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Basingstoke and Deane

Water Cycle Study - Groundwater

Draft

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Prepared by	Parvaneh Aghajani MSc MEng BEng FGS Hydrogeologist
Reviewed by	Michael McDonald BSc MSc PhD CGeol FGS Chief Hydrogeologist Richard Pardoe MSc MEng MCIWEM C.WEM Chartered Principal Analyst
Authorised by	Michael McDonald BSc MSc PhD CGeol FGS Chief Hydrogeologist

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Contract

JBA Project Manager	Richard Pardoe
Address	Pipe House, Lupton Rd, Wallingford OX10 9BS
JBA Project Code	2025s0617

This report describes work commissioned by Basingstoke and Deane Borough Council, by an instruction dated 22 April 2025. The Client's representative for the contract was Anne Shattock of Basingstoke and Deane Borough Council. Parvaneh Aghajani and Alexander Jones of JBA Consulting carried out this work.

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The methodology adopted and the sources of information used by JBA in providing its services are outlined in this Report. The work described in this Report was undertaken between April 2025 and November 2025 and is based on the conditions encountered and the information available during the said period. The scope of this Report and the services are accordingly factually limited by these circumstances.

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1 Groundwater Inputs to Water Cycle Study

1.1 Introduction

Basingstoke and Deane Borough Council (BDBC) has commissioned Jeremy Benn Associates Ltd (JBA) to undertake a Water Cycle Study (WCS) to inform the Council's emerging Local Plan. The purpose of this WCS is to form part of a comprehensive and robust evidence base for the Local Plan, which will set out a vision and framework for development in the area up to 2042 and will be used to inform decisions on the location of future development.

The objective of the WCS is to identify any constraints on planned housing growth that may be imposed by the water cycle. The WCS then identifies how these constraints can be resolved, i.e. by providing a strategic approach to the management and use of water which ensures that the sustainability of the water environment in the area is not compromised.

Development and housing growth in the area result in an increase in the discharge of effluent from Wastewater Treatment Works (WwTWs) which they serve, and can lead to a negative impact on the quality of the receiving waterbody. However, under the Water Framework Directive (WFD), a waterbody, including surface water and groundwater, is not allowed to deteriorate from its current WFD classification (either the overall watercourse classification or for individual elements assessed).

To support the development of a WCS, a Hydrogeological Assessment is advisable where there is a risk of groundwater contamination as a result of proposed development in the Local Plan. This assessment entails a review of the available geological, hydrogeological, and hydrological information to ascertain the potential risk associated with future development within the BDBC, as well as the escalating sewage effluent discharge from water companies into nearby waterbodies, encompassing both surface water and groundwater systems.

1.2 Objectives

The objectives of this study are to:

- Assess the environmental baseline to develop an understanding of the environmental setting of the area, including the hydrology, hydrogeology, and geology;
- Review of the WFD status of the receiving waterbodies;
- Review of the EA's active discharge permits;
- Desk based hydrogeological conceptualisation to understand how the hydrogeological system is believed to behave within the area;
- Water budget analysis within the Borough Council’s area.

1.3 Data sources

The data used in this assessment were obtained from the following sources:

- Geology:
  - British Geological Survey (BGS) 1:625,000 Geology Map;
  - British Geological Survey, 1981. Basingstoke. England & Wales Sheet 284. Solid & Drift Geology Map, 1:63,360/1:50,000 Series;
  - BGS digital geology mapping;
  - BGS online borehole database (BGS website);
  - BGS online Lexicon (BGS website).
- Hydrology and Hydrogeology:
  - Hydrogeology Scanned Maps (BGS website);
  - Aquifer classification (Environment Agency / Magic Map website);
  - Groundwater vulnerability (Environment Agency / Magic Map website);
  - Source Protection Zones (Environment Agency / Magic Map website);
  - Discharge permits (Environment Agency);
  - Catchment Data Explorer (Environment Agency);
  - Groundwater and surface water quality (Environment Agency WIMS website).

2 Environmental baseline

2.1 Introduction

This section aims to review the geological and hydrogeological setting of the study area and the aquifer properties of the groundwater bodies which receive discharges from the WwTWs, to build up a hydrogeological conceptual model.

2.2 Study area

The study area, located in the north of Hampshire, is relatively rural and covers approximately 630km^2. Less than 8% of the land is "built up"[1], and 60% of the population live in the main settlement of Basingstoke.

Across the study area, water supply services are provided by three water companies: South East Water (SEW) in the east of the study area, Southern Water (SW) in the West and Thames Water in a small area in the northeast. The study area of Basingstoke and Deane Borough Council and operating water companies across the study area are shown in Figure 2-1.

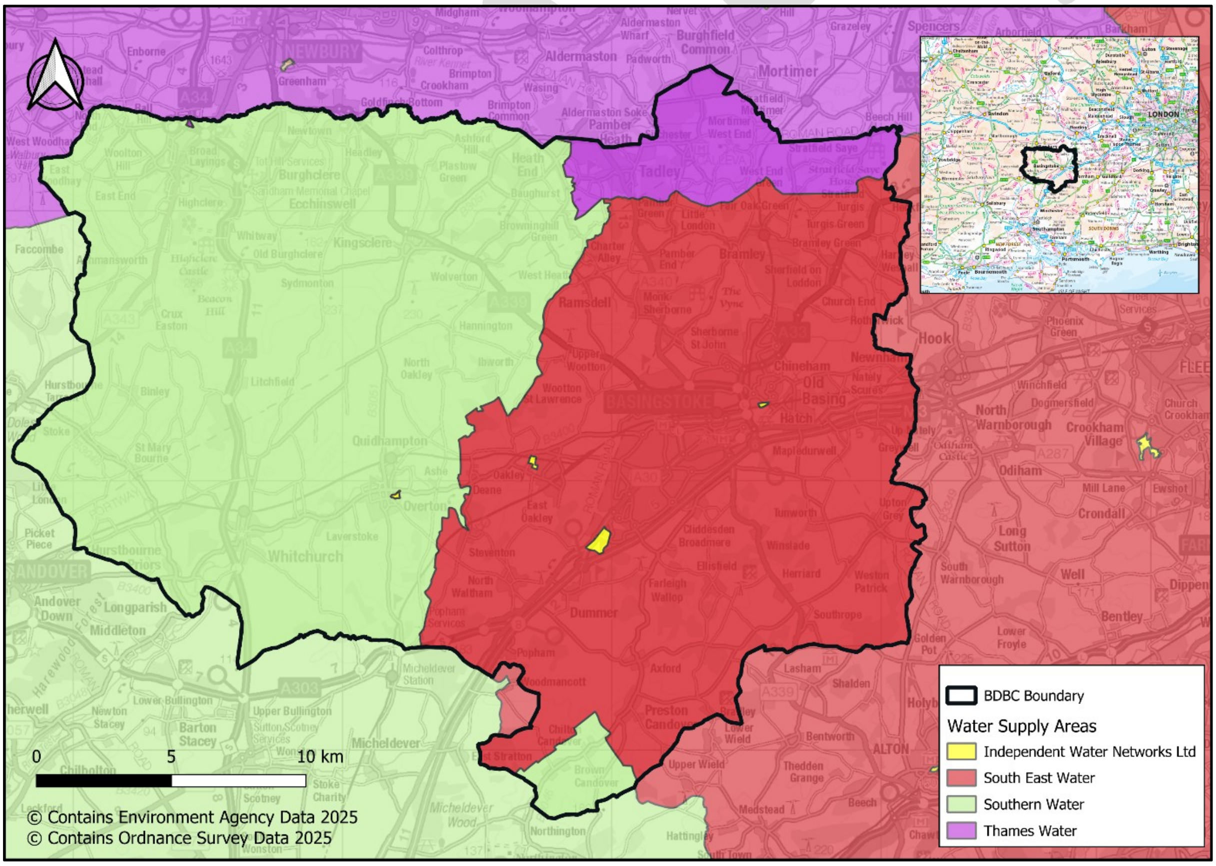

Figure 2-1: Water supply areas in Basingstoke and Deane

[1] Basingstoke and Deane Key Facts, Basingstoke and Deane Borough Council (2016). Accessed at: https://www.basingstoke.gov.uk/content/doclib/1876.pdf

Wastewater services are provided by Thames Water (TW) in the north east and Southern Water in the south west. There are also three small areas served by Independent Water Networks, Severn Trent Services and Icosa Water Services as part of a Nav arrangement (Figure 2-2).

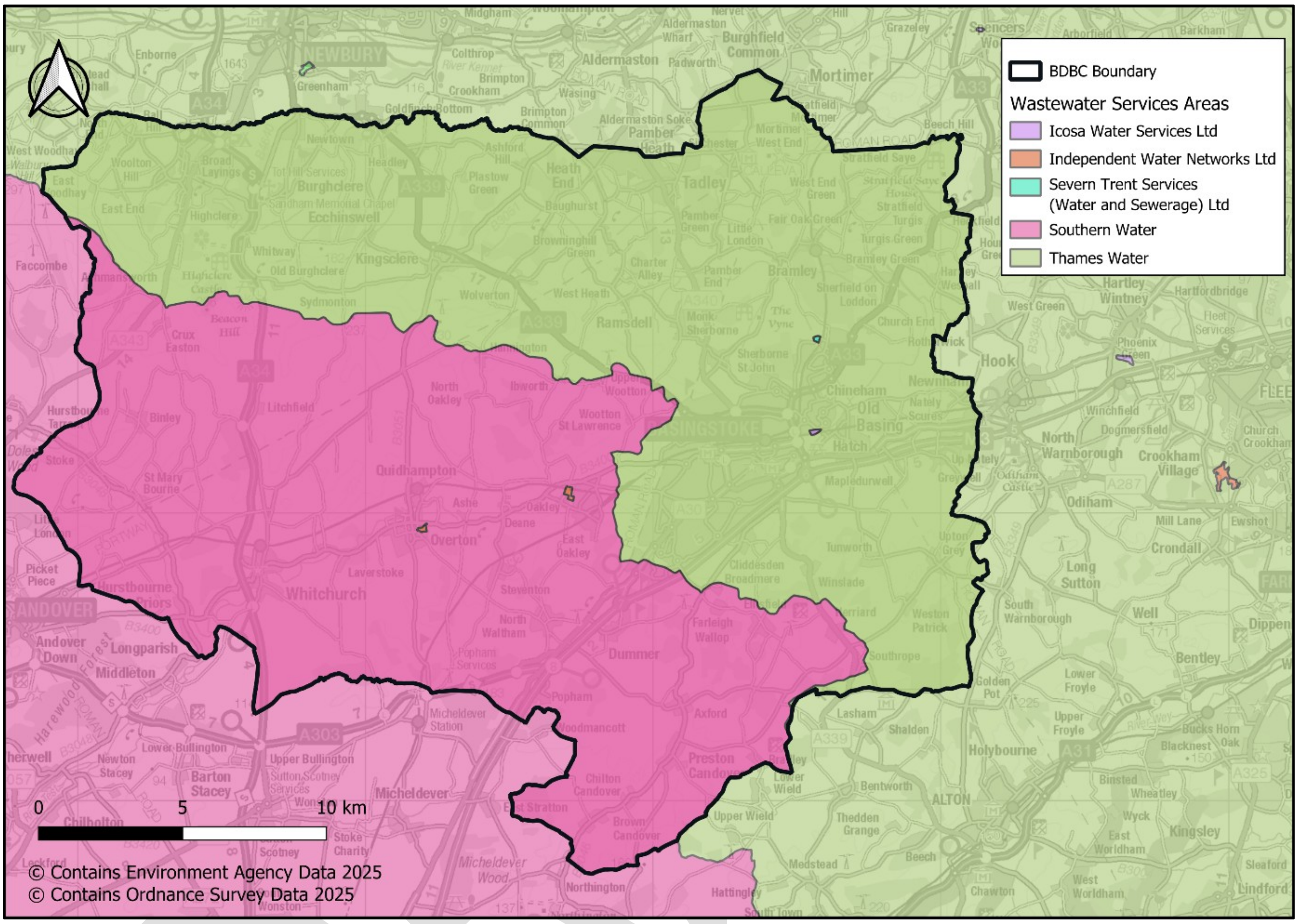

Figure 2-2: Wastewater service areas in Basingstoke and Deane

2.3 Topography

The topography of the site is shown in Figure 2-3. Ground elevations decrease sharply from 280 meters above ordnance datum (mAOD) in the higher areas, extending in a northwest-southeast orientation, to roughly 50mAOD in the northeastern and southwestern edges of the study area, which are characterised by river floodplains.

