Drainage and Wastewater Management Plans (DWMPs)

Summary of the methodology for the Baseline Risk and Vulnerability Assessment (BRAVA) on:

Groundwater Pollution

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Contents

1. Introduction

1.1. Purpose

The purpose of this document is to provide a summary of the method for undertaking the Baseline Risk and Vulnerability Assessment (BRAVA) for the planning objective to **reduce groundwater pollution** from drainage and wastewater systems.

The BRAVA is an important step in the development of Drainage and Wastewater Management Plans (DWMPs). It is an assessment of current and future risks for each of the planning objectives and is undertaken for the sewer catchments that were flagged during the Risk Based Catchment Screening (RBCS).

All Water and Sewerage Companies (WaSCs) were required to complete a BRAVA and report to Water UK on the following six national planning objectives:

1. Risk of sewer flooding in a 1 in 50 year storm
2. Storm overflow performance
3. Risk of WTW compliance failure
4. Internal sewer flooding risk
5. Pollution risk
6. Sewer collapse risk

We developed methodologies for conducting these six BRAVAs in accordance with the Water UK guidance and completed the BRAVAs in December 2020. The methodologies and outputs are published on our website at: https://www.southernwater.co.uk/dwmp/baseline-risk-and-vulnerability-assessment

We identified that two additional 'bespoke' objectives would complement the six common national objectives and have included these in our DWMPs:

7. Annualised Flood Risk - which is the flood risk arising from sewers as a result of different severities of rainfall
8. Wastewater Treatment Works (WTW) Dry Weather Flow (DWF) Compliance – to assess our compliance with the Environment Agency (EA) permit relating to the DWF arriving at a wastewater treatment works.

We are working collaboratively with partner organisations in the development of our DWMP. Through this collaboration we identified six additional planning objectives that will help us to achieve the wider environmental outcomes that our customers expect and we want to achieve. They are:

1. Secure nutrient neutrality
2. Achieve Good Ecological Status / Potential
3. Reduce groundwater pollution
4. Improve bathing waters
5. Protect shellfish water quality
6. Improve surface water management

Further information on planning objectives for DWMPs can be found on our website: https://www.southernwater.co.uk/dwmp/planning-objectives.

1.2. Objective

The inclusion of a planning objective on groundwater pollution in our Drainage and Wastewater Management Plans (DWMPs) is a significant step forward in safeguarding the groundwater environment for future generations. Protection of the groundwater quality ultimately enables the protection of:

- the quality of our drinking water resources
- the quality and ecological health of surface water bodies (streams, rivers and estuaries)
- the quality, flora and fauna in our groundwater dependant terrestrial ecosystems (GWDTEs).

A strategic and risk-based approach to the protection of groundwater quality from pollution caused by drainage and wastewater systems, or the lack of any drainage and wastewater systems, will help with many of the environmental issues that are currently occurring. It is recognised that it will not be possible to apply measures everywhere but with some core collaborative strategies and good management it is likely that future intervention can be targeted at the highest risk locations and prioritised to maximum effect.

This opportunity should present a major step forward in helping deliver the objectives and environmental outcomes of the Water Framework Directive (WFD), particularly with the delivery of the Catchment Schemes through the Environment Agency's Water Industry National Environment Programme (WINEP).

The issues that the DWMPs will help to highlight include:

- Increasing nitrate (or ammonia) concentrations in groundwater
- Increase in incidents of microbiological contamination of groundwater
- Development pressures – especially future housing needs
- Cumulative effects of private discharges to ground
- Groundwater flow and flooding, and
- That groundwater is 'out of sight' but not 'out of mind' for the management of water in the environment.

The BRAVA assessment for groundwater pollution will start to identify the potential sources of pollution, and assess the likelihood and consequences of any pollution so actions can be identified in the DWMP investment needs plan to reduce and manage those risks.

1.3. Background

Nitrate is the single biggest groundwater quality issue. Within England there is a widespread rise in nitrate concentrations in groundwater. This is a particular concern in the South-East of England as our water supplies are predominantly reliant on the transmission and storage of groundwater from the widespread chalk aquifer that underlies much of the region. This extends throughout parts of Kent, Sussex, Hampshire and the Isle of Wight and makes up 70% of our total water supply.

