GEOTECHNICAL STUDY AREA G8

BLACKGANG LANDSLIDE, VENTNOR UNDERCLIFF, ISLE OF WIGHT, UK

Plate G8 ***Aerial view of Blackgang landslide, Isle of WIght***

1. BACKGROUND

In January 1994 the impact of coastal erosion and exceptionally high antecedent rainfall resulted in extensive renewed landslide activity on 170m high cliffs in the Blackgang area of the Isle of Wight (see Plate G8 and Figure G8.1). The ground movements undermined several houses at the top of the cliff, two of which were destroyed along with the loss of secondary access roads and property. The impact of the event raised both national and international media attention. The initial emergency response to ensure public safety and security of the area was co-ordinated by the Council.

Following the emergency response, the Council commissioned a geomorphological investigation to identify the extent, causes and potential for further landslide or slope movement. The study also identified a range of options for managing the instability problems at Blackgang, which included the installation of an early warning monitoring system.

The investigation highlighted the extreme rates of clifftop recession (up to 5m per year) experienced at Blackgang and the increasing susceptibility of coastal slopes to landslide activity resulting from unchecked marine erosion at the cliffbase and over-steepening of the coastal slopes, such that normal to moderate winter rainfall could be expected to cause further slope movements or landslip and the recession of the clifftop inland. The land behind the clifftop is largely developed including a major theme park, but in the absence of a financially and environmentally acceptable slope stabilization and coast protection scheme, the policy of managed retreat of clifftop development and landuse is the only viable option, which is now being implemented (Clark et al. 1995).

2. THE IMPACT OF INSTABILITY

Blackgang is situated on the southern coast of the Isle of Wight. The area was affected by a major landslide on 12 January 1994 which resulted in the evacuation of twelve homes, the destruction of two cottages and areas of a theme park, an access road, several cars and a caravan, and a large section of coastal footpath (Gorman 1994), Plate G8a. The rapidly retreating high cliffs between Blackgang and Chale are well known to be very unstable (Hutchinson et al 1981) and have a long history of coastal instability.

Coastal erosion and instability has been taking place at Blackgang for thousands of years, particularly since the last ice age when sea-levels rose dramatically. The Blackgang area was developed in the mid to late nineteenth century with the construction of a series of villas and cottages (Plate G8b); the theme park was opened in 1843. Human influences, including site works and inadequate drainage has assisted nature in speeding up the landslide process in this area. Access to the beach from Blackgang Chine was lost earlier this century due to the rapid recession of the cliff face. In more recent years, clifftop recession of up to 5m a year (Rendel Geotechnics 1994) has not only led to the dramatic loss of land due to the retreat of the cliffs, but in January 1994, the failure and slumping of land immediately above the clifftop extended 40m inland, undermining buildings and the Old Blackgang Road.

Landslide activity was triggered by exceptional winter rainfall during December 1993 and in the early weeks of January 1994 (Figure G8.2), but was undoubtedly caused by the considerable retreat of the seacliffs in recent years through unchecked marine erosion (Bray 1994). The landslide in January 1994 was, therefore, the latest in a succession of such events, albeit a very major coastal slope failure.

Following the emergency landslide response, the Council commissioned its consultants to undertake a more detailed investigation of the extent and causes of the landslide, to undertake an assessment of landslide hazard potential and risk, and to identify a range of options for the future management of landslide hazard faced by the community at Blackgang.

The investigation identified a serious threat from continued slope instability within Blackgang Chine theme park, which had already lost a significant amount of land during the landslide event in January 1994. The assessment of landslide potential and management options within the area identified an urgent requirement for an early warning monitoring system to safeguard the public and residents at several critical locations. A range of other management options were considered in the short to medium term including coast protection, slope stabilization and the control of surface and groundwater drainage, although in practice such measures were considered to be constrained by major technical, economic and environmental factors. In the presence of such constraints pragmatic options such as the ‘managed retreat’ of the coastal slope, clifftop infrastructure and services and “do nothing” have been accepted as the most viable.

The latest problems at Blackgang emphasised the fact that the 1994 landslide was not an isolated event, but the combination of ongoing rapid coastal erosion and repeated coastal cliff instability which had led to a long history of notorious problems in the area. The community at Blackgang has diminished in size since the 1840s when the area was first developed by the Victorians as a tourist attraction. The progressive retreat of the coastal cliffs and periodic slope movements have destroyed houses and infrastructure and caused extensive loss of land in the past. The theme park has had to adapt to the impact of coastal cliff retreat by relocation of tourist attractions, reinstating footpaths and undertaking regular safety inspections in vulnerable areas (Plate G8c). The 1994 event heightened the need to consider the problems in terms of an overall management strategy for the area based on an understanding of contemporary coastal cliff behaviour and the level of risk to public safety, services and infrastructure.

