GEOTECHNICAL STUDY AREA G7

CASTLEHAVEN LANDSLIDE, NITON, VENTNOR UNDERCLIFF, ISLE OF WIGHT, UK

Plate G5 ***Reeth Lodge, Castlehaven, Isle of Wight, UK***

1. BACKGROUND

Castlehaven comprises a residential area behind Reeth Bay and is located on the southern-most point of the Isle of Wight, 1km east of St Catherine's Point and south of the village of Niton (see Figure G7.1). Castlehaven lies within an area of ancient deep-seating landslides in the western part of the Undercliff. The landslides have developed upon weak clay layers within the Gault Clay and Lower Greensand strata. The geomorphology of the area comprises three distinct landforms, an Upper Greensand plateau, Undercliff landslide features and sea cliffs. A palaeo-drainage valley has developed upon the ancient landslide features which has had significant influence on landform development at Castlehaven since post-glacial times.

In early January 1994, contemporary landslide activity extended into the developed area of Castlehaven for the first time, when the gardens of Reeth Lodge (Plate G7) and Victoria Lodge collapsed down a steep scarp slope. Ground movements have continued until the present time leading to the further extension of activity upslope into the developed area and further destruction of property in February 1995. A total of 95m recession of the coastal slope has occurred since January 1994. The principal cause of the problem has been clearly linked to the erosion of the sea cliffs since 1908 with specific landslide events being triggered during extreme rainfall periods which generate high groundwater levels (Plate G7a). The uncontrolled discharge of surface water from roads and domestic sources may have inadvertently contributed to the problem by raising groundwater levels.
Management of the problems at Castlehaven are being carried out within the framework provided by the Undercliff Landslide Management Strategy adopted by the Council in 1991, which highlights the need for improvement of ground conditions through coast protection and control of water as important objectives.

The Council is seeking to undertake coast protection and slope stabilization works with the assistance of grant aid from the Government, which will result in a future reduction in potential losses and damage to the various assets at Castlehaven by:

- A reduction or prevention of the removal of landslide debris from the foreshore by wave action.
- Prevention of sea cliff erosion.
- Slope drainage measures.

A number of scheme options have been considered in order to reduce the risk of widespread damage to property, infrastructure and environmental interests at Castlehaven. After considering a number of alternative schemes, a preferred scheme concept has been developed on the basis of cost, environmental impact and hydraulic performance. The preferred scheme comprises a rock armour revetment buttress structure located at the base of the sea cliff and drainage measures on the coastal slope. An application has been submitted to the Ministry of Agriculture, Fisheries and Food for coast protection grant aid on this basis in accordance with the Undercliff Landslide Management Strategy.

2. THE IMPACTS OF INSTABILITY - THE PROBLEM

In early January 1994, increased landslide activity was reported on the coastal slopes at Castlehaven, near Niton. The Council were first notified of the movements on 14 January when the gardens fronting Reeth Lodge and Victoria Lodge collapse down a steep scarp slope. A site inspection revealed that a considerable area of the lower Undercliff was on the move, exposing the steep scarp slope in front of Reeth Lodge. The recession of the sea cliff and failure of the lower undercliff lead to the area affected by movements spreading to within 15m of several homes and leading to the disruption of services (Rendel Geotechnics 1995).

Since January 1994, a series of relatively shallow failures have continued to develop upon the upper tier basal shear surface within the Gault Clay progressively extending further upslope. In 1994 the affected zone was approximately 60m upslope from the crest of the Gault Clay scarp and by February 1995 this zone had extended a further 35m upslope to behind Victoria Lodge. Dangerous structure notices were issued by the Council for both Reeth Lodge and Victoria Lodge, which were subsequently evacuated by the residents as a result of damage caused by ground movement.

Ground movement has continued since February 1995 and is evidenced by the continuing development and widening of cracks, steps and benches and movement of material downslope. These observations are borne out by automatic tiltmeter records monitored in the area by the Isle of Wight Council. Evidence of shearing at various levels within the landslide was also confirmed during the preliminary ground investigation undertaken in April and May 1996 (Rendel Geotechnics 1996).

It is readily apparent that the slope failure and landslide activity at Castlehaven is being promoted by marine erosion (removal of debris from the foreshore and sea cliff recession) and the consequent unloading of the slopes above. Recession of the sea cliff has led to the re-activation of the pre-existing deep-seated landslides. Small, almost continuous sea cliff erosion leads to intermittent larger scale events in other parts of the landslide system, whose timing is related to the severity of erosion and other factors such as high rainfall and high groundwater levels.

The nature of landsliding is complex, but broadly involves a two-tier failure mechanism; deep-seated multi-rotational slides which occupy a broad zone in the upper part of the Undercliff and secondly, deep-seated compound slides and mudslides which occupy a broad zone in the lower Undercliff. The two-tier model was confirmed during the preliminary ground investigation (Rendel Geotechnics 1996). In the vicinity of Reeth Lodge, partial landslide activity has generally been confined to the lower tier, significant ground movement within the upper tier being comparatively rare prior to January 1994.

