Water End swallow holes

[TL 231 043]

Highlights

The Water End swallow holes are some of the largest, best developed and most accessible swallow holes in the chalk karst of southern England. They admirably demonstrate the role of conduit flow within the Chalk aquifer.

Introduction

Mimmshall Brook has a catchment area of 45 km^2 draining the high ground to the south and west of Potters Bar (Figure 7.1). It drains an area of Tertiary London Clay and flows north onto the Cretaceous Chalk outcrop. For 3 km., the stream flows in a shallow valley floored by thin gravelly alluvium which rests on the chalk. At Water End, it drains underground through a series of sinkholes. Two other small streams drain into the same broad depression, and also sink into the chalk. In wet weather, the sinks cannot cope with the flow, and a lake develops; in extreme flood, this overflows into a surface course to the west to join the River Colne. The sinking water resurges between 7 and 15 km to the east at four springs along the River Lea.

The site has been described by Wooldridge and Kirkaldy (1937), Evans (1944), Waltham (1969), Ockenden (1972) and Reeve (1979). Kirkaldy (1950) included the area in his study of chalk solution in the Mimms Valley, and Walsh and Ockenden (1982) reviewed their detailed hydrological studies of the sinkhole complex.

Description

Water End lies at the edge of the London basin where the Tertiary outlier is eroded to expose the underlying chalk. Thin sandy Reading Beds are capped by London Clay, both of which are Eocene, and Pleistocene gravels form the higher ground around the valley; chalk is exposed along the floors of the main and tributary valleys (Figure 7.11). The chalk dips to the south at less than 0.5°. Glacial till is extensive to the north, and floors a shallow trough just north of Water End.

The sinkhole complex at the end of Mimmshall Brook occupies a large blind valley up to 10 m deep. The main sinks are clustered within an area of 1 ha at the end of the Mimmshall Brook surface course; this zone normally has about 15 discrete sinks and depressions, but the number may change after a major flood (Figure 7.11). Under normal weather conditions most of the water sinks at a single point, but under progressively wetter conditions the main sink is overwhelmed and a series of other sinks in the valley are utilized. In flood, the combined discharge of the streams may exceed the capacity of the swallets; a lake then forms and expands to cover ihore than 2 ha before overflowing down the normally dry valley to the west, to join the River Colne (Figure 7.11). Average stream discharge is about 801 s^{-1}, but the swallets have a capacity of about 1 m^3 s^{-1}, and this is exceeded in flood (Walsh and Ockenden, 1982). Fluorescein dye tracing proved that the water resurged at four springs spread out down 12 km of the Lea Valley (Morris and Fowler, 1937); these lie between 8 and 15 km from Water End, at elevations 20–45 m lower, and the flow-through rates averaged about 5500 m per day.

A second smaller stream, the Potterells Stream, drains the high ground to the north-east and also sinks in the northern corner of the Water End depression. Numerous sinkholes have been recorded along its lower course, which may be described as a degraded uvala, although the water normally flows across it (Wooldridge and Kirkaldy, 1937). A third very small stream sinks in Gobions Bottom, at the edge of the depression, and there are further sinkholes and dolines upstream along the floor of the Mimmshall Valley.

At the main sinks, the chalk lies just below the surface, buried under a few metres of sediment into which the streams are entrenched. Two main types of sinkhole are developed in the alluvium. Some are funnel-shaped holes with steep conical sides, in which the water drains directly into fissures within the chalk; they are often partially or totally choked with vegetation and domestic refuse. The others are shallow soakaway basins, in which the water gradually seeps through the sediment flooring the depression. Both types are essentially subsidence sinkholes, where the main surface feature is developed within the sediment overlying the chalk, but some collapse of the chalk does occur. New sinkholes appear at irregular intervals, and surface detail may be noticeably modified after a flood inundation. In some of the sinkholes, cave passages have been followed within the chalk for lengths of 10–20 m; they consist of narrow rifts with phreatic solutional enlargements and the water cascades along and down narrow floor fissures. Sediment chokes and flood risk have precluded further exploration.

Auger drilling across the sinkhole basin has revealed a layered sequence in the sediments (Walsh and Ockenden, 1982), which reach about 5 m in total thickness:

3. Dark-grey or black organic silts and clays, overlying light-brown silty clay, occasionally gravelly in part.

2. Greenish brown clay, overlying brown sands.

1. Brown silty clay with occasional chalk fragments, resting on chalk.

Interpretation

The initiation of the swallow hole complex appears to have been in the Pleistocene. The Radlett Mimms depression, in which the Mimmshall Brook is located, may have originated as part of a meander loop from a former course of the River Thames (Wooldridge and Kirkaldy, 1937). Subsequently, the underfit Mimmshall Brook was diverted by a plug of glacial till, which blocked the natural northerly continuation of the valley towards Hatfield, causing it to flow northwest to the River Colne. Since the last glaciation, a thin spread of gravels has been deposited over the valley floor.

