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Landslide Survey of North Yorkshire: Reconnaissance Report

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Landslide Survey of North Yorkshire: Reconnaissance Report

G. O. Jenkins, C. Foster, A. D. Gibson & S. J. Price

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British Geological Survey offices

Keyworth, Nottingham NG12 5GG
☎ 0115-936 3241 Fax 0115-936 3488
e-mail: sales@bgs.ac.uk
www.bgs.ac.uk
Shop online at: www.geologyshop.com

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Geological Survey of Northern Ireland, Colby House, Stranmillis Court, Belfast BT9 5BF
☎ 028-9038 8462 Fax 028-9038 8461

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☎ 01491-838800 Fax 01491-692345

Columbus House, Greenmeadow Springs, Tongwynlais, Cardiff, CF15 7NE
☎ 029–2052 1962 Fax 029–2052 1963

Parent Body

Natural Environment Research Council, Polaris House, North Star Avenue, Swindon, Wiltshire SN2 1EU
☎ 01793-411500 Fax 01793-411501
www.nerc.ac.uk

Foreword

This report describes a field reconnaissance survey carried out by the BGS in October 2005, in advance of detailed surveys to assess the landslide distribution and processes in the York area.

Acknowledgements

The authors would like to thank Anthony Cooper, Jon Ford and Simon Price for their assistance during the survey, highlighting key areas of land slide activity. Extended thanks also go to Mr & Mrs Stephen Gibson of Birkdale Farm, Low Mowthorpe, for their kind hospitality in granting BGS access to their land in order to survey in detail an active landslide complex.

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Summary

This report is a product of a study by the British Geological Survey (BGS) investigating the mechanisms and extent of the landslides in the North Yorkshire region, specifically the York Geological Sheet (63) area, and the North York Moors National Park. The study assessed the requirements of future survey of the area and makes recommendations for further surveys to properly assess the nature of mass-movement processes in the area.

1 Introduction

1.1 BACKGROUND

In October 2005, a joint survey was carried out by the BGS LandslideGB Project Team and the IGS Vale of York survey team to assess the extent and style of landsliding in North Yorkshire.Particular emphasis was given to the Jurassic escarpment that is shown on BGS 1:50 000 geological map sheets: York (63), Pickering (53), and Egton (43). The purpose of the survey was to discuss and clarify the extent to which landslides should be mapped within the area and to assess the methods that would be employed and the resources that may be required for such an exercise.

1.2 LOCATION, GROUND SURVEY AND DATA COLLECTION

The survey areas were identified in advance of the field survey, in discussion with the Vale of York mapping team. The main survey area was located south of Malton, an area covered by the York 1:50,000 Sheet (63). This area was chosen as it contained within it several contrasting stratigraphies, (each with varying terrain characteristics), considered to be representative of the York area as a whole (Figure 1). Further surveys were undertaken at Church Houses and Old Byland in the North York Moors National Park (Figure 2). These areas were investigated for potential landslides, based on evidence from geological maps and the NEXTMap digital terrain model (DTM). At each site, a walk over survey was carried out to ascertain the broad nature and extent of movement. A photographic record was made of the key landslide features observed. From these walkover surveys we were able to assess the most appropriate means of providing a landslide model for the area.

