Maritime Natural Area: M10. Whitstable to North Foreland	**Geological Significance:** Notable **(provisional)**

General geological/geomorphological character: The Whitstable to North Foreland Maritime Natural Area has a varied coastline with relatively low-lying coast in the east rising to boulder clay and chalk cliffs towards the Isle of Thanet.

Geological History: This coastline is characterised by the Cretaceous chalk of the Isle of Thanet bounded to the west by clays, silts and sands of the Lower Tertiary. Upper Cretaceous Santonian chalk (87-83 Ma) is exposed dipping gently to the west from Margate to the eastern side of Herne Bay. Unconformably overlying the chalk is a sequence of Lower Tertiary sediments which are exposed in Herne Bay; the Palaeocene Thanet, Woolwich and Oldhaven Formations overlain by the Eocene London Clay Formation.

The Chalk was deposited by a shallow sea which covered much of Northwestern Europe towards the end of the Cretaceous. Sea level fall was followed by the unconformable deposition of Tertiary Palaeocene and Eocene sediments. Dominantly marine in origin, these sediments were deposited by a rising, but fluctuating sea, which covered much of Southeast England. Marine conditions were well established by the Eocene leading to the deposition of the London Clay Formation. The fossil fauna and flora from the Tertiary rocks indicates a gradually warming climate with sub-tropical conditions established by the Eocene. Subsequent uplift (associated with the Alpine Orogeny) and resultant erosion removed much of the remaining Tertiary sediments, the next deposition occurring during the Pleistocene. Though not covered by ice, the area was affected by periglacial erosion in a tundra-like environment during the last glaciation (Devensian). Pleistocene deposits include extensive deposits of chalk and flint rubble ('Head').

Geomorphological evolution and Processes: A relatively low-lying coast around Whistable, rises to the east with boulder clay cliffs towards Herne Bay , and chalk cliffs and reef outcrops on the Isle of Thanet. On the highest cliffs, just east of Herne Bay, cliff slippage and mudstreams are relatively frequent occurrences with erosional processes significantly aided by landwater. Wave induced erosion is widespread along this stretch of the coast and the predominant eroding force. However along the Thanet coast at Foreness Point, on the extensive inter-tidal platforms, large numbers of Limpet holes have also contributed to the mechanical weakening of the chalk. There is a moderate, but strongly unidirectional, westward drift along the length of this NA, with no significant beach build up, due to an inadequate supply of sand and shingle. This has caused wide spread beach erosion. Shingle nourishment schemes have been used to make up the deficit in order to afford some coastal protection, particularly in the low-lying areas prone to inundation . The onshore sand supply, via tidal currents, from Sandwich Bay (*see* Marine Natural Area 11), to Thanet is inadequate for present day requirements.

Key geological/geomorphological features:

- Upper Cretaceous stratigraphy
- Lower Tertiary stratigraphy
- Lower Tertiary palaeontology
- Late Pleistocene periglacial erosion
- Foreness Point contains the most extensive intertidal shore platforms in chalk in Britain.

Number of GCR sites:

Palaeogene: 1 Tertiary Palaeobotany: 1 Mesozoic-Tertiary Fish/Amphibia: 1
Pleistocene/Quaternary of SE England: 1 Cenomanian-Maastrichtian: 1
Alpine Structures of Southern England: 1 Coastal Geomorphology of England: 1

Geological/geomorphological SSSI coverage: There is only a single coastal (P)SSSI in the MNA containing 7 GCR SIL's representing 7 different GCR networks. The site has a varied geological interest including Cretaceous, Tertiary and Pleistocene sediments as well as Alpine structures and an important modern coastal geomorphology. Chalk sections on the Isle of Thanet include the UK type (reference) section for the Santonian Chalk from Margate southwards. The chalk also exhibits tension joints associated with the Alpine Orogeny. The complete Palaeocene sequence (Thanet, Woolwich and Oldhaven Formations) is exposed on the eastern side of Herne Bay; these Tertiary sediments have provided the only unequivocal Palaeocene flora which includes a number species unique to this section. These coastal sections also expose evidence for the environmental changes occurring during the mid and late Devensian including frost shattered chalk and solifluction (Head) deposits. Foreness Point is a key site for coastal geomorphology, being an essential member of the suite of chalk coastal sites. It contains a classic cliff-shore platform system and the most extensive intertidal chalk platforms in Britain.

Key geological management issues:

- Maintain and enhance existing coastal exposures
- Maintain natural coastal processes
- Promote the educational value of the geological resource

Key geological objectives:

1. **Maintenance and enhancement of the geological resource** through a) continued maintenance of natural coastal processes (Shoreline Management Plans), b)development of local conservation strategies that include geology, c) continued assessment of educational/research value of the coastal outcrop.

2. **Promotion of geological resource** through a) assessment and promotion of site educational value b) on site interpretation (e.g. sign boarding, trail guides, leaflets), c) promotion of the influence of geology on local habitats and scenery.

3. **Coastal Defence schemes should be considered within an agreed Shoreline Management Plan,** particularly with regard to the likely 'knock-on' effect from Thanet to Whitstable. Where interruptions and reductions in the sediment supply will increase the need for nourishment schemes.

