GEOTECHNICAL STUDY AREA G6

WOODLANDS, ST LAWRENCE, VENTNOR UNDERCLIFF, ISLE OF WIGHT, UK

Plate G6 ***Aerial view of the St Lawrence Undercliff***

SUMMARY

Woodlands is the name of a house situated on the A3055 Undercliff Drive, the main coast road running along the south coast of the Isle of Wight through the Undercliff landslide complex in an area affected by ground instability (Figure G6.1). The instability section which affects the road lies west of the village of St. Lawrence, approximately 5 km west of Ventnor (Plate G6). The site lies within an ancient deep-seated landslide complex and historical records indicate a long history of instability at this location.

The ground model demonstrates that the main road at this location lies at the head of a mudslide failure which affects the sensitive area of the slopes below the road extending down towards the sea. Preliminary stability analyses indicate that the two principal causes of the mudslide failure are high groundwater levels and poor drainage at the site and secondly, loading at the head of the mudslide resulting from placement of fill during construction and maintenance of the road over many years.

The management issues in relation to this site made it suitable for investigation as part of the LIFE project on account of the lessons that can be learnt from this particular location with respect to LIFE project Task two -the relationship between rainfall, groundwater movements and instability. The Council has contributed a sum of £8,000 in instrumentation towards the LIFE project which has assisted in the determination of the ground movement model at this location and has illustrated an approach to landslide risk management through an understanding of the relationship between rainfall and groundwater movements.

1. BACKGROUND

Records indicate that within the vicinity of Woodlands at St Lawrence, Undercliff Drive (A3055), there has been a long history of slope instability. In the late 19th Century a local landowner installed a drainage system in the area and planted many trees in order to try and reduce instability. Early this century the road was reportedly relocated from beneath the main rear cliff further forward, possibly to avoid the risk from rock falls. The new road alignment crossed an area of unstable ground and a small valley, previously crossed by a stream. This valley was backfilled and the stream piped beneath the road. In response to ongoing settlement of the area, the level of the road has been successively built up during this century so that the original drainage pipe is now over 6 metres below current road level. Over the last 20 years the carriageway has begun to subside.

Drainage works were carried out by the Isle of Wight County Council in the mid-1980s to replace the original failed deep surface water drain. A pumped collector was installed which raised the water 5 metres to a high level discharge pipe installed 1 metre below current road level. In addition a series of plastic drains were installed downslope of the main road to a suitable outfall point. These works reportedly improved the situation but the road has continued to settle particularly in very wet winters. The road has been periodically closed during which time the damage, in the form of carriageway settlement and arcuate tension cracks, has been repaired. The length of the road which periodically shows signs of distress and settlement is approximately 60 metres. However, the scale of the downslope instability which is causing damage to the road (and which would require treatment) is significantly larger. The shallow mudslide failure on the slopes below the A3055 Undercliff Drive extends for approximately 180 metres and the area affected laterally is approximately 150 metres (an area in total of approximately 27,000 square metres).

2. GEOLOGY

The geology of the Undercliff has been reported elsewhere in this document (see Study Area G1, the Isle of Wight Undercliff. The stratigraphy broadly comprises a sequence of Upper and Lower Greensand rocks of Cretaceous age. At this site a prominent cliff is situated upslope of the road to the north-west, marking the rear scarp or landward extent of the ancient landslide complex. The Upper Greensand, Chert Beds and Malm Rock are exposed in the cliff. Lower Chalk can be seen at the crest of the scarp.

The Passage Beds outcrop between the Malm Rock and the underlying thick Gault Clay sequence. It is movement within the Gault Clay strata which has caused failure of the overlying strata. The Carstone and Sandrock strata of the Lower Greensand are present beneath the Gault Clay and these too are subject to large scale slope failure due to the presence of several clay-rich horizons within the Sandrock.

The geomorphology of the Undercliff at Woodlands was originally mapped in 1994. This study broadly recognised a two-tier deep-seated landslide system comprising multi-rotational failure upon the Gault Clay strata forming the upper slopes and compound failure upon the clay rich horizons withing the Sandrock forming the lower slopes. The two zones are separated by the Gault Clay scarp, which is generally subdued where unaffected by active slope instability. The geomorphological map of the site shows spatial distribution of these features in relation to the A3055 Undercliff Drive. It is apparent that the road is situated on the upper multi-rotational failure zone.

