

Action 19.4: Appendix 2 – WML Consulting Preliminary Land Stability Assessment Clod Lane, Haslingden (Main Report)




Preliminary Land Stability Assessment

For a site at

Clod Lane, Haslingden

Undertaken on behalf of

Pennine Timber Frame UK Limited

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1.0 INTRODUCTION

Appointment

- 1.1 WML Consulting has been commissioned by Pennine Timber Frame UK Limited to undertake a Preliminary Land Stability Assessment of a site referred to as Clod Lane, Haslingden.

Proposed Development

- 1.2 It is understood that Rossendale Borough Council have identified the site in their adopted Core Strategy (Part 1) of the Local Plan for a proposed land use allocation. Furthermore, should the site be taken forward into the adopted version of the Local Plan (Part 2), in principal it would be available for housing land use subject to obtaining planning permission.
- 1.3 Correspondence to this effect is presented in Appendix 01.
- 1.4 No proposed development plan is currently available although Rossendale MBC development guidelines consider a low density, high quality housing development with on-site affordable housing and open space. Furthermore, they consider that development would be located in a central band with appropriate woodland buffer.

Objective

- 1.5 The objective of the report is to collate available geological data for the site and its environs in order to undertake a preliminary assessment of land stability and in particular to assess whether the site is suitable for a proposed housing end use in view of its landslip history.
- 1.6 The Desk Study review enables a preliminary assessment of geological risks to be undertaken and provides information for the design of an appropriate Phase 2 Ground Investigation at the appropriate stage.

Scope

- 1.7 The Desk Study has comprised a site reconnaissance visit and a review of the following information sources:
- British Geological Survey (BGS) (1:50,000) Sheet 76 'Rochdale' (Bedrock and Superficial Deposits Edition).
 - BGS Digital Geological Map of Great Britain (DiGMapGB-50; available as a Web Map Service).
 - BGS archive borehole information available on the web-based interactive browser.
 - Site specific Groundsure GeoInsight Report (Appendix 04)
 - BGS publication paper entitled Lancashire Landslides, 2004 (Appendix 04).
 - Historical Ordnance Survey maps as provided by GroundSure (Appendix 04).
 - Coal Authority Report (Appendix 05).
 - Coal Authority interactive map viewer (available as a Web Map Service).
 - Various third party archive geological reports relating to recorded ground movement and subsequent structural damage to properties at the site (Appendix 06).
 - Records of site specific boreholes undertaken in April 2013 (Appendix 07).

2.0 SITE LOCATION AND DESCRIPTION

Site Location

- 2.1 The site is positioned on the west side of the Irwell Valley and some 2.4km to the south-south-east of Haslingden Town Centre. It is centred on approximate Ordnance Survey National Grid Reference E379500 N421300 with an indicative postcode of BB4 6LZ.
- 2.2 The subject site is bounded to the west by Clod Lane and to the north by land associated with Ewood Day Centre. To the east the site is bounded by Linden Park Road and houses fronting Manchester Road while the southern boundary is formed by the rear of residential properties fronting Hilltop Drive.
- 2.3 The site is indicated as Areas D and E on the Penny Bennett Landscape Architects Lives and Landscape Assessment Report of November 2014 in Appendix 01.

Site Description

- 2.4 The site is irregular in plan and covers an area of approximately 3 Hectares.
- 2.5 The westernmost area of the site to the east of Clod Lane is relatively flat lying at around 198 to 199 metres Above Ordnance Datum (mAOD) with generally relatively low-lying vegetative cover of immature and semi-mature trees, rough undergrowth, grass and reeds. Many of the immature trees appear to be associated with a planting scheme in this portion of the site. Several small ponds and standing surface water occur in this area.
- 2.6 A north-east to south-west trending line of semi-mature and mature trees occurs in roughly in the centre of the site and generally coincides with the crest of a steep sided easterly facing slope.
- 2.7 Eastwards from the crest the ground falls from around 197mAOD to around 173mAOD on Linden Park Road in two distinct steep slopes of around 11 to 14° with an intervening flatter 'platform' of variable width.
- 2.8 These slopes are formed by two major landslip scars, within the site boundary, representing the western limit of ground masses which have slipped in an easterly direction towards the valley floor.
- 2.9 The most westerly slip scar crosses Manchester Road some 100m from the site's northern boundary. It runs from here in a north-east to south-west direction and intersects Clod Lane roughly at the 90° bend where it meets the western extent of Hilltop Drive. From there it runs to the south of Ewood Drive some 100m from the site's southern boundary.
- 2.10 The easterly slip scar fluctuates in direction along its length but generally runs north to south from the south-east corner of the site to coincide with the westerly scar in the north of the site.
- 2.11 The steep sided sections of the site are covered by many trees and shrubs with these predominating in the southern area.
- 2.12 Signs of previous abandoned development are evident in the form of relict road curbs and manholes within overgrown areas of the sites flat western area, with large concrete boulders of demolition rubble evident on the steep sloping ground in the south-eastern section of the site.
- 2.13 The land surface to the east between Manchester Road and the River Irwell is hummocky and convex in nature, being typical of the toe of the mass landslips to the west. This extends almost to the River Irwell.
- 2.14 An overgrown area of raised ground comprising ash is present to the immediately to the north-west of the site off Clod Lane.