Useful guides/references:

HOLMES, S.C.A., 1981: Geological Survey of Great Britain, Geology of the Country around Faversham, Sheet 273.

OSBOURNE WHITE, H.J., 1928: The Geology of the Country near Ramsgate and Dover Sheets 274 and 290, Memoirs of the Geological Survey of England and Wales, HMSO London.

Earth science coastal (P)SSSIs in the Maritime Natural Area:

- Thanet Coast

Maritime Natural Area: M11. North Foreland to Folkestone	**Geological Significance:** Considerable **(provisional)**

General geological character: The North Foreland to Folkestone Maritime Natural Area is dominated by chalk cliffs from the Isle of Thanet (Margate to Pegwell Bay) and from the south side of Pegwell Bay through to Folkestone. The chalk is folded into a gentle anticline dipping beneath the surface of Pegwell Bay on the north and south sides and unconformably overlain by Tertiary sands which form the low lying cliffs of Pegwell Bay.

Geological History: To the west of Folkestone Cretaceous Greensand and Gault Clay (c. 119-97 Ma) crop out, marine in origin, they were deposited by rising seas that eventually deposited the Upper Cretaceous chalk (87-80 Ma). Sea levels fell towards the end of the Cretaceous with subsequent rise in the Tertiary leading to the unconformable deposition of the Thanet Formation (Palaeocene, 65-56 Ma) which is today seen in Pegwell Bay. The Thanet Formation sands and subsequent Tertiary sediments contain a fossil fauna and flora that indicates a gradually warming climate with sub-tropical conditions established by the end of the Palaeocene. Subsequent uplift (associated with the Alpine Orogeny, c. 15 Ma) produced the gently folded sequence of the Pegwell Bay syncline and the anticline of the Isle of Thanet which border the northern edge of the larger scale Wealden Anticline.

Though not covered by ice, the area was affected by periglacial erosion in a tundra-like environment during the last glaciation (Devensian). Pleistocene deposits include extensive deposits of chalk and flint rubble ('Head'), wind blown sands (loess) and various river gravel deposits associated with the changing course of the River Stour.

Geomorphological Evolution and Processes: North Foreland on the Isle of Thanet is an urban cliffed coast, with relatively undeveloped low-lying land to the south in Pegwell Bay. Pegwell Bay comprises a 2.2km stretch of low chalk cliffs much of which has undergone coastal protection work. Beyond the saltmarsh and sand dunes of Sandwich Bay an undeveloped cliff coast runs to Dover, Folkestone and beyond.

The chalk cliffs between Kingsdown and Dover almost without exception fall abruptly to a distinct junction with a platform which is about 200m in width. The cliffs are broken only by the deep valley and now protected bay at St. Margrets; rising to between 30m and 110m in height. They are amongst the most active vertical cliffs in England and Wales. The construction of Dover and Folkestone harbours during the second half of the nineteenth century prevented any continuing supply from the south-west. Beaches now depend on the contemporary erosion of the cliffs and platforms for material. The cliffs fall gradually to a hieght of 30m at Kingsdown. To the south of the South Foreland, the cliffline has been characterised by a large number of falls in recent years. Wave erosion along master joints and the effect of percolating water in the joints are thought to be the main processes by which instability and subsequent falls are produced in the cliffs. Evidence has shown that a freeze-thaw mechanism is likely to be a main factor of the larger cliff falls. The debris produced by cliff falls varies in size from fine sediments that are quickly dispersed by wave action and longshore currents, to boulders over 1m across. Folkestone Warren comprises 2 main areas: High cliff and Under cliff. The High cliff refers to the chalk cliffs (30m high), backing the area of landslips, consisting of a succession of broad irregularly spaced butresses. The 300-400m wide area of rotational slumps between the higher cliff and the shore is known as the undercliff. The trigger for massive landslips such as the 1915 slip, results from a combination of factors, but most significant is the amount of rainfall. The whole coastal front of the Warren is protected by a complex of coastal defence schemes, which have cumulatively improved stability.

There is a moderate northward shingle transport between Kingsdown and the entrance to the Stour. Tidal currents bring in sand and silt as suspended load into Pegwell Bay where they build up on the inter-tidal flats. Tidal currents also transport sand in small quantities across Sandwich Bay to North Foreland. There is no perceivable transport around south Foreland but there is a potential eastward drift from Dover to Kingsdown.

Key geological/geomorphological features:

- Upper Cretaceous stratigraphy
- Lower Tertiary stratigraphy
- Lower Tertiary palaeontology
- Late Pleistocene periglacial erosion
- Modern coastal geomorphology eg. mass movement, chalk platforms

Number of GCR sites:

Cenomanian-Maastrichtian: 3 Palaeogene: 1 Mesozoic/Triassic Fish/Amphibia: 1
Mass Movement: 1 Aptian-Albian: 1 Jurassic-Cretaceous Reptilia: 1
Pleistocene/Quaternary of SE England: 1 Coastal Geomorphology of England: 1

