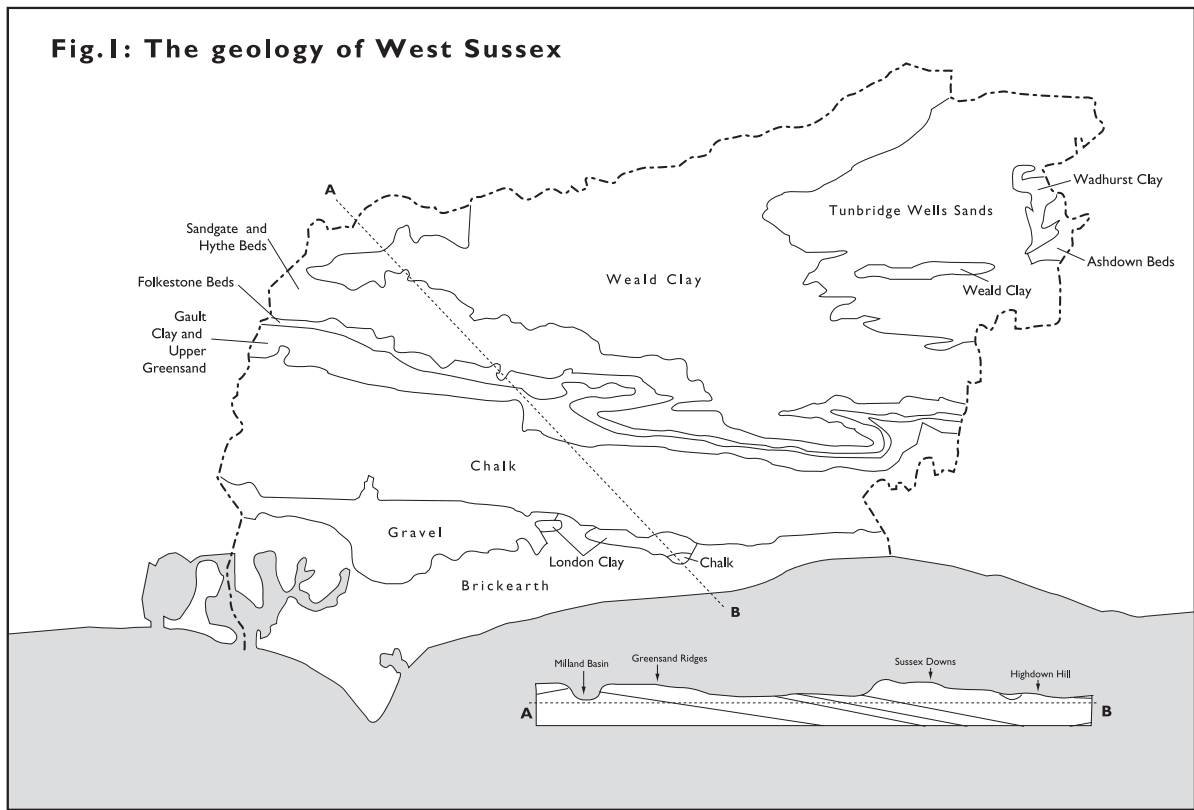


## **GEOLOGY AND HYDROGEOLOGY**

- 2.25 Geology affects the relief, drainage, surface soils and vegetation cover of the land and influences the character and landscape of the County and its water resources. The surface geology of West Sussex is characterised by the eroded exposure of the Wealden succession of the Cretaceous period (some 70 to 135 million years old) and south of the South Downs by Eocene materials overlain by gravels and brickearth deposits. A simple picture of the County's geology is shown in Figure 1 and a simplified table of geological formations in Figure 2. The County has a diverse geology fundamental to the appearance and use of the land, to the underlying water resources and to minerals planning.
- 2.26 The deeper geology, unexposed on the surface, has been proved by deep boreholes. At a depth of 1500 to 2100 metres the Jurassic rocks are much faulted and folded and have been found to contain hydrocarbons. Limited amounts of oil and gas have been exploited.
- 2.27 The Wealden basin contains sands, sandstone, clay and chalk. These were deposited and subsequently uplifted into a dome like structure extending across south east England and into the Low Countries and Northern France. The centre was later eroded exposing these materials although the edges are clearly defined by the chalk outcrop of the South and North Downs. The Cretaceous series in West Sussex is shown in Figure 2.
- 2.28 The South Downs are the most prominent natural feature in the county. Chalk has been worked for many centuries although only a few pits are in operation today. Chalk provides the most important aquifer in the South East region and is the principal source of water supply in West Sussex. The outcrop is largely free of superficial deposits and this combined with high borehole yields and rapid fissure flows means that many groundwater sources and the aquifers generally are highly susceptible to pollution.