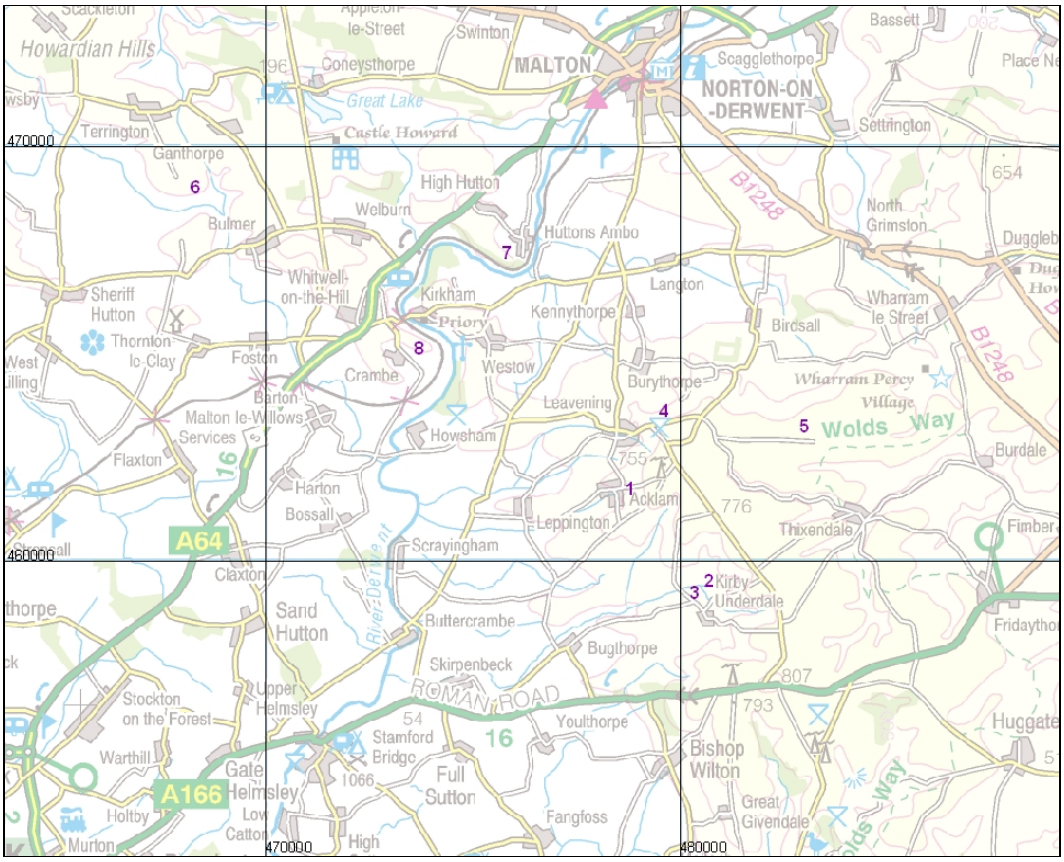

Figure 1. Area covered by October 2005 field survey, survey locations, as described in Section 3, are numbered in purple.