- 2.15 A topographical survey of the site and immediate surroundings by JLP Surveys Limited (reference S13-186 dated March 2013) is presented in Appendix 02.
- 2.16 A sketch plan (6813G/SK-01) indicating the slope and landslip scar geometry, based on the site contours and a site inspection undertaken in May 2013 is also presented in Appendix 02. Drawing 6813/SK-04 indicating the positions of the boreholes formed in 2013 is also presented in Appendix 02.
- 2.17 Photographs of the site and immediately surrounding area taken in May 2013 are provided in Appendix 03.

3.0 GEOLOGICAL AND HYDROGEOLOGICAL SETTING

- 3.1 The following sections are summarised from the GroundSure Reports and BGS information in Appendix 04.
- 3.2 The geology of the site is covered by the British Geological Survey (BGS) (1:50,000) Sheet 76 'Rochdale' (Bedrock and Superficial Deposits Edition) and the site specific GroundSure GeoInsight report supplemented by the BGS Digital Geological Map of Great Britain (DiGMapGB-50; available as a Web Map Service).

Geological and Hydrogeological Setting

Description	Comments
<p>Geology</p>	<p>The BGS plans indicated that the site is underlain by Devensian Glacial Till comprising mainly clay and sandy clay with common pebbles, cobbles and boulders.</p> <p>The Glacial Till is underlain at greater depth by solid strata of the Upper Carboniferous Marsden Formation comprising Mudstone and Siltstone.</p> <p>There are no geological faults recorded within 500m of the site.</p> <p>Three boreholes undertaken in April 2013 by Geo-Ventures (UK) Limited on behalf of Wainhomes North West encountered up to 2.00m of clay Made Ground overlying Glacial Till comprising predominantly firm and stiff clay with occasional gravel extending to a proven depth of 30m below ground level (mbgl).</p> <p>The deeper Made Ground was encountered in the south of the western area and probably represented previous re-profiling of the slope at this location.</p>
<p>Landslides</p>	<p>The BGS indicate that the eastern portion of the site is in an area which has been affected by landsliding. The BGS provide a Moderate Hazard rating in this respect, this being describes as 'a significant potential for slope instability with relatively small changes in ground conditions'. The BGS advise against allowing large amounts of water to enter the ground and, for new build, to consider the potential and consequence of ground movement during excavations or consequences of changes to loading or drainage.</p> <p>Conversely, the flat western area of the site is indicated by the BGS to have a 'Very Low' Hazard Rating with slope instability problems unlikely to be present.</p> <p>The BGS indicate that many landslides in Lancashire have occurred since the end of the last ice age some 13,000 years ago and while the majority have remained stable for over 10,000 years, reactivation may occur at any time. In particular, they consider that any interference with these areas by cutting or loading can lead to major disruption and unexpected costs and use the subject site as an example.</p>
<p>Mining related subsidence</p>	<p>According to the Coal Authority report in Appendix 05 the property is not within the zone of likely physical influence on the surface from past underground workings.</p> <p>This is confirmed by the Coal Authority interactive web-based viewer which indicates that the site is not within a 'development high risk' area and is not indicated to be within an area underlain by past or probable</p>

