HR Wallingford
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Capacity Assessment Framework - Surface Water Drainage - Initial trial of Surface Water Sewers

Recommendations Report for Water UK and Defra

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Executive Summary

The 21st Century Drainage Programme Capacity Assessment Framework provides a high-level overview of the hydraulic risks for different parts of sewerage networks, by using a set of leading metrics for pipe capacity and combined sewer overflow (CSO) performance. The Framework was published in April 2017 and since then the twelve UK sewerage undertakers, working with Water UK, have been embedding the Framework into their organisations.

Part of this process has been the development of a first draft National Picture of present day capacity of foul and combined sewers. This National Picture should not be used as a means of identifying current performance problems caused by the lack of network capacity, but instead as an indication of the level of risk associated with current capacity limitations. To understand those risks in detail, including how likely they are to materialise, their causes and the range of potential interventions available, the Capacity Assessment Framework should be used in conjunction with the Framework for Drainage and Wastewater Management Plans (DWMPs) that Water and Sewerage Companies are currently developing.

Long-term possibilities for the Capacity Assessment Framework include expanding the existing methodology to include an assessment of the performance of surface water drainage systems and, hence, developing a first draft National Picture of present day capacity of surface water drainage as well.

As a first step towards this, this project has applied the CAF approach to the assessment of surface water sewers. These public sewers form only part of the UK's surface water drainage assets. Other types of assets, such as highway drains, culverted watercourses and sustainable drainage systems (SuDS), have not been assessed as part of this trial.

However, focusing on surface water sewers was deemed a useful starting point on the basis that sewerage undertakers (a) have already been engaged in the development and application of the Capacity Assessment Framework; and (b) would have data and models available that could be used to trial the existing CAF approach for surface water sewers.

Three sewerage undertakers provided surface water sewer performance data for this trial: Northumbrian Water, Yorkshire Water and Severn Trent Water. Each of these companies had already undertaken a significant amount of hydraulic modelling of their surface water sewers, which could be utilised for the trial. This data comprises the majority of the performance data currently available across the UK.

The results of the trial indicate that the CAF approach can be used for surface water sewers where detailed hydraulic models are available. However, due to the fragmented nature of the networks, especially in rural areas, it is recommended that a threshold is applied, so that areas with relatively few sewers are not inappropriately categorised as being at risk on the national-scale mapping.

The main constraint with using the existing CAF approach for surface water sewers is the requirement for detailed hydraulic models. This limits the coverage of the mapping that could be achieved at the national-scale in the near-future for surface water sewers to roughly 22%, compared to the coverage achieved for the first draft National Picture for foul and combined sewers which was 79% for the equivalent metric and around 90% overall (i.e. including assets without hydraulic models). This also limits the level of coverage that could be achieved for surface water drainage assets not owned by the sewerage undertakers, which is likely to be much lower than 22%. This means that if the CAF is to be used for all types of surface water drainage, further research will be required to look at modifying the approach to accommodate assets without detailed hydraulic models.

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1. Introduction

1.1. The Capacity Assessment Framework

The vision of the 21st Century Drainage Programme is to enable the UK water industry, in partnership with the UK's governments and regulators, to take action now that will ensure the resilience and sustainability of our drainage infrastructure in the future.

As part of this Programme, the Capacity Assessment Framework (CAF) provides a high-level overview of the hydraulic risks for different parts of sewerage networks, by using a set of leading metrics for pipe capacity and combined sewer overflow (CSO) performance. The CAF was published in April 2017. Following on from this, the twelve UK sewerage undertakers, working with Water UK, embedded the Framework into their organisations and developed a first draft National Picture of present day capacity of foul and combined sewers.

This National Picture should not be used as a means of identifying current performance problems caused by the lack of network capacity, but instead as an indication of the level of risk associated with current capacity limitations. To understand those risks in detail, including how likely they are to materialise, their causes and the range of potential interventions available, the Capacity Assessment Framework should be used in conjunction with the Framework for Drainage and Wastewater Management Plans (DWMPs) that Water and Sewerage Companies are currently developing.

1.2. Purpose of this project

Long-term possibilities for the Capacity Assessment Framework include expanding the existing methodology to include an assessment of the performance of surface water drainage systems and, hence, developing a first draft National Picture of present day capacity of surface water drainage.

As a first step towards exploring these possibilities, this project has used the existing CAF metric for pipes using the Enhanced Method (referred to as the Enhanced Metric in the remainder of this report) to assess the performance of surface water sewers owned by the UK's sewerage undertakers. These public sewers form only part of the UK's surface water drainage assets. Other types of assets, such as highway drains, culverted watercourses and sustainable drainage systems (SuDS), have not been assessed as part of this trial.

The trial was based on data provided by three sewerage undertakers: Northumbrian Water, Severn Trent Water and Yorkshire Water. The purpose of the trial was to determine the suitability of using this metric and to present the mapped results in a similar way to that used for foul and combined sewers.

In order to select the sewerage undertakers to participate in the trial, HR Wallingford obtained information from all twelve UK sewerage undertakers. This also provided an opportunity to estimate the coverage that could be achieved if all sewerage undertakers provided data in the future in order to develop a National Picture.

1.3. Purpose of this report

The purpose of this report is to:

- Describe the approach taken for the trial;
- Present the mapped results for surface water sewers for the three participating sewerage undertakers;
- Discuss the findings from the trial and the feedback received from all sewerage undertakers;
- Provide recommendations regarding modifications to the existing CAF approach that would enable surface water sewers to be assessed across the UK;
- Provide recommendations regarding potential next steps to expand the CAF approach further to consider all types of surface water drainage systems.

2. Project approach

2.1. Review of coverage

HR Wallingford carried out a review of coverage of surface water sewer data and models for the UK using a combination of questionnaires and telephone interviews with representatives from the UK sewerage undertakers. This resulted in the Coverage Report, which summarises the data coverage available from each company and across the UK as a whole and provides details of the performance data to be used for the trial.

Discussion of the findings from this review is provided in Section 3.1. Further information can also be found in the Coverage Report.

2.2. Data selected for trial

The project brief required data from two to three sewerage undertakers to be used for the trial. These companies were selected based on the level of coverage they could achieve and whether the data could be provided within the timescale of the project. The chosen companies were Northumbrian Water, Severn Trent Water and Yorkshire Water.

Table 2.1 provides a summary of the data received from the three sewerage undertakers that took part in the trial. This shows that each sewerage undertaker was able to provide performance data for approximately 50% of their surface water sewers.

The data from Northumbrian Water and Yorkshire Water was already held by HR Wallingford, as it had been included in the data sent by the sewerage undertakers to HR Wallingford as part of the previous project (the development of the first draft National Picture of foul and combined sewers) although it was not used previously. Severn Trent Water produced new performance data from their existing models following the Framework approach in full. To assist with the successful delivery of this, HR Wallingford provided a Data Provision Guidance document, similar to the one produced for the previous project.

Table 2.1: Data received for the trial

Sewerage Undertaker	Number of pipes assessed(1)	% coverage provided(2)	Source of performance data
Northumbrian Water	103,962	54%	Provided as part of the previous project(3)
Severn Trent Water	206,822	49%	Based on new simulation results produced for the trial
Yorkshire Water	112,499	56%	Provided as part of the previous project(3)

Notes for Table 2.1:

(1) The number of pipes assessed is not the same as the number of manholes

(2) Number of manholes provided for the trial / Total number of surface water sewer manholes owned by the sewerage undertaker as reported in the Coverage Report

(3) Development of a first draft National Picture of present day capacity of foul and combined sewers

2.3. Draft mapping

Draft mapping was produced following the existing CAF approach, using the Enhanced Metric for pipes.

For the record, the following provides a summary of the steps undertaken with each dataset, as checked and agreed with each sewerage undertaker to ensure that the appropriate performance data was used for the assessment:

Severn Trent Water

- The new performance data was received in the same format as for the previous project.
- The data was processed using python script and FME[1] workbenches and only small adjustments were required.
- The data was loaded into the database using FME workbenches and no issues were encountered.
- The data contained only a single system type “storm”.
- Final checks were done in the database (missing lengths, full stop in node name, etc.) and no issues were found.

Northumbrian Water

- The data was already in the database, so all checks were done in the database and no issues were encountered.
- Multiple system types are included in the database. System types “other” and “storm” were used for the analysis.
- All conduits with “WC” (watercourse) or “HD” (highway drain) in the node ID were excluded from the analysis.

Yorkshire Water

- The original data received from the previous project was used for this phase.

[1] Feature Manipulation Engine

- All data with system types “STOR”, “storm”, “SURF”, “SW” and “SWR” were extracted.
- Python and FME were used to check the data and all system types were changed to “storm” or “surface”.
- The data was loaded into the database using FME workbenches.
- All conduits with no length and/or capacity were deleted once in the database, as these were assumed all to be ancillaries.

The mapping was produced using two alternative hexagon sizes: 10 km diameter (Figure 2.1) and 1 km diameter (Figure 2.2). Figure 2.4, Figure 2.5 and Figure 2.6 provide comparisons between the 10 km and 1 km diameter hexagons for different areas of the trial mapping, as indicated in Figure 2.3.

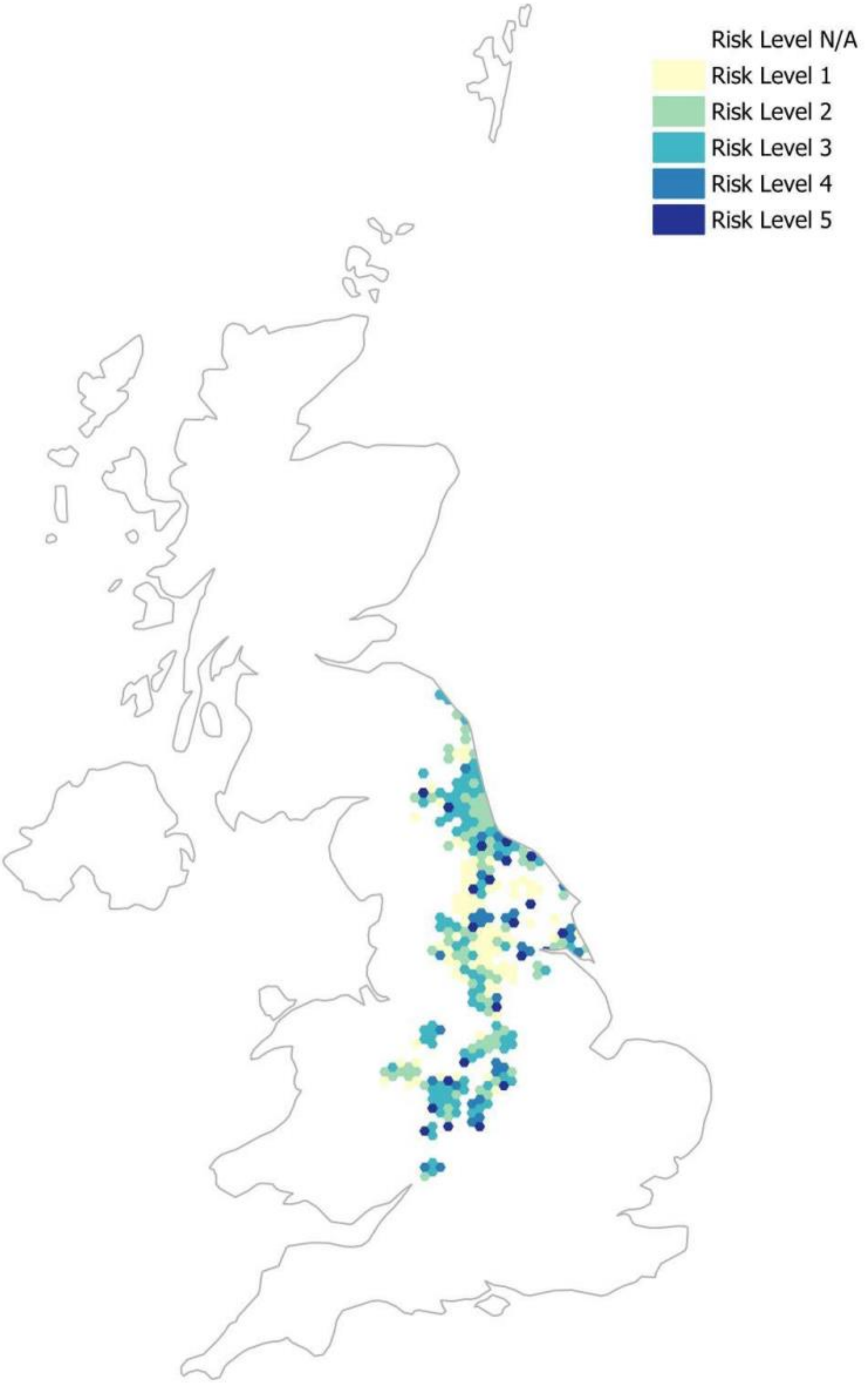

Figure 2.1: Draft mapping for surface water sewers following the existing CAF approach - 10 km diameter hexagons

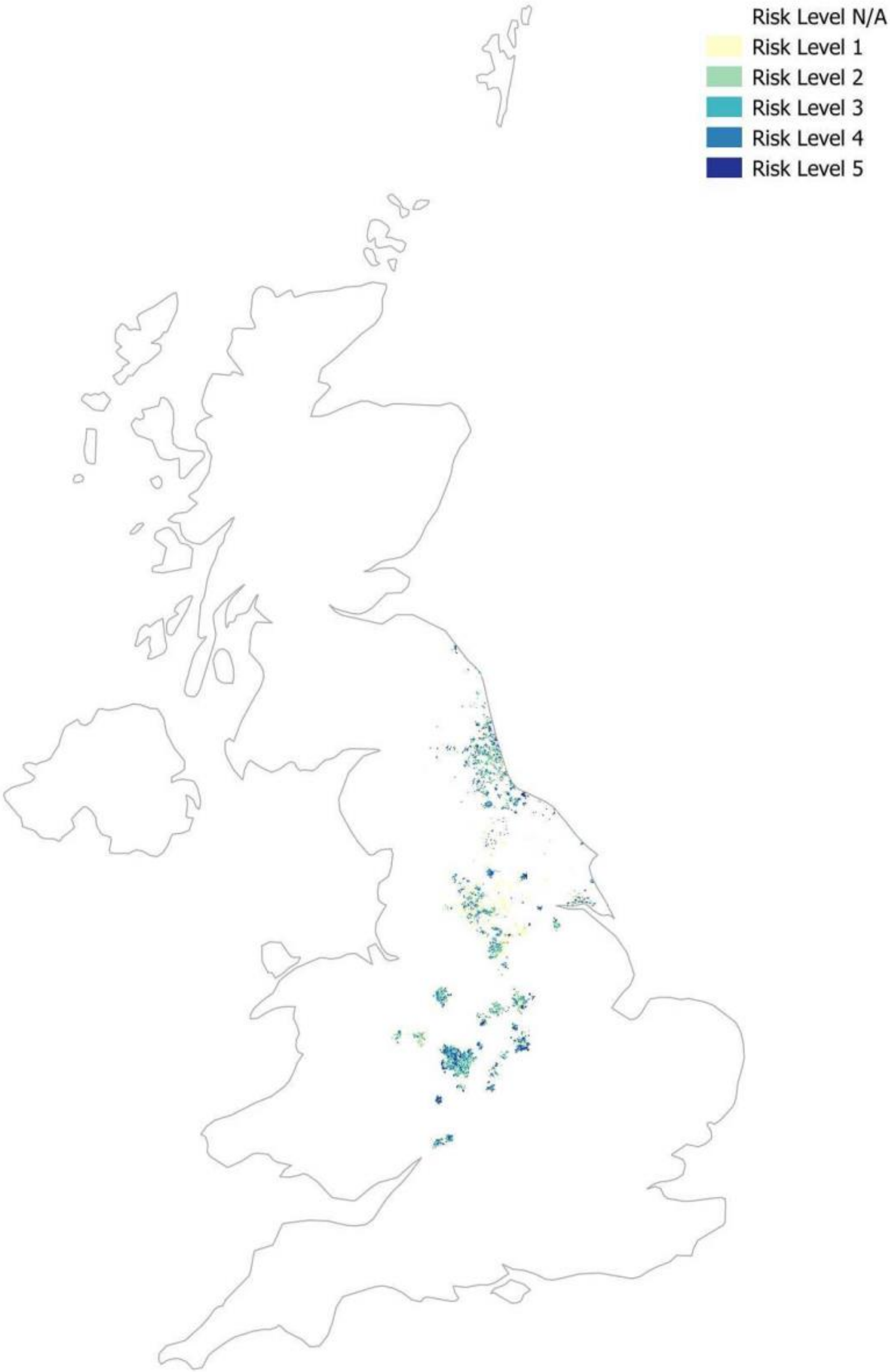

Figure 2.2: Draft mapping for surface water sewers following the existing CAF approach - 1 km diameter hexagons