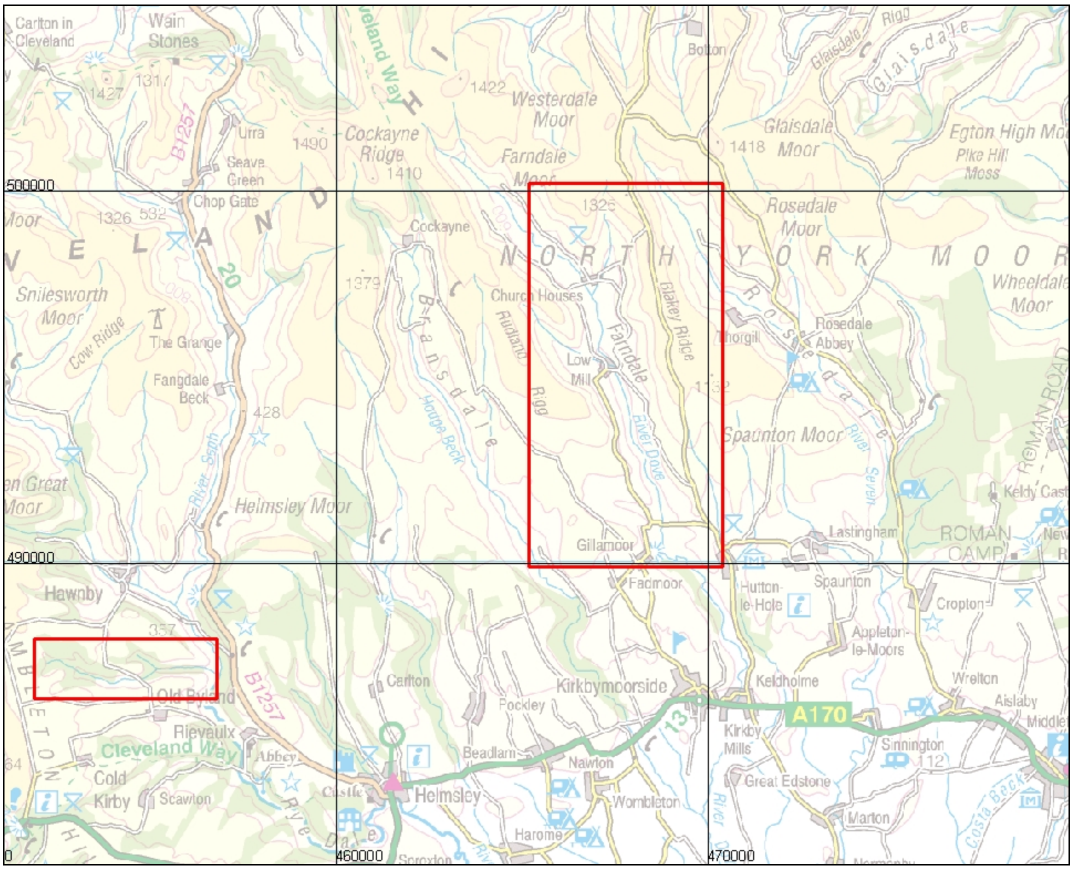

Figure 2. Location of valleys surveyed in the North York Moors National Park in order to assess the distribution of landslides.

2 Geological Background

2.1 VALE OF YORK

The geology and engineering geology of the area will be described in detail in subsequent reports. However, it is useful to briefly consider the regional geology. Jurassic and Cretaceous sedimentary rocks, all of marine origin, underlie the area of interest (Figure 3). A simplified stratigraphic table, outlining the main units within the area is provided below (Table 1).