Geological/geomorphological SSSI coverage: There are 3 coastal (P)SSSIs within this MNA of which Folkestone Warren is considered to be of international importance. The 3 (P)SSSIs contain 10 GCR SILs representing 8 different GCR networks. Folkestone Warren exposes Greensand, Gault Clay and chalk but is particularly important as the type site for the Lower Greensand Folkestone Beds. Mass movement is of particular importance at Folfestone Warren due to the great detail and time scale over which it has been studied. Chalk sections to the north of Pegwell Bay include the UK type (reference) section for the Santonian Chalk . The Thanet Formation in Pegwell Bay has yielded the most diverse fossil fish fauna of its age in the UK. The Cretaceous/Tertiary unconformity in Pegwell Bay is also important, elsewhere this boundary has been the subject of much debate as it marks a mass extinction event which saw the demise of the dinosaurs. These coastal sections also expose evidence for the environmental changes occurring during the mid and late Devensian including frost shattered chalk and solifluction (Head) deposits and, in Pegwell Bay, the UK's most extensive loess deposit. Between Kingsdown and Dover the coast is an essential member of the suite of chalk platform sites in England also providing insights into the significance of relic beaches in retarding recent cliff development and the dynamics of sediment supply.

Key geological management issues:

- Maintain and enhance existing coastal exposures (eg section clearance in Pegwell Bay)
- Maintain natural coastal processes
- Promote the scientific/educational value of the geological resource
-

Key geological objectives:

1. **Maintenance and enhancement of the geological resource** through a) continued maintenance of natural coastal processes (Shoreline Management Plans) and, where appropriate, clearance of existing sections, b) development of local conservation strategies that include geology, c) continued assessment of educational/research value of coastal sections.

2. **Promotion of geological resource** through a) assessment and promotion of site educational value (eg. Cretaceous/Tertiary boundary in Pegwell Bay), b) on site interpretation (eg. sign boarding, trail guides, leaflets), c) promotion of the influence of geology on local habitats and scenery.

3. **Maintenance of geomorphological resource** through a) Developments or constructions that may have an effect on the erosive efficiency of the coastline being considered within an agreed Shoreline Management Plan and, b) should be opposed where natural processes are altered and the integrity of geomorphological features are threatened.

Useful guides/references:

GALLOIS, R.W., 1965: British Regional Geology: the Wealden District. HMSO, London.

OSBOURNE WHITE, H.J., 1928: The Geology of the Country near Ramsgate and Dover Sheets 274 and 290, Memoirs of the Geological Survey of England and Wales. HMSO London.

ROBINSON, N.D., 1986: Lithostratigraphy of the Chalk Group of the North Downs, S.E England, Proc. Geol. Assoc. 97 141 - 170.

Earth science coastal (P)SSSIs in the Maritime Natural Area:

- Sandwich Bay to Hacklinge Marshes
- Dover to Kingsdown Cliffs
- Folkestone Warren

Maritime Natural Area: M12. Folkestone to Selsey Bill	**Geological Significance:** Outstanding **(provisional)**

General geological character: The Folkestone to Selsey Bill Maritime Natural Area has a varied geology which is largely controlled by the Wealden Anticline. From Selsey Bill to Shoreham the low lying coast is dominated by Tertiary clays and sands overlain by Pleistocene gravels, sands and clays. Chalk cliffs rise from Brighton to Beachy Head and eastwards from here the cliffs are dominated by Lower Cretaceous Wealden sandstones and clays. The low lying coastal plain of Dungeness forms the eastern end of this stretch of coast.

The oldest rocks belong to the Lower Cretaceous Wealden Series (145-130 Ma) and are exposed between Rye Bay and Eastbourne. These sandstones and clays were deposited by a complex river system which occupied much of the present Wealden area and extended into the Hampshire and Paris Basins. These sediments were derived from areas of high ground to the north, west and south. The earlier part of the Wealden was dominated by the Hastings Beds Group, a sequence of alternating sandy/silty to clay rich units, this Group marking the onset of the Lower Cretaceous fluvial environment. The Hastings Beds Group is locally fossiliferous and has yielded a substantial vertebrate fauna comprising freshwater fish, crocodiles, turtles, dinosaurs and, very rarely, the remains of mammals. These often occur in thin 'bone beds' and ironstone horizons. An important flora is also known from a limited number of sites. Overlying the Hastings Beds Group is the Weald Clay. The Weald Clay is made up of clays, silts and localised sandstones and limestones. It marks an increased marine dominance within the Wealden Series with possible links to the North Sea Basin. The Weald Clay is again locally fossiliferous, a number of sites yielding well preserved fossil insects, plants and reptiles. The end of Wealden times and the Lower Cretaceous is marked by a progressive rise in sea level depositing initially Greensand and Gault Clay and then the widespread chalk, a pure limestone deposited in a relatively shallow tropical sea.

The Tertiary (foreshore sediments from Bognor to Selsey Bill) saw an initial fall in sea level, Upper Palaeocene Reading Beds (54-51 Ma) at Bognor Regis being deposited in an area of freshwater marsh with dunes and temporary pools. The Reading Beds contain a diverse fossil flora unique to the Hampshire Basin. Rise in sea level lead to the deposition Eocene London Clay (51-47 Ma); a sequence of dark marine clays rich in fossil plants typical of a sub-tropical rain forest. The overlying Middle Eocene Bracklesham Group (47-41 Ma) was deposited in an alternating intertidal and off shore environment. Bracklesham sediments contain a diverse fossil fauna and flora, notably numerous shark teeth and rare birds. The area was eventually affected by the Tertiary Alpine Orogeny (c. 15 Ma). Compression at this time further tightened the Wealden anticline and caused dense faulting within the Hastings Group.