At Woodlands the ancient deep-seated landslides are generally thought to be marginally stable and only subject to periodic creep similar to that experienced elsewhere within the Undercliff landslide complex. Higher rates of deep-seated movement may be expected during particularly wet periods, although throughout the Undercliff these movements rarely manifest themselves at the ground surface or result in structural damage except in a few localised areas.

Of particular significance at this site is the presence of a multi-rotational degradation zone which is characterised by relatively active shallow rotational slips and landslides. The continued movement and degradation of the shallow mudslides in recent times has undoubtedly caused the repeated settlement of the road carriageway in recent years. The settlement of the road has involved slight rotation and backtilt of the road pavement, consistent with the mechanism of failure at the head scarp of a shallow slide.

By their very nature, the shallow degradation area and the mudslides will be particularly sensitive to antecedent groundwater and rainfall conditions with slope movement occurring most winters. Such behaviour is common for similar shallow slides found elsewhere on the south coast of the Island. During extreme wet periods, high rates of slope movement could be anticipated along with associated structural damage to the road pavement. The main causes of continuing mudsliding and slope degradation at the site include the presence of natural subsurface and surface drainage, the generation of seasonally high groundwater levels and pore water pressures, and the artificial loading at the crest of the degradation area caused by the addition of fill during the construction and long term maintenance of the main road.

3. HYDROGEOLOGY AND DRAINAGE

The hydrogeology and drainage at this site are fundamental to the understanding of the problems affecting the location. At Woodlands, as in adjacent areas of the Undercliff, there is widespread development of drainage valleys. Some of these contain surface streams and drainage channels. Others do not, indicating that they are either characterised by subsurface drainage or are relic features. At Woodlands, historic evidence suggests that at one time significant surface water flow may have occurred at the site.

It is apparent that various attempts have been made to drain the slopes in the past which undoubtedly would have improved the stability of the area. In particular, it has been suggested that a large diameter drain was installed at the turn of the Century to control the surface stream flow. Remnants of this drainage system may still be found today, albeit silted up and serving no function.

At the rear scarp of the Undercliff, upslope of the road, there is a permanent springline at the Passage Beds and underlying Gault Clay interface. The presence of the impermeable Gault Clay beneath the free-draining Chalk and Upper Greensand rocks gives rise to the horizontal drainage of groundwater towards the Undercliff. The spring line is obscured over most of the site and is believed to be located at around 68 metres AOD at the rear scarp. Evidence of large depressions and soft ground beneath the rear scarp indicate that these areas are prone to saturation and ponding. The extent of these low-lying areas coupled with evidence of seepage from elsewhere in the Undercliff, where the spring line is exposed, indicate that a significant volume of natural groundwater is continually discharged into the Undercliff from the Upper Greensand aquifer above.

4. THE CURRENT PROBLEM

This study indicates that the repeated settlement of the Undercliff Drive at this location has been caused by the ongoing movement of an active shallow slide developed upon the deep-seated multi-rotational failure zone forming the upper slopes of the Undercliff (Plate G6a). It is apparent that various attempts have been made in the past to drain the slopes, all of which have either failed or have fallen into disrepair. It was clear that if a “do nothing” option was adopted, the stability of the shallow slide would deteriorate further leading to more frequent and extensive damage to the road. Seasonal slope movements would increase and there would be an increased likelihood of major events such as occurred a short distance to the west in 1926. Furthermore, if slope instability was allowed to deteriorate, the shallow slide would become more extensive. There was also a risk that landslide activity will spread upslope, potentially destabilising the deep-seated slide and associated development together with an increased likelihood of debris runout at the foot of the slope in the vicinity of a major hotel.

The stability analysis demonstrated that under contemporary conditions the shallow slide was actively unstable (Factor of Safety is 0.87). It is clear that landslide activity was being caused by the particularly high groundwater levels and poor drainage at the site. Drainage measures aimed at reducing groundwater levels would bring about an improvement in slope stability; the sensitivity analysis indicated that an effective reduction of groundwater levels by 2 metres would bring about a 14% improvement in the Factor of Safety. Proposed stabilization measures are also shown in Figure G6.2.

Slope instability has also been promoted by artificial loading (i.e. placement of fill during construction and maintenance of the road) at the head of the shallow slide. The sensitivity analysis demonstrated that the shallow slide was particularly sensitive to the addition of load at the head scarp and that the Factor of Safety may have been reduced by as much as 76% through the construction of the road in its present location. Removal of some of this load would significantly improve the stability of the site with little disbenefit to the stability of the deep-seated multi-rotational landslide zone.

