recommended to confirm or otherwise this interpretation.

Steps (1) and (2) are illustrated by Figure 3. The underlying sewer level gives rise to a 'Discharging' status (whether via comparison to a spill threshold, or where spill start/stops are logged directly). Taking the discharge status values at precisely 0, 15, 30, 45 minutes past the hour gives rise to 'Discharging (15-minuted polled)' values. These 'Discharging (15-minute polled)' values are what should then be used to determine 12/24 spill counts.

Note that although discharge occurred at around 19:50, the 'Discharging (15-minute polled)' values do <u>not</u> identify a discharge around this time, and therefore this event would not contribute to 12/24 spill counting.

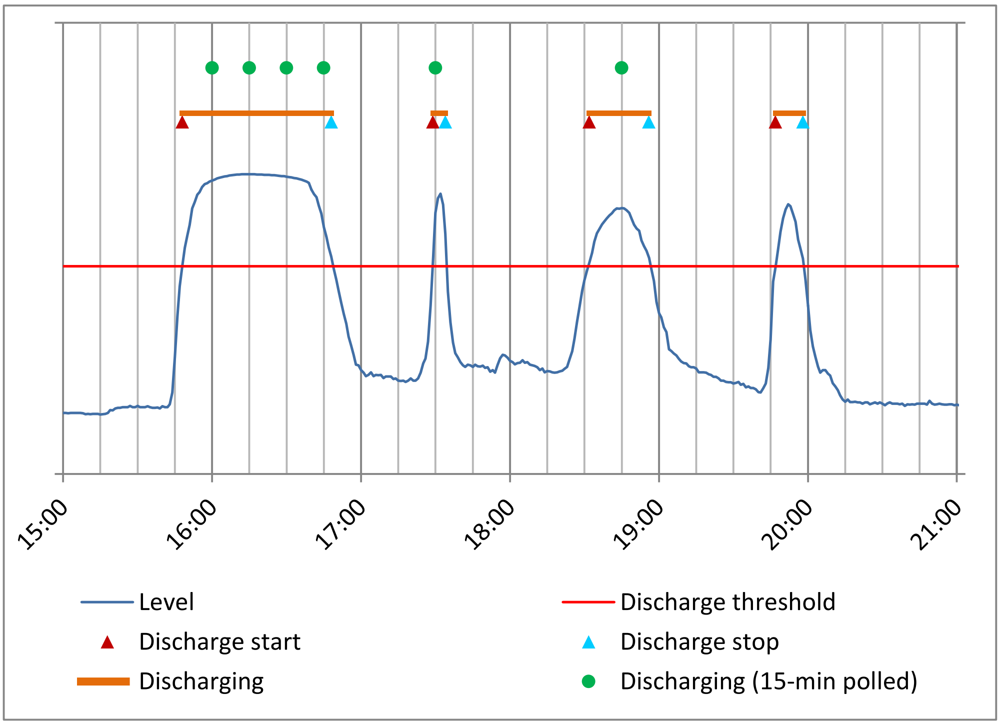

Figure 3: 15-minute polling of instantaneous values, versus underlying sewer level

Benefits

The principal benefits of this research are expected to be:

- Consistent calculation of 12/24 counting for spills from storm overflows with different overflow event monitoring frequencies
- Fairer assessments of sewer and CSO performance against regulatory requirements.

Acknowledgments

UK Water Industry Research Ltd is acknowledged as owner of this work, which is published here with permission.

With thanks to Phil Reaney and the project Steering Group for their thoughtful guidance throughout.

References

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