Ongoing Analysis and Interpretation of Coastal Monitoring Data

Review of First Additional Suite Monitoring

Geotechnical Interpretative Report

February 2010

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New information, changed practices or new legislation may necessitate revised interpretation of the report after the date of its submission.

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EXECUTIVE SUMMARY

In October 2008, Mouchel were instructed by Scarborough Borough Council (SBC) to provide services relating to an Analysis and Interpretation of Coastal Monitoring Data from sites (Runswick Bay, Whitby, Scalby Ness, Scarborough North and South Bay, Knipe Point, Killerby, Filey Town & Brigg and Filey Flat Cliffs) along the North Yorkshire coastline. Mouchel were required to review, analyse and interpret existing data, provided in electronic and hardcopy format, held by SBC for all the sites mentioned above. This data covered previous plans, monitoring records, strategies, ground investigations, borehole records, groundwater information, laboratory test data and geomorphological mapping.

The findings of this analysis and interpretation were presented in Mouchel Report "*Analysis and Interpretation of Coastal Monitoring Data" 721228/001/GR/01/02/FINAL*, March 2009. This report detailed a definition and understanding of the problems at each site based upon existing data, identified current and potential risks associated with ground movements at each site, a series of early warning signs and trigger levels which needed to be related to the findings of an Ongoing Monitoring regime, a series of appropriate response actions in relation to the findings of the above monitoring and recommended frequencies for the Ongoing Monitoring at each site related to the findings of the above monitoring.

The ongoing analyses are being undertaken in accordance with the recommendations of monitoring frequency detailed in the above report. Table 2 details the frequency of Full and Restricted Suite monitoring to be carried out over this period. Departures from this were evident where remedial works had not been undertaken at a site, where there were significant 'gaps' in monitoring data from a site and following periods of heavy and prolonged rainfall. The definition of '*significant rainfall*' has been developed through the analysis of rainfall data records (made available by the EA and SBC) and quantified within the context of the effects of such an event on the present monitoring regime frequency. A definition of heavy / prolonged rainfall events was investigated in terms of determining statistically derived values of daily rainfall per month for the period 1995/8 to 2008/9. Limiting values of rainfall in terms of how much rainfall, within a 24 hour period, can occur before advising that site inspections should be undertaken were identified. To this end, having reviewed the rainfall data, the 75th percentile was calculated as a threshold value. This showed that 75% of daily rainfall was below this value and the remaining 25% of rainfall exceeded this amount.

In the event that the 75th percentile of daily rainfall values (a period of heavy / prolonged rainfall) are exceeded, it was recommended to carry out monitoring one week after the end of the rainfall event and at monthly intervals thereafter for three months. Further to the heavy rainfall experienced in December 2009, these recommendations were followed by SBC and Mouchel were instructed to instigate additional monitoring events in order to comply with monitoring recommendations. This report describes and details the findings of the **First Additional Suite** monitoring event undertaken, in early January 2010.

At the majority of sites, little change to the amount of detected ground movements has been identified by the installed instrumentation during the period of monitoring from December 2009 to January 2010. Monitoring data from the inclinometer at Whitby West Cliff has so far shown that no discernible ground movements have occurred within the slopes at this site (although the survey stations at Whitby have recorded surface movements of -7mm since November). Results of monitoring at Scalby Ness indicate both slopes are also relatively stable although limited movements of 2mm have been detected in inclinometers I1 and I3 at 20.5 metres and from 18.0 to 19.5 metres depth, respectively.

The results of inclinometer monitoring in Scarborough North Bay indicate the slopes above the Oasis Café are presently in a stable condition within the vicinity of the inclinometers, although limited movement is indicated in BH1 and BH4 of up to 4mm in a down slope direction.

The lack of inclinometers and limited piezometer instrument coverage over The Holms site means that any ground movements over this area may not be detected. Along the gardens of Scarborough South Cliff, monitoring data from the inclinometers and survey pins has generally shown that ground movements so far detected are generally restricted to relatively shallow disturbances around AA04, AA11 and AA10 with no ground movements indicated at the remaining inclinometers. However, monitoring data from the previous month period has indicated ground movements within inclinometers AA07, AA08 and AA11 of up to 3mm. Within inclinometer AA10 ground movements of up to 4mm are apparent from 3.5 metres depth to ground level. This movement has occurred in made ground and is probably evidence of surface creep. Similarly, ground movements are evident in AA04 where 2mm of movement is illustrated from 6.5 to 6.0 metres depth within Glacial Till. Deeper ground movements are evident in AA07 where <3mm of movement is illustrated between 60.0 and 26.5 metres and also in AA11 where ground movements are evident from 19.5 to 18.5 metres and 15.5 to 14.0 metres depth. Tarmac surfaced pavements behind the Clock Café display evidence of slope instability where cracked pavements are present below which the slopes display bulging and have a hummocky ground appearance.

Monitoring at Runswick Bay has followed the recommended regime of monitoring having taken place on two occasions following the initial 'baseline' readings recorded in July 2009. Successive readings taken in December 2009 indicated some movement had occurred within inclinometers installed at A001 and A004. Within A001, 5mm of movement was indicated between 22.0 and 20.0 metres depth and in A004; 5mm movement is indicated from 10.0m depth increasing to 15mm at 2.0m depth. Readings recorded in January 2010 indicated this movement was repeated although to a lesser degree of 2-3mm between 22.0 and 20.0 metres depth. In each installation the ground movements were indicated as taking place in a down slope direction.

At Filey Town, a similar pattern of monitoring has been undertaken on the inclinometers (BH03 and 06) which have been installed atop glacial slopes above Royal Parade. Due to possible vandalism, BH03 has not been monitored and no further analysis of this instrument is available. The results of monitoring BH06 since July 2009, illustrates that at depths of between 10.5 and 7.0 metres up to 2mm ground movement had occurred in a down slope direction (perpendicular to the coastline).

Monitoring data from the inclinometer at Filey Flat Cliffs has shown that ground movements within the slopes have so far been limited to 3mm at depths of 19.80 metres and from 12.50 to 10.50 metres. Ground movements are also discernible nearby at surface level where cracking of the road pavement is evidently developing. Cracks in the access road were identified during a site visit in November 2008, these were subsequently repaired and sealed with tar poured into the cracks. More recent photographs (taken January 2010) of the cracked pavement show the continued expansion of these cracks.

A summary of the total observations made from the start of monitoring (July 2009) and observations made up to the last monitoring event of January 2010 are presented below in Table 1.

Table 1 Summary of Site Observations

SITE	Observations made since last Monitoring Event (Dec. 2009)*	Total observed movement since first Monitoring Event (July 2009)
Runswick Bay	A001 shows 2-3mm movement from 22.0 to 20.0 metres depth. A004 shows 5mm movement from 10.0m depth, reaching a maximum of 15mm at 2.0m depth.	5mm movement indicated in A001 between 22.0 and 20.0 metres depth. 5mm movement indicated in A004 from 10.0m depth increasing to 15mm at 2.0m depth.
Whitby West Cliff	Survey points not monitored since December. Inclinometer indicates slopes are stable around vicinity of BH2.	Survey pins show -7mm movement in top one metre of ground. Inclinometer indicates slopes are stable.
Scalby Ness	Cliff recession points not monitored since December. At I2 limited movement of 2mm indicated at 20.5 metres depth At I3 limited movement of 2mm indicated from 18 to 9.5 metres depth; may be erroneous readings.	10mm cliff recession recorded at MP3 between July-August, none at other three stations. At I2 limited movement of 2mm indicated at 20.5 metres depth At I3 limited movement of 2mm indicated from 18 to 9.5 metres depth; may be erroneous readings
Oasis Cafe	Previously reported movements of December now considered as erroneous readings. Slopes stable.	Slopes stable, limited movement of <4mm indicated in BH1 and 3.
North Bay	No coverage of The Holms area	No coverage of The Holms area
South Cliff	Survey points not monitored since December. AA04 shows no further movement AA07 shows <3mm movement from 60.0 to 26.5 metres AA08 shows <2mm movement from 6.5 to 6.0 metres AA10 shows further movement in top 3.50m of ground AA11 shows <2mm movement from 19.5 to 18.5 metres and 15.5 to 14.0 metres depth Continued development of cracks in pavements	AA04 shows 2mm movement in top 7.0m of ground AA07 <3mm movement from 60.0 to 26.5 metres AA08 shows <2mm movement from 6.5 to 6.0 metres AA10 shows 4mm movement in top 3.50m of ground AA11 shows <3mm movement in top 3.0m of ground
Filey Town	No change in slope stability. Slopes indicated as stable around Glen Gardens above Royal Parade.	2mm ground movement indicated in BH06 between 10.5 and 7.0 metres depth. Slopes stable.
Flat Cliffs	BB02 shows 3mm movement from 12.5 to 10.5 metres and 2-3mm movement at 19.80 metres. Continued development of cracks in road surfaces	BB02 shows 3mm movement from 12.5 to 10.5 metres and 2-3mm movement at 19.80 metres. Continued development of cracks in road surfaces

1 Introduction

1.1 Description of the Project

1.1.1 Monitoring

Scarborough Borough Council's (SBC) local coastal monitoring programme extends along the length of its North Yorkshire coast from Staithes in the north to Speeton in the south, a distance of approximately 68 km. Coastal settlements include Runswick Bay, Whitby, Scalby Ness, Scarborough North and South Bay, Knipe Point, Killerby, Filey Town & Brigg and Filey Flat Cliffs, most of which have defended frontages. Some of these coastal defences are now ageing, in poor condition and are subjected to an aggressive wave climate. Furthermore the defences are, for the most part, backed by coastal slopes which show evidence of both instability and climatic denudation. These factors, together with environmental considerations of predicted climate change scenarios and sea level rise, focus the need for constant attention in order to minimise potential risks to the public and coastal assets of the Borough.

The extent of the monitoring area (Figure 1) considered for the Ongoing Monitoring analysis is along the full length of Scarborough Borough Council's coastline from Staithes to Speeton. Through the Shoreline Management Plan 2007 (SMP2) and Coastal Strategy process, several sites within the Borough have been identified and are either subject to an on-going monitoring regime or as having been monitored in the past.

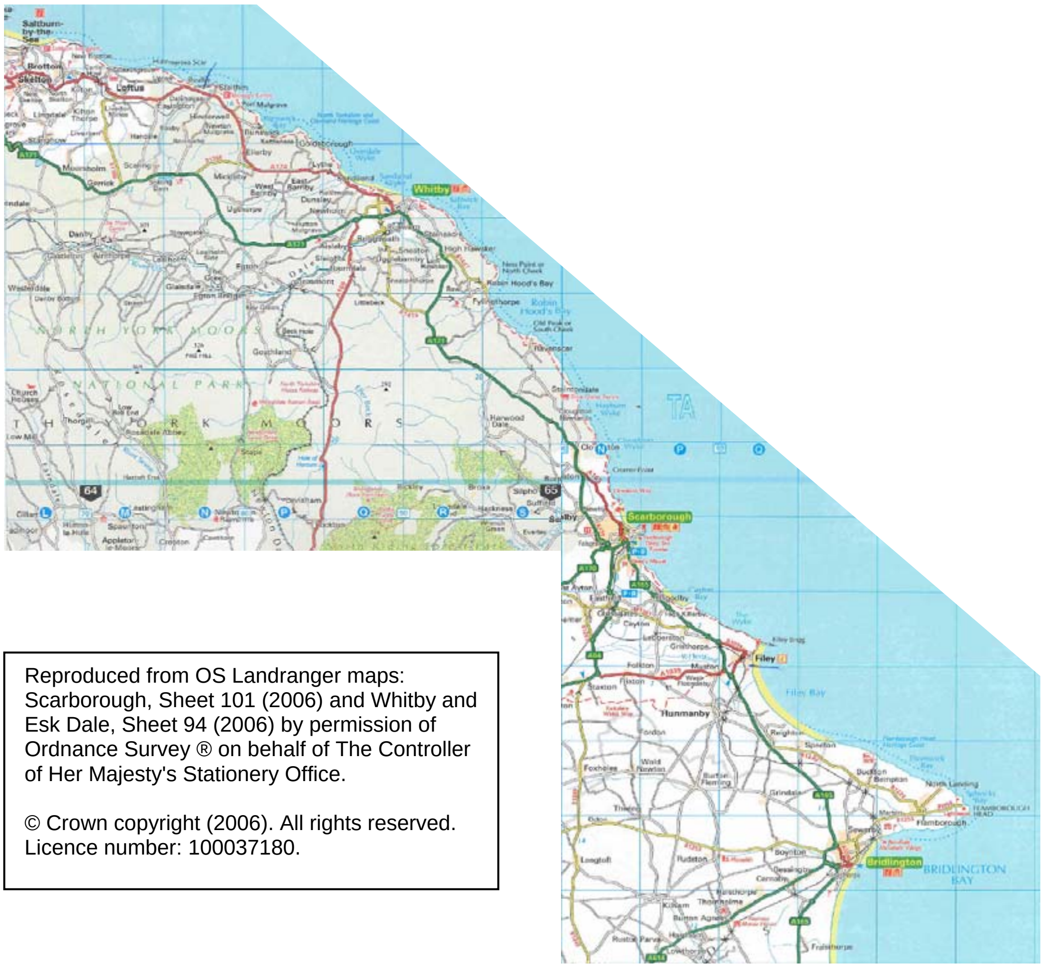
Table 2 Frequency of Ongoing Monitoring

YEAR	MONTH	SCOPE OF MONITORING
ONE (2009)	July (1)	Full Suite
	Aug, Sept, Oct, Nov (2,3,4,5)	Restricted Suite
	Dec (6)	Full Suite
	Feb, Apr (8,10)	Restricted Suite
	June (12)	Full Suite
TWO (2010)	Dec (6)	Full Suite
	June (12)	Full Suite
THREE (2011)	Dec (6)	Full Suite
	June (12)	Full Suite

The ongoing analyses are being undertaken in accordance with recommendations for monitoring frequency detailed in Mouchel Report No. *721228/001/GR/01/02/FINAL.* Site specific monitoring regimes have been planned to take place at intervals of one, two, three and six months beginning in July 2009. The monitoring regimes have been grouped together to be undertaken as ‘Full’ and ‘Restricted’ Suites, detailed in Table 2.

Site location plans are presented as Figures 2 to 8 within the relevant chapters. Exploratory holes location plans illustrating the locations of instrumentation (automated piezometers, piezometers / slip indicators and inclinometer installations) are presented in Appendix A.

Figure 1 Scheme Location



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1.2 Previous Studies

Mouchel were required to review, analyse and interpret existing data, provided in electronic and hardcopy forms, held by SBC for all the sites mentioned in Section 1.1. This data covered previous plans, monitoring records, strategies, ground investigations, borehole records, groundwater information, laboratory test data and geomorphological mapping. A geotechnical interpretation and appraisal of these reports has been presented in Mouchel Report No. *721228/001/GR/01/02/FINAL*. An Arcview GIS layer has been produced with all monitoring data and reports made available by SBC in addition to reports produced and monitoring data collected by Mouchel. At each interval of monitoring, this layer is subsequently up-dated with the latest results of recorded monitoring data.

1.3 Definition of Prolonged Periods of Rainfall

Rainfall data records have been made available to Mouchel by SBC and the Environment Agency (EA). The data has been referenced to weather stations throughout the region notably at Loftus, Fylingdales, Whitby School, Scarborough and Knipe Point, Mulgrave Castle and Ruswarp. Within Mouchel Report "*Analysis and Interpretation of Coastal Monitoring Data" 721228/001/GR/01/02/FINAL,* reference was made to 'periods of heavy and / or prolonged rainfall' in terms of considering such an event with respect to their effects upon slope stability.

Departures from this monitoring regime were evident where remedial works had not been undertaken at a site, where there were significant 'gaps' in monitoring data from a site and following periods of heavy and prolonged rainfall. The definition of '*significant rainfall*' has been developed through the analysis of rainfall data records (made available by the EA and SBC) and quantified within the context of the effects of such an event on the present monitoring regime frequency. A definition of heavy / prolonged rainfall events was investigated in terms of determining statistically derived values of daily rainfall per month for the period 1995/8 to 2008/9. Limiting values of rainfall in terms of how much rainfall, within a 24 hour period, can occur before advising that site inspections should be undertaken were identified. To this end, having reviewed the rainfall data, the 75th percentile was calculated as a threshold value. This showed that 75% of daily rainfall was below this value and the remaining 25% of rainfall exceeded this amount.

In the event that the 75th percentile of daily rainfall values (a period of heavy / prolonged rainfall) are exceeded, it was recommended to carry out monitoring one week after the end of the rainfall event and at monthly intervals thereafter for three months. Further to the heavy rainfall experienced in December 2009, these recommendations were followed by SBC as Mouchel were invited to undertake additional monitoring events in order to comply with monitoring recommendations. The additional monitoring suites are to be undertaken for January and March 2010.

This subject has been refined through analysis of rainfall data records made available by the EA and SBC and the definition of such an event has been quantified within the context of the effects of such an event on the present monitoring regime frequency. The analysis and definition of this subject has been presented in Mouchel Report '*Definition of Heavy and / or Prolonged Rainfall* – 721229/004/GIR/001/FINAL'.

1.4 Instrumentation Monitoring Procedures

1.4.1 Inclinometers

The initial monitoring event for the Ongoing Monitoring Regime was initiated in July 2009 by a suitably qualified geotechnical engineer. Inclinometer instruments were initially investigated using a test probe (dummy) inclinometer on a 100 metre length cord. The test probe was lowered to the base of the tubing to prove its integrity. Where the instrument did not reach the base, due to a blockage or loss of tubing integrity, this depth was recorded and no further inclinometer data was recorded. Groundwater within the instrument tubing was measured and recorded using a dip meter. The measurement of groundwater in inclinometers is to continue throughout the term of the contract.

Although some inclinometer instruments are not monitored due to various failures / blockages within the installed tubing, these instruments are still being read with a dip meter to provide an indication of groundwater levels.

Where the instrument tubing was proved to be intact, a Vertical Digital Inclinometer probe {using a Bluetooth system (MkII) with a TDS Recon 200 PDA} was lowered to the base of the tubing, allow the probe to temperature stabilise and measurements were recorded at half metre intervals as the probe is raised. (The probe must be left at the base of the tube to allow for temperature stabilise prior to beginning data acquisition). Readings of inclination were recorded in two directions (A0 and A180) within the inclinometer tube; A0 being the principal direction of interest in ground movements and A180 is in the opposite direction to this. B0 and B180 readings are also recorded automatically, B0 represents +90 degrees to the A0 direction and B180 is +90 degrees to A180 direction. The 'B' directions are not read manually as the biaxial accelerometers read both B axes during the survey.

This process was repeated in order to give two sets of 'Baseline' readings, which are averaged to give a more accurate 'Baseline' reading and create repeatable base data. Successive sets of readings are compared to the initial 'Baseline' readings to provide an indication of ground movements. The follow-up readings consist of recording a single set of readings in the A0 and A180 direction for each individual inclinometer instrument.

As further readings are recorded and processed, a graph of individual plots is built up over the monitoring period which will either display the effects of ground movement as successive plots deviate further from the baseline reading or, if no movements occur then the graphs will plot within millimetres of the baseline reading.

1.4.2 Piezometers and Slip Indicators

Groundwater levels within piezometer tubes have been recorded using a 50 metre length dip meter. A piezo tip emits an audible signal when it comes into contact with water, the depth to water is read off the tape and this is recorded. A comparison of the known installed instrument depth with the dipped depth gives an indication as to whether the tubing is clear to its base or is blocked / impeded at that depth.

Where slip indicators are present, they consist of one metre length mandrels resting at the base of piezometer tubes attached to a chord at ground level. The mandrels are lifted from base to top of the tube to indicate if any distortion or blockages have occurred within the tubing. Where mandrels were found to be jammed within the tubes, a reading was taken from ground level to the top of the mandrel to give an indication of the depth at which possible failure of the ground had taken place. Where this had occurred, the installation ceases to be of use since it has served its purpose in demonstrating failure or movement of the ground. Other installations continue to be read as the inserted mandrels function free of any obstacles. Hence, these instruments continue to demonstrate that no discernible ground movements are occurring.

Groundwater level readings recorded from inclinometer instruments should be viewed and interpreted with care. This type of installation is used for the monitoring of sub-surface ground movements and not groundwater monitoring. However, in conjunction with the correct instrumentation (piezometers), readings extracted from inclinometers can provide additional information on the nature of the prevailing groundwater regime at a site under observation.

1.5 Interpretation Views

1.5.1 Cumulative displacement

The most commonly used plot type is the Cumulative Displacement plot, which shows a displacement profile of a borehole. The plot shows the change in the position of the casing since the initial set of readings. If a user error has occurred during reading, the error will be accumulated through successive readings. If this is suspected, or anomalies occur, the data can be examined using the Incremental Displacement function.

1.5.2 Incremental Displacement

Another form of data presentation is the Incremental Displacement plot. This shows displacement over each probe length during the period since the initial reading sets. Unlike the Cumulative Displacement plot operator error or instrument malfunction does not accumulate as the data are plotted from reading to reading (i.e. delta previous not delta datum).

1.5.3 Absolute Position

This type of plot shows the absolute position of the casing and will determine the verticality of the installation. It does not pick up movement, but can be used for assessing installation error.

The Cumulative displacement plot is used to display results of inclinometer readings in-line with historic inclinometer data.

Historic inclinometer data has not been amalgamated with that currently being collated as the various formats of the data would not produce a true, coherent interpretation of possible ground movements occurring at each of the sites being monitored. In some cases historic inclinometer monitoring data is not available (i.e. Filey and Filey Flat Cliffs) and hence comparisons with current data have not been possible. Where an interpretation of historic inclinometer data has been formulated, this will permit a continuum of interpretation to be developed. As further inclinometer data is recorded, consecutive graphs may illustrate the general nature, direction and rate of any ground movements occurring at a site.

2 Runswick Bay

2.1 Site Location and Description

Runswick Bay is situated on the north east coast of England some 16 km north west of Whitby town at NGR NZ 800 160. It is formed between the headlands of Caldron Cliff to the north and Kettleness to the south and comprises a deeply indented sandy bay approximately 2 km in length. The bay is backed mostly by cliffs and steep glacial till coastal slopes. The village of Runswick Bay is developed within the general valley formed by the Runswick and Nettledale Becks. The village straddles the boundary between the glacial till slopes which occupy most of the bay and the Jurassic shale and sandstone cliffs to the north. Most of the village is founded on weathered shale but properties to the southern edge and the access road (Runswick Bank) and car parks are founded on glacial till landslide debris. The village is fronted by four separate sea defences, of varying age and construction, which stretch from Runswick Beck north of Caldron Cliff around to Nettledale Beck to the south.

Figure 2 Site Location - Runswick Bay

2.1.1 Historic Review of Problems

Runswick Bay has a long history of slope instability, the first recorded slope failures occurred in 1682 when the whole village, located further north than at present, collapsed towards the shore. Successive landslips of varying severity occurred in 1873, 1953 and, in 1958 when the old road was closed twice in one week due to landslides. This road was abandoned in 1961 with the construction of a new access road constructed further to the west between 1961 and 1963, on its present alignment. Around the same time a sea wall extension and new car park were constructed at the base of this road. Landslips and rockfalls were experienced immediately north of the village during the 1970's, including a landslip at Rose Cottage in 1975, resulting in the loss of various, limited assets.

A mass concrete sea-wall constructed in 1970 provided coastal protection to the southern edge of the village, access road and car park areas. Since its' construction, the sea-wall was subjected to a combination of marine and land based erosional mechanisms causing the wall to move in a seaward direction with backwards rotational tilting. Sea-wall deterioration and failure has been caused by earth pressure loading from slope failures behind the wall, beach erosion exposing the toe of the wall and wall toe failure of the fractured and folded shale bedrock.

Three areas of slope instability have been identified within Runswick Bay which have influenced the failure of the previous sea-wall and other sea defences and are still having an effect. These areas are identified in Figure 3 and are described as being:

- Upgarth Hill – The Upper Lias shales and sandstones of the Saltwick Formation forming the cliffs below Upgarth Hill are covered by a thin mantle of glacial clay. Intact cliffs stand at angles of 50 to 70 degrees whereas previous failures have led to slopes of talus debris standing at 20 to 30 degrees with light vegetation cover. The toe of the east facing slopes are protected by a concrete sea-wall and the toe of the south facing slopes are continually being undercut by Runswick Beck which forms an incised valley with over steepened sides to the north east of Runswick village.

- Topman End – is located immediately north of the village, with heavily vegetated, glacial slopes characterised by a network of scarps and transverse tension cracks behind small superficial failures. Slope angles vary between 30 and 40 degrees, decreasing to 5 to 10 degrees mid-slope. These superficial failures are caused by the entrapment of excessive ground water.

- Ings End – this area extends from south of Nettledale Beck to Limekiln Beck a distance of approximately 500 metres over an area known as Dother Pits. Sub-vertical headscarps, formed in glacial tills, are present below the cliff tops between the two becks. Below this scarp are a series of undulating slopes formed by the retrogressive failure of deep seated basal shear planes along the shale bedrock. The slopes can be divided into three distinct zones characterised by uneven ground, ponding water, irregular springs and streams and dense vegetation. Slope angles vary between 15 and 20 degrees with the crests of individual landslide blocks well defined by breaks of slope at lesser angles of between 5 and 10 degrees. Subsequent failures have been triggered by the destabilising effect of an initial failure caused by undercutting of the leading block by progressive coastal erosion. The back scarp areas of the landslip complex has been found to contain saturated sand layers and lenses which are thought to be supplied by the sandstone present further inland. Groundwater seepages have been experienced, during ground investigations, from the basal backscarp areas and from within disturbed shales immediately below the glacial tills some distance from the slope toe.

Due to the ground movements detailed, it became evident by 1998 that the sea-wall was in danger of imminent collapse which would have lead to large scale landslip failures and loss of amenities in the village. Accelerated movements of the sea-wall, particularly at the southern end, eventually lead to the structure being replaced by a rock armoured revetment and an intermediate compressible buffer zone.

2.1.2 Existing Information

A number of reports were provided by SBC for consultation, these are detailed in Mouchel Report "*Analysis and Interpretation of Coastal Monitoring Data" 721228/001/GR/01/02/FINAL, pp9-10.* Additional reports have been provided by SBC for further consultation by Mouchel for the Ongoing Analysis. This data has been placed on an Arcview GIS layer for ease of use and availability.

2.2 Stratigraphy

The published geological map of the area 1:50,000 British Geological Survey (BGS) Sheet 34 Solid and Drift Guisborough indicate the site is underlain by superficial deposits of glacial till (Boulder Clay). These comprise stiff silty sandy clays, sands and gravels and laminated stiff silty clays. The solid succession of the area is indicated as Middle Jurassic sandstones (Saltwick Formation) and ironstones (Dogger Formation) (rocks of the high cliff headland north of the village) which lie unconformably on Lower Jurassic shales (Whitby Mudstone Formation). The shales are exposed as a wave cut platform, dipping at 2^{o} in a southerly direction, at the front of the cliffs along the north of the bay. The map indicates a north-south trending fault passing beneath the village and across the upper beach area to the south, with down throw and inclination to the west.

2.3 Groundwater Regime

Hydrogeology

The Groundwater Vulnerability Map (Sheet 9) of North East Yorkshire has classified the area as a Non-Aquifer because of their negligible permeability. These formations are generally regarded as containing insignificant quantities of groundwater. However, groundwater flow through such soils, although imperceptible, does take place and needs to be considered in assessing the risk associated with persistent pollutants. Some Non-Aquifers can yield water in sufficient quantities for domestic use. Major and Minor Aquifers may occur beneath Non-Aquifers.

2.4 Instrumentation

2.4.1 *Definition of Existing Problems*

Since the failure mechanisms affecting the old sea-wall and car parks were identified during the late 1990's, remedial works were instigated and completed in 2001.

The reduction in the rate of displacement of the land-slipping is evidence that the permanent works which comprised of drainage and earthworks, undertaken on the slopes to the north of and at the toe of the slopes below Ings End, have had a positive effect upon increasing slope stability. The greater significance has been the re-orientation of the vector angle of slope movement in a clockwise direction, in a more easterly direction. It is envisaged that following prolonged periods of heavy rainfall, the slopes would continue to fail. However, the probability and risk to village infrastructure of deep seated failures occurring in the future is considered low due to the stabilising effects of the piling and earthworks.

2.5 Monitoring Regime

2.5.1 *Recommended Monitoring Regime*

As a consequence of the analysis and interpretation of monitoring data and reports made available by SBC, a regime of future monitoring was formulated. These recommendations have been reported in Mouchel Report "*Analysis and Interpretation of Coastal Monitoring Data" 721228/001/GR/01/02/FINAL.*

The recommendations for Runswick Bay were that a regime of regular monitoring and inspection be undertaken at six monthly intervals (bi-annually). This should be carried out over a period of three years to retrieve long term data for analysis in order to determine any seasonal patterns of rainfall, ground water levels and ground movements. The monitoring encompasses recording readings of inclination in two directions (A0 and A180) within the inclinometer tubes and also monitoring groundwater levels.

2.5.2 Ongoing Monitoring Regime

The ongoing monitoring regime was initialised in July 2009 and follows that detailed in Section 2.5.1, above. Following on from the findings of the *Condition Survey Report,* the monitoring regime consists of existing inclinometers (A001, A002, A003 and A004) located along the edge of the main access road leading down into Runswick village. Groundwater was measured with a dip meter.

2.5.3 Ongoing Monitoring Results

Inclinometer Readings

Monitoring inclinometers has been undertaken in accordance with the procedures detailed in Section 1.4 of this report. Monitoring at Runswick Bay has taken place on two occasions, the first in July and a repeat visit in December 2009. The initial visit collected ‘baseline’ readings against which all successive readings are compared. The latest readings indicate some movement has occurred within inclinometers installed at A001 and A004. Within A001, 5mm of movement has been indicated between 22.0 and 20.0 metres depth and in A004; 5mm movement is indicated from 10.0m depth increasing to 15mm at 2.0m depth. In each installation the ground movements are indicated as taking place in a down slope direction.

Inclinometer readings are presented in Appendix B of this report.

Groundwater Readings

Groundwater levels were recorded during the Condition Survey (16th June 2009), the initial Full Suite Monitoring readings (9th July 2009), the Second Full Suite Monitoring (8th December 2009) and 11th January 2010. A comparison of the readings shows groundwater levels have changed very little over this period, the maximum difference of 110mm recorded in A004 (BH3) between July and December 2009. Ground water levels within A001 and A004 have increased since December by up to 0.09 metres, while decreases in water levels have been recorded in the remainder inclinometers. Groundwater data graphs are presented in Appendix C.

2.6 Conclusions

Inclinometer instrumentation was installed within selected piles of a portal frame shear key system which was constructed as part of remedial works to restrict ground movements within the Runswick Bay area. Inclinometers were installed in piles in order to measure shear stresses within them caused by ground movements. Within Report No. 136 (from SBC) reference has been made to the determination of the piles response to loading from successive inclinometer readings. It has not been stated how this was to be done or how it was to be achieved. To date, Mouchel Ltd have been made aware by the Client that this information is not available and therefore no further comment can be made relating to this. Therefore, initial and successive inclinometer readings are only related to any general ground movements indicated by instrument readings.

Groundwater levels recorded from the inclinometers have remained relatively stable over the period of monitoring. This would be expected given that the instruments are installed within concrete piles of unknown diameters and as such are isolated from the natural groundwater regime prevailing at this site.

Monitoring at Runswick Bay has followed the recommended regime of monitoring and has taken place on two occasions following on from initial ‘baseline’ readings recorded in July 2009. Successive readings taken in December 2009 indicated some movement had occurred within inclinometers installed at A001 and A004. Within A001, 5mm of movement was indicated between 22.0 and 20.0 metres depth and in A004; 5mm movement is indicated from 10.0m depth increasing to 15mm at 2.0m depth. Readings recorded in January 2010 indicated this movement was repeated although to a lesser degree of 2-3mm between 22.0 and 20.0 metres depth. In each installation the ground movements were indicated as taking place in a down slope direction. The results from monitoring the inclinometers A002 and A003 have so far shown that no movement has taken place within the vicinity of these instruments.

As the instrumentation at this site was being monitored at a frequency of six-monthly intervals and in light of the detected ground movements reported from previous monitoring visits (December 2009 and January 2010), it was recommended that Runswick Bay site should be monitored more frequently, on a monthly basis, for a minimum period of six months. With additional monitoring events, this would provide monitoring results covering the period December 2009 to July 2010 on which to analyse the nature and rates of ground movements occurring at Runswick Bay.

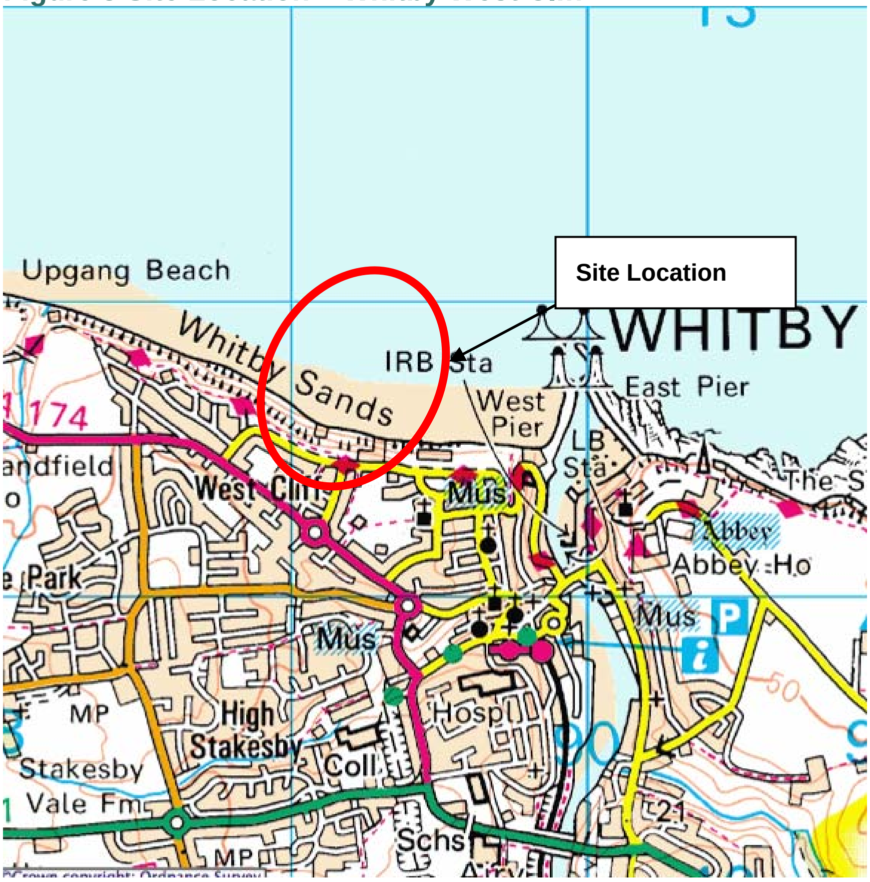
3 Whitby West Cliff

3.1 Site Location and Description

Whitby is located on the north east coast of England approximately 30 miles south of the industrial town of Middlesbrough and 20 miles north of Scarborough. West Cliff is part of a long stretch of exposed cliffs running west-east forming protected soft, glacial till cliffs to the west of Whitby harbour and, further west towards Sandsend the coastline is formed of unprotected soft, glacial till cliffs.