The lower tier of the landslide is perched upon a prominent sea cliff which extends some 650 metres in length from Castlehaven headland in the west to Puckaster Cove in the east. The cliffs are formed of Sandrock strata (unit 2c) which is highly erodible under direct wave attack. Unit 2c is a "locked" fine sand with no cement, which behaves as a competent rock standing in near vertical cliffs until abraded or eroded. When undercut the cliffs fail in large joint-bounded blocks, which generally break up completely on impact to form a fine sandy scree (Bromhead et al 1991).

Future rates of cliff retreat and landslide activity are inherently difficult to predict but may be based on a projection of past erosion and landslide extension. On this basis Figures G7.4 and G7.5 have been compiled from the geomorphological map of this part of the Undercliff (Figures G7.2 and G7.3) and show future landslip potential in terms of a series of zones, which will become increasingly at risk of failure if retreat of the sea cliff and Gault Clay scarp continues. The landslide potential can also be substantiated by historical evidence from elsewhere within the Undercliff.

The consequences of continued marine erosion and destabilisation of the upper tier over the next 50 years are:

1. Physical loss of areas of land, estimated to be approximately 210,000m². This estimate may be on the low side bearing in mind projected sea-level rise and increased climate storminess.
2. Considerable direct and indirect loss of property, in the order of 40 properties with risk-free values totalling approximately £5.8m.
3. Loss of infrastructure, such as statutory services and roads, including the main coast road A3055 running round the Isle of Wight, totalling approximately £1.4m.
4. Loss of amenity and considerable environmental interest.

3. ROLE OF THE KEY AGENCIES

The key agencies involved at Castlehaven are the Isle of Wight Council as Coast Protection, Highway and Planning Authority, Southern Water Services Ltd with responsibility for drainage matters and water supply, and English Nature - the Government's Nature Conservation advisors.

The Council has experienced difficulty promoting its coast protection and stabilization scheme following the designation of the foreshore and littoral zone along the south coast of the Isle of Wight as a Candidate Special Area of Conservation under the European Habitats Directive. The Council believes that its proposals will not have an adverse impact on this European site.

Southern Water Services would have an involvement at this location should the Council wish to promote a first time sewerage (new foul drainage) system for the area. At the present time the Council is not mindful to do this because of the substantial capital costs. However it will be encouraging local residents to improve their drainage arrangements so that there are no longer uncontrolled discharges of sewage into the landslide system. Local residents do, therefore, have an important role to play in this situation as indeed they did at Luccombe (Study Area G2). The

Council wishes to seek a co-ordinated solution to the instability problems at Castlehaven comprising coast protection and slope stabilization measures, drainage improvements and ongoing maintenance of the area for both ground stability and environmental reasons. The Council firmly believe that by working with local residents this is the best way that these objectives can be achieved and sustained for the future.

4. THE STUDY AREA

4.1 Geology

The geology of the south coast of the Isle of Wight comprises a series of Upper and Lower Cretaceous strata. The youngest deposits include Chalk, Upper Greensand and Gault Clay which overly the older deposits of the Lower Greensand formation.

The Malm Rock and Chert beds of the Upper Greensand are exposed in a near vertical rear scarp, on the eastern side of Niton marking the landward limit of the Undercliff. The Lower Chalk is mostly absent above the rear scarp resulting in a level Upper Greensand plateau. The Passage Beds and underlying Gault Clay are obscured by relic landslide debris at the foot of the inland scarp. However, the Gault Clay (known locally as 'Blue Slipper') is exposed in the prominent scarp on the coastal slopes near Reeth Lodge, which arcs towards the coast between Puckaster and Castlehaven. See Figure G7.6.

The older underlying Lower Greensand sequence comprises the Carstone and Sandrock. The Sandrock sequence has been divided into five lithological groups. Recent movement in the Undercliff has exposed the Carstone which is 'in-situ' at the base of the Gault Clay scarp. The Sandrock is well exposed along the coast between Puckaster and Castlehaven in the 8-15m high sea cliff.

The foreshore is cut in very weak sandstone (Sandrock unit 2c) overlain by a thin cover of superficial deposits. The beach deposits comprise sand, cobbles and boulders derived from deposition and erosion of landslide debris from the above sea cliff. In the eastern half of Reeth Bay a 'reef' formed of resistant boulders occurs approximately 100m seawards of the cliffs. A smaller reef is also present near the western end of the bay.

The geological structure of the Southern Downs dip gently to the south at 1-2° (White 1921). The Upper Greensand strata are strongly jointed by two principal sets of near vertical joints. Superimposed on this structure if a shallow syncline, the Ventnor syncline, the axis of which plunges gently to the south-south-east in the vicinity of Ventnor (Hutchinson 1965; Chandler 1984). On either side of this axis the elevation of strata increases, leading to significant variations in the geological exposures and mechanisms of the landsliding along the coast.

4.2 Land Drainage and Hydrogeology

The geological sequence of the area exerts a significant control on the distribution of groundwater within this part of the Undercliff. The geology comprises an alternating sequence of relatively low permeability strata inter-bedded with relatively high permeability strata. The groundwater regime is principally controlled by the low permeability strata of the Gault Clay and the clay rich Unit 2d of the Sandrock.