Description	Comments
	<p>shallow coal workings.</p> <p>Therefore, risks to the development from subsidence relating to shallow, unrecorded abandoned mine workings is considered negligible and can be discounted.</p> <p>The risk from non-coal mining activity at the site is also considered low.</p>
Hydrology	<p>With the exception of localised ponding in the western area, there are no surface water features evident on the site, although several water seepages were noted along the eastern slip scar, at the northern end of Linden Park Road, during the site inspection of May 2013.</p> <p>Local surface water drainage flows eastwards towards the River Irwell which flows southwards some 200m to the east of the site.</p> <p>Water issues from the ground at two locations some 100m to the north-east of the site and flows eastwards to the river. A surface watercourse also runs eastwards along Ewood Lane some 100m from the site's southern boundary.</p>
Hydrogeology	<p>The Glacial Till is classified by the Environment Agency as Unproductive, being drift deposits with low permeability that have negligible significance for water supply or river base flow. Groundwater within the Till is therefore unlikely to be in hydraulic continuity with the River Irwell.</p> <p>The underlying bedrock is classified as a 'Secondary A Aquifer' (former Minor Aquifer). These are permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers.</p> <p>The nearest recorded groundwater abstraction is approximately 200m to the east of the site which expired in October 2010. A further abstraction licence is recorded some 450m to the north-west of the site. The licence appears to be current for abstracting a maximum daily volume of 1650m³ of groundwater since August 1970. This is considered sufficiently remote from the site as not to influence hydrogeological conditions significantly.</p>
Flooding	<p>Reference to the Environment Agency website and the Groundsure report indicates that the site is not in an area at Risk of Flooding from Rivers and the Sea (RoFRaS).</p> <p>However, according to the BGS the site is in an area which has a 'Very High' susceptibility to groundwater flooding.</p>

4.0 SITE HISTORY

- 4.1 The historical development of the site has been determined by reference to archive Ordnance Survey (OS) map extracts obtained from the GroundSure Report in Appendix 04.
- 4.2 It should be noted that historical plans with no mapping information at or around the immediate site area have been omitted from the Map Dates.
- 4.3 It should also be noted that the site boundary indicated on the historical maps is of a slightly larger site than that now considered in this assessment.

Historical Development

Map Dates	Scale	Comments	
		On Site	Surrounding Area
1851	1:10,560	<p>A farmhouse referred to as Springwood was located in the northernmost area of the site. This was accessed from Clod Lane by a track which ran centrally through the western area before diverting northwards at an unidentified building in the central north area. A track ran eastwards from here to Manchester Road with a Well, being located just off and to the north of the site.</p> <p>A small watercourse ran from the south-western site boundary eastwards to join a reservoir adjacent to the River Irwell to the south-east of the site.</p> <p>The site was crossed by several tree-lined field boundaries with a roughly north to south hedge line delineating the top of the sloping ground to the east.</p>	<p>Surrounding land was predominantly rural and agricultural with several field ponds. A large water body associated with Ewood Mill to the south-east of the site was being used as a reservoir.</p> <p>A small building referred to as the Old Cote was present immediately to the south-east of Manchester Road.</p>
1891	1:2,500	<p>Springwood Farm was no longer in existence at this time with the unidentified building in the north-central area being referred to as Clod Farm. The Well to the north of the track from Clod Farm was no longer shown although a small pond had appeared immediately to the north of Clod Farm.</p> <p>Also, the watercourse crossing the south of the site was no longer shown but a small pond was present along its former line.</p> <p>Haslingden Sewage Settling Tanks (4no) had been</p>	<p>The building referred to as The Old Cote was no longer in existence.</p> <p>No other significant changes were apparent.</p>

Map Dates	Scale	Comments	
		On Site	Surrounding Area
		constructed to the north-east of Clod Farm	
1892	1:10,560	No significant changes apparent.	No significant changes apparent.
1909	1:10,560	The small ponds in the south of the site and adjacent to Clod Farm were no longer shown on the small scale map.	A triangular area of land immediately to the north-west of Clod Lane and the site had been up-filled. The reservoir to the south-east of the site was no longer in use and was shown to have become marshy ground.
1911	1:2,500	No significant changes apparent. The two small ponds previously shown on the site were indicated to be marshy ground.	No significant changes apparent.
1928	1:10,560	No significant changes apparent. The hedgerow demarcating the top of slope in the western area of the site was no longer continuous.	A row of houses had been constructed between the site and Manchester Road to the east of the northern site area with a further row of terraced housing having been built to the south of the site.
1930	1:2,500	No significant changes apparent although the Sewage Settling Tanks appeared to have been discontinued.	No significant changes apparent.
1938	1:10,560	No significant changes apparent.	No significant changes apparent.
1950	1:10,560	No significant changes apparent.	No significant changes apparent.
1961	1:2,500	The small pond indicated in the southern area of the site was shown as a Spring with water flowing south-eastwards. Clod Farm was no longer present.	No significant changes apparent. A Spring was indicated along the line of the previous watercourse to the south-east of the site.
1968	1:10,560	No significant changes apparent.	No significant changes apparent.
1978	1:10,000	Housing development was shown to have extended northwards into the site from Hilltop Drive. The Sewage Settling Tanks were no longer in existence.	Linden Park Road and Hilltop Drive, together with associated housing development had been constructed to the south-east and south-west of the site respectively. This is known to have been completed by 1973. Significant residential development had occurred to the north of the site together with the construction of the Ewood Centre and adjacent School.
1983	1:1,250	The housing structures were shown to be still present along an access road extending from Hilltop Drive.	No significant changes apparent.
1987	1:1,250	Partial coverage only. The access road off Hilltop Drive had been terminated.	No significant coverage.