3. ROLE OF KEY AGENCIES

The key agencies involved with respect to the Blackgang landslide were the Council who are responsible for planning, coast protection, building control, highways and emergency planning arrangements. The service industries, who were involved with respect to cutting off supplies

severed through landslide damage, and the Government, who provided some finance to assist with the emergency response.

4. TOPOGRAPHY AND GEOMORPHOLOGY

The coastal slopes at Blackgang comprise a complex pattern of landslide types, developed in Upper and Lower Greensand rocks, arranged within a series of landslide systems (Figure G8.3). These systems are long-established and were probably formed several thousand years ago. Over this period the landslides have developed in response to fluctuations in sea-level and climate, which promoted coastal instability. A geomorphological map of the coastal slopes at Blackgang was prepared during a field reconnaissance survey, which made use of aerial photographs flown after the event in January 1994 to obtain detail of the inaccessible unstable areas and coastal cliffs (Plate G8d). The geomorphological map showed three distinct landforms at Blackgang; these include the Chalk downs, Blackgang Valley (combe) and the coastal landslide features.

The area affected by landslide activity in January 1994 was far more extensive than first reported by the media (Plate G8e and G8f). Four landslide systems were all affected by first time or renewed instability. The most notable movements occurred in the Cliff Cottage landslide where a large 150m x 40m wide section of ancient rotational landslides, forming the upper tier of the Undercliff, appeared to have suddenly dropped 15m down the rear scarp. This sudden movement caused the dramatic tilt and damage to Blackgang and Gore Cliff Cottages (Plate G8g) reported on 12 January when the alarm was first raised. A further effect of the deep-seated rotational movement was to shunt thousands of tonnes of landslide debris over a steep scarp slope, along with the Old Blackgang Road and cars and caravans, where charged with high groundwater levels, mudslides rapidly transported the debris to lower benches on the cliff and eventually to the beach.

4.1 Coastal Erosion

The underlying cause of cliff recession and landslide activity at Blackgang is undoubtedly the persistent marine erosion at the cliffbase which has been ongoing for many centuries. It is apparent that the coastal slopes have a long history of deep-seated landsliding that probably dates back to the end of the last glaciation around 10,000 BP. The main trigger for the 1994 landslide was the almost continuous, and at times intense, rainfall that fell during December 1993 and the early part of January 1994. Rainfall records have shown a close association with extreme winter (September-January) rainfall in past landslide events. During the 19th and 20th centuries the wettest winters to date have been (see Table 1):

YEAR (winter)	RAINFALL (mm)
1960-61	857mm
1852-53	713mm
1976-77	710mm
1878-79	677mm
1935-36	672mm
1974-75	644mm
1874-75	616mm
1993-94	597mm
1994-95	507mm

Table 1 Wettest winters in the Ventnor Undercliff, Isle of Wight, UK, during the 19th and 20th centuries.

The winter rainfall total for 1993-94 had an expected return period of 1 in 20 years based on rainfall records dating back to 1839; this cannot be considered to be particularly extreme. However, between 28 December 1993 and 6 January 1994 153mm rain fell in 10 days which is more than double the monthly averages for December and January, which are around 77mm; this gives an indication of the rainfall intensity prior to the landslide. The combination of antecedent and high intensity rainfall coupled with the unloading and over-steepening of the coastal slopes resulting from intense marine erosion was, therefore, responsible for triggering the major landslide event on 12 January 1994.

5. LANDSLIDE MANAGEMENT AND MONITORING

Although cliff recession and landslide activity had been a problem at Blackgang in the past, the impact of the 1994 event was a significant deterioration of stability of the coastal slopes. The potential for a further major landslide event remains high and may be expected with an estimated likelihood of 1 in 20 years, or less in many areas (Figure G8.4). Areas affected by the landslip remain active until a new equilibrium or relatively stable condition is attained. The threat to the community at Blackgang prompted a careful consideration of the options for managing the problem. These options included:

1. The control of cliffbase retreat through coast protection measures.
2. Landslide stabilization measures.
3. The control of groundwater and surface water drainage in unstable areas.
4. 'Managed retreat' of infrastructure and development.
5. Monitoring to provide early warning of landslide events and preparation of emergency actions.
6. Do nothing.