The relatively impermeable, often over-consolidated Gault Clay restricts the vertical drainage of groundwater to lower levels, so that large quantities of water are stored above in the Upper Greensand. This forces the groundwater to plane horizontally along the dip of the strata into the Undercliff landslide debris which also rests on the Gault Clay. Similarly, at depth the clay rich 2d unit of the Sandrock is an aquiclude, which inhibits downward drainage. Thus water may be confined between the 2d unit of the Sandrock and the base of the Gault Clay above, which may provide a source of groundwater and high pore water pressures on the lower levels of the landslide.

Evidence of surface water drainage, in the form of springs, issues, seepages, surface streams and ponds is abundant throughout the Castlehaven Undercliff. In addition to the surface drainage, the presence of underground streams has been reported by local residents (Harvey, Pers.comm) and can be inferred between the location of springs and sinks within the area. Surface drainage occurs throughout the year, being fed from the large downland catchment and aquifers comprising highly permeable Chalk and jointed Upper Greensand strata. The origin of the springs probably relates to the presence of low permeability in-situ Gault Clay or disturbed blocks of Gault Clay and Passage Beds within the landslide debris. When more permeable strata are encountered, water re-entered the deposits at locations referred to as "sinks" (High-Point Rendel 1998).

In addition to the natural sources of water within the Undercliff, artificial surface drainage makes a significant contribution to the groundwater regime. Uncontrolled discharge of surface water through soakaways and highway drains and the discharge of foul sewage from septic tanks and cesspools occurs from all of the properties in the lower Niton area. The progressive deterioration and leakage of services such as water mains and service pipes caused by ground movement has added to this problem by artificially recharging the water table. This prevents the ground from "drying out" during the summer months which undoubtedly contributes to the destabilisation of the coastal slopes.

4.3 Geomorphology

The Castlehaven Undercliff is part of the relic deep-seated landslide complex which was formed by a range of mass movement activities, stimulated by past fluctuations in sea-level and climate (Rendel Geotechnics 1995).

A complex pattern of landslide features has been identified in the area arranged within a number of distinct landslide systems (Figures G7.2 and G7.3). These systems are long established and probably developed in excess of several thousand years ago. Since that time they have remained largely inactive, although periodic slow ground movement will have occurred, particularly during extreme wet periods. The Castlehaven landslide system coincides with the presence of a palaeo-drainage valley within this part of the Undercliff which probably postdates the formation of the ancient landslide complex.

These marginally, stable, deep-seated landslides are similar in form to the landslide systems found elsewhere in the Ventnor Undercliff (Rendel Geotechnics 1995; Geomorphological Services Ltd 1991) and broadly involve different mechanisms of landsliding developing at two principal levels within the stratigraphical column:

1. Deep-seated, multi rotational slides, which occupy a broad zone in the upper parts of the Undercliff, giving rise to large blocks of Upper Greensand separated by steep scarp slopes;
2. Deep-seated compound slides and mudslides which occupy a broad zone in the lower parts of the Undercliff, with the basal shear surface coinciding with clay rich unit 2d of the Sandrock.

At Castlehaven, the lower tier is perched above an 8-15m high sea cliff developed in unit 2 of the Sandrock.

At Reeth Lodge, located directly above the coastal slopes, past landslide activity has generally been confined to the lower tier compound failure zone. However, in January 1994 and February 1995 ground movements extended into the upper tier multiple rotational zone causing damage to structures and loss of land and put at risk other homes and properties in the area. The geomorphology of the Castlehaven area was mapped in detail in January 1994 following significant landslide activity near Reeth Lodge (Rendel Geotechnics 1994). The field survey utilised colour vertical aerial photographs at 1 : 4,000 scale taken in January 1994, to obtain details on the more active and inaccessible areas and to identify landslide system boundaries. The photographs were also compared with earlier photographs taken in 1985 to identify any notable changes over the period.

Further cliff recession and landslide activity occurred in February 1995 which caused additional damage in the area around Reeth Lodge and Victoria Lodge. Consequently the geomorphological map was updated in March 1995 to show the extent of the latest movement. Movement has continued since March 1995 and is evidenced by the continued development and widening of cracks, steps and benches and movement of material downslope, particularly in the area around Reeth Lodge, Victoria Lodge and Puckaster Farm. These observations are borne out by automatic tiltmeter records monitored in the area by the Isle of Wight Council.

5. MONITORING

Following the landslide in 1994, the Council, as a matter of urgency, commissioned its consultants to develop a monitoring strategy for the area. The purpose of the monitoring strategy was two-fold. First to provide an early warning system to alert the Council and local residents in the event of a major landslide being triggered and second to provide information on trends to assist a long-term resolution for the instability problems in the area if that was possible. As a result the Council installed a range of instrumentation in the Castlehaven area based on geomorphological advice. The equipment comprises five electro-level tiltmeters, one piezometer and a data logger. Information from the data logger is transmitted to both the police headquarters for the Isle of Wight at Newport and to the Isle of Wight Council. Since the installation of the equipment, the Isle of Wight Council have been monitoring results and these investigations are supported by field visits at regular intervals.