All groundwater bodies, delineated for the WFD, are designated as Drinking Water Protected Areas, and in many areas Safeguard Zones (SGZ) are designated as a result of increasing nitrate concentrations. With this widespread rise in nitrate concentrations, low nitrate waters for blending are becoming increasingly limited and water supply companies are now installing costly treatment plants to remove nitrate from water supply.

We are working with Catchment Partnerships and Natural England to identify and address diffuse sources of nitrate pollution arising from farming practices. We have established farm cluster groups with farmers to improve agricultural practices to reduce nitrate run-off from fields into rivers and groundwater, as well as financially supporting rural homeowners to replace leaking septic and oil tanks.

The DWMP has the ability to target sources of nitrogen introduced to groundwater by sewage effluent. Raw sewage has a high ammoniacal nitrogen content which can transform in the presence of oxygen in surface waters and in the ground, via nitrite, to nitrate.

There is also a risk of local microbiological contamination which can cause significant problems for drinking water supply.

1.4. Definitions[1]

Groundwater Quality Safeguard Zones (SGZs) are designated areas in which the use of certain substances must be carefully managed to prevent the pollution of raw water sources that are used to provide drinking water and to avoid extra treatment of water. Safeguard Zones are one of the main tools for delivering the drinking water protection objectives of the WFD, and they are the highest priority areas for protecting and improving groundwater quality.

Groundwater Source Protection Zones (SPZ1, SPZ2 and SPZ3) are designated areas around wells and boreholes used for potable public water supply[2]. SPZ1 (Inner Protection Zone) is the zone within a 50 day travel time from any point below the water table to the abstraction point with a minimum default distance of 50m from the source. SPZ2 (Outer Protection Zone) is the zone around the borehole site outside of SPZ1 defined as the 400 day travel time from below the water table to the source. It covers a 250 or 500 metres minimum radius around the source depending on the amount of water taken. SPZ3 is the total catchment within which all the groundwater ends up at the abstraction point.

Designated SGZs generally cover SPZs1 and 2, but for nitrate they can extend to cover SPZ3.

Aquifers have been divided into three categories; Principal Aquifers; Secondary Aquifers and Unproductive Strata. The categories are defined by the EA[3] as;

- Principal Aquifers “are layers of rock or drift deposits that have high intergranular and/or fracture permeability - meaning they usually provide a high level of water storage. They may support water supply and/or river base flow on a strategic scale.”
- Secondary Aquifers include a wide range of drift and bedrock types and are sub divided into three types:

[1] Source: https://www.gov.uk/government/publications/protect-groundwater-and-prevent-groundwater-pollution/protect-groundwater-and-prevent-groundwater-pollution
[2] https://www.gov.uk/guidance/groundwater-source-protection-zones-spzs
[3] Source: http://apps.environment-agency.gov.uk/wiyby/117020.aspx

  - Secondary A aquifers are “permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers.”
  - Secondary B aquifers are “predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering. These are generally the water-bearing parts of the former non-aquifers.”
  - Secondary Undifferentiated was assigned “where it has not been possible to attribute either category A or B to a rock type.
- Unproductive Strata are “rock layers or drift deposits with low permeability that have negligible significance for water supply or river base flow.” Note: unproductive strata are not mapped.

Aquifers can be unconfined or confined. An unconfined aquifer is when the upper surface of the aquifer (and water table) is open to the atmosphere either directly or through permeable overlying material. Because of this it’s more vulnerable to pollution than a confined aquifer. A confined aquifer is overlain by a low permeability material (for example clay) that does not transmit water in any appreciable amount. It’s less vulnerable to pollution than an unconfined aquifer because there is greater protection.

Nitrate is likely to be the dominant form of nitrogen in oxygenated unconfined aquifers. In confined aquifers, nitrate will reduce to ammonia as oxygen levels decrease.