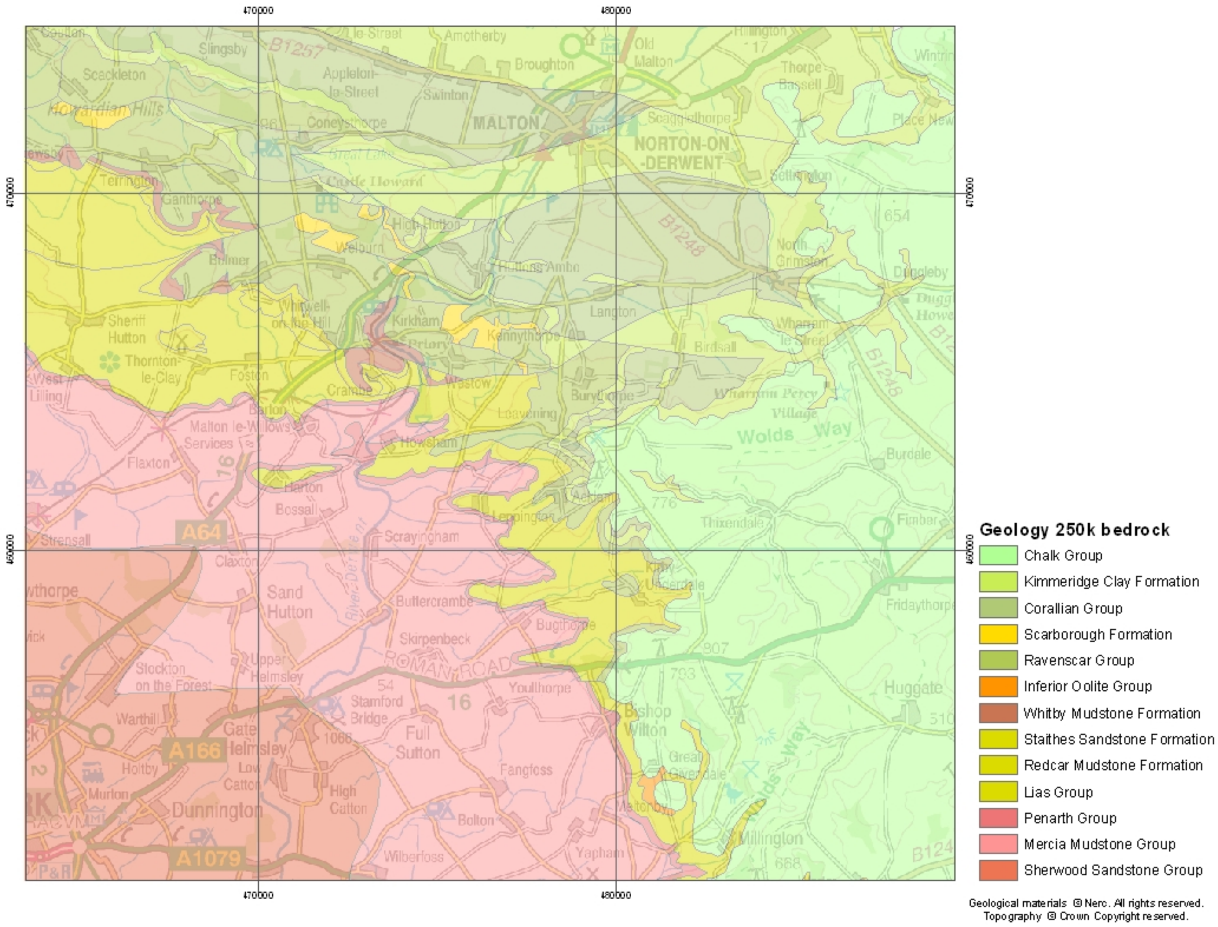

Figure 3. Geology of the Vale of York landslide survey area.

2.2 NORTH YORK MOORS

The stratigraphy in the North York Moors is similar to that found in the Vale of York (Figure 1,