**Fig.1: The geology of West Sussex**

**Fig. 2 Simplified table of geological formations present in West Sussex**

RECENT AND PLEISTOCENE (SUPERFICIAL DEPOSITS)	Eg. ALLUVIUM, COOMBE DEPOSITS, BRICKEARTH ETC.		
EOCENE	LONDON CLAY		
	WOOLWICH AND READING BEDS		
UPPER CRETACEOUS	CHALK	UPPER CHALK	
		MIDDLE CHALK	
		LOWER CHALK	
LOWER CRETACEOUS	UPPER GREENSAND		
	GAULT		
	LOWER GREENSAND	FOLKESTONE BEDS	
		SANDGATE BEDS HYTHE BEDS	
WEALDEN SERIES	WEALD CLAY	TUNBRIDGE WELLS SAND WADHURST CLAY ASHDOWN SAND	
	HASTINGS BEDS		
JURASSIC SERIES	NO SURFACE EXPOSED		

2.29 Sand and some building stone is won from the outcrop of the Folkestone, Hythe and Sandgate Beds of Lower Greensand. The Upper Greensand is not currently exploited. In particular, the Folkestone Beds provide a clean sand which varies in particle size and colour and which contains little silt or stone. There are a number of pits, some being worked to considerable depth, for supplies of "sharp" sand (angular grains used mainly in concrete and concrete products, for drainage material and constructional base) and "soft"

sand (round grains used mainly as a building sand for mortars and in asphalt), frequently from within the same pit. These beds form a major aquifer providing water of good quality which is extracted, for example, at Hardham near Pulborough. Weald Clay covers a wide area of the central parts of the County and produces a rolling land form characterised by heavy soils and is used predominantly for pasture and woodland purposes. The material varies from fine silt to shales, silty sandstones and limestones, and in particular includes harder sandstone bands (Horsham Stone) in its lower deposits.

- 2.30 The brickmaking industry has been long established in the area and a number of pits are worked. Associated brickworks provide Wealden stock bricks of a distinctive character which are much in demand. However, the variability of the clay has caused some problems in brickmaking. The strata is of no importance as an aquifer, having low permeability.
- 2.31 The lowest exposures of the Wealden series in West Sussex are found in the north east of the County in the High Weald where the Hastings Beds sands, sandstones and clays are exposed. The eroded strata produces the distinctive character of the High Weald Area of Outstanding Natural Beauty east of Horsham and north of Haywards Heath. Wadhurst Clay is exploited at two locations for the manufacture of bricks, and a number of small pits in the Tunbridge Well Sands near West Hoathly have planning permissions to produce good quality masonry stone.
- 2.32 The later, Eocene, deposits of London Clay and the sandy clays of the Reading Beds overlie the chalk south of the Downs and form the solid geology of the coastal plain. These deposits are almost entirely obscured by recent 'drift' deposit of sands, clays and flint gravels which form an important source of aggregate material. The gravels are derived from the weathering of the chalk outcrop during and after the last Ice Age whilst the rich soils which lie above much of the gravel field are derived from wind blown sources. Variations in climate and sea levels have produced distinctly different deposits to the north of a line approximating to the route of the A27 road, compared to those to the south. Coarser, silty gravels lie to the north over the chalk and have been exploited in the dry workings at Hambrook, Lavant, Eartham and Slindon. South of the line the gravels overlie London Clay and are cleaner, better sorted materials but their working results in wet pits which are particularly noticeable around the eastern and southern fringes of Chichester. The underlying hydrology is a significant constraint on working of the gravels in all parts of the gravel field.
- 2.33 The brickearths are extremely fine fertile soils and most are included within the "best and most versatile agricultural land" category which is identified by surveys undertaken by the Ministry of Agriculture, Fisheries and Food (now the Department for Environment, Food and Rural Affairs (DEFRA) and defined as Land of Grades 1, 2 and 3a (Planning Policy Guidance 7, Annex B para. B2). The river alluviums usually take the form of heavier, clay-like, and less well drained soils of rather lower importance and of no significance for water supply.