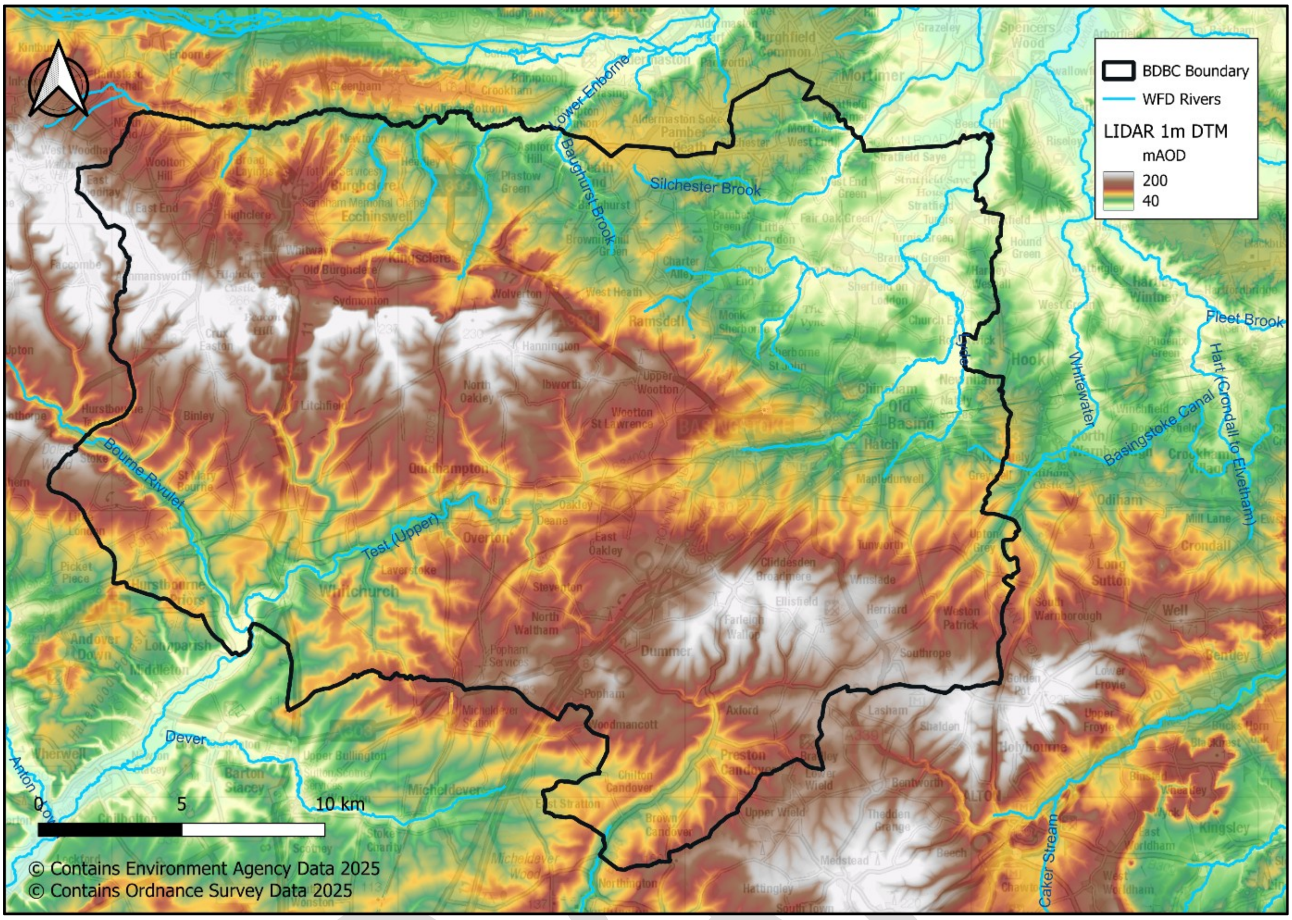

Figure 2-3: Topography

2.4 Catchment

The closest EA gauging station identified from the UK Hydrometric Register (2008) is located on the Test at Chilbolton, approximately 8km southwest of the Borough's southwestern edge. The data provided from this station gives the BFI as 0.94. The Baseflow Index (BFI) is the proportion of total streamflow made up of baseflow (groundwater input). This suggests that 94% of the local watercourses are made up of groundwater baseflow. For the catchment comprising the study area, the Standard Annual Average Rainfall (SAAR) is 801 mm/yr for the period 1961 - 1990, 834 mm/yr for the period 1941 - 1970 and 871 mm/yr for the period 1991-2020.

2.5 Surface water hydrology

The main surface watercourses within the BDBC study area, along with their respective WFD operational catchments and their status under the WFD's 2022 classification, are detailed in the Table 2-1 and Figure 2-4.

Table 2-1: Surface water WFD's 2022 classification

Name	WFD Management Catchment	WFD Ecological Status	WFD Chemical Status	Reasons for Not Achieving Good Status (RNAG)
Test (Upper)	Test Upper and Middle	Good	Does not require assessment	-
Bourne Rivulet	Test Upper and Middle	Moderate	Does not require assessment	-
Penwood Stream	Kennet	Moderate	Does not require assessment	Dissolved Organic Carbon (DOC): moderate (Drought)
Earlstone Stream and Burghclere Brook (source to Enborne)	Kennet	Poor	Does not require assessment	Biological elements: Poor Dissolved Organic Carbon (DOC): moderate (Drought)
Ecchinswell Brook (source to Enborne)	Kennet	Moderate	Does not require assessment	Biological elements: Moderate Phosphate: moderate (Poor nutrient/livestock management)
Kingsclere Brook (Source to Enborne)	Kennet	Moderate	Does not require assessment	Phosphate: moderate (Sewage discharge)
Baughurst Brook	Kennet	Moderate	Does not require assessment	Biological elements: Moderate
Silchester Brook	Kennet	Moderate	Does not require assessment	Biological elements: Moderate Phosphate: Poor (Sewage Discharge)
Bow Brook (Pamber End to Bramley)	Loddon	Poor	Does not require assessment	Biological elements: Poor
Loddon (Sherfield on Loddon to Swallowfield)	Loddon	Moderate	Does not require assessment	Phosphate: moderate (Urbanisation, Sewage discharge, Poor nutrient management)
Bow Brook (Bramley to Sherfield Green)	Loddon	Moderate	Does not require assessment	Phosphate: moderate (Sewage discharge, Poor nutrient management)
Vyne Stream	Loddon	Moderate	Does not require assessment	Biological elements: Moderate Phosphate: Poor (Sewage Discharge, Poor nutrient management)
Loddon (Basingstoke to River Lyde confluence at Hartley Wespall)	Loddon	Moderate	Does not require assessment	Biological elements: Moderate Phosphate: moderate (Sewage Discharge, Poor livestock management)
Lyde	Loddon	Moderate	Does not require assessment	Biological elements: Moderate
Candover Brook	Itchen	Moderate	Does not require assessment	Biological elements: Moderate

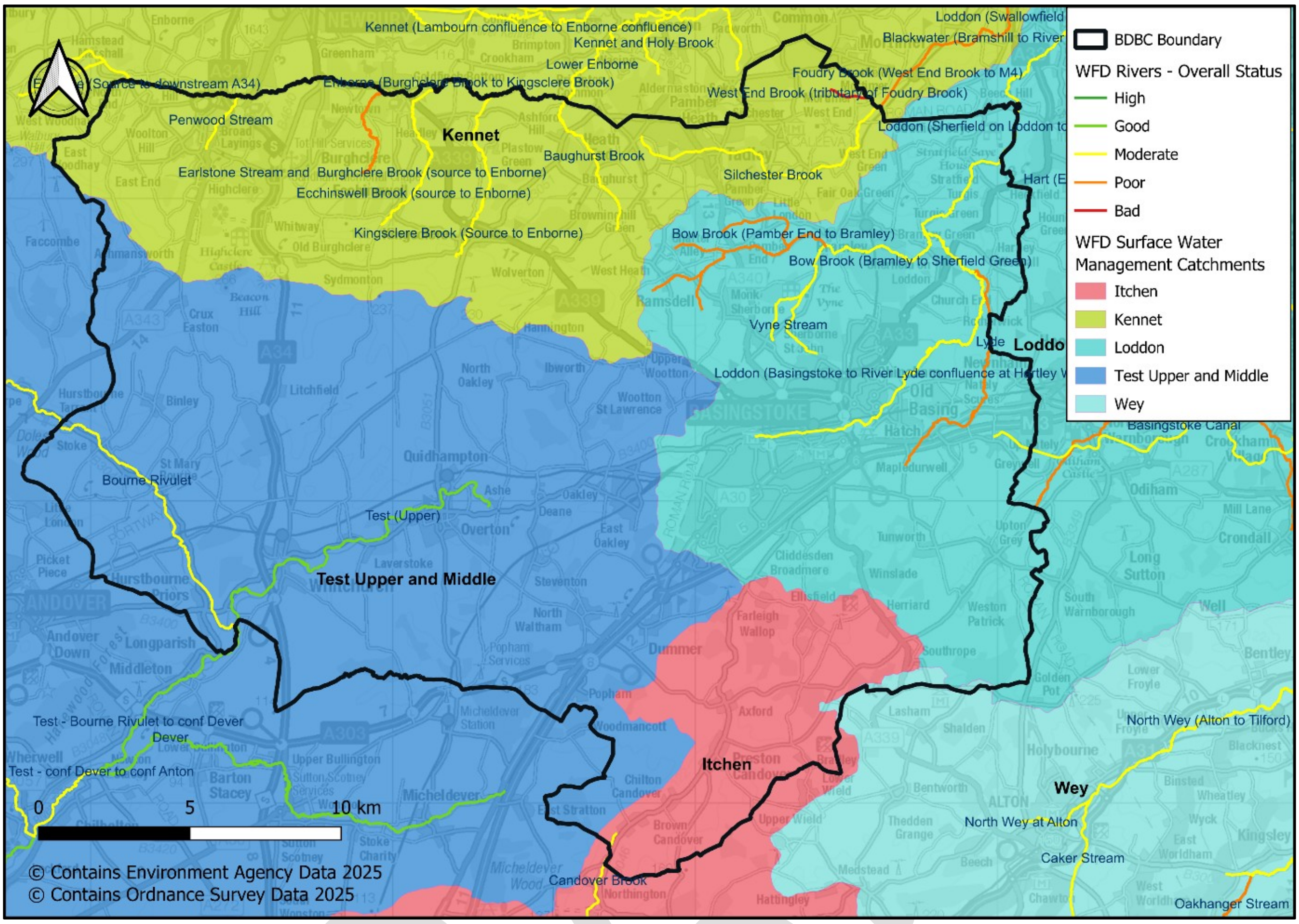

Figure 2-4: Surface water

2.6 Geology

2.6.1 Summary

Information on the geology of the study area has been derived from 1:625,000 British Geological Survey geology mapping (BGS online map viewer), BGS Solid & Drift Geology Map, 1:63,360/1:50,000 Series England & Wales, Basingstoke, Sheet 284, 1981, and BGS online borehole archive. The geology underlying the site is summarised in Table 2-2.

Table 2-2: Geology

Age	Group	Unit	Description	Thickness (m)
Quaternary	Superficial deposits	Alluvium	Clay, silt, sand and gravel **	0 - 20 *
Quaternary	Superficial deposits	Clay-with-Flint	Sandy clay with angular flints **	0 - 10 *
Quaternary	Superficial deposits	River Terrace	Sand and gravel, with lenses of silt, clay **	0 - 10 *

Age	Group	Unit	Description	Thickness (m)
Quaternary	Superficial deposits	Sand & Gravel (of uncertain age & origin)	Sand and gravel **	0 - 6 *
Tertiary	Bedrock	Bracklesham Group and Barton Group	Sand, silt and clay **	Up to 30 ***
Tertiary	Bedrock	Thames Group (London Clay)	Clay, silt, sand and gravel **	30 - 100 ***
Tertiary	Bedrock	Lambeth Group	Clay, silt, sand and gravel **	18 - 24 ***
Cretaceous	Bedrock	White Chalk Subgroup	Chalk **	Up to 180 ***
Cretaceous	Bedrock	Grey Chalk Subgroup	Chalk **	50 - 70 ***
Cretaceous	Bedrock	Gault Fm & Upper Greensand Fm	Mudstone, sandstone and limestone **	100 - 130 ***

Notes:

* BGS GeoIndex Borehole Data

** BGS Online Lexicon of Named Rock Units

*** BGS (British Geological Survey), 1981. Basingstoke. England & Wales Sheet 284. Solid & Drift Geology Map, 1:63,360/1:50,000 Series

2.6.2 Superficial deposits

The superficial deposits of the Borough and local area are shown in Figure 2-5. The BGS GeoIndex (1:625k) indicates that the main superficial deposits in the study area consist of sparsely deposited Alluvium, River Terrace Deposits, Clay-with-Flints and Sand & Gravel deposits of uncertain age and origin.