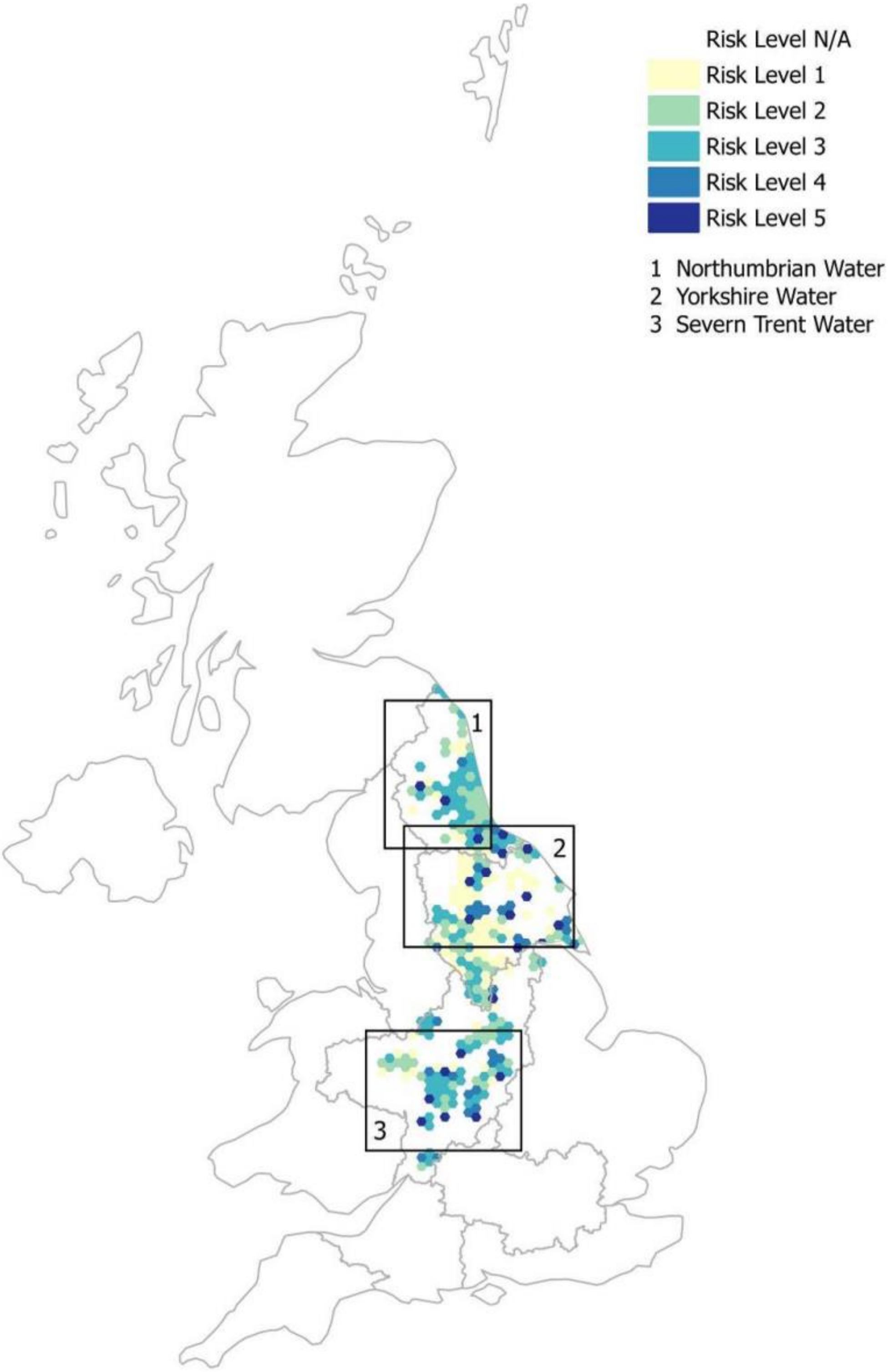

Figure 2.3: Comparison between 10 km and 1 km draft mapping for surface water sewers following the existing CAF approach - key to detailed maps

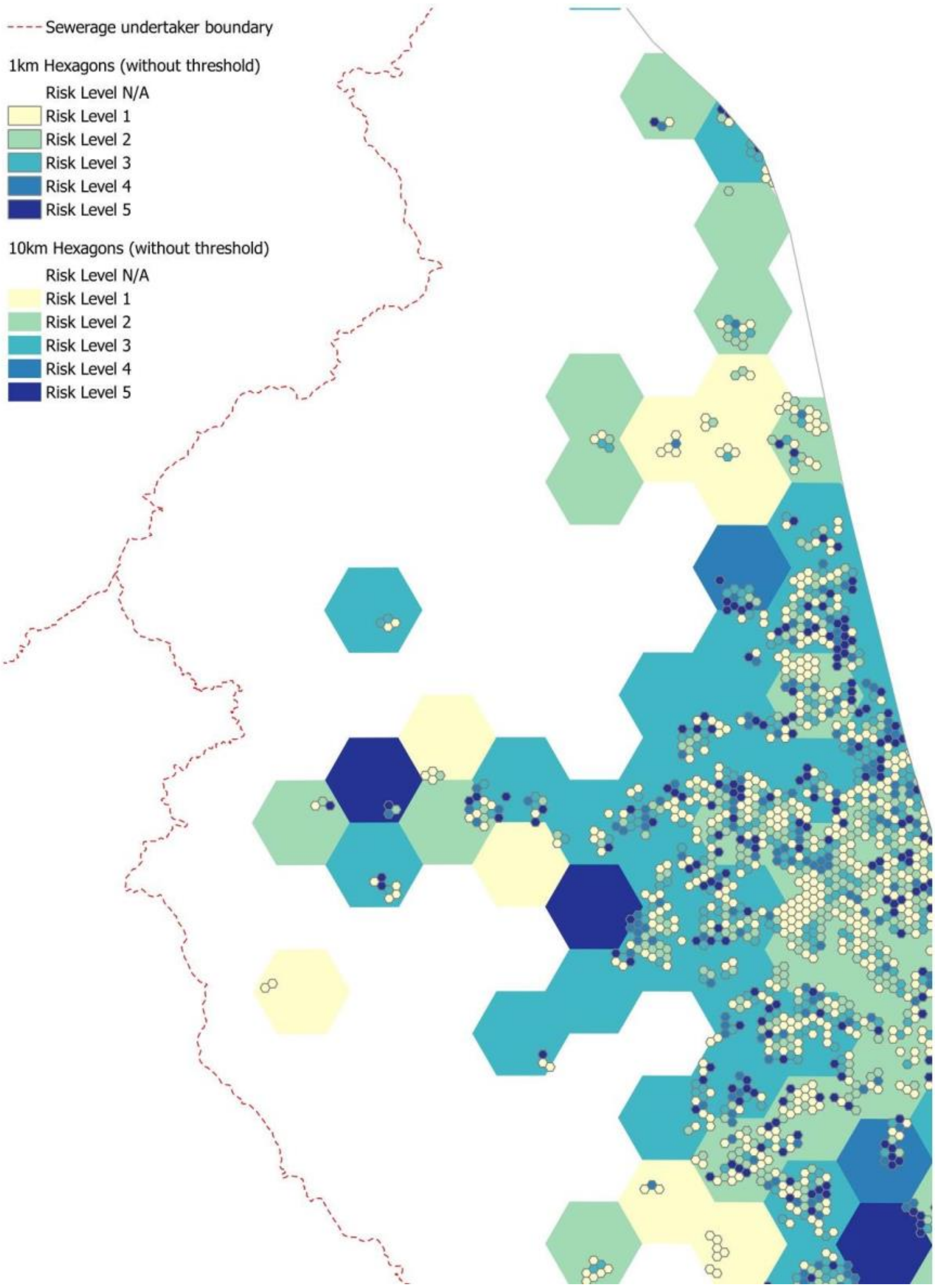

Figure 2.4: Comparison between 10 km and 1 km draft mapping for surface water sewers following the existing CAF approach - example for part of Northumbrian Water

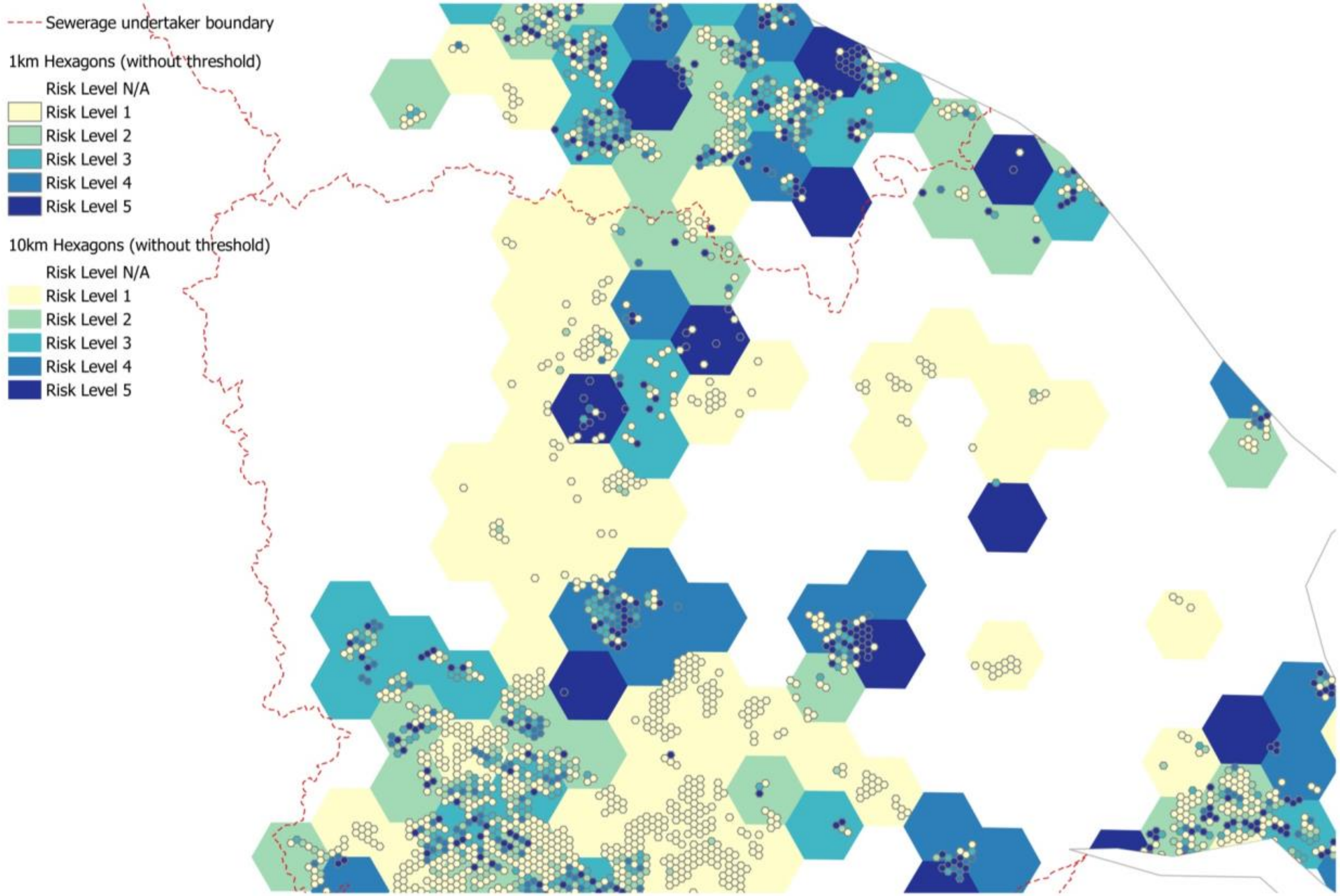

Figure 2.5: Comparison between 10 km and 1 km draft mapping for surface water sewers following the existing CAF approach - example for part of Yorkshire Water

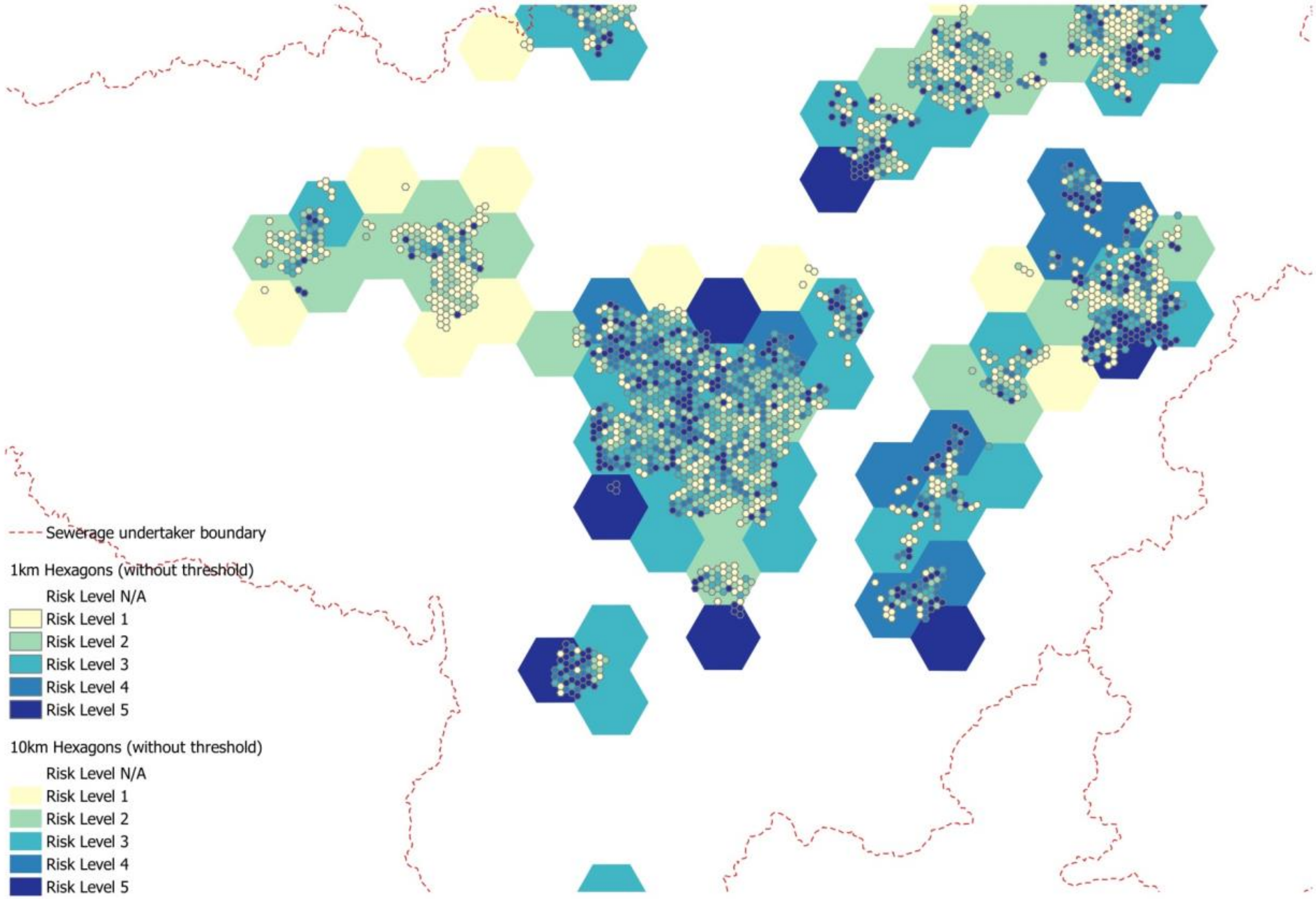

Figure 2.6: Comparison between 10 km and 1 km draft mapping for surface water sewers following the existing CAF approach - example for part of Severn Trent Water

2.4. Review of draft mapping

The sewerage undertakers participating in the trial were given the opportunity to review the draft mapping. In discussion with representatives from the three sewerage undertakers, it was concluded that in urban areas where there was a high proportion of modelled surface water sewers both the 10 km and 1 km diameter hexagon mapping represented available capacity reasonably well. However, too many 10 km diameter hexagons were shown with Risk Levels 2 to 5 (green to dark blue) where the total number of pipes in the hexagon was relatively small. This was most pronounced in rural areas where the available data for surface water sewers was more fragmented, as illustrated in Figure 2.4 and Figure 2.5. Therefore, a threshold should be applied to the 10 km diameter hexagons to exclude those that contain too little data to justify inclusion in the assessment.

