

8 UK: BEDHAMPTON AND HAVANT SPRINGS

8.1 Overview

The Bedhampton and Havant springs are located in southern England, within the county of Hampshire. They are often referred to as a 'spring complex' as they are made up of over 28 discrete springs that issue along a 1.5 km east–west trending line (Jones and Robins, 1999). The average combined discharge of the springs is 94 Ml/day (James Bucknall, personal communication 2017). The springs sustain a major public supply to the surrounding areas, including the city of Portsmouth.

The Cretaceous Chalk forms a principal aquifer under much of the South East of England, including beneath the Bedhampton and Havant Springs. It has a high transmissivity due to an extensive fracture network which is enhanced by dissolutional processes. The Chalk in this region displays classic signs of karst, including dissolutionally enlarged cavities, dolines, solution pipes and stream sinks (McDowell et al., 2008; Barton et al., undated). A series of tracer tests conducted in the region, primarily injected into swallow holes, suggest groundwater velocities of up to 12.30 km/day, over distances of up to 6.6 km (Price, 1979; Barton et al. undated).

8.2 Geology

The Cretaceous Chalk is the major aquifer in this region of the UK, with the Bedhampton and Havant springs issuing from its upper formations. Palaeogene sediments from the Lambeth Group and London Clay Formation overlie the Chalk in areas. Parts of the Chalk outcrop are covered in even younger superficial deposits such as [alluvium](#) and the [Clay-With-Flints Formation](#), the latter is reworked Palaeogene material.

The Chalk in this region is formed of the White Chalk Sub-Group which consists of 5 independent Formations (*Figure 28*), and known for its high density of stratigraphic features including flint bands, marl seams and hard grounds. Fractures are also common, and often found with increased aperture due to dissolution. The nature of the fractures and inception horizons are dependent on the local hydrogeological conditions. *Figure 28* shows the dominant lithology in the Bedhampton and Havant area.

Group	Formation	Lithology
Thames Group	London Clay Formation	Clay, some silt and sand and pebbles
Lambeth Group	Reading Formation	Clay and sand
White Chalk Subgroup	Newhaven Chalk Formation	Soft to medium hard smooth white chalk with numerous marl seams and flint bands.
	Seaford Chalk Formation	Firm white chalk with large nodular and tabular flints.
	Lewes Nodular Chalk Formation	Hard to very hard nodular chalks with interbedded soft chalk and marls.
	New Pit Chalk Formation	Firm and blocky white chalk with sporadic flint and numerous marls.

	Holywell Formation	Nodular Chalk	Hard nodular chalk with thin marls and often significant shell debris.
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Figure 28: Table of lithology of the Bedhampton and Havant spring complex

The geological structure of the area is dominated by the east-west trending Chichester Syncline (Figure 29). The Chalk outcrops to the north and southwest of the syncline, and superficial deposits outcrop in the centre. The springs at Bedhampton and Havant are situated within the upper part of the Chalk group on the steep northern limb of the Portsdown anticline (Figure 29).