6. COASTAL DEFENCE

A comparison of the sea cliff position from old photographs and early editions of the Ordnance Survey maps between 1862 and the present day demonstrates significant sea cliff recession at Castlehaven. The recession over the last 130 years has ranged between 20-40 metres and has resulted in:

1. Loss of the three storey Victoria Hotel, which was sited on the foreshore below Reeth Bay between 1850 and 1908.
2. Loss of coast protection and buildings on the foreshore, mostly fishing huts, at the Victoria Hotel site and at Puckaster Point between 1939 and 1971.
3. Loss of various small scale coast protection measures, groynes and slipways since 1862.
4. Loss of Victoria Lodge and Reeth Lodge properties upon the coastal slopes in February 1995 due to destabilisation of the Undercliff landslide by marine erosion.
5. Risk of further losses of property, roads and infrastructure due to the threats of sea cliff recession and landslip.

The Isle of Wight Council has submitted an application to the Ministry of Agriculture, Fisheries and Food seeking coast protection grant-aid for a £3m coast protection and stabilization scheme for the area. The scheme has been approved by the Isle of Wight Council and by all statutory consultees with the exception of English Nature. Ongoing discussions with English Nature it is hoped will enable the scheme to be implemented within the next year.

7. EXPERIENCE, SUCCESSES/PROBLEMS WITH CURRENT APPROACH

The Castlehaven landslide system was reactivated after a long period of relative stability following the extreme rainfall event of December 1993/January 1994. A further very wet winter in early 1995 led to an increase in landslide activity with a total retreat of the unstable coastal slope by some 95m over a period of 18 months. This represented probably the fastest retreat of any section of coastal slope in the United Kingdom over that period.

The approach adopted towards investigation and remedial solutions at Castlehaven provides a model for studies of this kind and is based upon the criteria set out by the Ministry of Agriculture, Fisheries and Food for developing coast protection schemes eligible for funding under the Coast Protection Act 1949. A succession of studies and activities comprising - emergency response and the installation of monitoring equipment, a scoping study, site investigation, assessment of the preliminary engineering options, consultation with statutory and non-statutory consultees, leading to the submission of an Engineer's Report to MAFF was the sequence of events at Castlehaven.

The installation of ground instability monitoring equipment at an early stage provided a degree of security for local residents who knew that the Council was monitoring the area and would be able to alert residents in the event of an increase in ground movement rates. The site investigation has confirmed provisional findings arising from a geomorphological study of the area and has enabled preliminary design work to commence with respect to coastal protection of the sea cliff at Reeth Bay below the developed area and has allowed consideration to be given of the requirements for groundwater mangement within the coastal slope.

Over the course of scheme development, the south coast of the Isle of Wight (comprising the reefs in the inter-tidal area) was designated as a candidate Special Area of Conservation under the European Habitats Directive; the coastal slope is locally designated as a 'Site of Importance for Nature Conservation'. Although the Council did not believe that its proposed scheme would have any impact on the European site, the Candidate designation has led to considerable delays and protracted discussions with English Nature, the Government's nature conservation advisers. Environmental issues have now been resolved with English Nature following the development of a package of mitigation measures.

The Council is hopeful that outstanding issues will be resolved to enable the engineering solution to be undertaken allowing an improved level of protection for properties and infrastructure including the main A3055 coastal road at this location.

8. LESSONS LEARNT

The instability at Castlehaven has shown how quickly a dormant coastal landslide can be re-activated. This reactivation followed the loss of support at the toe of the landslide as a result of coastal erosion and due to a 1 in 100 year rainfall event (1994). The speed of the retreat of the landslide into the developed area provides a warning for other vulnerable locations where similar geological, geomorphological and hydrological conditions exist.

The instrumentation installed at Castlehaven to improve the understanding of ground conditions and to act as an alarm system has been invaluable. First because the data has provided information to assist the engineering scheme design and second by providing a degree of reassurance of local residents with respect to their safety and that of their properties over the protracted scheme development period.

The Castlehaven proposal was being developed during the period of introduction of the Habitats Regulations. The uncertainty over the implementation of the Regulations by English Nature has caused considerable delay as has the evolution of their thoughts on national nature conservation policy. The implications of a range of environmental initiatives (Biodiversity Action Plans, Habitat Action Plans etc.) could have serious implications for cliff and slope stabilization and coast protection schemes of this kind in the future. There will be a presumption against stabilization measures to protect life and property if there is an adverse impact on the environment.

A number of coastal communities may be put at increasing risk as a result of climate change impacts and it will not necessarily be possible to provide an engineering solution. In some situations local residents see plants and insects being protected by European and national environmental targets and legislation, whilst human life and property does not benefit from a similar level of protection. A number of local authorities, residents and other organisations believe that environmental legislation is now becoming out-of-step with socio-economic and human requirements in Great Britain and that nature conservation legislation has become too powerful as a result of the implementation of the Habitats and Birds Regulations and other Government commitments to environmental protection and conservation. This issue highlighted by the Castlehaven proposal is discussed further in Volume 1, Chapter 1 (Legislative and Administrative Frameworks), section 1.3.