It was also considered that the 1 km diameter hexagon mapping was useful for interrogating the results of the assessment, but the 10 km diameter hexagon mapping remained more appropriate for presenting the results from this high-level assessment and provided consistency with the foul/combined mapping.

2.5. Revised mapping with threshold

Following consultation with the Water UK Programme Manager, it was agreed that HR Wallingford would produce revised 10 km diameter mapping based on a suitable threshold determined by HR Wallingford, which was then reviewed by the participating sewerage undertakers.

The threshold was chosen by reviewing the number of hexagons in each region with relatively low total pipe lengths and comparing these figures with the rural areas that had been identified by the participating sewerage undertakers as showing unrepresentative results. The threshold chosen was deemed to be the best compromise between (a) excluding as many as possible of the hexagons that were showing Risk Levels that were unrealistically high - based solely on a visual check - and (b) minimising the total number of hexagons excluded.

The threshold chosen was 2500 m total pipe length per 10 km diameter hexagon, which corresponded with a removal of around 21% of hexagons across the whole of the trial area, with the largest proportion of hexagons being excluded in the Yorkshire Water region. Table 2.2 provides a breakdown of the percentage of hexagons excluded with the 2500 mm threshold. These figures are based on the overall number of hexagons produced for the trial, rather than for each sewerage undertaker region. These figures show that most of the hexagons excluded are from the lowest risk level - Risk Level 1.

Table 2.2: Percentage of 10 km diameter hexagons excluded with the 2500 m threshold for each Risk Level - surface water sewers

	Severn Trent Water	Northumbrian Water	Yorkshire Water	Total
Risk Level 1	2.7	1.7	7.4	11.7
Risk Level 2	0.7	1.3	1.0	3.0
Risk Level 3	0.3	0.7	1.0	2.0
Risk Level 4	0.0	0.0	1.7	1.7
Risk Level 5	0.3	0.3	2.0	2.7
Total	4.0	4.0	13.1	21.1

The statistical distribution of total pipe length per 10 km diameter hexagon for each of the three participating sewerage undertakers are shown in Figure 2.7. The percentage of 10 km diameter hexagons excluded for a range of thresholds is shown in Figure 2.8.

Further discussion regarding the use of a threshold and the suitability of using 2500 m is provided in Section 3.5.

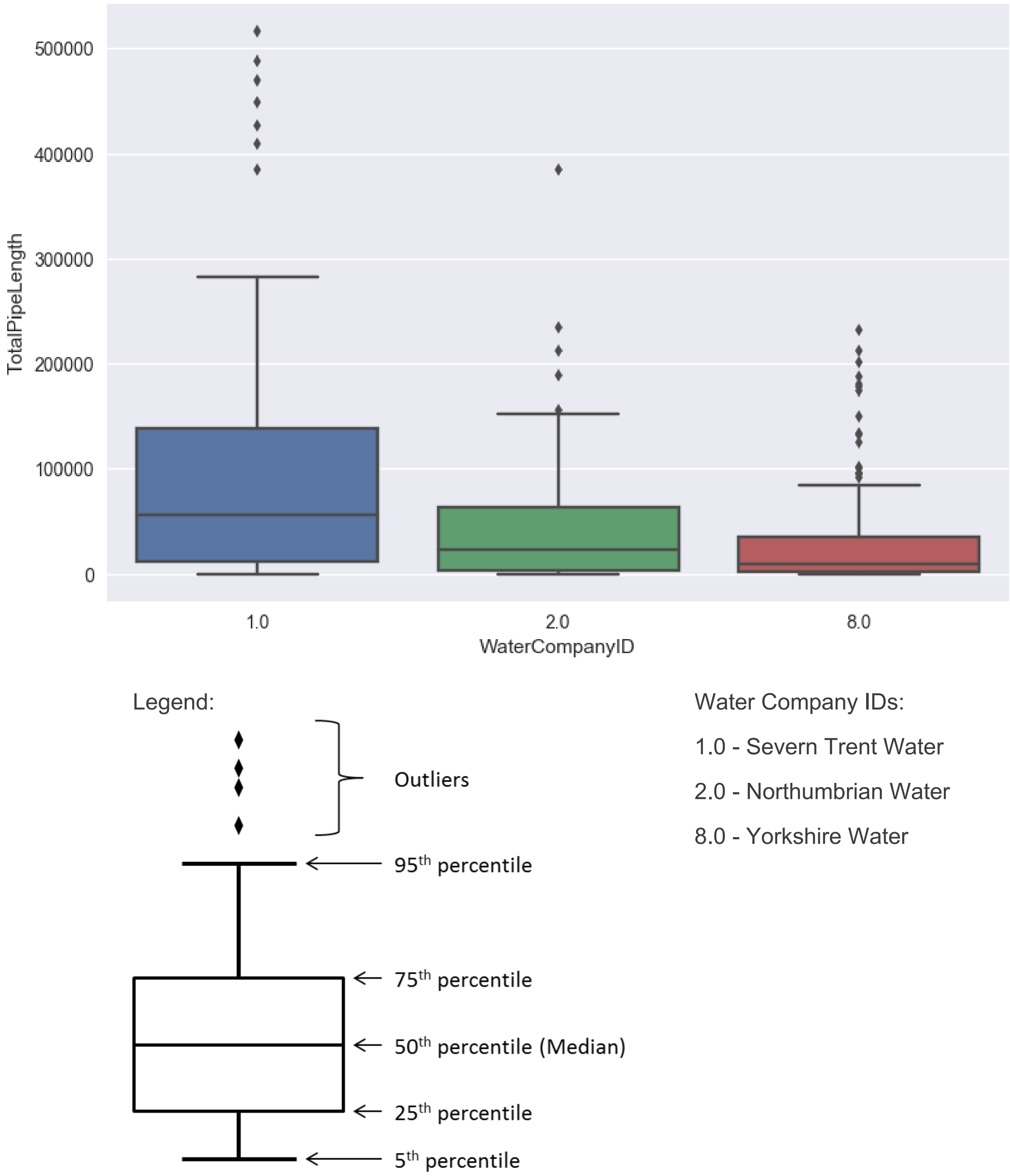

Figure 2.7: Distribution of total pipe length (m) for 10 km diameter hexagons - surface water sewers

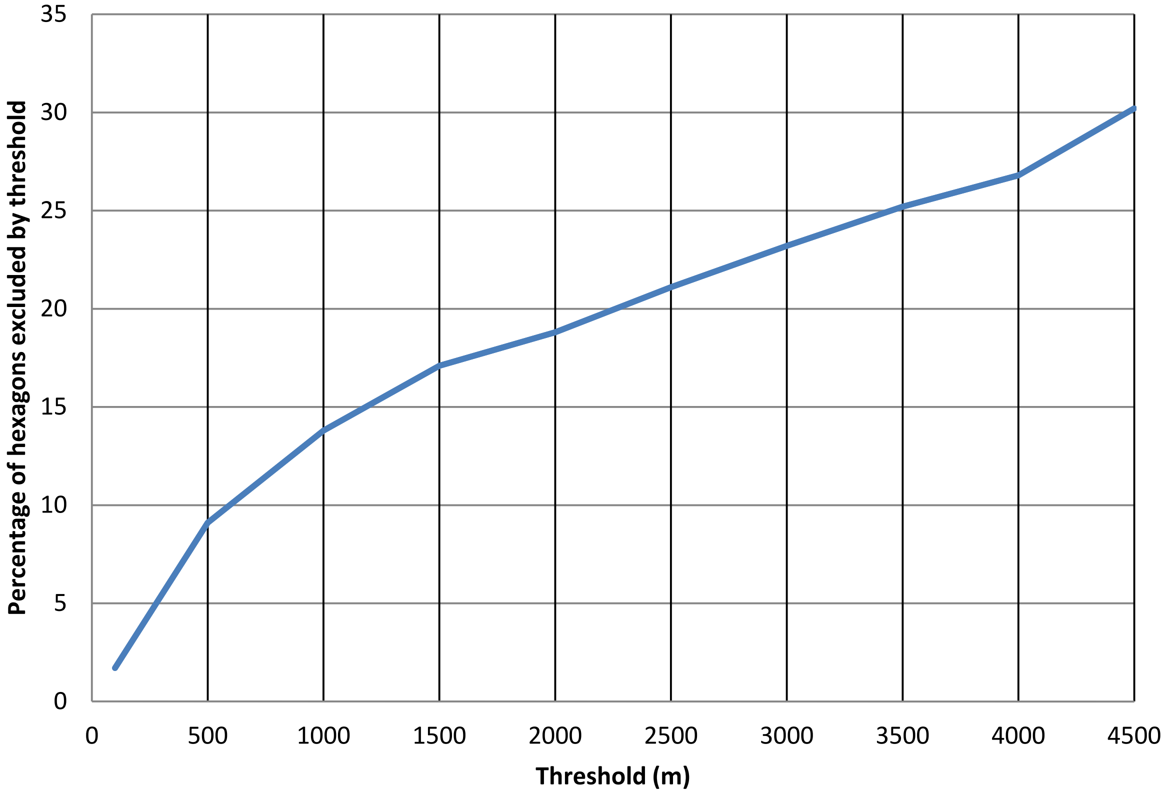

Figure 2.8: Percentage of 10 km diameter hexagons excluded using different thresholds - surface water sewers

The revised 10 km diameter hexagon mapping using the 2500 m threshold is provided in Figure 2.9. Appendix A provides a set of detailed surface water sewer maps comparing the draft mapping with the revised mapping with the 2500 m threshold. It should be noted that the figures in Appendix A that show the excluded hexagons in shades of red (i.e. Figure A.3, Figure A.6 and Figure A.9) are for comparison purposes only and it is not proposed that any published mapping would be presented in this way.

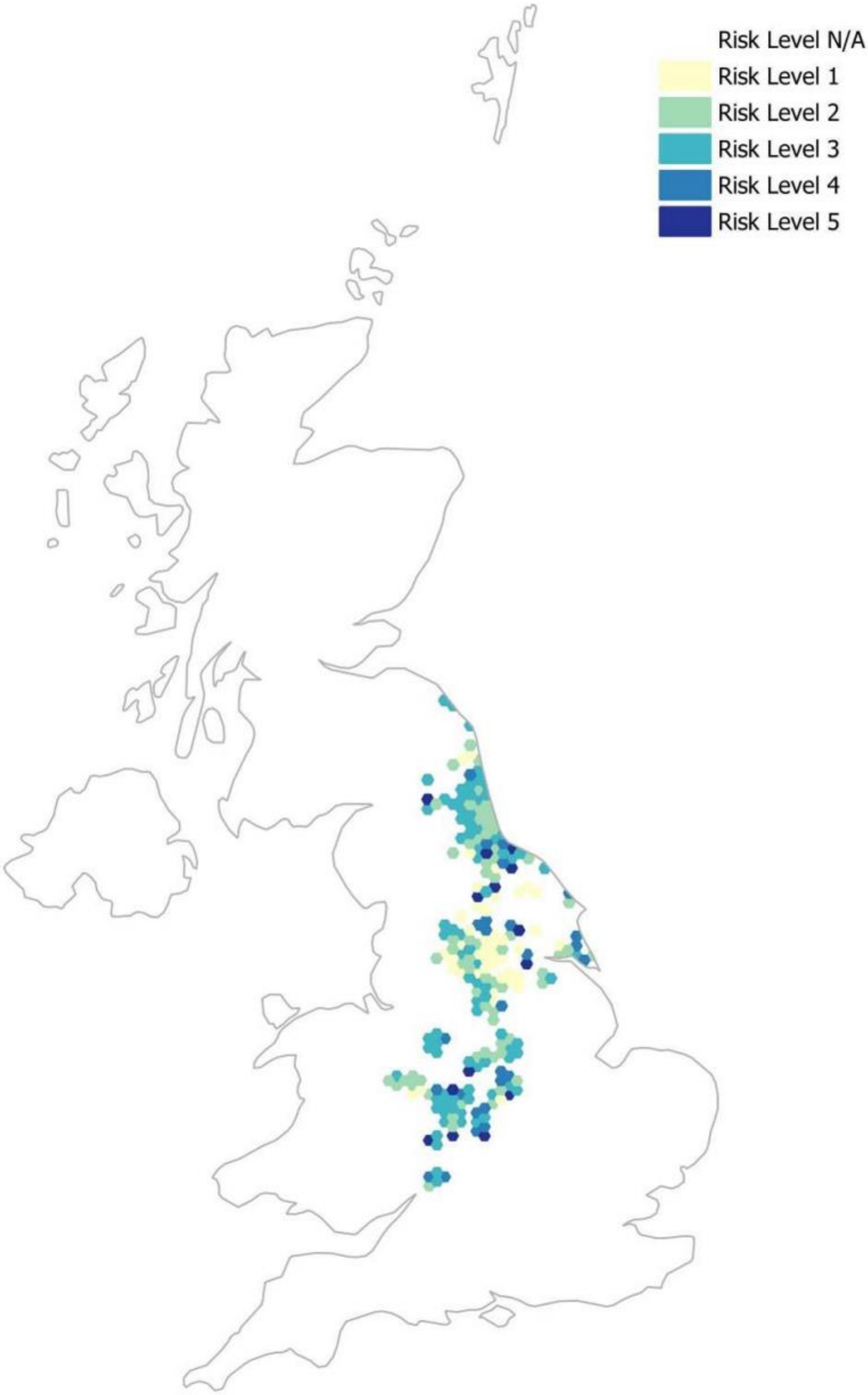

Figure 2.9: Revised mapping for surface water sewers using 2500 m threshold - 10 km diameter hexagons

3. Discussion

3.1. Overview

Surface water drainage includes a number of different types of assets including:

- Surface water sewers;
- Sustainable drainage systems (SuDS);
- Highway drainage;
- Land drainage and private drains;
- Small urban watercourses (including culverted watercourses); and
- Other type of artificial drainage systems (e.g. canals and drainage channels).

It should be noted that surface water is also drained by combined sewers owned by sewerage undertakers.

This project focused on surface water sewers as a useful starting point to understanding the capacity of the UK's surface water drainage on the basis that (a) the 12 sewerage undertakers have already been engaged in the development and application of the Capacity Assessment Framework; and (b) several sewerage undertakers would have data and models available that could be used to trial the existing CAF approach for surface water sewers. Therefore, most of the following discussion is based around the current status of surface water sewer models held by the sewerage undertakers and understanding surface water drainage performance from this perspective.

However, this is only part of the overall picture and it is important to recognise the limitations of focusing on surface water sewers. Consideration of assets not owned by sewerage undertakers is at least as important as those owned by sewerage undertakers in order to understand the capacity of the UK's surface water drainage.