An assessment of the viability of these options requires an appreciation of the nature of coastal cliff behaviour, the elements at risk, and the benefits and costs for undertaking such works. When considering the elements at risk, the safety of the public was by far the greatest concern at Blackgang, particularly where the public were allowed access on or adjacent to slopes which were subject to active slope movement or landslip and which might be liable to sudden collapse. The avoidance of such areas through managed retreat and monitoring were, therefore, seen as the most appropriate and cost-effective management options which allowed for the optimum use of land, based on a knowledge of coastal cliff behaviour whilst ensuring the safety of the public through installation of automatic monitoring and early warning equipment.

Automatic tiltmeters were installed at ten locations within the Blackgang area in July 1994. The main objective in the selection of sites was to provide an early warning of ground movement, in areas classified as high risk, where development and/or the public were exposed to significant landslide potential. The tiltmeters were wired to one of two data loggers recording at 15 minute intervals. The loggers were fitted with alarm cards linked by telemetry to the police, the theme park operator and the Council, so that if ground movements exceeded the threshold of 75mm between consecutive readings, an alarm would be raised and appropriate emergency action taken. The monitoring system was commissioned by the Council and is fully remote with all communications taking place via telemetry.

There are a number of reasons why 'managed retreat' (planned set-back) has been adopted on the Blackgang coastal frontage:

1. The coastal cliffs face south-west towards the English Channel and the Atlantic Ocean and suffer from the full force of Atlantic storm waves from the prevailing south-westerly direction.

2. The problem at Blackgang is not just one of coastal erosion but also seepage erosion of the high soft cliffs, weathering and mass movement; a coast protection solution would be impractical on its own. Although coast protection schemes could be developed to protect the Lower Greensand seacliffs, it is considered most unlikely that they would satisfy the Ministry of Agriculture, Fisheries and Foods' criteria for allocating coast protection grant-aid, or that the scheme would be technically and environmentally sound and economically viable (MAFF 1993).
3. The south-west coast of the Isle of Wight is designated as Heritage Coast and is an Area of Outstanding Natural Beauty.
4. The section of coast at Blackgang is of considerable scientific interest, both geologically, on account of the completeness of many of the "type" successions and ecologically.
5. Landslide stabilization measures to improve the stability of slopes may be of benefit in some areas. At Blackgang, however, the height of the cliffs and magnitude and extent of the instability problem would make a large scale engineering solution impractical and prohibitively costly.
6. The Blackgang Chine theme park has been practising an effective policy of managed retreat for over a century.

The role of rainfall and surface water drainage in promoting ground movements is well recognised but is not always well understood. The prevention of water entering the ground from surface drainage and water leakage is helping to reduce the frequency and magnitude of damaging ground movement events. Natural drainage from the Blackgang Valley, which originally discharged down over the seacliff at Blackgang Chine, has more recently had a profound influence on the soft cliffs (Figure G8.5). Although much effort has been directed at draining the area more effectively down over the seacliff, the addition of the groundwater at the base of Blackgang cliffs has had a significant influence on the rapid recession of the clifftop. It is considered, therefore, that much benefit would be gained from avoiding the discharge of water over the clifftop by diverting groundwater and surface water to the adjacent village of Chale and beyond. Consideration is being given to intercepting groundwater flows within the shallow superficial deposits at Blackgang, possibly by constructing a cut-off trench along the 125m OD contour where springs occur due to the presence of the underlying Gault Clay.

6. EXPERIENCE, SUCCESSES AND PROBLEMS WITH CURRENT APPROACH, AND LESSONS LEARNT

The landslide which occurred at Blackgang in January 1994 was the largest of its kind to affect the Isle of Wight coast since the Bonchurch landslides of 1810 and 1818. The latest event resulted in the Council commissioning detailed geomorphological studies and risk assessments, which have advanced considerably the understanding of coastal cliff behaviour in this area.

The landslide was caused by prolonged antecedent rainfall, particularly over a ten day period prior to the event, together with severe coastal erosion and seepage erosion of the soft cliffs, which had been ongoing for many years. The geomorphological assessment identified three main landforms, namely the Chalk downs, the Blackgang valley and the coastal landslides. Four main landslide systems were recognised involving contrasting mechanisms of failure at different levels within the geological succession. Three of these landslide systems were developed at the western limit of the Undercliff, an area characterised by pre-existing deep-seated landslides developed in Upper and Lower Greensand strata. The fourth landslide system developed within the soft Lower Greensand strata and is characterised by high cliffs and benches subject to severe rates of recession through marine and seepage erosion.