Map Dates	Scale	Comments	
		On Site	Surrounding Area
1992	1:10,000	With the exception of a single structure, the housing extending northwards from Hilltop Drive had been removed by this time.	No significant changes apparent.
2002	1:10,000	The remaining structure in the central area of the site was no longer present.	No significant changes apparent.
2012	1:1,250 & 1:10,000	No significant changes apparent.	No significant changes apparent.

- 4.4 In summary, the site has not been subject to significant development with the exception of two farms and Sewage Settling Tanks in the northern section, these being later demolished.
- 4.5 Some modifications to the slope occurred between 1851 and 1891 with the watercourses which crossed the southern area of the site, being apparently piped underground with a resulting pond emerging along its length.
- 4.6 Housing development associated with Hilltop Drive and Linden Park Road had extended into the southern area of the site by 1978 but the majority of the structures were no longer present on the historical maps by 1992.
- 4.7 Further details on the course of events relating to the housing development within the site are provided in the following sections.

5.0 PREVIOUS REPORTS

Introduction

- 5.1 As part of a separate commission by Wainhomes North West, WML Consulting visited the offices of Rossendale Borough Council on 23rd May 2013 to inspect information held by the Council relating to historical ground investigations in their possession.
- 5.2 The following reports were available for review:
- Sub-Soil Surveys Limited, Report on Ground Investigation, dated 6th August 1976, undertaken on behalf of Rossendale Borough Council.
 - Allott & Lomax, Report on Stability of the Site, dated May 1977, undertaken for Rowlinson Construction.
 - Allott & Lomax, Addendum Report on Stability of the Site, dated April 1978, undertaken for Rowlinson Construction.
 - Sub-Soil Surveys Limited, letter report Housing Development Manchester Road, Haslingden, dated 20th October 1978, undertaken for Rossendale Borough Council.
 - Allott & Lomax, Further Report on the Stability of the Site, dated October 1980, undertaken for Rowlinson Construction.
 - Sub-Soil Surveys Limited, letter report Housing Development, Manchester Road, Haslingden, dated 2nd April 1981, undertaken for Rossendale Borough Council.
- 5.3 Initially, the reports could only be reviewed in the Borough Council offices. However, subsequently the 1980 Allott & Lomax report, together with the 1981 Sub-Surface reports were released to Wainhomes for their records and are presented in full in Appendix 06 of this report.
- 5.4 In brief, Sub-Soil Surveys were initially commissioned by Rossendale Borough Council to report on the stability of the site. This had arisen as a result of serious damage to the foundations of four houses constructed by Rowlinson Construction in the south of the site in 1973. The Sub-soil Surveys report of August 1976 presented their assessment and conclusions.
- 5.5 Subsequently, Rowlinson Construction commissioned Allott & Lomax to undertake a similar study of the stability of the hillside. The assessment and conclusions of Allott & Lomax were presented in their report of May 1977.
- 5.6 As a result of conflicting opinions from the two parties, Allott & Lomax were commissioned by Rowlinson Construction in May 1977 to undertake detailed ground investigations to establish the ground conditions at the site. The findings and opinions of Allott & Lomax were presented in their report of April 1978.
- 5.7 The reports that followed from the two parties provided further conflicting opinions on the mechanism of failure leading to the reported structural damage.
- 5.8 Detailed information and opinions are provided in the reports on the historical development, anticipated modes of failure and ground conditions from retrospective post-failure site investigations.
- 5.9 Unfortunately, the borehole findings of the site investigations were not available for review during the writing of this report, therefore the descriptions as provided in the relevant report texts cannot be verified as being accurate at this stage.
- 5.10 Notwithstanding this, it is considered that adequate data is available to form an informed opinion on the risks to future development from possible ground instability at the site.