- Where it is present the Alluvium is generally up to 20m thick and consists of sands, silts and clays with some bands of gravel. It is found in the buried valleys and forms sinuous tracts along the valley floors and tidal reaches of the River Test and its tributary in the area as well as in the valley of Loddon in the northeast of Basingstoke.
- The River Terrace Deposits are generally up to 10m thick and consist of gravels and loams of various ages bordering the Alluvium in the river valleys.
- The Clay-with-Flint Deposits are more extensive in the area and are generally up to 10m thick, comprising of poorly bedded silty loams, which sometimes includes seams of flint and chalk pebbles.

- The Sand & Gravel Deposits comprise of clayey silty sand and gravel, are of variable thickness and occur on the upper slopes of catchments.

The superficial deposits are not laterally present across the entire area, and therefore, they are absent underneath the majority of the study area.

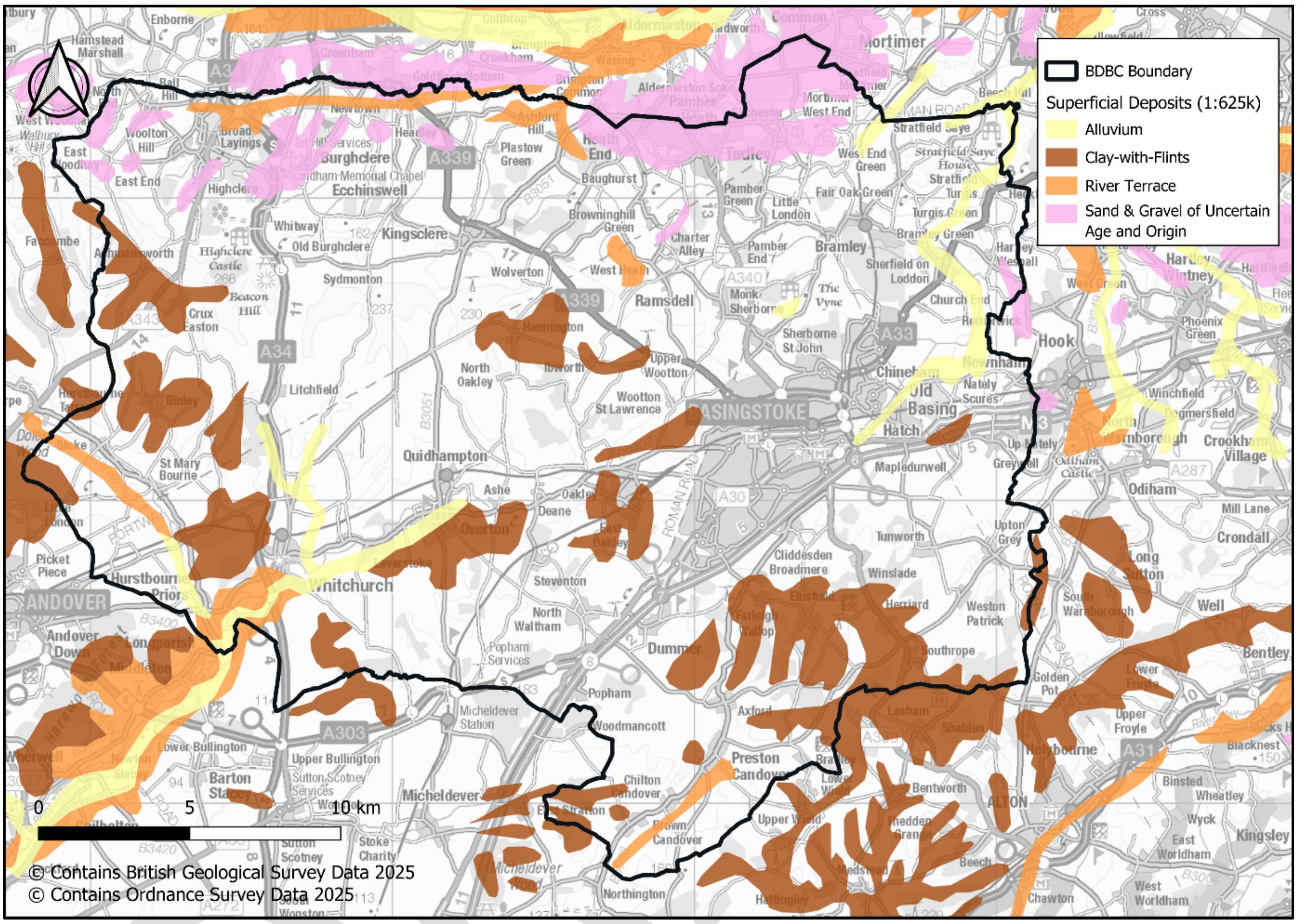

Figure 2-5: Superficial deposits

2.6.3 Bedrock Geology

The BGS 1:625k geology mapping shows that the bedrock geology of the study area comprises seven lithologies of Tertiary and Cretaceous Periods (See Figure 2-6) including:

- Tertiary
  - Thames Group (London Clay) mainly comprising up to 100m of silty clays and clays, some sandy or gravelly, with some silts, sands, gravels and calcareous mudstones underlying the northern region of the study area.
  - Lambeth Group comprising up to 24m vertically and laterally variable sequences mainly of clay, some silty or sandy, with some sands and gravels, minor limestones and lignites and occasional sandstone and conglomerate.
- Cretaceous

- White Chalk Subgroup comprising over 50m soft white Chalk with flints, with discrete marl seams, nodular chalk, sponge-rich and flint seams, underlying the majority of the study area.
- Grey Chalk Subgroup comprising over 45m clayey ('marly') Chalk without flint
- Gault Formation & Upper Greensand Formation comprising over 100m mudstone, sandstone and limestone.

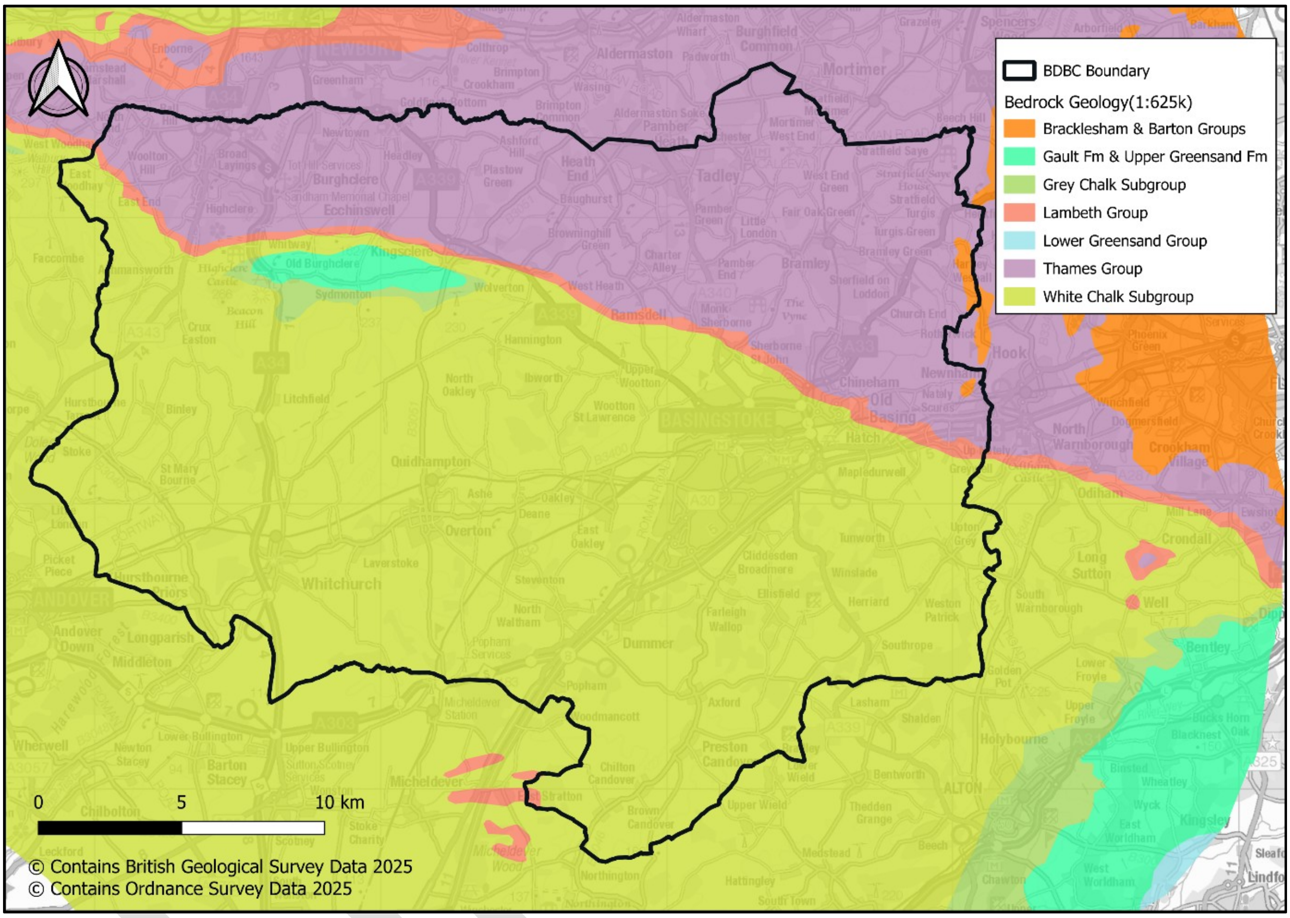

Figure 2-6: Bedrock geology

2.7 Hydrogeology

2.7.1 Aquifer classification

Table 2-3 summarises the Environment Agency's (EA) hydrogeological classification of the bedrock and superficial deposits.

The alluvium, river terrace and sand and gravel deposits are designated Secondary A Aquifers (EA, 2020). Secondary A Aquifers comprise 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. These are generally aquifers formerly classified as minor aquifers.

The clay-with-flints is classified as Secondary undifferentiated aquifer, which is used when it is not possible to attribute either category A or B to a strata type, and in most cases, this means that the layer in question has previously been designated as both minor and non-aquifer in different locations due to the variable characteristics of the strata.

The underlying bedrock units are shown in Figure 2-7 and classified as:

- Thames Group: Unproductive strata - Rocks with essentially no groundwater comprising predominantly clayey sequence up to 140 m thick confining underlying aquifers.
- Lambeth Group: Secondary A, Low productivity aquifer - Variable sequence of clays, shell beds, fine sands, silts and pebble beds giving low yields. Sometimes in hydraulic continuity with the underlying Chalk aquifer.
- White Chalk Subgroup: Highly productive Principal aquifer in UK up to 450 m thick and yielding 50 to 100 L/s from large diameter boreholes and up to 300 L/s from adited systems (a large diameter flow pathway through the geology). Hard to very hard, good quality water.
- Grey Chalk Subgroup: Highly productive Marly Chalk Principal aquifer that can yield up to 5 L/s from wells with headings.
- Upper Greensand Fm: Moderately productive Principal aquifer of glauconitic sands yielding up to 25 L/s and often in hydraulic continuity with overlying Chalk.

Table 2-3: Aquifer classification

Drift/Bedrock	Unit	Environment Agency Aquifer Classification
Superficial (drift) deposits	Alluvium	Secondary A aquifer
Superficial (drift) deposits	Clay-with-Flints	Secondary undifferentiated
Superficial (drift) deposits	River Terrace Deposits	Secondary A aquifer
Superficial (drift) deposits	Sand and Gravels	Secondary A aquifer
Bedrock	Thames Group	Unproductive
Bedrock	Lambeth Group	Secondary A aquifer
Bedrock	White Chalk Subgroup	Principal Aquifer
Bedrock	Grey Chalk Subgroup	Principal Aquifer
Bedrock	Upper Greensand Fm	Principal Aquifer

Explanation of aquifer classes (from Environment Agency website)

Principal aquifers - "may support water supply and/or baseflow to rivers on a strategic scale."