3.2. Surface water sewer coverage

Based on the consultation with the UK's sewerage undertakers that was undertaken as part of this project, there are over 2.7 million surface water sewer manholes in the UK compared to nearly 8 million foul and combined sewer manholes.[2] The distribution of those surface water sewer manholes across a sewerage undertaker's region depends on a number of factors, including the following:

- Combined sewers also drain surface water runoff and some sewerage undertakers, especially those with the highest urban densities, have lower coverage of surface water sewers because of this. Where surface water sewers do exist in dense urban areas, these sometimes discharge into combined sewers. Estimates provided by some sewerage undertakers[3] suggest that such connections represent on average between 1% and 5% of their total surface water sewers.
- Coverage of surface water sewers can be influenced by the predominant soil conditions, especially in more rural areas. For example, the Wessex region has relatively high usage of soakaways in rural areas and, hence, very limited coverage of surface water sewers. On the other hand, the Northumbrian region

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[2] The number of sewer pipes will differ slightly, as this depends on the connectivity between the manholes.

[3] This information was not readily available for all sewerage undertakers.

has relatively low usage of soakaways and, therefore, more surface water sewers can be found in rural areas.

Table 3.1 provides a summary of the scale of public surface water sewer assets (based on manholes and outfalls) in the UK, taken from sewerage undertaker estimates. On the basis of this data, it is reasonable to assume that coverage of the surface water sewer mapping will be more patchy across the UK than for the foul/combined sewer mapping and this may include urban as well as rural areas. Comparing the number of surface water sewer outfalls with the total number of manholes suggests that on average there are only 35 manholes per surface water sewerage system. This highlights the fact that many surface water networks are much smaller than foul/combined systems. Therefore, there is a need to consider whether the existing CAF approach is appropriate in areas with a low density of sewers (see Section 3.5).

Table 3.1: Comparison between numbers of foul/combined and surface water sewer assets

Sewerage Undertaker	Total no. of foul/ combined manholes(1)	Total no. of surface water manholes	Estimated surface water sewerage coverage compared to foul/combined(2)	Total no. of surface water sewer outfalls
Anglian Water	~600,000	~270,000	~30%	~9,300
Northern Ireland Water	321,475	173,093	~55%(3)	9,621
Northumbrian Water	644,167	190,049	~30%(4)	4,274
Scottish Water	624,212	_	_	_
Severn Trent Water	770,883	416,298(5)	*~54%*	13,948(6)
South West Water	250,775	98,400	~40%(7)	2,702
Southern Water	522,345	123,369	*~24%*	4,644
Thames Water	821,640	~715,000(8)	~45%	12,772
United Utilities	1,205,388	~240,000	*~20%*	~5,800
Welsh Water	500,433	126,953(9)	*~25%*	3,782(9)
Wessex Water	431,195	~200,000(10)	~44%	~3,900(11)
Yorkshire Water	1,225,121	~140,000(12)	~25%	~5,500
TOTAL	~7,900,000	>2,700,000	20-55%	>76,000

Notes for Table 3.1:

Numbers in blue italics have been estimated by HR Wallingford, not the sewerage undertaker, based solely on the other numbers provided.

(1) Includes all manholes that are known about / mapped. Sewerage undertakers estimate that the section 105a / transferred assets in their region have increased their total number of manholes by somewhere between 40 and 200%. Most sewerage undertakers estimate only around 5% of the transferred assets have currently been mapped.

(2) This estimate has been determined differently by different sewerage undertakers. Unless stated otherwise, this is based on population served.

(3) Based on total length of surface water sewers compared to the total length of foul plus combined sewers.

(4) Based on foul only equivalent

(5) Number of public surface water sewer manholes, but a further 13,208 manholes designated as “other” are also recorded. These will be private or not owned by Severn Trent Water.

(6) Number of public surface water sewer outfalls, but a further 1,714 outfalls designated as “other” are also recorded. These will be private or not owned by Severn Trent Water.

(7) Based on a number of CSO flow calculation spreadsheets where population to combined is separated from population served by separate systems.

(8) GIS Mapped + S105a estimated

(9) Number recorded, but not believed to be comprehensive. Figure includes both public and transferred assets.

(10) Number of public surface water sewer manholes, but a further ~45,000 private surface water sewer manholes are also recorded

(11) Number of public surface water sewer outfalls, but a further ~1,900 private surface water sewers are also recorded

(12) Number of public surface water sewer manholes, but a further ~10,000 S24 manholes are also recorded

As part of the consultation, sewerage undertakers also questioned whether there is a need to consider how sewers should be assigned to the mapping - in particular, should surface water sewers that discharge into combined sewers (not watercourses) be represented on the foul/combined sewer mapping rather than the surface water sewer mapping, bearing in mind that the downstream capacity of the combined system can influence the performance of the upstream surface water sewers. This has the potential to become more complicated once consideration is also given to assets not owned by sewerage undertakers, as it is also possible (for example) that highway drainage discharges into a combined system (see Section 3.6).

Equally, where combined sewer overflows (CSOs) discharge into surface water sewers, should these surface water sewers be represented on the foul/combined sewer mapping or the surface water sewer mapping? It should be noted that for this trial, it was left to the sewerage undertaker to ensure that sewers were correctly designated as surface water sewers and to decide how inflows into the surface water sewers were represented. It has been assumed that where CSOs discharge into surface water sewers this has been modelled and the performance data reflects this. If the receiving sewers have been designated as surface water sewers, these will have been included in this assessment. If the receiving sewer only receives flows from the CSO, this is a CSO outfall pipe and should have been designated as a foul/combined sewer.

Due to these interactions, it has been suggested that all sewers should be shown on the same map, so that a more comprehensive picture of capacity can be determined. However, providing a distinction between foul/combined sewers and surface water drainage would be challenging. It would make the scoring and reporting of levels of risk more complex (see Section 4.6); especially given that the design capacity for some combined sewers may be based on a longer return period than generally used for the design of surface water sewers due to the floodwater being more hazardous. Additionally, it would make it harder to identify the asset owners and, hence, the types of interventions required to address capacity problems.

3.3. Status of surface water sewer modelling

Table 3.2 provides a summary of the current status of surface water sewer modelling for each sewerage undertaker. Based on data availability, it is estimated that around 25% of the surface water sewers in England and Wales have been modelled to date, compared to at least 80% of foul and combined sewers.[4]

Table 3.2: Summary status of surface water sewer modelling

Sewerage Undertaker	% of surface water sewers currently modelled			% of modelled surface water sewers in urban areas	% of surface water sewers with performance data available for the trial	% of surface water sewers with performance data likely to be available by end of 2018
	Total	Verified(1)	Unverified			
Anglian Water	unknown				0%	0%
Northern Ireland Water	<5%	<1%	<5%	100%	0%	0%
Northumbrian Water	~55%	<5%	50-55%	~90%	~55%	~55%
Scottish Water	–	–	–	–	–(2)	–
Severn Trent Water	75%	~75%(3)	0%	94%	~50%	~73%
South West Water	~2%	<1%	~2%	67%(4)	0%	~2%
Southern Water	~12%	~7%	~5%	100%	0%	0%
Thames Water	8%	5%	3%	100%(5)	~4%	~4%
United Utilities	~20%	unknown			~20%	~20%
Welsh Water	<15%	<1%	<15%	100%	0%	<2%
Wessex Water	~35%	10%	~25%	<<100%	0%	~30%
Yorkshire Water	30%	15%	15%	97%	30%	30%

Notes for Table 3.2:

(1) Whether a model is considered verified has been determined by the sewerage undertaker, based on what they have deemed as reasonably achievable and necessary. The level of verification undertaken varies between sewerage undertakers. This is discussed further in the text below.

[4] This is based on the sewerage undertakers being able to provide performance data for the Enhanced Metric for pipes for 80% of foul and combined sewers in England and Wales. Scottish Water provided performance data for the Enhanced Metric for pipes for 67% of their foul and combined sewers and Northern Ireland Water provided an equivalent 11%.

(2) HR Wallingford currently holds performance data provided by Scottish Water for ~48,000 surface water sewers, provided as part of the previous phase of work. However, it is unknown what proportion of total surface water sewers in Scotland this represents.

(3) Level of verification varies significantly. Surface water sewer models are generally only verified where there is a risk-based driver to do so, but many surface water sewers that have a neighbouring foul system with a verified model are considered as having "inferred" verification.

(4) Six out of 9 modelled catchments are described as urban

(5) Based on 20ha+ with 1500 population exceedance

Where data is indicated as "unknown" in Table 3.2, this is due to the data not being readily available from the sewerage undertaker's records, i.e. detailed GIS analysis would be required to determine these numbers. Given greater time and sufficient justification for assigning resources to this analysis, more information could be made available at a future date.

Verification for surface water sewerage systems in this context is based on what is reasonably achievable in each sewerage undertaker region. There are intrinsic difficulties in carrying out conventional short-term flow surveys in many surface water sewers: the pipes are often too small; there are no (or low) flows for the majority of the time; and the water can be too clear for standard flow monitors that rely on signals reflecting off particulates. This can mean that it is not cost-effective to carry out verification exercises for many systems. Different sewerage undertakers have adopted different approaches to verification and set different levels of acceptance of model adequacy. In some regions verification is rarely attempted as it is often not considered cost-effective. However, there are instances where integrated models have been produced in partnership with local authorities (see Section 3.6) and grant in aid funding to investigate local flood risk has been used to fund flow surveys, but the value of this depends on the specific characteristics of the drainage system being assessed.

It was also noted that, in general, surface water sewer flooding does not get reported by the public as often as foul flooding, which can mean that historical flooding records are of limited value. This is thought to be due to a number of factors including: the flooding is usually reported to the local authority rather than the sewerage undertaker[5]; it can be difficult to determine whether the flooding is the result of runoff not being able to drain into a sewer or whether it has come out of the sewer; and flooding that is not contaminated with sewage is not considered as much of a nuisance (especially if not entering properties). It should also be born in mind that the design capacity of surface water sewers is often limited to a return period shorter than for foul/combined systems and, therefore, exceedance occurs more often. This does not mean that the CAF scoring approach needs changing, as this reflects capacity, but this should be taken into consideration when interpreting the Risk Levels, as discussed in Section 4.6.

In the absence of model verification based on a short-term flow survey or historical records, the focus is often placed on having accurate impermeable area take-off, coupled with (where possible) verification of the parallel foul sewerage system. For those sewerage undertakers that expressed an opinion regarding the accuracy of their surface water sewer models to predict system performance, it was generally felt that their standard modelling approach compensated for the lower confidence in the model results by overestimating flows in the surface water sewers and, hence, their models would provide a conservative estimate of available capacity.

[5] Often as a result of standard guidance provided by the sewerage undertaker, as it is more likely to be the responsibility of the local authority.

The information provided in Table 3.2 shows that only a few sewerage undertakers have invested in significant surface water sewer modelling programmes to date. The vast majority of surface water sewers in the UK are currently not modelled. For most sewerage undertakers, surface water sewer modelling has only been carried out where these sewers are deemed to be in high risk or high priority areas, for example due to flooding, pollution, maintenance issues or development growth.

Some sewerage undertakers intend to increase significantly the extent of their surface water sewerage models over the next couple of AMP periods - these being Anglian Water, South West Water, United Utilities, Yorkshire Water and Wessex Water. Severn Trent Water is unusual in already having the majority of its surface water sewers modelled. The remaining sewerage undertakers will continue to apply a risk-based approach and only model surface water sewers where there is an identified need.

The majority of sewerage undertakers have reasonably high confidence that they know the locations of their public surface water sewers and these are mapped in their GIS databases. There is greater uncertainty about locations of transferred assets. However, the "completeness" of the data, such as cover levels, invert levels, pipe diameters, etc. (in other words all of the information required to produce a hydraulic model) is variable across the sewerage undertakers, with most of the data for transferred assets being missing. Therefore, any future modelling of surface water sewers is likely to require a significant investment in data collection prior to model build. Such programmes are resource intensive and time consuming. Therefore, it could take 10 or even 15 years before the level of coverage is comparable to that available for foul/combined sewers, even if significant modelling programmes are implemented by the majority of sewerage undertakers. Should it be decided that this is the appropriate way forward, consideration will also need to be given to addressing the skills/resource shortages in the industry. These are long-term issues to address and cannot be fixed quickly.

3.4. Expected coverage for UK-wide surface water sewer mapping

If the existing CAF approach is applied to surface water sewers, the coverage that can be expected for the mapping will be dependent on the coverage of surface water sewer modelling. This is because it is currently only possible to apply the existing Enhanced Metric to surface water sewers.

If it is decided to produce a national map within the next 12 months using the existing Enhanced Metric only, this is likely to provide coverage of around 22% of the total number of surface water sewers in England and Wales. Less than 1% of surface water sewers in Northern Ireland have been modelled. The percentage modelled in Scotland has not been determined as part of this project.

The mapping produced for this trial provides around 15% coverage of England and Wales. Therefore, expansion of this mapping to include all sewerage undertakers would only increase the coverage by around 7% in England and Wales, with the majority of this additional coverage likely to be from only 2 or 3 sewerage undertakers.

This coverage is significantly lower than the coverage achieved for the first draft National Picture for foul/combined sewers, which was 79% for the Enhanced Metric with a further 11% for the Initial Metric (based on the whole of the UK, not just England and Wales). This therefore raises two questions:

- Should effort be made in the near-term to increase coverage? This could only be achieved using an Initial Metric to supplement results available using the Enhanced Metric. This is discussed in Section 3.8.
- Would there be greater benefit in improving understanding of the assets not owned by sewerage undertakers? This is discussed in Section 4.1.

3.5. Areas with a low density of surface water sewers

As discussed in Section 2.4, it was decided to apply a threshold to the 10 km diameter hexagon mapping to exclude hexagons from the assessment where they contain too little data to justify inclusion in the assessment. The threshold chosen was a total pipe length of 2500 m.

Application of the threshold appears to have worked successfully, particularly for the data provided by Northumbrian Water and Yorkshire Water, where outlying rural areas with only a very small number of scored 1 km diameter hexagons are mostly excluded from the 10 km diameter hexagon mapping when the threshold is applied (see Appendix A). For Severn Trent Water the density of 1 km diameter hexagons is generally much greater (due to the almost 100% coverage in the urban conurbations provided) and when comparing the 1 km diameter hexagons with the 10 km diameter hexagons (see Figure A.8 and Figure A.9 in Appendix A) it can be seen that some of the outlying areas of these urban conurbations with only a few 1 km diameter hexagons still generate 10 km diameter hexagons with a Risk Level of 1 or higher.

Sensitivity testing was carried out looking at thresholds above and below 2500 m. These results showed that, although changes appeared in the Northumbrian Water and Yorkshire Water regions, very few changes appeared in the Severn Trent Water region up to a threshold of 4000 m. But going beyond this threshold was potentially detrimental overall due to the number of hexagons excluded in total. Therefore, it was decided that there was little benefit in changing the threshold from 2500 m to improve the Severn Trent Water results.

As part of this exercise, it was noticed that there was a higher density of surface water sewers in the Severn Trent Water region than foul/combined sewers. This might be an anomaly resulting from the areas selected for this trial or could be a reflection of the modelling practices applied when the models were originally built, for example more of the foul/combined sewerage models might have pruned networks, while the surface water sewer models are all-node models. This highlights one of the limitations of using a threshold that is based solely on total pipe length. An alternative might be to set a threshold based on the total pipe length of pipes above a specified diameter, but this has not been investigated as part of this trial.

Where hexagons fall below the 2500 m threshold they have been excluded from the mapping, i.e. they are shown as white (Risk Level n/a). There is no distinction between these and hexagons where no data has been provided. It has been suggested that it would be useful to have a way of showing this distinction. For example, these excluded hexagons could be grey rather than white. Examples of this are shown in Appendix A - Figure A.10 and Figure A.11. However, as discussed in the previous recommendations report, there can be a number of reasons why performance data has not been provided for the mapping exercise: no sewers exist in these areas; sewers do exist but the records are incomplete; modelling has not been carried out because the sewers are deemed low risk; modelling has been carried out but the model is not deemed fit for purpose; or modelling has been carried out but the performance data could not be provided. Therefore, care would need to be taken regarding the conclusions drawn by having a separate colour for hexagons where data had been provided but excluded - it would not be appropriate, for example, to state that these are the only hexagons outside of those scored with a Risk Level of 1 to 5 for which there are models.