5.11 The following paragraphs summarise the salient details which lead to the conclusions and recommendations made in the later Section 6.

Historical Background

- 5.12 For ease of reference, the sketch 6813G/SK02 in Appendix 02 has been extracted from the Allott & Lomax October 1980 report to aid in providing a detailed summary of the site's historical development.
- 5.13 It is understood that construction for a housing development commenced in June 1972. By 1973 several of the houses were sold and occupied, presumably along Hilltop Drive and Linden Park Road.
- 5.14 However, towards the end of 1973, it was noted that defects were appearing in houses under construction, up to ground floor level, to the east of the road constructed into the site off Hilltop Drive (Estate Road 3 on sketch 6813G/SK02). In particular excessive movement of ground floor slabs and brickwork to Plots 50 to 53 at the northern end of Estate Road 3 had occurred, in a generally easterly direction.
- 5.15 The line of cracking to these plots was considered to correspond fairly closely with the estimated position of the easterly slip scar with tension cracks being noted at the top of the slope at this location.
- 5.16 It was also reported that cracking had occurred to the external brickwork of Plots 42 to 49, located just to the west of the estimated position of the easterly slip scar, although it was unclear whether the damage had occurred as a result of the slip surface or as a result of poor construction practices. Internal fill beneath the floor slabs beneath these properties was noted to have settled by 300mm.
- 5.17 It was noted that earthmoving was being carried out to the east of the houses under construction on Estate Road 3 and to the west of Estate Road 4. This comprised cutting into the hillside at the bottom of the slope and filling at the top.
- 5.18 Instability was recorded in as much as the toe of the regraded slope had moved towards the foundations of properties 238 and 239 situated to the west of Estate Road 4 (Linden Park Road) resulting in inward bulging of the foundations.
- 5.19 The northern part of Estate Road 1 was constructed fairly close to the westerly slip scar. It is understood that soon after laying the edges and drains, the ground immediately east of the road moved away from the kerb edges, which was also noted to have moved away from the road gullies.
- 5.20 This was evident during the site inspection of May 2013, although it could not be established whether the ground movement was a result of the ground instability or poor construction practices.
- 5.21 It is understood that large movements at the southern end of Estate Road 4 had required frequent remedial works. In addition, large ground movements of the roadway were experienced during excavation for a sewer in this area, which corresponds roughly with the southern extent of the easterly slip scar.
- 5.22 It was noted that significant regrading of the slope was required to make the ground level for the construction of Estate Roads 3 and 4 with little or no regrading required in the western area of the site.
- 5.23 It was also noted that several cracks of varying magnitude were evident on nearly all properties fronting Estate Road 1 (Hilltop Drive) and some of the reinforced concrete retaining walls and brick facing between the houses appeared to have tilted and cracked. This was not evident during the site inspection of May 2013.
- 5.24 It was also reported that settlement had occurred to a drainage run serving Plots 54 and 55 on Hilltop Drive.

- 5.25 Off-site, it has been reported that several repairs have been made historically to the surface of Manchester Road to the north of the subject site, with several earlier road surfaces being encountered to depths of up to 1.50mbgl.