5. VALUE OF THE SITE IN TERMS OF THE LIFE PROJECT

The contribution to the equipment budget by the Council with respect to the Woodlands site has proved valuable in assessing the impact of changing groundwater conditions on a sensitive mudslide. It is clear that some landslides are particularly suseptible to human interference and therefore an understanding of the hydrological conditions and the landslide triggering factors is essential.

Although the ground investigation at Woodlands cost the Council approximately £40,000, this sum represented good value for money because the engineered solution would have cost £700,000. The information gained through the provision of monitoring equipment and interpretation over the last three years has enabled this substantial capital cost of £700,000 to be deferred and instead fairly minor drainage improvements implemented.

The site at Woodlands is in a relatively remote semi-rural location. The provision of equipment in more remote locations of this kind enables more effective 24-hour monitoring to take place, not only recording ground conditions but also providing an alarm system. The emergency services (the Police and the Council) will be alerted if movements exceed pre-set thresholds. Monitoring at Woodlands over the past three years of the LIFE project has allowed a comparison to be made with the previous system of manual monitoring and has demonstrated the efficiency and cost savings of resulting from the automatic system.

The monitoring results have also improved the Council's predictive ability in the case of landslides of this kind through a better understanding of the effects of rainfall occurrence and intensity. By comparing the meteorological readings from the weather station at Ventnor with the instrumentation readings at Woodlands a sensitivity matrix can be established indicating the likelihood of ground movements taking place when antecedent rainfall exceeds a certain threshold. This approach is illustrated in Volume 1 Chapter 3, setion 3.33.

In summary, therefore, the Woodlands study has demonstrated the benefits of an automated system for both predictive and alarm purposes and has contributed to the development of a sensitivity model for landsliding in sites like the Undercliff. Readings have confirmed that the area is very sensitive to groundwater increase after autumn/winter rainfall resulting in movements taking place every 1-2 years. This information can advise the engineering design process with the aim of remedying the problem.
The Woodlands study alongside the case studies at Wheeler's Bay (Geotechnical Study Area G4) and Blackgang (Geotechnical Study Area G8) contribute to Project Task Two alongside further studies at Barton-on-sea in Hampshire (Study Area G12), Salins-les-Bains, France (Study Area G17) and Léaz in the French Alps (Study Area G18). The lessons learnt from these study areas have been translated into practice within the Best Practice Guide ('Managing ground instability in urban areas -A guide to best practice.'

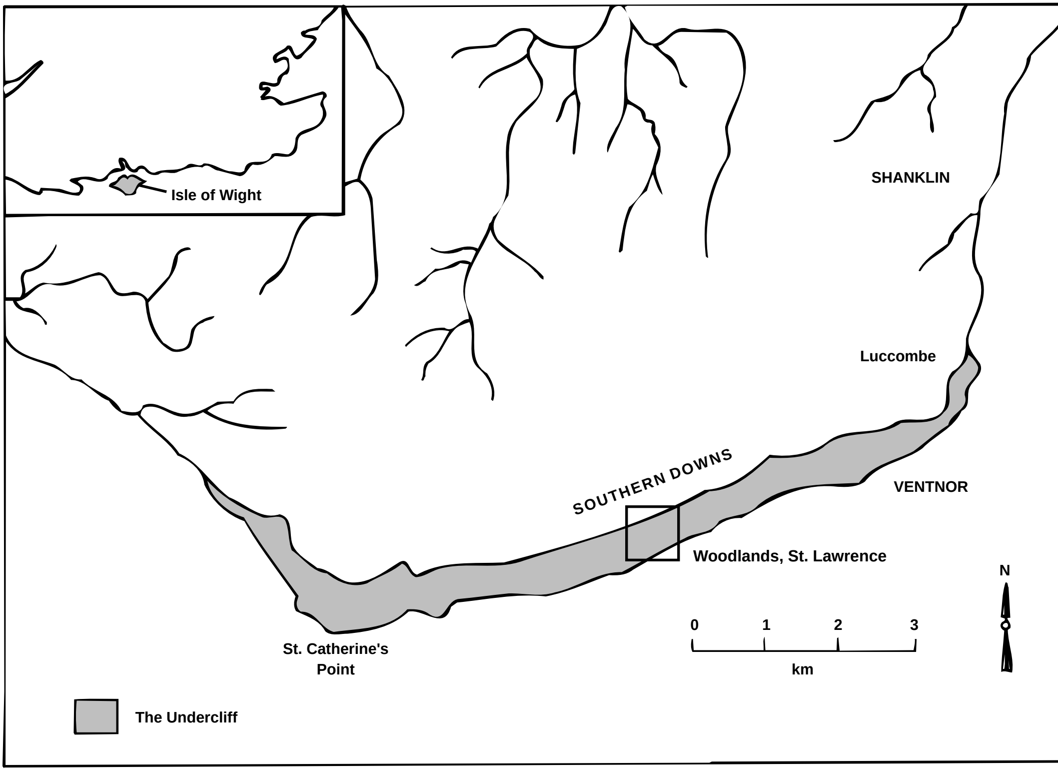

Figure G6.1 Woodlands, St.Lawrence location map.