Added to this, it is also important to consider how assets not owned by sewerage undertakers should be represented if the Framework is to be expanded to include all types of surface water drainage. The availability of this data is likely to be even more variable. Therefore, it may be more appropriate to adopt a different approach to scoring capacity. For example, the existing Enhanced Metric for pipes is based on the percentage of total pipe length that surcharges for a 2 year return period. Percentage was chosen over absolute pipe length because this was deemed as providing a better overall picture of capacity. But this was based on the premise that all relevant pipes are provided for the assessment. Where there is a much greater likelihood that not all pipes (or channels) are provided for the assessment, using a percentage is less helpful and it may be better to use absolute pipe length, on the basis that if the total pipe length that is under-capacity is above a specified length then this triggers the need to take action. This is an example of a decision-driven rather than a data-driven approach and this is discussed further in Section 3.9.

3.6. Assets not owned by sewerage undertakers, but included in models

Assets not owned by the sewerage undertakers, in particular highway drainage and local watercourses, are occasionally included in existing surface water sewer models. However, the majority of sewerage undertakers said that these did not represent a significant number of modelled assets at the present time.

On the whole, outfalls to inland watercourses are modelled with free discharges, i.e. downstream boundary conditions are not applied. But where such outfalls are deemed to have discharges affected by downstream water levels, it is more common for the receiving watercourse to be included in the model, rather than applying a level hydrograph. In low-lying parts of the country, this may include the representation of networks of ditches or rhynes. Outfalls to tidal waters, on the other hand, are commonly modelled with a level hydrograph.

Where receiving watercourses have been modelled, there is some variation across sewerage undertakers as to whether their GIS asset databases include this additional data. The models themselves often do not distinguish between assets that have different owners. Therefore, there is a risk that assets not owned by the sewerage undertakers could be included in the CAF mapping. However, sewerage undertakers were generally of the view that this occurred too infrequently at present for it to have a significant influence on the mapped results.

Although currently relatively rare, there are examples in England where integrated modelling studies have been carried out due to multiple sources of flooding or there is an inherent hydraulic interaction. These modelling exercises tend to be very expensive and therefore they are only undertaken where flood risk is high. This usually involves the sewerage undertaker sharing models with the local authorities and the models have then been enhanced with additional asset data provided by the local authority. However, these models do not necessarily include all local drainage. For example, records for highway drainage and ordinary watercourses are often limited and only included in specific areas of need.

Sewerage undertakers identified by this project as having undertaken integrated modelling studies include Anglian Water, Northumbrian Water, Severn Trent Water, South West Water, United Utilities, Wessex Water and Yorkshire Water. At present, these integrated models tend not to be included in the suite of drainage models held by the sewerage undertaker and, therefore would not make a significant contribution to the performance data that could be provided for the mapping in the near-term. But the approach adopted for these integrated modelling studies needs to be taken into consideration for future development of the Framework, whether or not all types of surface water drainage are to be included in the subsequent mapping.

For the trial, the only dataset that had a distinction between different asset types was Northumbrian Water's - watercourses and highway drainage were provided in the original data but excluded from the CAF analysis. Taking this data as an example, 1.4% of the conduits provided were watercourses and 2.5% were highway drains.

In summary, at the present time, assets not owned by sewerage undertakers but included in existing models are too few in number to have a significant influence on the high-level CAF mapping. However, should integrated modelling become more commonplace, then being able to make a distinction between different types of asset and asset owners will become more important. This would be the case whether future mapping remains focused solely on surface water sewers owned by the sewerage undertakers (because any other assets would need to be excluded from the analysis) or if future mapping includes other types of surface water drainage (in which case it becomes important to understand how complete the data is from each asset owner and report this accordingly).

3.7. Responsibilities of different stakeholders

When considering surface water drainage as a whole, it is important to be clear about responsibilities of different stakeholders and feedback suggests that this is not always the case. For example, groundwater flooding can be problematic in some areas and this can find its way into highway drainage, surface water sewers or foul/combined sewers, reducing the available capacity in all of them, but the source of flooding is outside of the responsibility of either the sewerage undertaker or the highway authority.

Another grey area is the effect of downstream boundary conditions on an upstream sewer network. If sewer flooding occurred due to the conditions in the receiving watercourse this was not the responsibility of the sewerage undertaker, according to Ofwat reporting guidelines. However, it is now often considered a shared responsibility and, depending on the level of risk, the Lead Local Flood Authority or Environment Agency will get involved. This perhaps provides a reason for expanding the Framework to look at all types of surface water drainage, as it would have the potential to report on these interactions. However, it would still be necessary to be able to distinguish between different stakeholder responsibilities in these circumstances in order to obtain all relevant data/information and to identify appropriate interventions and investment needs. However, this might be best done at a more local level, rather than as part of a UK-wide high-level assessment.

3.8. Using an Initial Metric

The results of this project suggest that the existing Enhanced Metric for pipes provides a satisfactory indicator of available capacity for surface water sewers, but provides limited coverage due to its reliance on existing hydraulic models. Therefore, the question remains as to whether this approach should be used as part of an assessment for all surface water drainage where the availability of hydraulic models is likely to be even more limited. The preference would be to retain the existing assessment approach and results, but with the expansion of the Framework it may become apparent that this is not helpful (see Section 3.9).

The existing Initial Metric is unsuitable for assessing surface water sewers, because it relies on dry weather flow generated from domestic wastewater. This means that a new Initial Metric would need to be found for surface water sewers, should it be decided that using the existing Enhanced Metric alone is insufficient.

It should also be noted that there remains a concern over the suitability of the Initial Metric for foul and combined sewers due to it appearing to overestimate available capacity, potentially because of there being a relatively high probability that properties will at least in part drain to the nearby foul or combined system. Where the remaining surface water runoff drains to is much more uncertain, as this could be to a soakaway, highway drain, surface water sewer or directly to a watercourse.

An additional reason to consider using an Initial Metric comes from the desire to explore the potential for expanding the Framework to include assets not owned by sewerage undertakers and reducing the reliance on hydraulic models. In some instances models do exist for these assets (see Section 3.6), but it is assumed that in the majority of cases they do not and this is unlikely to change significantly in the near-future for a number of reasons, including lack of expertise and resources available to these organisations, as well as the limited justification for modelling drainage systems deemed to be low risk. This suggests that any significant inclusion of assets other than surface water sewers in a UK-wide map of surface water drainage capacity will be dependent on finding a suitable Initial Metric.

In order to have consistency and to keep things simple, it would be preferable for any new Initial Metric to be applicable to both surface water sewers and other types of surface water drainage assets. But any metric would be dependent on the data available. Focusing solely on surface water sewers in the first instance, the information gathered during this trial suggests that the "completeness" of surface water sewer GIS data is variable, ranging from around 30% to 100% for sewerage undertakers in England and Wales[6]. This is excluding data for transferred assets, which is generally poor. Assuming that all GIS data that is currently reported as "complete" could be used, this would provide a total coverage in England and Wales of around 73% (excluding transferred assets). Therefore, this in itself does not present a barrier to the use of an Initial Metric. However, this GIS data would only be suitable for determining the pipe full capacity of a sewer (based on pipe diameter, gradient and roughness). In order to determine available capacity, pipe full capacity needs to be compared with the flows experienced in the sewer during specified conditions (e.g. return periods). This is usually determined based on an understanding of the upstream contributing area. GIS data is generally based on sewer records and survey data. Contributing areas tend only to be derived from detailed modelling exercises.

As mentioned above, the chances of models being available for assets not owned by sewerage undertakers are small and the rate at which this is likely to change over time is slow. So this presents the following options:

- Go down the hydraulic modelling route and develop a simple or automated method for estimating upstream contributing areas, which is probably only viable for surface water sewers as the data and modelling skills required are more likely to be available.
- Adopt a predictive modelling approach that carries out data analytics using machine learning tools, which will take advantage of what can be learnt from the outputs from existing models and/or case study areas, but then predict available capacity based on variables that are available for all types of surface water drainage assets.
- Have a hybrid of the two options above, which is a multiple-tiered approach where national datasets are used to identify areas of low, medium and high potential risk (predictive modelling). Then carry out hydraulic modelling of high (and possibly medium) risk areas, which may also require the collection of additional local data.

The identification of suitable capacity metrics for all types of surface water drainage would be dependent on which types of data are available, what can be readily collected and how easily it can be used. As mentioned in Section 3.6, there are many potential data owners depending on which data is required. It would be preferable to keep the number of data owners involved to a minimum, as long as this does not jeopardise the objectives of the assessment.

[6] Estimates have not been available from Scottish Water and Northern Ireland Water.

3.9. Expanding and using the Framework

This project provides the first step in understanding data sources for surface water drainage - what is available, who holds it, how reliable it is and how readily it can be used. But the focus has been on surface water sewers and it will be important to ensure that any future expansion and use of the Framework (for just surface water sewers or for all types of surface water drainage) is proportionate and that the outputs are correctly interpreted.

Feedback received from the sewerage undertakers participating in the trial highlighted that there is a desire to revisit the purpose of the Framework to ensure that it produces information that is relevant to decision-making, as well as allowing the intended audience to draw appropriate conclusions that can be justified by the industry. For example, it will be important that any approach adopted does not result in property blight for communities that fall within areas of the mapping shown with a high Risk Level. Therefore, it is also important that the experience gained from the publication of the foul/combined mapping is taken into consideration before the Framework is developed further.

Something to consider is whether the use of "leading metrics" (such as the existing Enhanced Metric that relates to frequency of surcharge) is too reductionist[7] in approach for assessing surface water drainage as a whole, even if deemed appropriate for foul and combined sewerage networks. Options that have a more systematic (or systems-based) approach should also be considered as part of any future review of next steps. This might take the form of a more decision-driven rather than data-driven approach. In order to do this, it is first necessary to identify what those decisions are and what information these decisions are based on. These concepts were explored at the inception stage of the CAF, but without the benefit of having real data and outputs. Now that the mapping is available for foul/combined sewers and an example of the mapping for surface water sewers has been produced as part of this trial, this presents an opportunity to ask these questions again and to work with the intended audience to discuss the tangible (and intangible) benefits of having this information. Embedding this Framework within industry practices will also be easier to justify with stakeholders, if the benefits are identified, demonstrated and communicated.

4. Recommendations

The recommendations in this report relate solely to the findings from this trial and should be considered alongside lessons learnt from the previous application of the CAF to foul and combined sewers.

4.1. Assessing assets not owned by sewerage undertakers

As highlighted in Section 3.1, this project has focused on the potential means of assessing the capacity of surface water sewers. Therefore the recommendations in this report also focus on the existing CAF approach and its application to surface water sewers.

However, it is recognised that there is a longer-term potential to expand the assessment approach in future to consider other types of surface water drainage assets and all of the recommendations presented here are equally relevant for assets not owned by sewerage undertakers.

The fundamental issue with including all types of surface water drainage assets in the CAF is current data availability and what is likely to be available in the foreseeable future. Linked to this are issues of data

[7] Analysing and describing a complex system in terms of simple criteria.

ownership and roles of different stakeholders; availability of the required skills/resources; and perhaps most importantly the purpose and benefits of investing in a UK-wide surface water drainage capacity assessment.

Therefore, before any investment is made into expanding the Framework to include assets not owned by sewerage undertakers, it is recommended that a stakeholder consultation exercise is carried out, alongside collation of information already available from recent and ongoing national-scale reviews.

Added to this, the development of the framework for DWMPs may also present an opportunity to consider how sewerage undertakers should work with other asset owners to develop a combined understanding asset performance. Therefore, it is recommended that any future review of the CAF approach should align as closely as possible to the DWMP approach.

4.2. Increasing the coverage of a surface water sewer map

The three sewerage undertakers that participated in the trial have by far the best coverage of surface water sewer performance data currently available in the UK. As discussed in Section 3.4, it would be possible to expand the mapping produced as part of this trial to include similar performance data (to varying degrees) from a further five sewerage undertakers by the end of 2018. This would increase the overall coverage for England and Wales from 15% to approximately 22%.[8] This would provide a further opportunity to test the approach, but would not provide a significantly more representative picture at the national scale.

In order to deliver this mapping, it would be necessary to carry out the following steps:

- Ensure suitable data sharing agreements are in place with the additional sewerage undertakers[9];
- Update the Data Provision Guidance, based on the lessons learnt from the trial and the first draft National Picture of present day capacity of foul/combined sewers;
- Provide technical support to the sewerage undertakers providing the data to maximise the chances of receiving the correct data in the appropriate format;
- Carry out data checks and data cleaning to ensure that the data can be successfully used;
- Complete the analysis using the existing Enhanced Metric for pipes;
- Prepare the 10 km and 1 km diameter hexagon mapping, as recommended in Section 4.4, and apply the threshold as recommended in Section 4.5.

Increasing coverage further based only on the existing Enhanced Metric for pipes would require substantial investment in surface water sewer modelling. Some, but not all sewerage undertakers are planning to invest in such modelling in the coming and subsequent AMP periods. Therefore, it will be possible to increase coverage in some parts of the UK in the medium to long term, but mapping that would be UK-wide to the same level of coverage achieved for the foul/combined mapping is unlikely to be possible in the near-term (i.e. in the next 1 to 2 years). Therefore, should it be decided that coverage for the mapping needs to increase significantly in the near-term this would require the use of a new Initial Metric (see Section 4.3).

[8] Less than 1% of surface water sewers in Northern Ireland have been modelled to date and none of this data would be available by the end of the year. The availability of Scottish Water data is currently unknown.

[9] For the majority of sewerage undertakers, it is expected that this would be a relatively straightforward exercise following on from the agreements put in place for previous projects. However, this is not the case for all sewerage undertakers.

4.3. Metrics

On the basis of the findings from this trial, the existing Enhanced Metric for pipes can be used successfully to assess capacity of surface water sewers where models are available. As discussed in Section 3.7, the existing Initial Metric for pipes should not be used.

In theory it would be possible to use the Enhanced Metric for other types of surface water drainage assets, but because of the reliance on detailed hydraulic models, the practicality of this is uncertain and it is anticipated that this would be challenging.

Any decision to develop a new Initial Metric should involve a review of the purpose and value of such an exercise. Assuming it is decided that a new Initial Metric is needed, either because (a) the coverage for surface water sewers needs to be increased or (b) other types of surface water drainage assets are to be included, it will first be necessary to understand better what data is available. If the focus is solely on surface water sewers, this will be a relatively straightforward exercise. However, if the intention is to expand the Framework to other types of surface water drainage, this will be significantly more challenging, as discussed in Section 4.1.

4.4. Size of hexagons

Based on the feedback received from the sewerage undertakers participating in this trial, it is believed that the 10 km diameter hexagons remain the most appropriate for the purpose of a high-level, national-scale assessment of capacity. There are benefits, however, of also using 1 km diameter hexagons as part of the CAF approach - in particular to enable sewerage undertakers to compare the CAF results with catchment-scale assessments.

Therefore, it is recommended that further consideration is given to allowing the CAF approach to use different sized hexagons to support different applications of the results. For example, national and regional-scale assessments might focus on the 10 km diameter results and catchment-scale management planning (as part of DWMPs) might also utilise the 1 km diameter results.

It is also recommended that any future modifications to the CAF approach should take into consideration feedback received from stakeholders on the interpretation and usability of the 10 km diameter hexagons for the foul/combined mapping to be published shortly.

Based on the findings from this trial and discussions during the previous phases of work, the main benefits of using 10 km diameter hexagons are considered to be the following:

- The impact of the visualisation of the CAF results on a national map (i.e. they look better than smaller hexagons and the brain can process the information more quickly).
- The high-level nature of the assessment is demonstrated, as it is not possible pin-point the performance of individual catchments, but it is possible to see the variation in Risk Level across urban conurbations.