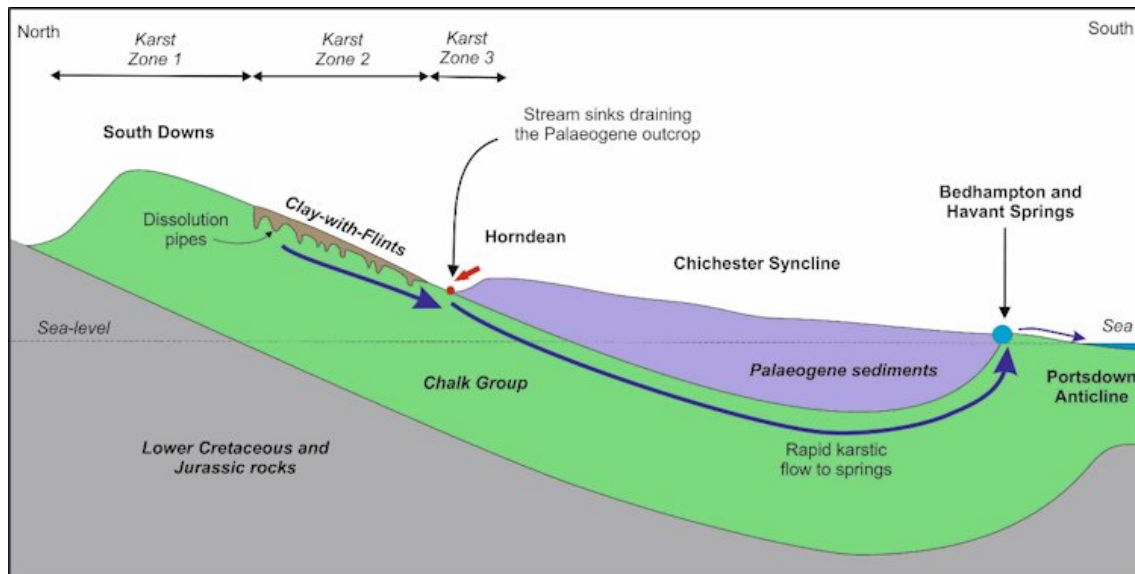


Figure 29: Schematic cross-section of the Chichester Syncline. Geological material © NERC. All rights reserved. Topography © Crown Copyright reserved.

8.3 Geomorphology

Surface karst features are observed in abundance in the Bedhampton and Havant area, suggesting the presence of well-developed karstic networks. Barton et al. (undated) state that there are around 50 stream sinks within the Bedhampton and Havant area. Stream sinks in outcrops of the Chalk mostly occur near the boundary with the Palaeogene formations due to focused infiltration into the Chalk where water drains off these impermeable beds (Maurice et al., 2017). Stream sinks are important points of recharge into the Chalk aquifer, especially as there are no permanent streams in the area.

Dolines are common features in the Cretaceous Chalk and are generally associated with the Chalk-Palaeogene boundary. They may be abandoned stream sinks or other types of dolines (Maurice et al., 2017). There are more than 300 recorded “surface depressions” in the Bedhampton and Havant area, from BGS, EA and Portsmouth Water records. It is extremely difficult to distinguish between karst dolines and manmade pits in the Chalk and surface depressions may not all be karst solution features. The density of dolines is reported to be significantly larger than the remaining South Downs Chalk, with a density of solution features of 55 per km² near Rowlands Castle and Horndean, compared to an average 15 features per 100 km² across the South Downs (McDowell et al., 2008). Dissolution pipes are also common in the Chalk. BGS hold no record of dissolution pipes in the Bedhampton and Havant area. However,

they are likely to be present, especially on the northern limb of the Chichester Syncline (*Figure 29*) where the Chalk is overlain by the Clay-with-Flints formation, but may have no surface expression. Dry valleys also occur within the catchments.

8.4 Climate

The UK is split into a number of climate zones, with the Bedhampton and Havant spring complex lying within the 'Southern England' zone. In this zone the mean annual temperatures vary between 11.5°C in central London and along the southern coast, to 9.5°C inland (Met Office, 2016). This is slightly higher than the UK average between 7 and 11°C.

Bedhampton and Havant, are not far from the wettest areas in the South Downs and the higher parts of Dorset, which have an average of over 950 mm of rain per year. The driest parts of eastern England get only 500 mm per year (Met Office, 2016). Prolonged rainfall can lead to widespread flooding especially when the soils are near saturation, making it prone to flood events.

8.5 Hydrogeology

Groundwater levels indicate that regional groundwater flow is focused towards the Bedhampton and Havant springs. The Chichester Syncline acts as a barrier to groundwater flow through the Chalk (Jones and Robins, 1999) deflecting groundwater flow beneath the Palaeogene deposits coastward from the topographic highs of the South Downs. It is likely that the Chalk is intensely fractured in this area, allowing groundwater movement across the Chichester syncline (Day, 1964).

Substantial proportions of groundwater flow in karstic areas is through solutionally enhanced fissure networks. Stream sinks are important points of recharge for the aquifer as there are no permanent streams in the area. Flow into some nearby stream sinks were measured by Portsmouth Water in 1961 and recorded flows of more than 7 Ml/day into single sink holes (Price 1979).