Secondary A aquifers - "permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of baseflow to rivers."

Secondary B aquifers - "predominantly lower permeability layers which may store and yield limited amounts of groundwater."

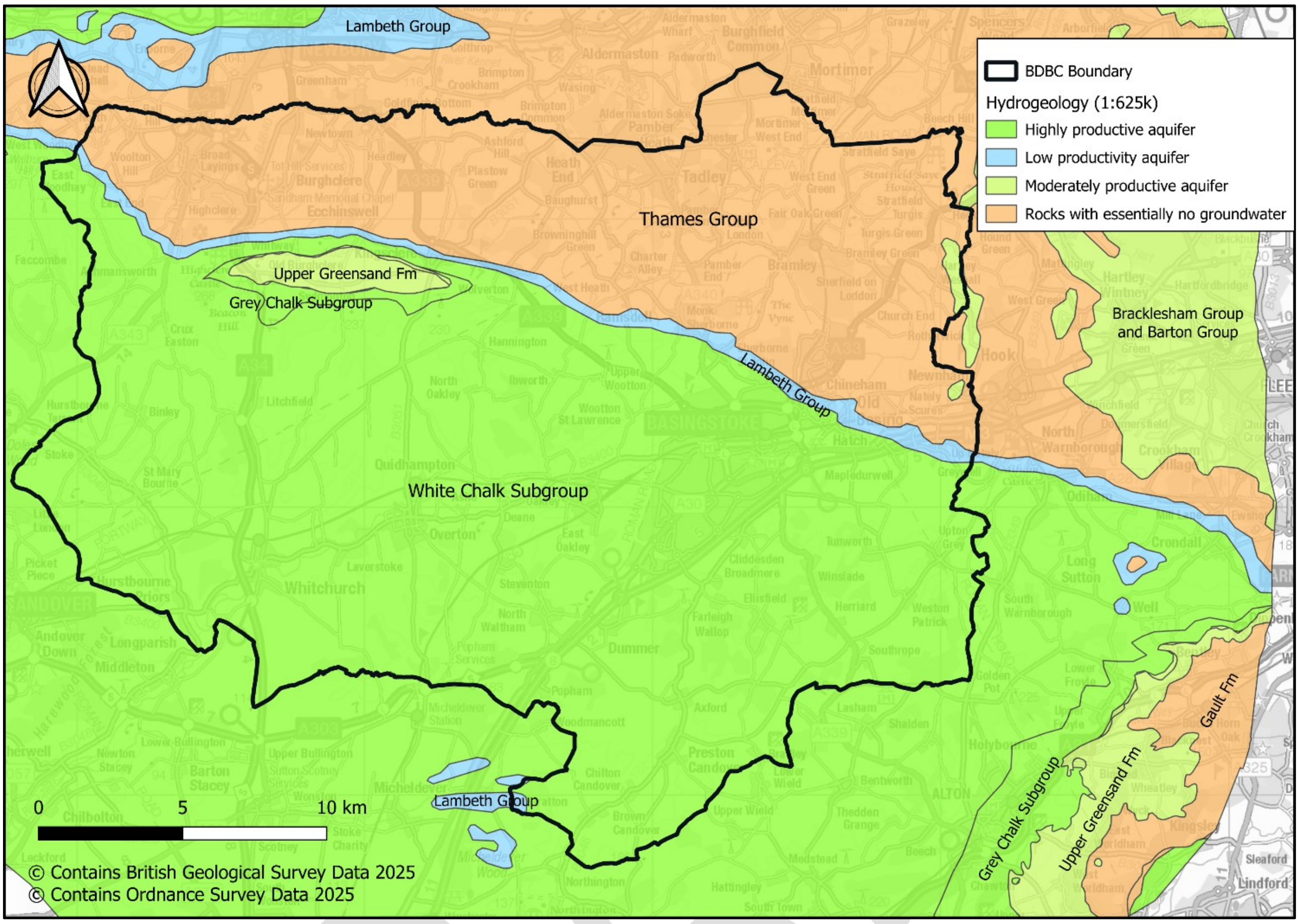

Figure 2-7: Hydrogeology (1:625k)

2.7.2 Aquifer vulnerability

The BGS's aquifer vulnerability mapping indicates underlying bedrock units of most of the study area as having high vulnerability with soluble rock risk, meaning they are high priority groundwater resources that have very limited natural protection with almost no superficial deposits on top of these units. This results in a high overall pollution risk to groundwater from surface activities. Operations or activities in these areas require additional measures over and above good practice pollution prevention requirements to ensure that groundwater isn't impacted.

2.7.3 Groundwater Source Protection Zone

Source Protection Zones (SPZs) are used to protect areas of vulnerable groundwater that is used for abstraction and where water quality is of high importance (such as drinking water abstractions). SPZs are categorised into three zones, 1-3, with 1 being most sensitive to pollution, and 3 representing the lowest risk but still within the groundwater catchment of the abstraction. Figure 2-8 shows the Source Protection Zones 1 to 3 within the study area.

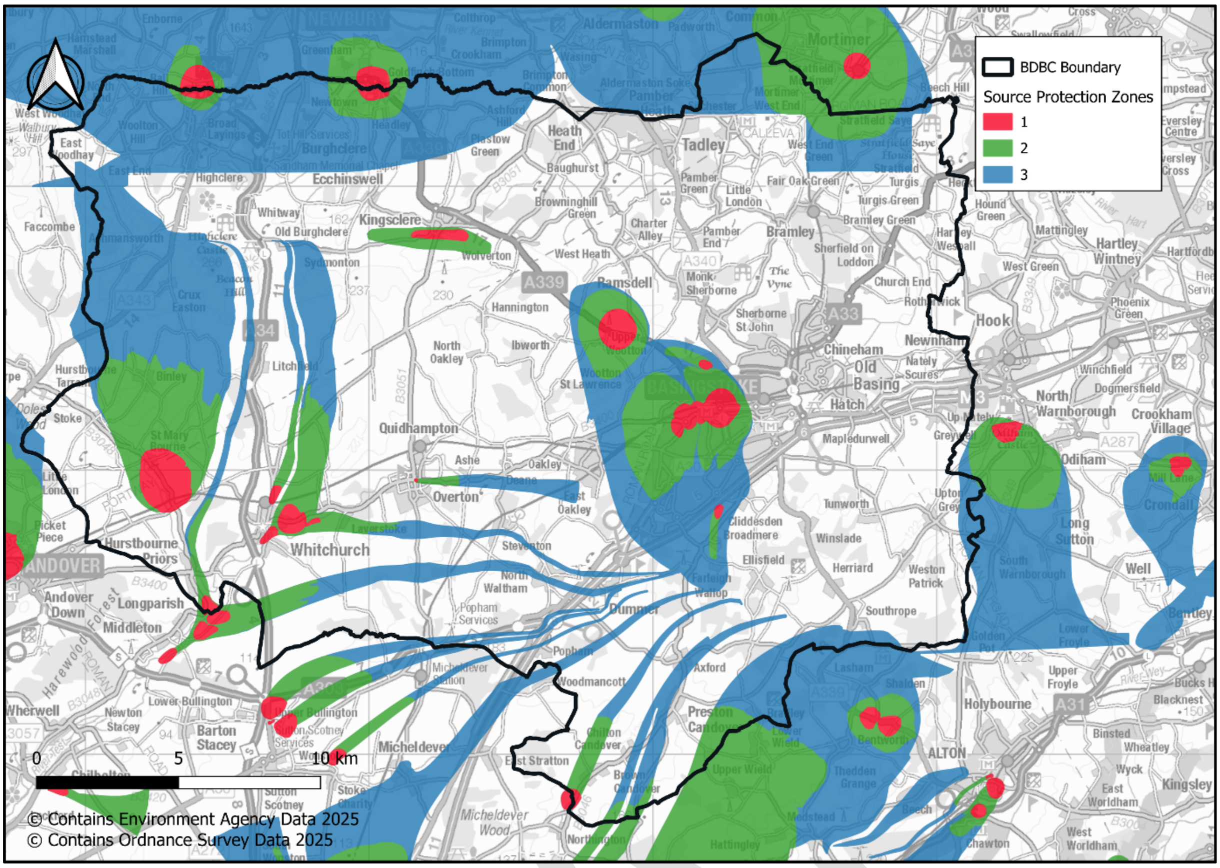

Figure 2-8: Source Protection Zone

2.7.4 Groundwater quality

Figure 2-9 shows the groundwater bodies within the study area. Details of WFD groundwater bodies and their water quality are given in Table 2-4:

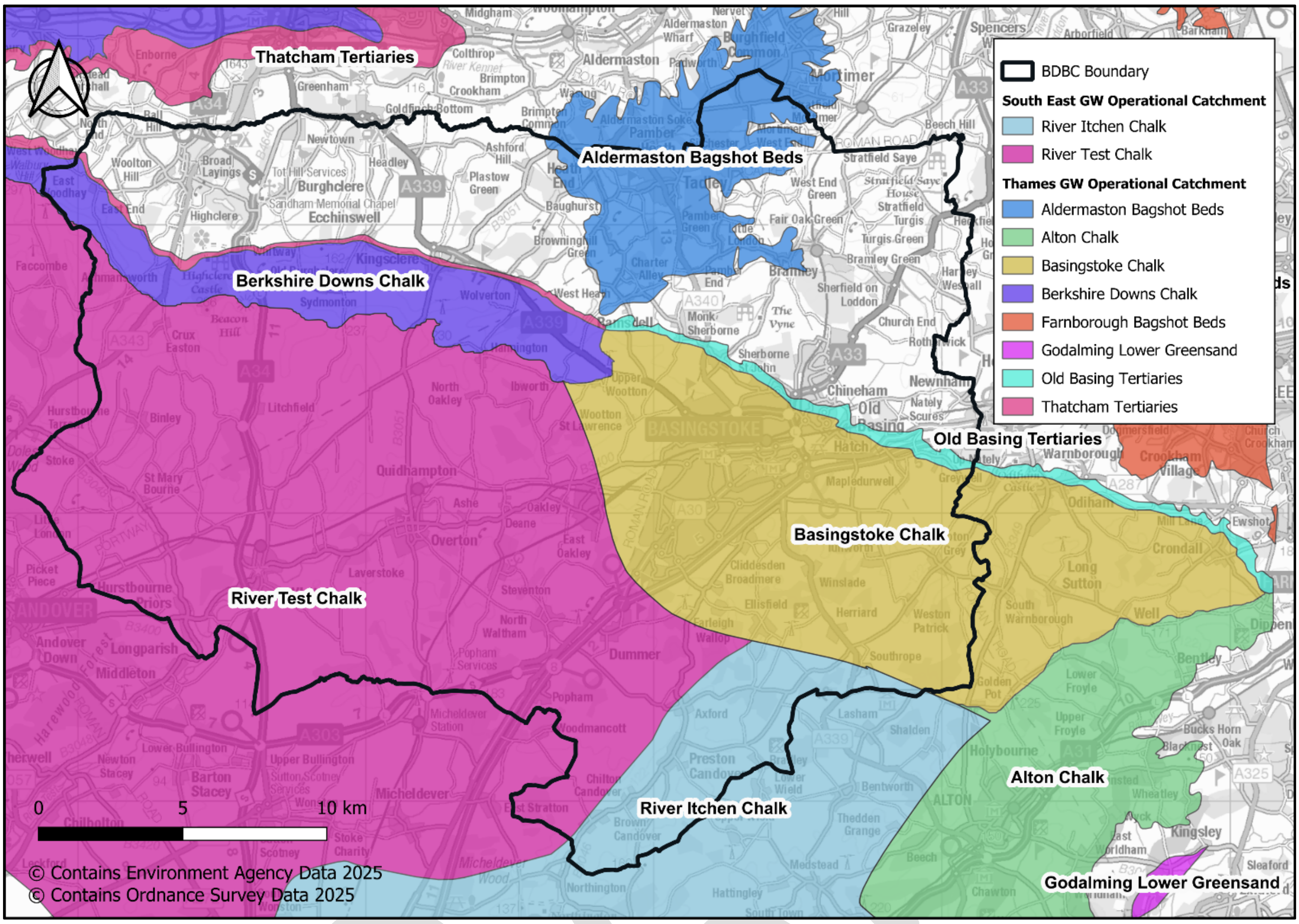

Figure 2-9: Groundwater body

Table 2-4: Groundwater quality

Groundwater body	WFD Quantitative status	WFD Chemical status	WFD Overall status	Reasons for Not Achieving Good status (RNAG)
River Test Chalk	Good	Poor	Poor	Chemical status - Poor nutrient management (pollution from agricultural rural areas)
River Itchen Chalk	Poor	Poor	Poor	Quantitative status - GW abstraction; Chemical status - Poor nutrient management (pollution from agricultural rural areas)
Basingstoke Chalk	Poor	Poor	Poor	Quantitative status - GW abstraction; Chemical status - Poor nutrient management (pollution from agricultural rural areas)

Groundwater body	WFD Quantitative status	WFD Chemical status	WFD Overall status	Reasons for Not Achieving Good status (RNAG)
Berkshire Downs Chalk	Poor	Poor	Poor	Quantitative status - GW abstraction; Chemical status - Poor nutrient management (pollution from agricultural rural areas)
Thatcham Tertiaries	Good	Good	Good	n.a
Old Basing Tertiaries	Good	Good	Good	n.a
Aldermaston Bagshot Beds	Good	Good	Good	n.a

2.8 Discharge permits

2.8.1 Wastewater Treatment Works (WwTWs)

Figure 2-10 shows the Environment Agency's permits to water companies to discharge sewage effluent into water and groundwater within the boundary line of the Basingstoke and Deane Borough Council (BDBC). The permits are held by the three water companies of Southern Water Services Limited, South East Water Limited, and Thames Water Utilities Limited.