The West Cliff site is bounded by The Spa complex to the east and the Cliff Lift towards the west. The natural slope morphology of the protected cliffs has been modified by several phases of slope stabilisation works which included drainage and slope re-profiling that has been undertaken since the 1960's. The slopes attain a height of up to 40-45 metres at slope angles of 25 to 35 degrees. Set back approximately 10 metres from the crest of the slopes is a main road (North Terrace) and beyond this are large terraced, residential and commercial properties. The faces of the slopes are criss-crossed by pedestrian footpaths which give public access from the top of the cliffs to the beach below. Other features present over the slopes are low retaining walls, gabion walls and relict slip failure scars. At the base of the slopes is a sea wall with a promenade, forming a sea defence, with a wide sandy beach foreshore.

Figure 3 Site Location – Whitby West Cliff



3.1.1 *Historic Review of Problems*

There is evidence of small scale failures along much of the coastal section being investigated, both in the past and at present. The first sections of coastal defences along this stretch of coast were constructed in the 1930's. These defences comprised vertical concrete and masonry seawalls with a promenade, slipways and access ramps to the beach, possibly founded on glacial till materials. Slope stabilisation measures involving slope re-profiling, placement of gabion baskets and drainage improvements have been undertaken over the coastal slopes of West Cliffs in an attempt to reduce the probability of slope instability occurrences since the late 1960's.

3.1.2 *Existing Information*

A number of reports were provided by SBC for consultation, these are detailed in Mouchel Report "*Analysis and Interpretation of Coastal Monitoring Data" 721228/001/GR/01/02/FINAL, pp33-34.* Additional reports were presented by SBC for further consultation for the Ongoing Analysis. This data has been placed on an Arcview GIS layer for ease of use and availability.

3.2 Stratigraphy

The 1:50,000 British Geological Survey (BGS) Sheet 35 Solid & Drift, Whitby indicates the site to be underlain by glacial till of Devensian (Quaternary) age. The glacial till is typically comprised of over-consolidated, red-brown sandy silty clays with lenses and discontinuous beds of sands and sandy silts. Within the protected cliffs along West Cliff, there is a persistent mid-slope exposure of fluvio-glacial sand and gravels up to 5 metres in thickness. The underlying solid geology is indicated as the Middle Jurassic Scalby Formation, consisting of limestone, sandstone and mudstone.

3.3 Groundwater Regime

Hydrogeology

The Groundwater Vulnerability Map (Sheet 9) of North East Yorkshire has classified the area as a Minor Aquifer, overlain by soils of intermediate class 1. Soils of class I1 are those possibly able to transmit a wide range of pollutants. Minor Aquifers are variably permeable rocks, usually fractured rocks with a low primary permeability or unconsolidated deposits. They rarely produce large quantities of water for abstraction but often provide important base flow supplies to rivers. Major Aquifers may occur beneath Minor Aquifers.

3.4 Instrumentation

3.4.1 Definition of Existing Problems

The West Cliff area has been modified by slope stabilisation measures which included the re-grading of slopes and the installation of drainage, carried out during the 1960's and 1970's. These remedial works are now showing signs of distress and appear to be near the end of their design life-cycle. During a site walkover there was evidence of slope instability with visible back scars on the slopes and cracks present in the footpaths; drainage problems were also evident as seepages emanating from retaining walls. However, it is not known whether the seepages were from slope drainage or burst water pipes.

The existing problems on site relate to the instability of the glacial till slopes of West Cliff site which have been the subject of modifications by remedial works over a period of seventy years. The slopes are susceptible to shallow failures of varying size and extent, being 1 to 2 metres in depth and up to 5 metres in extent. Their size has often been determined by the spacing of vertical drainage. Without remedial measures, small and medium sized slope failures can develop into more serious deep-seated failures which may cause substantial damage and cliff top recession leading to the loss of amenities and possible danger to the public.

3.5 Monitoring Regime

3.5.1 Recommended Monitoring Regime

As a consequence of the analysis and interpretation of monitoring data and reports made available by SBC, a regime of future monitoring was formulated. These recommendations have been reported in Mouchel Report "*Analysis and Interpretation of Coastal Monitoring Data" 721228/001/GR/01/02/FINAL.*

The recommendations for Whitby West Cliff were that a regime of regular monitoring and inspection should be undertaken at monthly intervals for six months then reverting to bi-annual intervals for the remaining two and a half years if no significant movement is detected.

A line of survey pins was installed at 5 metre intervals down the line of the slope from beyond the crest and in line with the existing inclinometer (BH2). The survey stations are to be measured initially at a monthly frequency for six months to build up base data. If there is no significant movement (<5 mm) between each survey point, (between each monitoring event) then the frequency will be reduced to that in line with the inclinometer monitoring i.e. on a bi-annual frequency.

3.5.2 Ongoing Monitoring Regime

The ongoing monitoring regime was initialised in July 2009 and follows that detailed in Section 3.5.1, above. Following on from the findings of the *Condition Survey Report*, monitoring consists of a single inclinometer (B001 / BH2) located within a path near the base of the coastal slope of West Cliff and the monitoring of surveying points. Groundwater was measured with a dip meter.

3.5.3 Ongoing Monitoring Results

Inclinometer Readings

Monitoring of inclinometers has been undertaken in accordance with the procedures detailed in Section 1.4 of this report and are presented in Appendix B. Readings have so far shown that little or no ground movements have occurred within the slopes around BH2 at West Cliff.

Groundwater Readings

Groundwater levels have been recorded on a monthly basis from the Condition Survey (16th June 2009) up to January 2010. From an initial reading of 7.73 metres, consecutive readings have recorded successive rises in water levels of +900mm, +130mm, +110mm, +450mm, +460mm and +480mm. Given that the tidal position is known and observed at the time readings were taken, this data can be interpreted as reflecting the changes in tidal levels at the time of monitoring and not indicative of the groundwater regime. Groundwater data graphs are presented in Appendix C.

Survey Point Readings

A single line of 6 No. survey pins were set out from the crest extending down slope to borehole BH2 in order to supplement the monitoring of any slope movements at these locations. The pins were surveyed monthly between July and December and showed that over a distance of 49metres, -7mm of surface movement had occurred during that period. The survey points are to be monitored next in June 2010. The readings from the survey points are presented in Appendix D.

3.6 Conclusions

Monitoring data from the inclinometer in BH2 has so far shown no discernible ground movements within the coastal slopes at West Cliff. A slight deviation was evident in the second set of inclinometer readings and was interpreted as being attributed to the use of a different probe for the recording of readings rather than an indication of ground movements. Successive readings recorded between October 2009 and January 2010 confirm this to be the case as these plots follow the first set of readings and therefore indicate that no ground movements have occurred. The inclinometer data, recorded so far, currently indicate the slopes within the vicinity of BH2 to be in a stable state.

Groundwater levels within BH2 are considered to be influenced by and reflect the changing tidal regime rather than that of a prevailing groundwater regime. Successive results would seem to confirm this as the tidal condition is know and observed at the time readings are recorded.

Previous inclinometer data (22 March 2001 to 28 November 2005) illustrated the occurrence of surface creep taking place within the top metre of ground. Although current inclinometer readings do not reflect this type of movement (showing -6mm movement between November and December 2009), ground movements of up to +13mm, in a down slope direction, were recorded by survey pins within the surface of the slopes between October and November 2009. During the previous period, from September to October, a difference of +11mm was recorded illustrating that there is some differential fluctuation in ground movements. The total recorded movement within the slope is -7mm, measured between July and December 2009. The variation in spacing between the survey pegs could be accounted for by seasonal temperature fluctuations and / or inaccuracies in measuring.

Due to the limited coverage of the site offered by the single inclinometer, there is the possibility of undetected ground movements occurring elsewhere along West Cliff.

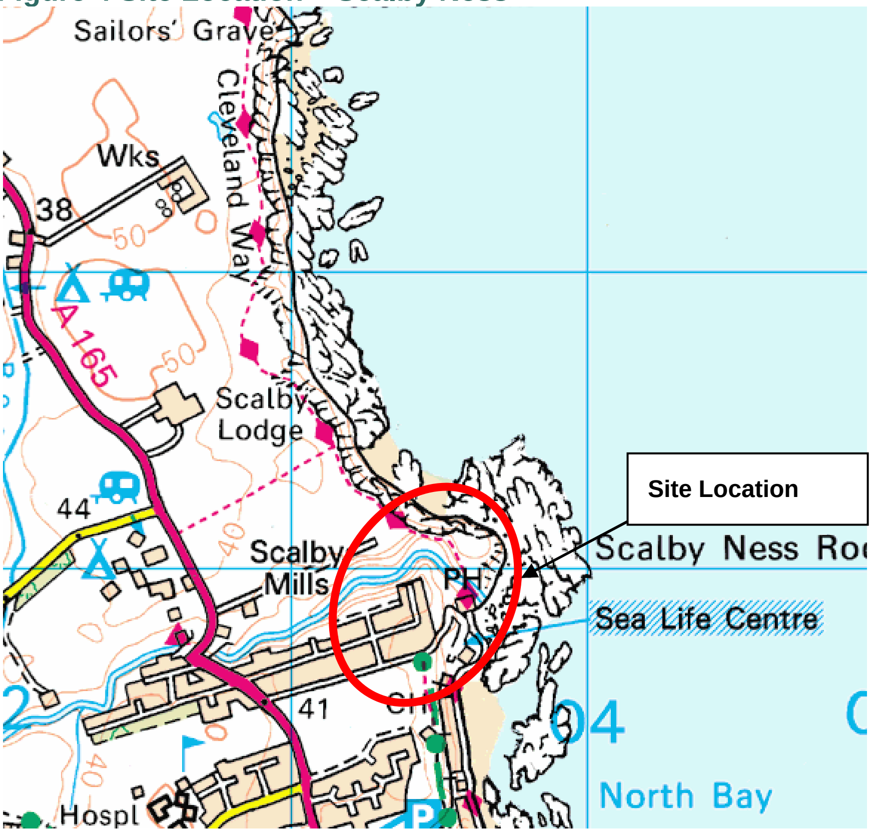
4 Scalby Ness

4.1 Site Location and Description

Scalby Ness forms a broad promontory to the north of Scarborough North Bay, approximately 3 km north of Scarborough. The headland is incised by Scalby Beck which acts as an overflow from the River Derwent when in flood. The beck flows in an east-north easterly direction through Scalby, where at Scalby Mills it changes direction sharply through 90 degrees to flow south easterly at Scalby Ness and outfalls to the sea between Scalby Ness headland and the Sea Life Centre.

A housing development was constructed during the 1970's and 1980's on land forming a plateau approximately 25-30 m above the beck at Scalby Ness. Over-steepened glacial till cliffs are present on the north west and north east sides of the development, falling down towards the beck. The beck contributes to toe erosion of these slopes and is a contributing factor of the mechanism of slope instability. Scalby Mills Road bounds the southern edge of the north east slopes. This road was constructed to give access to the Sea Life Centre on the coast. Part of the works involved re-profiling slopes with toe protection offered by rock outcrops at Scalby Beck and emplaced toe protection around the Sea Life Centre.

Figure 4 Site Location – Scalby Ness



4.1.1 *Historic Review of Problems*

A review of the available data detailed in Section 5.1.4 covers previous ground investigations and interpretative report work on the site of Scalby Ness. An interpretation of the over-riding mechanisms acting upon the slopes has identified three landslide behavioural units.

- Behavioural Unit I (North west slopes) – Intermittently active non-circular failure within the glacial till unit, characterised by over-steepened slopes which have been subjected to shallow translational movements accompanied by localised mudslide / debris flows. The head scarp (crest) is undergoing periodic movement giving rise to blocky detachment with cracks forming in mid-slope. Active erosion at the toe is leading to unloading of the slope with a reduction of support for material above.

- Behavioural Unit II (North east slopes, northern part) – This is an episodically active unit characterised by an over-steep head scarp with cracking and shallow surface movements. A mid-slope deep seated, back-tilted block is present across the unit. The location and morphology of this block suggest that it is part of a large, ancient deep-seated translational or rotational landslide. Localised active toe unloading is present within parts of the lower slopes which are also characterised by ponding surface water, tension cracks and hummocky ground. Active toe erosion and undercutting is taking place by the tidally influenced beck, leading to loss of support to the lower slopes.

- Behavioural Unit III (North east slopes, southern part) – The slopes have been re-profiled during earthworks as part of construction works for the access road into the Sea Life Centre and car park. These slopes show no signs of instability and are currently considered to be stable.

4.1.2 *Existing Information*

A number of reports were provided by SBC for consultation, these are detailed in Mouchel Report "*Analysis and Interpretation of Coastal Monitoring Data" 721228/001/GR/01/02/FINAL, p50.* Additional reports were presented by SBC for further consultation for the Ongoing Analysis. All this data has been placed on an Arcview GIS layer for ease of use and availability.

4.2 Stratigraphy

The 1:50,000 British Geological Survey (BGS) Sheets 35 and 44 Solid & Drift, Whitby and Scalby, indicates that the site is underlain by superficial deposits of glacial till of Quaternary age. The underlying solid geology is indicated as the Long Nab Member of the Scalby Formation (Middle Jurassic) characterised by interbedded mudstones, siltstones and sandstones.

4.3 Groundwater Regime

Hydrogeology

The Groundwater Vulnerability Map (Sheet 9) of North East Yorkshire has classified the northern area of Scalby Ness as a Minor Aquifer, overlain by soils of low leaching potential. Soils of class L are those in which pollutants are unlikely to penetrate the soil layer because either water movement is largely horizontal or because they have the ability to attenuate diffuse pollutants.

Minor Aquifers are variably permeable rocks, usually fractured rocks with a low primary permeability or unconsolidated deposits. They rarely produce large quantities of water for abstraction but often provide important base flow supplies to rivers. Major Aquifers may occur beneath Minor Aquifers.

The southern part of Scalby Ness is classified as a Minor Aquifer, overlain by class HU soils. Due to the less reliable nature of data collected in urban areas, the worst case scenario is assumed and soils are classified as having a high leaching potential.

4.4 Instrumentation

4.4.1 Definition of Existing Problems

It has been known that there is a risk of slope failure on the north west and north east slopes (in Behavioural Unit I and II) of Scalby Ness if groundwater levels were to rise significantly following periods of prolonged heavy rainfall. The presence of more permeable layers of sand and gravel within the glacial tills could lead to localised failures and the possibility of this could be increased if these layers are prevented from draining freely due to slipped soils from above.

The main threat to slope instability and the assets located above results from coastal erosion of the toe and crest erosion from surface water flowing down the slopes.

Behavioural Unit III is considered to be in a stable state since undergoing re-profiling and re-grading works as part of earthworks for the access road to the Sea Life Centre.

4.5 Monitoring Regime

4.5.1 Recommended Monitoring Regime

As a consequence of the analysis and interpretation of monitoring data and reports made available by SBC, a regime of future monitoring was formulated. These recommendations have been reported in Mouchel Report "*Analysis and Interpretation of Coastal Monitoring Data*" *721228/001/GR/01/02/FINAL.*

The recommendations for Scalby Ness were that a regime of regular monitoring and inspection be undertaken at three monthly intervals. Monitoring is to be carried out over a period of three years to retrieve long term data for analysis in order to determine any seasonal patterns of rainfall, ground water levels and ground movements. In addition to this, survey pins set out at four locations on the upper plateau area have been monitored at monthly intervals for six months up to December 2009 and then bi-annually for the remaining two and a half years.

4.5.2 Ongoing Monitoring Regime

The ongoing monitoring regime, initialised in July 2009, follows that detailed in Section 4.5.1, above. Following on from the findings of the *Condition Survey Report*, monitoring at Scalby consists of 3no. inclinometers (I1, I2 and I3) and 2no. piezometers (B6 and B9) located within the inner headland of Scalby Ness. The monitoring of the automated piezometers (P1, P2, P3 and P4) was carried out on 12th November 2009. A subsequent monitoring visit in mid-January revealed the data loggers were not functioning following a service in late November 2009. Ground water data from these instruments is not available from this date up to late January 2010 and hence there is a gap in the data set. Groundwater data graphs are presented in Appendix C.

4.5.3 Ongoing Monitoring Results

Inclinometer Readings

Monitoring inclinometers has been undertaken in accordance with the procedures detailed in Section 1.4 of this report and are presented in Appendix B of this report. Readings from the inclinometers have so far illustrated that little, if any, ground movements have occurred since monitoring began in July 2009.

Groundwater Readings

Groundwater levels were recorded during the Initial Full Suite Survey (16th July 2009), during the Fourth Restricted Suite monitoring (11th November 2009), the Second Full Suite on 8th December 2009 and 11th January 2010. In general, groundwater levels recorded at locations across the site are indicated as having risen by levels ranging from 0.04m to 0.76m between December 2009 and January 2010. At instruments I1 and B6, decreases in water levels were noted in the magnitude of 0.38 m and 0.01m, respectively. Rainfall data revealed that rainfall from March to June 2009 was lower than average ranging between -5% and -52% less and August was also drier than average with -61% less rainfall. Groundwater data would seem to highlight the lower than average amounts of rainfall recorded over a similar period of time from July to September.

Piezometric data has been downloaded from data loggers operating within P1, P2A, P3 and P4 and made available by SBC. Groundwater level details have been recorded by the instruments at six hourly intervals from the date of installation 29th June 2004 up to 5th November 2009. Further data from these instruments is not available from this date up onwards due to a malfunction of the loggers. Within the upper piezometers, it can be seen that groundwater levels are similarly affected by rainfall. At various times over the monitoring period, peaks in groundwater levels have been experienced. An analysis of rainfall data shows that peaks in groundwater levels have been preceded by periods of precipitation which have resulted in raised groundwater levels. This phenomenon is clearly illustrated in graphical data from BH P4 where the peaks and troughs of groundwater levels are more pronounced than in other graphs. The piezometers, within this borehole, have been installed at shallower depths than the other instruments and are therefore more sensitive and responsive to groundwater fluctuations.

Groundwater levels within the lower piezometers of P1 (Tip at 18.12mAOD), P2 (Tip at -0.75mBOD) and P3 (Tip at 9.80mAOD), installed to target a lower water table; have remained reasonably constant over the monitoring period. Within P1 the recorded water levels have remained fairly constant at a level of approximately 17.20mBGL. A similar situation can be seen within P2 and P3 where the lower piezometer has recorded regular groundwater levels at approximately 33.50mBGL and 16.10mBGL, respectively within separate water tables. Groundwater data graphs are presented in Appendix C.

Survey Point Readings

Survey pins were set out at four locations on the upper plateau area around the existing houses, some distance from the slope crest. Measurements are taken, in the same direction at each event, from these points to the slope edge in order to monitor cliff recession rates and slope movements at these locations. Readings are presented in Appendix D.

4.6 Conclusions

The survey pins have been measured at monthly intervals from July to December 2009. A comparison of the measurements taken from stations (MP1, MP2, MP3 and MP4) showed that zero cliff recession rates had occurred during the period August to November. At recession point MP3 a cliff recession rate of 10mm was noted to have occurred between July and August, though zero recession rates have been recorded from August onwards.

An analysis of the groundwater data and available rainfall data illustrates peaks in groundwater levels have been preceded by periods of precipitation which have resulted in raised groundwater levels. This is clearly illustrated in graphical data from the shallow piezometers of P1, P2, P3 and P4 where the peaks and troughs of groundwater levels are more pronounced than in other graphs of deeper instruments. The lower instruments of P1, P2 and P3 have been installed to target a deeper water table below the site which has remained at approximately the same level throughout the period of monitoring and is not so susceptible to variable rainfall.

The results of inclinometer monitoring indicate both slopes are relatively stable although it is very evident that the higher rainfall of autumn / winter months has lead to some increased activity of slope instability. Due to the limited coverage of the site offered by the reduced number of instruments, there is the possibility of undetected ground movements occurring elsewhere, particularly below the plateau area, where the majority of instruments are recorded as having failed.

A walk-over survey of the plateau area and surrounding slopes was carried out in early January 2010. The over-steep headscarps of the north west slopes display refreshed spalling and some block failure at the crest of the slopes and, the surfaces of the headscarp clays are heavily desiccated and cracked. Immediately below the headscarp the fresh deposits of soil present have left the slopes exposed with no vegetation protection. There is evidence of tension crack development in the slopes with localised slumping of materials and soil creep from above and vegetation disturbance associated with this.

On the north east over-steepened slopes, fresh spalling and minor slumping (Appendix H, Plate 13 and 14) has occurred immediately below the headscarp although not to the same extent as the north west slopes. In the mid-slope area large ponds of rain water have formed between the backscarp and the mid-slope deep seated, back-tilted block (Appendix H, Plate 17) and widened tension cracks accompanied by slope collapse were observed lower down the slopes (Appendix H, Plate 15 an 16). It is evident that recent periods of heavy rain have resulted in some degradation of the slopes of Scalby Ness.

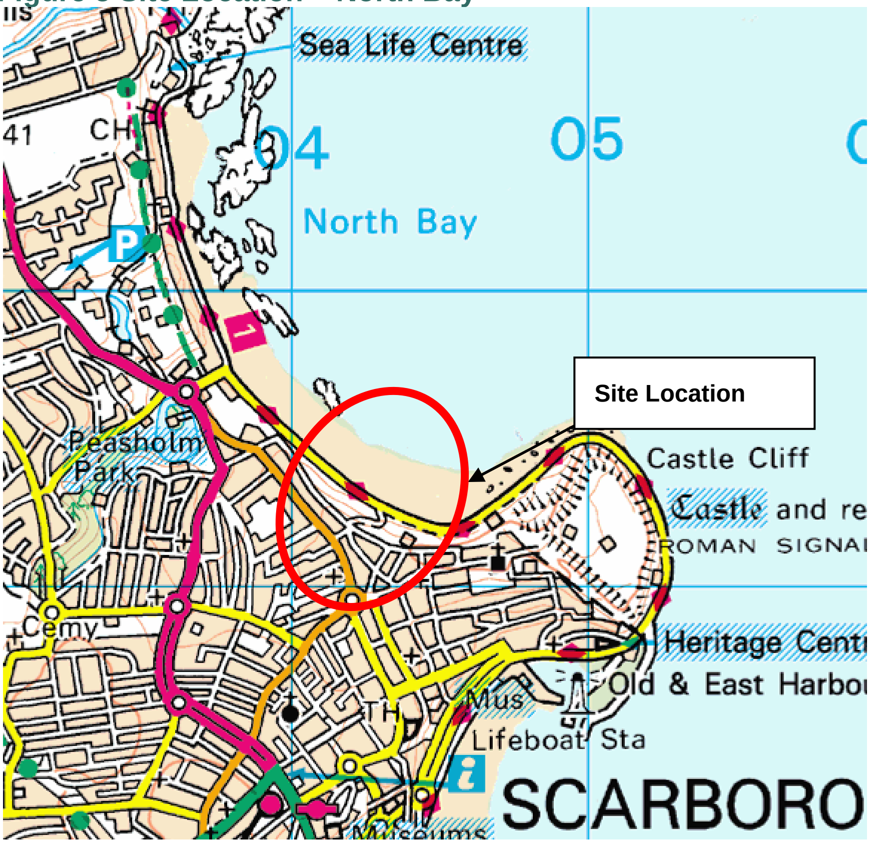
Weathering of the soils leads to a reduction in shear strength and with cohesive soils this can be accompanied by a loss of strength. On un-vegetated slopes the weathering processes are increased. An increase in pore pressures within the slopes can also lead to a decrease in the stability of the slopes by causing a reduction in shear strength. Such effects are more pronounced during periods of intense, heavy rainfall and where such an event follows a dry period this can cause a sudden increase in pore water pressures in the slopes. Any desiccation and tension cracks which may have developed will permit the ingress of rainwater into the slopes quickly leading to slope instability.

5 Scarborough North Bay

5.1 Site Location and Description

North Bay is one of two bays either side of a headland around which the town of Scarborough has developed on the north east coast of Yorkshire. North Bay extends from Castle Cliff northwards to Scalby Ness. The site is known as The Holms, an area of sloping, open parkland between the Castle above and Royal Albert Drive (Marine Drive) along the coast. The parkland consists of open grassed areas with groups of semi-mature trees and shrubs and, meandering tarmac footpaths which increase in steepness from the sea front leading up to the south western flanks of Castle Headland. Discrete rock outcrops are clearly visible across the slopes.

Figure 5 Site Location – North Bay



5.1.1 Historic Review of Problems

In 2000, a 200mm displacement of the seawall was monitored. These movements were caused by the widespread reactivation of a deep-seated, pre-existing landslide system at The Holms. Although this caused extensive damage to footpaths and cracking of the seawall, movements were relatively minor, with ground displacements of the main landslide body probably in the order of 10's of centimetres. Following this event, a programme of

Preventative Emergency Works was undertaken in 2000-2001. This pre-empted the main works of improvement and reconstruction of the seawall defences under the Coastal Protection Scheme.

The underlying landslide system comprises 10 to 17 metres of landslide debris overlying intact Scalby Formation of inter-bedded sandstone, siltstone and mudstone. Two units have been identified from ground investigations carried out in 2000.

- An eastern unit, comprising of a deep-seated landslide which 'daylights' close to foreshore level.

A western unit, composed of a shallower landslide which 'daylights' approximately 1.50m above Marine Drive.

5.1.2 *Topography and Geomorphology*

The Holms is an area of public open space laid over to informal gardens with a network of tarmac footpaths which provide access from the sea front to the Castle Headland above. The slopes are heavily terraced, displaying hummocky, irregular ground comprising glacial till and possible landslide debris with a mid-slope bench feature dominating the slopes. The glacial slopes rise from Marine Drive, approximately 7.0mAOD, at angles of 20-35 degrees to a mid-slope bench and terrace at 35.0mAOD, beyond this plateau the slopes, composed of rock debris and scree, rise to approximately 50 to 55.0mAOD to near shear cliff faces. These cliff faces rise to the pinnacle (83.31mAOD) of Castle Hill on which the remains of Scarborough Castle are apparent. A thin mantle of top soil, up to 0.17m thick directly overlying bedrock, is present in the mid-slope plateau of the site where glacial till is absent. Glacial till is present over the remainder of the site varying in thickness between 16.0m in the west section and 2.50m-2.95m in the eastern section. Outcrops of the Cornbrash Limestone Formation are prominent on the lower and middle slopes of The Holms.

5.1.3 *Existing Information*

A number of reports were provided by SBC for consultation, these are detailed in Mouchel Report "*Analysis and Interpretation of Coastal Monitoring Data" 721228/001/GR/01/02/FINAL, pp67-68.* Additional reports were presented by SBC for further consultation for the Ongoing Analysis. All this data has been placed on an Arcview GIS layer for ease of use and availability.

5.2 Stratigraphy

The 1:50,000 British Geological Survey (BGS) Sheets 35 and 44 Solid & Drift, Whitby and Scalby, indicate that the northeast of the site is underlain by superficial deposits of glacial till of Quaternary age. This directly overlies

Scalby Formation deposits of mudstones and sandstones. A north west –south east trending fault and a north – south trending fault gives rise to glacial tills underlying Oxford Clay, which in turn overlies the Hackness Rock Member sandstones of the Osgodby Formation. The Scalby Formation sandstones and mudstones are unconformably overlain by the Cornbrash limestones and the Osgodby Formation. The strata generally dip at an angle of 7 degrees in a south easterly direction.

5.3 Groundwater Regime

Hydrogeology

The Groundwater Vulnerability Map (Sheet 9) of North East Yorkshire has classified the area as a Minor Aquifer, overlain by class HU soils. Due to the less reliable nature of data collected in urban areas, the worst case scenario is assumed and soils are classified as having a high leaching potential. Minor Aquifers are variably permeable rocks, usually fractured rocks with a low primary permeability or unconsolidated deposits. They rarely produce large quantities of water for abstraction but often provide important base flow supplies to rivers. Major Aquifers may occur beneath Minor Aquifers.

5.4 Instrumentation

5.4.1 Definition of Existing Problems

Widespread reactivation of a deep-seated landslide system at The Holms occurred during 2000. This caused extensive damage to footpaths and cracking of the seawall. Ground displacements of the main landslide body were in the region of 10's of centimetres although monitoring of the seawall revealed movements of 200mm had occurred.

Additional installations comprised of 3no. inclinometers and 4no. piezometers located on slopes above The Oasis Café, North Bay were included in the monitoring regime in August 2009. Instruments have been installed in the slopes above and behind a café that is to be re-built 20 metres away from the existing one. Part of the construction process involved excavating material from the base of the slopes, partially unloading the toe with the possibility of destabilising the slopes. Hence, instrumentation was installed in order to monitor the condition of these slopes. Inclinometer I1 was lost to construction works (in early January 2010) of the proposed new café adjacent to the existing Oasis Café and is no longer available for monitoring.

5.5 Monitoring Regime

5.5.1 Recommended Monitoring Regime

As a consequence of the analysis and interpretation of monitoring data and reports made available by SBC, a regime of future monitoring was formulated. These recommendations have been reported in Mouchel Report "*Analysis and Interpretation of Coastal Monitoring Data" 721228/001/GR/01/02/FINAL.*

Due to the lack of valid continuous data from the installed piezometers, it has been recommended that piezometer monitoring is reinstated. Inclinometer and piezometer monitoring is to be carried out at monthly intervals for six months then every two months until month twelve. If no significant movement is revealed during this twelve month period then monitoring should revert to six monthly intervals (bi-annually) for the remaining two years.

5.5.2 Ongoing Monitoring Regime

The ongoing monitoring regime was initialised in July 2009 and follows that detailed in Section 5.5.1, above. Following the findings of the *Condition Survey Report*, monitoring consists of groundwater readings from 3no. piezometers and 2no. inclinometers (located within the grounds of The Holms) and 2no. inclinometers located atop the cliffs above The Holms.

Inclinometers L4 and L6 at The Holms were located by SBC staff although the integrity of these was such that they were unsuitable for monitoring purposes other than to provide monitoring data for groundwater levels.

Additional installations comprising 3no. inclinometers and 4no. piezometers located on slopes above The Oasis Café, North Bay were included in the monitoring regime in August 2009. Inclinometer I1 was lost to construction works (in early January 2010) of a new café adjacent to the existing Oasis Café and is no longer available for monitoring.

5.5.3 Ongoing Monitoring Results

Inclinometer Readings

Inclinometers L4, L6, L11 and L12 and slip indicator in N2 have been proved to be blocked at various depths and hence, readings have not been retrieved from these instruments. Inclinometer I1 was lost to construction works in early January 2010 . Inclinometers (I3 and I4) above The Oasis Café continue to be monitored within the regime of North Bay.

Groundwater Readings

Groundwater levels were recorded at monthly intervals from the Initial Full Suite Survey (15th July 2009) up to January 2010. Groundwater levels recorded over this period show very little fluctuation although a variance of 5.67m has been recorded in L1 (b) which is attributed to changes in tidal levels. Also, within L11 and L12 a variance in groundwater levels of 4.77m and 1.85m, respectively was recorded over this same period. Groundwater data graphs are presented in Appendix C.

5.6 Conclusions

The wide fluctuation of groundwater levels within L11 and L12 may be the result of surface water run-off which has infiltrated the installations and affected water level readings. Groundwater levels within borehole L1 would appear to be affected by tidal influences.

Previous monitoring data from inclinometers BH1 and BH4, around the café have illustrated 'apparent' movement occurring within the slopes above the cafe area. This apparent movement has been attributed to inaccuracies in the data sets arising from the use of two different inclinometer probes (different calibration values) for separate monitoring events. Successive inclinometer data graphs have somewhat deviated from baseline readings giving the impression that ground movements have occurred. Inclinometer readings from BH3 do not illustrate this as a single probe was used to record all data.

The results of inclinometer monitoring undertaken so far indicate the slopes above the Oasis Café are presently in a stable condition within the vicinity of the inclinometer instruments. However, there is evidence of limited shallow ground movements (surface creep) within the slopes as shown in BH4.

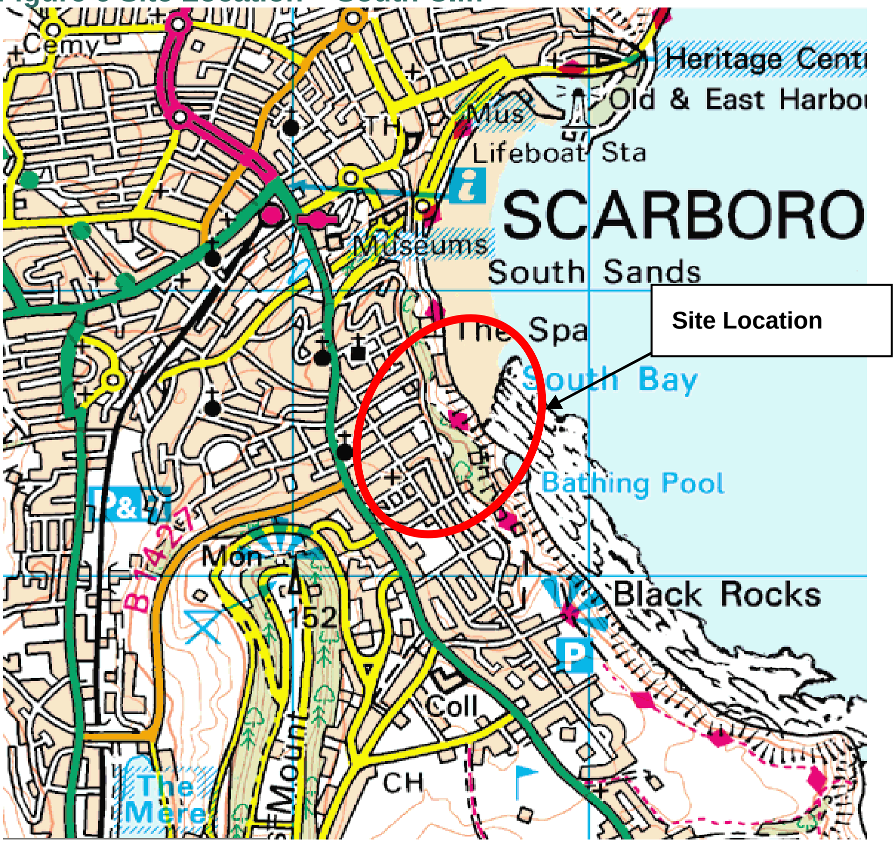
Due to the limited coverage of the site offered by the inclinometers at Oasis Cafe, there is the possibility of undetected ground movements occurring elsewhere in North Bay. Instrumentation in The Holms area has been recommended to be installed in order to provide information to identify shearing on potential failure surfaces at depth.