Tracer testing described in Atkinson & Smith (1974) aimed to establish a potential connection between swallow holes associated with the Cretaceous-Palaeogene boundary and the Bedhampton and Havant spring complex. The tracer tests demonstrated rapid groundwater flow, with first arrival velocity of 2.60 km/day at Bedhampton and 2.08 km/day at Havant (Atkinson & Smith, 1974). Dye tracers were used and first detected at Bedhampton springs, 5750 m from the injection site 53 hours after injection, giving a calculated velocity of 2.60 km/day. The first detection at Havant springs, 5800 m from the injection site was 67 hours after injection, giving a velocity of 2.08 km/day. A total of 69.7% of the tracer was recovered, 69.1% was recovered at Bedhampton springs and 0.6% recovered at Havant springs, implying a stronger connection from Hazelton Wood Swallet to the Bedhampton springs than to the Havant springs. Atkinson & Smith (1974) concluded that it is possible that the two springs drain different parts of the Chalk, but are connected by fractures near the springs which results in some mixing. The theory is backed up by the water quality records from Portsmouth Water, which highlight different responses to rainfall of dissolved solids and turbidity in the springs at Bedhampton and those at Havant (Atkinson & Smith, 1974).

Eight further connections were identified in 1978 between four stream sinks on the northern limb of the Chichester Syncline and the Bedhampton and Havant springs over distances of 4.6

to 6.6 km, the results of which are discussed in Price (1979) and Barton et al. (undated). The tracer tests show that fast preferential flow routes that occur in the Chalk are commonly associated with close proximity to the Palaeogene cover, where the surface karst features are primarily located (Allen, 1995). The most westerly stream sink (No. 13) showed no connection to either the Bedhampton or Havant springs. Three others showed connections to both Bedhampton and Havant springs, but with varying velocities and recovery rates. Out of the three, the westerly stream sink (No. 26) recorded a first arrival at Bedhampton 57 hours after injection, with a flow velocity of 2.65 km/day, and to Havant after 50 hours at 3.17 km/day. Of a total 8.8% tracer recovery, 7.9 % was recovered at Bedhampton and 0.9% at Havant. The central stream sink (No. 41) was first detected at Bedhampton after 27 hours and at Havant after 35 hours. Groundwater velocities determined from this test were therefore 5.07 km/day from No. 41 to Bedhampton and 4.00 km/day to Havant. Of the 49.6% recovered tracer, 39.7% was recovered at Bedhampton, while only 9.9% was recovered at Havant. The most easterly stream sink (No. 39) located between 4.6 km and 4.8 km from the springs recorded velocities of 10.5 km/day to Bedhampton and 12.3 km/day to Havant (based on first arrival times). The total calculated recovery for this test was 38.4%, with 23.2% recovered at Bedhampton and 15.2% at Havant.

8.6 Hydrodynamic characteristics of the springs

The discharge data available for the Bedhampton and Havant springs is on a weekly timestep, and is corrected for the influence of a nearby abstraction. Between 1908 and 2016 the average combined discharge of Bedhampton and Havant springs was 94 MI/day where the minimum weekly average yield was 53 MI/day and the maximum was 169 MI/day. However, we hold no discharge data for the separate springs.

Turbidity data are available at roughly a weekly timestep from January 2001 to January 2019. Turbidity in the Bedhampton and Havant springs has been observed by Portsmouth water to be caused by turbid water entering the karstic network via stream sinks situated to the north of the springs. Coincidence between the turbidity in the springs and significant rainfall events was previously noted and discussed in Price (1979).

Coliform data are available at roughly a weekly timestep from January 2001 to November 2018. High coliform counts are indicative of short groundwater residence times. At Bedhampton approximately 29% of samples recorded over 100 NO/100 ml, with 6% of these greater than 1000 NO/100 ml. Seasonal fluctuations are observed, with higher coliform counts observed during the wetter winter months. A similar distribution of data is observed at the Havant springs.