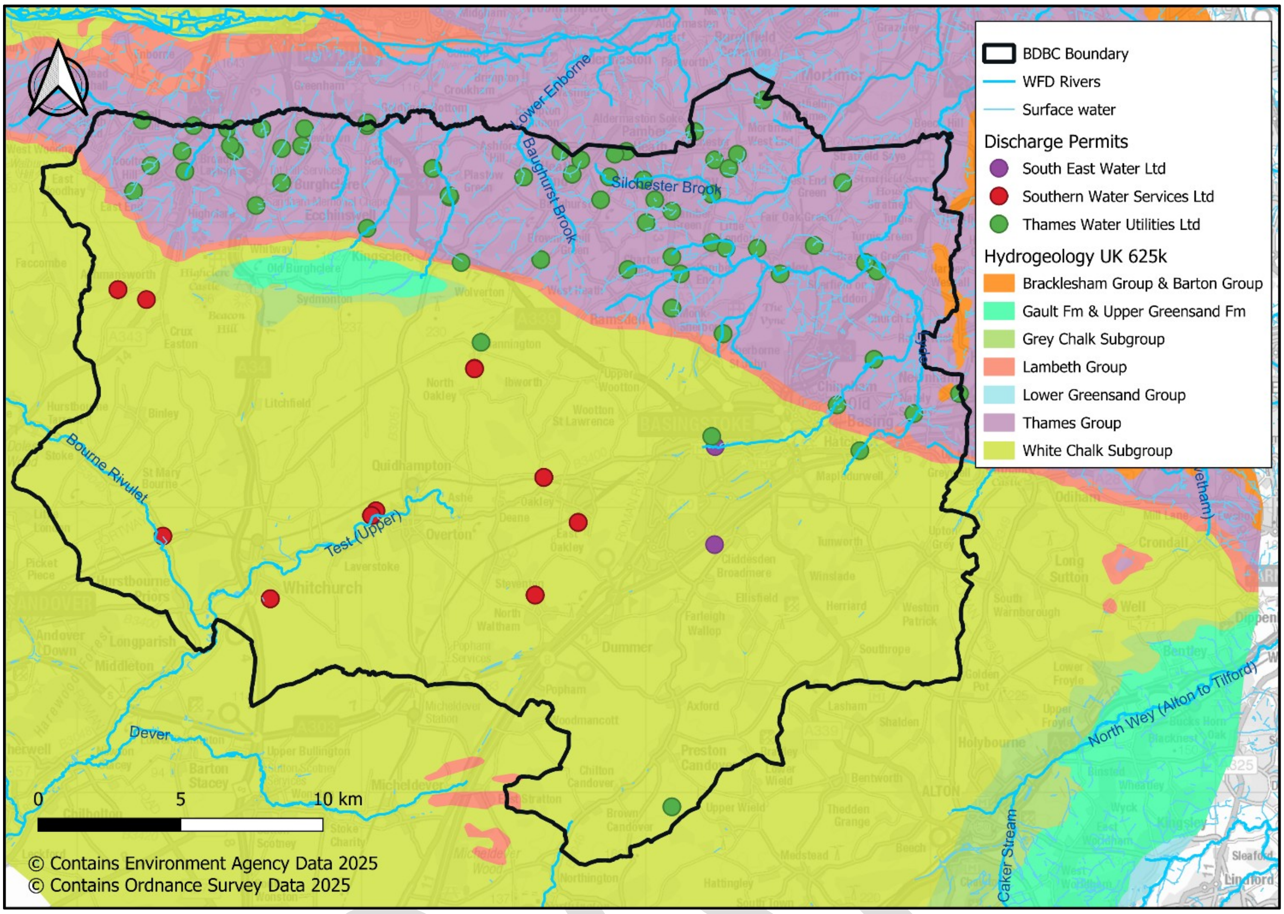

Figure 2-10: Discharge permits

Of the total 73 discharge permits within the BDBC boundary, 7 active permits are for discharging secondary-treated sewage effluent from WwTWs into the ground (underlying White Chalk Subgroup), and one active permit is for discharging potable water from a reservoir via a borehole into the ground. Table 2-5 shows the details of the active discharge permits, discharging into the ground (underlying Chalk) and the Dry Weather Flow (DWF) rate of each permit in m^3/d. Dry Weather Flow (DWF) is the average daily volume of wastewater entering a sewage treatment plant or sewer system during dry weather conditions.

Table 2-5: Details of the EA's active discharge permits to the underlying Chalk aquifer

Name	No. of Permits	Permit No. & Start Date	Operation Period	Operated By	Discharging to	DWF (m^3/day)
HANNINGTON WWTW	3	SO/W00050/001 (10/1985) to SO/W00050/003 (05/2016)	1985-now	Southern Water Services Limited	Discharge into land of secondary-treated sewage effluent via an infiltration system	10.2
IVY DOWN LANE WWTW	8	SO/W00225/001 (09/1979) to SO/W00225/008 (01/2017)	1979-now	Southern Water Services Limited	Discharge into land of secondary-treated sewage effluent via a series of soakaway lagoons	722
NORTH WALTHAM WWTW	5	SO/W00226/001 (09/1979) to SO/W00226/005 (02/2017)	1979-now	Southern Water Services Limited	Discharge into land of secondary-treated sewage effluent via an infiltration system	167
BARN CLOSE ASHMANSWORTH WWTW	4	SO/W00287/001 (12/01979) to SO/W00287/004 (05/2016)	1979-now	Southern Water Services Limited	Discharge into land of secondary-treated sewage effluent via an infiltration system	5
WHITCHURCH WWTW	8	SO/W00292/001 (09/1979) to SO/W00292/008 (12/2024)	1979-now	Southern Water Services Limited	Discharge into land of secondary-treated sewage effluent via infiltration systems (2 outlets)	2,336

Name	No. of Permits	Permit No. & Start Date	Operation Period	Operated By	Discharging to	DWF (m^3/day)
OVERTON WASTEWATER TREATMENT WORKS	5	SO/NPSWQD010441/001 (03/2010) to SO/NPSWQD010441/005 (03/2025)	2010-now	Southern Water Services Limited	Discharge into land of secondary-treated sewage effluent via one or a combination of infiltration systems	1,160
HANNINGTON (HANTS) STW (REQUESTED)	1	TH/RET/TH/5/RG/001	1999-now	Thames Water Utilities Limited	TBC	TBC
CLIDDESDEN RESERVOIR	1	TH/CTWC.1611/001	1987-now	South East Water Limited	Discharge into land of potable water from a reservoir via a borehole	n.a

Figure 2-11 shows the EA's record of active discharge permits discharging sewage effluent into the underlying White Chalk Subgroup aquifer and the groundwater bodies.

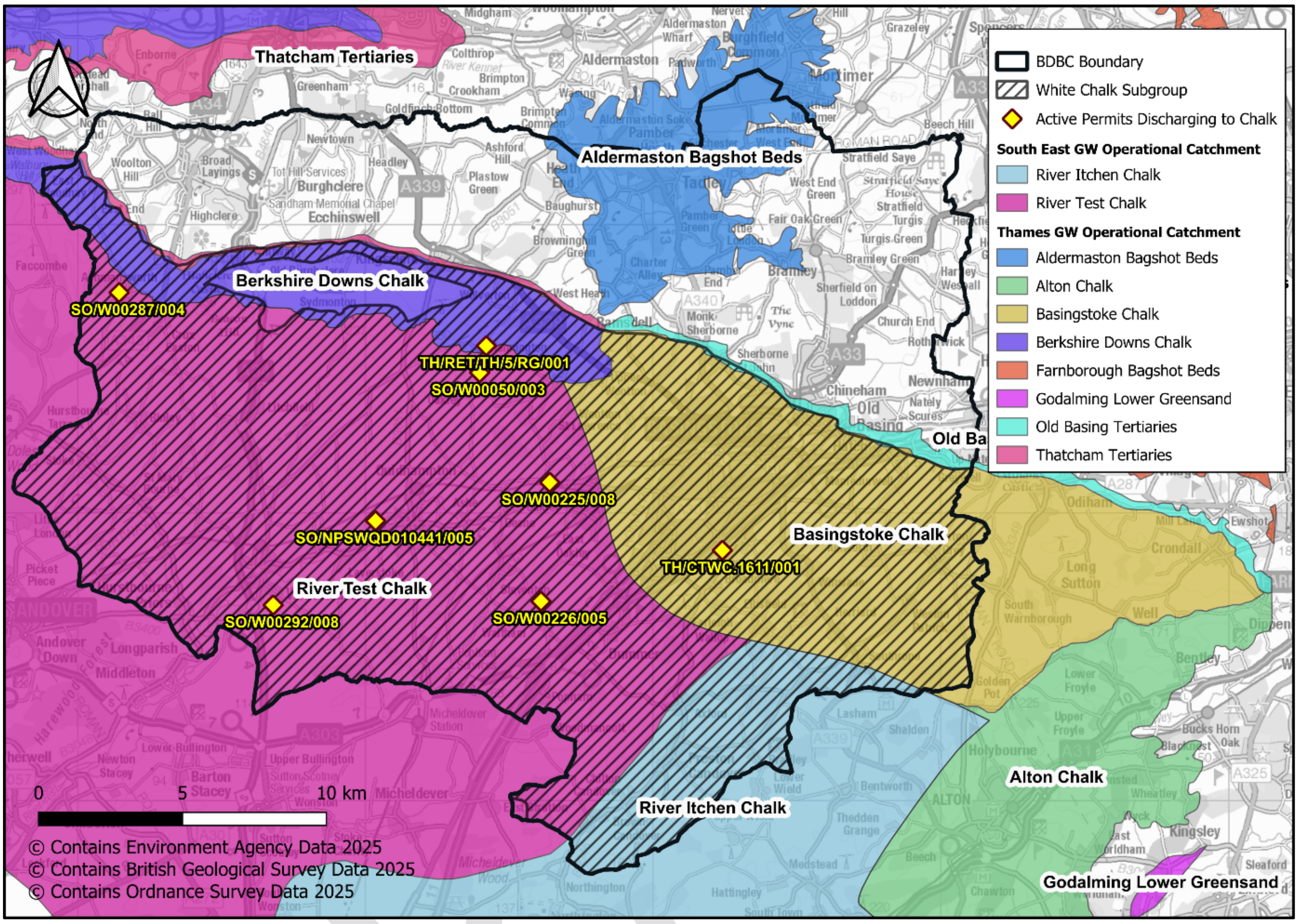

Figure 2-11: Active discharge permits discharging sewage effluent into the underlying Chalk

2.8.2 Emissions limits and monitoring requirements

Table 2-6 presents the monitoring requirements and emission limits of the parameters in the sewage effluent of the active discharge permits.