Based on the finding of this trial, the main benefits of using 1 km diameter hexagons are considered to be the following:

- The fragmentation of sewer networks, especially in more rural areas and especially for surface water sewers, is more readily demonstrated.
- It is easier to identify specific areas within catchments and/or urban conurbations that have high Risk Levels, which would otherwise unduly influence the overall Risk Level for the comparative 10 km diameter hexagon.

4.5. Thresholds for mapping

A threshold to prevent hexagons with a low density of pipes from having unrealistically high Risk Levels in the mapping appears to have been successfully applied in this trial. A threshold of 2500 m total pipe length per 10 km diameter hexagon was applied and, based on the feedback received from the sewerage undertakers participating in the trial, this is considered to have adequately addressed their concerns. However, should it be decided that UK-wide surface water sewer mapping will be produced, further sensitivity testing and statistical analysis should be carried out on this threshold to ensure that Risk Levels are appropriate overall. This would present an opportunity to look more closely at what would be deemed as localised restrictions in capacity (and likely to be dealt with using small-scale innovations), and therefore should be excluded from this high-level assessment. It would also be possible at this stage to consider how best to take into account pruned networks.

On the basis of it being decided that the mapping for surface water sewers should include the 2500 m threshold as presented in this report, the accompanying description for Risk Level N/A should be changed to the following:

These areas have no surface water sewers or there are too few surface water sewers to be included in this high-level assessment or the surface water sewers in this area have already been assessed as low risk and not included in this assessment.

If it is decided that the mapping should be produced using hexagons of a different diameter, further work would be required to identify a suitable threshold. For example, this project has not reviewed the need for or suitability of applying a threshold of 250 m for 1 km diameter hexagons.

4.6. Risk levels and aggregate scoring

The aggregate scoring of hexagons applied to the foul/combined (Enhanced Metric) mapping (based on 15% bands) has also been applied to the surface water sewer mapping in this trial. This appears to have been successful and no modifications are required to the CAF approach for surface water sewers - assuming that the Enhanced Metric for pipes continues to be used (see Section 4.3).

However, consideration should be given to the different levels of service required from surface water networks compared to foul/combined networks, which means that the descriptions for Risk Levels 1 to 5 for surface water sewers should be reviewed and modified accordingly. Consideration should also be given to the accompanying narrative, should the foul/combined mapping and surface water mapping be placed side by side.

4.7. Confidence

As discussed in the recommendations report from the previous project, there are concerns that the CAF approach at present does not represent the level of confidence in the assessment results.

Based on the feedback received from sewerage undertakers, it is reasonable to assume that generally confidence is lower for the existing surface water sewer models than foul/combined sewer models, because fewer surface water sewer models have been fully verified. There may also be greater variability in confidence, as modelling approaches differ between sewerage undertakers to a greater extent for surface water sewers than foul/combined sewers. However, there is a difference between knowing that confidence is low and/or variable and bench-marking the performance data in a way that ensures consistency across all sewerage undertakers. It is also important to bear in mind that this is only a high-level assessment for strategic decision-making. Therefore, the question remains as to what influence knowing the confidence in the mapping would have on decision-making or any other use of the results.

Therefore, as per the CAF guidance for foul/combined sewer models, it is recommended that a minimum standard is set for surface water sewer models for use in this high-level assessment. It may be possible for this to be set at a lower level than currently recommended for foul/combined sewer models. This would require further investigation.

Developing the CAF approach to include a representation of levels of confidence should only be considered once the costs and benefits of increasing the rigor of the CAF approach and providing more detailed mapping compared to keeping things as they are (with perhaps expanded narrative). Now that mapping is available to stakeholders, this presents an opportunity to identify the benefits and to ask for feedback on how understanding confidence might add to these benefits.

Added to this, the development of the framework for Drainage and Wastewater Management Plans (DWMPs) may also present an opportunity to review how confidence is assessed and reported. Therefore, it is recommended that any future review of the CAF approach should align as closely as possible to the DWMP approach.

4.8. System types

As can be seen from the system types provided in the data used for the trial (see Section 2.3), surface water sewers are sometimes given a multitude of names. Added to this, surface water sewer models can contain assets that are not owned by the sewerage undertaker, such as highway drainage and local watercourses. Over time, especially with the anticipated increase in adoption of SuDS by sewerage undertakers, data regarding asset type will become more important.

The approach adopted by Northumbrian Water of having a standard naming convention (Section 2.3) proved helpful and, therefore, it is recommended that all future models (and associated GIS databases) should apply a standard naming convention to enable easy identification of asset type and owner. However, it is recognised that sewerage undertakers have a legacy of changed ownership and different methods for recording data over many years. Therefore, it is unrealistic to expect existing databases and models to be updated except on an ad hoc basis. This means that a degree of uncertainty regarding the results from the high-level assessment will remain for the time being.

Appendices

A. Draft and revised mapping for surface water sewers

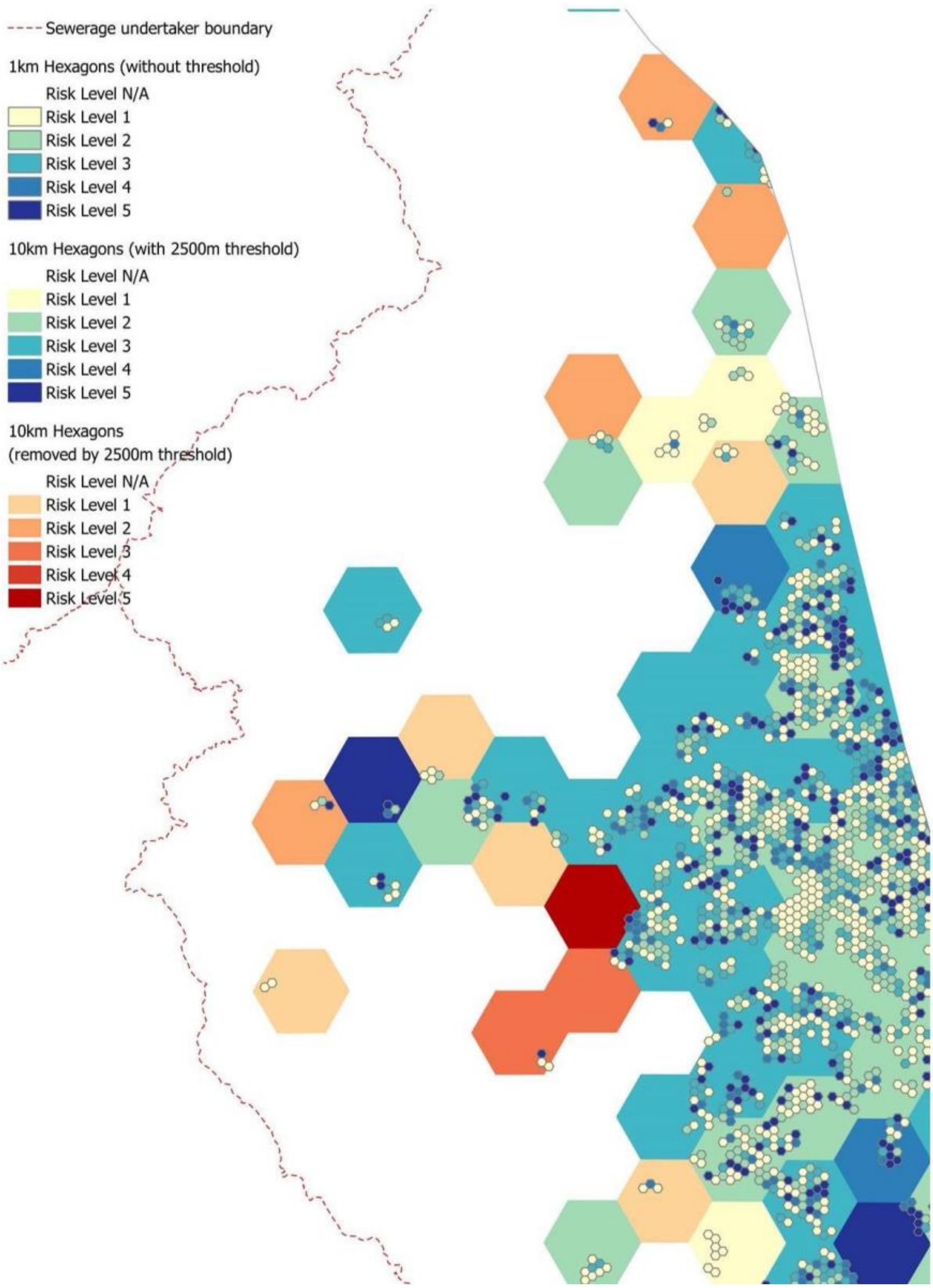

Figure A.1: Selected hexagons for exclusion from revised mapping for surface water sewers - 10 km diameter hexagons - example for part of Northumbrian Water

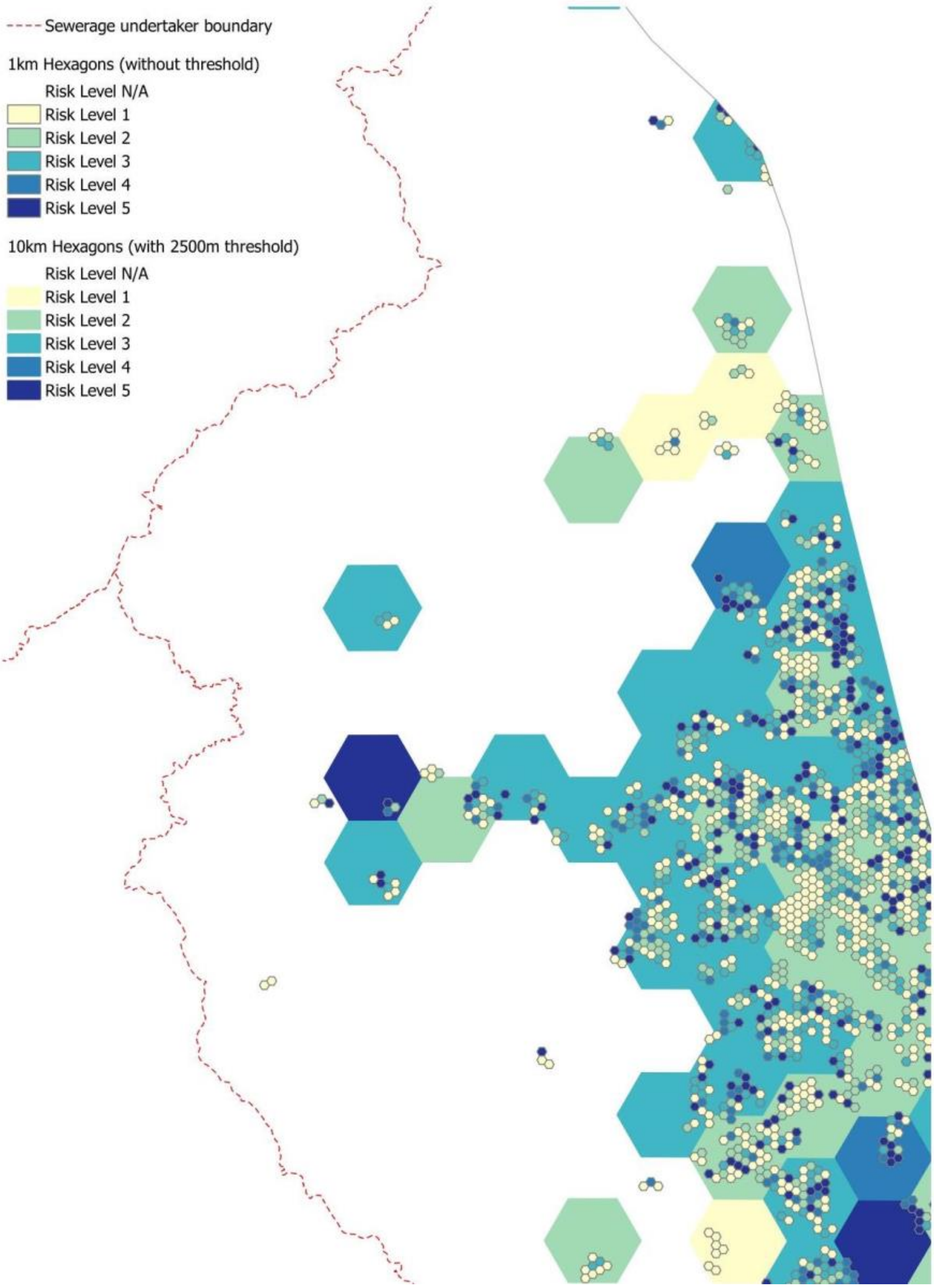

Figure A.2: Revised mapping for surface water sewers - 10 km diameter hexagons - example for part of Northumbrian Water

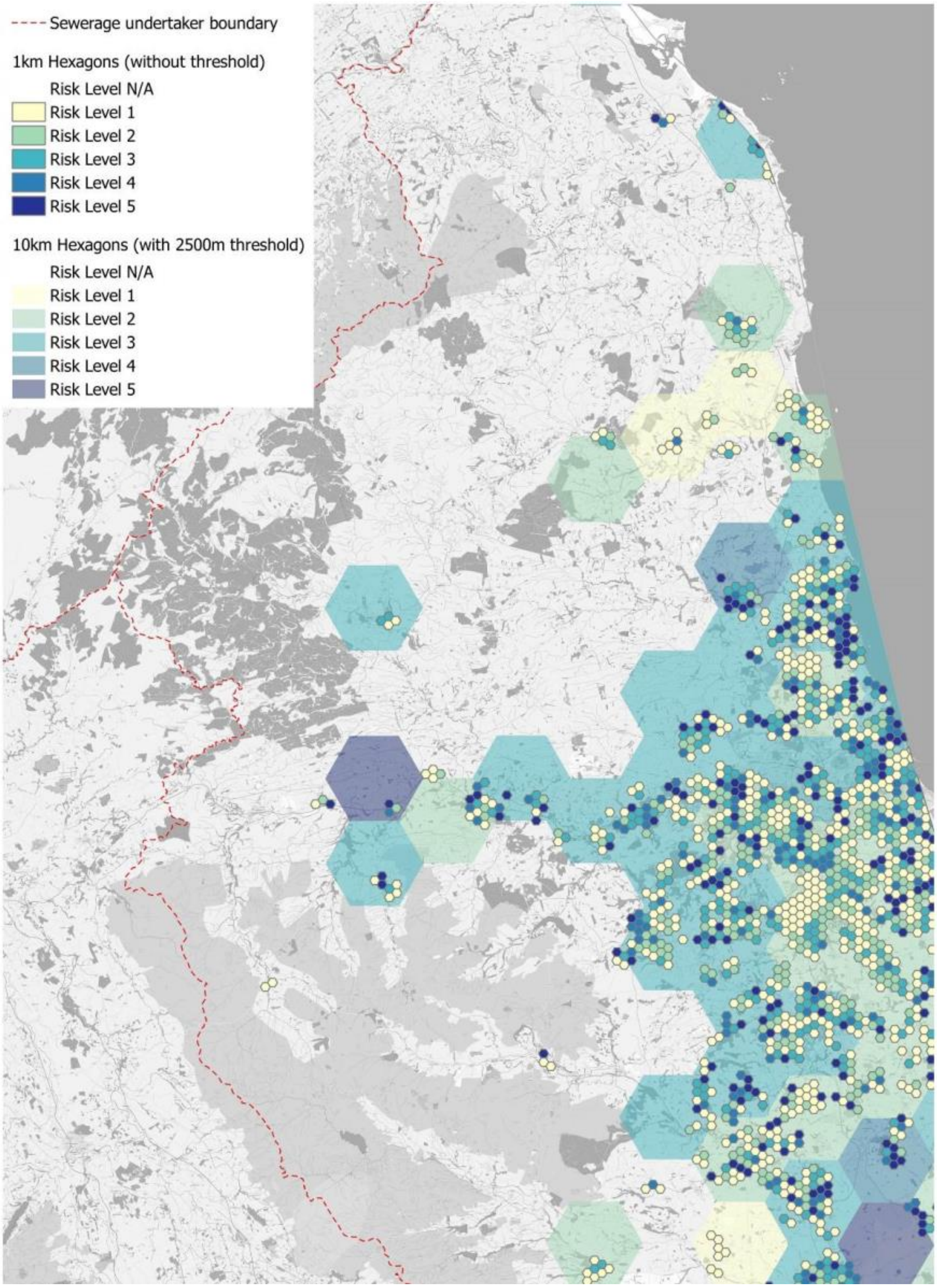

Figure A.3: Revised mapping for surface water sewers with OS map background - 10 km diameter hexagons - example for part of Northumbrian Water