During the Pleistocene the ancient River Solent flowed eastwards past Selsey Bill, associated terrace gravels contain vertebrate remains associated with the Pleistocene Hoxnian, Cromerian and Ipswichian interglacials (350,000-125,000 BP). Though the area was not covered by ice during the Pleistocene there is evidence for sea ice which has deposited a number of erratics in the area as well as numerous periglacial erosional features on the chalk cliffs.Flandrian coastal deposits have accumulated over the last 9,500 years and form the cuspate shingle foreland of Dungeness. This started to form about 5,000 BP following the development of a sandy bar across Rye Bay. Eastward longshore drift caused by southwest prevailing winds has transported flint shingle from Beachy Head to Dungeness (some 50 km). Today the shingle foreland is characterised by storm gravel beach deposits forming semipermanent ridges or 'falls'. Associated sediments include marine alluvium (deposited over the last 3,000 years) and blown sand forming sand dunes such as Camber Sands. The evolution of the Dungeness foreland over the last 5000 years has been researched in detail providing much information about coastal changes in southern England and includes historical records of the abandonment of towns such as Old Winchelsea and Broomhill due to storm damage in 1287 AD.

Geomorphological Evolution and Processes: Between Folkestone and Selsey Bill there is a moderate, eastward transport of sand and shingle by predominant south-westerly waves, with local reversal on the east face of Dungeness and interruption by a number of harbours west of Beachy Head such as the River Cuckmere and River Ouse. This stretch of coastline has heavily developed frontages interspersed by long frontages of marshland (e.g. Romney marsh), and agricultural land. Between Selsey Bill and Beachy Head the stretch of coastline requires heavy expenditure on extensive coastal protection schemes.

Dungeness forms a large cuspate foreland between Romney marsh and Rye Bay. Chesil beach and Orfordness while comparable in length do not contain the enormous volume of shingle stored in the shingle ridges at Dungeness. The feature forms an integral part of a system of former barrier beaches extending 40km from Fairlight to Hythe. These beaches reflect some 5,000 years of coastal development and provide an exceptional record of Holocene coastal changes and progradational features. The cuspate foreland has been stabilized to a certain extent by the location of the power station, which requires a sediment re-cycling operation, constantly moving sediment from the east to back infront of the station to avoid a threat to the integrity of the site.

A shingle beach extends from the east side of Selsey Bill to the Pagham Beach Estates, and forms a spit which crosses the mouth of Pagham Harbour. It is composed of a series of sub-parallel shingle ridges and recurves, which mark different phases of extension and accretion. Shingle reaches the beach via the intertidal zone and the so-called 'Pagham delta'. The behaviour of the spit and delta are intimately linked with water and sediment circulation around the Selsey peninsula. Sediment for the growth of the spit comes from two sources; erosion of the cliffs at Selsey and from offshore. The on-offshore transport of material is principally by wave action although the unusual process of Kelp-rafting is believed to contribute to shingle movement.

The chalk of the South Downs reaches the sea between Brighton and Eastbourne in a series of cliffs which become generally higher towards the east and culminate in the 150m high of Beachy Head. The highest part faces south and is exposed to south-westerly gales. Between the western side of Beachy Head and Birling Gap the cliffs are similar to those of the world renowned Seven Sisters. However these cliffs produce large debris fans and there is greater mass of residual boulders on the platform. At Birling Gap the rate of cliff retreat is greater than at any other point along this stretch of coast. Along this cliffline marine erosion is very effective in removing the debris from falls. The cliff is under cut and frequently collapses along the line of joints which are parallel to the cliff face. Weathering of the cliffs and platform produce substantial quantities of smaller debris, which together with the debris from falls, provide the main input to the beaches. A single cave passage extending for nearly 400m exists in the cliffs of Beachy Head.

Key geological/geomorphological features:

- Lower Cretaceous stratigraphy and environments - Hastings Beds Group and Weald Clay
- Lower Cretaceous palaeontology
- Upper Cretaceous stratigraphy and environments
- Lower Tertiary stratigraphy
- Lower Tertiary palaeontology
- Evolution of the River Solent and Pleistocene environments
- Flandrian coastal evolution
- Dungeness forms a large shingle cuspate foreland
- A shingle spit composed of a series of sub-parallel ridges crosses the mouth of Pagham Harbour.
- Includes the famous and geomorphologically important chalk cliffs of Beachy Head
- Rye Harbour is 1 of only 4 large shingle beach-plains in England and Wales

Number of GCR sites:

Coastal Geomorph. of England: 4 Tertiary Palaeobotany: 3 Pleistocene/Quaternary of SE England: 3
Wealden: 2 Cenomanian-Maastrichtian: 2 Alpine Structures of S England: 2
Mesozoic Palaeobotany: 2 Palaeoentomology: 1 Mesozoic-Tertiary Fish/Amphibia: 1
Caves: 1 Pleistocene/Quaternary of S. England: 1 Pleistocene Vertebrata: 1
Mesozoic Mammals: 1 Jurassic-Cretaceous Reptilia: 1 Aves: 1

Geological/geomorphological SSSI coverage: There are 9 coastal (P)SSSIs within this Maritime Natural Area containing 26 GCR SILs representing 15 different GCR networks. Hastings Cliff to Pett Beach coastal section is viewed as a classic European reference section for the Hastings Beds Group of the Wealden Series. This site has also yielded an important vertebrate fauna including reptiles, fish and rare mammals (the Cliff End Bone Bed has long been a source of comminuted bone material). Brighton to Newhaven Cliffs and Seaford to Beachy Head SSSIs expose comprehensive sections through the Cretaceous chalk and are particularly important for our understanding of Coniacian, Santonian and Campanian stratigraphy. Felpham foreshore exposes Reading Beds yielding the most diverse flora of its age in the UK while Bognor Reef provides the best exposure of London Clay in the Maritime Area and has yielded many type specimens of fossil birds, insects, fish and plants.A Pleistocene fossil sea cliff is exposed at Black Rock in Brighton (Brighton-Newhaven Cliffs), comprising sand and shingle with shell fragments it is believed to date from the end of the Ipswichian interglacial. These chalk cliffs also display a range of periglacial features including unique dry valley cross-sections.

Dungeness (viewed as internationally important) and Rye Harbour form a network of sites all associated with the Flandrian coastal deposits and the development of the Dungeness shingle foreland. Dungeness, itself, is a large, complex of geomorphologically important site, first because of the shingle ridges themselves, and second for the shingle foreland itself. While the individual geomorphological features of Dungeness are not unique, their association together is. Dungeness can be described as the most important shingle-spit cuspate foreland complex in Britain. Beachy Head Cave is valuable as Britains only known cave in chalk of more than a few metres in length. It is totally natural of phreatic solutional origin, and has only been intersected by the sea cliff by chance.

Key geological management issues:

- Maintenance and enhancement of existing coastal exposures (cliff and foreshore)
- Maintenance of natural coastal processes such as the well developed cliff-beach-platform sequence and rapid cliff erosion.
- Promote the scientific/educational value of the geological and geomorphological resource
- Protection of sites from mineral extraction
- Protection of sensitve sites from potentially damaging recreational activities such as Dungeness shingle ridges and Rye Harbour beach-plains.

Key geological/geomorphological objectives:

1. **Maintenance and enhancement of the geological resource** through a) enhancement of key exposures through site clearance (eg. Black Rock, Brighton), b) development of local conservation strategies that include geology, c) maintenance of natural coastal processes - development of Shoreline Management Plans, d) assessment of educational/research value of new sites (eg. quarries and cuttings, temporary or permanent).

2. **Promotion of geological resource** through a) promotion of site educational and scientific value (eg. Hastings Cliffs to Pett Beach), b) on-site interpretation (eg. sign boarding, trail guides, leaflets), c) promotion of the link between geology and local habitats, and geomorphology and the development of the landscape.

3. **Prohibition or Heavy Restrictions placed on Gravel and mineral extraction** through their consideration within an agreed Shoreline Management Plan.

4. **Coastal Defence works must be considered within an agreed Shoreline Management Plan** as such Geomorphological features as Dungeness, Rye Harbour, Beachy Head etc, all depend on the free movement of shingle from east to west.

5. **Restrictions must be placed on potentially damaging recreational activities such** as cycling along the foreshore, other vehicles, military exercises, boat launching etc.

Useful guides/references:

CURRY, D., 1992: Tertiary. *In*: McL. D. Duff, P. & Smith, A.J. (eds). Geology of England and Wales, 389-408, publ. Geological Society, London.

GALLOIS, R.W., 1965: British Regional Geology, The Wealden District. British Geological Survey, HMSO.

LAKE, R.D. & SHEPHARD-THORN, E.R., 1987: Geology of the country around Hastings and Dungeness. Memoirs of the British Geological Survey, Sheets 320 and 321, England and Wales.

LAKE, R.D., YOUNG, B., WOOD, C.J. & MORTIMORE, R.N., 1987: Geology of the country around Lewes. Memoirs of the British Geological Survey, Sheet 319, England and Wales.

MELVILLE, R.V. & FRESHNEY, E.C., 1982. British Regional Geology: The Hampshire Basin and adjoining areas. British Geological Survey, HMSO.

Earth science coastal (P)SSSIs in the Maritime Natural Area:

- Brighton to Newhaven Cliffs
- Seaford to Beachy Head
- Pagham Harbour
- Bognor Reef
- Felpham
- Selsey, East Beach
- Hastings Cliff to Pett Beach
- Dungeness
- Rye Harbour

Maritime Natural Area: M13. Selsey Bill to Studland Cliffs	**Geological Significance:** Outstanding **(provisional)**

General geological character: The Selsey Bill to Studland Cliffs Maritime Natural Area is dominated on the mainland by Tertiary sands and clays producing a relatively low lying and eroding coastline while the Isle of Wight has a northern coast dominated by Tertiary sediments but a southern coast dominated by Cretaceous sands, silts and clays and notably, the more resistant Upper Cretaceous chalk.