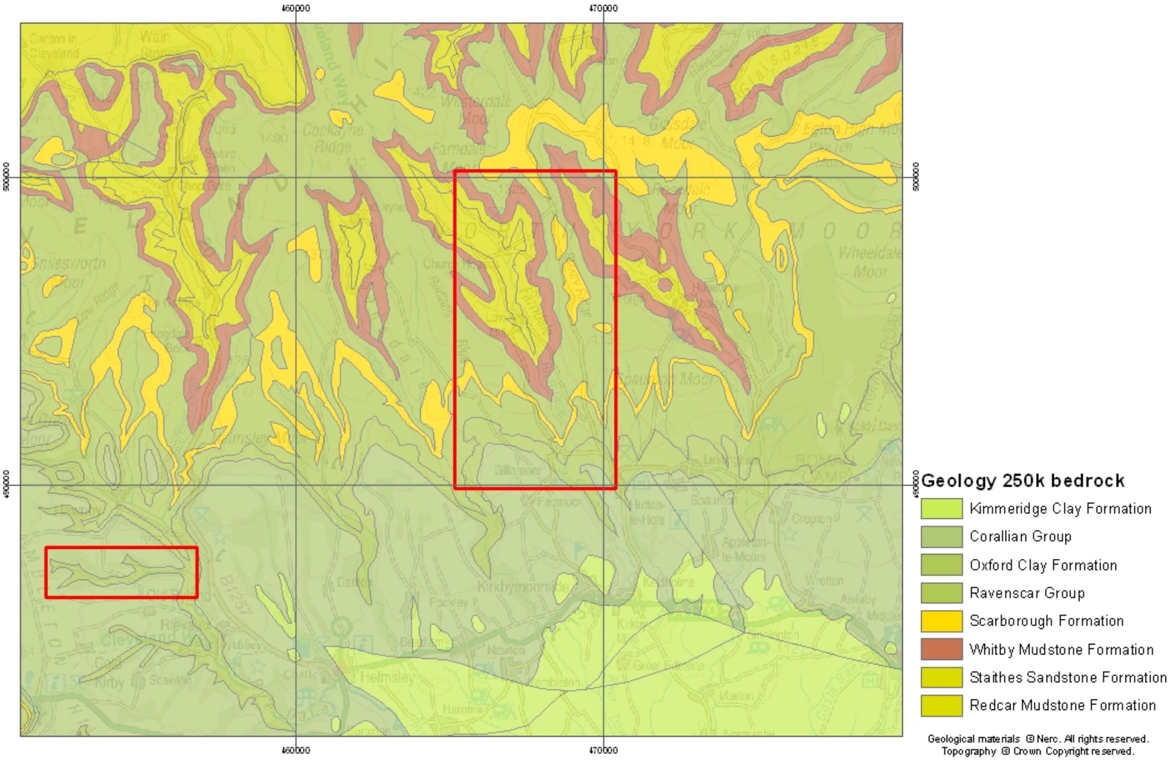

Figure 4. Geology of the North York Moors survey area, with survey areas in red.

Table 1. Simplified stratigraphy of the survey area.

Period	Stage	Group	Formation	Simplified lithology
Cretaceous	Turonian/Coniacian/Santonian	Chalk Group	Burnham Formation	Chalk with flint
	Turonian		Welton Chalk Formation	Chalk with flint
	Cenomanian		Ferriby Chalk Formation	Chalk
	Albian		Hunstanton Formation	Chalk
Jurassic	Oxfordian	Corallian Group	Coralline Oolite Formation	Limestone
			Lower Calcareous Grit Formation	Calcareous sandstone and limestone
	Kimmeridgian	Ancholme Group	Kimmeridge Clay Formation	Mudstone
	Oxfordian		Ampthill Clay Formation	Mudstone
			Oxford Clay Formation	Mudstone
	Callovian			
		Ravenscar Group	Osgodby Formation	Sandstone
	Bathonian		Scalby Formation	Quartzite/sandstone
	Bajocian		Scarborough Formation	Calcareous sandstone and limestone
	Aalenian		Cloughton Formation	Sandstone and some coal
			Eller Beck Formation	Limestone
			Saltwick Formation	Sandstone and some coal
		Lias Group	Dogger Formation	Sandstone and limestone
	Toarcian		Whitby Mudstone Formation	Mudstone
	Pliensbachian		Staithes Sandstone/Cleveland Ironstone Formation	Sandstone and Ironstone
	Hettangian/Sinemurian/Pliensbachian		Redcar Mudstone Formation	Mudstone and limestone
Triassic	Rhaetian	Penarth Group		Mudstone

3 Landslides in the York area

For the first two days of the survey, the landslide team were accompanied by Simon Price and Anthony Cooper, who provided the background to key sites within the mapping area. They highlighted the geology and geomorphology of the terrain with regard to the landslides, and the problems faced by the mapping team when identifying and classifying landslides in the area, where they could be observed.

3.1 ACKLAM (1)

Mass movement at Acklam occurs on the slope immediately behind the abandoned church (GR ^{4}78831 ^{4}61571). The slopes consist of the Oxford Clay Formation overlain upslope by the Lower Calcareous Grit Formation. The slope was extremely wet at the time of the survey, with several streams draining into a covered, engineered reservoir system. The steps in front of the church displayed marked deformation consistent with movement downslope. Farther up the valley sides, degraded lobate forms and degraded rotational blocks are visible. However, the area is heavily overgrown which makes delineation and interpretation of the landslide difficult. It is unlikely that these landslides are recognisable by aerial photograph interpretation. Consistent mapping of such features will require an integrated analysis of slope characteristics from NEXTMap, coupled with ground truthing to prove the presence of landsliding.

3.2 UNCLEBY (2)

Figure 5. Slope at Uncleby displaying creep. Photograph taken from ^{4}81482 ^{4}59408, orientation 060°(NE).