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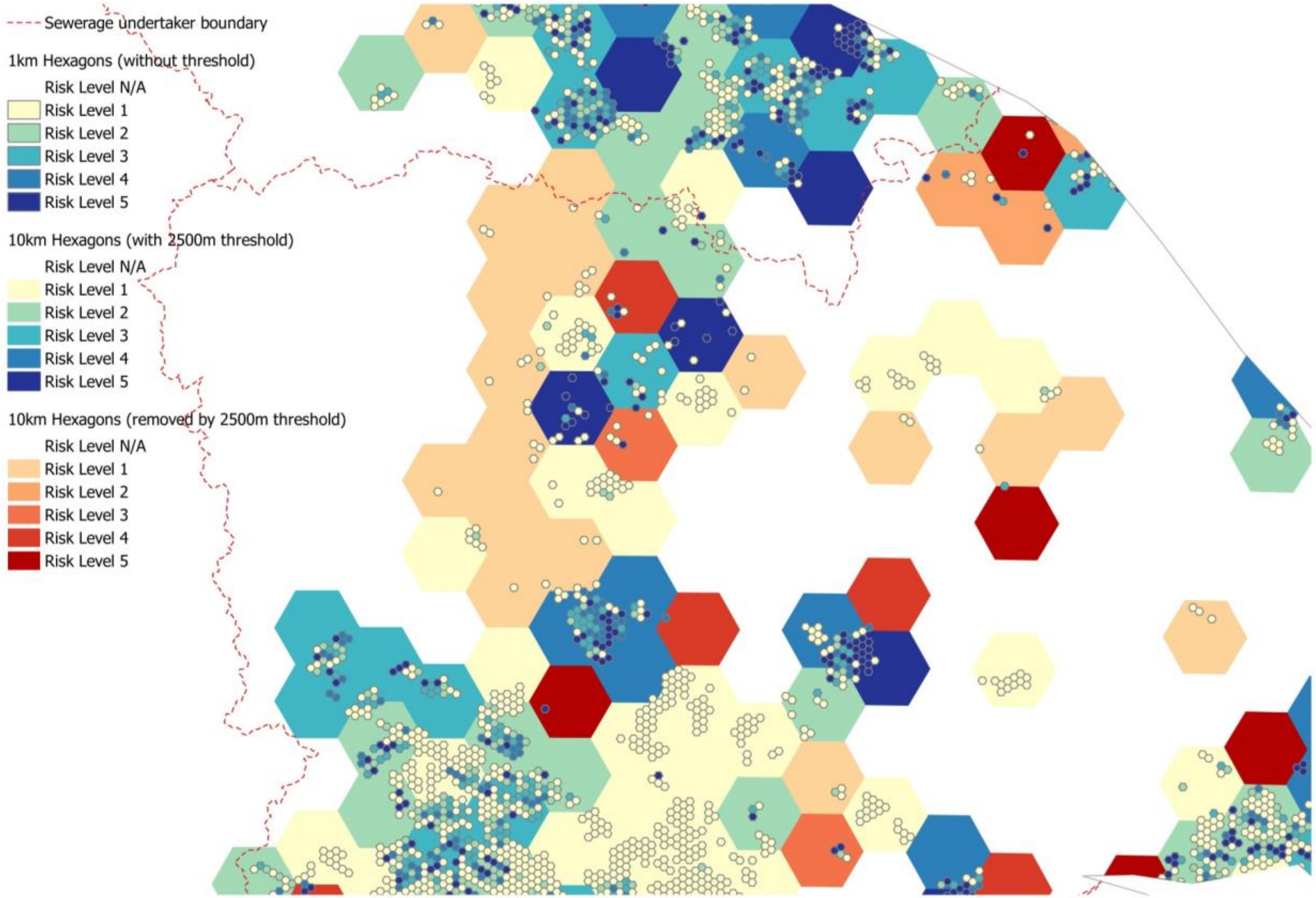

Figure A.4: Selected hexagons for exclusion from revised mapping for surface water sewers - 10 km diameter hexagons - example for part of Yorkshire Water

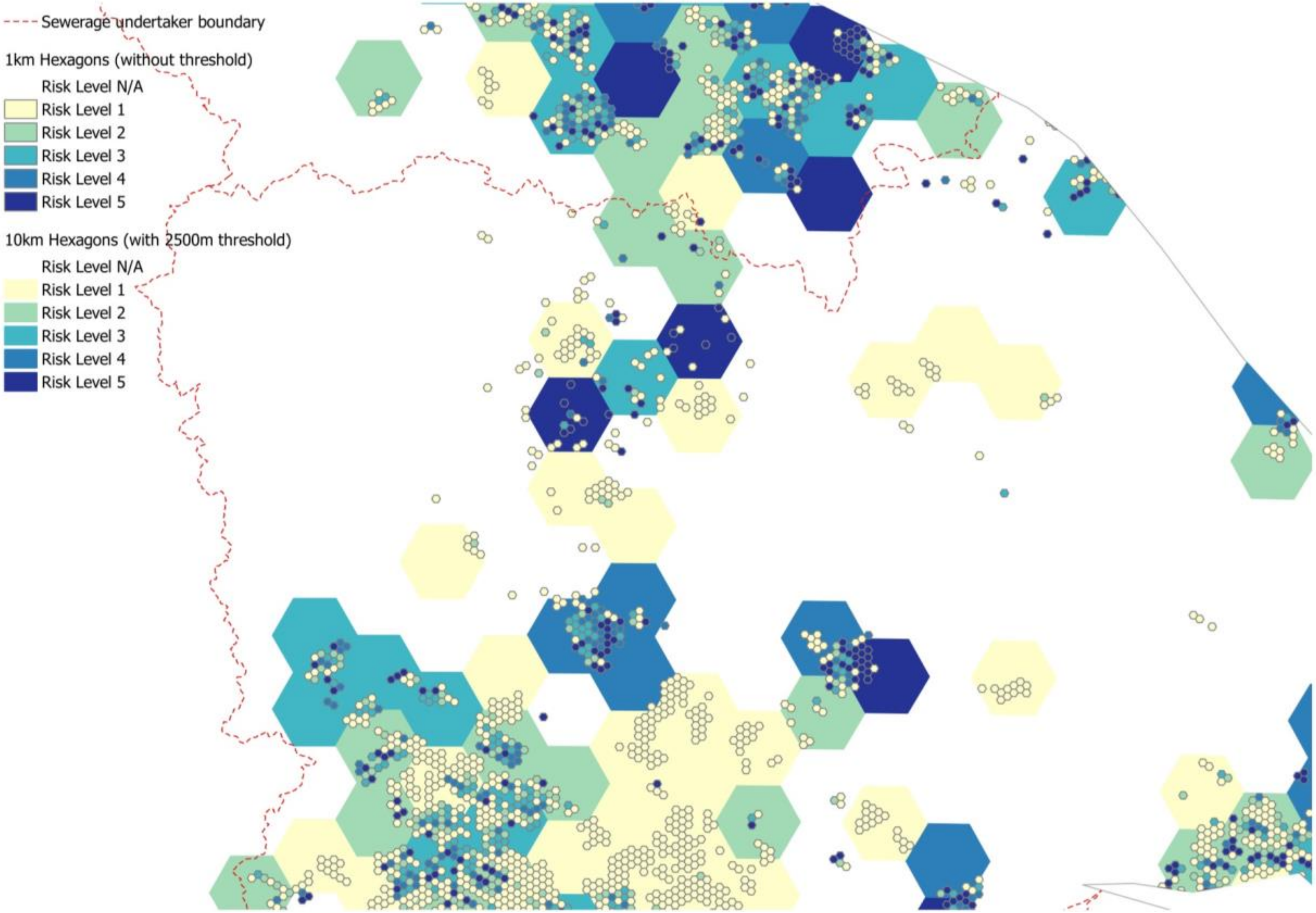

Figure A.5: Revised mapping for surface water sewers - 10 km diameter hexagons - example for part of Yorkshire Water

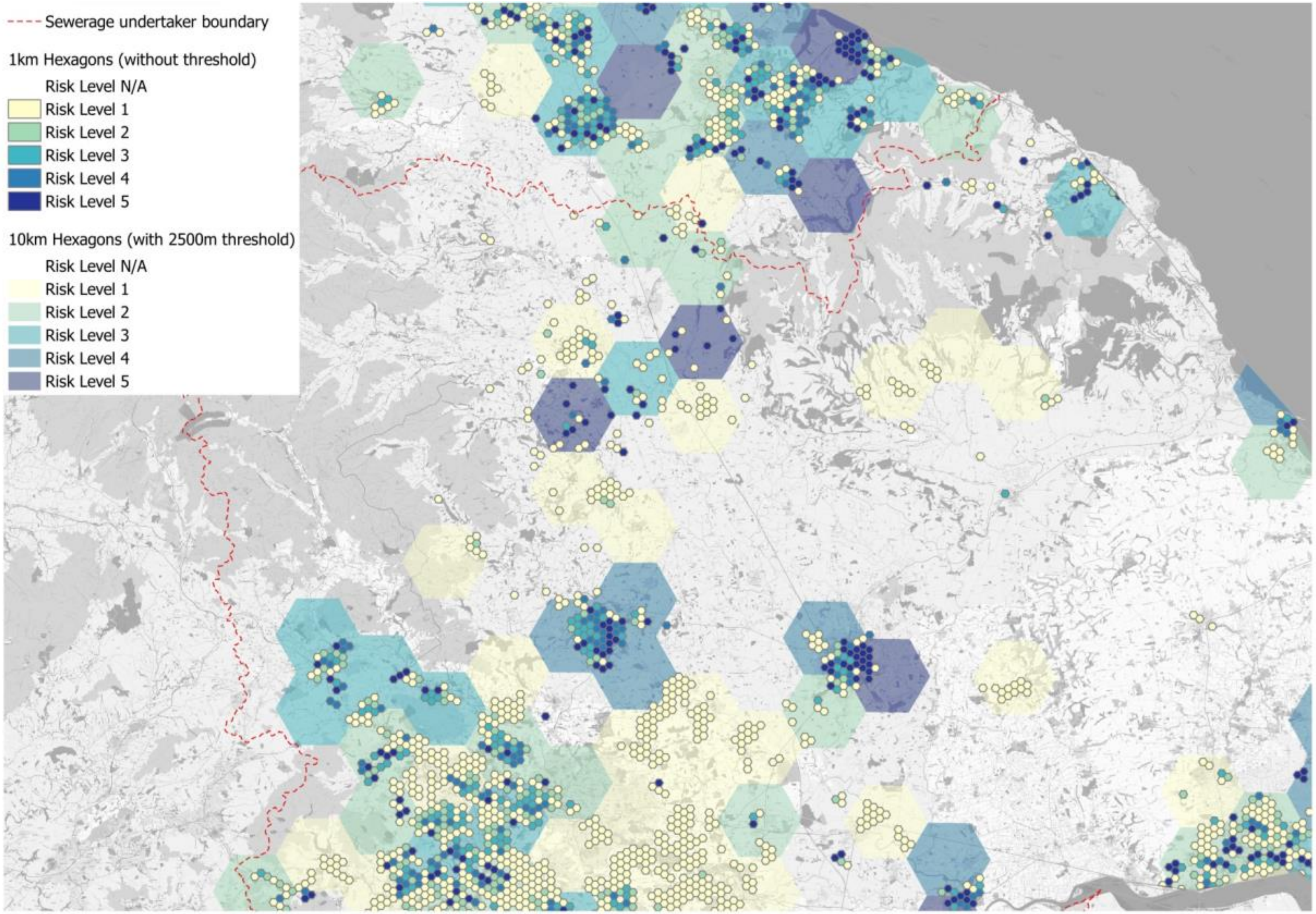

Figure A.6: Revised mapping for surface water sewers with OS map background - 10 km diameter hexagons - example for part of Yorkshire Water

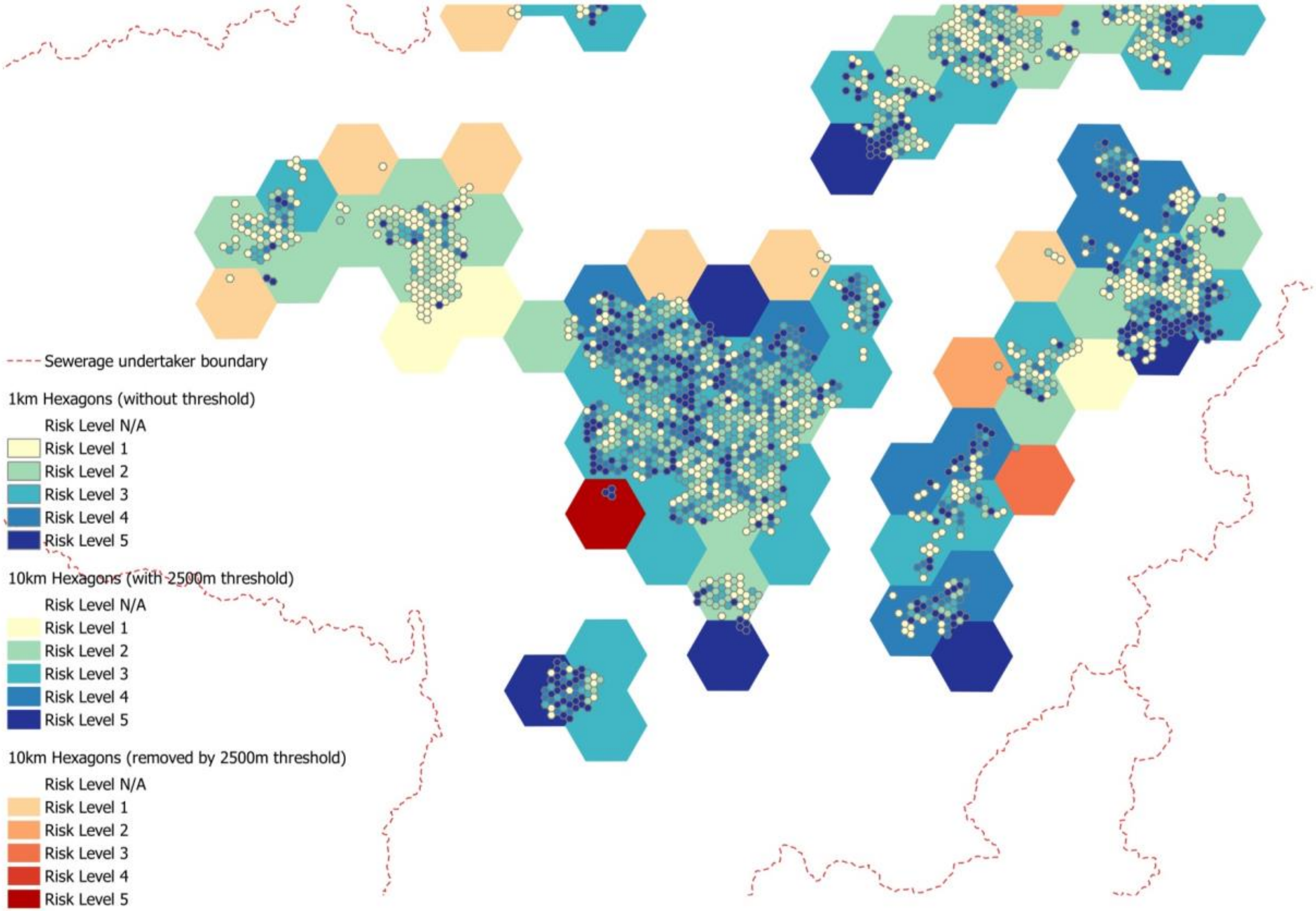

Figure A.7: Selected hexagons for exclusion from revised mapping for surface water sewers - 10 km diameter hexagons - example for part of Severn Trent Water