1.5. Scope

There are many potential sources of groundwater pollution from drainage and wastewater systems, as well as from other sources such as agriculture. For this risk assessment we will initially focus on the sources from the wastewater systems that we own and operate.

The scope for this first BRAVA on groundwater pollution is to include three top issues. These are:

a) **Assessment of the risk arising from the integrity of our sewers** in Groundwater Safeguard Zones (and specifically high vulnerability Source Protection Zones). This could then lead on to future sewer replacement, or lining, in areas where it is deemed necessary to stop contaminants being discharged. This would enable a future work plan to be developed on a risk assessed basis.

b) **Assessment of storm overflows that allow discharge to ground**, specifically in high vulnerability Source Protection Zones.

c) **Assessment of the risk of ingress of groundwater to sewers** as an indicator of the risk of egress of contaminants to groundwater, and the interactions between the sewer and the groundwater. This will identify areas of the sewerage network prone to influence by groundwater flow or flooding. The groundwater in these locations is more susceptible to pollution as it is nearer to the ground surface.

The BRAVA will identify areas where we are concerned about the performance of our wastewater system in relation to the potential impact on groundwater quality. We will then be able to

investigate these further as part of the problem characterisation stage of the DWMP before developing options to improve our systems.

We have 22 Wastewater Treatment Works (WTW) discharging treated final effluent to ground. Detailed hydrogeological investigations were completed for all the sites in AMP3 (covering the period 2000 – 2005) and AMP4 (2005 – 2010) to assess compliance with the Groundwater Regulations, 1998, with the sites now requiring to be complaint with the Environmental Permitting (England and Wales) Regulations 2016[4].

Following on from the investigations,16 of the sites have been part of the Effluent and Groundwater Monitoring Action Plan (EGWMAP) programme since 2013 and 2014, with sampling of treated final effluent and groundwater up and downgradient as required by the site permits. Reports are submitted annually for the programme. A 17th site has been recently added to the programme. Seven of the sites are also part of the third phase of the Chemical Investigations Programme (CIP3). CIP is a research programme focused on how trace and emerging substances may impact legislation. CIP3 is the first to include groundwater. The remaining sites undertake Operator Self-Monitoring (OSM) as defined in the site environmental permits.

All discharge to ground sites have had risk assessments completed with ongoing monitoring as required by the environmental permits. As such they have not been included in this assessment.

For this cycle of DWMP the assessment will focus on the 2020 baseline.

1.6. Reporting Requirements

We are not required to report the BRAVA outcomes for our bespoke and additional planning objectives to Water UK. However, we will publish the results on our website for consideration by our customers and partner organisations.

[4] https://www.legislation.gov.uk/uksi/2016/1154/contents/made

2. Data Sources

The following provides a short description of the data that has been used and where it has been obtained from.

2.1. Sewer Length / Sewer Structural Grade

We undertake CCTV surveys to assess the condition of sewers and assign a condition grade to the sewer using a scoring system of 0 to 5 based on its structural condition. Condition grade 1 means it is in good condition and grade 5 means a very poor structural condition. A score of 0 is applied where the condition is unknown.

The condition grades are recorded on our Geographical Information System (GIS) mapping tool called 'Asset Miner'. Our current coverage of CCTV surveys is approximately 10% of the mapped sewer network. In the order of 40% of our sewer network is yet to be mapped (these are mainly the private sewers that were recently transferred over to us). Therefore, the assessment undertaken does not take into account the length of currently unmapped sewers and their condition. However, we generally have good information of the sewer condition grade for most of the groundwater sensitive areas, and this risk assessment can be an additional source of information to help prioritise where future CCTV surveys of the sewer network should be completed.

2.2. Aquifer Designation Mapping

This data is obtained from the EA and provides mapping layers for all principal and secondary aquifers to be used in GIS. Unproductive strata comprises all the remaining rock types that are not explicitly mapped on the aquifer mapping layer.

There are two separate layers, superficial aquifers comprising drift deposits and bedrock aquifers. The layers of superficial and bedrock hydrogeological maps are used separately to identify principal aquifers and secondary aquifers within each deposit. The superficial aquifers are more limited in extent and thickness so, to be conservative, the bedrock aquifer category has been applied for water abstracting from bedrock.