6 Scarborough South Cliff

6.1 Site Location and Description

Scarborough is a popular sea-side resort located on the north east coast of England. The South Cliff occupies the southern bay of Scarborough town with a gently sweeping coastline from the northern promontory of Castle Hill to the Black Rocks some 2km southwards. The South Cliff site comprises a variety of landscaped gardens stretching from north to south in the following order: Spa Chalet Cliff, Spa Cliff, Prince of Wales Cliff, South Cliff Gardens, Rose Gardens, South Bay Pool Cliff, Holbeck Gardens, Holbeck Cliff and Wheatcroft Cliff. The cliff top is a gently undulating plateau surface with a road, Esplanade Crescent, running parallel to the cliff line. Large houses and hotels line the landward side of the road, set-back generally 30metres, but up to 100metres in places, from the cliff edge.

Figure 6 Site Location – South Cliff



6.1.1 Historic Review of Problems

The cliffs of Scarborough's south bay are formed from glacial till slopes of varying thickness, underlain by Jurassic sandstones and siltstones, which are prone to landsliding. All of the cliffs along this section have toe protection provided by seawall / coastal defences, but localised activity on the slopes and head scarps is common. At the Spa Cliffs, South Cliff Gardens and South Bay Pool the cliffs comprise steep rear scarps, forming arcuate embayments up to 200metres in width, with gentle sloping stepped slopes at the base. Geomorphological features such as the steep rear scarps and mid-slope benches, present at these gardens, possibly display the remnants of historic deep-seated retrogressive rotational failures within the glacial tills. At Holbeck Cliff, the 1993 landslide involved a complex series of retrogressive displacements which overwhelmed the seawall and extended 150metres across the foreshore.

The remaining sites present between those mentioned above consist of Spa Chalet Cliff, Prince of Wales Cliff, Rose Gardens, Holbeck Gardens and Wheatcroft Cliff. These sites represent intact coastal slopes which are subjected to localised small-scale shallow slope failures within the glacial tills due in part to increases in porewater pressures which lead to softening of and a decrease in shear strength of the tills. Such failures result in disrupted footpaths and minor damage to other structures and could be expected to occur on a yearly basis.

6.1.2 Site Walk-over

A site walkover was conducted by a geotechnical engineer from Mouchel on 27th November 2008 and in early June 2009 as part of the Condition Survey. The Condition Survey (Mouchel Report No. 721229/001/CSR/02/FINAL, July 2009) was conducted in order to provide factual information on the existence, condition and functionality of the four inclinometer installations. The instruments were recorded as being in good working order and as such, they were deemed to be of use in providing useful ongoing data for recording ground movements where this phenomenon is occurring.

6.1.3 Topography and Geomorphology

Late Devensian age glacial tills have been emplaced across much of the landscape composed of Jurassic sedimentary rocks (predominantly sandstones and siltstones). These tills include stiff silty sandy clays, sands and gravels and, laminated silty clays. At South Cliff, the till has completely in-filled a pre-glacial valley and now the whole cliff profile has developed in these glacial tills attaining a height of between 50m and 65m. The glacial till slopes have been subjected to coastal protection measures, landscaping and drainage improvements since becoming the property of SBC in the late 19th century.

The South Cliff is occupied by a series of terraced gardens developed into glacial till slopes of varying thickness underlain by Jurassic sandstones and siltstones. At the Spa Cliffs, South Cliff Gardens and South Bay Pool the cliffs comprise steep rear scarps, forming arcuate embayments up to 200metres in width, with gentle sloping stepped slopes at the base. At other areas of the garden complex the landscaped slopes attain angles of up to 40 degrees becoming steeper at the base and are criss-crossed by a network of footpaths, bench-cut into the slopes and supported by small walls and revetments. A concrete seawall and promenade has been built along the base of the cliffline from Spa Chalet Cliff to Holbeck Cliff where in the absence of a seawall, a rock armour revetment was constructed to replace the seawall destroyed in 1993 by a landslide. A variety of buildings occupy sites within South Cliff from the Spa Complex and Ocean Ballroom constructed at the base of Prince of Wales Cliff, a cliff railway operating from cliff top down slope to the Spa complex and, a swimming pool and a series of chalets at South Bay Pool Cliff.

6.1.4 Existing Information

A number of reports were provided by SBC for consultation, these are detailed in Mouchel Report "*Analysis and Interpretation of Coastal Monitoring Data" 721228/001/GR/01/02/FINAL, pp80-81.* Additional reports were presented by SBC for further consultation for the Ongoing Analysis. All this data has been placed on an Arcview GIS layer for ease of use and availability.

6.2 Stratigraphy

The 1:50,000 British Geological Survey (BGS) Sheet 54 Solid & Drift, Scarborough indicates that the site is underlain by superficial deposits of Quaternary glacial till comprising stony clay, underlain by Oxford Clay of up to 36-76 metres in thickness. This overlies Osgodby Formation calcareous sandstones above undifferentiated strata of the Cayton Clay Formation and Cornbrash Formation consisting of limestones and mudstones. An unconformity separates this stratum from the underlying Scalby Formation mudstones and sandstones. The Scalby Formation is underlain by the Scarborough Formation limestones and mudstones, which outcrop as the Black Rocks of the South Bay foreshore.

6.3 Groundwater Regime

Hydrogeology

The Groundwater Vulnerability Map (Sheet 9) of North East Yorkshire has classified the area as a Minor Aquifer, overlain by class HU soils.

Due to the less reliable nature of data collected in urban areas, the worst case scenario is assumed and soils are classified as having a high leaching potential. Minor Aquifers are variably permeable rocks, usually fractured rocks with a low primary permeability or unconsolidated deposits. They rarely produce large quantities of water for abstraction but often provide important base flow supplies to rivers. Major Aquifers may occur beneath Minor Aquifers.

6.4 Instrumentation

6.4.1 Definition of Existing Problems

Existing problems of slope failure along South Cliffs vary between and include both first-time shallow slip failures within the intact slopes and the reactivation of existing deep-seated rotational failures related to increased ground water pressures.

6.4.2 History of Monitoring

Within the various garden areas of South Cliffs, 12 no. inclinometers and 22 no. piezometers have been installed as part of eight ground investigations carried out between January 1996 and January 1998.

Monitoring data for inclinometer instruments has been provided from the instrument installation date until late September 2006. A single set of readings ('baseline') are available for 24-25 July 2006 and November 2008.

Piezometer data recording groundwater levels across the site has been recorded from the date of instrument installation up to August 2008.

Groundwater levels are available for 5 no. piezometer instruments installed around the Spa Ocean Room area. Monitoring data has been recorded from 16 January 2003 until 5 August 2008. However, no further details of ground investigation works, installation details, etc have been made available for analysis.

Crack monitoring was undertaken at several locations at the Prince of Wales Cliff gardens from installed survey pins (C21A, B and C) covering the period 21 June 2000 to 17 January 2006.

A photographic record of the sites covering South Cliffs has been undertaken on a periodic basis since June 2001 onwards. The photographs record damage caused by slope instability encompassing slip failures, back scars, cracking in paths, pavements and structural damage to footsteps and retaining walls.

6.5 Monitoring Regime

6.5.1 Recommended Monitoring Regime

As a consequence of the analysis and interpretation of monitoring data and reports made available by SBC, a regime of future monitoring was formulated. These recommendations have been reported in Mouchel Report "*Analysis and Interpretation of Coastal Monitoring Data" 721228/001/GR/01/02/FINAL.*

The recommendations for South Cliff were that a regular monitoring and inspection regime should be undertaken at monthly intervals for a period of six months and then every two months until month twelve. If no significant movement was revealed during this twelve month period then monitoring should revert to six monthly intervals (bi-annually) for a further two years.

Monitoring is being carried out over a period of three years to retrieve long term data for analysis in order to determine any seasonal patterns of rainfall, ground water levels and ground movements.

6.5.2 Ongoing Monitoring Regime

The ongoing monitoring regime was initialised in July 2009 and follows that detailed in Section 6.5.1, above. Following on from the findings of the *Condition Survey Report*, monitoring consists of five inclinometers, fourteen piezometers and three lines of survey pins (associated with boreholes H4, E3 and BH2) located within the gardens of South Cliff.

6.5.3 Ongoing Monitoring Results

The monitoring regime, based upon the findings of the *Condition Survey Report,* detailed five inclinometers and fourteen piezometers to be in a serviceable condition and have been included in the monitoring regime.

Inclinometer Readings

Monitoring of inclinometers has been undertaken in accordance with the procedures detailed in Section 1.4 of this report and are presented in Appendix B. Readings have so far illustrated the occurrence of ground movements in the form of surface creep within several inclinometers at South Cliff.

Groundwater Readings

Groundwater levels have been recorded on a monthly basis from the Initial Full Suite Survey (15th July 2009) up to January 2010. A comparison of the readings show a wide variation in depth changes illustrating variations in tidal levels and groundwater regimes active across the sites of South Cliffs. Groundwater data graphs are presented in Appendix C.

Survey Point Readings

Three lines of survey pins were set out from the crest extending down slope to boreholes H4 and E3 and, from BH2 in order to supplement the monitoring of slope movements at these locations. Readings are presented in Appendix D and photographs of the survey points are presented in Appendix E.

6.6 Conclusions

The most recent suite of monitoring data for the inclinometers and survey pins readings has generally shown that ground movements are either relatively shallow or deep in nature. In inclinometer AA04 demonstrates no movement has occurred since the last monitoring suite of December 2009. Within inclinometer AA10 ground movements of up to 4mm are apparent from 3.5 metres depth to ground level. This movement has occurred in made ground and is probably evidence of surface creep. Similarly, ground movements are evident in AA04 where 2mm of movement is illustrated from 6.5 to 6.0 metres depth within Glacial Till. Deeper ground movements are evident in AA07 where <3mm of movement is illustrated between 60.0 and 26.5 metres and also in AA11 where ground movements are evident from 19.5 to 18.5 metres and 15.5 to 14.0 metres depth.

Boreholes located behind The Spa area of South Cliffs have recorded increases in groundwater levels within several instruments of up to 410mm compared to the previous monitoring event of December 2009. Groundwater levels within BH1 and BH2 showed decreases of 0.92 metres and 0.39 metres and in BH01(a) 0.14 metres in the shallow piezometer. Water levels within the inclinometer instruments have followed a general trend of increased groundwater within the glacial till slopes. Piezometric data from (Holbeck Gardens to Prince of Wales Cliff (Areas C to G) generally shows that increases in groundwater levels have occurred as a result of high rainfall levels experienced in December 2009. Across other areas around South Cliff, piezometer readings show varying increases and decreases in groundwater levels with no particular pattern emerging.

Ground movements are evidently on-going within the slopes of South Cliff gardens. At Spa Cliff Plates 75 and 76 (Appendix E) illustrate the effects of ground subsidence where cracking has occurred in the pavement along the promenade to the south of BH01 Prom. This part of the cliff top is immediately above an arcuate embayment formed from a past deep-seated retrogressive rotational failure. This has left mid-slope benches with a steep rear scarp up to the promenade. At other locations within the gardens, there is evidence of slope movements as seen in hummocky ground in slopes, collapsed edging stones to pavements and pavement cracking (Plate 82, Appendix E). Tarmac surfaced pavements behind the Clock Café (Plates 77-80, Appendix E) display evidence of slope instability where cracked pavements are present below which the slopes display bulging and have a hummocky ground appearance.

Due to the limited coverage of the site offered by the reduced number of inclinometers and slip indicators, there is the possibility of undetected ground movements occurring elsewhere particularly along the promenade (cliff top) where the majority of instruments are recorded as having failed.

7 Filey Town

7.1 Site Location and Description

The site is located to the south and east of Filey town centre, a popular holiday resort, on the north east coast of England.

Martin's Ravine is a steep sided valley to the south of Filey, through which a footpath leads, sloping downwards from a car park to the southern end of Royal Parade and the sea. Royal Parade is a flat esplanade along the sea front extending from the south at the base of Martin's Ravine, northwards to where The Crescent approaches from above, and continues north towards Filey town centre and Church Ravine. To the rear of Royal Parade is a line of small chalets behind which is a steep slope rising up to a level grassed area (Glen Gardens). The northern edge of this area is bounded by Crescent Hill which leads off The Crescent, from the top of the recreation grounds, and winds down to join Royal Parade. A number of footpaths criss-cross the slopes allowing pedestrian access from the cliff top to the beaches below.

Figure 7 Site Location - Filey

7.1.1 Historic Review of Problems

The severe adverse impacts of an intense period of prolonged and extremely heavy rainfall, in July 2007, resulted in considerable and widespread flooding to parts of Filey. The resulting rainwater run-off caused slope failures and scour damage to riffles and bridge abutments in a stream within Martin's Ravine. Existing drain runs were damaged due to excessive rainwater around Glen Gardens and this also caused drainage to collapse leading to slope instability behind Royal Parade chalets and Crescent Hill.

7.1.2 Site Walk-over

A site walkover was conducted by a geotechnical engineer from Mouchel on 27th November 2008 and in early June 2009 as part of the Condition Survey. The Condition Survey (Mouchel Report No. 721229/001/CSR/02/FINAL, July 2009) was conducted in order to provide factual information on the existence, condition and functionality of the four inclinometer installations. The instruments were recorded as being in good working order and as such, they were deemed to be of use in providing useful ongoing data for recording ground movements where this phenomenon is occurring.

7.1.3 Topography and Geomorphology

During the last glacial period (Devensian), ice sheets spread south and east across this area to the North Sea. As these ice sheets retreated glacial till was emplaced over the landscape, formed of Jurassic rocks, completely infilling pre-glacial valleys and embayments. Filey is part of a long stretch of exposed cliffs running north-south forming protected, soft, glacial till cliffs between Church Ravine and Martin's Ravine and, further south towards Reighton the coastline is formed of unprotected, soft, glacial till cliffs. The slopes attain a height of up to 30 metres at slope angles of 25 to 35 degrees. The faces of the slopes are criss-crossed by pedestrian footpaths which give public access from the top of the cliffs to the beach below. Other features present over the slopes are benched, viewing points and relict slip failure scars with thin and bare patches of vegetation. At the base of the slopes is a sea wall with a broadwalk, forming a sea defence, with a wide sandy beach foreshore.

Martin's Ravine is bounded by steeply sided sloping edges (1v:1.5h to the north and 1v:1h to the south) and slopes downwards from a car park in the west to the sea front in the east. The side slopes measure about 12m in height at their highest point. The toe of the slope has been scoured by recent floodwater leading to more extensive slope failure at isolated locations. There is evidence of past instability at the toe of the slopes with remnants of rock armouring present in the stream bed. The presence of sheet piles, low retaining walls and lengths of culvert indicates past erosion / stability problems within the Ravine.

The eastern most edge of Glen Gardens slopes steeply (>1v:2h) down to the back of chalets along Royal Parade; the slope is 15-18m high with upper slope angles steeper than at the toe. The steep slope separating Glen Gardens and Crescent Hill has an estimated height of 14 metres and both are crossed by stepped footpaths ascending the slopes. The road at Crescent Hill slopes gently down to the sea front.

7.1.4 Existing Information

A number of reports were provided by SBC for consultation, these are detailed in Mouchel Report "*Analysis and Interpretation of Coastal Monitoring Data" 721228/001/GR/01/02/FINAL, pp107-108.* Additional reports were presented by SBC for further consultation for the Ongoing Analysis. All this data has been placed on an Arcview GIS layer for ease of use and availability.

7.2 Stratigraphy

The 1:50,000 British Geological Survey (BGS) Sheet 54 Solid & Drift, Scarborough indicates that the site is underlain by superficial deposits of glacial till (Boulder Clay) composed of stony clay. The solid succession at depth in the area is indicated as solid strata of the Kimmeridge Clay Formation of Upper Jurassic age. This typically comprises bituminous clays.

7.3 Groundwater Regime

Hydrogeology

The Groundwater Vulnerability Map (Sheet 9) of North East Yorkshire has classified the area as a Non-Aquifer because of their negligible permeability. These formations are generally regarded as containing insignificant quantities of groundwater. However, groundwater flow through such soils, although imperceptible, does take place and needs to be considered in assessing the risk associated with persistent pollutants. Some Non-Aquifers can yield water in sufficient quantities for domestic use. Major and Minor Aquifers may occur beneath Non-Aquifers.

7.4 Instrumentation

7.4.1 Definition of Existing Problems

The prevailing problems at Filey would seem to originate from the inadequacy of the existing drainage systems to cope with heavy and / or prolonged periods of rainfall. Surface water is constricted by a railway embankment trending north-south, to the west of the site. Surface water east of the embankment flows towards the coast where it is channelled and concentrated within the ravines. The erosive potential of the waters is increased by flowing down the steep gradients of the ravines resulting in undercutting of the bed of the streams and slopes and the eventual collapse of the slopes. This is coupled with surface water run-off flowing down over the slopes from plateaux north and south of the ravine.

7.4.2 History of Monitoring

Standpipe piezometers were installed in BH01 at 14.00m and BH04 at 9.00m in cohesive boulder clay, in BH02 at 2.00m in non cohesive boulder clay and in BH05B at 6.45m in made ground. Groundwater readings were taken during and after the completion of site works, up to early October 2008. Inclinometers installed in BH03 and BH06 to depths of 29.70m and 30.00m, respectively have been similarly monitored.

A photographic record of the sites covering Filey Town and The Brigg has been undertaken on a periodic basis since June 2001 onwards. The photographs record damage caused by slope instability encompassing slip failures, back scars, cracking in paths, pavements and structural damage to footsteps and retaining walls.

7.4.3 Recommended Monitoring Regime

It is recommended that a regime of regular monitoring and inspection of Filey should be undertaken at six monthly intervals (bi-annually). This should be carried out over a period of three years in order to retrieve long term data for analysis in order to determine any seasonal patterns of rainfall, ground water levels and ground movements. The frequency of walkover surveys and instrument monitoring should be increased following periods of heavy and prolonged rainfall.

7.5 Monitoring Regime

7.5.1 Recommended Monitoring Regime

As a consequence of the analysis and interpretation of monitoring data and reports made available by SBC, a regime of future monitoring was formulated.

These recommendations have been reported in Mouchel Report “Analysis and Interpretation of Coastal Monitoring Data” 721228/001/GR/01/02/FINAL.

The recommendations for Filey were that a regular monitoring and inspection regime should be undertaken at six monthly intervals (bi-annually) for a period of three years to retrieve long term data for analysis to determine any seasonal patterns of rainfall, ground water levels and ground movements.

7.5.2 Ongoing Monitoring Regime

The ongoing monitoring regime was initialised in July 2009 and follows that detailed in Section 7.5.1, above. Following on from the findings of the *Condition Survey Report*, monitoring consists of a single inclinometer and a piezometer located within Glen Gardens above the coastal slopes of Royal Parade. Piezometer instruments were located south of and also at the base of Martin's Ravine and on Royal Parade below Glen Gardens.

7.5.3 Ongoing Monitoring Results

Inclinometer Readings

Monitoring inclinometers BH03 and BH06 has been undertaken in accordance with the procedures detailed in Section 1.4 of this report and are presented in Appendix B. While undertaking this round of monitoring of the site (10th December 2009), BH03 was found to have been vandalised and has not been monitored.

Groundwater Readings

Groundwater levels were recorded during the Initial Full Suite Monitoring (8th July 2009), the Second Full Suite Monitoring (10th December 2009) and the Additional Suite Monitoring (13th January 2010). Groundwater readings from BH03 show very little change over this whole period. The largest changes in groundwater levels of 690mm, recorded in BH01, indicates an increase in the groundwater level as a response to higher levels of rainfall prior to this period of monitoring. Changes in groundwater levels (of 310mm) in BH05B reflect the tidal influence has upon the water level in this instrument. There is limited data available for BH04 due to non-location and vandalism and, BH02 has been flooded. Groundwater data graphs are presented in Appendix C.

7.6 Conclusions

The results of monitoring inclinometer BH06 have indicated that a total of 2mm of ground movements had occurred between depths of 10.5m and 7.00m over the period from July to December 2009. An analysis of data from January's monitoring suite does not indicate that ground movements have developed further since December 2009. Ground movements are in a down slope direction towards Royal Parade along the coastline. Despite the apparent movement shown in the previous inclinometer data, the slopes at this location would appear to be in a stable condition. Inclinometer readings for BH03 are inconclusive as they only consist of initial 'Baseline' readings.

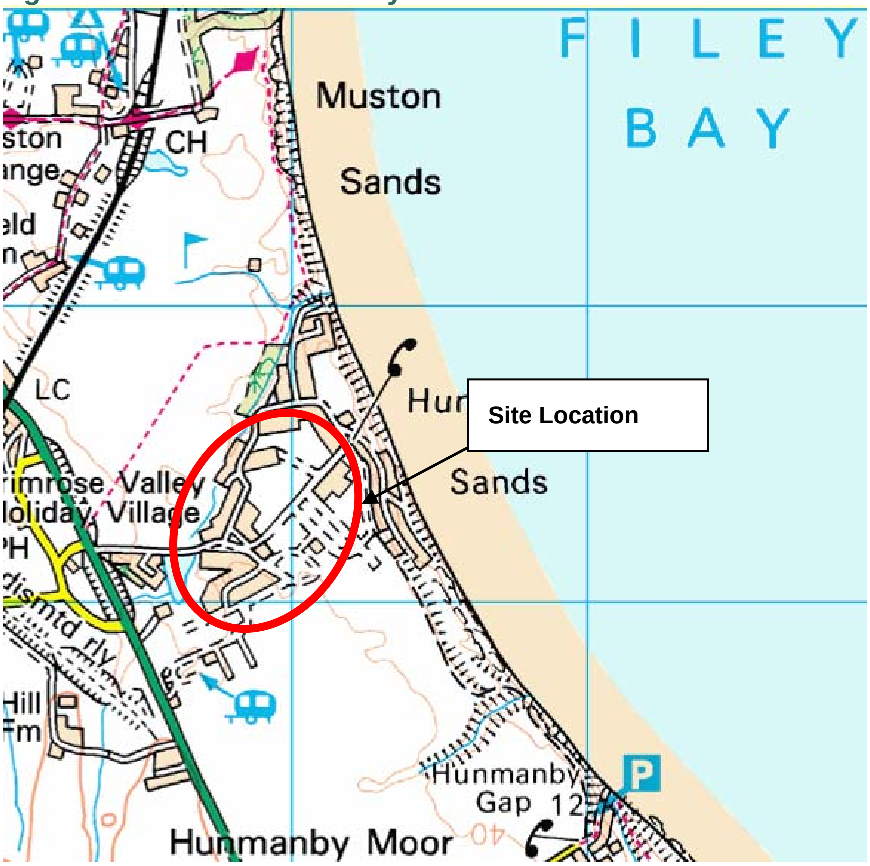
Groundwater levels at this site remain fairly static. BH05B reflects the tidal fluctuations affecting water levels in this borehole. While water levels in BH01 have risen, these illustrate the variations prevalent in the groundwater regime particularly water levels within the stream in Martin's Ravine.

8 Filey Flat Cliffs

8.1 Site Location and Description

Filey Flat Cliffs is situated near Primrose Valley Holiday Park, 2 km south of Filey town centre on the north east coast of England. The site comprises steep unprotected coastal slopes of glacial till on which holiday homes and static caravans have been constructed with narrow tarmac access roads. The site is bounded to the north, west and south by the holiday park and to the east by the cliffs.

Figure 8 Site Location – Filey Flat Cliffs



8.1.1 *Historic Review of Problems*

At Flat Cliffs there is evidence of active slope erosion, cliff-top recession and slope instability. Slope instability is particularly apparent at this site where an active landslip (rotational failures forming a benched slope profile) now threatens to breach the only vehicle access route into the area.

8.1.2 Topography and Geomorphology

The coastal cliffs are entirely composed of glacial till with solid rock formations dipping below sea level. The glacial till deposits comprise a highly variable mixture of clays, silts and, sands and gravels. They are easily eroded by wave action and are susceptible to groundwater effects and mass movements. Complex landslides are present at Flat Cliffs, large-scale, deep-seated failure of the glacial till cliffs has occurred. At the north end of Flat Cliffs, the surface morphology indicates rotational failure of the glacial till has occurred. At Flat Cliffs (south), large undercliffs have formed which appear from the surface morphology to be formed by translational failure of the glacial till slopes, possibly founded upon or within weathered bedrock at depth.

8.1.3 Existing Information

A number of reports were provided by SBC for consultation, these are detailed in Mouchel Report *"Analysis and Interpretation of Coastal Monitoring Data" 721228/001/GR/01/02/FINAL, p117.* Additional reports were presented by SBC for further consultation for the Ongoing Analysis. All this data has been placed on an Arcview GIS layer for ease of use and availability.

8.2 Stratigraphy

The 1:50,000 British Geological Survey (BGS) Sheet 54 Solid & Drift, Scarborough indicates that the site is underlain by superficial deposits of glacial till (Quaternary), overlying the Speeton Clay Formation. This formation overlies the Kimmeridge Clay Formation.

8.3 Groundwater Regime

Hydrogeology

The Groundwater Vulnerability Map (Sheet 9) of North East Yorkshire has classified the area as a Non-Aquifer because of their negligible permeability. These formations are generally regarded as containing insignificant quantities of groundwater. However, groundwater flow through such soils, although imperceptible, does take place and needs to be considered in assessing the risk associated with persistent pollutants. Some Non-Aquifers can yield water in sufficient quantities for domestic use. Major and Minor Aquifers may occur beneath Non-Aquifers.

8.4 Instrumentation

8.4.1 Definition of Existing Problems

The presence of confined granular strata within the glacial till slopes may result in excess groundwater pressures to develop resulting in the collapse and recession of the head scarp and cliff crest.

8.5 Monitoring Regime

8.5.1 Recommended Monitoring Regime

As a consequence of the analysis and interpretation of monitoring data and reports made available by SBC, a regime of future monitoring was formulated. These recommendations have been reported in Mouchel Report "*Analysis and Interpretation of Coastal Monitoring Data" 721228/001/GR/01/02/FINAL.* The recommendations for Flat Cliffs were that a regular monitoring and inspection regime should be undertaken at monthly intervals for a period of six months and then every two months until month twelve. If no significant movement was revealed during this twelve month period then monitoring should revert to six monthly intervals (bi-annually) for a further two years.

8.5.2 Ongoing Monitoring Regime

The ongoing monitoring regime was initialised in July 2009 and follows that detailed in Section 8.5.1, above. Following on from the findings of the *Condition Survey Report*, monitoring is to consist of a single inclinometer (BB02/A2) located on the landside of the main access road down through Flat Cliffs and 3 no. piezometers (A3, B1 and D1), one located within Flat Cliffs and the remainder located above the village beyond the cliff crest.

The reduced monitoring regime is based upon the findings of the *Condition Survey Report* which detailed inclinometer BB01 (D2) as being blocked 8 metres short of the installed depth. Hence, due to the discrepancy between the two depths this instrument was not monitored and has been recommended for replacement.

8.5.3 Ongoing Monitoring Results

Inclinometer Readings

Inclinometer readings for BB02 (A2) has been undertaken in accordance with the procedures detailed in Section 1.4 of this report and are presented in Appendix B.

Groundwater Readings

Groundwater levels have been recorded at monthly intervals from the Initial Full Suite Survey (8th July 2009) up to January 2010. A comparison of the readings over this period showed maximum variations in groundwater levels within boreholes of up to 0.47m BB02 (A2), 15.66m (D1), 0.67m (A3) and 1.12m (B1). Borehole BB01 (D2) was recorded as dry on each occasion although this inclinometer has sheared at 14.20m depth. This instrument was originally installed to 22.50m depth. Groundwater data graphs are presented in Appendix C.

8.6 Conclusions

Monitoring data from inclinometer BB02 (A2) indicates that slight ground movements have occurred within the vicinity of this borehole since the previous monitoring in December 2009. A slight deviation of 3mm, between 12.5 and 10.5 metres depth, is apparent from the inclinometer readings. This disturbance coincides with the presence of a layer of mudstone at this depth. Inclinometer readings also indicate up to 2-3mm of movement at 19.80 metres depth where a band of silt is recorded on borehole logs.

The single inclinometer offers very limited coverage of the site of Flat Cliffs and there is the distinct possibility of undetected ground movements occurring elsewhere at this site. Previous interpretative reports (provided by SBC) have drawn attention to the fact that there is a lack of valid geotechnical data retrieved from this area with which to build a meaningful geotechnical model and also carry out slope stability analyses.

Groundwater levels at this site have generally increased due to high levels of rainfall at Flat Cliffs, although the lower reading from BB02 (A2) is probably influenced by tidal fluctuations. Piezometers A3 and D1 installed on the cliff tops along with B1 (within the village) show that groundwater levels have risen since last read in December 2009. These instruments have been installed in the glacial tills (present overlying the bedrocks of the Speeton Clay Formation) in order to target the groundwater regime present here.

As porewater pressures increase within the slopes, this can lead to a decrease in the stability of the slopes by causing a reduction in shear strength. These effects are more pronounced during periods of intense, heavy rainfall and where such an event follows a dry period this can cause a sudden increase in pore water pressures in the slopes. Any desiccation and tension cracks which may have developed will permit the ingress of rainwater into the slopes quickly leading to slope instability. Further evidence of slight ground movements is provided in the form of cracking within the surface tarmac of the access road which has advanced over a short period of time. Plates 32 and 33 (Appendix L) show surface cracking and a repair composed of tar poured into the developed cracks. The repair was carried out some time during August 2009 and since then it is apparent that the cracks have continued to develop in line with ground movements. Other evidence of ground movements is a ridge that has developed across the road near the top of the access road. This has noticeably increased in size over the period monitoring visits have taken place. Plate 29 (Appendix L) shows this bulge although its development is not very apparent from the photograph.

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Mouchel Report *"Ongoing Analysis and Interpretation of Coastal Monitoring Data*, Feasibility Report into the Replacement of Damaged Monitoring Equipment" 721229/017/GIR/002/FINAL, September 2009

Mouchel Report "Ongoing *Analysis and Interpretation of Coastal Monitoring Data. Initial Review of Full Suite Monitoring" 721229/002/GIR/002/Draft*, October 2009.

Mouchel Report *"Ongoing Analysis and Interpretation of Coastal Monitoring Data*, *Initial Review of Restricted Suite Monitoring*" 721229/002/GIR/003/FINAL, October 2009

Mouchel Report *"Ongoing Analysis and Interpretation of Coastal Monitoring Data*, *Second Review of Restricted Suite Monitoring*" 721229/002/GIR/004/FINAL, October 2009

Mouchel Report *"Ongoing Analysis and Interpretation of Coastal Monitoring Data, Third Review of Restricted Suite Monitoring*" 721229/002/GIR/005/FINAL, November 2009

Mouchel Report *"Ongoing Analysis and Interpretation of Coastal Monitoring Data, Fourth Review of Restricted Suite Monitoring*" 721229/002/GIR/006/FINAL, December 2009

Mouchel Report *"Ongoing Analysis and Interpretation of Coastal Monitoring Data, "Definition of Heavy / Prolonged Rainfall Events*" 721229/004/GIR/001/FINAL, January 2010

Mouchel Report *"Ongoing Analysis and Interpretation of Coastal Monitoring Data, Second Review of Full Suite Monitoring*" 721229/002/GIR/007/FINAL, January 2010

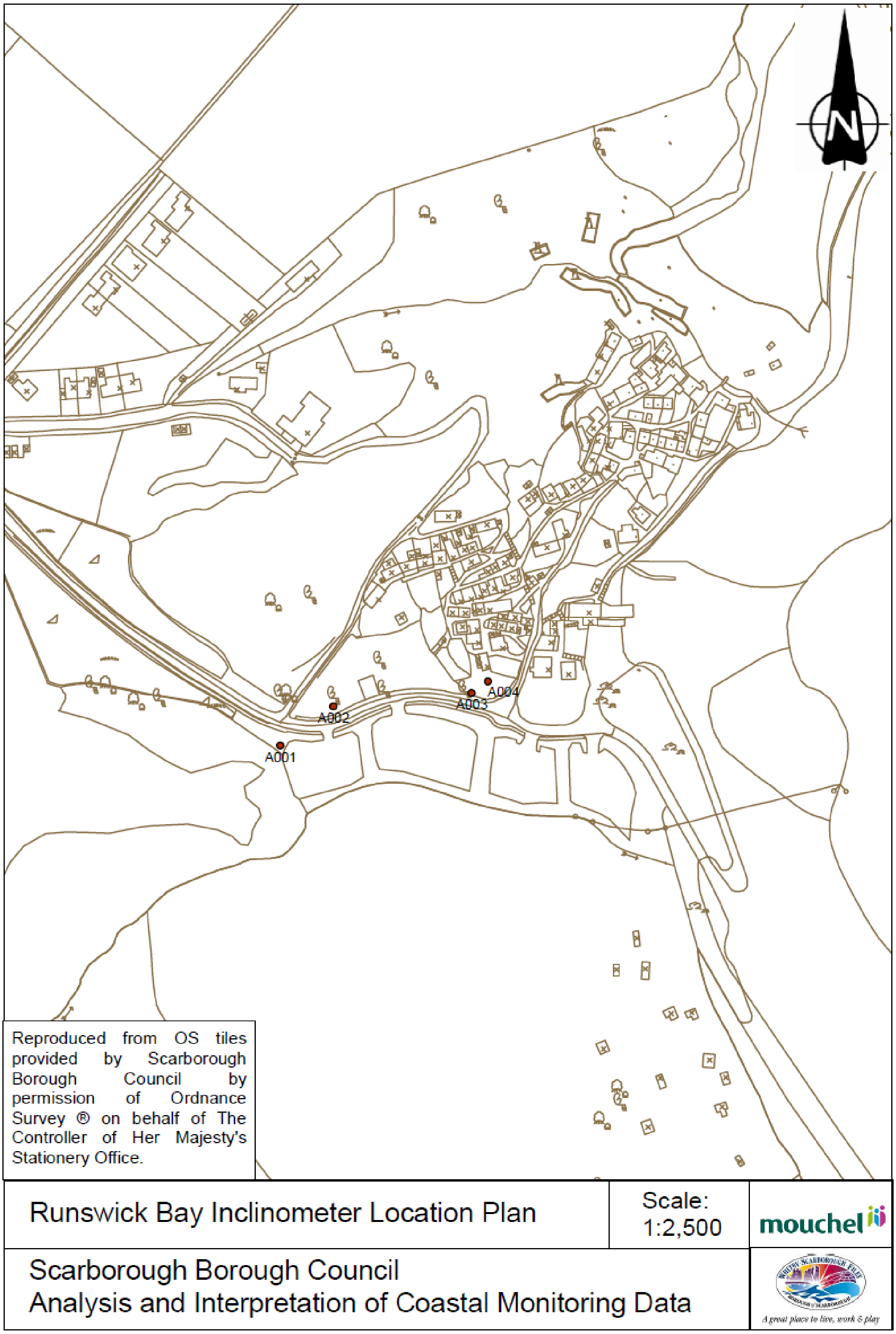
Mouchel Report *"Ongoing Analysis and Interpretation of Coastal Monitoring Data*, First Additional Full Suite Monitoring" 721229/021/GIR/001/FINAL, February 2010

Scarborough Borough Council Records.