## **MINERAL DEPOSITS IN WEST SUSSEX**

- 2.34 Various minerals are present in West Sussex which are of economic interest. Some present features peculiarly local to this county; for example, sand and gravel deposits are seldom combined in West Sussex, whereas this is more usual elsewhere. Similarly, it is common in West Sussex for both soft and sharp sands to be found within a single pit. Different issues arise from the particular characteristics of the material, the various extraction methods used and the character of the area where working takes place. The following summary highlights these points and deals with each mineral in the order in which it occurs, roughly from north to south, within the County.

## CLAY



- 2.35 Material suitable for brickmaking is contained in subsoils throughout most of the County although there are four principal clay outcrops. During the nineteenth century peak virtually every Parish had at least one tile works or brickyard, but due to a number of factors including rationalisation and amalgamation only eight remain.
- 2.36 Nationally, clay brick demand has declined since the 1970's with severe falls since 1988, when despatches of clay bricks were 4178 million, to 2710 million in 1995. (Department of the Environment (DoE) figures). Clay bricks represent 92% of brick despatches, the remaining 8% being calcium silicate and concrete. This drop is due to the recession in the construction industry, but more specifically to the fall in the number of total housing starts in the same period from 252.6 thousand (1988) to 169.7 thousand in 1995. Total brick production in the South East was 539 million in 1995 and accounted for 16.6% of the Great Britain total; despatches at 509 million were 17.3%. At the end of 1995, brick stocks in the South East were 173.5 million, the equivalent of 18 weeks demand; the clay brick industry requires a working stock of approximately 8 weeks demand.
- 2.37 Because of the wide range of colours and textures, bricks produced in a particular region may be used in other regions or nationally. The rationalisation within the industry with a concentration into large manufacturers with high volume plants able to deliver nationwide has contributed to this. Large manufacturers produce approximately two-thirds of all bricks, but the industry still contains small, family owned, brickworks which make products that are in demand because of their aesthetic qualities. These bricks may attract higher prices than those produced in high volume works, as well as providing local employment as they are more labour-intensive. It is unlikely that a substitute material, capable of producing bricks of comparable quality, will take the place of clay in West Sussex brickmaking in the foreseeable future.
- 2.38 In West Sussex, the Hastings Beds, which form part of the High Weald, consist of a series of deposits of clays and sands including Wadhurst Clay which is used for brickmaking at two sites, Freshfield Lane Brickworks and West Hoathly. The broad band of Weald Clay, which forms the Low Weald, is of great depth and supports four brickworks at Ashpark, Rudgwick, Warnham and Laybrook and Keymer Tiles at Burgess Hill. A permitted reserve at Southwater is not worked at present. The Gault Clay deposit lies between the Weald and the Downs. It contains a small brickworks at Pitsham near Midhurst and a large clay pit at Small Dole. This used to supply the Shoreham Cement Works but following its closure supplies clay as a cover material for landfill sites. There are no longer any workings in the London Clay outcrop which lies to the south of the Downs, or in the brickearth of the coastal strip.

- 2.39 In January 1997, permitted reserves of clay in West Sussex were 17,727,000 tonnes. The average annual production of clay over the period 1987-1996 was 294,800 tonnes. During this period a number of sites reduced production as new plant was installed interrupting brick making and the building industry experienced a period of recession. However the County has an overall reserve extending to nearly eighty years requirements. Individual works generally have an adequate reserve but at Ashpark and West Hoathly brickworks their reserves may run out before the end of the Minerals Local Plan period in 2006. Clay brick and tile manufacturing is a capital intensive industry and between twenty and thirty years of reserves to support each particular works is generally necessary before large investments are made. Some sites, have reserves of this size and this has supported the considerable investment made recently in modernising and expanding production facilities and improvements in environmental standards to all the larger brickworks.

#### FULLERS EARTH



- 2.40 Fuller's earth is a highly plastic clay with an unusual combination of properties on which its varied industrial applications are based. However, it is more familiar as a constituent of cat litter. It occurs within the Lower Greensand. It is an important mineral which occurs in few places in the United Kingdom and therefore the Government has made particular efforts to identify and protect resources. A deposit has been found in the Petworth area but investigations have shown it to be uneconomic to work at present and no submission has been made during preparation of this Plan. Periodic reviews are undertaken and it is possible, albeit remotely, that at some time in the future the deposit could become important.