Ground Conditions and Postulated Mode of Failure

- 5.26 It appears that at least four ground investigations have previously been undertaken at the site although information from these has not been available for the current review.
- 5.27 Three were undertaken by Ground Tests Limited between October 1974 and May 1975 with the most recent being undertaken between 1st September 1977 and 16th January 1978 by Foundation Engineering on behalf of Allott & Lomax. This comprised nineteen trial pits and nine cable tool percussion boreholes to depths of between 25.8 and 49.2m below ground level (mbgl) and the installation of piezometers and standpipes for the measurement of groundwater pressures. The results were summarised by Allott & Lomax in their report of April 1978 and later by Sub-Surface Limited in their letter report of 20th October 1978.
- 5.28 From the brief information that is available for review, the following ground conditions are surmised beneath the site.
- 5.29 Firm and stiff clay representing Glacial Till was proven in all boreholes to depths of between 19 and 41mbgl. This was underlain by Lacustrine Deposits which were up to 6m thick and comprising firm and stiff laminated and 'varved' silty clay with partings of silt. The boundary between these two deposits appeared to dip by between 3 and 6° (with an average of 4.5° to the horizontal in a south-easterly direction).
- 5.30 The Lacustrine Deposits were underlain by gravels, silts and clays although these were absent locally. The underlying rock was proven in all boreholes at depths varying between 26 and 42mbgl, rising in a westerly direction.
- 5.31 The groundwater table within the relatively shallow drift was initially found to be sub-parallel with the sloping ground surface, being approximately 4mbgl at the higher, flatter western area, increasing to around 7mbgl beneath the sloping ground. However, at greater depths, the water pressure generally fell below hydrostatic pressure through the Glacial Till, suggesting that the hillside being 'underdrained' to a significant extent by the underlying bedrock and possibly the gravels overlying this.
- 5.32 Subsequently, more detailed records by Allott & Lomax indicated the uppermost groundwater table to lie in the superficial deposits at a depth of around 0.50 to 1.00mbgl with the water pressure decreasing with depth to be consistent with a 'considerable degree of underdrainage' to underlying permeable strata.
- 5.33 They also considered that water levels in the lower bound permeable strata were probably in hydraulic continuity with the River Irwell and during a 3 year period, over which groundwater pressures were measured, little or no fluctuations were recorded.
- 5.34 Importantly also, the investigations undertaken by Allott & Lomax encountered discontinuities showing evidence of shearing generally within laminated clay above the Lacustrine Deposits. This confirmed that the hillside had been subject to past large scale slipping.
- 5.35 The results of residual shear box tests undertaken on high plasticity clays from all investigations gave angles of residual shearing resistance (ϕ_r') of 8 to 12° with a mean value along the possible slip failure zone of around 9 to 10°.
- 5.36 Non-circular stability analysis undertaken by Allott & Lomax on two sections (Sections A and B shown on Figure 7 in their report of October 1980) provided a Factor of Safety for Sections A and B of 1.09 and 1.30 respectively. Section A was in the north of the site while Section B was along a line immediately to the north of Hilltop Drive.

- 5.37 They concluded that Section B had been demonstrated to be acceptable in terms of overall stability and this is confirmed to a degree by the fact that no discernible structural damage has been recorded to houses along Hilltop Drive.
- 5.38 However, they considered that Section A did not have a sufficiently large margin against stability for it to be considered acceptable in development terms.
- 5.39 Furthermore they considered that a minimum acceptable Factor of Safety would be achieved approximately midway between Sections A and B. They further concluded that the cause of structural failure to the plots along Estate Road 3 was a local event caused by some form of slip failure in Made Ground materials resulting from preparatory earthworks activities. This was considered to be further exacerbated by poor construction activities rather than overall hillside movement as contested by Sub-Surface Limited.
- 5.40 From their conclusions, Allott & Lomax divided the site into zones relating to development suitability. Figure 7 in their report of October 1980 provides an indication of the zones which extend over a wider site area than that which is considered for future development by Rossendale Borough Council.
- 5.41 Sketch 6813G/SK03 in Appendix 02 indicates the zones within the current site boundary being considered for development. The suitability of each zone for development is discussed further in the following section.

6.0 CONCLUSIONS AND RECOMMENDATIONS

- 6.1 The previous reports outlined in Section 5 generally relate to conflicting opinions between two parties of consultants. The disagreement is in regards to the cause of structural failure, of the house foundations, to specific plots in the south of the site and specifically relate to the stability of the historical landslide in this area.
- 6.2 Very broadly, Allott & Lomax contested that the southern area of the slope was stable and that the foundation failure was due to differential settlement relating to previous cut and fill operations. Sub-Surface Limited did not agree and considered the Factor of Safety for the slope as determined by Allott & Lomax to be questionable.
- 6.3 Importantly, both parties agreed that the Factor of Safety for the slope in the northern and central areas of the site (Zone C) was close to unity and, as such, could be rendered unstable if the site was developed in these areas. WML agree with these conclusions.
- 6.4 Both parties also agree that the area to the west and north-west (Zone A) is unlikely to be affected by the landslide and can be developed. WML are of the same opinion although the development potential for the southern portion, beyond the 90° bend on Clod Lane, is considered questionable as the slip scar in this area has been masked by previous groundworks which may also have resulted in localised instability potential.
- 6.5 With reference to Sketch 6813G/SK02 in Appendix 02 the following details are considered relevant:

Zone A

- 6.6 The majority of the area is suitable for development although further ground investigations will be required to establish the extent of the slip scar to the east and south. Once delineated accurately, it is recommended that no houses should be constructed within an approximate zone of 30m westwards of the western slip surface scar.
- 6.7 Sketch 6813G/SK03 in Appendix 2 indicates the approximately location of western slip scar crest, based on ground investigation information, a walk-over survey and an appreciation of the ground contours from the topographical survey.
- 6.8 It is suspected that the line of the scar has been masked by past ground re-profiling in the south of Area A, therefore it has been indicated as a conjectured line until further ground investigations are undertaken.
- 6.9 The drawing also indicates an arbitrary 25 - 30m zone extending westwards from the slip scar crest. This area will be suitable to accommodate rear gardens but no substantial structures, unless detailed ground investigations are undertaken. Restrictions will also need to be imposed in planning on any future proposed building extensions within this area.

Zone B

- 6.10 Allott & Lomax concluded that this area could be developed without remedial works but with great care not to provide over-steepening due to earthworks. However, it is suspected that this area may have been re-profiled as part of the previous abandoned development, thus masking the original ground profile and possibly the slip scar.
- 6.11 This area should therefore be considered suspect until further detailed stability analysis, which would include significant ground investigations and specialised laboratory testing is undertaken. Detailed slope stability analysis will then determine whether the area can be developed and what extent of preparatory works are required to render the area stable.

Zone C

- 6.12 This area is considered unsuitable for development without significant remedial works being undertaken. Such works would involve significant excavation of soil at the slip surface 'head' and up-fill at the toe of the slip surface. In consideration of the anticipated size of the slip surface, such up-fill works would need to be undertaken within the land separating the River Irwell from Manchester Road, an area which is presumably under separate ownership and is not being considered under the current Rossendale Borough Council Draft Local Plan.
- 6.13 Furthermore, any possible future earthworks undertaken on the land to the east of Manchester Road could affect the stability of the hillside leading to possible ground movements. Any such actions in this respect would be outside the control of any parties developing the current area of interest.
- 6.14 In addition, removal of large volumes and re-grading of soil at the slip 'head' would significantly reduce the developable area of Zone A.
- 6.15 It is considered therefore that development of this area would be at significant risk and is thus impractical and probably uneconomical.
- 6.16 Also, it may be a recommendation that remedial works such as suitable drainage be undertaken against further deterioration of the slope even if no development is undertaken in this area.

Zone E

- 6.17 There have been conflicting opinions on the mechanism for structural failure in this area. It is the view of WML that ground re-profiling to provide the proposed development platform will have greatly affected the stability of the slope locally, this being exacerbated by possible poor construction practices. Notwithstanding this, and the fact that the area is located on an ancient landslip cannot be ignored, the significant potential for uncharted ground weakness to be present as a result.
- 6.18 In view of the knowledge that slope stability has already been previously compromised as part of the outlined earthworks and construction, the risk of reactivating further ground movement in this area is considered high.
- 6.19 Also, the steep nature of the slope will probably preclude any sensible development in this area.
- 6.20 Added to this, it may be a recommendation that remedial works such as suitable drainage be undertaken in order to reduce the risk of further deterioration of the slope, even if no development is undertaken in this area.

Zone D, F and G

- 6.21 These zones are outside the current area indicated by Rossendale Borough Council in their Draft Local Plan. However, for completeness they are discussed briefly as follows:
- 6.22 *Zone D* is a heavily wooded area and is indicated by the British Geological Survey to have a High Hazard rating, this being indicative of a very significant potential for slope instability. In view of the existing topography and visual signs of ground instability in this area, WML would concur with this assessment.
- 6.23 *Zone F* is in an area which has been potentially affected by local instability and could be affected further by any future ground works associated with land to the west of Manchester Road. As such, no development should be undertaken in this area without detailed ground investigations and assessment to confirm its stability.
- 6.24 *Zone G* is almost wholly occupied by the slope scar, therefore development should not be considered in this area.

Concluding Summary

- 6.25 In summary, WML conclude from the preliminary assessment that the western area of the site beyond the slope scar is suitable for development subject to further ground investigation.
- 6.26 It is considered that other areas of the site are not suitable for development although a further detailed ground investigation and slope stability assessment of the southern portion of Zone A may determine that development is possible, albeit with potentially a substantial degree of remedial measures.