Table 2-6: Emission limits of the discharge permits

Permit No.	DWF (m^3/day)	Parameter	Limit [2]	Surface Water and Groundwater Monitoring Requirements
SO/W00050 (Hannington WwTW)	10.2	Visible oil or grease	No significant trace	-
SO/W00225 (Oakley Ivy Down WwTW)	722	Ammoniacal nitrogen (as N)	5 mg/l *	Effluent and groundwater monitoring at the discharge point, up gradient and down gradient
SO/W00225 (Oakley Ivy Down WwTW)	722	Suspended solids	60 mg/l *	Effluent and groundwater monitoring at the discharge point, up gradient and down gradient
SO/W00225 (Oakley Ivy Down WwTW)	722	Total inorganic nitrogen	35 mg/l **	Effluent and groundwater monitoring at the discharge point, up gradient and down gradient
SO/W00225 (Oakley Ivy Down WwTW)	722	Visible oil or grease	No significant trace	Effluent and groundwater monitoring at the discharge point, up gradient and down gradient
SO/W00226 (North Waltham WwTW)	167	Ammoniacal nitrogen (as N)	5 mg/l *	Effluent and groundwater monitoring at the discharge point, up gradient and down gradient
SO/W00226 (North Waltham WwTW)	167	Suspended solids	60 mg/l *	Effluent and groundwater monitoring at the discharge point, up gradient and down gradient
SO/W00226 (North Waltham WwTW)	167	Total inorganic nitrogen	20 mg/l **	Effluent and groundwater monitoring at the discharge point, up gradient and down gradient
SO/W00226 (North Waltham WwTW)	167	Visible oil or grease	No significant trace	Effluent and groundwater monitoring at the discharge point, up gradient and down gradient
SO/W00287 (Barn Close Ashmansworth WwTW)	5	Visible oil or grease	No significant trace	-
SO/W00292 (Whitchurch WwTW Discharge)	2,336	Ammoniacal nitrogen (as N)	5 mg/l *	Effluent and groundwater monitoring at the discharge point, up gradient and down gradient
SO/W00292 (Whitchurch WwTW Discharge)	2,336	Suspended solids	60 mg/l *	Effluent and groundwater monitoring at the discharge point, up gradient and down gradient
SO/W00292 (Whitchurch WwTW Discharge)	2,336	Total inorganic nitrogen	32 mg/l **	Effluent and groundwater monitoring at the discharge point, up gradient and down gradient
SO/W00292 (Whitchurch WwTW Discharge)	2,336	Visible oil or grease	No significant trace	Effluent and groundwater monitoring at the discharge point, up gradient and down gradient
SO/NPSWQD010441 (Overton WwTW Discharge)	1,160	Ammoniacal nitrogen (as N)	5 mg/l *	Effluent and groundwater monitoring at the discharge point, up gradient and down gradient
SO/NPSWQD010441 (Overton WwTW Discharge)	1,160	Suspended solids	60 mg/l *	Effluent and groundwater monitoring at the discharge point, up gradient and down gradient

[2] Additional details on the limit values for the parameters included within this table are included in Appendix A.

Permit No.	DWF (m^3/day)	Parameter	Limit [2]	Surface Water and Groundwater Monitoring Requirements
SO/NPSWQD010441 (Overton WwTW Discharge)	1,160	Total iron as Fe	8 mg/l ***	Effluent and groundwater monitoring at the discharge point, up gradient and down gradient
SO/NPSWQD010441 (Overton WwTW Discharge)	1,160	Total Phosphorus as P	1 mg/l ****	Effluent and groundwater monitoring at the discharge point, up gradient and down gradient
SO/NPSWQD010441 (Overton WwTW Discharge)	1,160	Visible oil or grease	No significant trace	Effluent and groundwater monitoring at the discharge point, up gradient and down gradient
TH/RET/TH/5/RG (Hannington (Hants) STW)	TBC	TBC	TBC	TBC

Notes:

* The limits may be exceeded in certain circumstances given in Appendix A.1.

** Annual mean in a calendar year ending 31 December.

*** Maximum.

**** Rolling 12-month mean and t-values methodology presented in Appendix A.2

2.8.3 Sewage discharge quality

Sewage discharge quality monitoring has been undertaken at the WIMS locations shown in Figure 2-12 from 2000 to 2025.

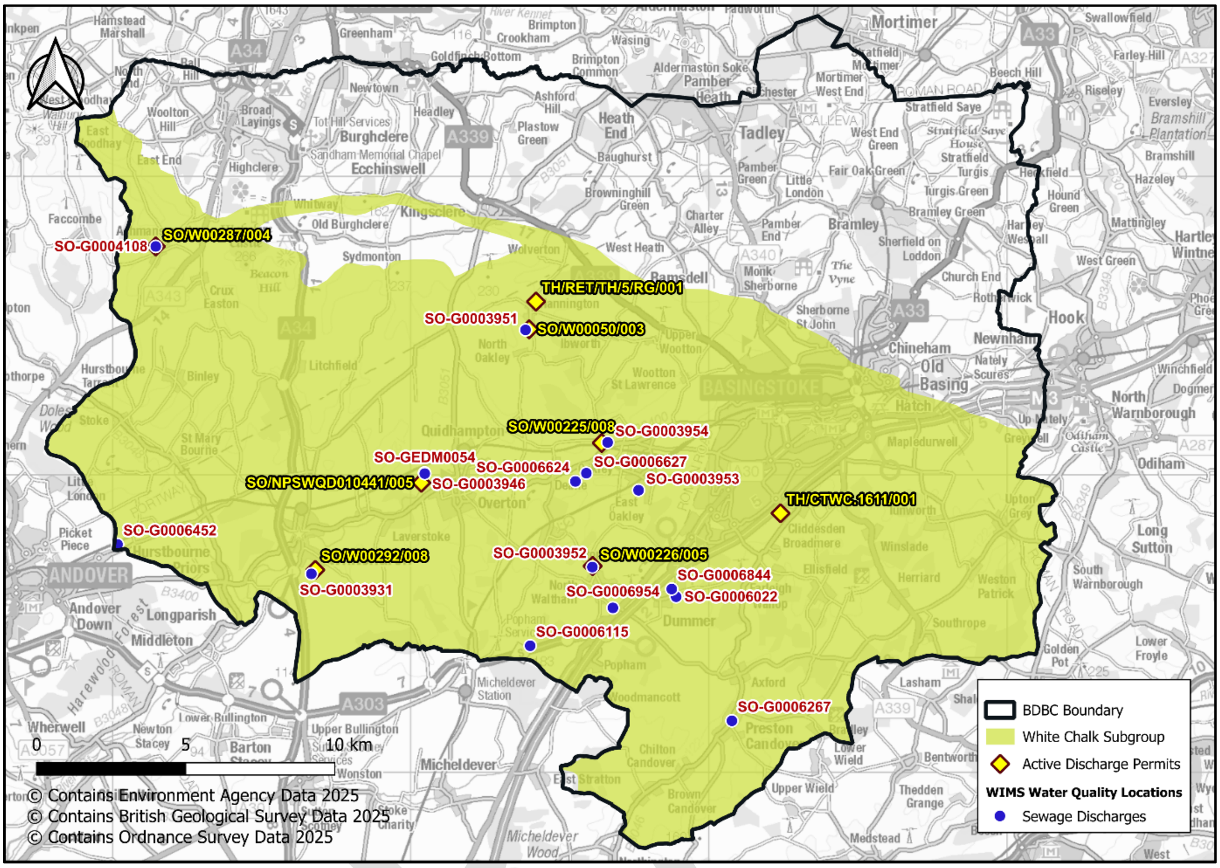

Figure 2-12: Sewage discharge quality monitoring locations

Table 2-7 summarises the sewage discharge quality monitoring locations and the relevant permits.

Table 2-7: Sewage discharge locations and the EA's permits

Location	Permit No.	WIMS Reference No.
North Waltham WwTW	SO/W00226	SO-G0003952
Overton WwTW Discharge	SO/NPSWQD010441	SO-G0003946
Oakley Ivy Down WwTW	SO/W00225	SO-G0003954
Whitchurch WwTW Discharge	SO/W00292	SO-G0003931

2.8.3.1 North Waltham WwTW

The summary of results from WIMS sewage discharge chemical testing in North Waltham WwTW is summarised in Table 2-8. The results have been compared to the emission limits of North Waltham WwTWs discharge permit (SO/W00226). This permit comprises 5 variations issued from 1979, with the current permit issued in February 2017. The table below shows the minimum and maximum of the data set, as well as the period of the last exceedance of the current permit limit during the monitoring period. Historically the permit may have had higher thresholds than it does currently, so the recorded value in October 2013 may not have been an exceedance of the permit at the time. There have been no exceedances during period that the current permit has been issued.

Table 2-8: North Waltham STW sewage discharge quality

North Waltham Stw (SO-G0003952)	Minimum	Maximum	Permit emission limit (SO/W00226)	Last exceedance
Ammoniacal Nitrogen as N (mg/l)	0.06	11.7	5	October 2013 - No breach during the period of the current permit
Total inorganic Nitrogen as N (mg/l)	7.59	27.7	20 (annual average)	See Table 2-9
Solids Suspended at 105 °C (mg/l)	1	24.4	60	None
Visible Oil - Times observed	None		None	None

Table 2-9 shows the annual averages (AA) for the total inorganic nitrogen (mg/l) in the period of 2016 to 2020 and 2024 at the North Waltham WwTW, along with a comparison to the permit threshold. The table shows that the total inorganic nitrogen annual average concentrations (mg/l) do not exceed the permit limit of 20 mg/l since 2016. However, during the monitoring period in North Waltham Stw, the annual average of total inorganic nitrogen concentrations has been approximately 60% to 81% of the current permitted threshold.

Table 2-9: Total inorganic nitrogen (as N) at the North Waltham WwTW

Calendar year (1 January to 31 December)	Total inorganic nitrogen AA (mg/l)	Total inorganic nitrogen relative to permit threshold
2016	12.95	64.8 %
2017	12.35	61.8 %
2018	12.16	60.8 %
2019	12	60 %
2020	16.23	81.2 %
2024	14.9	74.5 %

2.8.3.2 Overton WwTW Discharge

Table 2-10 summarises the results from WIMS sewage discharge chemical testing in Overton WwTW Discharge. The results have been compared to the emission limits of the Overton WwTWs discharge permit (SO/NPSWQD010441). This permit comprises 5 variations issued from 2010, with the current permit issued in March 2025 and the former permit issued in August 2021. The table below shows the minimum and maximum of the data set, as well as the period of the last exceedance of the current permit limit during the monitoring period. Historically, the permit may have had higher thresholds than it does currently, so the recorded value of 27.1 mg/l Ammoniacal Nitrogen in December 2004 or 1,620 mg/l Suspended Solid in July 2003 may not have been an exceedance as the permit in this location was initiated in 2010. There have been no exceedances during period that the current permit has been issued.

Table 2-10: Overton Stw sewage discharge quality

Overton Stw Discharge (SO-G0003946)	Minimum	Maximum	Permit emission limit (SO/NPSWQD010441)	Discussion of Maximum Result
Ammoniacal Nitrogen as N (mg/l)	0.01	27.1 (before 2010); 13.3 (after 2010)	5	December 2004 - No breach during the period of the current permit
Total iron as Fe	0.026	2.98	8 (maximum)	None
Phosphorus Total as P (mg/l)	0.25	2.2	1 (rolling 12 months mean)	See Table 2-11 and Appendix A.2.1
Solids Suspended at 105 °C (mg/l)	1	1,620 (before 2010); 57.9 (after 2010)	60	December 2008 - No breach during the period of the current permit
Visible Oil - Times observed	None		None	None

Table 2-11 shows the parameters used to calculate phosphorus rolling 12-month mean (mg/l) (see methodology in Appendix A.2) from 2013 to 2024 in Overton WwTW, along with a comparison to the permit threshold. The table shows that the phosphorus rolling 12-month means (mg/l) do not exceed the permit limit of 1 mg/l since 2013. However, during the monitoring period, the calculated phosphorus rolling 12-month means have been approximately 41% to 76% of the current permitted threshold.