The attention given to this event by the media requires particularly careful management. For a small local authority valuable time can be taken up responding to the press when engineering demands are at their greatest.

There are a range of perceptions about safety with respect to public access by landowners and businesses, the Local Authority, local residents and visitors. The development of a safety plan can be particularly difficult when economic, tourism and employment issues are at stake. Concern over safety in high risk areas led to the installation of a fully automatic monitoring system supported by a visual monitoring programme to ensure public safety.

'Managed retreat' has been practised by the owners of the Blackgang Chine them park for over 100 years; this is recognised as the only realistic management options.

The landslide event of 1994 has emphasised to politicians on the Isle of Wight as well as to engineers and planners the need for an effective coastal planning policy. Following a range of geotechnical studies these data are now firmly established within the planning framework in line with the Government policy. The observations of early scientists, visitors and writers, who recorded the geological conditions and processes taking place around the Isle of Wight coast, were largely ignored by their successors through the Victorian development period of 1850 to 1900. The lesson to be learnt is that due notice should always be taken of the advice of coastal and geotechnical engineers.

Blackgang is a location where the Council has implemented a coastal policy of 'no action' (other than monitoring), having weighed up the technical feasibility, economic justification and environmental impact of engineering measures. On all accounts a stabilization scheme was regarded as inappropriate. As a result the Council has been working with local property owners and the owners of the theme park to assist them in understanding the inevitable loss of their properties as the coastline retreats.

In Great Britain there is no insurance against coastal erosion and there is no state compensation system. Property owners may be required to bear the cost of demolishing their own properties if they become dangerous. This contrasts with the situation in France where state compensation may be available to relocate property owners affected by natural hazards where engineering solutions are not justifiable on cost-benefit grounds (see Study Area G16 Criel-sur-Mer).

The Blackgang case study illustrates the importance of obtaining an appreciation of geomorphology and groundwater movements in such locations as a tool to aid decision-making. Historical records of landslide events and monitoring reveal that locations such as Blackgang are highly sensitive to changes in groundwater levels with movements occurring almost annually and major events every 15-20 years, again largely dependent on antecedent rainfall (but also marine erosion at the base of the sea cliff). Local knowledge combined with longstanding meteorological data is invaluable when assessing landslide risk in such areas particularly if combined with instrumentation results. The impacts of predicted climate change such as more winter rainfall and an increase in the frequency of storm events need to be carefully assessed for sensitive sites such as Blackgang.

Major landslides at Blackgang have attracted considerable media attention in the past. Whilst this may highlight the particular financial burden facing small local authorities such as the Isle of Wight in terms of management of its long and complex coastline there are also disadvantages. The Council has made considerable efforts to reduce the impact of landsliding on the local communities of the Isle of Wight through both engineering measures and public education and information. Rarely does the media present a balanced picture, generally focussing on bad news rather than any positive measures being proposed. Such coverage by television and newspapers can raise fears and reduce confidence out of all proportion with the adverse effects on the local economy and insurance policies. In such situations it is often the local authority who is best placed to address media issues and to provide regular, factual press releases.