2.3. Safeguard Zone (SGZ) / Source Protection Zone (SPZ) mapping

This data is obtained from the EA and provides mapping layers for all SGZs and SPZs to be used in GIS.

2.4. CSOs Discharging to Ground

We record the permit condition of our assets in a database referred to as CALMS. According to this database we have 12 CSOs discharging to ground.

2.5. Event and Duration Monitoring Data

The Event and Duration Monitoring (EDM) data is recorded by instruments installed in our sewer network to record and monitor any discharges from combined sewer overflows (CSOs). The data is used to assess the performance of storm overflows and determine the frequency of discharges.

A '12 / 24 hour event counting' method is used to count the number of spills per year. The 12hr / 24hr event counting criteria is performed as follows:

- event counting starts when the first discharge occurs
- any discharge(s) in the first 12 hour block is counted as 1 spill
- any discharge(s) in the next and subsequent 24 hour blocks are each counted as 1 additional spill per block
- this counting continues until there is a 24 hour block with no discharge
- for the next discharge after a 24 hour block with no discharge, the sequence begins again.

2.6. Baseline Dry Weather Flow

The Dry Weather Flow (DWF) is the flow arriving at our WTWs in dry weather. It is a measure of the expected baseflow in the sewer system based on the number of properties connected in the catchment.

We submit data to the EA annually in line with our permit conditions to report on the performance of our wastewater systems. The data from the last three years (2017 / 2018 / 2019) compliance record has been used to calculate the three year average DWF. This is compared against theoretical dry weather flow calculated as a function of the population served by a WTWs. The difference between recorded DWF and theoretical DWF allow us to estimate infiltration as described in section 2.7, below.

2.7. Groundwater Infiltration

The contribution of infiltration to baseline DWF is estimated by deducting estimated foul flow from the recorded flow as shown in the equation below:

$$\text{Infiltration } (I_{19}) = DWF_{19} - P_{RC19} \times PCC_{AMP6} \times 0.925 - E_{RC19} - C_{RC19}$$

Where:

P_{RC19} - Resident and Non-resident population reported in RC19 (annual return 2019)
E_{RC19} - Contribution of trade effluent – annual return 2019
C_{RC19} - Contributions from cesspit – annual return 2019

3. Method of Assessment

The following methodology has been developed and is used for the assessing the risk of groundwater pollution.

3.1. Process

The 2020 baseline risk assessment takes into account three potential sources of pollution. These are sewer network condition, CSO spills to ground, and sewer infiltration rates.

Three risk bands are used for the risk assessment in accordance with the Water UK Guidance on DWMPs. These are Band 0 'not significant', Band 1 'moderately significant' and Band 2 'very significant'. The highest assigned band from the risk assessment for each of the three sources of pollution risk is adopted as the overall banding for the wastewater catchment / system.

3.1.1. Sewer Network Condition

The first step in the process is to map the existing sewer network with the SGZs, SPZs and aquifer designation mapping on our GIS to identify which sewers lay within groundwater zones.

The lengths of sewer in each SGZ and SPZ number (1, 2, 3, 4) by structural condition grade (1, 2, 3, 4, 5) are summed for each wastewater catchment. The lengths of sewer in each aquifer type (principal, secondary A, secondary B) which lay outside of any SPZ by structural grade (0, 1, 2, 3, 4,5) are then summed. Weighting factors are applied for each protection area SGZs, SPZ 1, 2. 3 and principal aquifer as shown in Table 1 below. The weighting factor is used in a manner to prioritise the most vulnerable groundwater zones. As such, no allowance of weighting factor is made for secondary aquifers. After the risk in the most vulnerable groundwater zones is identified and removed, further attention can be given to principal and secondary aquifers outside of SGZ and SPZs. Table 2 presents the weighting factor used to structural grades. Structural grades 4, 5 are given the highest weightings.

If a wastewater catchment is intersecting with a groundwater body which has either been identified for nitrate pressures, or as having a high concentration of nitrates, a penalty multiplier of 1.5 is applied to the score.