The slope at Uncleby (Figure 1) consists of the Whitby Mudstone Formation, overlain by the Saltwick Formation (and possibly the Lebberston Member) and the Chalk Group. Local topography is characterized by the presence of a series of large steps at the foot of a steep cliff formed within the Chalk (Figure 5). It is inferred from these that the steps are actually the remains of blocks from the overlying Gristhorpe Member and Chalk that have moved downslope, most likely from weaknesses and movement within the underlying Whitby Mudstone Formation. Further evidence for slope instability is shown in the form of soil creep at the back of the photographed embayment (Figure 5).

3.3 KIRBY UNDERDALE (3)

A survey was undertaken at Kirby Underdale to obtain a better view of the slope surrounding the slopes at Uncleby. The panoram a afforded by this site displayed extensiv e landsliding all along the western edge of the chalk escarp ment to the east of Kirby Underdale, demonstrating that the landslides described at Uncleby form part of a much larger complex

3.4 LEAVENING BROW (4)

Figure 6. Slope at Leavening Brow. Photograph taken from $^{4}79565$ $^{4}63408$, orientation 070°(ENE).

The slope at Leavening Brow is composed of a complex landslide on a large s cale. On the lower part of the slope, below the road, blocks of th e overlying Chalk have ro tated on the Ki mmeridge Clay. The landslide is very large, of the order of 100’s of metres in width, and its length covers the upper half of the entir e slope. On the upper part of the slope, above th e road, there is also possible evidence of cambering. However due to the subdued nature of the slope (a result of a long legacy of farming), key geomorphological features are difficult to distinguish.

3.5 BIRDSALL BROW (5)

The geology at Birdsall Brow is si milar to L eavening Brow, with Ki mmeridge Clay underlying the Chalk. The slope is alm ost entirely com posed of Kimm eridge Clay, with the Chalk occupying the very top of the slop e. The stepped topography of th e area again suggests that a series of blocks from the Chalk have failed in a rotational manner, with a f ailure surface within or near the Ki mmeridge Clay Fo rmation. The slope at Birdsall Brow displays a large landslide complex, with little of the slope *in situ*. Th ere are a n umber of different pro cesses and mechanisms of move ment evident, and further su rvey is nec essary to co nfidently categorise the nature of the landslides in detail.

Figure 7. Eastern end of Birdsall Brow. Photograph taken from $^{4}83654$ $^{4}63983$, orientation 045°(NE).

Figure 8. Western end of Birdsall Brow. Photograph taken from $^{4}83150$ $^{4}63676$, orientation 270°(W).

3.6 HOLLIN HILL, BIRKDALE FARM, LOW MOWTHORPE (6)

BGS was alerted to the presence of a landslide at Birkdale Farm by the landowner, Mr Stephen Gibson, who approached field survey geologist Jon Ford at a meeting of the Ryedale Vernacular Building Materials Research Group. A survey was undertaken at the farm by the landslide and mapping team during the October field reconnaissance survey. The slope at Hollin Hill consists of the Redcar Mudstone Formation (Lower Lias) at the base, with an outcrop of the Staithes Sandstone Formation and Cleveland Ironstone Formation (undivided), (Middle Lias) running across the middle section of the slope (evidenced from sandy soil excavated by badger setts). The Whitby Mudstone Formation (Upper Lias) overlies this, with the upper part of the slope composed of the Dogger Formation. Both the Redcar Mudstone Formation and the Whitby Mudstone Formation are highly susceptible to landsliding, and movement across the entire slope is facilitated by these two Formations.

A second survey was undertaken at Birkdale Farm in March 2006 by Gareth Jenkins, Lee Jones and Mike Raines to assess the site for a terrestrial LiDAR and geophysics survey. The two photographs taken below (Figures 11 and 12) show that the site is active, with the first photograph taken in October 2005, and the second in March 2006. The later photograph displays movement, albeit on a small scale, but notable blocky failure is occurring along the failure planes of the hummock. A further survey is planned for summer 2006 to provide baseline data for future integrated monitoring of movement on the slope.

Figure 9. Part of the landslide complex at Hollin Hill, Birkdale Farm. Photograph taken from $^{4}68122$ $^{4}68895$, orientation 045°(NE).