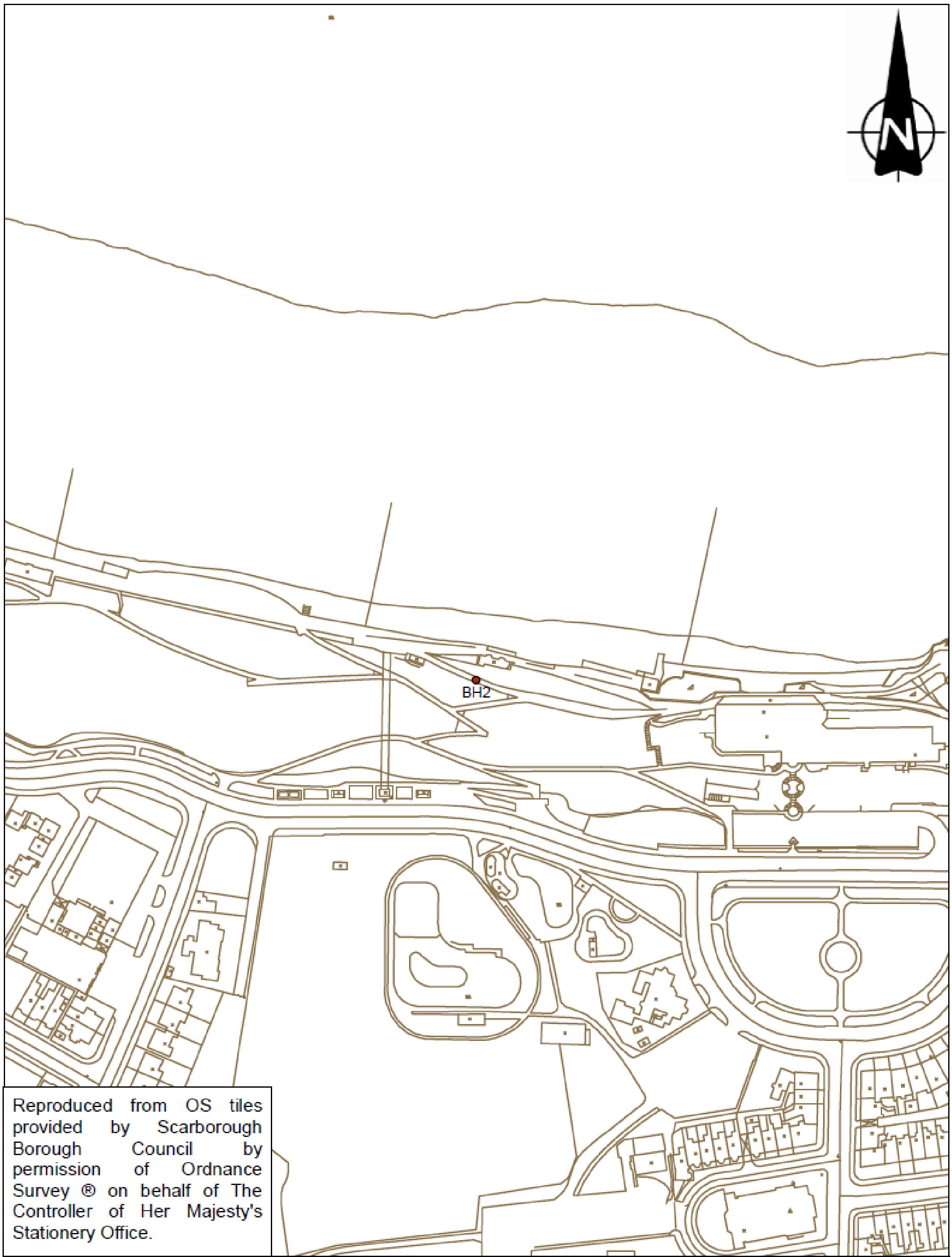
Spark, B W (1981) Geomorphology - 2nd Edition. Longman.

Tomlinson, M. J. (2001) Foundation Design and Construction - 7th Edition. Longman Ltd

Appendix A Exploratory Holes Location Plans

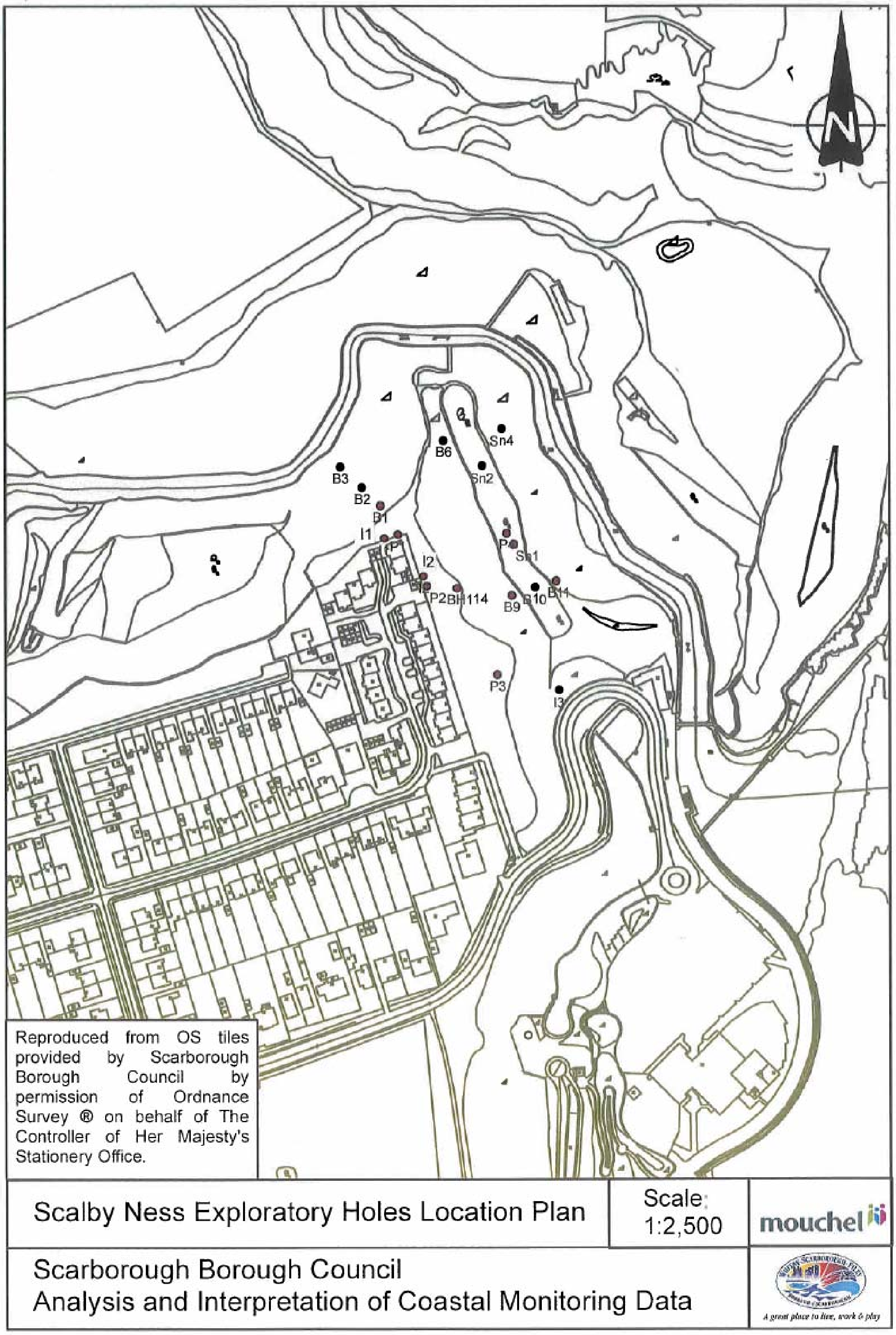


Drawing No. 1 Location Plan of Runswick Bay

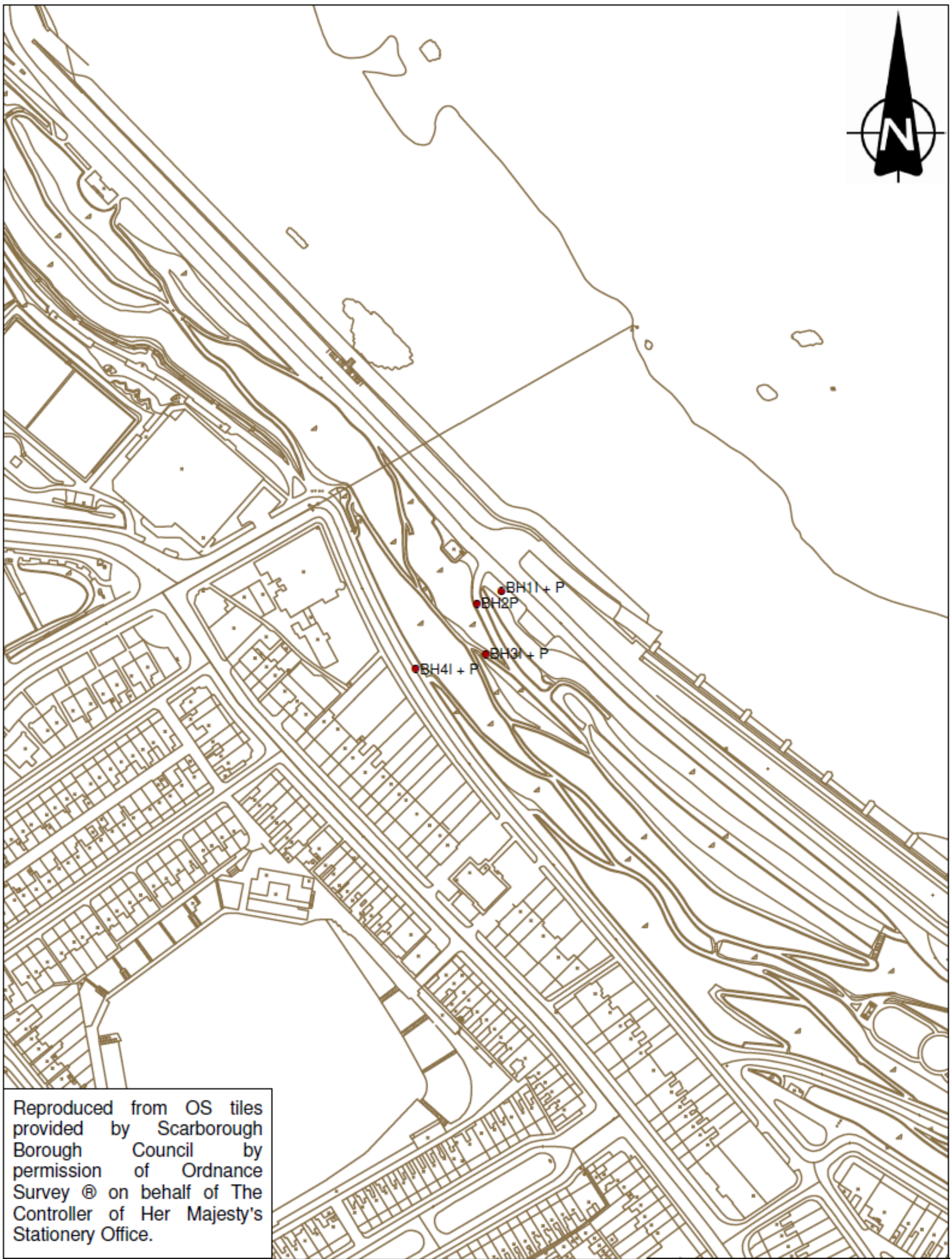


Whitby West Cliff Inclinometer Location Plan	Scale: 1:2,500	mouchel
Scarborough Borough Council Analysis and Interpretation of Coastal Monitoring Data		A great place to live, work & play

Drawing No. 2 Location Plan of Whitby West Cliff



Drawing No. 3 Location Plan of Scalby Ness



Scarborough North Bay
Exploratory Holes Location Plan

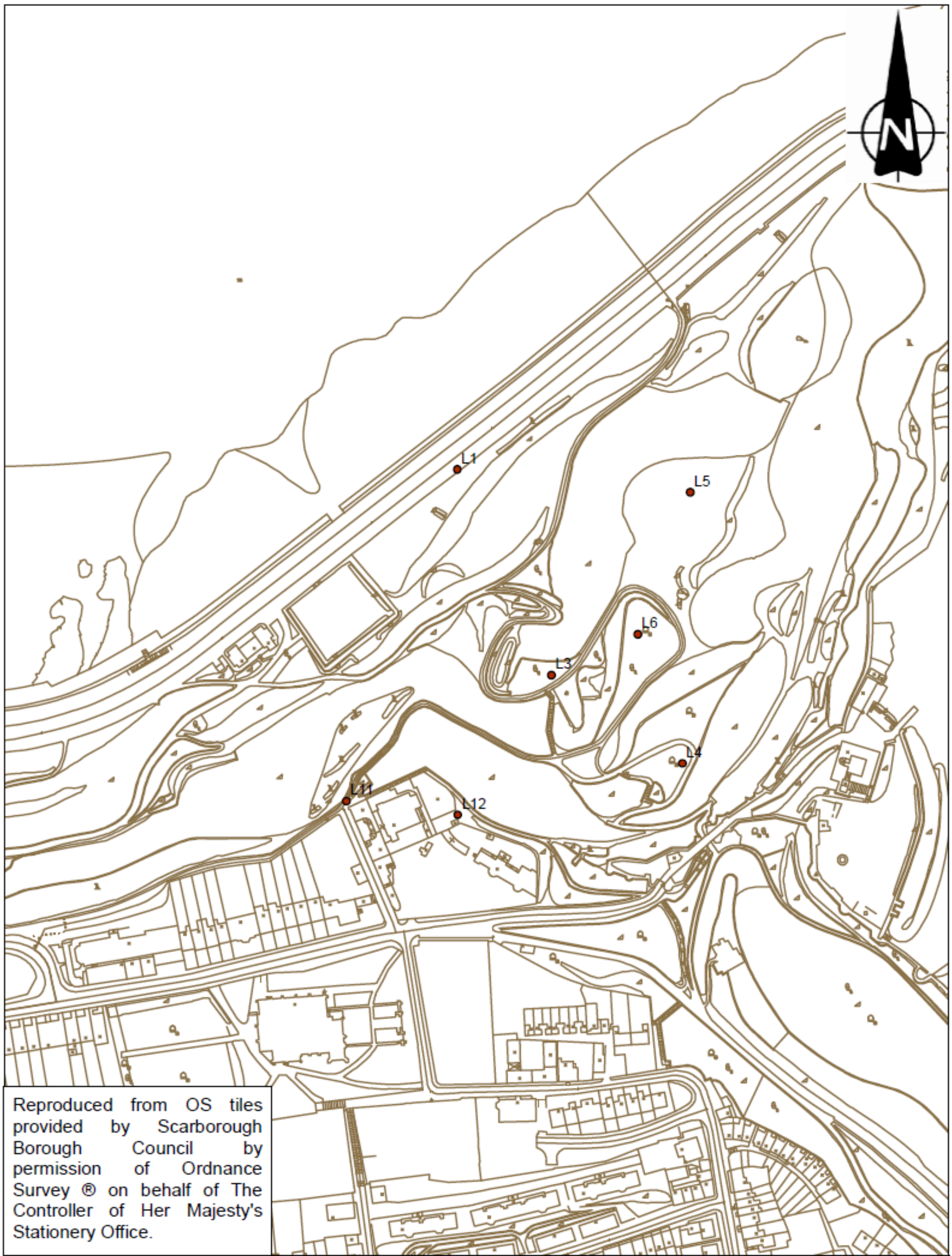
Scale: 1:2,500

mouchel

Scarborough Borough Council
Analysis and Interpretation of Coastal Monitoring Data

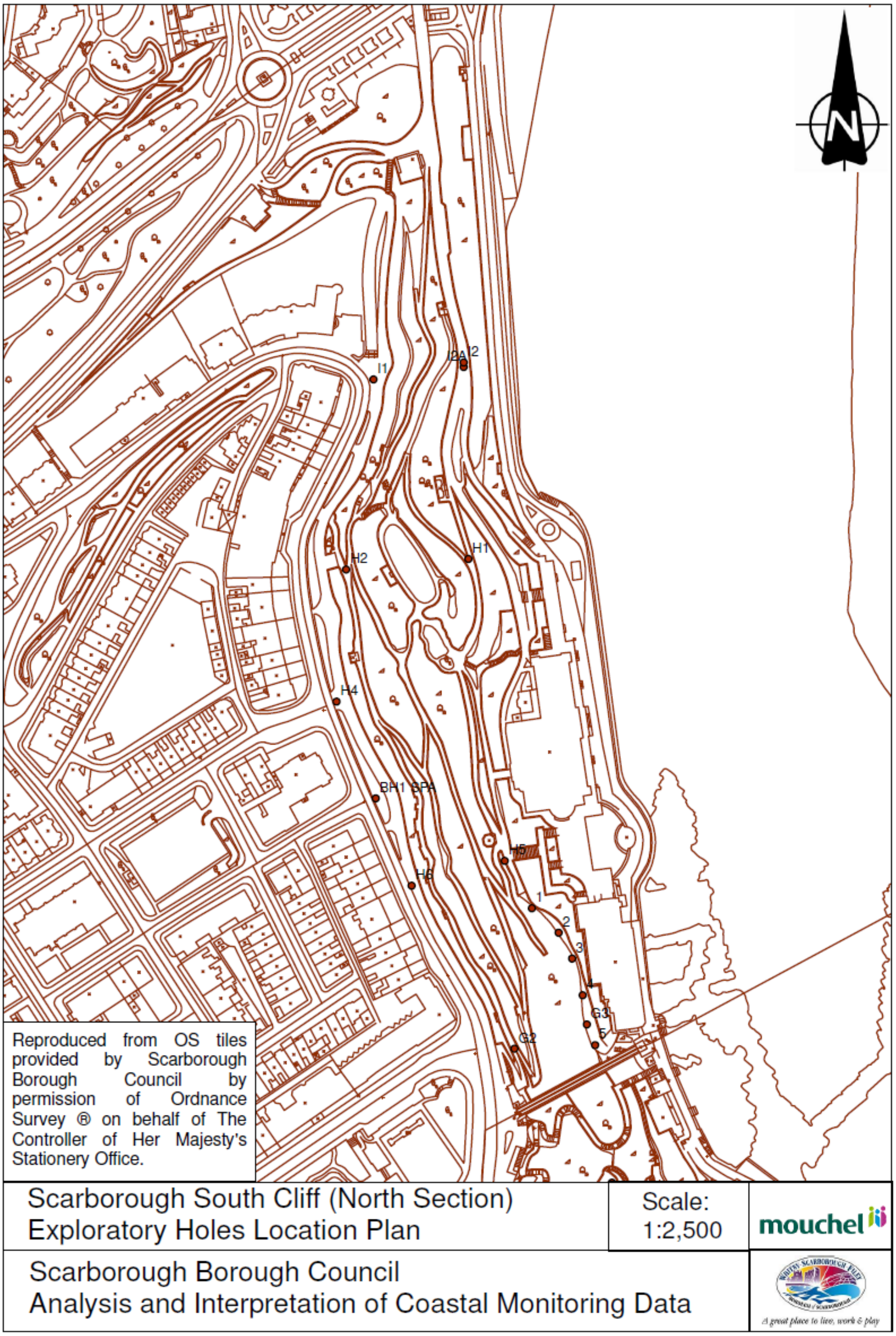
A great place to live, work & play

Drawing No. 4 Location Plan of Scarborough North Bay (Oasis Cafe)



Scarborough North Bay (East Section) Exploratory Holes Location Plan	Scale: 1:2,500	mouchel
Scarborough Borough Council Analysis and Interpretation of Coastal Monitoring Data		A great place to live, work & play

Drawing No. 5 Location Plan of Scarborough North Bay (East)



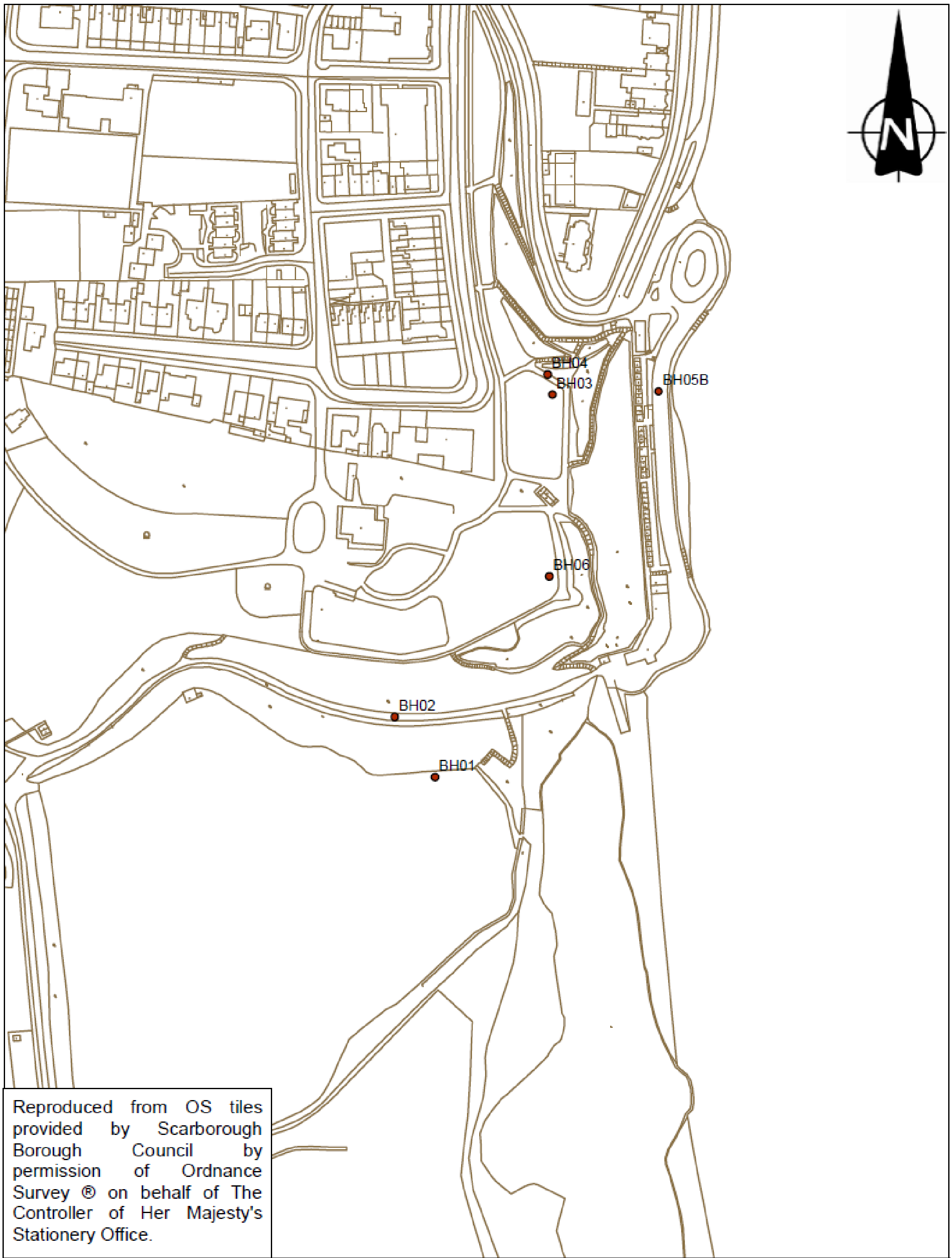
Drawing No. 6 Location Plan of Scarborough South Cliff (North)

Scarborough South Cliff (Central Section) Exploratory Holes Location Plan	Scale: 1:2,500	mouchel
Scarborough Borough Council Analysis and Interpretation of Coastal Monitoring Data		A great place to live, work & play

Drawing No. 7 Location Plan of Scarborough South Cliff (Central)

Scarborough South Cliff (South Section) Exploratory Holes Location Plan	Scale: 1:2,500
Scarborough Borough Council Analysis and Interpretation of Coastal Monitoring Data	

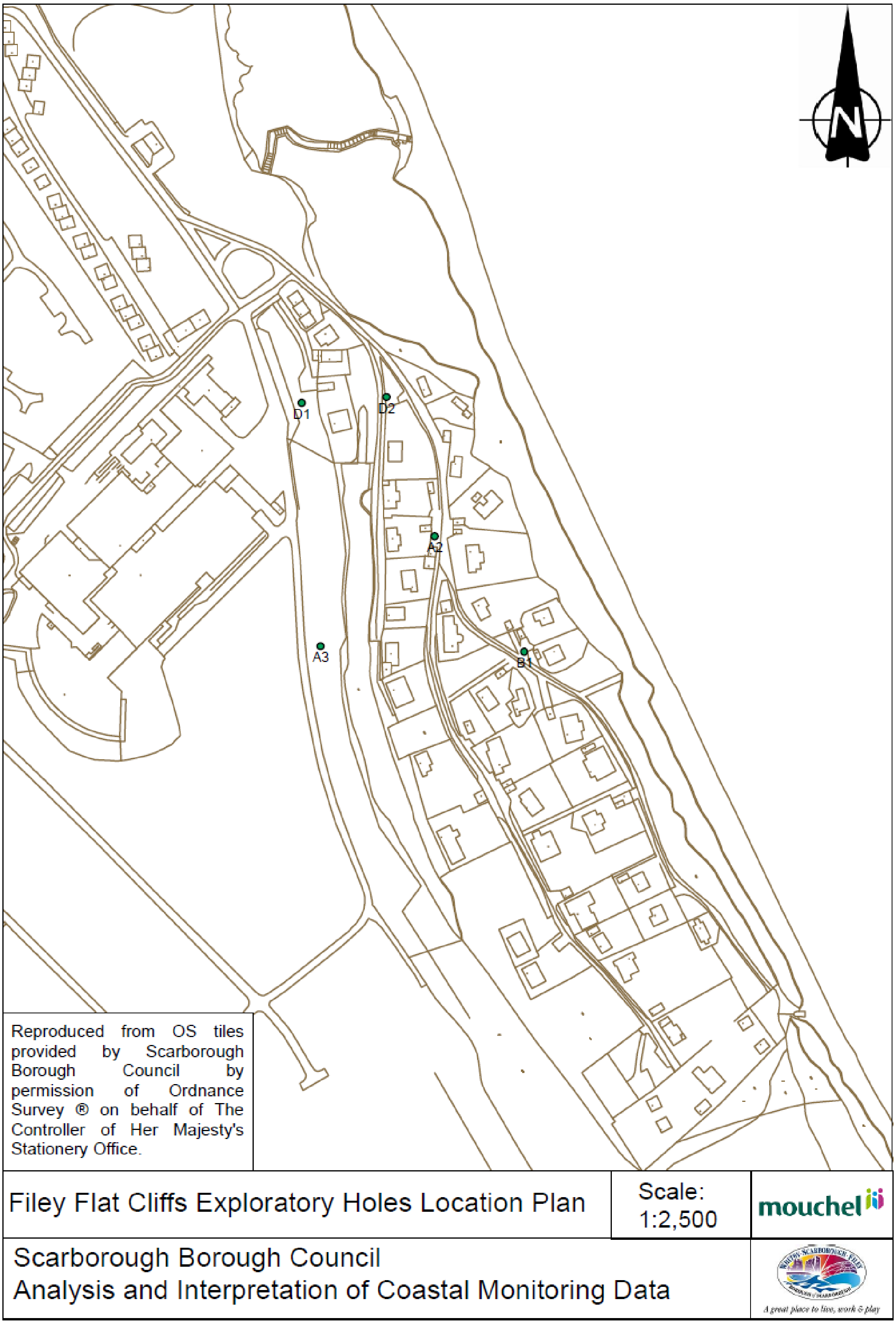
Drawing No. 8 Location Plan of Scarborough South Cliff (South)



Filey Exploratory Holes Location Plan	Scale: 1:2,500
Scarborough Borough Council Analysis and Interpretation of Coastal Monitoring Data	

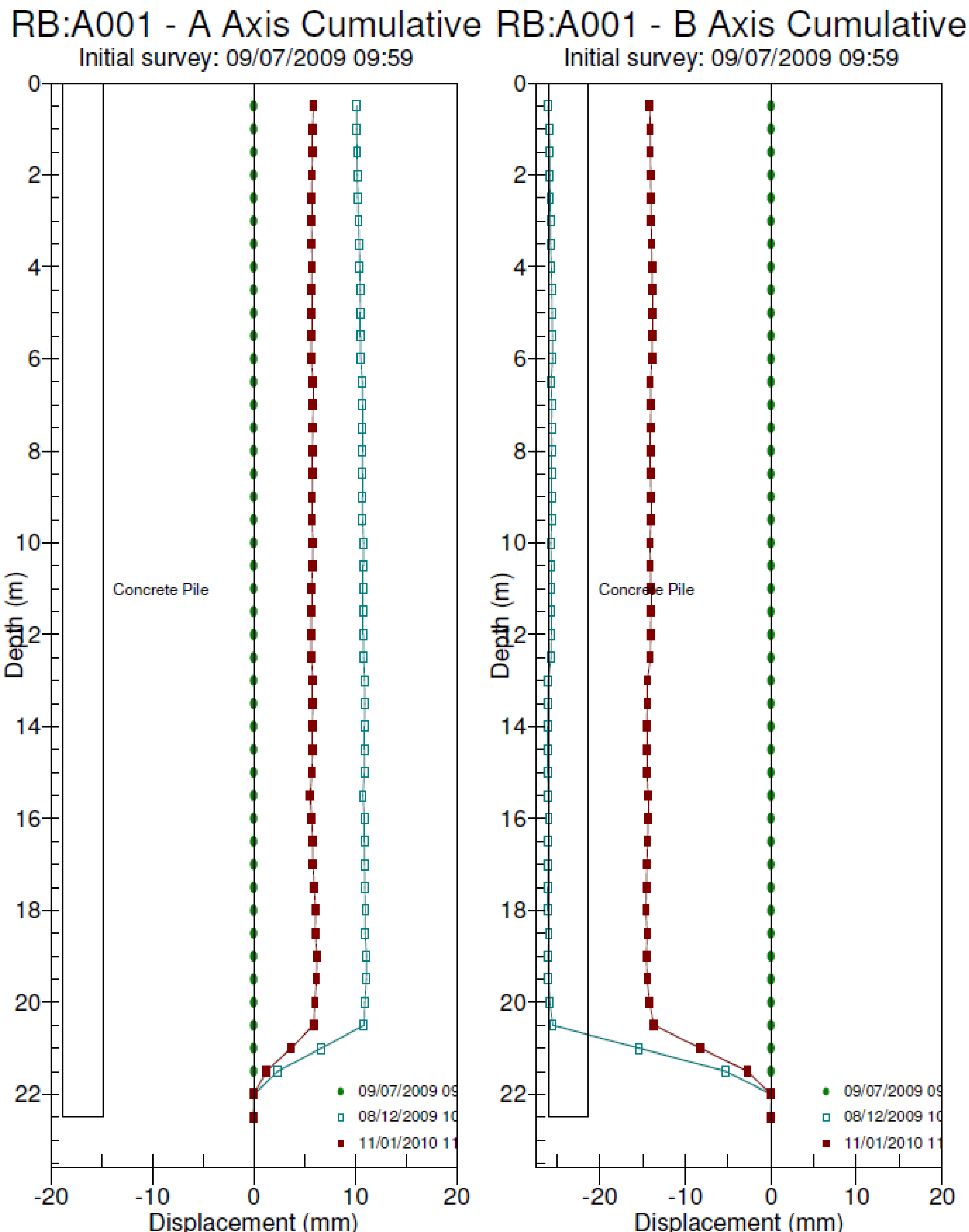
A great place to live, work & play

Drawing No. 9 Location Plan of Filey Town



Drawing No. 10 Location Plan of Filey Flat Cliffs

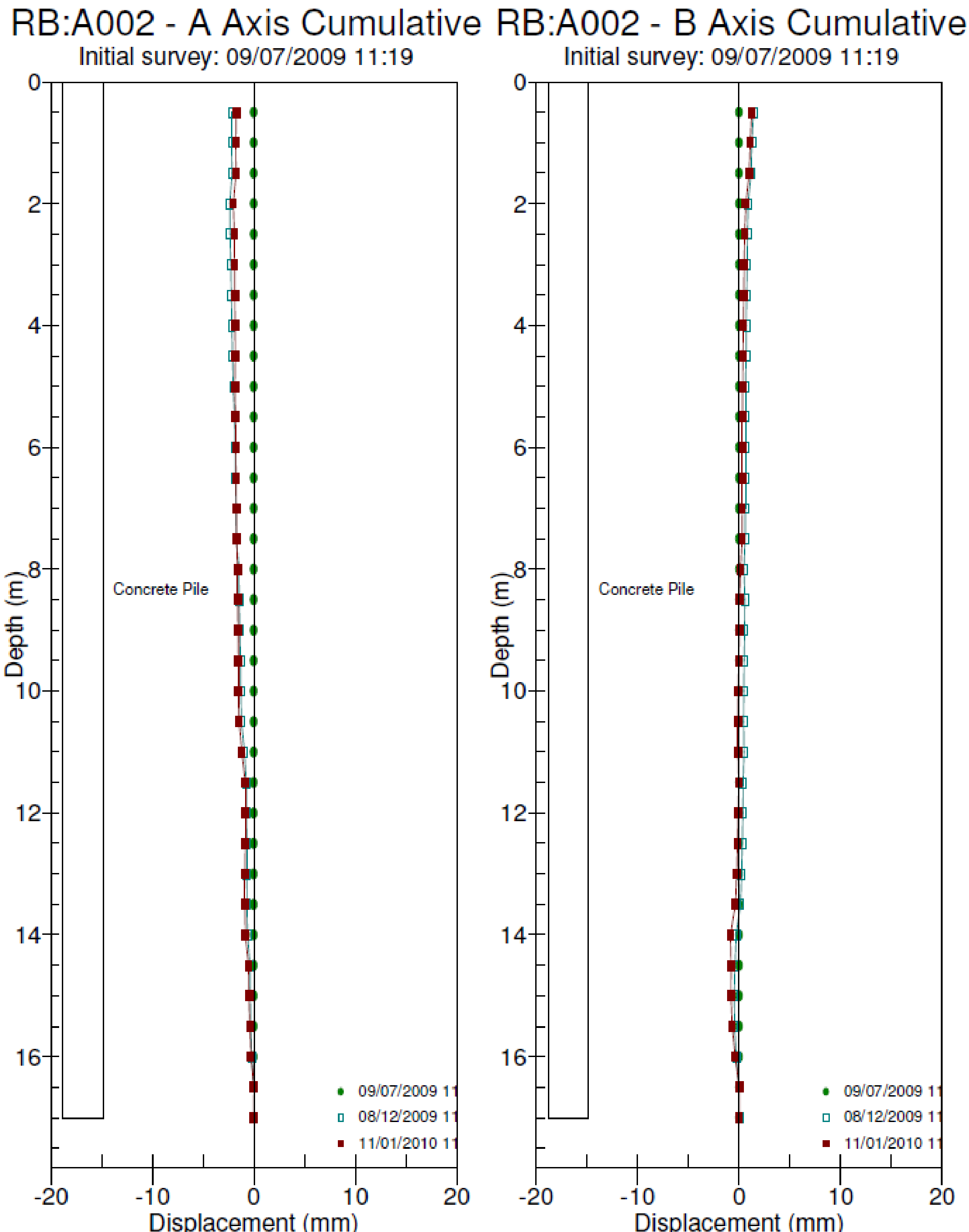
Appendix B Inclinometer Data Graphs



PROJECT: 721229 Ongoing Analysis of Coastal Monitoring Data
SITE: Runswick Bay
INSTALLATION: A001
COMPANY: Mouchel Ltd
CLIENT: Scarborough Borough Council