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Plate G7a ***Reeth Bay looking inland over Castlehaven***

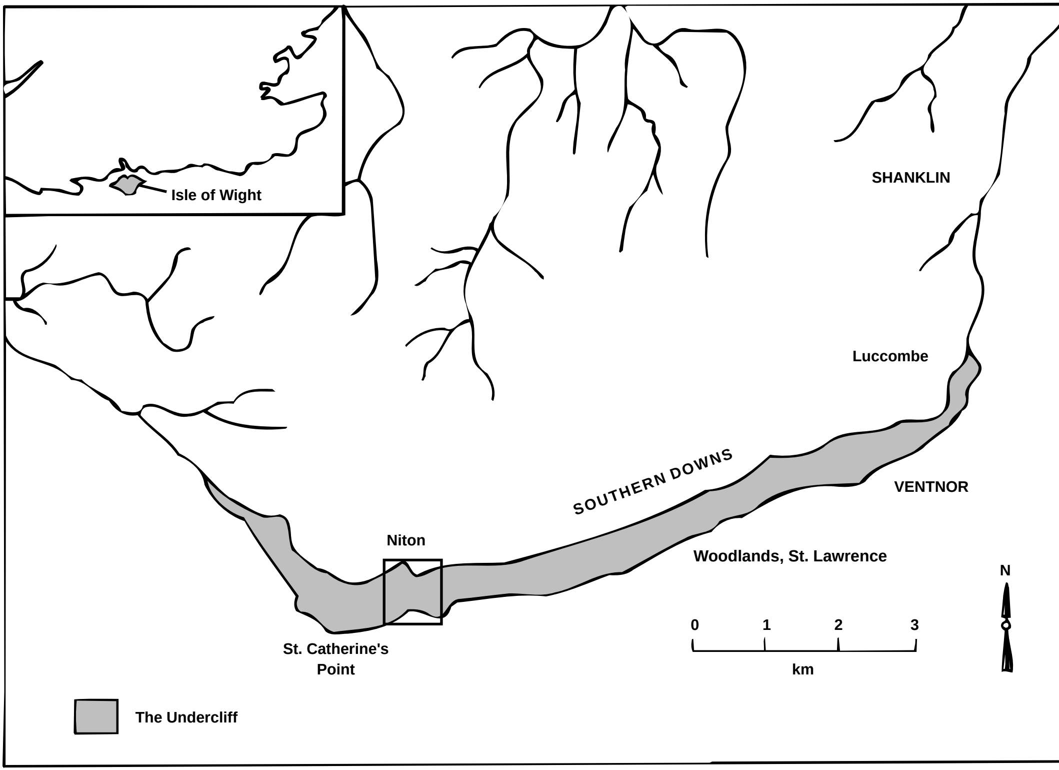

Figure G7.1 Niton location map

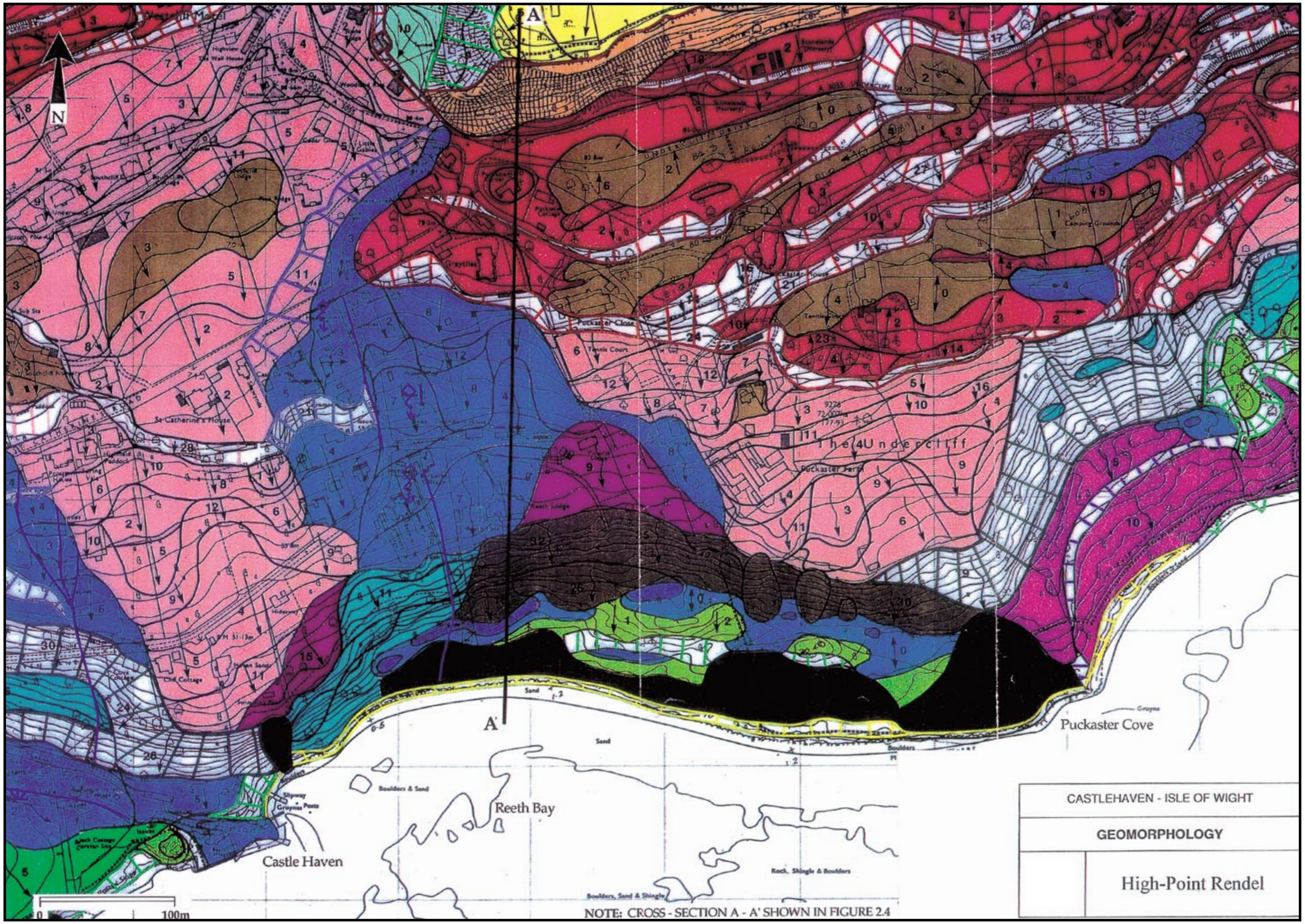

Figure G7.2 Geomorphological map of the Castlehaven area (see Figure G7.3 for the Key).

Key and Explanatory Notes

Undercliff Landslide Features

Rotational landslide failure zone II (failure within Gault Clay)

- Rear-scarp; near vertical cliffs developed in Upper Greensand and Chalk
- Talus slope at base of rear-scarp incorporating Upper Greensand and Chalk debris
- Multiple-rotational failures within Gault Clay comprising buried backtilted blocks of mainly Upper Greensand beneath a mantle of superficial debris
- Multiple-rotational failures within Gault Clay comprising buried backtilted blocks of Upper Greensand and Chalk beneath a mantle of superficial debris
- Low-lying depressions landward of the multiple-rotational blocks characterised by soft ground and localised ponding
- Degradation zone of multiple-rotational blocks above the failure boundary zone I and II

Gault Clay scarp (boundary between zones I and II)

- Gault Clay scarp and talus slope
- Boundary between failure zones I and II

Mudslides

- Inland shallow mudslides developed in Gault Clay: active shallow failures developed in Gault Clay including Upper Greensand and Chalk with gently sloping benches and steep scarp slopes
- Shallow mudslides developed upon the Gault Clay scarp
- Coastal shallow mudslides