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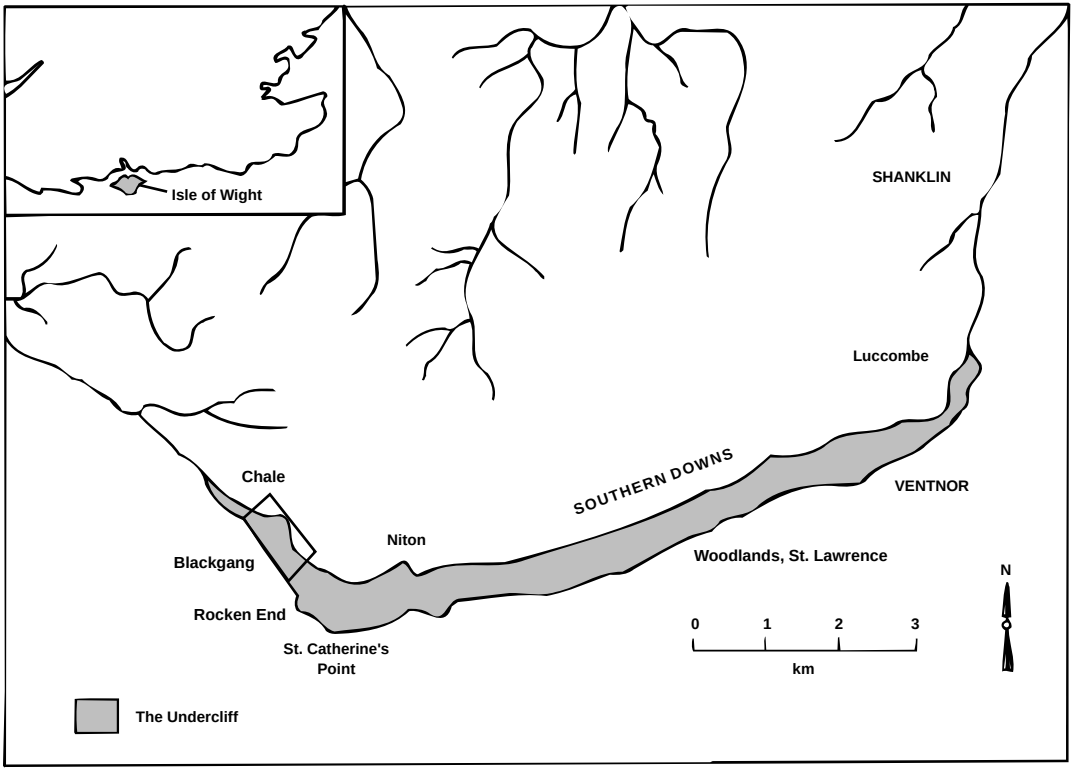