#### SANDSTONE



2.41 Sandstone in West Sussex is found within the Sandgate and Hythe beds of the Lower Greensand. It used to be worked locally for building- stone and road-stone but generally fails to meet modern construction specifications for aggregates unless it is blended with other material. Large scale extraction occurs at just one location in the County; Bognor Common, Fittleworth. It is considered that the quarry has sufficient reserves to provide for County needs well beyond the Plan period. The Hastings Beds of the Wealden Series also contain sandstones but these are generally of little commercial value because of their variable nature. They consist principally of silty sands but can vary from clay-like silts through to 'massive' sandstone. Horsham Stone is a calcareous sandstone found in the Weald Clay, and is an important traditional material used mainly for paving stones and roofing slabs.

'CLUNCH'



2.42 'Clunch' is the local name given to a grey/white sandy limestone that lies on the north side of the Downs in the Upper Greensand. It is poorly developed in the east of the County but at the western end from Cocking to Harting it forms a prominent ridge, and is especially noticeable at Torberry Hill, west of Harting. In the past the material was extensively worked as a building material and gives a characteristic appearance to many buildings in the area where it is found. At present the material is not worked and no new sites have been considered.

SAND



2.43 Sand extraction in West Sussex takes place within the Lower Greensand and in particular the Folkestone Sand Beds. The outcrop of these Beds forms a low ridge below the scarp face (i.e. the steeper north facing slope) of the South Downs covering an area in the region of 5,400 hectares. The deposit is generally thin in the east of the County but its thickness

increases in the west. In 1996, ten sand pits were active in the County and produced a total of 720,500 tonnes of material. A further permitted site was inactive. Peaks in sand production were reached in 1964 (1,400,000 tonnes) and in 1988 (1,170,000 tonnes).

- 2.44 The sand which is extracted is almost pure with little silt or stone. Great variations exist in particle size and colour, which can be a restriction on its application in the building trade, but it is the principal source of building and concreting sand for the whole of Sussex and for parts of south east Hampshire, as well as having specialised uses further afield. The balance between sharp sand and soft sand has shifted in recent years. In 1984, 72% of sand production was soft, but by 1996 this had declined to 68%. This is partly a reflection of the unpredictability of the deposits but is also a consequence of the change in market requirements. Efforts will be made to maintain the supply of a variety of sands during the Plan period.
- 2.45 The annual average production at sandpits for 1994 to 1996 was 648,100 tonnes. Permitted reserves are estimated (1.1.97) to be 7,516,000 tonnes which would be sufficient for 12 years' supply if recent levels of production were to continue. While this figure is more than adequate for supply purposes, it is dominated by a single site at Sandgate Park near Storrington. A significant proportion of the reserve lies in the hands of one operator and production decisions could be made which relate less to local matters than to much wider company concerns. There is no indication that company policy will change, but MPG6 advises that circumstances such as these could have a bearing on supply and should be considered in providing for an appropriate Landbank.

#### HYDROCARBONS (OIL AND GAS)



- 2.46 Geological structures which may bear hydrocarbons underlie much of the United Kingdom. It is government policy to encourage exploration for and production of the County's oil and gas resources, home supplies being more secure than imports. The main sources for hydrocarbons in West Sussex are the faults and folds in the Corallian Beds and the lower Oolites of the Jurassic period which have created structures that have trapped oil and gas. These extend under the whole County.
- 2.47 The development of onshore oil and gas resources is controlled by the Department of Trade and Industry Licensing and by the County Council's planning powers. A new single licence (Petroleum Exploration and Development Licence, PEDL) covering both exploration and development was introduced in June 1995 and holders of existing licences will be given the opportunity to convert them to PEDLs. In addition, planning permission is required for exploratory boreholes and operational development.