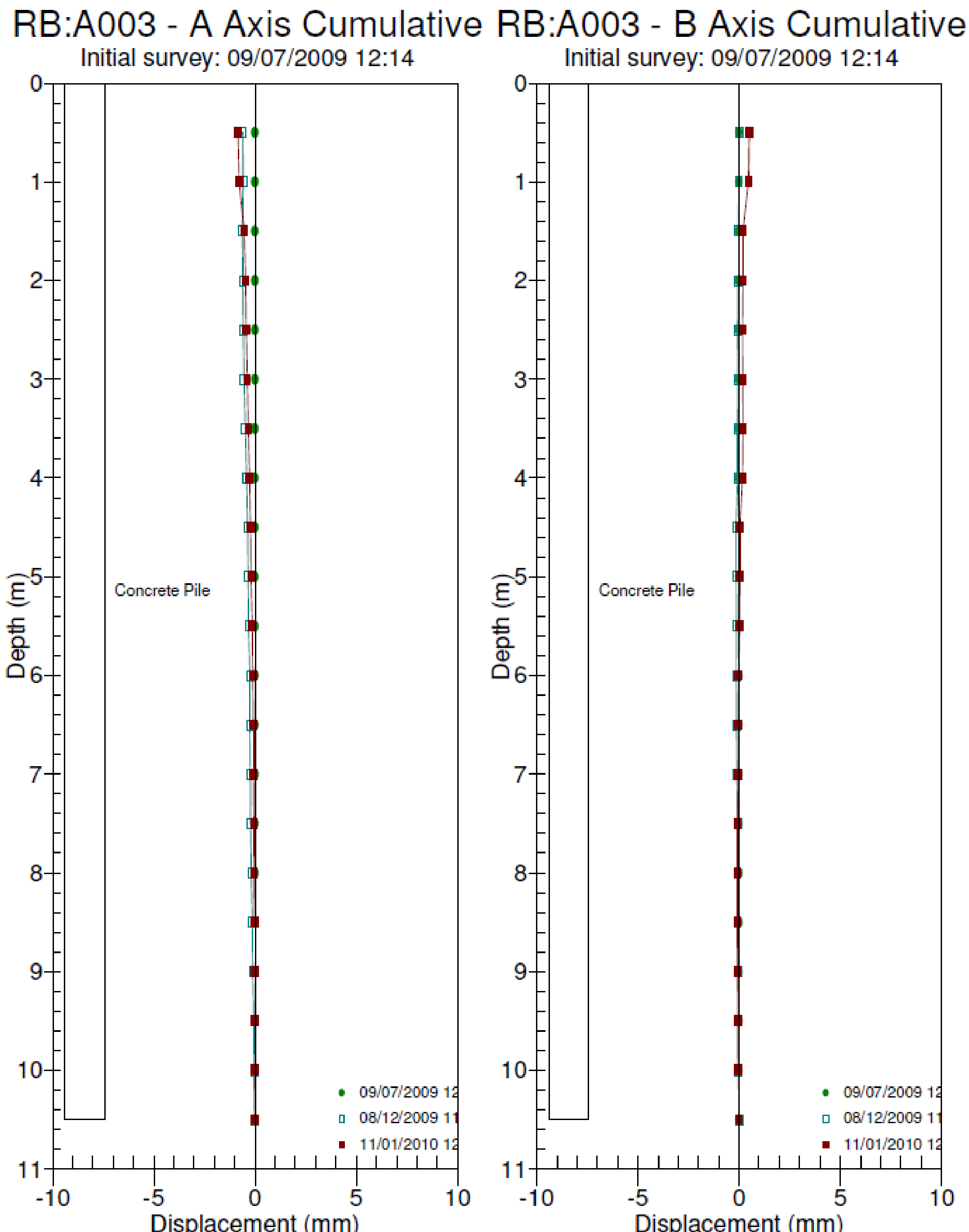
mouchel

NOTE: A0 direction: East



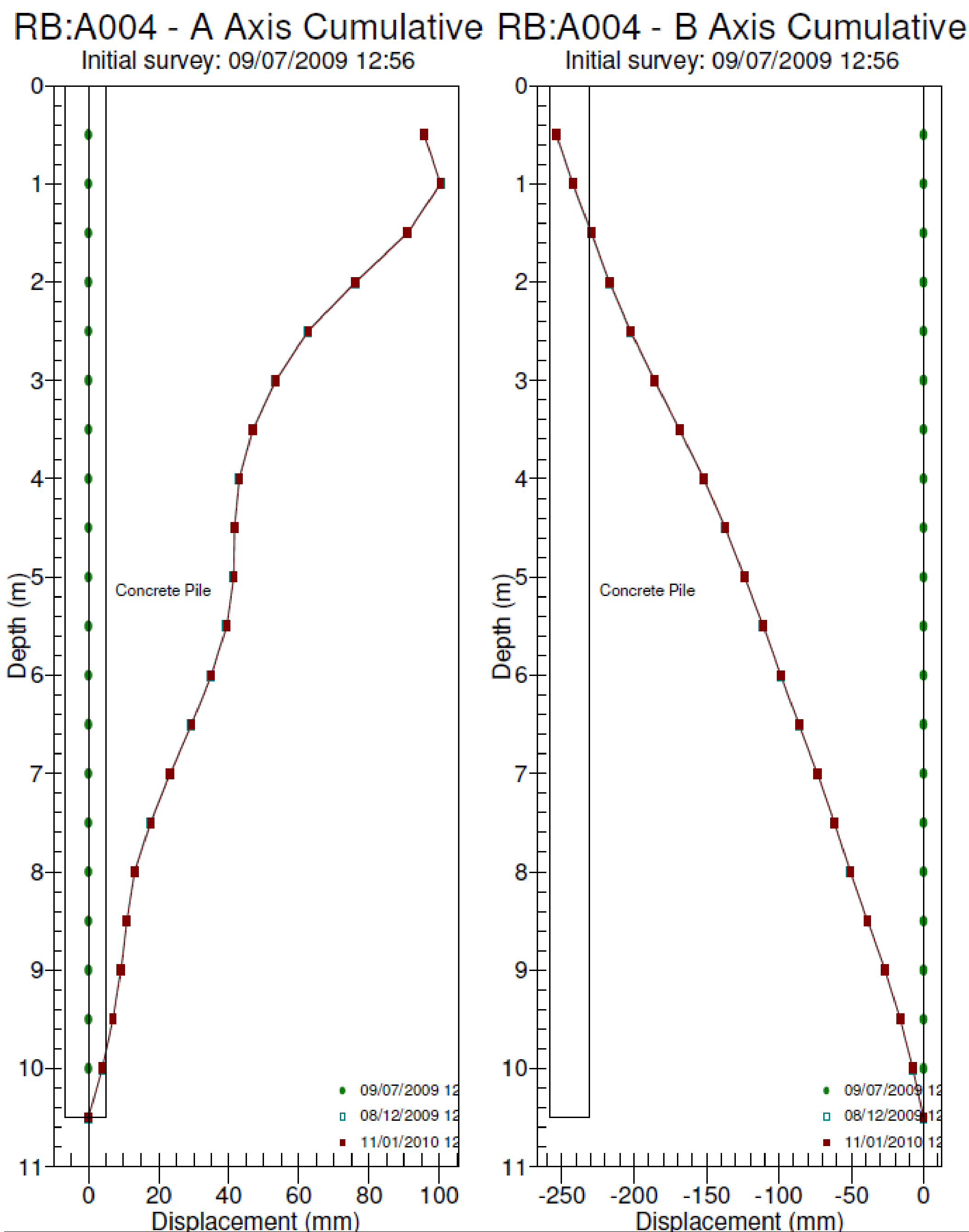
PROJECT: 721229 Ongoing Analysis of Coastal Monitoring Data
SITE: Runswick Bay
INSTALLATION: A002
COMPANY: Mouchel Ltd
CLIENT: Scarborough Borough Council

NOTE: A0 direction: East



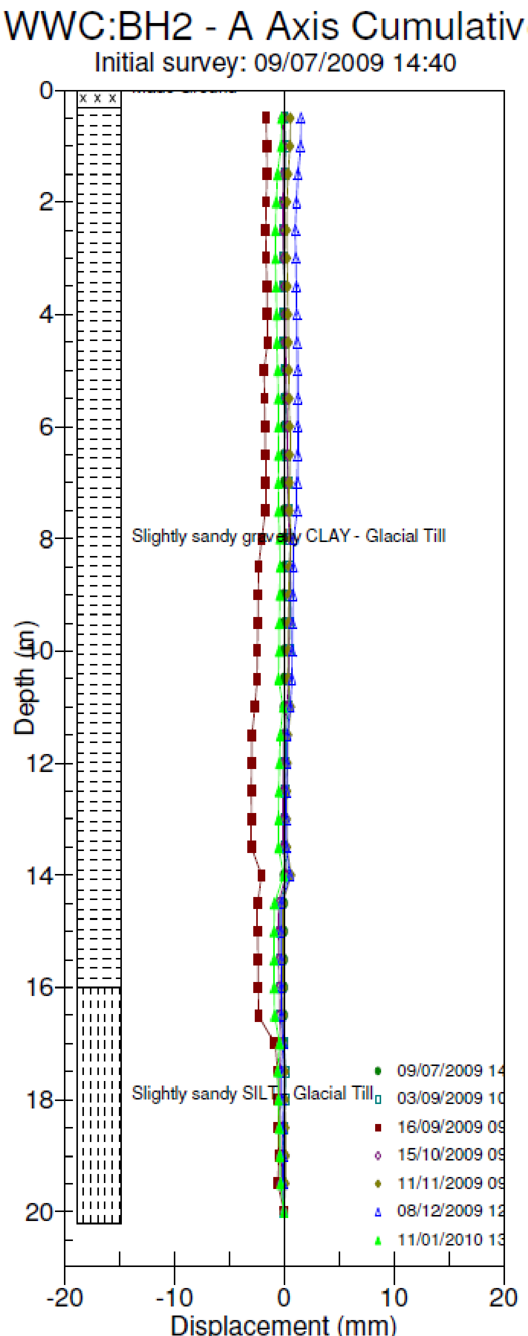
PROJECT: 721229 Ongoing Analysis of Coastal Monitoring Data
SITE: Runswick Bay
INSTALLATION: A003
COMPANY: Mouchel Ltd
CLIENT: Scarborough Borough Council

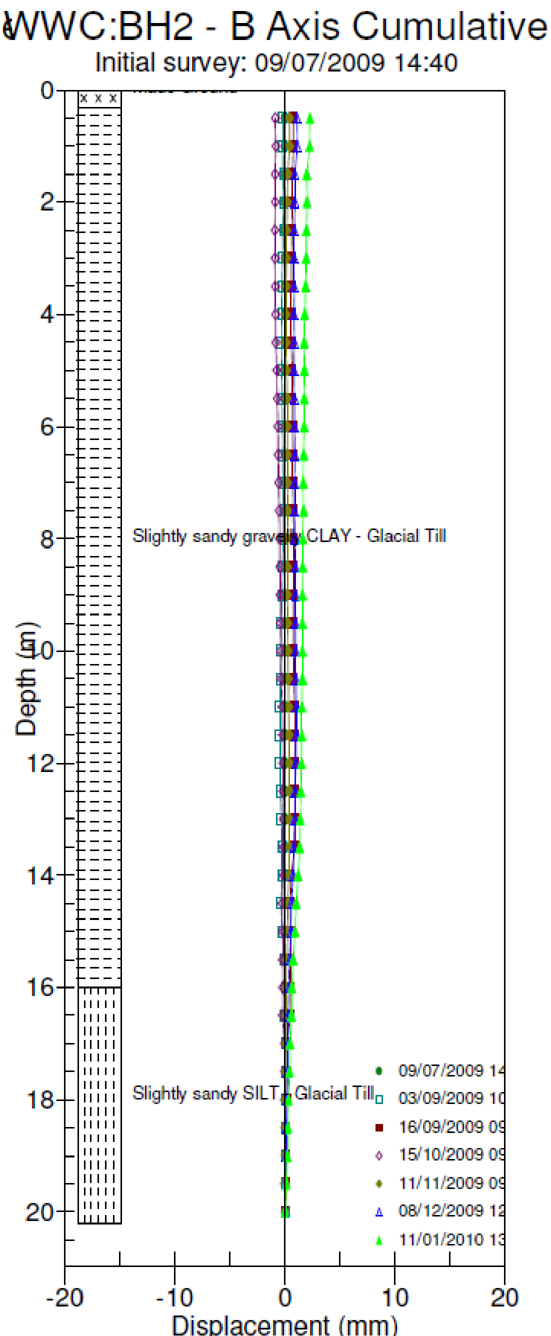
NOTE: A0 direction: South East



PROJECT: 721229 Ongoing Analysis of Coastal Monitoring Data
SITE: Runswick Bay
INSTALLATION: A004
COMPANY: Mouchel Ltd
CLIENT: Scarborough Borough Council

NOTE: A0 direction: East

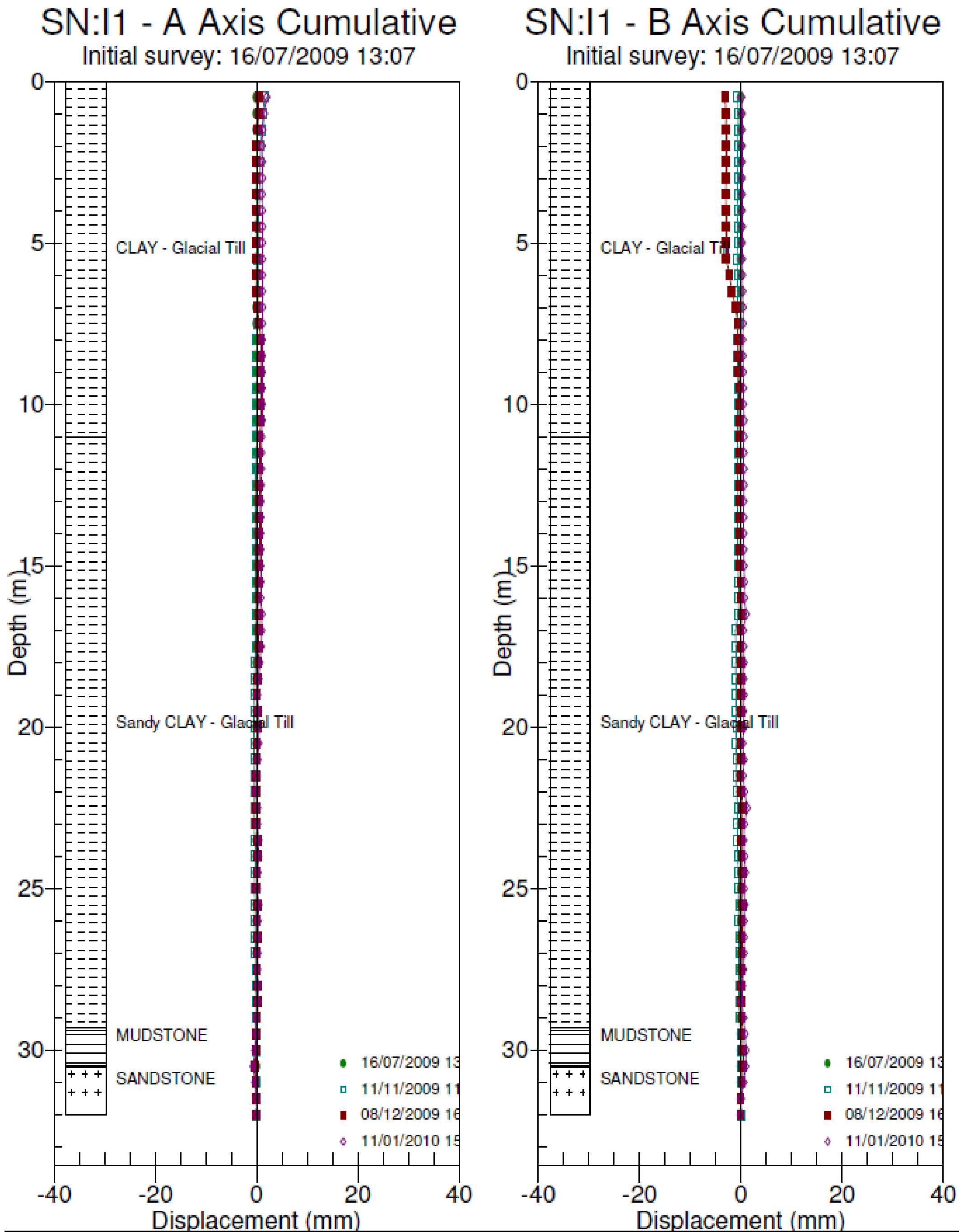




PROJECT: 721229 Ongoing Analysis of Coastal Monitoring Data
SITE: Whitby West Cliff
INSTALLATION: BH2
COMPANY: Mouchel Ltd
CLIENT: Scarborough Borough Council

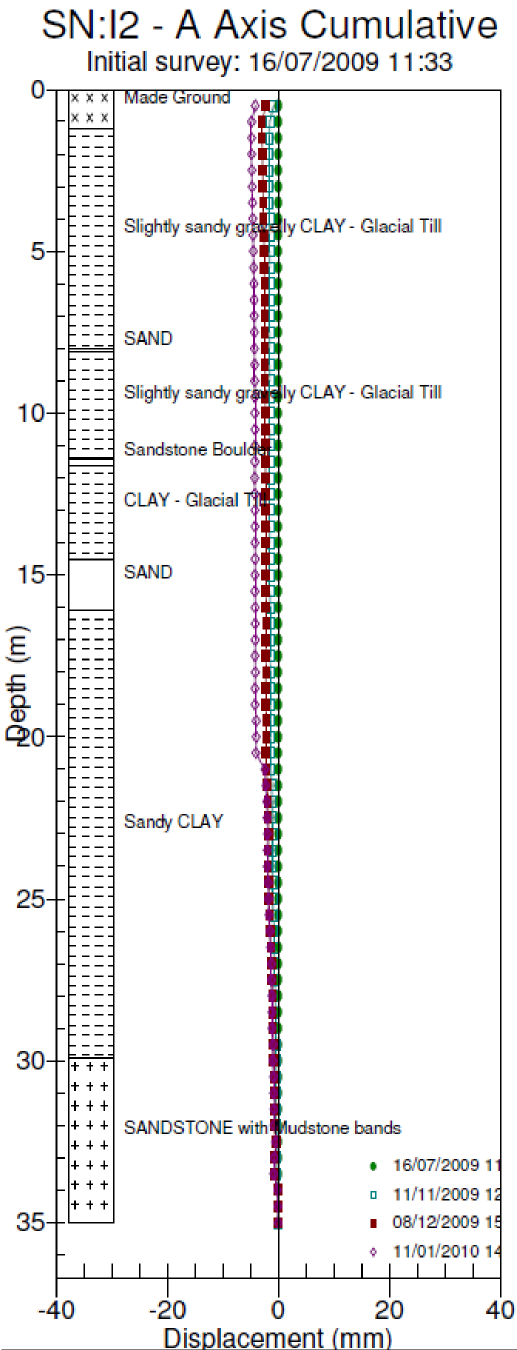
mouchel

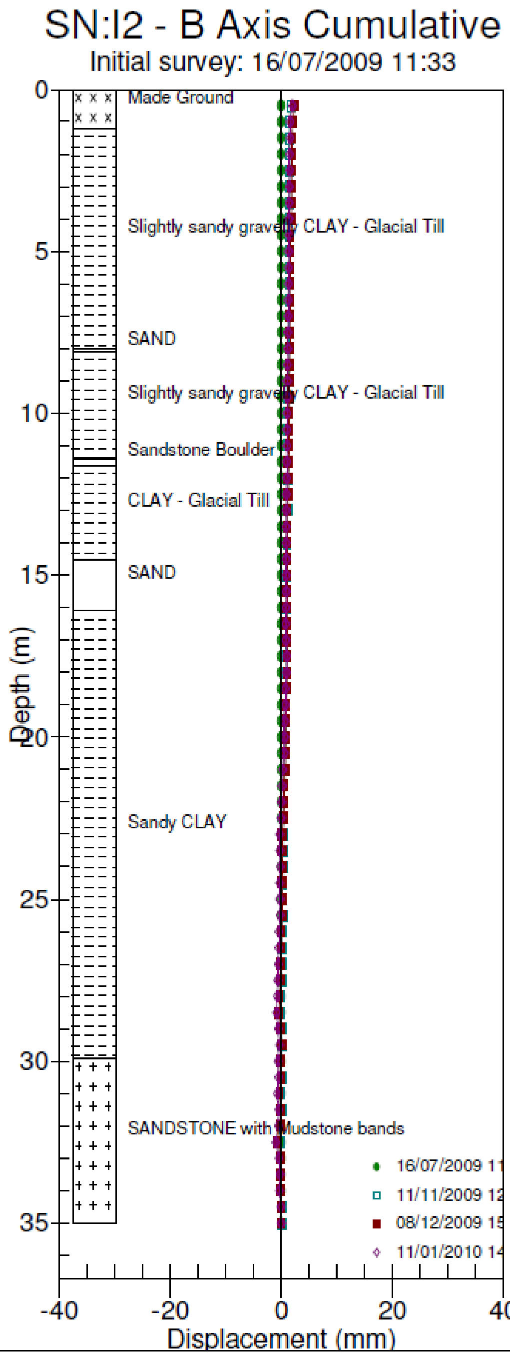
NOTE: A0 direction: North



PROJECT: 721229 Ongoing Analysis of Coastal Monitoring Data
SITE: Scalby Ness
INSTALLATION: I1
COMPANY: Mouchel Ltd
CLIENT: Scarborough Borough Council

NOTE: A0 direction: North

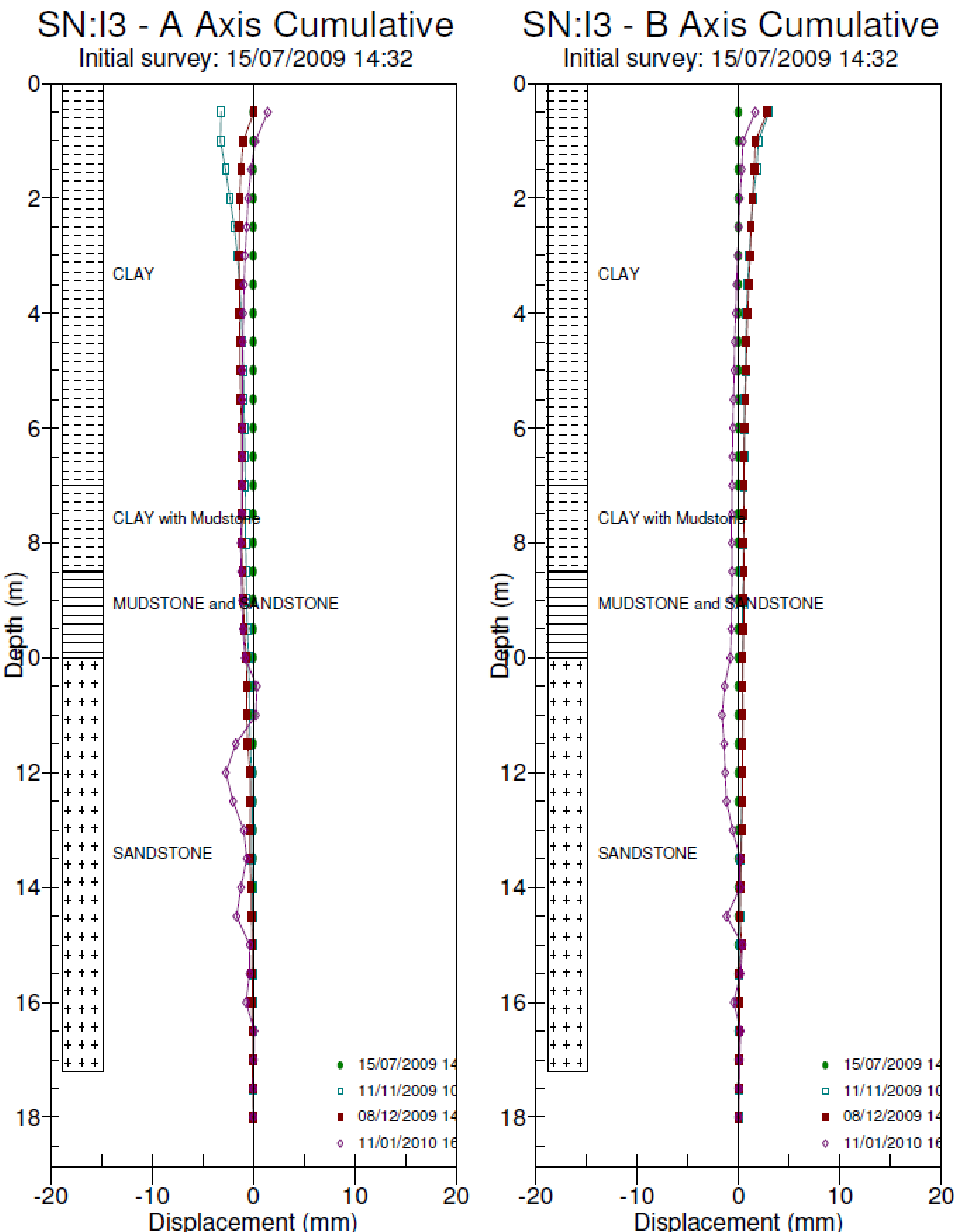




PROJECT: 721229 Ongoing Analysis of Coastal Monitoring Data
SITE: Scalby Ness
INSTALLATION: I2
COMPANY: Mouchel Ltd
CLIENT: Scarborough Borough Council

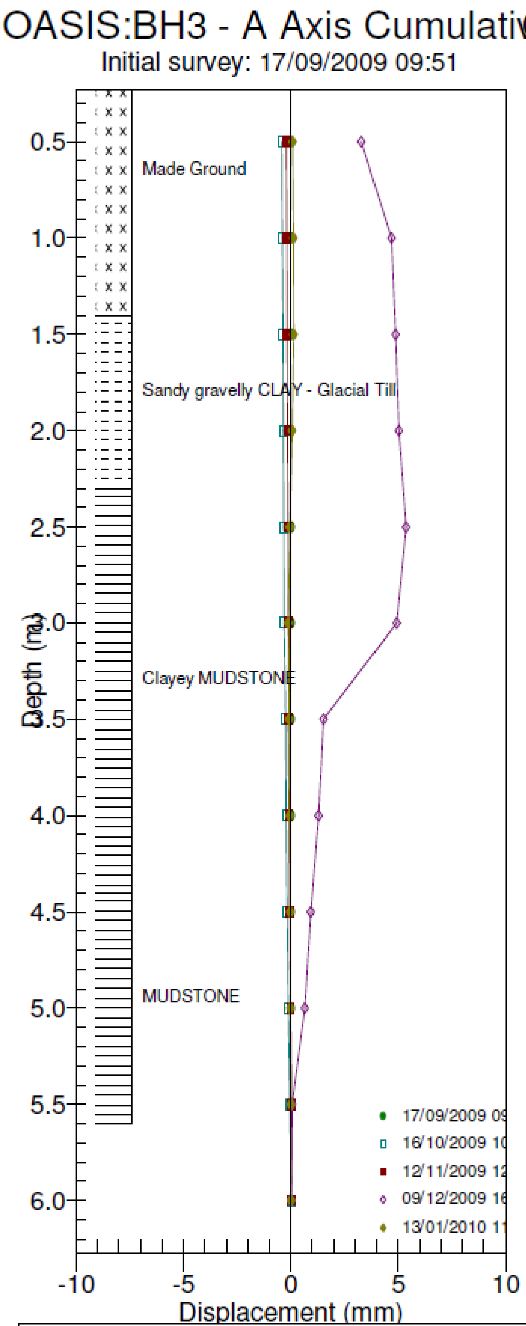
mouchel

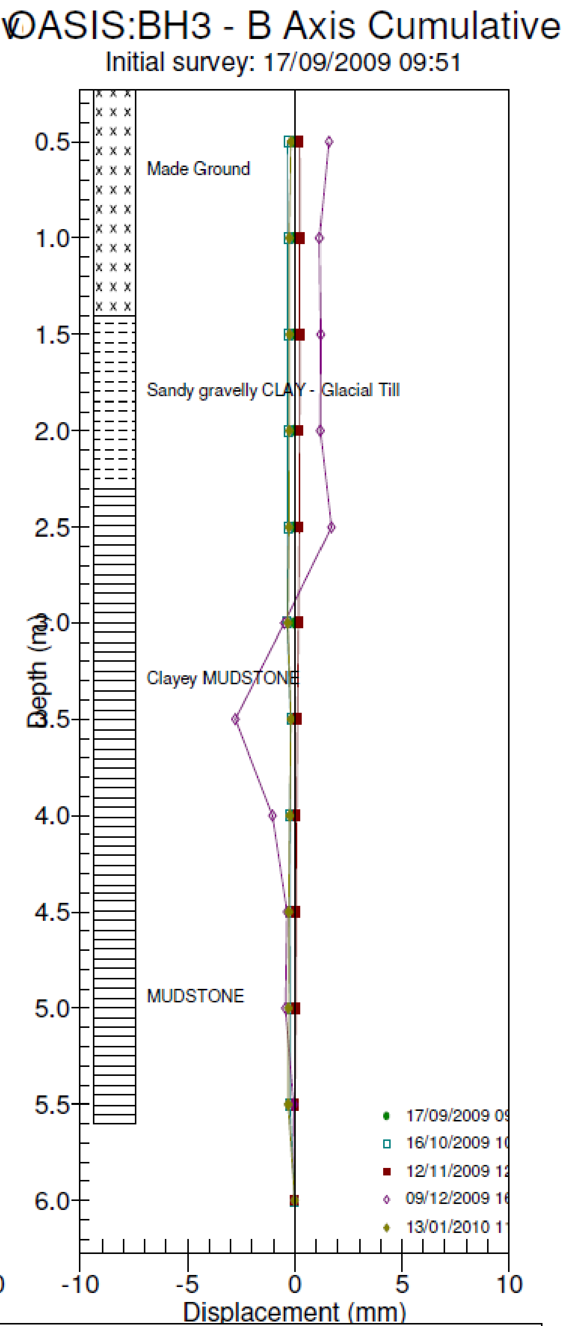
NOTE: A0 direction: North East



PROJECT: 721229 Ongoing Analysis of Coastal Monitoring Data
SITE: Scalby Ness
INSTALLATION: I3
COMPANY: Mouchel Ltd
CLIENT: Scarborough Borough Council