The wastewater catchments are then ranked and banded 0, 1 or 2 based on thresholds detailed in section 3.2.

Table 1 Weighting factors for consequence of leaking sewers in of groundwater zones and aquifers

GW Zone/ Aquifer Classification	Weighting factor
SGZ	100%
SPZ1	80%
SPZ2	60%
SPZ3	40%
SPZ4	20%
Principal Aquifer	10%
Secondary Aquifer	0%

Table 2 Weighting Factors for likelihood of leakage from sewers in each Condition Grade in Groundwater protected areas

Sewer pipe Structural grade		Weighting factor
0		0%
1		10%
2		20%
3		50%
4		75%
5		100%

3.1.2. CSO Spills to a Groundwater Body

The CSOs with a permit to discharge to ground are overlaid on GIS with both SGZ / SPZ and aquifer designation mapping to identify the groundwater protection zone or aquifer they discharge into.

EDM data is used to calculate the average number of spills for each of these CSOs over the past 3 years (2017 / 2018 / 2019). Weighting factors are then applied to the number of spills based on which SPZ or aquifer type they discharge into. This is similar to the assessment we have used to determine the volume of sewage leaking from the sewer network based on its condition.

The wastewater catchments are then ranked and banded 0, 1 or 2 based on thresholds detailed below in section 3.2.

3.1.3. Groundwater Infiltration

Groundwater infiltration into a sewer network is calculated as set out in section 2.7 above. The rate of infiltration is then adjusted according to the mapped sewer length to give an indicative volume.

The reason for including infiltration in this risk assessment is that sewers that infiltrate are also likely to exfiltrate, and infiltration indicates close proximity of the groundwater saturated zone to the sewer network. The rate of exfiltration will be less than infiltration due to the pressures involved. Close proximity of the water table to the sewer network mean that there is likely to be more interaction between sewage and groundwater, hence the risks of pollution are potentially higher than for groundwater zones where the water table is a long way below the surface.

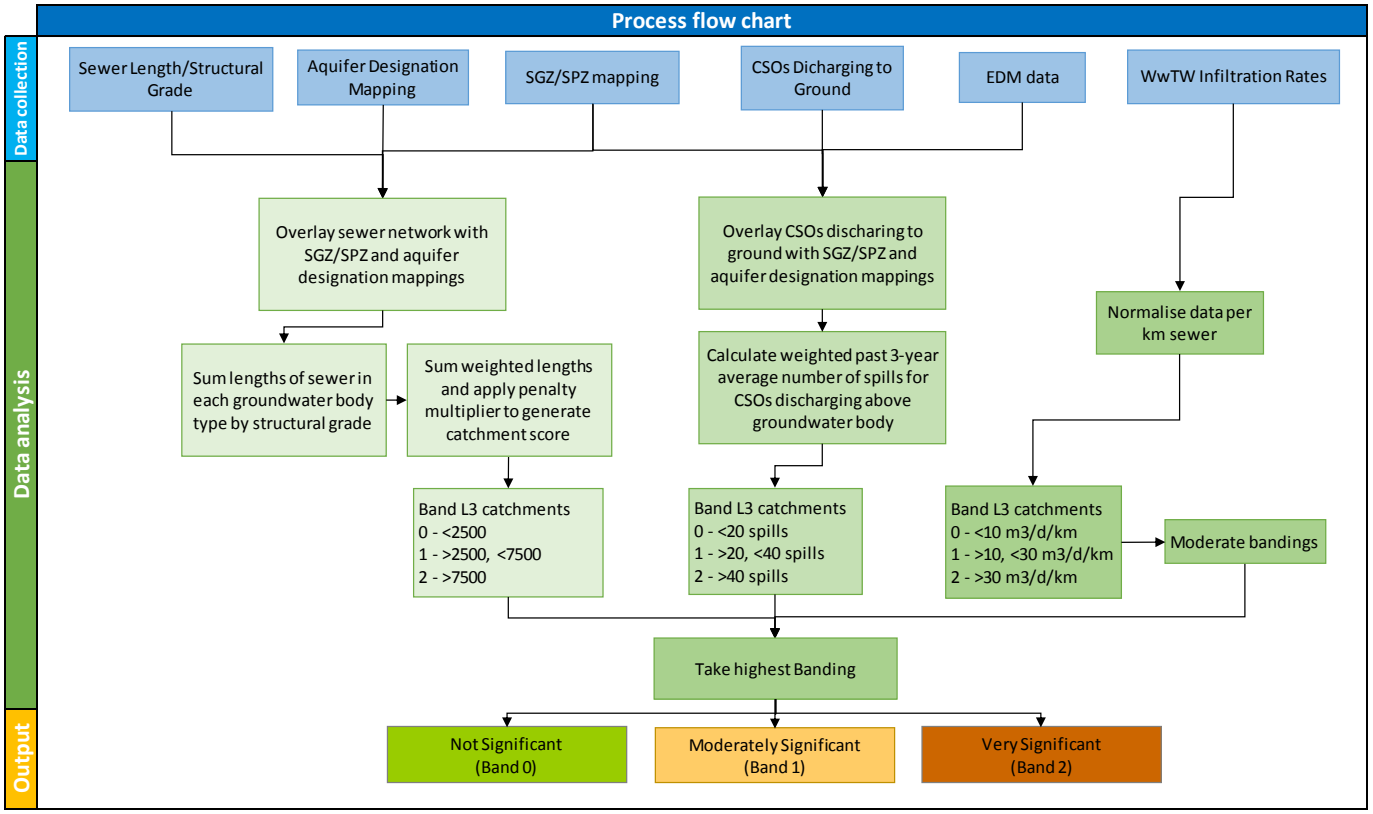
The wastewater catchments are ranked and banded 0, 1 or 2 based on thresholds detailed in section 3.2.