Compound landslide failure zone I (failure within Sandrock)

- Upper Greensand ridge: elongated ridge of backtilted Upper Greensand blocks with steep reverse slopes
- Chalk and Upper Greensand ridge: elongated ridge of backtilted Chalk and Upper Greensand blocks with steep reverse slopes
- Lower Greensand ridge: elongated ridges of sub-horizontal blocks of Carstone and Sandrock
- Low-lying depressions landward of the ridges, with soft ground bounded by steep scarp slopes
- Degradation zone developed in Lower Greensand; active shallow translational and rotational failures within Sandrock incorporating Upper Greensand debris, with gently sloping benches and steep scarp slopes

Coastal cliffs

- Coastal cliffs formed of Upper Greensand and Gault Clay debris
- Coastal cliffs formed of *in situ* Lower Greensand

Fluvial features

- Stream valley, buried channels and contemporary valley floors formed of Upper Greensand and Chalk infill and recent alluvium
- Pond
- Spring
- Wet ground

Downland Features:

Chalk downs

- Convex slopes of the Chalk downs
- South facing relic dry valleys; remnants of a periglacial stream network
- Truncated north facing relic drainage channels
- High angle shallow translational failure of weathered Chalk and head deposits
- Upper Greensand plateau and benches

Artificial slopes

- Made ground: artificial cut and fill slopes

SOURCE: Extract from Niton Extension Study: Geomorphology Sheet 6 (carried out for Isle of Wight Council by Rendel Geotechnics, 1996)

Figure G7.3 Key to the Castlehaven geomorphological map (Figure G7.2).