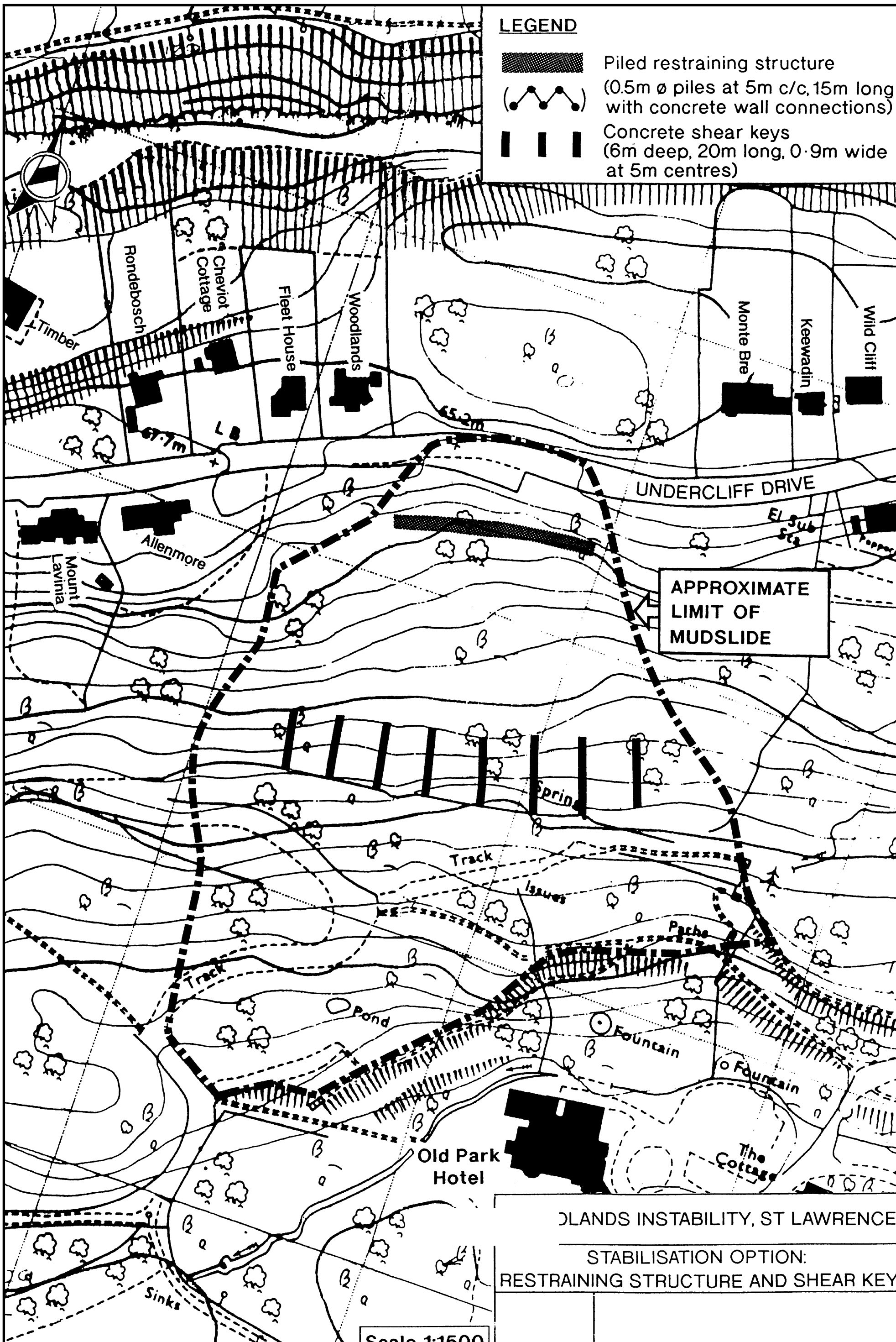

Figure G6.2 Proposed stabilisation measures.

Plate G6a ***Damage to the main road A3055 at Woodlands***