The consequences of pollution in SGZs is of most concern, so the thresholds for the risk bands for infiltration are moderated to take greater account of the percentage of sewer length in SPZ1 and 2. If the overlap between a network catchment which is identified to have an infiltration issue and SPZ1 or 2 is less than 10% (calculated based on length of mapped sewer in SPZ1 and 2), then the wastewater catchment is downgraded to 0. If this is above 10%, the initial banding given to the wastewater catchment remains unchanged.

3.2. Process Flowchart

The process flow chart below describes the steps and procedures followed in assessing the risk of groundwater contamination from the three key issues described in sections above.

Figure 1 – Process flow chart for 2020 baseline Groundwater Pollution



3.3. Thresholds and Bands

The outputs from the data analysis process are:

(a) a sewer network overall condition and length score
(b) weighted number of CSO spills to a groundwater body, and
(c) infiltration rate normalised per km sewer.

These scores are assigned to one of three risk bands 0, 1 and 2. We have assigned a risk band to each of our wastewater systems/catchments.

The assessment criteria (thresholds) and bands shown in the tables below applies to the 2020 baseline assessment. The thresholds for the sewer network condition score were calculated to establish a similar banding to the thresholds for the infiltration rates assuming a typical sewer pipe of 225mm diameter infiltrating 10% of its volume in the ground.

Sewer Network Condition (Score for each WW catchment)		
Assessment Criteria / Thresholds	Bands	
<2500	0	*Not Significant*
>2500, <7500	1	*Moderately Significant*
>7500	2	*Very Significant*

The thresholds for infiltration rates in the table below are based on the 75th and 95th percentiles of all wastewater treatment works.

Infiltration Rates		
Assessment Criteria / Thresholds	Bands	
<10 m3/d/km	0	*Not Significant*
>10, <30 m3/d/km	1	*Moderately Significant*
>30 m3/d/km	2	*Very Significant*

The thresholds set for CSOs discharging to ground are shown in the table below. These have been set with reference to the Environment Agency's Storm Overflow Assessment Framework guidance, using the bands for discharges to fresh waterbodies.

CSO Discharging to Ground in a GW protected area		
Assessment Criteria / Thresholds	Bands	
<20 spills	0	*Not Significant*
>20, <40 spills	1	*Moderately Significant*
>40 spills	2	*Very Significant*

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