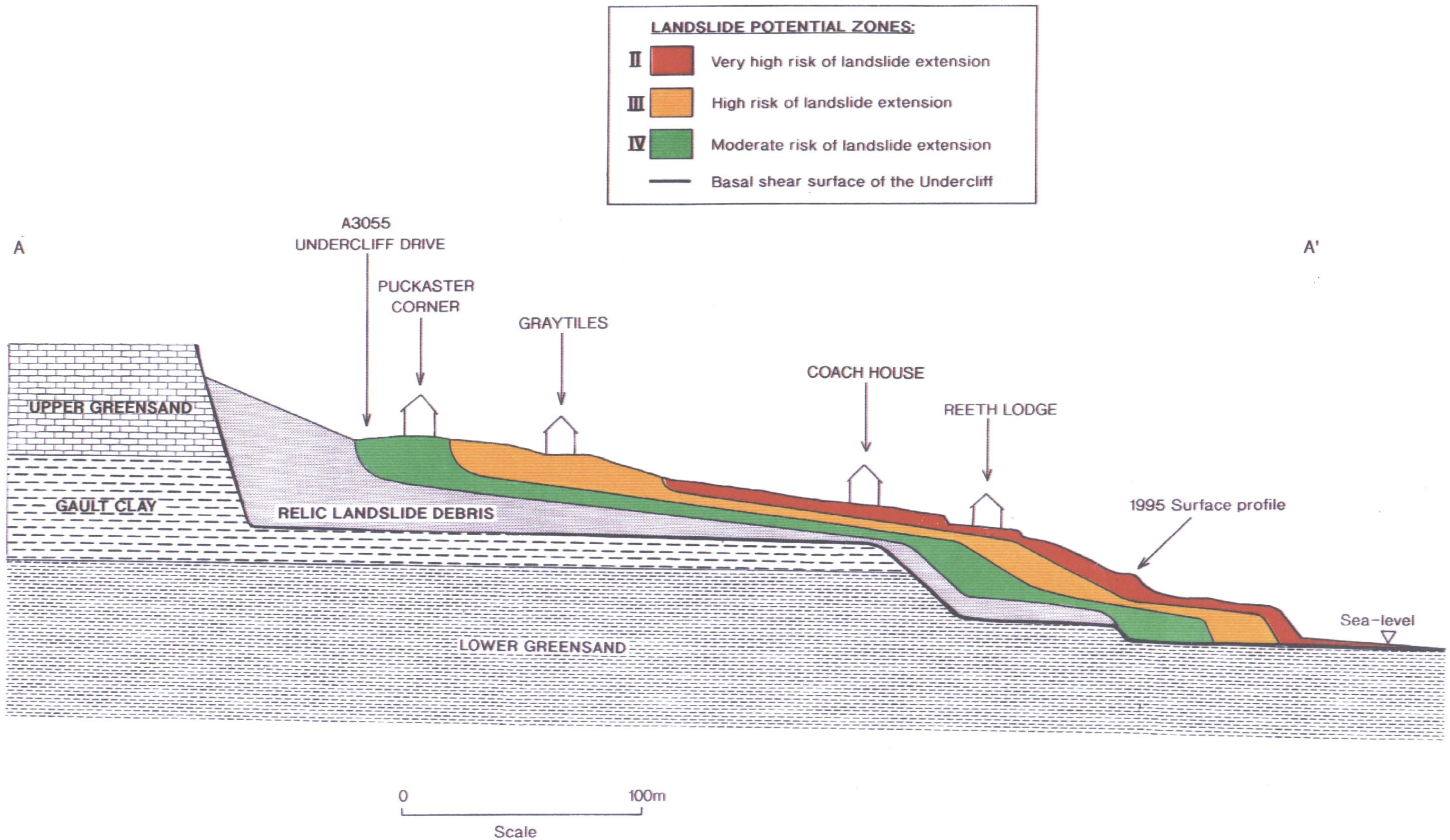

Figure G7.4 Diagram showing landslide potential at Castlehaven.