8.7 Data available for the project

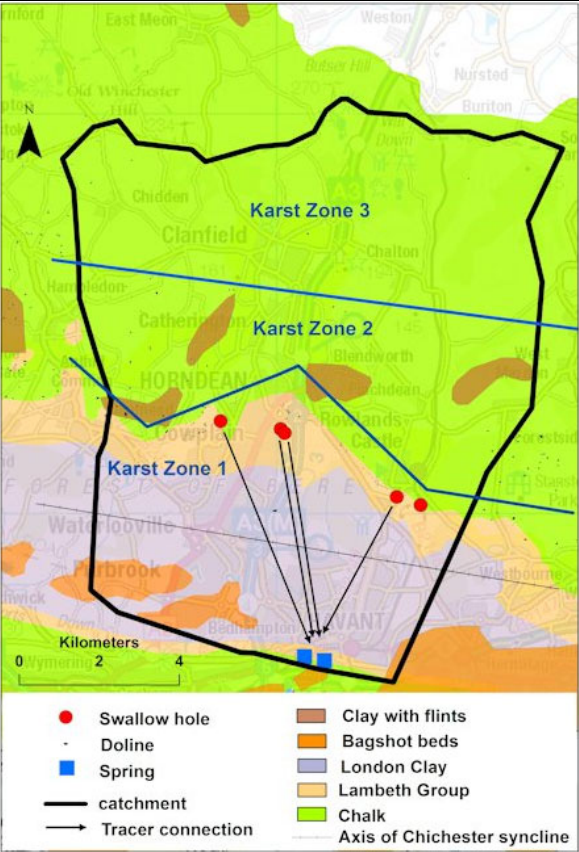
1. Bedhampton springs			
Data type	Time step	Monitoring period	Time period
Discharge (combined for B & H)	Weekly	107.5	01/1908 – 04/2016
E.Coli	4-7 days (Weekly)	18 years	01/2001 – 11/2018
Total coliforms	4-7 days (Weekly)	18 years	01/2001 – 11/2018
Turbidity	4-7 days (Weekly)	18 years	01/2001 – 01/2019
Pesticides (various)	1-2 per month	12 years	01/2008 – 01/2019
Electrical conductivity	4-7 days (Weekly)	18 years	01/2001 – 12/2018

Major anions/cations	4-7 days (Weekly)	18 years	01/2001 – 12/2018
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2. Havant springs			
Data type	Time step	Monitoring period	Time period
Discharge (combined for B & H)	Weekly	107.5 years	01/1908 – 04/2016
E.Coli	4-7 days (Weekly)	18 years	01/2001 – 11/2018
Total coliforms	4-7 days (Weekly)	18 years	01/2001 – 11/2018
Turbidity	4-7 days (Weekly)	18 years	01/2001 – 01/2019
Pesticides (various)	1-2 per month	12 years	01/2008 – 01/2019
Electrical conductivity	4-7 days (Weekly)	18 years	01/2001 – 12/2018
Major anions/cations	4-7 days (Weekly)	18 years	01/2001 – 12/2018

*unreliable data

8.8 Summary

Pilot name	Bedhampton and Havant Springs		
Country	UK	EU-region	
Area (km ²)		Lithology	Chalk
Short description:	Large springs at Bedhampton and Havant have a combined average discharge of 94 Ml/day. The fast flow pathways are demonstrated by various tracer tests carried out between surface karstic features and recovered at the spring complex. High velocities and high recovery rates suggest that the springs are connected to an extensive karstic network. Correlations between high turbidity events and rainfall also suggests a link between surface karstic features and the underlying Chalk aquifer that issues in the Bedhampton and Havant area.  <i>Geology and karstic features of the Bedhampton and Havant area with some of the known tracer connections highlighted. Geological material © NERC. All rights reserved. Topography © Crown Copyright reserved.</i>		
Monitored objects	3 sample locations		
Monitored data	Discharge, turbidity, EC, chemistry, pesticides		
Contact person	sbun@bgs.ac.uk and loma@bgs.ac.uk		

8.9 References

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