The swallow holes appear to have formed after the gravels were deposited, as they cannot be shown to be older than the gravels (Walsh and Ockenden, 1982). Thus the sinkholes appear to be relatively recent features, formed over chalk fissures which were enlarged by solution over a very much longer period; new collapses occur at frequent intervals (Evans, 1944; Reeve, 1979; Walsh and Ockenden, 1982), usually after the basin has flooded.

The upper sediment layer (3) is interpreted as flood lake deposits, laid down during the last few decades or centuries (Walsh and Ockenden, 1982); the change from silty clay to organic clay is ascribed to geographical or vegetational changes in the drainage basin. The middle layer of sediment appears to be identical to the Reading Beds which crop out on the slopes to the east. The lowest clastic horizon (1) is a thin insoluble weathering residue of the chalk. Pollen analysis of the sediments (Walsh and Ockenden, 1982) indicates that they are postglacial. The Reading Beds (layer 2) lie under the basin at levels below the chalk on all sides, which suggests that they have been lowered by solution of the chalk on which they rest.

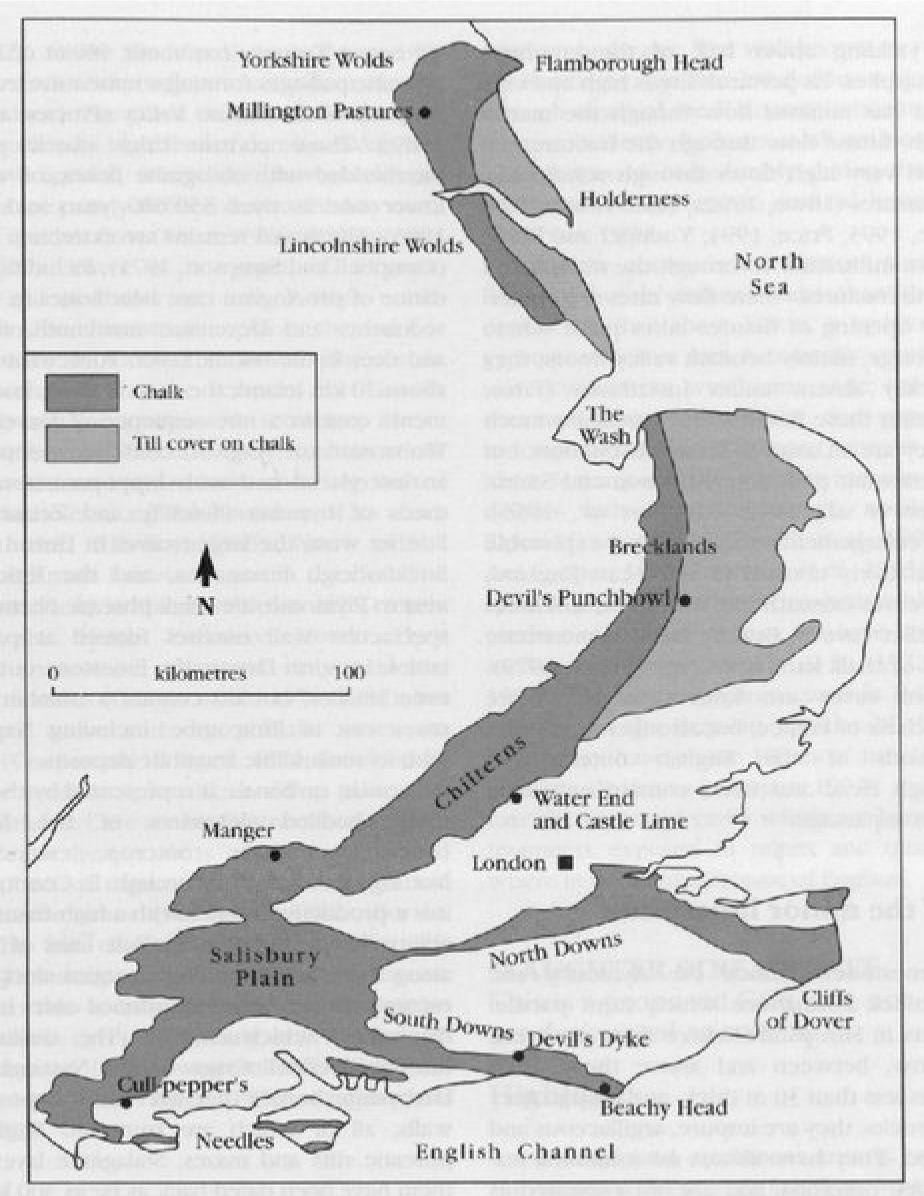
The nature of the cavity system under the swallow holes, and the pattern of underground drainage, remain conjectural. Dispersion of the dye from the single sink to the four widely spaced springs suggests that the water sinking in the swallow holes does not flow through a discrete cave system; the flow is probably mostly through a network of micro-fissures and a maze of larger fissures. The rapid flow rate suggests that there is a significantly large passage allowing vadose flow for at least part of the flow route, probably in the initial stages. The North Mimms Well, 500 m from Water End, has a very stable water table about 12 m below the sinkhole level, and recorded none of the dye injected at the sinks. This suggests that the chalk is honeycombed by a fissure system which allows free drainage from the sinks down to the regional water table, as seen in the short vadose sections of accessible cave. The large amount of clastic sediment which has been carried into the stream sinks during formation of the surface depressions is a further indication of the considerable size of the solutional cavities within the chalk.