Geological History

South coast from Selsey Bill to Studland: This stretch of coast is dominated by Tertiary sediments that were deposited in the Hampshire Basin between the late Palaeocene and early Oligocene (c. 57-35 Ma) and include the Reading and London Formations, the Bracklesham and Barton groups and the Headon Hill and Bouldner Formations. The low angle of dip gives wide outcrops of most formations.

The Tertiary saw an initial fall in sea level, Upper Palaeocene Reading Beds were deposited in an area of freshwater marsh with dunes and temporary pools. The Reading Beds contain a diverse fossil flora unique to the Hampshire Basin. Rise in sea level lead to the deposition Eocene London Clay; a sequence of dark marine clays rich in fossil plants typical of a sub-tropical rain forest. The overlying Middle Eocene Bracklesham Group was deposited in an alternating intertidal and off shore environment. Bracklesham sediments contain a diverse fossil fauna and flora, notably numerous shark teeth and rare birds. The overlying Barton Group represents a complex sequence of marine and non-marine estuarine deposits. Many levels are fossiliferous and have yielded bones of crocodiles, other reptiles and early mammals. Particularly important are the marine clays of the 'Barton Beds' around Highcliffe and Barton-on-Sea which have given their name to a division of the Eocene - the Bartonian.

During the Pleistocene the ancient River Solent flowed from west to east (Poole to Portsmouth) until rising sea levels eventually breached the bounding chalk ridge to the south isolating the Isle of Wight from the mainland. Terrace gravels from the Solent, which are still found on the coast, contain vertebrate remains associated with the Pleistocene Hoxnian, Cromerian and Ipswichian interglacials 350,000-125,000 BP. Though the area was not covered by ice during the Pleistocene there is evidence for sea ice which has deposited a number of erratics in the area. Today, coastal processes are important in particular the development of shingle beach, spit, dune and intertidal marsh complexes.

Isle of Wight: The island has magnificent coastal exposures with a virtually unbroken succession from the early Cretaceous Wealden Series to the Oligocene Hamstead Beds (c. 144-24 Ma). The whole sequence strikes E-W across the island having been folded during the Miocene Alpine Orogeny (c. 15 Ma) to produce a monoclinal fold, vertically dipping chalk forming a central 'backbone' across the island. To the north and south of this central area beds dip at a low angle. The south coast is dominated by Cretaceous rocks. The earliest (Wealden Series) were deposited in a complex fluvial environment that covered the Hampshire and adjacent Wealden Basins between 144 and 132 Ma. The Wealden Series is noted for its diverse fossil fauna and flora, notably this is the richest Lower Cretaceous reptile locality in the UK and among the best in the world. Sea level rise towards the Upper Cretaceous led to the deposition of the Lower Greensand, the most complete section in the UK. The succeeding Gault and Upper Greensand are also present and overlain by key sections in the Cretaceous chalk deposited by a shallow sea covering much of England during the Upper Cretaceous. Tertiary beds including the Upper Palaeocene Reading Formation, the Eocene London Clay Formation, Bracklesham Group, Barton Group and Headon Hill Formation, and the Oligocene Bouldner Formation, these are well exposed in near vertical sections on the eastern and western points of the island. The Bouldner Formation forms much of the northern part of the island. Initially estuarine (Reading Formation) the bulk of this Tertiary sequence is marine in origin and contains a diverse reptile, mammal, insect and plant fauna.

Fluvial gravels and raised beaches were deposited during the Pleistocene and provide a valuable record of Pleistocene sea level changes, including the highest Pleistocene deposit in the UK. This diversity of geology has also produced some of the UK's most important coastal geomorphology producing differential erosion rates, varied headland development and classic coastal landforms such as the Needles.

Geomorphological Evolution and Processes: This MNA includes nationally important features such as Poole Harbour, Hurst Spit, and the Needles (IoW) and is indented by numerous bays, estuaries and harbours.

Selsey Bill to Studland Cliffs: The coastline between Selsy Bill and the entrance to Southampton Water is generally low-lying formed in Bracklesham clays and overlain by gravels. It is therefore a "soft" coastline and beach erosion is prevalent. Littoral processes are complex but there is a moderate westward drift due to westerly and easterly waves (predominant SW waves are defracted towards the north by the Isle of Wight). The rate of drift has been considerably reduced in the last 25 years due to coast protection works and the diminution of beach material supply has been causing erosion from Selsey to Hayling. The drift is intercepted by harbour mouths and beach material is transported offshore to tidal deltas by rapid ebb currents. Portsmouth Harbour entrance forms an effective boundary with little interaction between beaches to the west and those to the east.

Between Portsmouth Harbour and Southampton the coastline is generally low-lying with a low littoral drift. Wave exposure is not severe, however locally generated wave action (in the Solent), is sufficiently strong to cause cliff erosion between the rivers Meon and Hamble and to transport material north-westwards or south-eastwards from a "drift divide", situated approximately centrally on this frontage. (near Solent breezes). Southampton Water is a wide and very deep tidal channel formed by submergence.