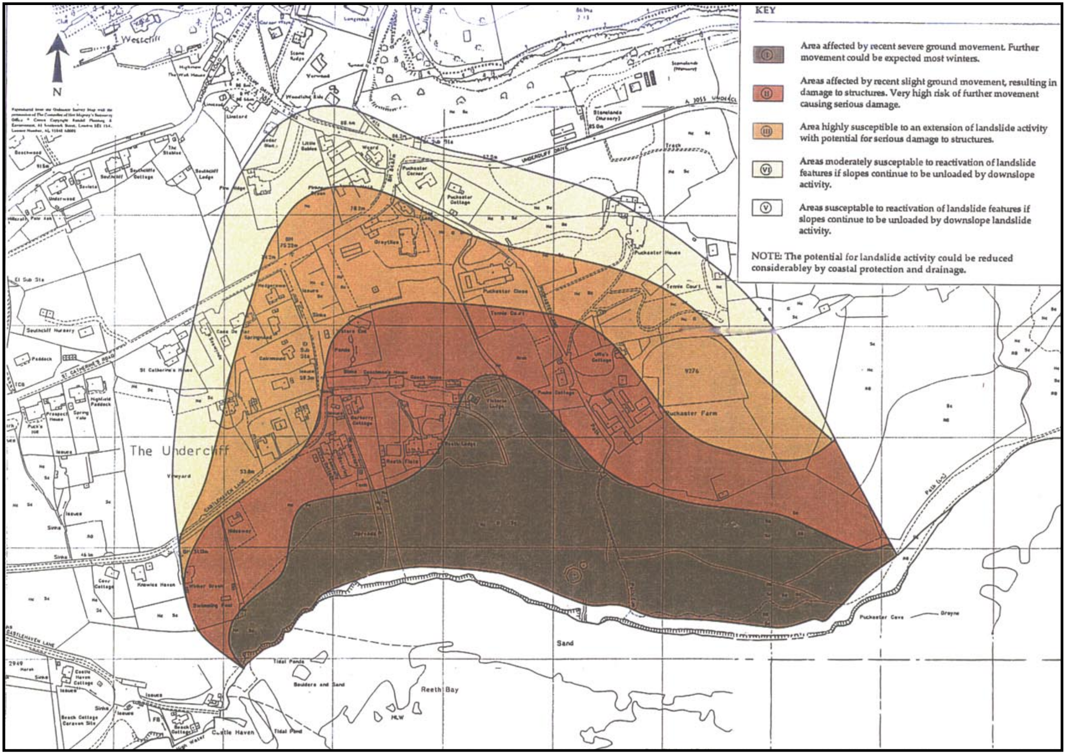

Figure G7.5 Potential land loss map around Reef Bay, Castlehaven.

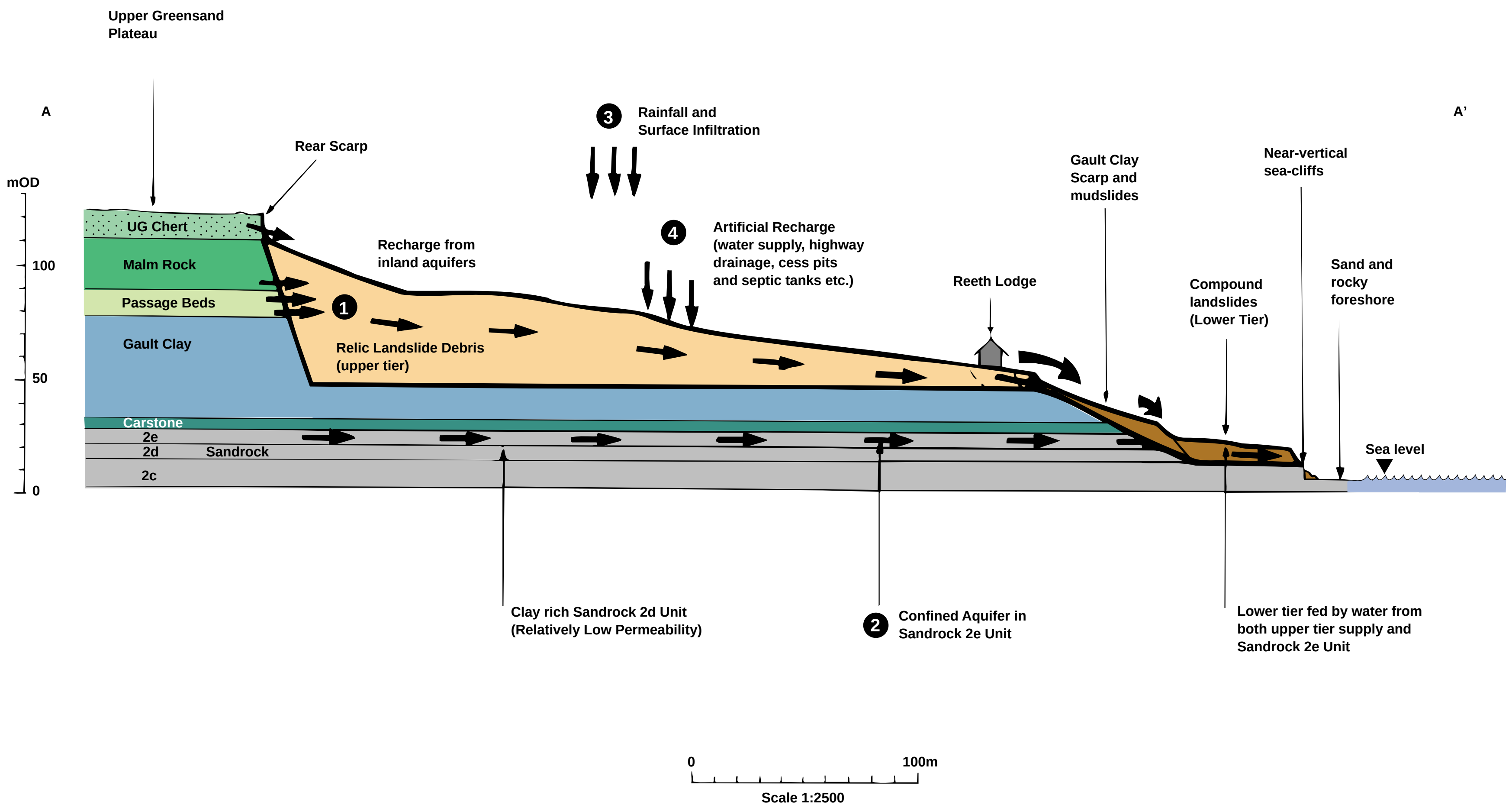

Figure G7.6 Principal sources of groundwater to the Castlehaven landslide.