NOTE: A0 direction: East

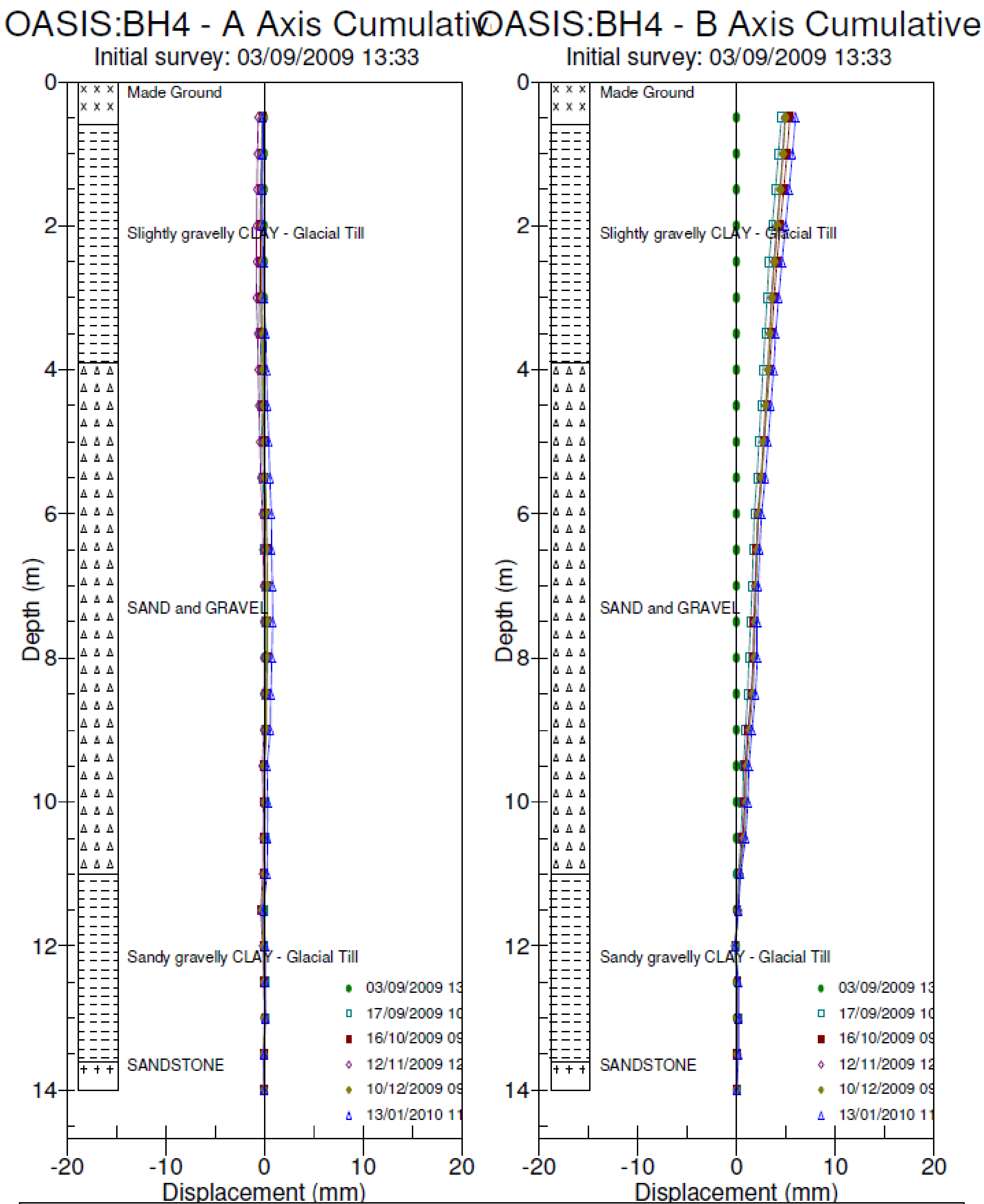




PROJECT: 721229 Ongoing Analysis of Coastal Monitoring Data
SITE: Oasis North Bay
INSTALLATION: BH3
COMPANY: Mouchel Ltd
CLIENT: Scarborough Borough Council

mouchel

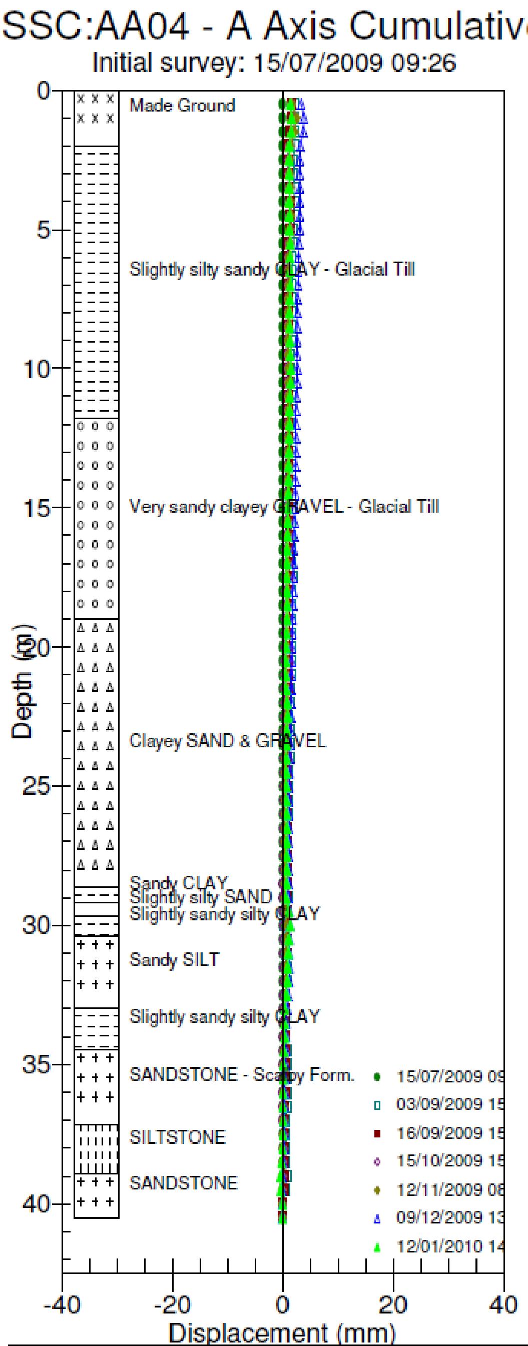
NOTE: A0 direction: East

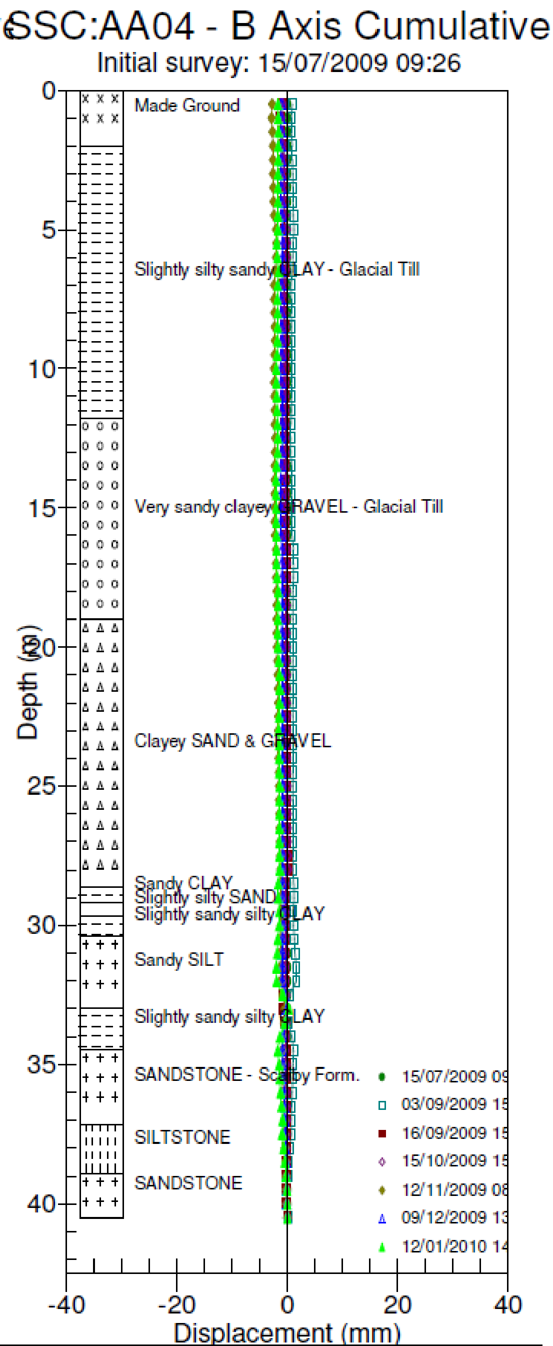


PROJECT: 721229 Ongoing Analysis of Coastal Monitoring Data
SITE: Oasis North Bay
INSTALLATION: BH4
COMPANY: Mouchel Ltd
CLIENT: Scarborough Borough Council

mouchel

NOTE: A0 direction: East

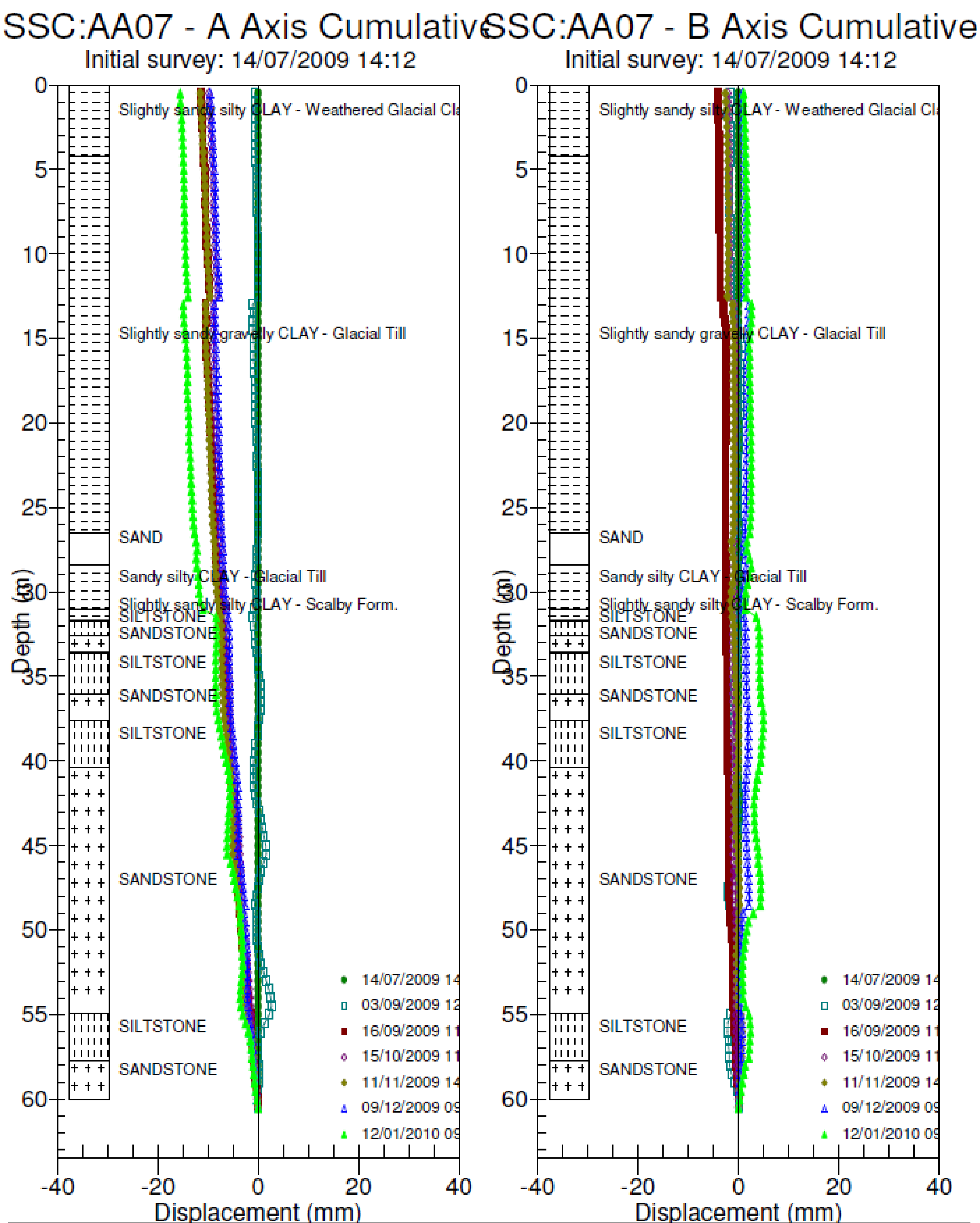




PROJECT: 721229 Ongoing Analysis of Coastal Monitoring Data
SITE: Scarborough South Cliff
INSTALLATION: AA04 (G2)
COMPANY: Mouchel Ltd
CLIENT: Scarborough Borough Council

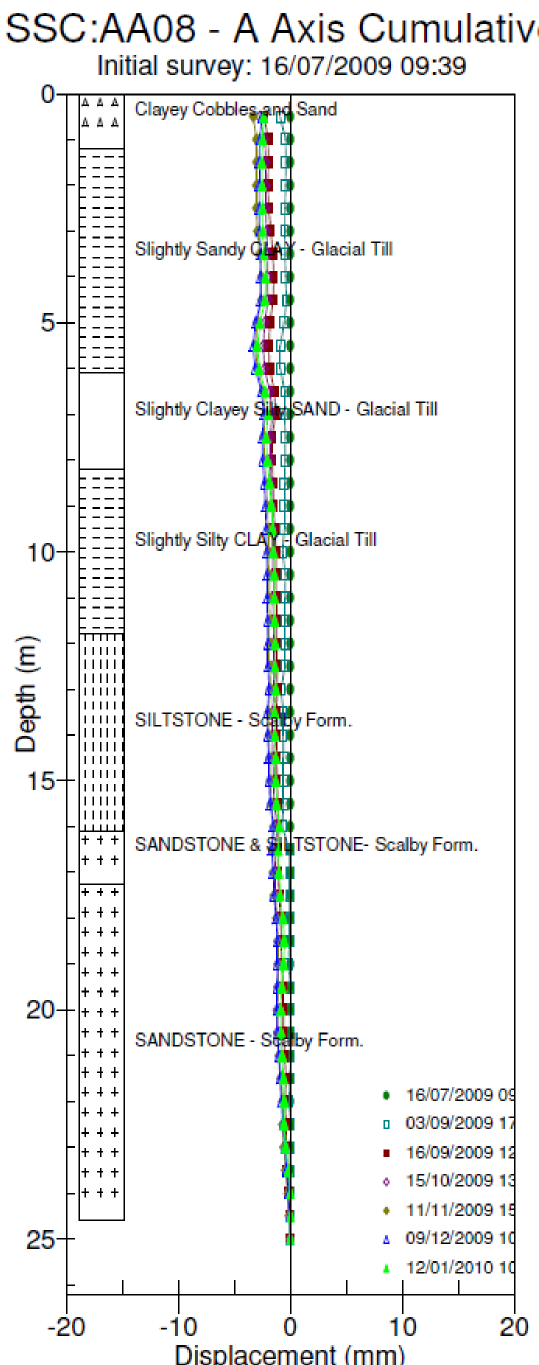
mouchel

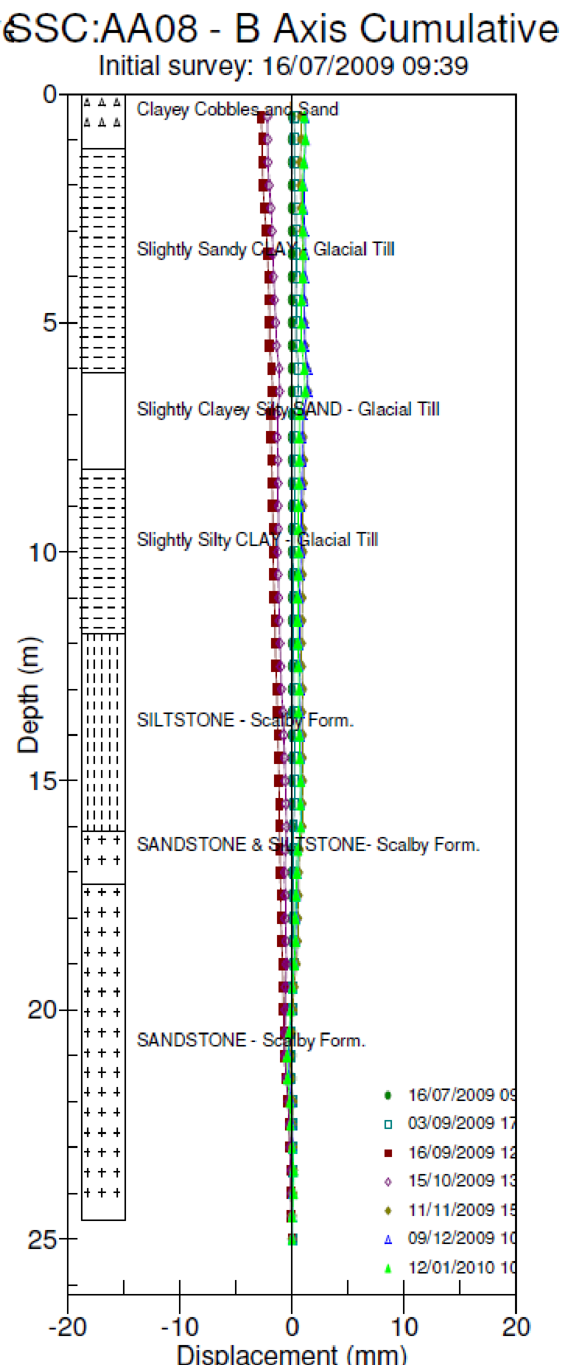
NOTE: A0 direction: North East



PROJECT: 721229 Ongoing Analysis of Coastal Monitoring Data
SITE: Scarborough South Cliff
INSTALLATION: AA07 (BH2)
COMPANY: Mouchel Ltd
CLIENT: Scarborough Borough Council

NOTE: A0 direction: North East

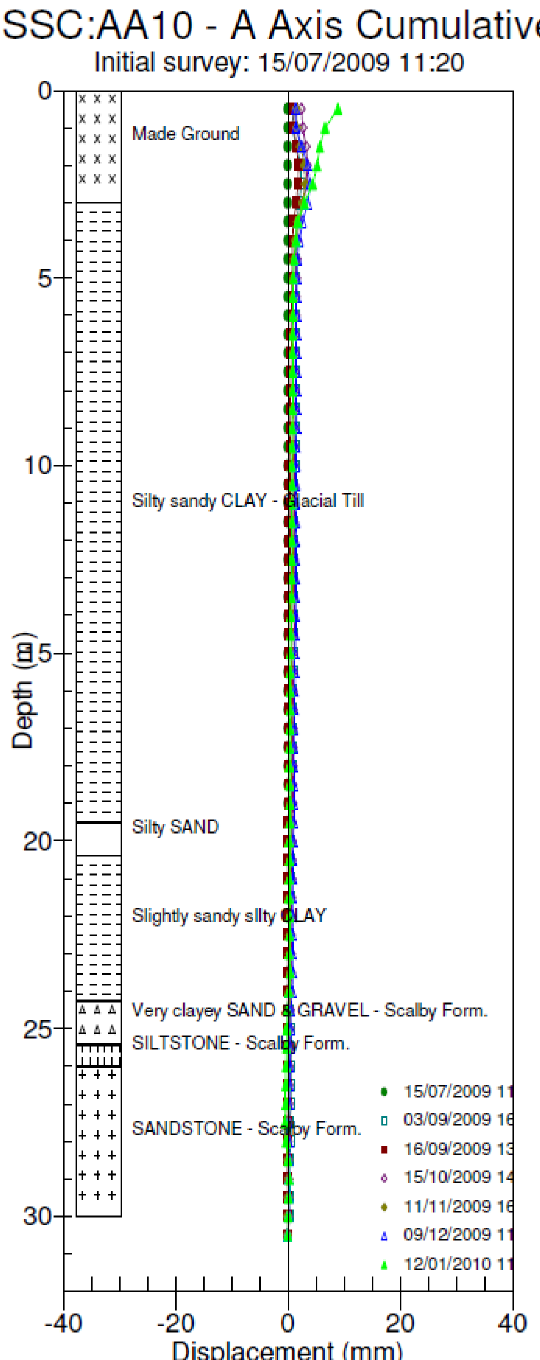


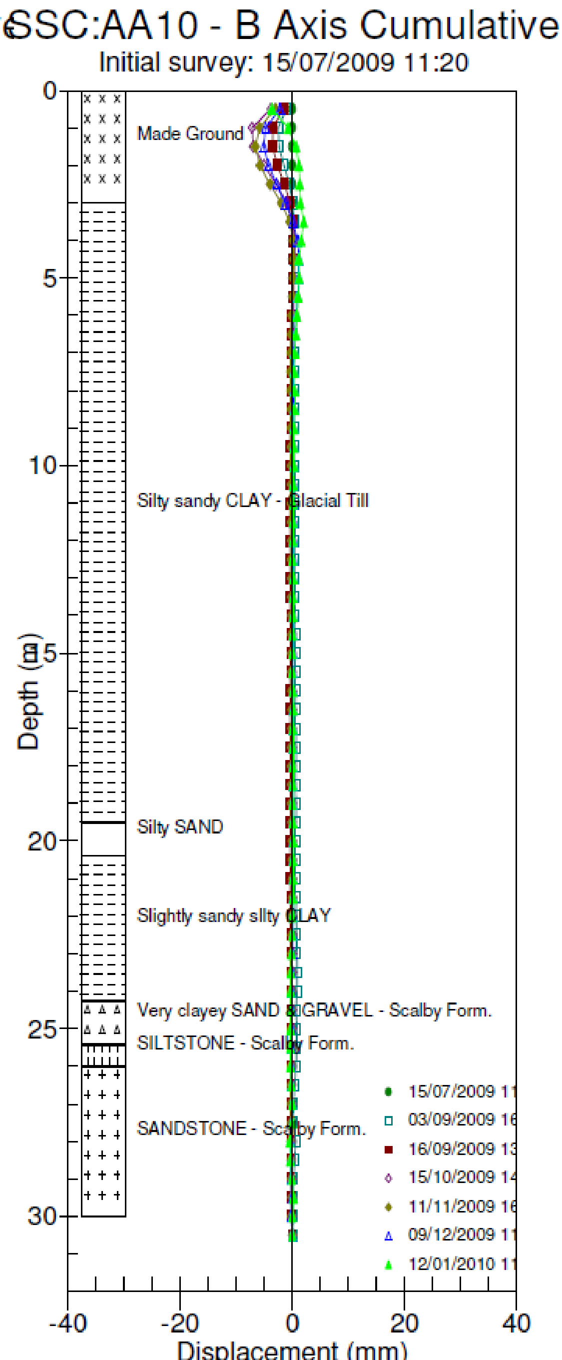


PROJECT: 721229 Ongoing Analysis of Coastal Monitoring Data
SITE: Scarborough South Cliff
INSTALLATION: AA08 (D3)
COMPANY: Mouchel Ltd
CLIENT: Scarborough Borough Council

mouchel

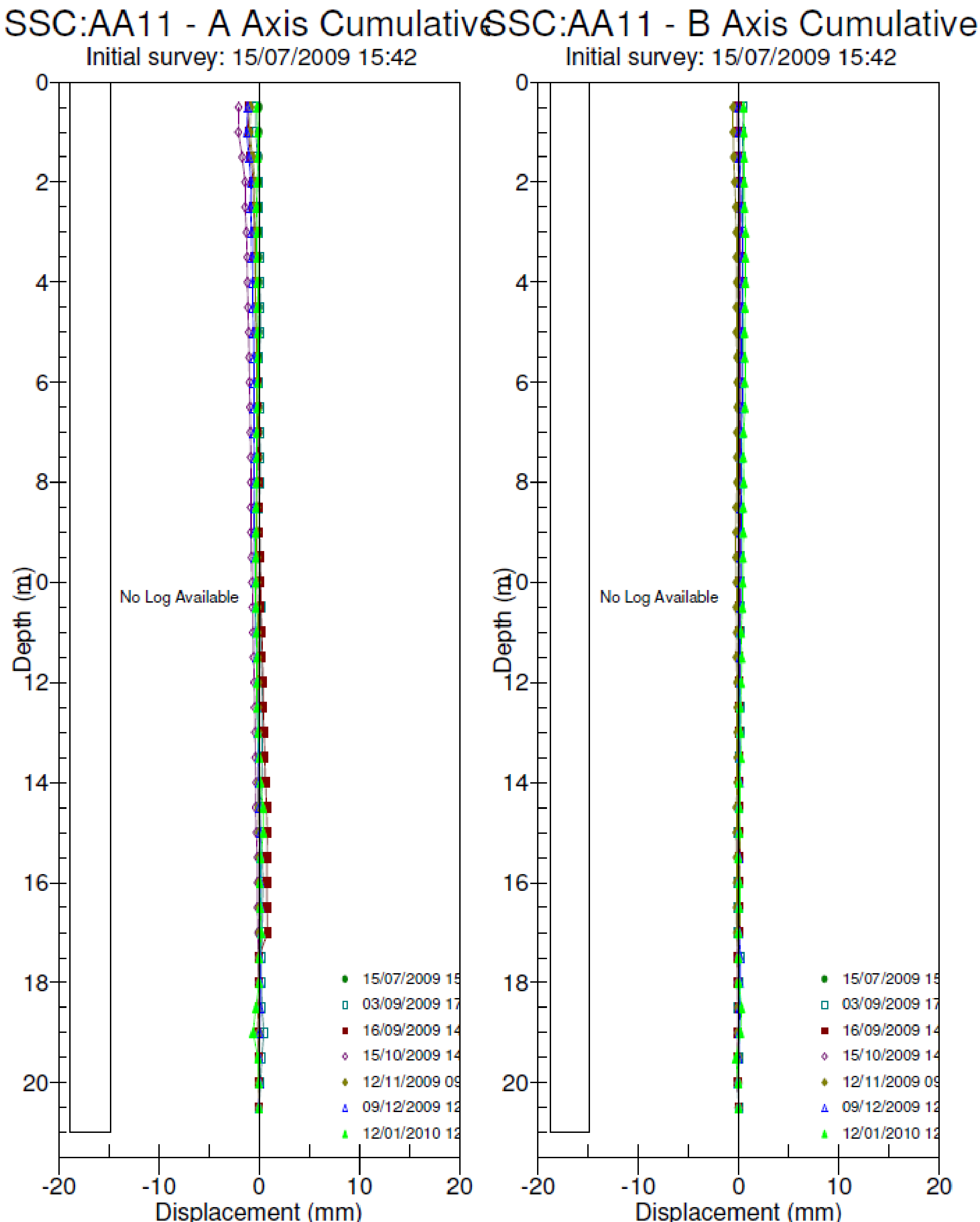
NOTE: A0 direction: East





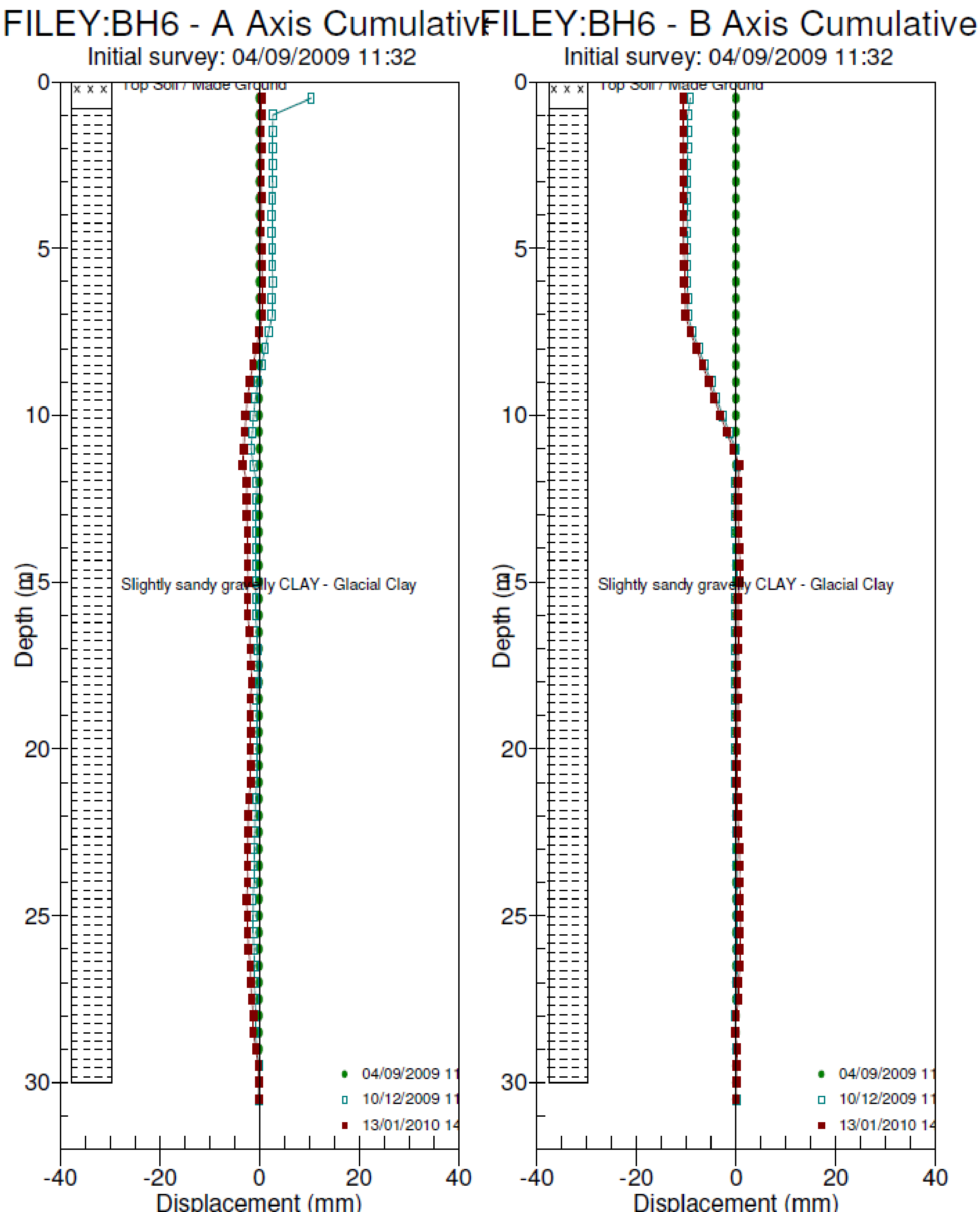
PROJECT: 721229 Ongoing Analysis of Coastal Monitoring Data
SITE: Scarborough South Cliff
INSTALLATION: AA10 (F2)
COMPANY: Mouchel Ltd
CLIENT: Scarborough Borough Council

NOTE: A0 direction: North East



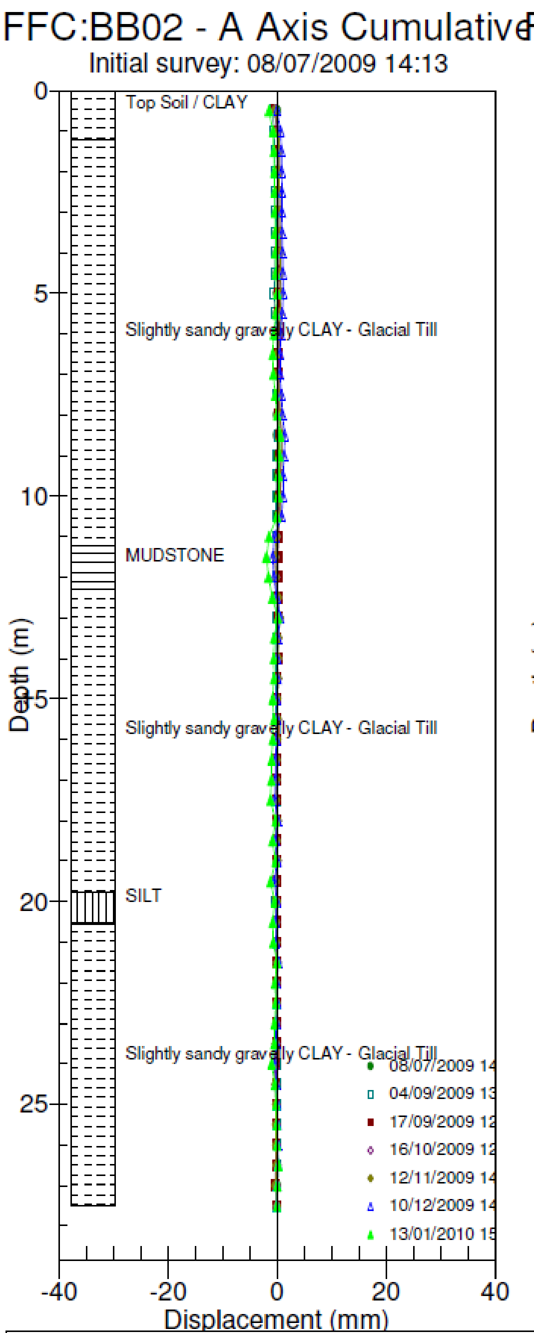
PROJECT: 721229 Ongoing Analysis of Coastal Monitoring Data
SITE: Scarborough South Cliff
INSTALLATION: AA11 (F4)
COMPANY: Mouchel Ltd
CLIENT: Scarborough Borough Council

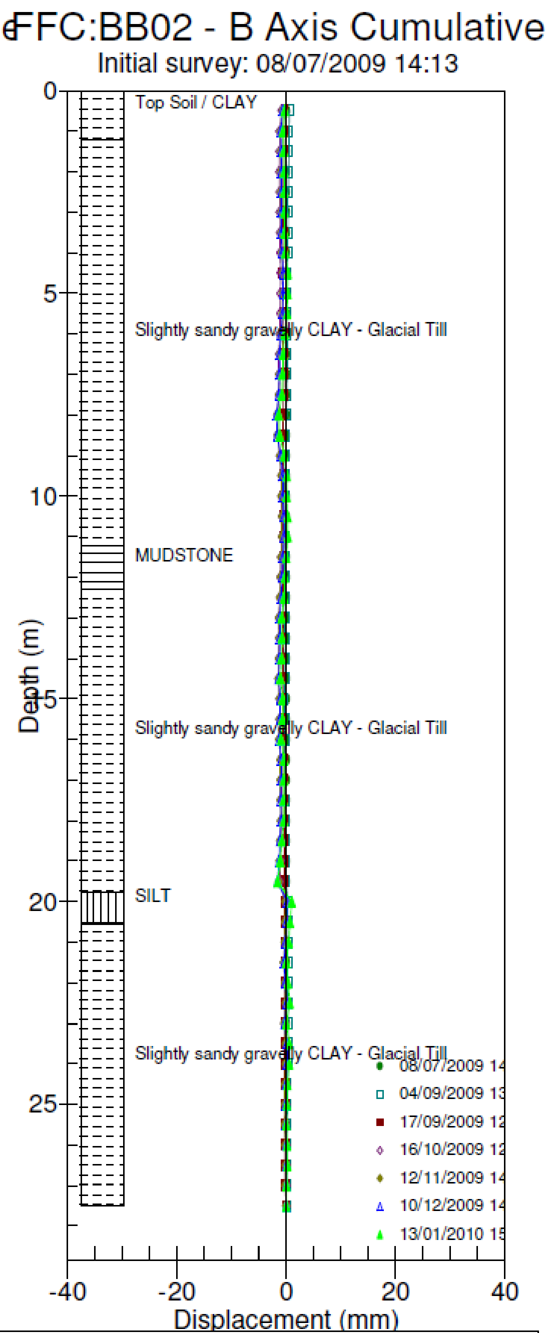
NOTE: A0 direction: North East



PROJECT: Ongoing Analysis of Coastal Monitoring Data
SITE: Filey Town
INSTALLATION: BH6
COMPANY: Mouchel Ltd
CLIENT: Scarborough Borough Council