Littoral drift is low and eastwards on the north shore of the west solent with a "soft" coastline that is prone to erosion particularly from Calshot Spit to Keyhaven. Calshot Spit lies at the western entrance to Southampton Water and broadening out at its distal end where a castle still stands. The spit has been formed by wave induced Longshore drift from the south-west within the West Solent. Hurst Spit lies at the western entrance to the West Solent and at the eastern end of Christchurch Bay. It projects some 2km across the solent in a southerly direction from Milford-on Sea. The crest of the bank is only 6m wide and has a maximum hieght of 5.5m ODN. There is local accretion of shingle in the lee of Hurst Spit. much of the coarse shingle comprising the spit is derived from the erosion of cliffs further west and also from glacial deposits which originally covered the floor of the English Channel. These are subsequently moved to the littoral fringe by wave action under rising sea levels. Although Hurst castle spit is much weakened at its proximal end by the steady retreat of the cliffs at Milford and their protection by walls and groynes, the spit maintains its form. Rapid tidal currents transport shingle from off the end of Hurst Spit seawards onto offshore banks.

There is moderate to high easterly drift of sand and shingle in Christchurch and Poole Bays with a local drift reversal at the entrance to Poole Harbour. (Poole Harbour also the estuary of the present River Frome, is a large natural tidal lagoon formed by the submergence of low-lying land by post glacial sea-level rise. Areas of higher ground now form islands such as Green Island, Brownsea Island and Furzey Island). Tidal currents carry sand around Hengistbury Head, some of this being transported offshore and some reaching the Christchurch Bay frontage. Generally this section of the NA is easily erodible/unstable cliffs of clays, sands and gravels, with areas of saltmarsh in Christchurch and Poole Harbours and build up of sand dunes in Studland Bay. In Christchurch Bay the rate of cliff recession is most rapid to the west of Barton, approximately 1m/year, as aresult of deep seated rotational slips and mudflows in the clay. In Poole Bay a massive beach nourishment scheme has been relatively successful in protecting the backshore.

Isle of Wight: A central chalk 'back bone' lies from East to West across the island emerging at the coast in the form of the Needles and the Bembridge Downs on the east coast. The south coast is dominated by Cretaceous rocks which are exposed to severe wave regimes compared to the sheltered north coast and the coastline is receding at a relatively rapid rate.

The north coast (The Needles to the Foreland), of the Isle of Wight is mainly undeveloped and relatively shelterd from wave action. Strong tidal currents play a leading role in the dispersion of fine sands and clays from areas of erosion and slippage, which affects most of the coast. From the Needles to Cowes the cliffs are predominantly sands and clays and prone to slippage and also from Seaview to Foreland where sands and clays overlie limestone the erosion rates are high. However between Cowes and Ryde, the clay cliffs are less steep and fairly stable with Ryde being a major zone of sand accretion and also at Bembridge. The sediment source for these sinks must be derived from the SE coast or from the Solent itself, since cliff erosion between Totland and Yarmouth is probably barelty sufficient to feed beaches locally. The dominant processes are wave action

on the west and east coasts, and combined waves/tidal currents on the north coast. There is little transport across the medina (between E and W Cowes), so the NW and NE coasts can be treated independantly in, many cases.

The south coast of the Isle of Wight in comparison has a severe wave exposure, and erosion and cliff slippage is prevalent around most of the coast providing beach material for the SE coast. This side of the IoW includes many classic land forms including the chalk pinnacles/stacks known as the Needles at the far western side of the island and the chines between Compton and Blackgang. A moderate to high eastward drift occurs from the Needles to St. Catherines Point, reducing slightly to the east. This eastward drift has created pocket sand and pebble beaches in bays between St. Catherines Point and Ventor, and sand accretion in Sandown Bay.

Key geological features:

- Lower Cretaceous Wealden stratigraphy and palaeoenvironments (IoW)
- Lower Cretaceous Wealden palaeontology (IoW)
- Upper Cretaceous stratigraphy (IoW)
- Tertiary stratigraphy and palaeoenvironments
- Tertiary palaeontology
- Evolution of the River Solent and Pleistocene environments
- Coastal geomorphological features including Hurst Spit, Poole Harbour and The Needles (IoW).

Number of GCR sites:

Tertiary Palaeobotany: 11 Palaeogene: 10 Pleistocene/Quaternary of S. Central England: 7
Coastal Geomorphology of England: 6 Mesozoic-Tertiary Fish/Amphibia: 4 Tertiary Reptiles: 4
Tertiary Mammals: 4 Aves: 3 Palaeoentomology: 3 Aptian-Albian: 3
Alpine structures of S. England: 2 Jurassic-Cretaceous Reptilia: 2 Mesozoic Palaeobotany: 2
Cenomanian-Maastrichtian: 1 Wealden: 1 Salt Morphology: 1

Geological/geomorphological SSSI coverage: There are 21 coastal (P)SSS's in this MNA containing 64 GCR SILs representing 16 different GCR networks.