Table 2-11: Phosphorus rolling 12-month mean at the Overton WwTW

Year	Phosphorus rolling 12-month mean	Phosphorus concentration relative to permit threshold
2013	0.76	76 %
2014	0.62	62 %
2015	0.42	42 %
2016	0.45	45 %
2017	0.48	48 %
2018	0.6	60 %
2019	0.49	49 %
2020	0.44	44 %
2021	0.49	49 %
2022	0.41	41 %
2023	0.43	43 %
2024	0.54	54 %

2.8.3.3 Oakley Ivy Down WwTW

The summary of results from WIMS sewage discharge chemical testing in Oakley Ivy Down WwTW Discharge is summarised in Table 2-12. The results have been compared to the emission limits of Oakley Ivy Down WwTWs discharge permit (SO/W00225). This permit comprises 8 variations issued from 1979, with the current permit issued in February 2017. The table below shows the minimum and maximum of the data set, as well as the last exceedance of the current permit limit during the monitoring period. Historically the permit may have had higher thresholds than it does currently, so the recorded value in January 2016 may not have been an exceedance of the permit at the time. There have been no exceedances during period that the current permit has been issued.

Table 2-12: Oakley Ivy Down Stw sewage discharge quality

Oakley Ivy Down Stw (SO-G0003954)	Minimum	Maximum	Permit emission limit (SO/W00225)	Last exceedance
Ammoniacal Nitrogen as N (mg/l)	0.01	11.1	5	January 2016 - No breach during the period of the current permit
Total inorganic Nitrogen as N (mg/l)	17.7	41.4	35 (annual average)	See Table 2-13

Oakley Ivy Down Stw (SO-G0003954)	Minimum	Maximum	Permit emission limit (SO/W00225)	Last exceedance
Solids Suspended at 105 °C (mg/l)	1	50.5	60	None
Visible Oil - Times observed	None		None	None

Table 2-13 shows the annual averages (AA) for the total inorganic nitrogen (mg/l) from 2016 to 2024 in Oakley Ivy Down WwTW, along with a comparison to the permit threshold. The table shows that the total inorganic nitrogen annual average concentrations (mg/l) do not exceed the permit limit of 35 mg/l since 2016. However, during the monitoring period in Oakley Ivy Down Stw, the annual average of total inorganic nitrogen concentrations has been approximately 80% to 93% of the current permitted threshold.

Table 2-13: Total inorganic nitrogen (as N) at the Oakley Ivy Down WwTW

Calendar year (1 January to 31 December)	Total inorganic nitrogen AA (mg/l)	Total inorganic nitrogen AA concentration relative to permit threshold
2016	27.71	79.2 %
2017	27.88	79.7 %
2018	28.38	81.1 %
2019	28.75	82.1 %
2020	32.43	92.7 %
2021	31.18	89.1 %
2022	28.84	82.4 %
2023	29.41	84 %
2024	28.59	81.7 %

2.8.3.4 Whitchurch WwTW Discharge

The summary of results from WIMS sewage discharge chemical testing in Whitchurch WwTW Discharge is summarised in

Table 2-14. The results have been compared to the emission limits of Whitchurch WwTWs discharge permit (SO/W00292). This permit comprises 8 variations issued from 1979, with the current permit issued in December 2024. The table below shows the minimum and maximum of the data set, as well as the period of the last exceedance from the current permit limit during the monitoring period.

Table 2-14: Whitchurch Stw sewage discharge quality

Whitchurch Stw Discharge (SO-G0003931)	Minimum	Maximum	Permit emission limit (SO/W00292)	Last exceedance
Ammoniacal Nitrogen as N (mg/l)	0.01	4.31	5	None
Total inorganic Nitrogen as N (mg/l)	13.6	28	32 (annual average)	None
Solids Suspended at 105 °C (mg/l)	1	33.7	60	None
Visible Oil - Times observed	None		None	None

2.8.4 Upgrade plans

The Government Website[3] (updated May 2024), indicates that the water companies have a duty to ensure wastewater treatment works serving a population equivalent of over 2,000 discharging into designated catchments meet specified nutrient removal standards. The nutrient pollution standards specified (10 mg per litre for nitrogen and 0.25 mg per litre for phosphorus) align with current Technically Achievable Limits. This is the most stringent limit the Environment Agency will normally set in a permit to reduce a certain pollutant from wastewater using currently available technology.

From the four WwTWs assessed above, Overton and Whitchurch WwTWs, located in the Solent catchment area, have been identified to meet the new nutrient pollution standard for nitrogen (only) at the upgrade date of 01 April 2030.

[3] https://www.gov.uk/government/publications/notice-of-designation-of-sensitive-catchment-areas-2024/information-about-nutrient-significant-plants

Table 2-14 shows that in Whitchurch WwTW, the nitrogen concentrations have always been higher than the proposed upgraded standard during the monitoring period. Additionally, Overton WwTW discharge permit indicates that the nitrogen had never been a parameter which required monitoring in this location and therefore, had never been measured during the monitoring period. This suggests that upgrades to the works may be required to meet these new requirements.

2.8.5 Summary

The findings from the comparison between WIMS sewage discharge chemical testing and the thresholds of the discharge permits, in the monitoring period of 2000 to 2025, is summarised below:

- Regarding Ammoniacal Nitrogen (as N) - no exceedances have been recorded during the period of the current permits.
- Historically emissions of ammoniacal nitrogen (as N) were routinely higher, and would have exceeded current thresholds on multiple occasions. Below are the last dates of exceedances based on current permit thresholds:
  - North Waltham Stw (SO-G0003952) - Last exceedance: October 2013
  - Overton Stw Discharge (SO-G0003946) - Last exceedance: February 2012
  - Oakley Ivy Down Stw (SO-G0003954) - Last exceedance: January 2016
- Suspended solids within the discharges from the WwTWs do not exceed the emission limit.
- Total inorganic nitrogen concentrations (as N) within the discharges from the WwTWs do not exceed the annual average limit.
- Total iron concentrations within the discharges from the WwTWs do not exceed the maximum limit.
- Total phosphorus concentrations (as P) within the discharges from the WwTWs do not exceed the rolling 12-month mean limit.

3 Hydrogeological conceptual model

This section presents an example of a hydrogeological conceptual model of the Whitchurch WwTW. This is representative of WwTW discharges to ground in the study area.

3.1 Hydrogeological conceptual model

The Environment Agency defines a conceptual model as "a description of how a hydrogeological system is believed to behave" and its development as "an iterative or cyclical process of development and testing in which new observations are used to evaluate and improve the model" (Environment Agency, 2002, p.4.1-2). Figure 3-1 presents an example of the schematic conceptual model in close proximity of a discharge permit (SO/W00229) near Whitchurch within the study area.

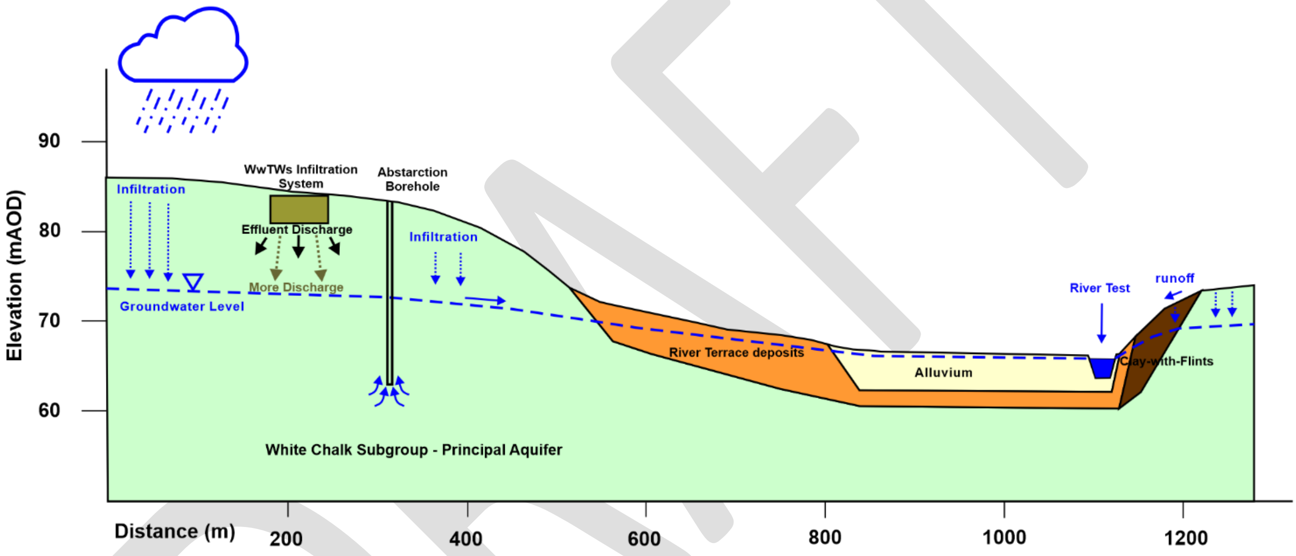

Figure 3-1: Schematic hydrogeological conceptual model of the Whitchurch WwTW

The main features of this conceptual model are as follows:

- Geology:
  - The superficial deposits including alluvium, clay-with-flints and river terrace deposits, are limited to the valley floor of the river floodplain with a thickness of up to 20m.
  - The majority of the area is underlain by up to 180m White Chalk Subgroup (Upper Chalk and Middle Chalk) belonging to Cretaceous Period. Away from the valley floor the Chalk outcrops at higher elevations.
- Hydrogeology:
  - Alluvium, river terrace and glaciofluvial sand and gravel superficial deposits are shallow, locally important Secondary A aquifers.

- The underlying White Chalk Subgroup is a highly productive Principal aquifer yielding 50 to 100 L/s from large diameter boreholes. This strata has high vulnerability with very limited natural protection.
- Away from the valley floor the thickness of the unsaturated zone within the Chalk is expected to increase. However, the water table within the Chalk will rise and fall in response to changes in infiltration rates and other local factors such as groundwater abstraction.
- The River Test is in hydraulic continuity with the underlying deposits and is also supported by baseflow from the Chalk aquifer.

- Surface water and groundwater interactions:
    - Chalk bedrock outcrops in most of the study area and is overlain by limited superficial deposits. The superficial deposits are relatively thin compared to the chalk and so have a limited role in the groundwater-surface water interface.
- Abstractions:
    - Several abstraction licences (public water supplies) and the relevant Source Protection Zones are located within the study area.
- Infiltration pattern:
    - Infiltration into the chalk where it outcrops is rapid, and there is very limited runoff from the chalk.
    - The clay-with-flints has a limited impact on infiltration. Runoff infiltration from the clay-with-flint onto the chalk is very limited.
- Effluent discharge to the ground from WwTWs infiltration system:
    - The housing growth in the area increases the discharge of effluent from WwTWs, and may potentially lead to a negative impact on the quality of the underlying Chalk in localised plumes.
    - Discharges from WwTW are however controlled by the Environmental Permitting (England and Wales) Regulations 2016. Under the Environment Agency's Approach to Groundwater Projection 2018 (available at Groundwater protection position statements - GOV.UK) Permits will only be granted by the EA where: it will not result in pollution of groundwater and is unlikely to lead to an unacceptable cumulative impact.
    - Discharge of sewage via boreholes is not routinely encouraged with the EA stating "the Environment Agency cannot prevent the use of boreholes or other deep structures for sewage effluent disposal, their use must not be regarded as a routinely appropriate disposal option". It goes on to say "The extent of examination is site-specific and a matter for local judgement by Environment Agency staff based on local groundwater sensitivity. In general, the larger the proposed discharge and the more vulnerable the location, the more likely it is that a detailed quantitative risk assessment is required. This may need to be supported by site-specific data on the aquifer properties, seasonal variation in depth to water table and baseline groundwater quality." Overall, very high

standards of assessment and quantification will be required by the EA on new Environment Permits or variations where sewage is being discharged to ground due to sensitive groundwater environment coupled with the method of disposal to ensure the overall quality of the aquifer. Section 8.3 of the Water Cycle Study provides information on the likelihood of WwTWs exceeding the volumetric permit.