Quantitative dye-tracing from the sinks under different stage conditions would provide further data on the nature of the underground drainage network beneath the swallow holes, and this would have implications for waste disposal and water management in Chalk areas.

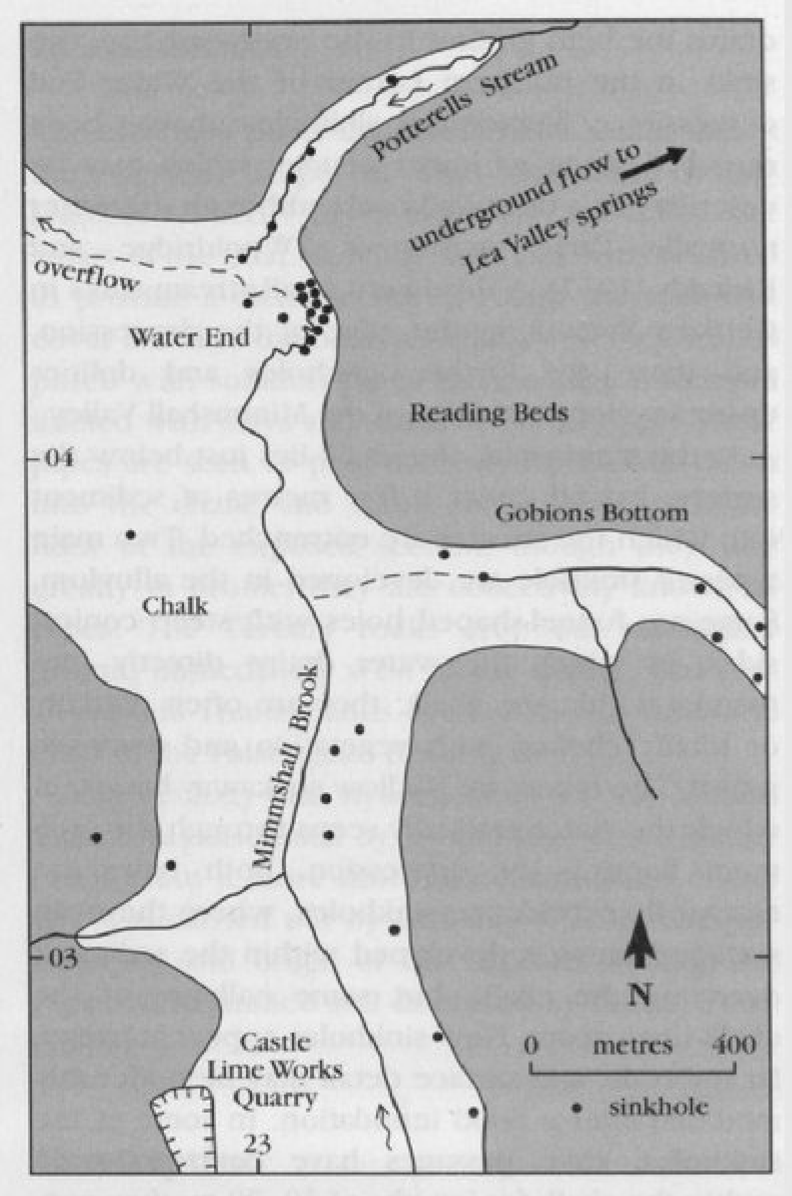
Conclusions

The Water End swallow holes are the best and largest examples in Britain of permanent stream sinks developed in the chalk karst, and they clearly demonstrate the role of conduit flow within the Chalk aquifer.

[References](#)



(Figure 7.1) Outline map of the chalk karst of England, with locations documented in the text. Superficial deposits occur on many parts of the Chalk outcrop; only the large areas of glacial till are distinguished on this map, as they mask most topographic expression of the karst.



(Figure 7.11) Geological map of the Mimmshall Valley with the Water End sinkholes and the Castle Lime Works Quarry.