South coast from Selsey Bill to Studland: Highcliffe to Milford Cliffs expose the internationally important Barton Group while Bracklesham Bay is the type (reference) locality for the Tertiary Bracklesham Group and, together with Lee on the Solent to Itchen Estuary , has yielded type fossil fish, bird and plant material. Terrace gravels from the River Solent are exposed at Lee on the Solent, Bracklesham Bay and Selsey; these gravels contain important Pleistocene vertebrate remains and Palaeolithic artifacts. Chichester Harbour provides classic examples of the modern development of shingle beach, spit (East Head), dune and intertidal marsh complexes. Hurst Castle spit SSSI is a key site for coastal geomorphology concerning its form and development and is much weakened at its proximal end by the steady retreat of the cliffs at Milford.

Isle of Wight: Hanover Point to St Catherine's Point and Whitecliff Bay are currently considered to be of international status. The south coast exposes a near complete Cretaceous sequence from the Lower Cretaceous Wealden Beds (Hanover Point to St Catherine's Point) to the Upper Cretaceous Lower Greensand (Bonchurch Landslips) and the Upper Cretaceous Chalk (Headon Warren & West High Down and Bembridge Down). The north coast exposes Tertiary rocks, most notably the vertical sequences in Alum Bay and Whitecliff Bay in the extreme west and east. The youngest Tertiary rocks, and the type section for the Bouldner Formation, are exposed at Bouldner & Hamstead Cliffs. The Cretaceous Wealden sequence of Hanover Point to St Catherine's Point is particularly noted for its reptile fauna and plant flora while Tertiary Beds have yielded important mammal, reptile (Alum Bay and Bouldner & Hamstead Cliffs), insect (Gurnard Ledge and St Helen's Ledges) and plant remains (King's Quay Shore). The sequence in Whitecliffe Bay and Bembridge Ledges displays

folding and faulting associated with the Alpine Orogeny while at Bembridge Ledges an important Pleistocene sequence documents recent sea level changes affecting the Isle of Wight. Southwest IoW is an important site for coastal geomorphology. It is one of the major southwest facing beaches in southern England. It displays the effect of differential erosion on coastal forms. Intertidal shore platforms are a significant feature together with a range of classic landforms including the Needles and the chines between Compton and Blackgang.

Key geological/geomorphological management issues:

- Maintenance of natural coastal processes; threat of coastal defence (eg. Highcliffe to Milford Cliffs)
- Maintenance and enhancement of existing coastal exposures
- Promote the scientific/educational value of the geological and geomorphological resource
- Fossil collecting, especially Cretaceous rocks (IoW)
- Extensive areas of intertidal erosion and saltmarsh die back are potentially increasing the risk of innundation in certain areas (eg. West Solent), and means the present levels of defence are probably inadequate.
- Recession and breaching of Hurst Spit
- Any development on one part of the coast is likely to affect sediment supply in the direction of longshore drift, with a potential knock-on effect eg. beach loss, scouring, increased erosion etc..

Key geological objectives:

1. Maintenance and enhancement of the geological resource through a) development of local conservation strategies and initiatives that include geology, b) maintenance of natural coastal processes - development of Shoreline Management Plans, c) development of responsible fossil collecting policies on the island (eg. IoW Geology Mus. Fossil collecting leaflets), d) assessment of educational/research value of coastal sections (Cliff and foreshore).

2. Promotion of geological resource through a) promotion of site educational and scientific value, b) on-site interpretation (eg. sign boarding, trail guides, leaflets), c) promotion of the link between geology/geomorphology, local habitats and landscape evolution.

3. Maintenance and enhancement of the geomorphological resources through a) coastal defence schemes must be considered carefully within a Shoreline Mangement Plan.

4. Dune management (in Studland Bay) through a) public awareness campaigns, b) wardening, c) restricting access, d) reseeding 'worn' areas and e) restricting access particularly in vulnerable areas for example around carparks or breeding areas.

Useful guides/references:

CURRY, D., 1992: Tertiary. *In*: McL. D. Duff, P. & Smith, A.J. (eds). Geology of England and Wales, 389-408, publ. Geological Society, London.

HOUSE, M.R., 1993: The Dorset Coast. Geologists' Association Guide, 2nd edition.

MELVILLE, R.V. & FRESHNEY, E.C., 1982: British Regional Geology: The Hampshire Basin and adjoining areas. British Geological Survey, HMSO.

WHITE, H.J.O., 1922 (reprinted 1990): Geology of the Isle of Wight. Memoirs of the Geological Survey of Great Britain.

Earth science coastal (P)SSSIs in the Maritime Natural Area:

- White Cliff bay and Bembridge Ledges
- St Helen's Ledges
- Gurnard Ledge to Saltmead Ledge
- Bouldner and Hamstead Cliffs
- Bembridge Down
- Bonchurch Landslips
- Colwell Bay
- Compton Down
- Hanover Point to St Catherine's Point
- Headon Warren and West High Down
- King's Quay Shore
- Watcombe Bay
- Chichester Harbour
- Bracklesham Bay
- Lee on the Solent and the Itchen Estuary
- North Solent
- Hurst Castle and Lymington River Estuary
- High Cliff to Milford Cliffs
- Poole Bay Cliffs
- Studland Cliffs
- Arne