Figure G8.1 Blackgang location map

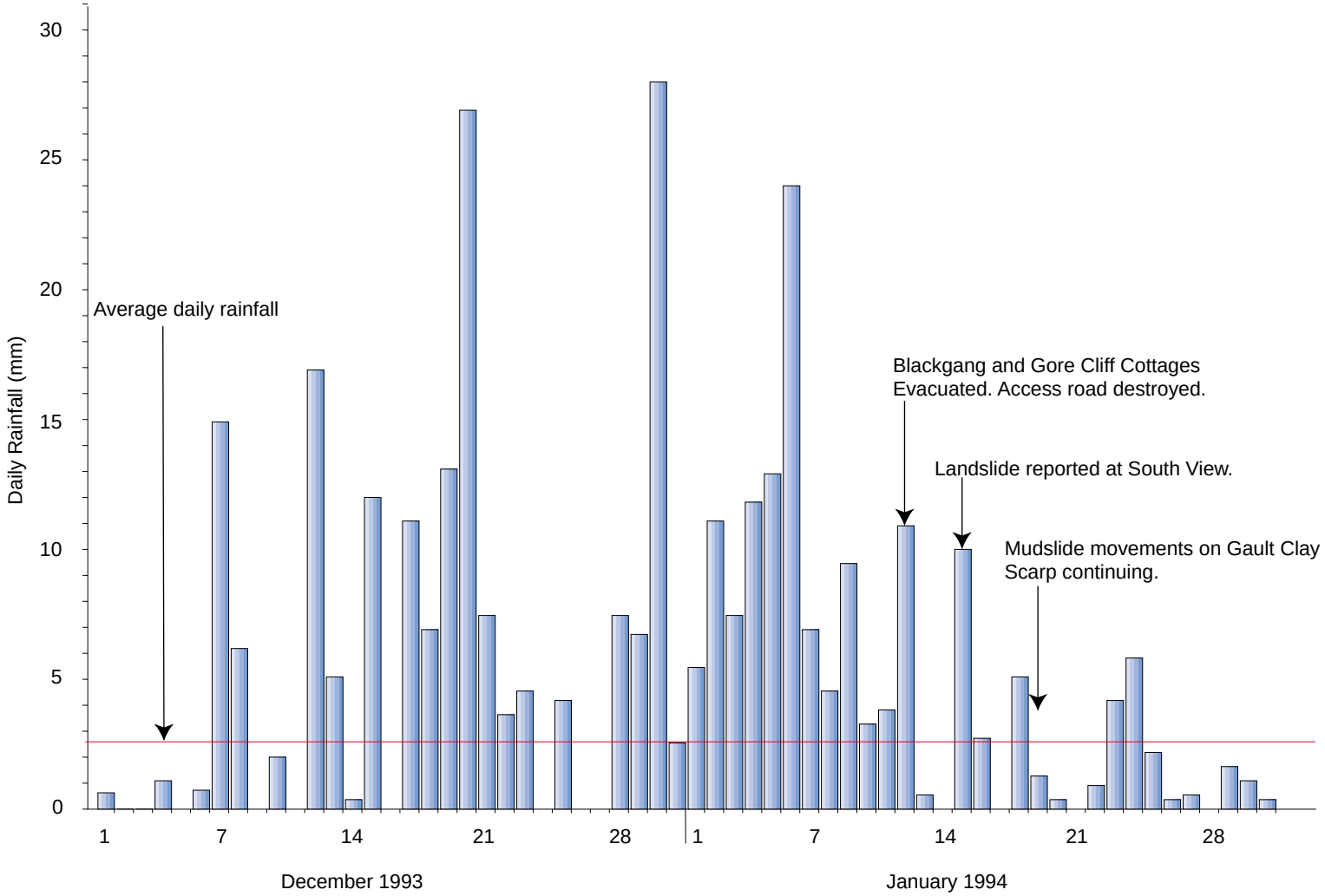
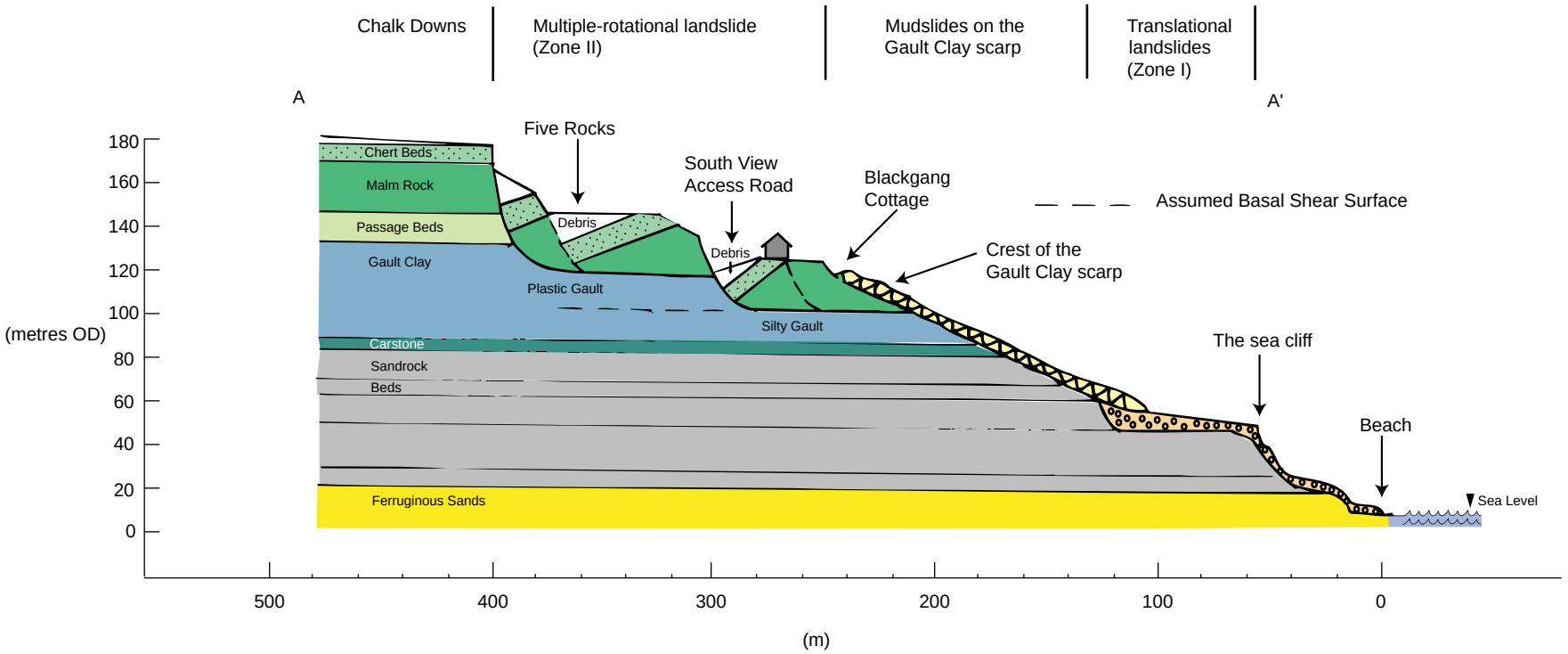


Figure G8.2 Blackgang, Isle of Wight, UK. Rainfall and landslide events, January 1994 (after Clark et al. 1995).