4 Water Budget

4.1 Test and Itchen (T&I) Groundwater Model

In 2020[4], the Environment Agency commissioned Wood Environment & Infrastructure Solutions UK Ltd to review and develop the conceptual understanding of groundwater and river flow processes across the Chalk and Upper Greensand aquifers drained by the Rivers Test, Itchen, Wey, and by other Thames tributaries in order to update the 2005 Test and Itchen (T&I) Regional Groundwater Model. The model covers the Basingstoke area, and the Chalk to the south all of the way to Southampton. The updated regional groundwater model was then used by JBA in 2020 and 2022 to quantify the benefits of a range of Nature-Based Solutions (NBS) from the baseline (no NBS interventions) for water resources benefits in the Test and Itchen Catchment, commissioned by the Environment Agency. The modelling area in the T&I regional groundwater model encompasses the BDBC area, stretching north to Newbury, south to Southampton, west to Salisbury, and east to Farnborough. A summary of results from the T&I groundwater model is presented in Table 4-1:

Table 4-1: Water balance over the Long Term Average (LTA) across the catchment

Parameter	LTA (mm/day) - Jan 1965 to Mar 2018
Rainfall	915
Actual evapotranspiration	496
Runoff	113
Interflow	7
Recharge	383
Baseflow Index (BFI) range (%)	92 - 94

From the information presented in Table 4-1, and given the area of the White Chalk Subgroup within the BDBC as being approximately 422km^2, it can be concluded that the long-term average recharge into the underlying Chalk aquifer within the BDBC area is approximately 4.5E+05 m^3/day. Table 2-5 shows that the total permitted effluent discharge from the WwTWs to the ground is 4,400.2 m^3/day, approximately 1% of the total infiltration to the underlying White Chalk Subgroup.

[4] Test and Itchen groundwater and river flow model update and rebuild report, Wood Environment & Infrastructure Solutions UK Limited – April 2020

5 Conclusion

This hydrogeological assessment has been developed to assess the impact of the housing growth in the BDBC study area and the consequent increase in the discharge of effluent from WwTWs into the ground. This was achieved by developing a site specific hydrogeological conceptual model of Whitchurch WwTW discharge which was representative of discharges in the wider study area. This has identified that the study area lies within a highly sensitive groundwater environment and therefore, any development within this area can lead to a negative impact on the quality of the receiving groundwater body. Under the Water Framework Directive (WFD), a waterbody, including surface water and groundwater, is not allowed to deteriorate from its current WFD classification (either the overall watercourse classification or for individual elements assessed).

In summary, the findings of this assessment are:

- The underlying Chalk groundwater bodies have poor WFD status due to the poor nutrient management and pollution from agricultural and rural areas (nitrate).
- The total permitted effluent discharge from the WwTWs to the ground is estimated to be approximately 1% of the total infiltration to the underlying White Chalk Subgroup.
- The Environment Agency has defined emission limits and monitoring requirements at discharge permits as follows:
  - Oakley Ivy Down WwTW (SO/W00225): Ammoniacal nitrogen (as N): 5 mg/l, Suspended solids: 60 mg/l, Total inorganic nitrogen (AA): 35 mg/l, Visible oil or grease: No significant trace
  - North Waltham WwTW (SO/W00226): Ammoniacal nitrogen (as N): 5 mg/l, Suspended solids: 60 mg/l, Total inorganic nitrogen (AA): 20 mg/l, Visible oil or grease: No significant trace
  - Whitchurch WwTW (SO/W00292): Ammoniacal nitrogen (as N): 5 mg/l, Suspended solids: 60 mg/l, Total inorganic nitrogen (AA): 32 mg/l, Visible oil or grease: No significant trace
  - Overton WwTW (SO/NPSWQD010441): Ammoniacal nitrogen (as N): 5 mg/l, Suspended solids: 60 mg/l, Total iron as Fe (max): 8 mg/l, Total Phosphorus as P (rolling 12-month mean): 1 mg/l, Visible oil or grease: No significant trace
  - From the assessed WwTWs, Overton and Whitchurch WwTWs have been identified to be required to meet the new nutrient pollution standard for nitrogen (10 mg/l) at the upgrade date of 01 April 2030.Upgrades may be required to these works to meet the new requirements.
- The comparison between WIMS sewage discharge chemical testing and the emission limits of the discharge permits, in the monitoring period of 2000 to 2025, shows that:
  - Regarding ammoniacal nitrogen (as N), there have been no exceedances beyond the limits set by the current permits, and no violations of the permit's

conditions have been observed. However, historically emissions of ammoniacal nitrogen (as N) were routinely higher, and would have exceeded current thresholds on multiple occasions. It is likely that the water companies have effectively managed to control ammoniacal nitrogen (as N) emissions into the ground by treating wastewater effluent to a more stringent standard.
  - Suspended solids within the discharges from the WwTWs do not exceed the emission limits.
  - Total inorganic nitrogen concentrations (as N) within the discharges from the WwTWs do not exceed the annual average limit.
  - Total iron concentrations within the discharges from the WwTWs do not exceed the maximum limit.
  - Total phosphorus concentrations (as P) within the discharges from the WwTWs do not exceed the rolling 12-month mean limit.

Based upon the assessment of the current permits up to date, it can be concluded that the development and housing growth within the BDBC area could result in exceedances of the emission limits, mainly ammoniacal nitrogen (as N) concentrations, if the capacity for wastewater effluent treatment does not expand with the increase of effluent volumes that housing would generate. Although the total inorganic nitrogen and total phosphorus concentrations do not exceed the EA's thresholds, it is possible that the housing growth will result in breaching these limits in the future and consequently deteriorating groundwater quality of the Principal Chalk aquifer, which already suffers from high nitrate concentrations should no action be taken. This could be managed through a tightening of the permit so there is no increase in the pollutant load (load standstill), On the basis of the current permits (5mg/l Ammoniacal Nitrogen) this looks to be achievable as the nationally agreed technically achievable limit for Ammoniacal Nitrogen is 1mg/l.

A Permit conditions - Emissions to water

A.1 Ammoniacal nitrogen (as N) and suspended solids

The permit conditions for emissions and monitoring to water include:

- The limits shall not be exceeded.
- The limits to which this conditions applies may be exceeded where: in any series of samples of the discharge taken to a regular but randomised intervals in any period of twelve consecutive months as listed in column 1 of Table A-1, no more than the relevant number of samples, as listed in column 2, exceed the applicable limit for the relevant parameter.

Table A-1: Monitoring look up table

Number of samples taken in any period of 12 months	Maximum number of samples permitted to exceed limit of given parameter
1 - 4	1
8 - 16	2
17 - 28	3
29 - 40	4
41- 53	5
54 - 67	6
68 - 81	7
82 - 95	8
96 - 110	9
111 - 125	10
126 - 140	11
141 - 155	12
156 - 171	13
172 - 187	14
188 - 203	15
204 - 219	16
220 - 235	17
236 - 251	18
252 - 268	19
269 - 284	20

Number of samples taken in any period of 12 months	Maximum number of samples permitted to exceed limit of given parameter
285 - 300	21
301 - 317	22
318 - 334	23
335 - 350	24
351 - 365	25

A.2 Phosphorus Total as P - Rolling 12 months mean assessment methodology and t-values

Use concentrations from the pre-scheduled samples taken in any period of 12 consecutive months unless a fixed 12-month period is specified by the permit.

- Take the log10 value of all P concentrations in the data set. For a zero value, take the log10 value of the minimum detection limit of the analytical method used. Treat less thans or greater thans as face value.
- Calculate the mean of the log10 values.
- Calculate the standard deviation of the log10 values.
- Calculate the lower confidence interval using the formula lower confidence interval = mean – (t x standard error of mean).
    - t is derived from the values of t table for n-1 degrees of freedom, where n is the number of samples
    - the standard error of the mean is the standard deviation of the dataset ÷ √n.
- Antilog the lower confidence interval.

If the lower bound confidence interval exceeds the permit limit, then we are 95% confident that the limit has been exceeded and a failure is recorded.

A.2.1 Phosphorus Total as P - Rolling 12 months mean assessment at the Overton WwTW

Year	Mean of the log10 values	Standard deviation	Standard error	Number of samples	Degree of freedom	t value	Lower confidence	Antilog the lower confidence interval	Phosphorus concentration relative to permit threshold
2013	-0.049	0.147	0.041	13	12	1.782	-0.122	0.76	76 %
2014	-0.1	0.208	0.06	12	11	1.796	-0.208	0.62	62 %
2015	-0.327	0.099	0.029	12	11	1.796	-0.378	0.42	42 %
2016	-0.295	0.109	0.031	12	11	1.796	-0.351	0.45	45 %
2017	-0.206	0.211	0.61	12	11	1.796	-0.315	0.48	48 %
2018	-0.146	0.149	0.043	12	11	1.796	-0.224	0.6	60 %
2019	-0.206	0.197	0.057	12	11	1.796	-0.308	0.49	49 %
2020	-0.27	0.16	0.046	12	11	1.796	-0.353	0.44	44 %
2021	-0.218	0.176	0.051	12	11	1.796	-0.309	0.49	49 %
2022	-0.277	0.218	0.063	12	11	1.796	-0.39	0.41	41 %
2023	-0.283	0.154	0.044	12	11	1.796	-0.363	0.43	43 %
2024	-0.228	0.073	0.021	12	11	1.796	-0.266	0.54	54 %

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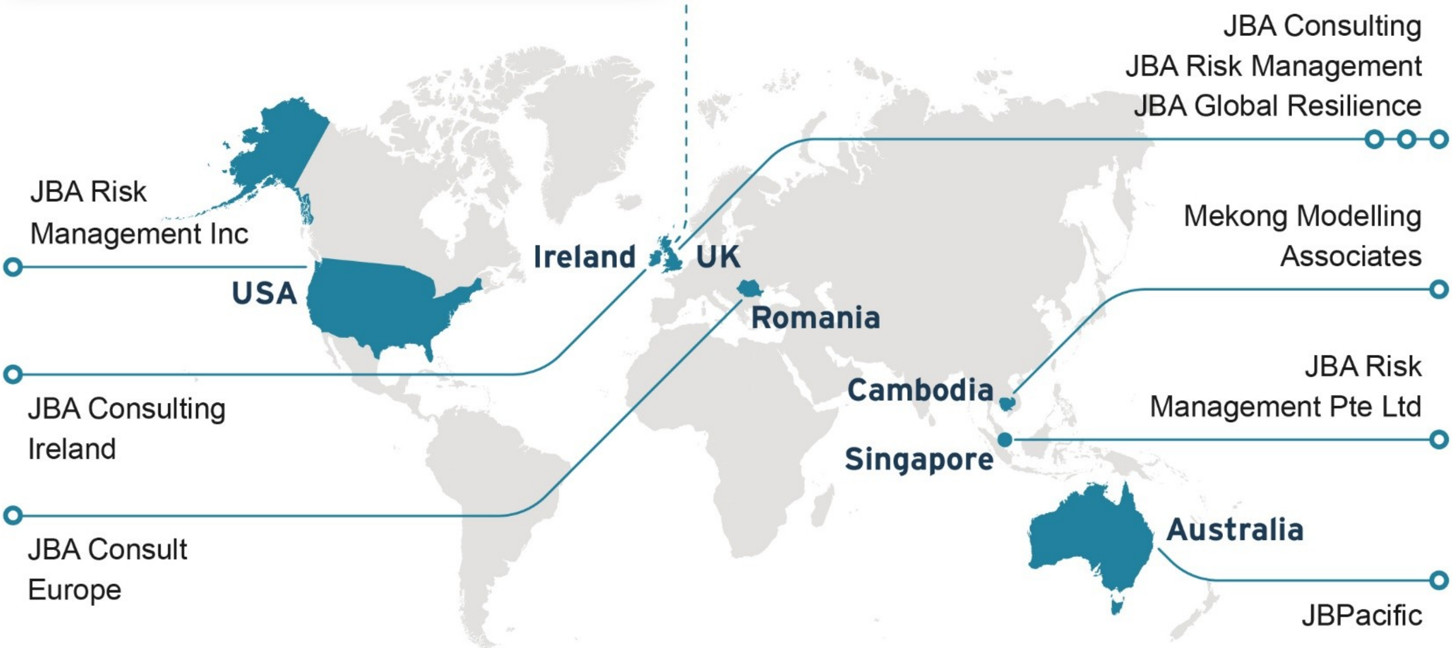

Registered Office
1 Broughton Park
Old Lane North
Broughton
SKIPTON
North Yorkshire
BD23 3FD
United Kingdom

+44(0) 1756 799919
info@jbaconsulting.com
www.jbaconsulting.com

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