NOTE: Ao direction: North East



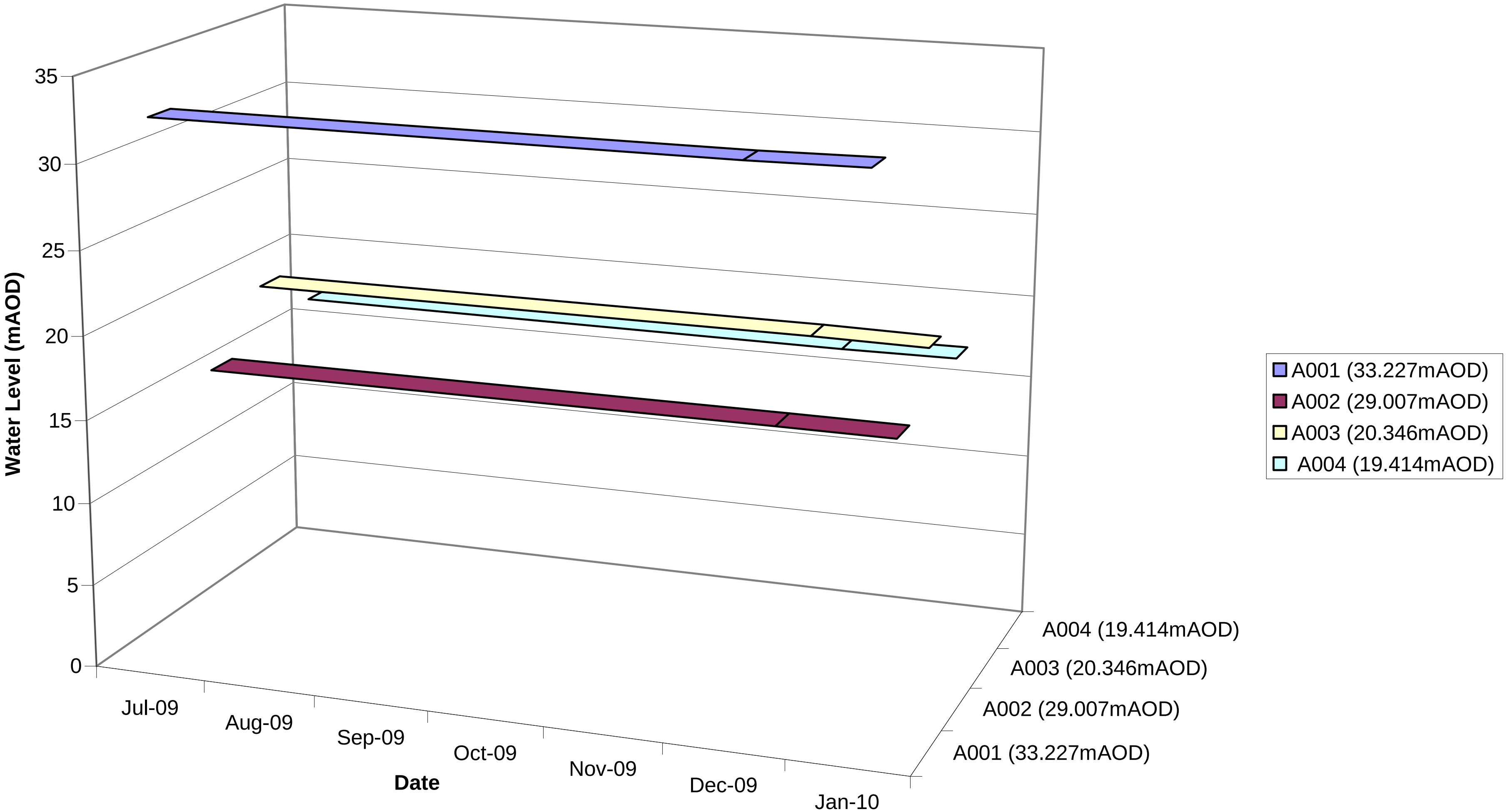


PROJECT: 721229 Ongoing Analysis of Coastal Monitoring Data
SITE: Filey Flat Cliffs
INSTALLATION: BB02
COMPANY: Mouchel Ltd
CLIENT: Scarborough Borough Council

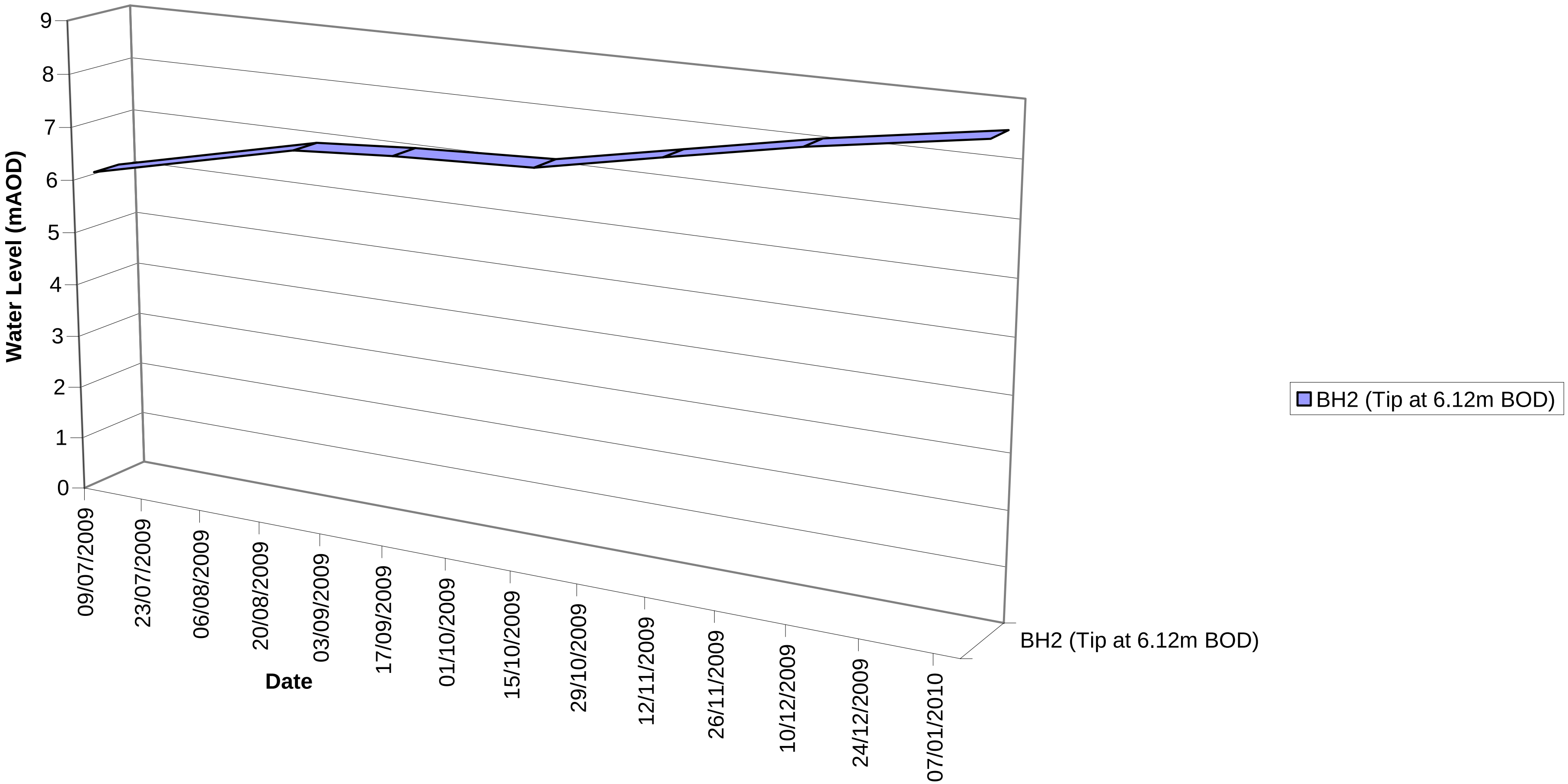
NOTE: A0 direction: East

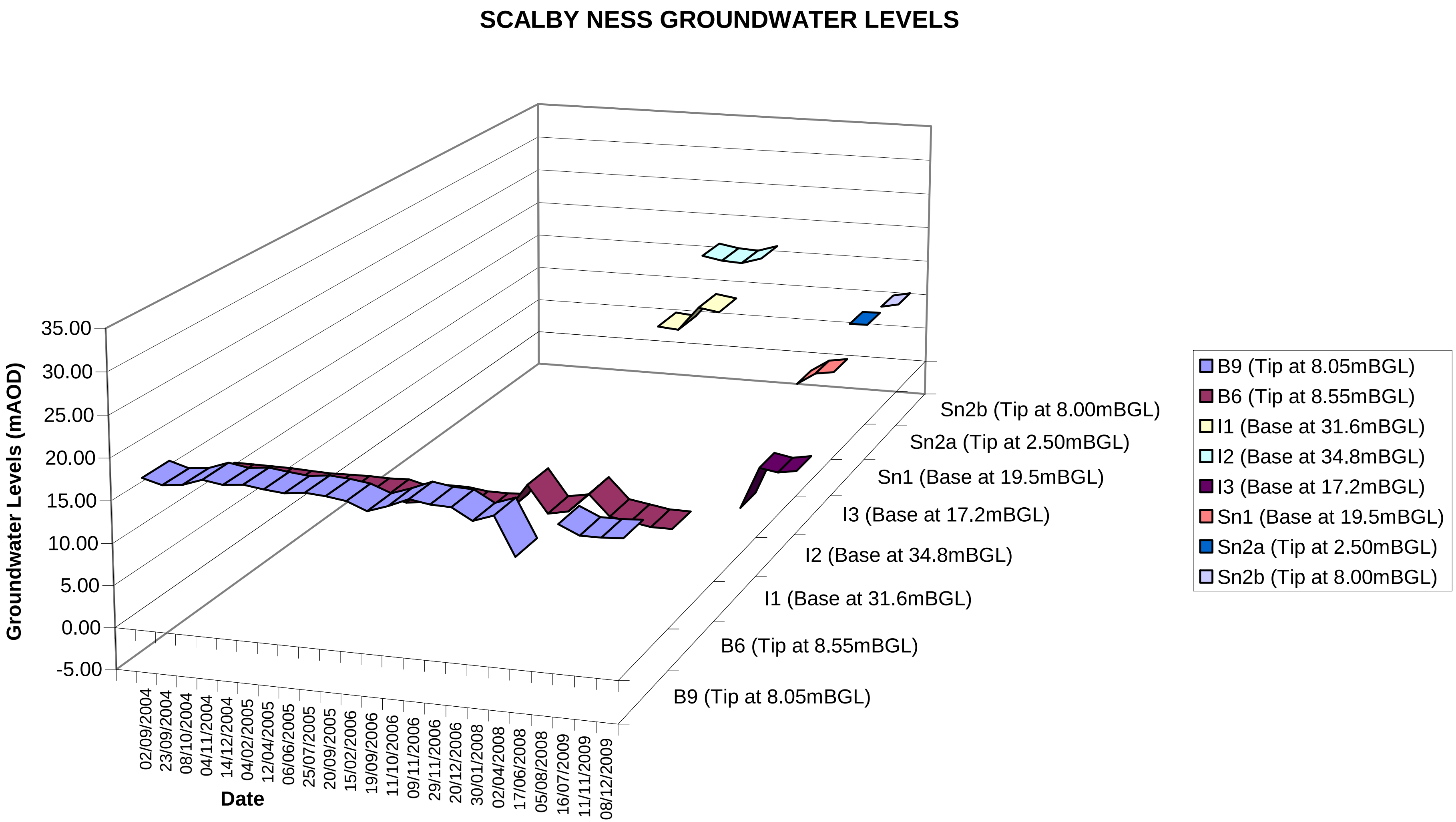
Appendix C Groundwater Monitoring Graphs

RUNSWICK BAY GROUNDWATER LEVELS

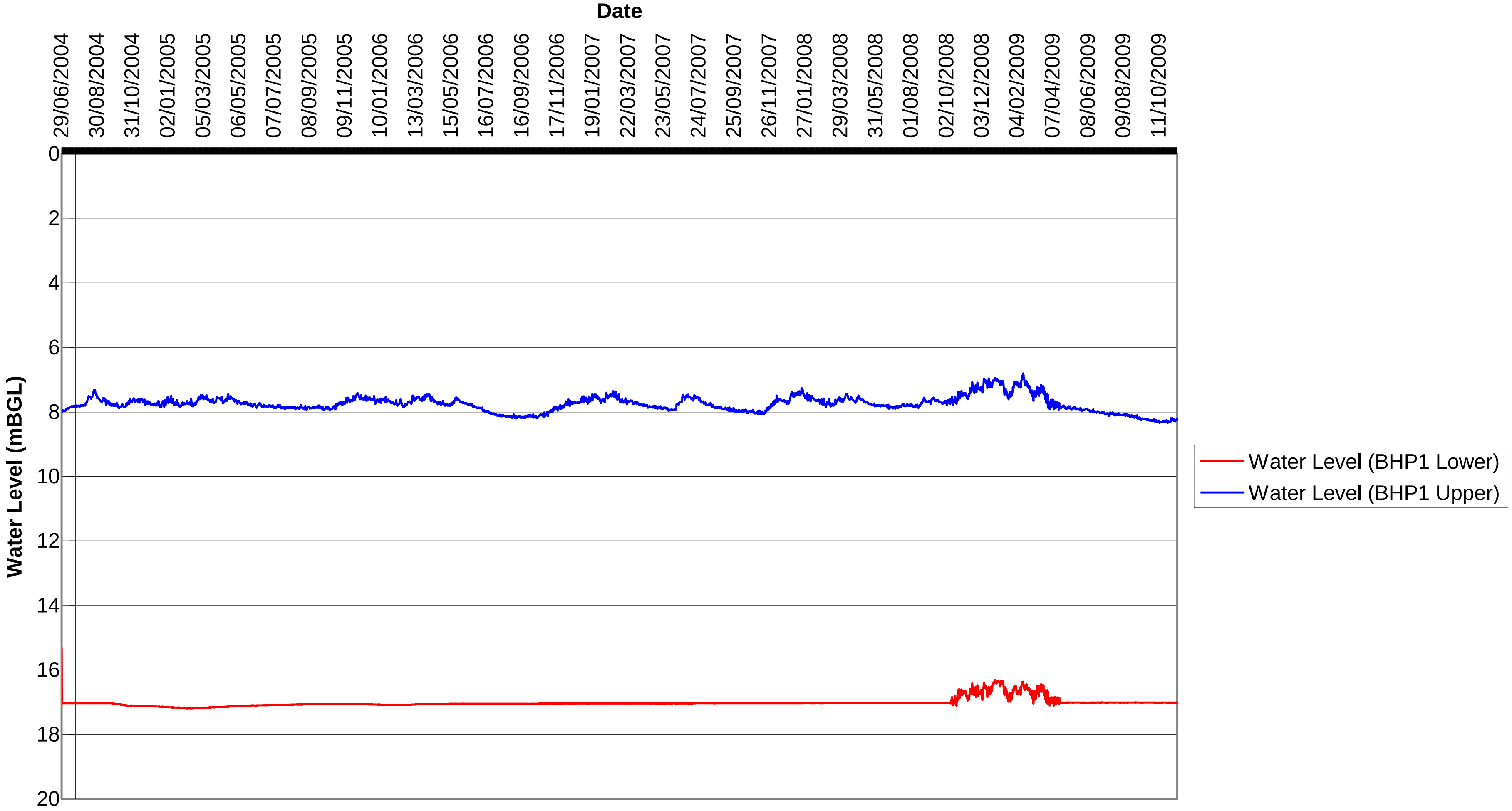


WHITBY WEST CLIFF GROUNDWATER LEVELS

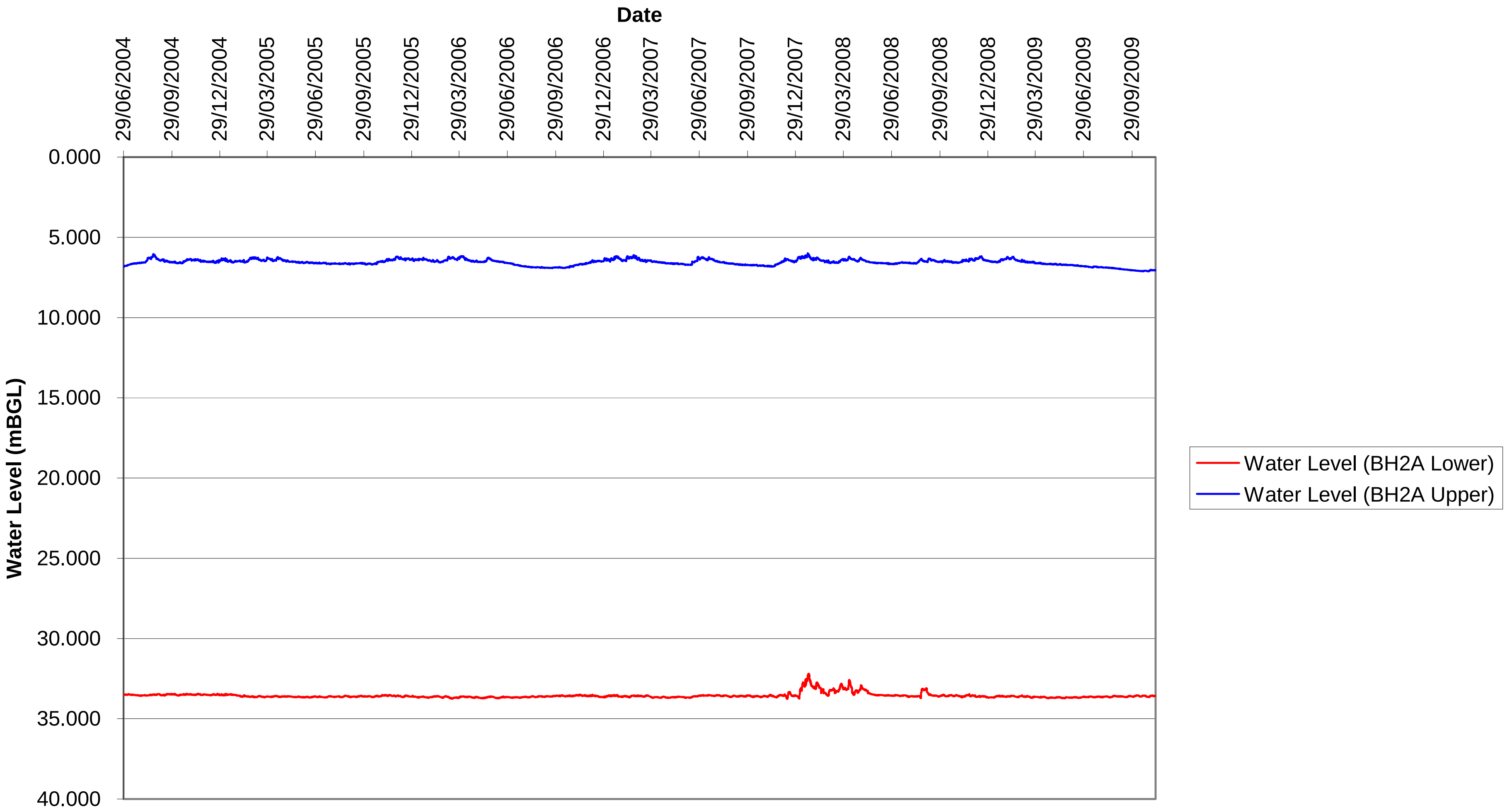



SCALBY NESS GROUNDWATER LEVELS
Groundwater Levels (mAOD)
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
-5.00
02/09/2004
23/09/2004
08/10/2004
04/11/2004
14/12/2004
04/02/2005
12/04/2005
06/06/2005
25/07/2005
20/09/2005
15/02/2006
19/09/2006
11/10/2006
09/11/2006
29/11/2006
20/12/2006
30/01/2008
02/04/2008
17/06/2008
05/08/2008
16/07/2009
11/11/2009
08/12/2009
Date
B9 (Tip at 8.05mBGL)
B6 (Tip at 8.55mBGL)
I1 (Base at 31.6mBGL)
I2 (Base at 34.8mBGL)
I3 (Base at 17.2mBGL)
Sn1 (Base at 19.5mBGL)
Sn2a (Tip at 2.50mBGL)
Sn2b (Tip at 8.00mBGL)

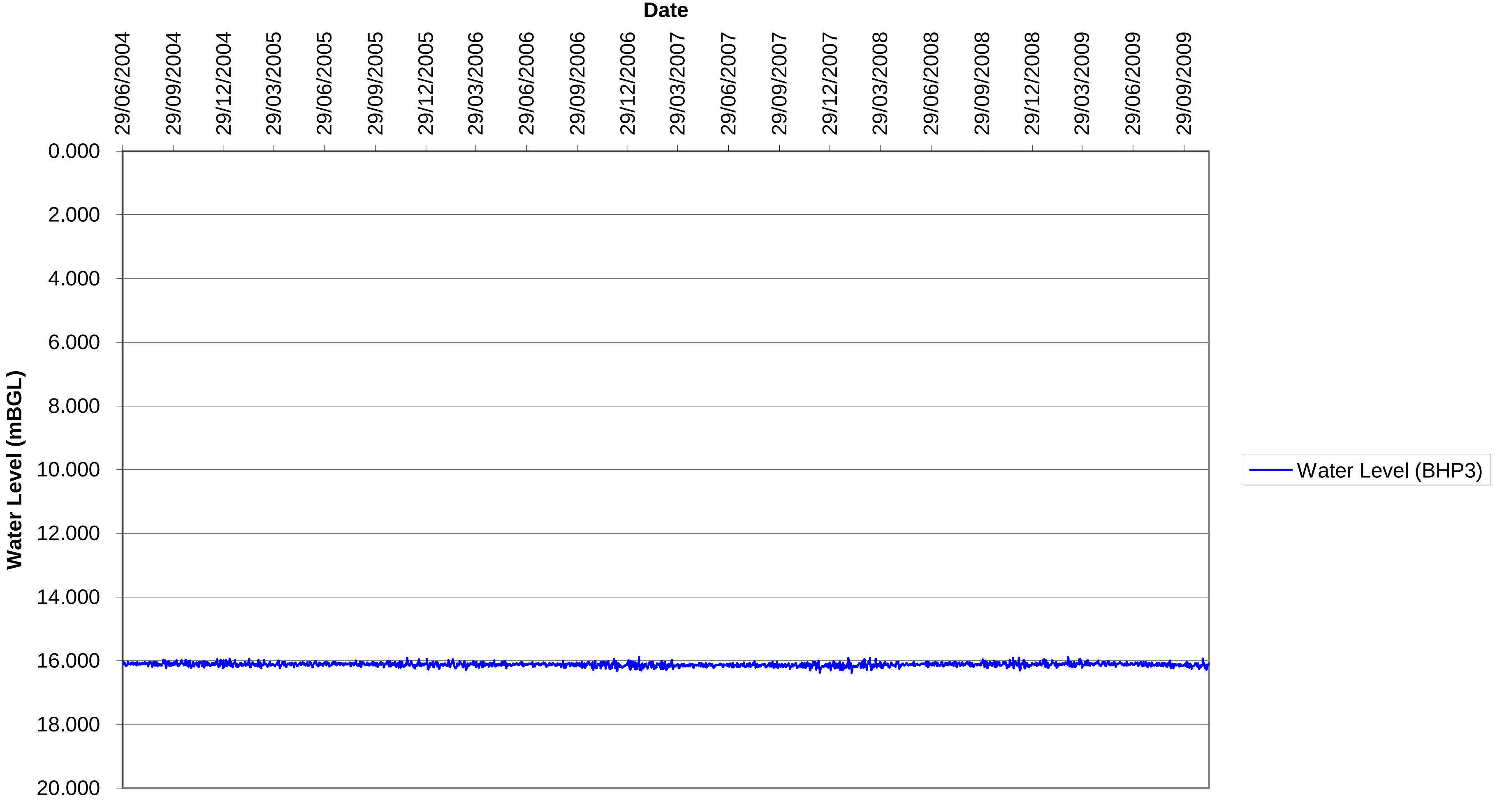
SCALBY NESS (AUTOMATED) GROUNDWATER LEVELS

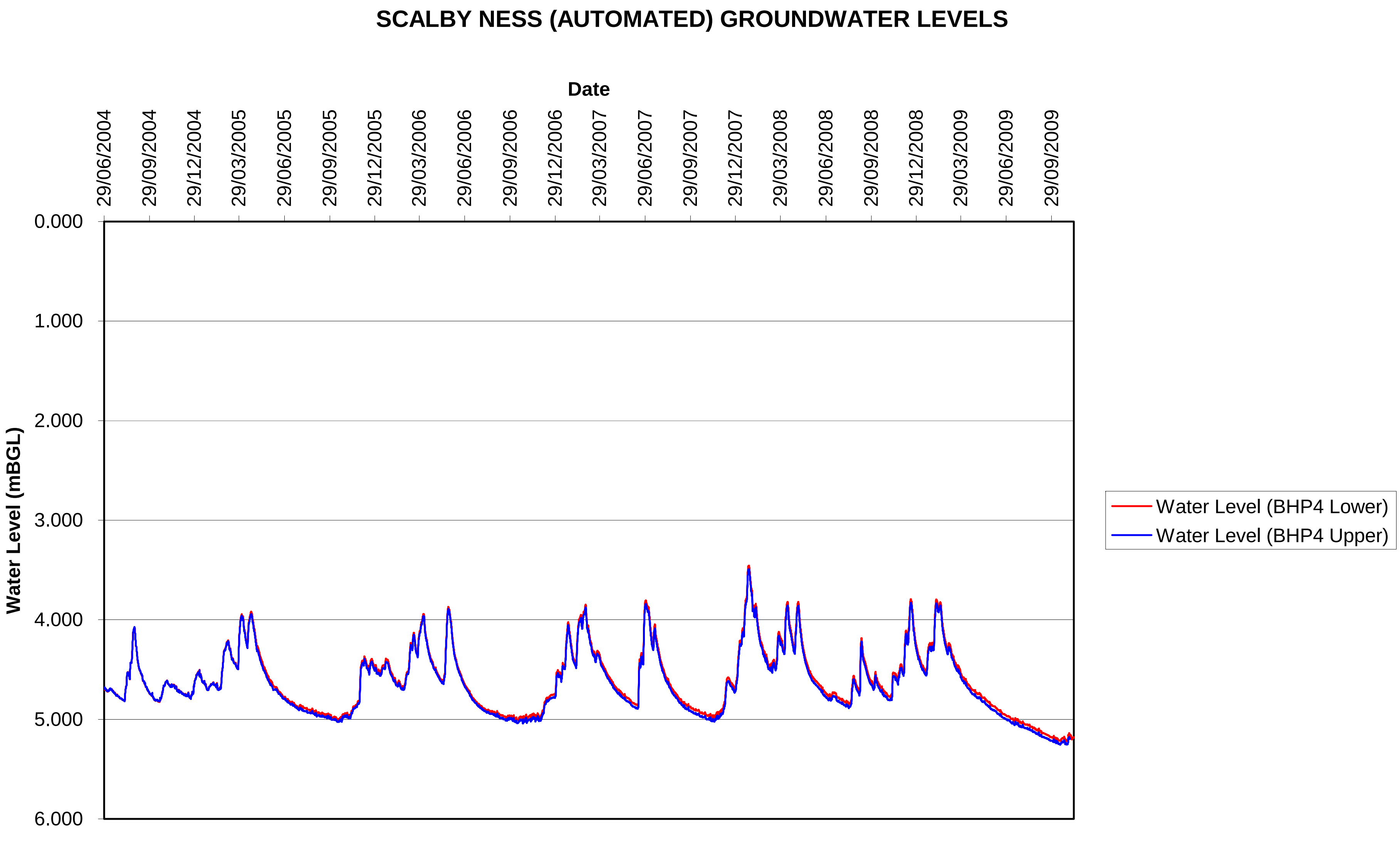


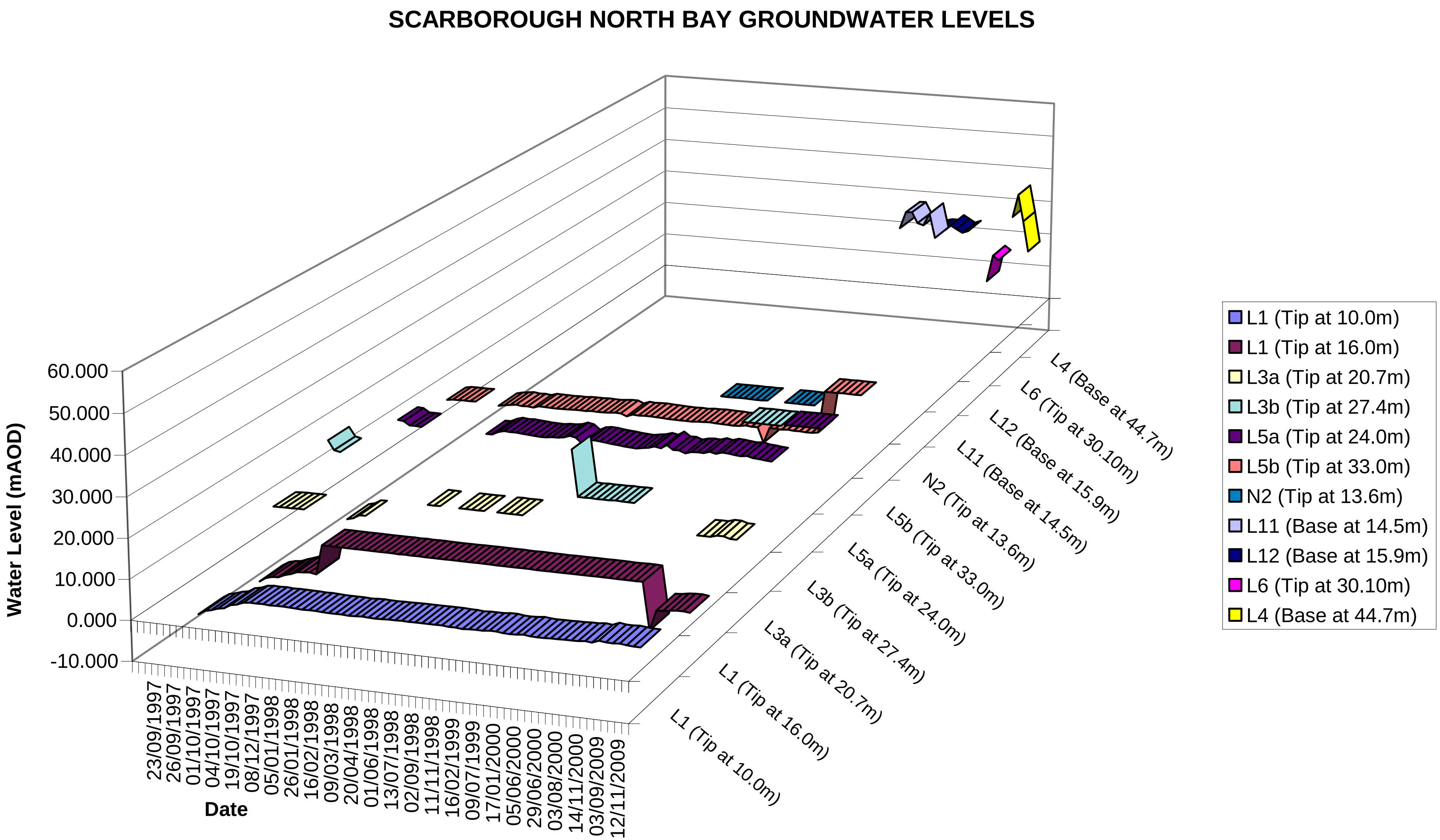
SCALBY NESS (AUTOMATED) GROUNDWATER LEVELS



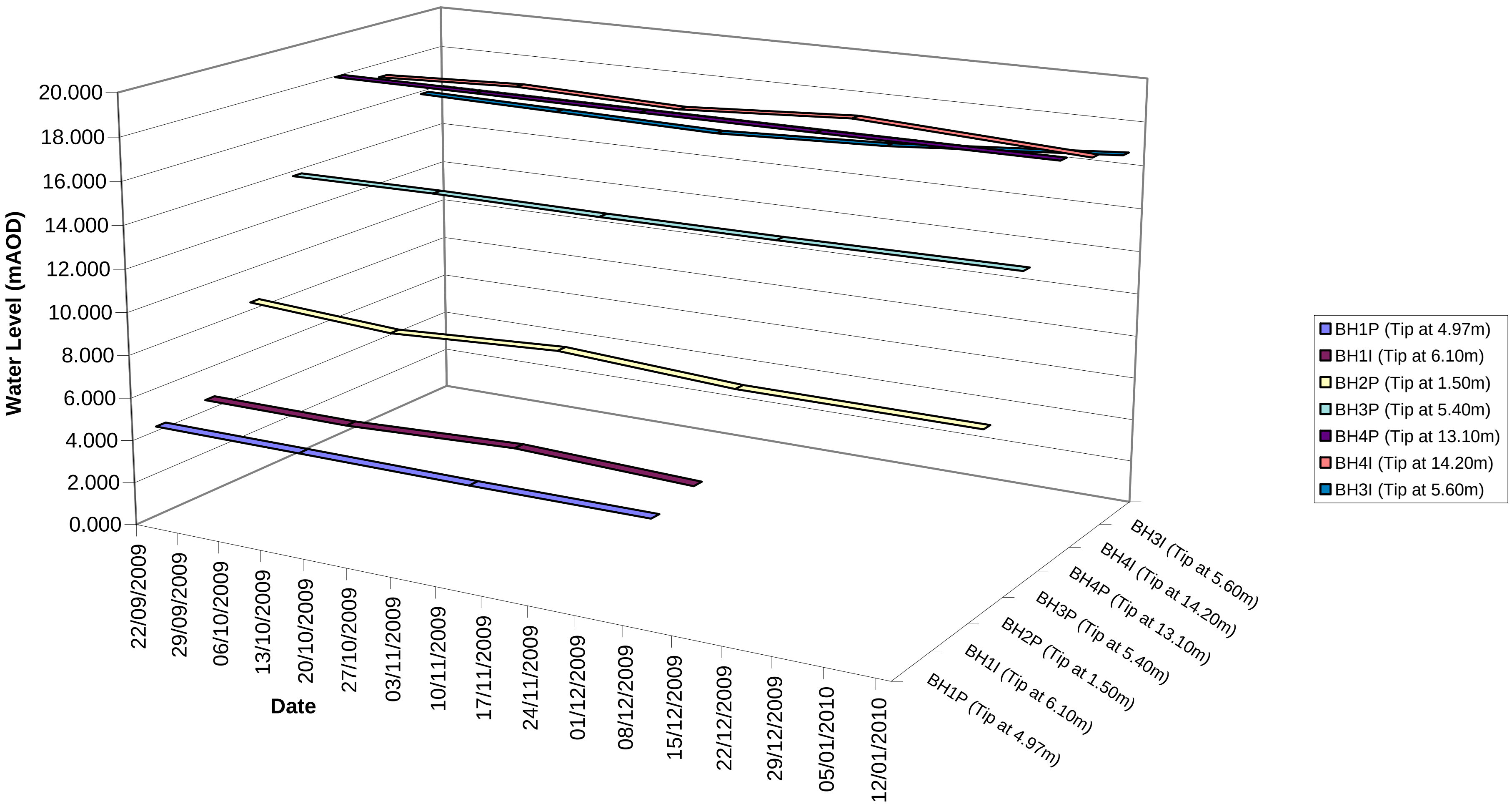
SCALBY NESS (AUTOMATED) GROUNDWATER LEVELS