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Note: Geological boundaries and shear surfaces are approximate

After High Point Rendel

Figure G8.3 Diagrammatic cross-section of the Blackgang cliffs showing the coastal geology and geomorphology.

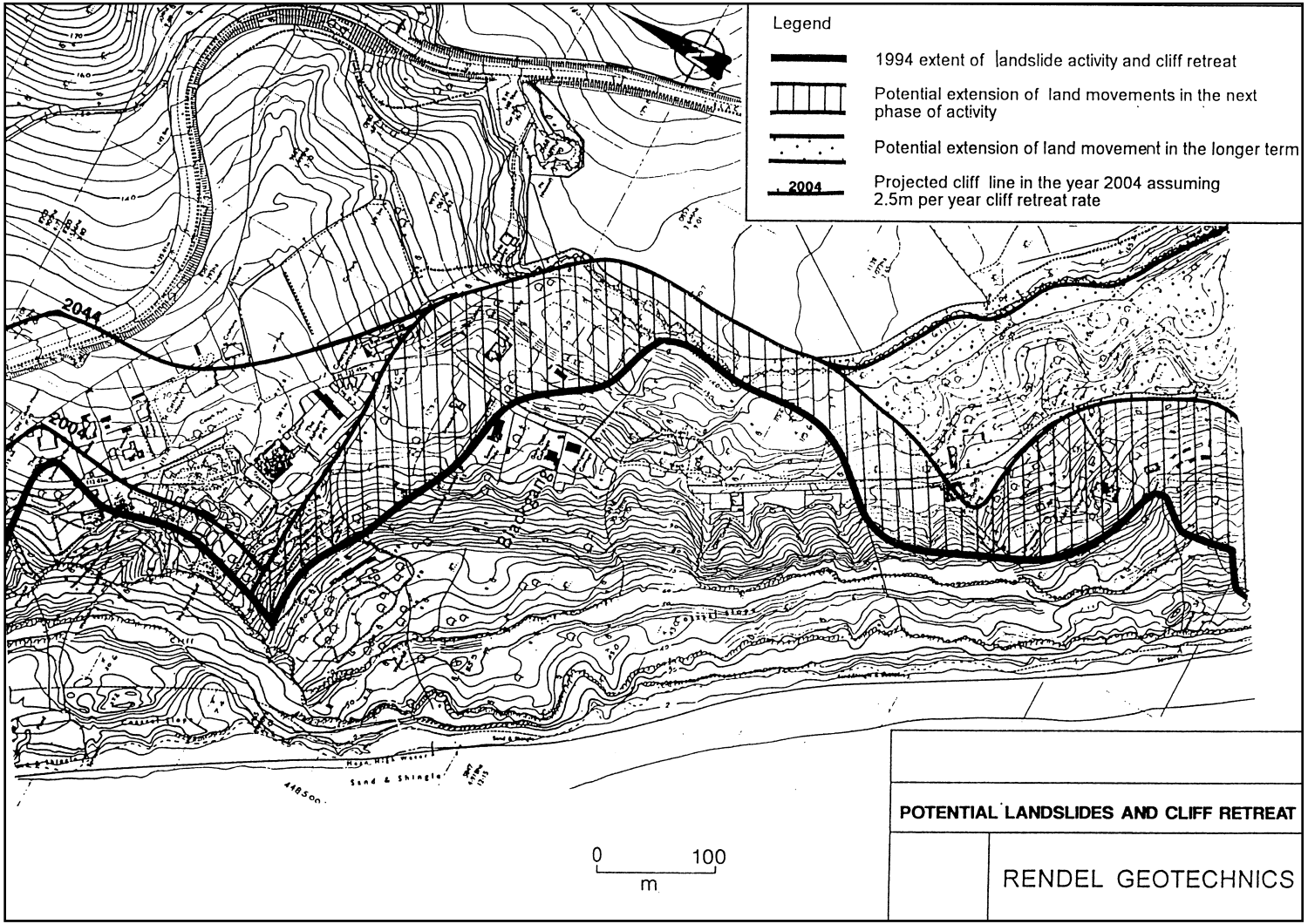

Figure G8.4 Landslide potential map, Blackgang.