- 2.48 Since the early 1980s licences have been awarded by the Department of Industry for initial hydrocarbon testing (employing mainly seismic techniques) over much of the County. Exploration by drilling at some sites resulted in the subsequent award of Appraisal Licences under the old system. Borehole drilling occurred at 14 sites. Only three sites proved to be potentially productive and are active or likely to be active during the Plan period. Hydrocarbon production currently takes place at two locations, Singleton and Storrington. Gas produced at Singleton is used to generate electricity for site use and export to the National Grid. This is expected to also take place at Storrington. The remaining site is at Lidsey near Bognor Regis.
- 2.49 Oil and gas development offshore is also subject to a licensing system, but is mainly outside the planning system. Currently, there are no blocks licensed off West Sussex. All licences previously awarded (5) have now been relinquished, and no commercially extractable deposits have been found. The County is a member of the Standing Conference on Offshore Oil and Gas Exploration (comprising representatives of coastal authorities, both County and District, from Devon to West Sussex) which keeps a watching brief on exploration proposals and any concerns are expressed through the Standing Conference to the Department of Trade and Industry. Development onshore which is ancillary to offshore development is subject to local authority planning control.

#### CHALK



- 2.50 The chalk hills of the South Downs, dissected by coombes and steep sided dry valleys, are probably the most well known landscape in the County although they occupy a relatively small area. Chalk is a white, often friable and much fractured limestone consisting of over 95% calcium carbonate. It is remarkably pure for a naturally occurring material. It reaches thicknesses of up to 400 metres in the Downs north of Chichester. The chalk was formed during the Cretaceous geological period which lasted for perhaps 80 million years and ended about 65 million years ago. There are three main subdivisions:-
- Lower Chalk, of up to 70 m thick and which is flint free.
  - Middle Chalk, approximately 64 metres thick. Flints may be found in the upper beds.
  - Upper Chalk, which has a complete thickness of perhaps 200 metres and is composed of the familiar soft white chalk with flints. However, the higher succession is incomplete in Sussex due to erosion.
- 2.51 Chalk being a microporous limestone and an aquifer is the principal source of water supply in West Sussex. The quality of the water is usually very good. Care, therefore, needs to be exercised during extraction of the material.



- 2.52 In West Sussex chalk is extracted primarily for the production of agricultural lime. After drainage, it is the most important aspect of soil husbandry adding essential nutrients and making fertilisers more effective. Chalk is also used as an aggregate for bulk fill in construction projects and some chalk in the County meets the specification for capping layers in road building. The Rustington and Westhampnett bypasses have incorporated chalk partly because it could be readily obtained from local sources. Extraction for cement production ceased in 1991 with the closure of the Shoreham Cement Works, although the pit contains substantial reserves. In ancient times flints taken from chalk pits (and gravel deposits) were used to make tools and their use has continued, mainly for building, to the present day. Flint is an important material in the historic fabric of many West Sussex settlements.
- 2.53 There are six, long established, chalk pits in the County with permissions for extraction all of which lie within the Sussex Downs Area of Outstanding Natural Beauty. Only two pits are active at present. Current reserves are significant although difficult to quantify because some old planning permissions are unclear about the depth of permitted working. However, it is anticipated that current reserves are sufficient for the Plan period.

#### GRAVEL



- 2.54 Some 7,700 hectares of gravel deposits that extend along the coastal plain to the west of Worthing have accumulated during the 20,000 years since the last Ice Age which affected this area. They reflect changes in climate and sea level and the gradual erosion of the once much higher chalk hills. During the later part of the Ice Age this area was in a semi frozen state and during the contemporaneous very rapid erosion of the Downs, a sludge-like deposit of mixed chalk, clay and flint slumped off the hills over the coastal plain. As it moved, streams sorted the coarse and fine materials so that today coarse unworn flint gravels are found immediately on the break in the slope below the Downs (for example at Lavant, Eartham and Slindon), while finer more evenly graded material (Coombe deposits) occurs in the area south of Chichester. Action by the sea and wind both before and after the deposit of the gravels has produced great variations in deposits. It is difficult to determine their precise nature without extensive survey work. In addition, chalk pinnacles thrusting up through the gravel deposits are a feature peculiar to West Sussex and can cause difficulties in working. A high water table is present in the lower terrace deposits around Chichester where the gravels overlie the Reading Beds and London Clay deposits.
- 2.55 The gravel deposits in the County are of significant economic importance and have been extensively exploited. The annual average production at gravel pits 1994 to 1996 was 255,400 tonnes. Permitted reserves (1.1.02) are estimated to be 830,000 tonnes which would be sufficient for 2.0 years of supply if recent levels of production were to continue.