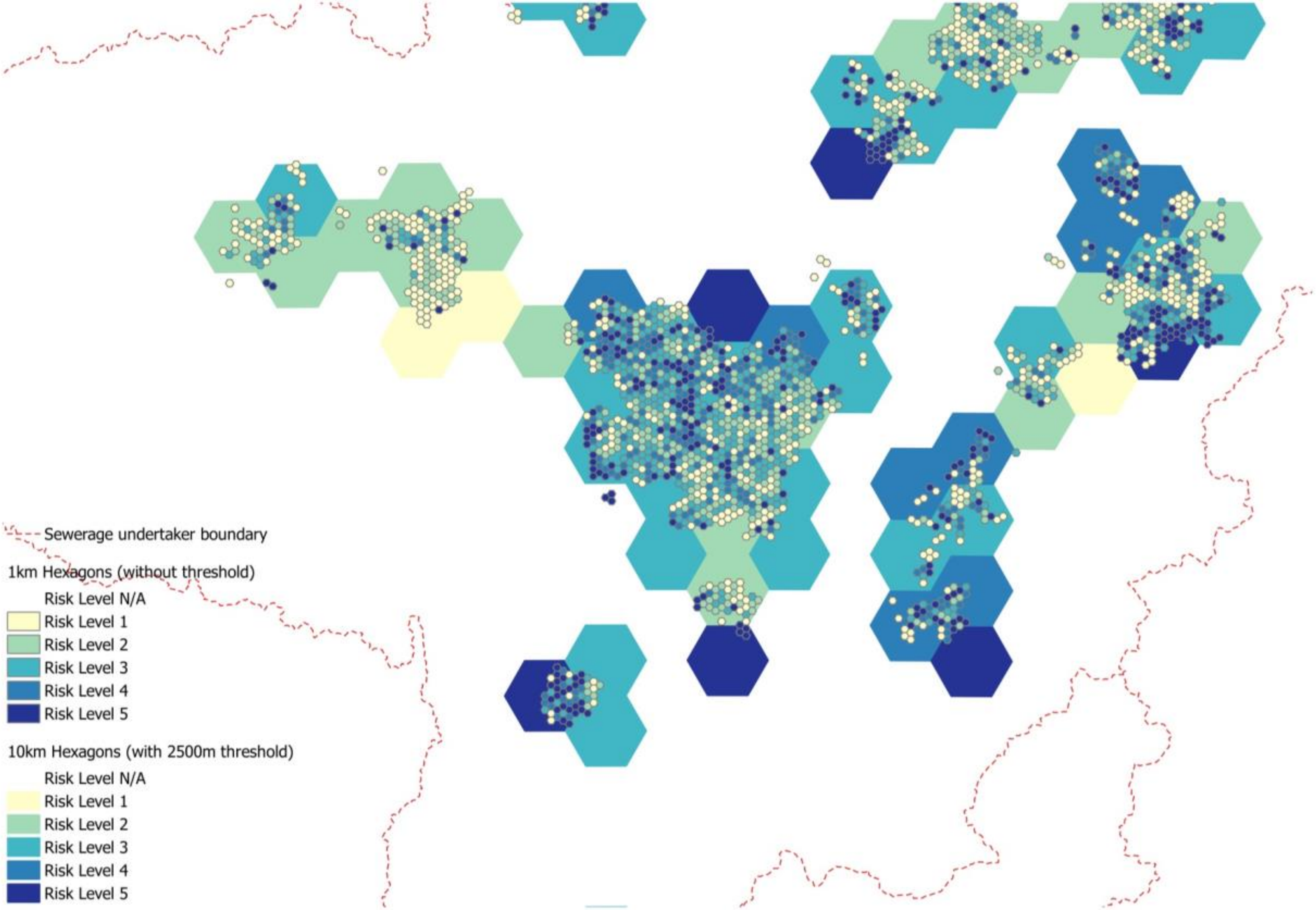

Figure A.8: Revised mapping for surface water sewers - 10 km diameter hexagons - example for part of Severn Trent Water

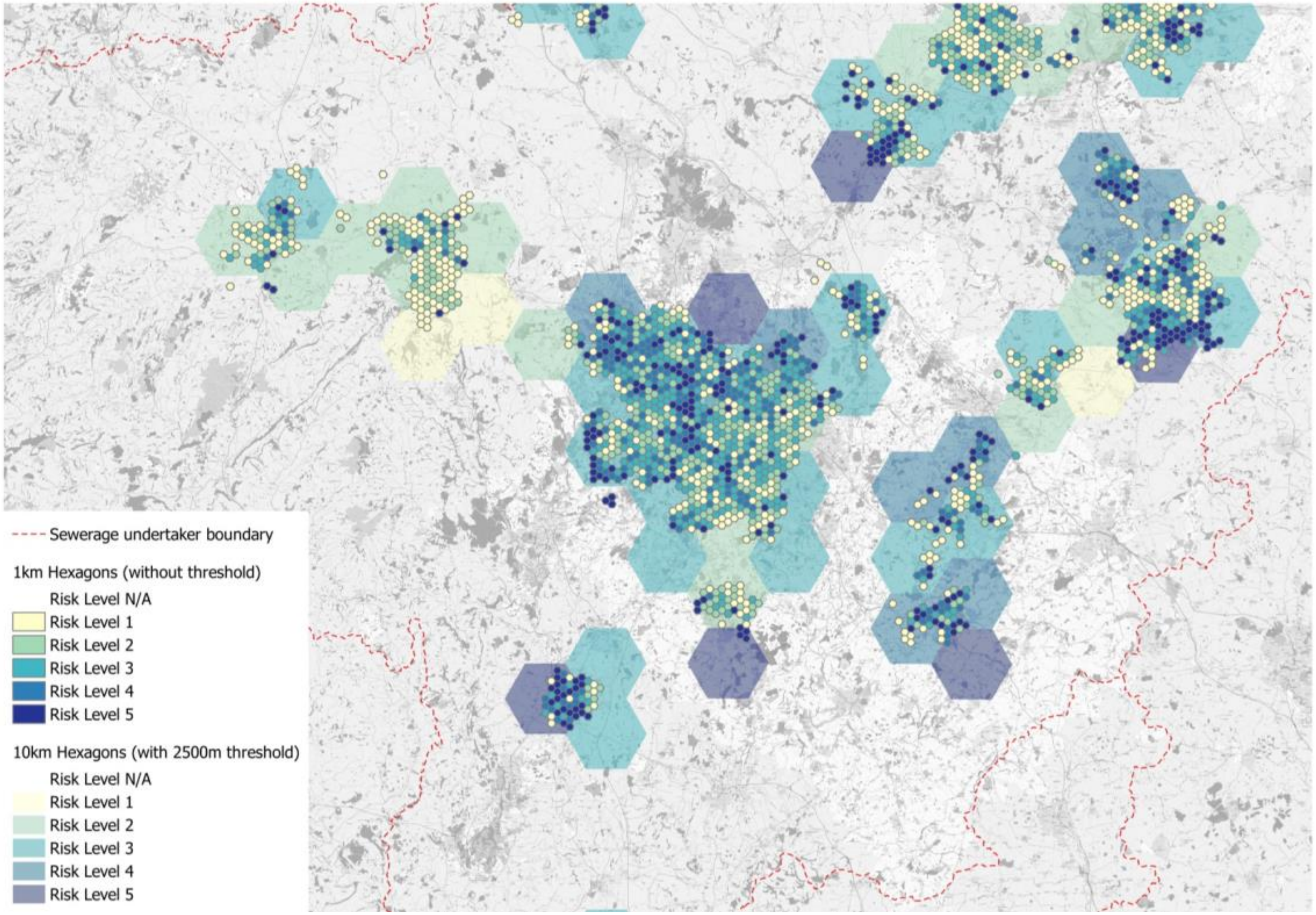

Figure A.9: Revised mapping for surface water sewers with OS map background - 10 km diameter hexagons - example for part of Severn Trent Water

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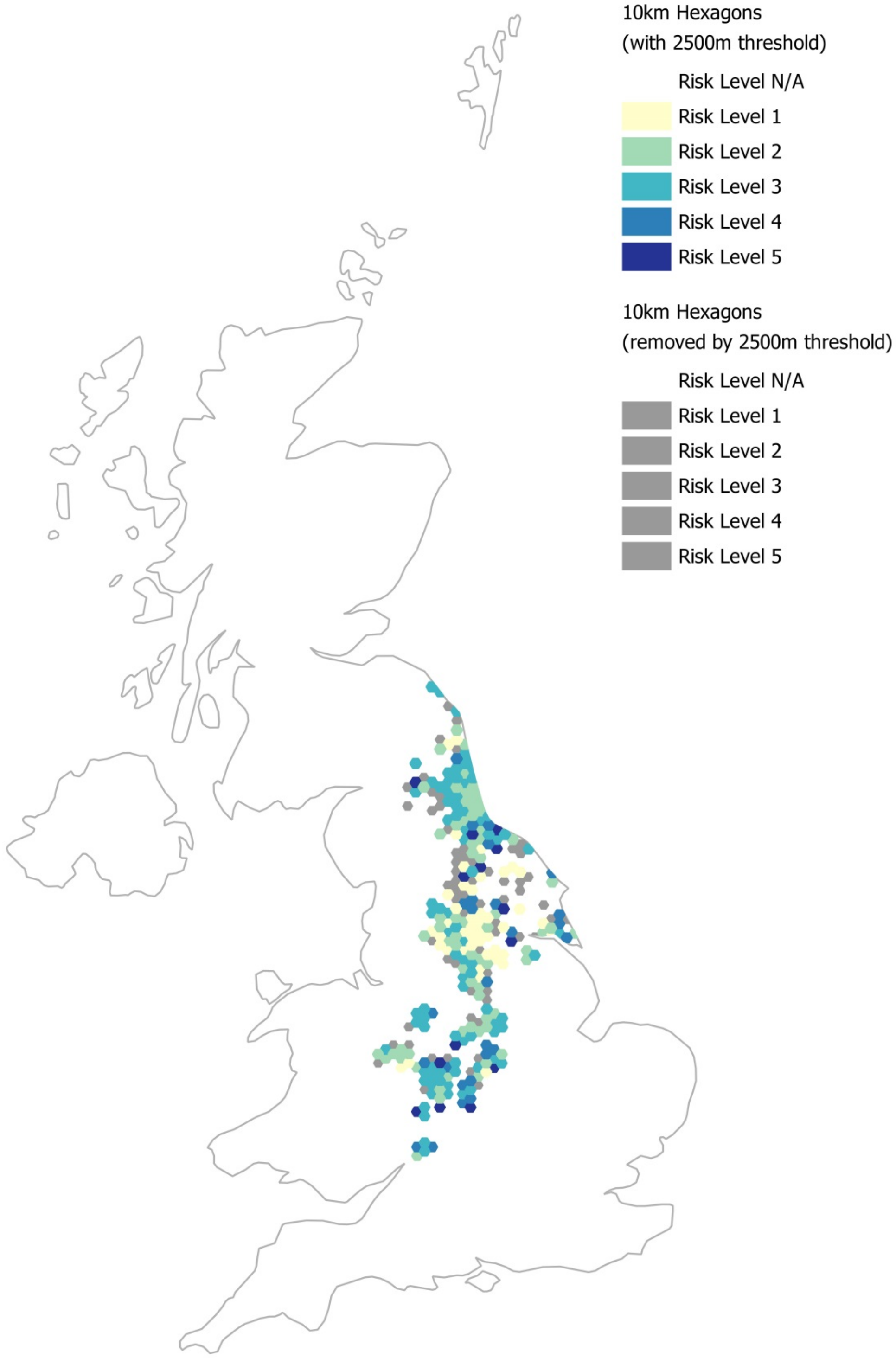

Figure A.10: Revised mapping for surface water sewers using grey hexagons for those removed by the 2500 m threshold - 10 km diameter hexagons

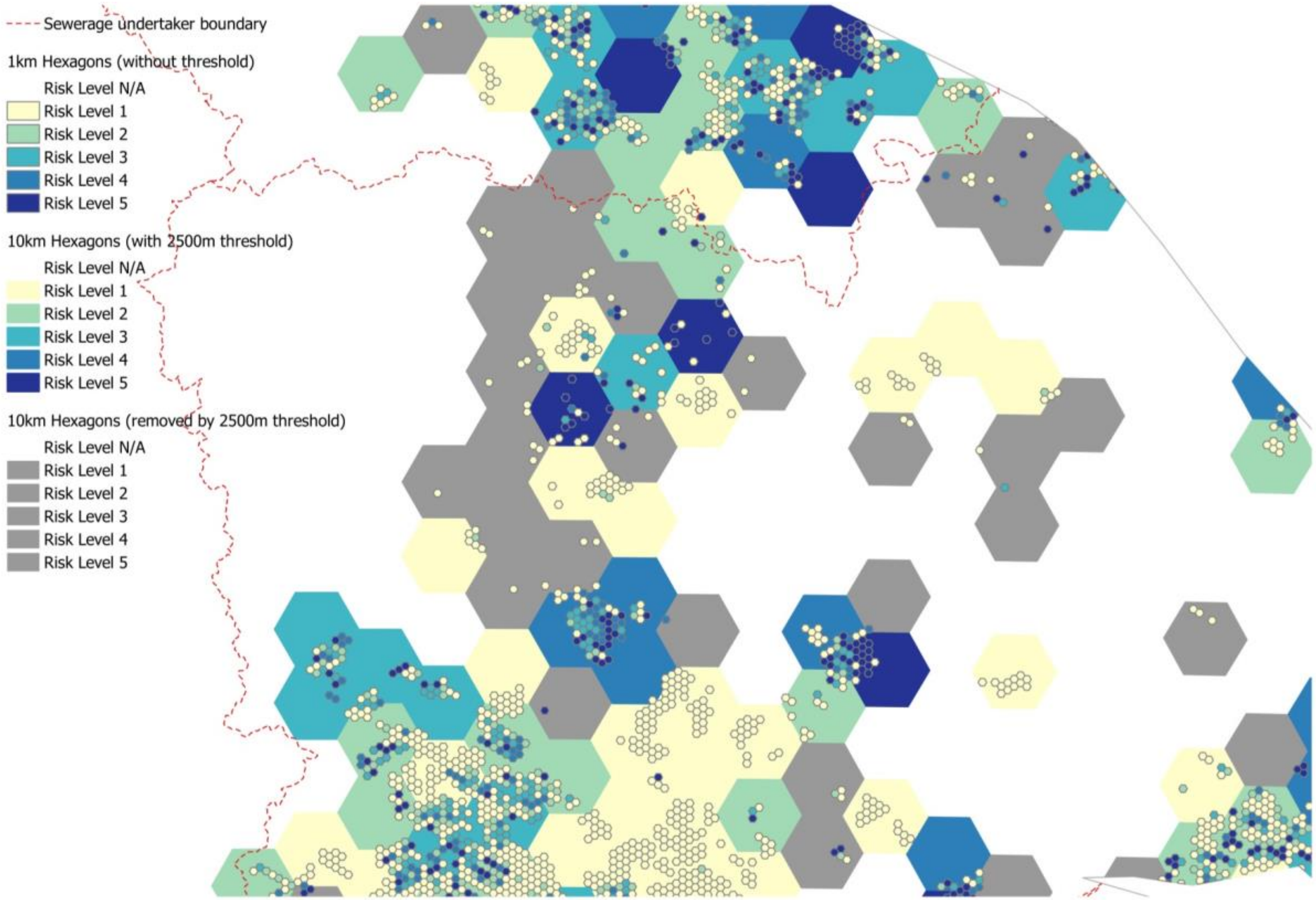

Figure A.11: Revised mapping for surface water sewers using grey hexagons for those removed by the 2500 m threshold - 10 km diameter hexagons - example for part of Yorkshire Water

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