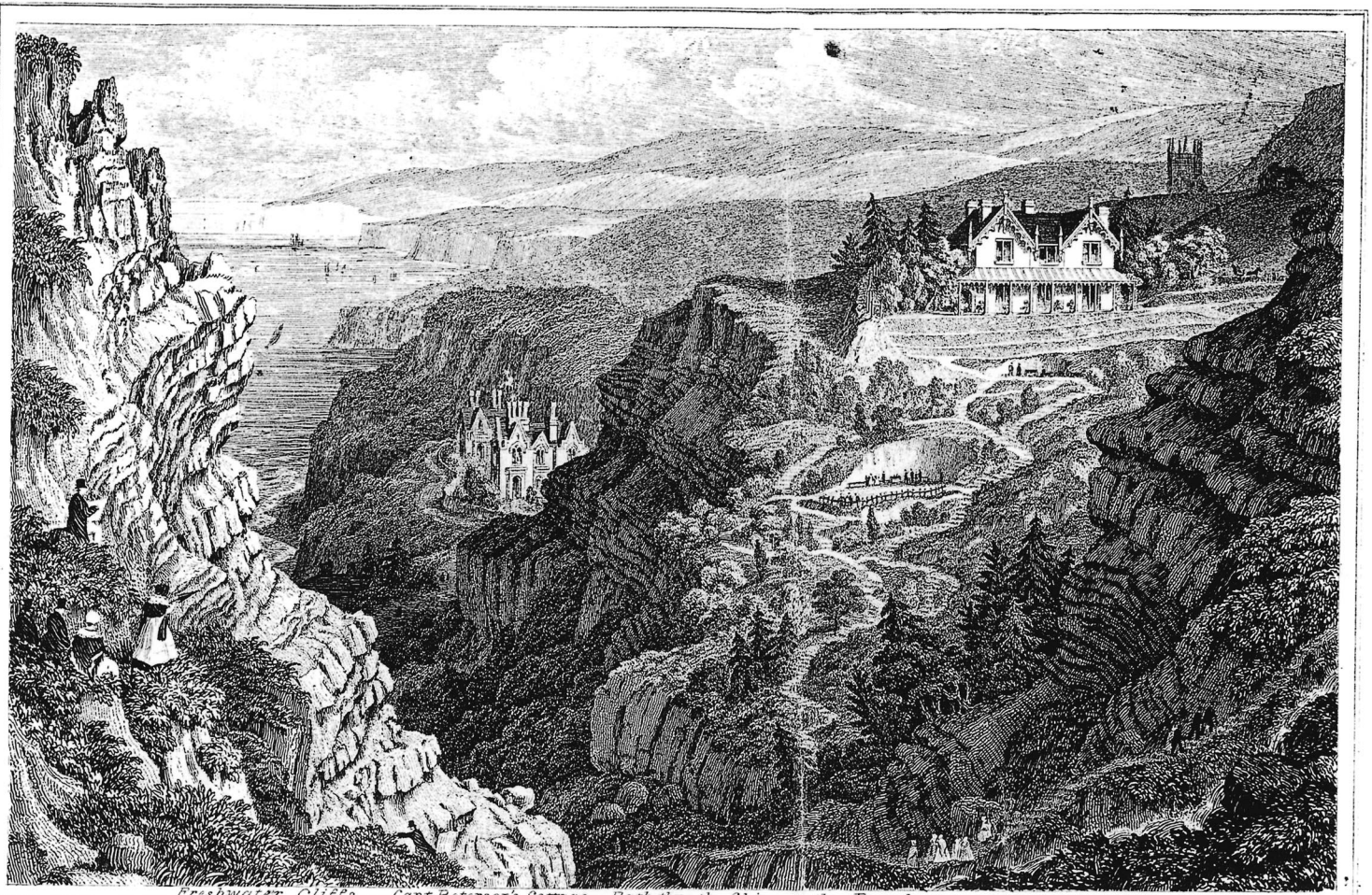

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Plate G8a ***Photo showing the 1994 landslide at Blankgang (County Press)***

Plate G8b ***Old colour postcard showing the view looking west across Blackgang in 1890. All the land in the foreground has been lost through coastal erosion and landsliding***

Plate G8c ***Blackgang and south-west coast from the Isle of Wight***

Plate G8d ***Blackgang cliffs from the sea***

Plate G8e ***Road damage at Blackgang***

Plate G8e ***Road damage at Blackgang***

Plate G8g ***Gore Cliff Cottage, Blackgang***