Figure 10. October 2005 view of Hollin Hill landslide. Photograph taken from 468050 468807, orientation 165°(SSE).

Figure 11. March 2006 view of Hollin Hill landslide. Photograph taken from 468050 468807, orientation 145° (SSE).

3.7 LOW HUTTON (7)

A survey was undertaken at Low Hutton (Figure 1) to assess the potential for landsliding in the Oxford Clay Formation that outcrops along the valley sides of the River Derwent. The slopes along the northern banks of the Derwent are heavily wooded, often with conifer plantations. Therefore it was difficult to fully assess the degree of landsliding. However in a few of the clearings it was evident that notable movement has occurred in the Oxford Clay Formation, and the site would benefit from further work in the future to ascertain the extent and mechanisms of landsliding.

3.8 CRAMBE (8)

A brief survey was undertaken at Crambe to assess the degree of landsliding in the Lias sedimentary rocks that comprise the slopes surrounding the village. Landslides were also observed to be common here. However due to the brevity of the survey, the exact extent and mechanisms of landsliding was not established, and a more detailed survey should be carried out in the future.

3.9 NORTH YORK MOORS

The BGS landslide team were also interested in evaluating the extent of landslide activity in the North York Moors National Park. Two sites were visited (Figure 2) based on their geology and characteristic geomorphological features identified on DTM plots of the area. The first site, at Church Houses in the central part of the moors (GR $^{4}66965$ $^{4}97496$) provided an excellent panorama of the valley slopes, with landsliding evident in a number of locations. The valley slopes are predominantly underlain by the Whitby Mudstone Formation. It was difficult to distinguish without further inspection, which geomorphological features related to mass movement and which were *in situ* sandstone benches (Figure 12). However the majority of slopes showed some evidence of landsliding and suggested further survey of the area would yield sufficient useful evidence to produce an accurate landslide hazard map for the North York Moors.

The second site, at Old Byland, GR $^{4}54298$ $^{4}86670$(Figure 2), consists of steep valley sides, which are underlain by the Oxford Clay Formation. Again, landslides were clearly evident within the vicinity, and the team was satisfied that the North York Moors would benefit from further survey in order to produce a landslide hazard map for the area.

Figure 12. Slope above Church Houses, North York Moors. Photograph taken from [4]67783 [4]98526, orientation 290°(WNW).

4 Conclusions and future work

The October 2005 reconnaissance survey of the York sheet revealed that it is an area where landslides are very common. In general wherever there were underlying mudstones (Penarth Group, Lias Group, Oxford Clay and Kimmeridge Clay Formations), coinciding with a relatively high angle slope, there was a high possibility that elements of mass movement would be encountered. It was also evident that no one process of landsliding is prevalent, and several different mechanisms of landsliding were observed according to the aspect and geology of the slope. This reconnaissance survey has provided a very useful foundation for the planning of a follow-up field survey in the financial year 2006-07.

In order to comprehensively and accurately map the landslides in the Vale of York area it will be necessary to employ a wide range of techniques, based on the nature, extent and local terrain associated with each landslide. Aerial photo interpretation, coupled with analysis of NEXTMap data should be utilised to identify the general distribution of landslides. The majority of landslides are on a scale large enough to be identified by this method. It has already been highlighted in this report which geological formations are most susceptible to mass movement. Identification of terrain (from NEXTMap and OS data) with oversteepened slopes that coincide with the appropriate geology would also help provide a base map for landslide hazard in the area.

It is also recommended that a detailed survey is undertaken of the areas highlighted in this report (along with any other slopes that may be identified as being susceptible to landsliding), in order to ground truth the findings from the desk study. It is also recommended that constant liaison with the Vale of York mapping team regarding the mapping of landslide features in the area is maintained.

The North York Moors also proved to be an area in which there is a high frequency of geomorphological features indicative of landslides. However due to the vast area of ground to be covered, the North York Moors survey would favour a bias towards a remote sensing approach, utilising aerial photography and NEXTMap data, with limited ground truthing at key sites.