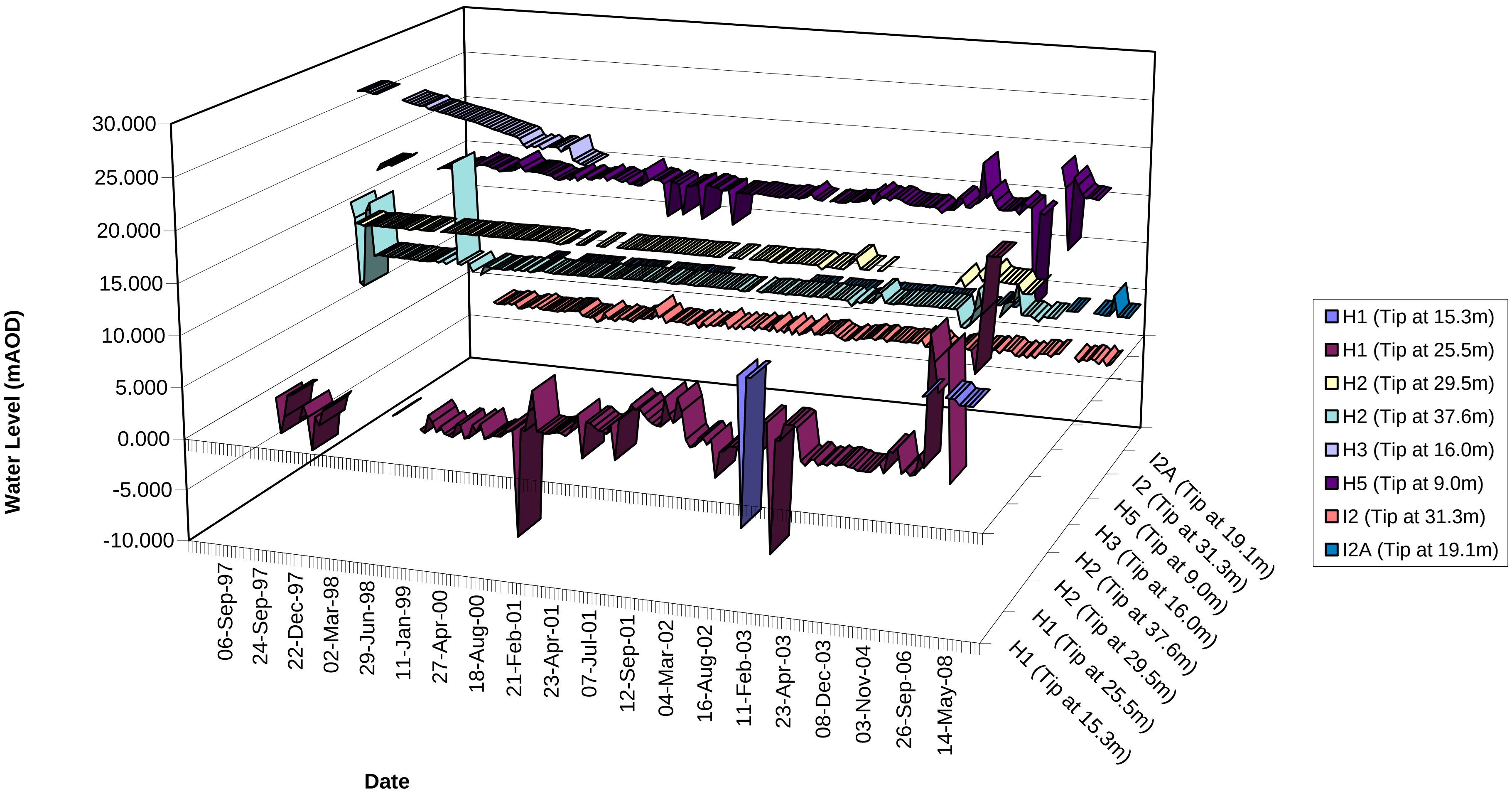

SCALBY NESS (AUTOMATED) GROUNDWATER LEVELS
Date
29/06/2004
29/09/2004
29/12/2004
29/03/2005
29/06/2005
29/09/2005
29/12/2005
29/03/2006
29/06/2006
29/09/2006
29/12/2006
29/03/2007
29/06/2007
29/09/2007
29/12/2007
29/03/2008
29/06/2008
29/09/2008
29/12/2008
29/03/2009
29/06/2009
29/09/2009
Water Level (mBGL)
0.000
1.000
2.000
3.000
4.000
5.000
6.000
Water Level (BHP4 Lower)
Water Level (BHP4 Upper)

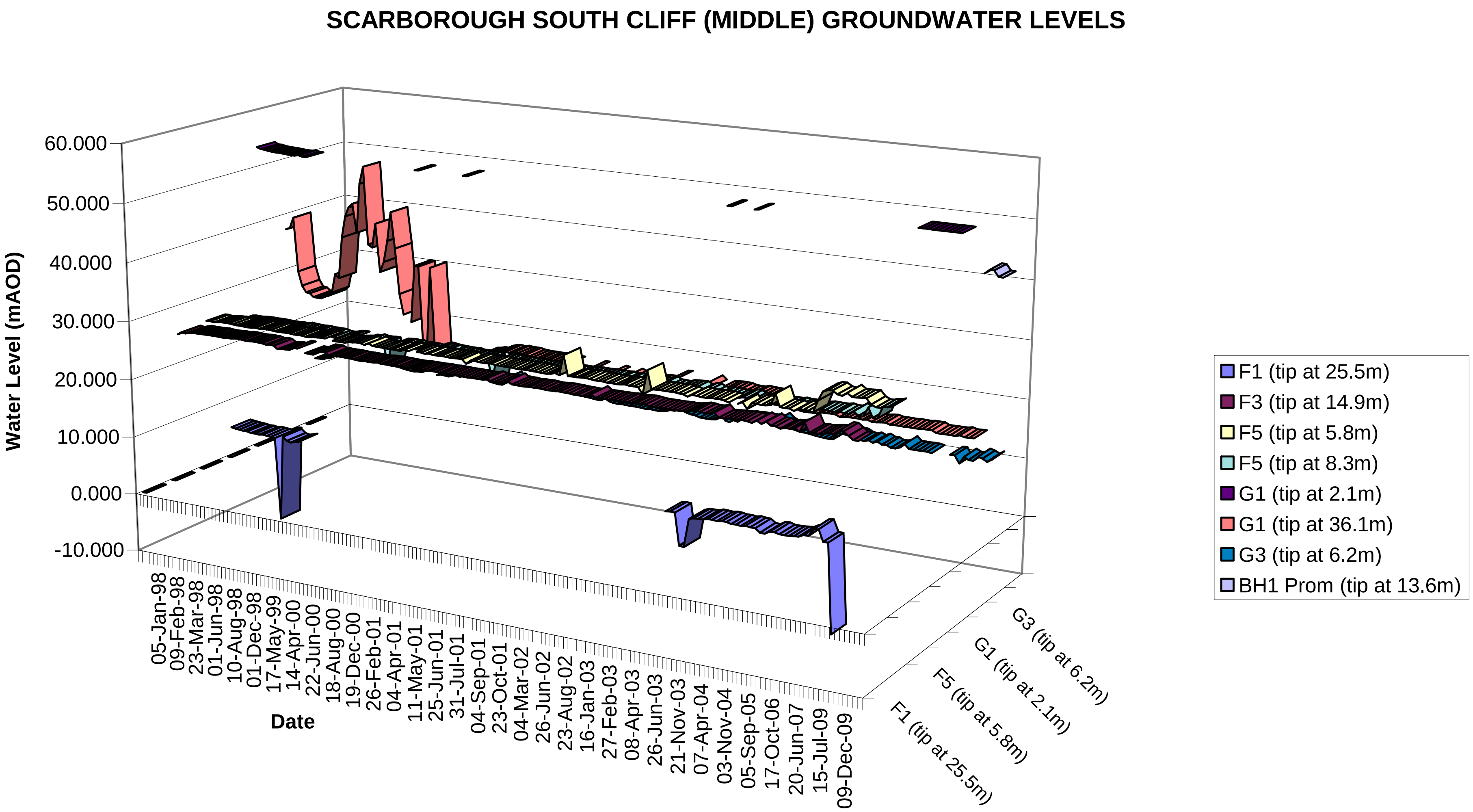

SCARBOROUGH NORTH BAY GROUNDWATER LEVELS
Water Level (mAOD)
60.000
50.000
40.000
30.000
20.000
10.000
0.000
-10.000
Date
23/09/1997
26/09/1997
01/10/1997
04/10/1997
19/10/1997
08/12/1997
05/01/1998
26/01/1998
16/02/1998
09/03/1998
20/04/1998
01/06/1998
13/07/1998
02/09/1998
11/11/1998
16/02/1999
09/07/1999
17/01/2000
05/06/2000
29/06/2000
03/08/2000
14/11/2000
03/09/2009
12/11/2009
L1 (Tip at 10.0m)
L1 (Tip at 16.0m)
L3a (Tip at 20.7m)
L3b (Tip at 27.4m)
L5a (Tip at 24.0m)
L5b (Tip at 33.0m)
N2 (Tip at 13.6m)
L11 (Base at 14.5m)
L12 (Base at 15.9m)
L6 (Tip at 30.10m)
L4 (Base at 44.7m)

OASIS CAFÉ GROUNDWATER LEVELS



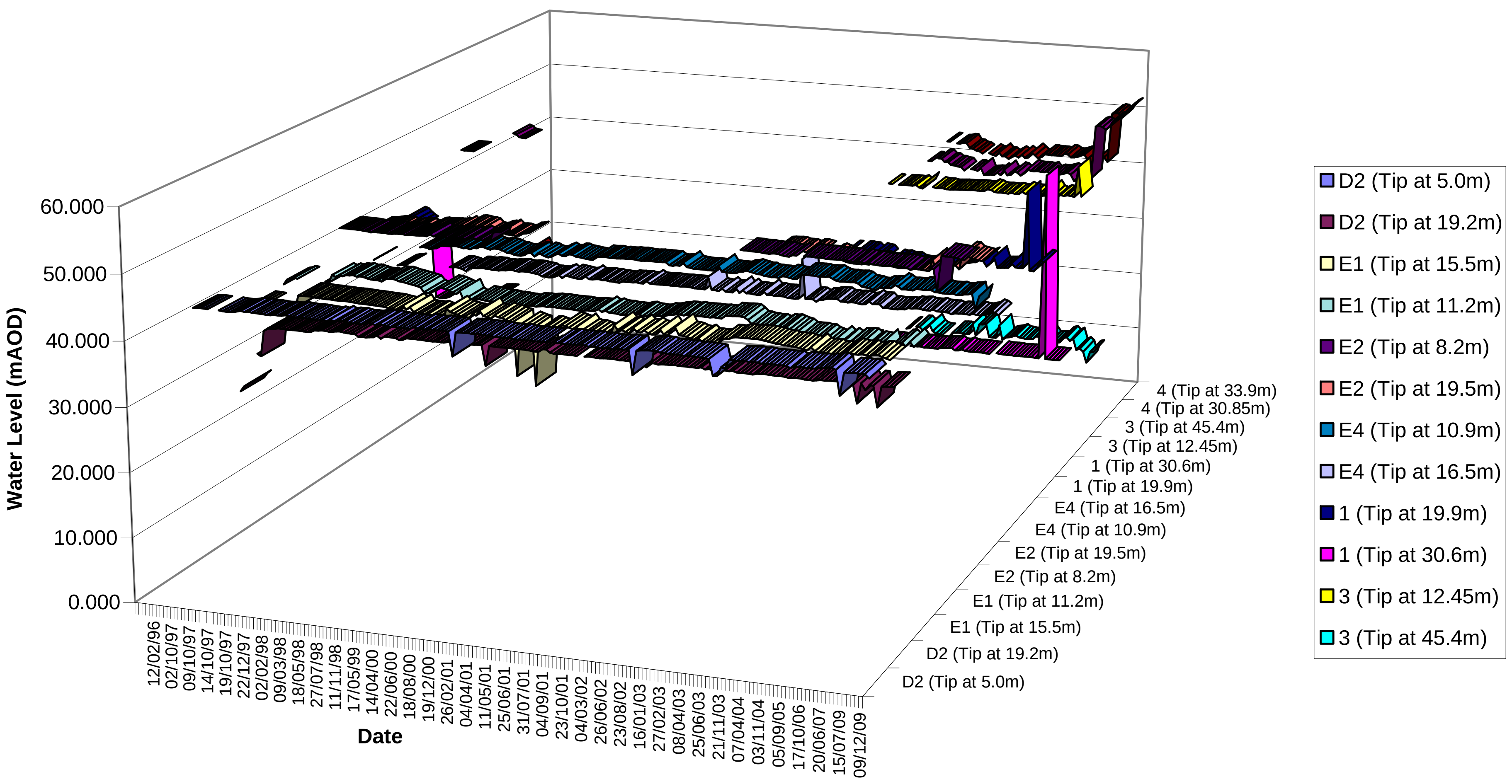
SCARBOROUGH SOUTH CLIFF (NORTH) GROUNDWATER LEVELS



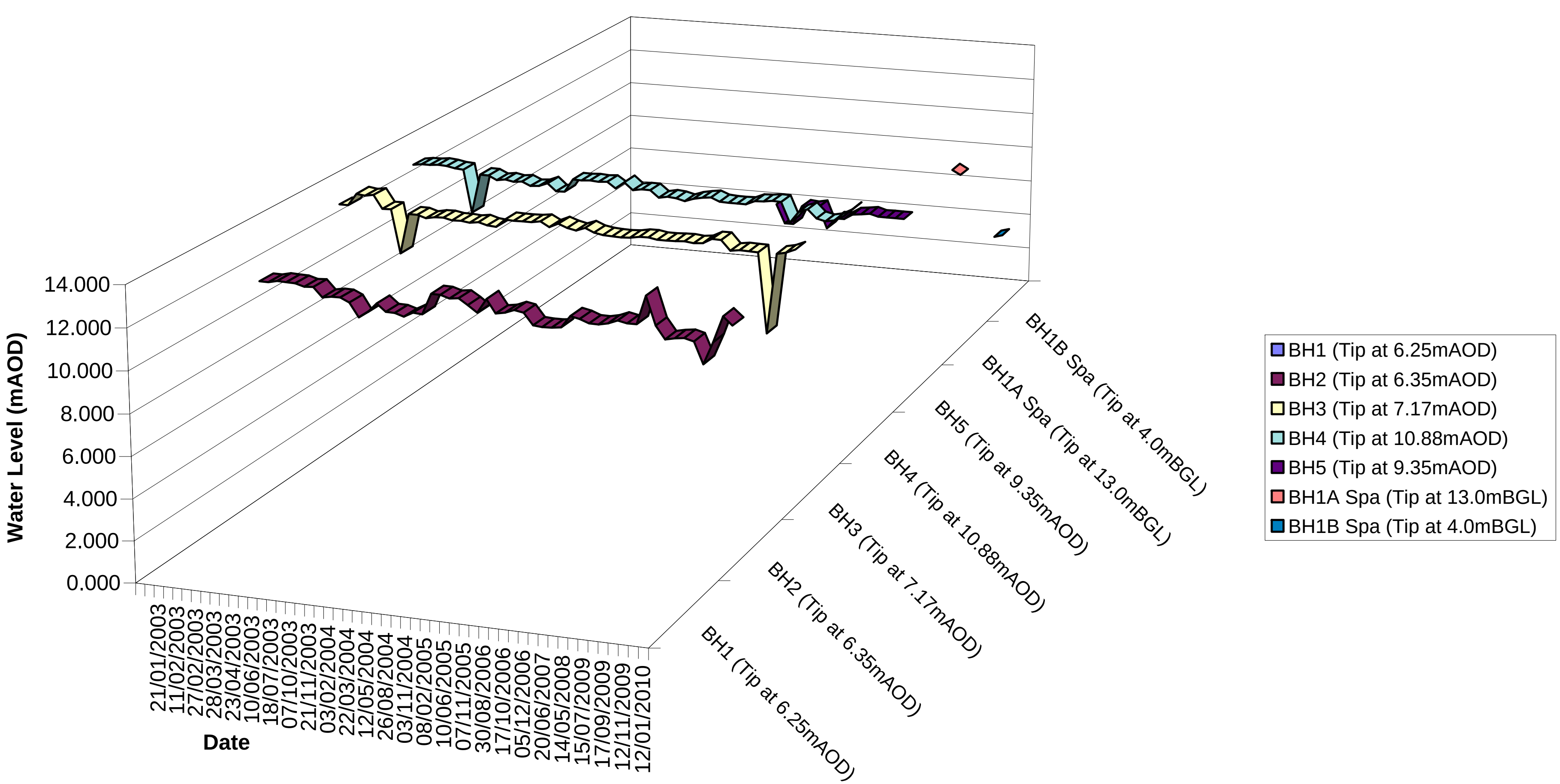


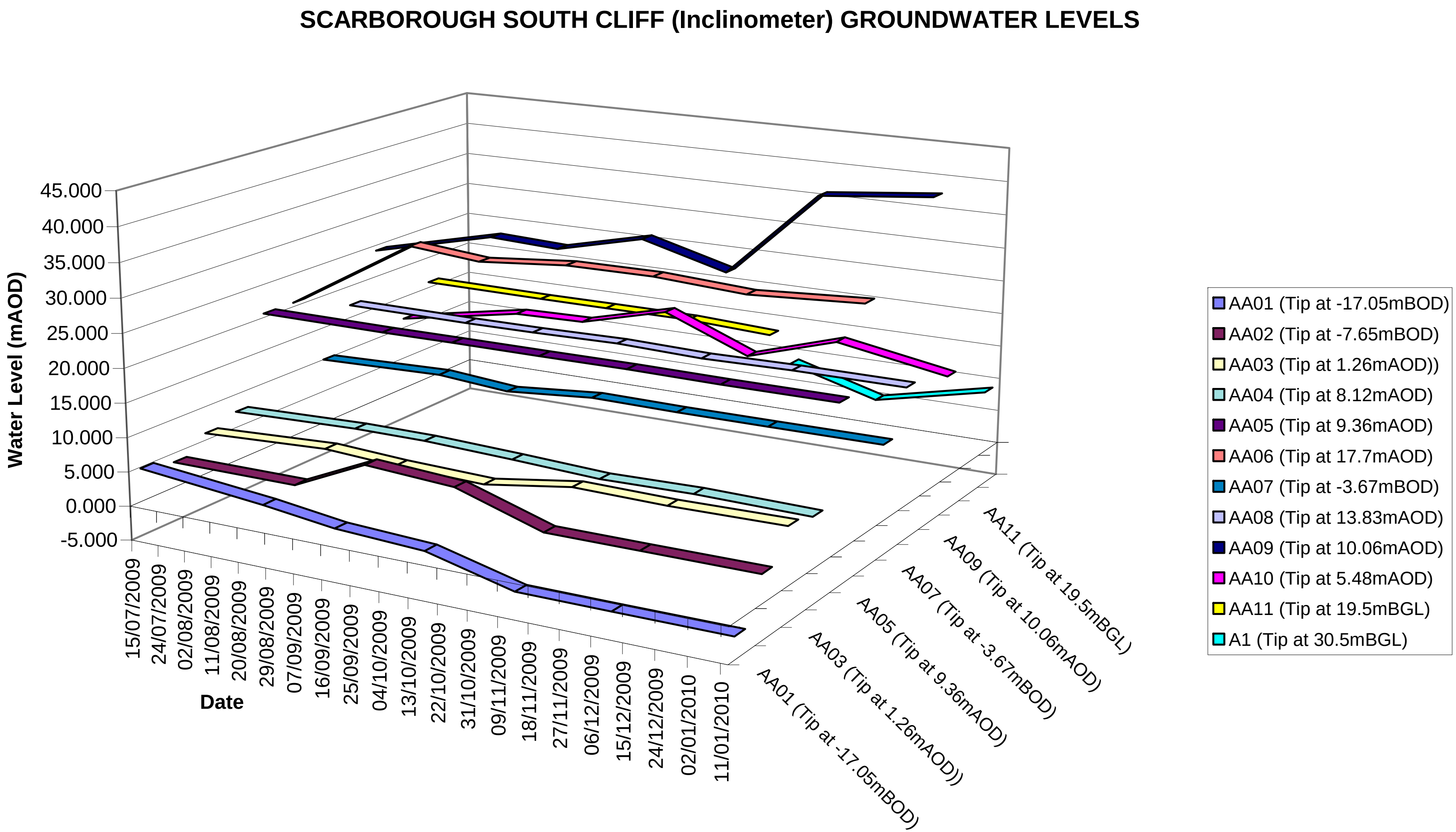
SCARBOROUGH SOUTH CLIFF (MIDDLE) GROUNDWATER LEVELS
Water Level (mAOD)
60.000
50.000
40.000
30.000
20.000
10.000
0.000
-10.000
05-Jan-98
09-Feb-98
23-Mar-98
01-Jun-98
10-Aug-98
01-Dec-98
17-May-99
14-Apr-00
22-Jun-00
18-Aug-00
19-Dec-00
26-Feb-01
04-Apr-01
11-May-01
25-Jun-01
31-Jul-01
04-Sep-01
23-Oct-01
04-Mar-02
26-Jun-02
23-Aug-02
16-Jan-03
27-Feb-03
08-Apr-03
26-Jun-03
21-Nov-03
07-Apr-04
03-Nov-04
05-Sep-05
17-Oct-06
20-Jun-07
15-Jul-09
09-Dec-09
Date
F1 (tip at 25.5m)
F5 (tip at 5.8m)
G1 (tip at 2.1m)
G3 (tip at 6.2m)
F1 (tip at 25.5m)
F3 (tip at 14.9m)
F5 (tip at 5.8m)
F5 (tip at 8.3m)
G1 (tip at 2.1m)
G1 (tip at 36.1m)
G3 (tip at 6.2m)
BH1 Prom (tip at 13.6m)

SCARBOROUGH SOUTH CLIFF (SOUTH) GROUNDWATER LEVELS

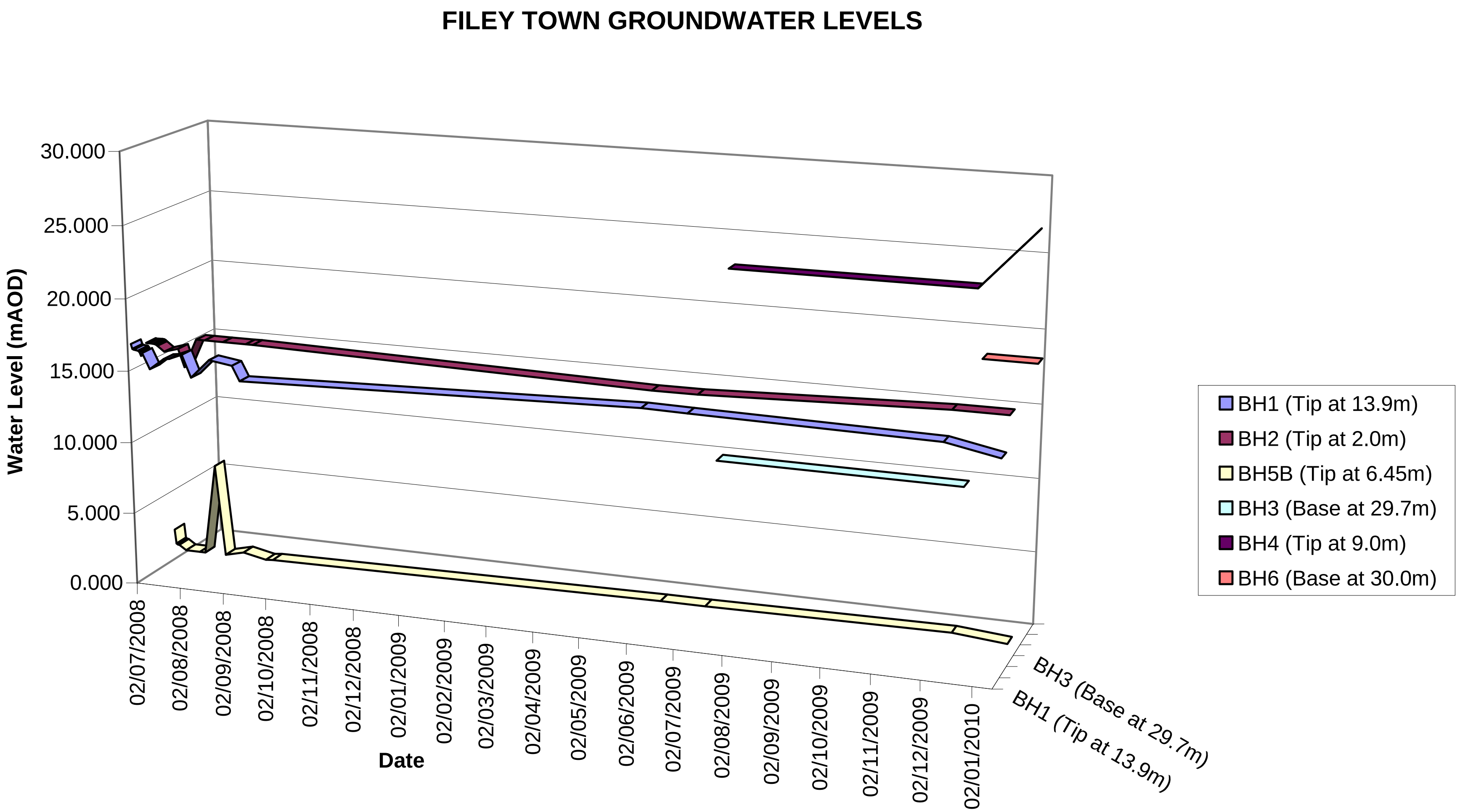


SCARBOROUGH SPA GROUNDWATER LEVELS

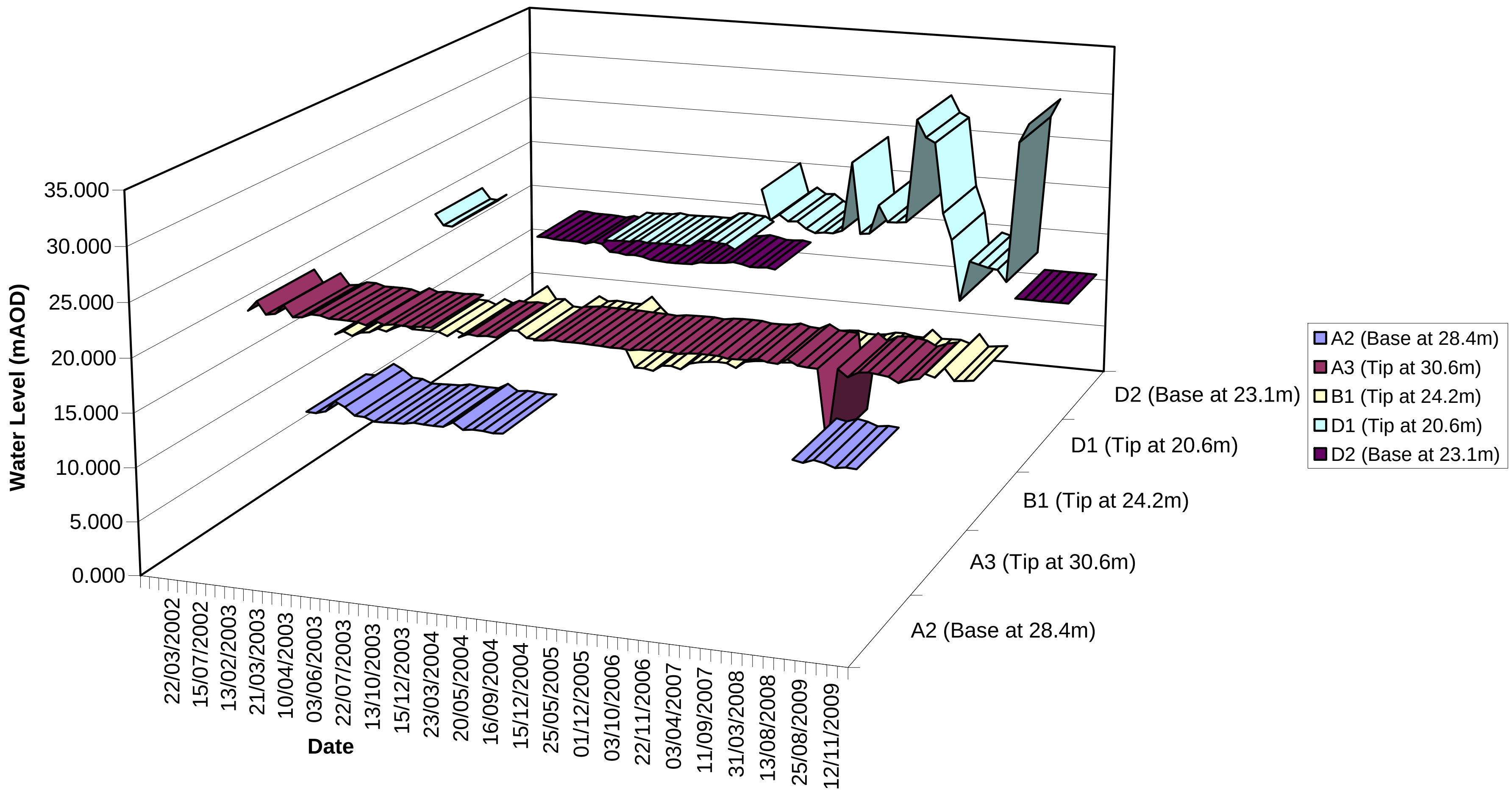




SCARBOROUGH SOUTH CLIFF (Inclinometer) GROUNDWATER LEVELS
Water Level (mAOD)
45.000
40.000
35.000
30.000
25.000
20.000
15.000
10.000
5.000
0.000
-5.000
Date
15/07/2009
24/07/2009
02/08/2009
11/08/2009
20/08/2009
29/08/2009
07/09/2009
16/09/2009
25/09/2009
04/10/2009
13/10/2009
22/10/2009
31/10/2009
09/11/2009
18/11/2009
27/11/2009
06/12/2009
15/12/2009
24/12/2009
02/01/2010
11/01/2010
AA01 (Tip at -17.05mBOD)
AA03 (Tip at 1.26mAOD))
AA05 (Tip at 9.36mAOD)
AA07 (Tip at -3.67mBOD)
AA09 (Tip at 10.06mAOD)
AA11 (Tip at 19.5mBGL)
AA01 (Tip at -17.05mBOD)
AA02 (Tip at -7.65mBOD)
AA03 (Tip at 1.26mAOD))
AA04 (Tip at 8.12mAOD)
AA05 (Tip at 9.36mAOD)
AA06 (Tip at 17.7mAOD)
AA07 (Tip at -3.67mBOD)
AA08 (Tip at 13.83mAOD)
AA09 (Tip at 10.06mAOD)
AA10 (Tip at 5.48mAOD)
AA11 (Tip at 19.5mBGL)
A1 (Tip at 30.5mBGL)


FILEY TOWN GROUNDWATER LEVELS
Water Level (mAOD)
30.000
25.000
20.000
15.000
10.000
5.000
0.000
02/07/2008
02/08/2008
02/09/2008
02/10/2008
02/11/2008
02/12/2008
02/01/2009
02/02/2009
02/03/2009
02/04/2009
02/05/2009
02/06/2009
02/07/2009
02/08/2009
02/09/2009
02/10/2009
02/11/2009
02/12/2009
02/01/2010
Date
BH3 (Base at 29.7m)
BH1 (Tip at 13.9m)
BH1 (Tip at 13.9m)
BH2 (Tip at 2.0m)
BH5B (Tip at 6.45m)
BH3 (Base at 29.7m)
BH4 (Tip at 9.0m)
BH6 (Base at 30.0m)

FILEY FLAT CLIFFS GROUNDWATER LEVELS



Appendix D Survey Data

Initial Monitoring of Survey Points – 22nd July 2009

Whitby West Cliff					
BH2	Easting	Northing	Height (m)	Slope Distance	Remarks
MP1	489306.554	511468.120	40.864	8.319	Monitor point co-ordinates derived directly from GPS observations. Distances to edge measured with tape measure.
MP2	489308.296	511474.546	35.887		
MP3	489310.241	511481.188	32.126	7.869	
MP4	489313.968	511487.066	26.988	8.655	
MP5	489315.765	511498.358	21.652	12.623	
MP6	489314.795	511508.928	16.825	11.657	

Scalby Ness					
	Easting	Northing	Height (m)	Slope Distance	Remarks
MP1	503417.846	490962.702	35.853	3.15	Monitor point co-ordinates derived directly from GPS observations. Slope distances calculated from separate TPS observations.
MP2	503425.536	490962.701	36.059	4.30	
MP3	503429.459	490952.269	35.509	2.66	
MP4	503434.045	490941.940	34.969	4.18	

Scarborough South Cliff (North Section)					
H4	Easting	Northing	Height (m)	Slope Distance	Remarks
MP1	504353.903	487885.382	48.508	7.206	Monitor point co-ordinates derived directly from GPS observations. Slope distances calculated from separate TPS observations.
MP2	504359.701	487888.093	45.197	6.079	
MP3	504364.788	487888.922	41.974	9.117	
MP4	504372.839	487890.600	38.039	10.317	
MP5	504381.799	487893.850	34.090	9.246	
MP6	504389.334	487897.564	30.228		

Initial Monitoring of Survey Points – 22nd July 2009 (Continued)

Scarborough South Cliff (Central Section)					
E3	Easting	Northing	Height (m)	Slope Distance	Remarks
MP1	504549.325	487431.090	54.322	10.725	Monitor point co-ordinates derived directly from GPS observations. Slope distances calculated from separate TPS observations.
MP2	504559.474	487434.499	53.691	12.990	
MP3	504571.837	487437.291	50.847	10.256	
MP4	504579.847	487440.336	45.212	13.849	
MP5	504592.579	487444.628	41.856		

Scarborough South Cliff (South Section)					
BH2	Easting	Northing	Height (m)	Slope Distance	Remarks
MP1	504754.082	487134.614	55.305	12.035	Monitor point co-ordinates derived directly from GPS observations. Slope distances calculated from separate TPS observations.
MP2	504764.242	487137.096	49.350	6.004	
MP3	504769.607	487136.013	46.881	7.212	
MP4	504775.961	487137.850	44.007		

Ongoing Coastal Monitoring of Survey Points – 24th August 2009

Whitby West Cliff					
BH2	Easting	Northing	Height (mAOD)	Slope Distance	Remarks
MP1	489306.554	511468.120	40.864	8.311	Monitor point co-ordinates derived directly from GPS observations. Slope distances calculated from separate TPS observations.
MP2	489308.296	511474.546	35.887	7.874	
MP3	489310.241	511481.188	32.126	8.657	
MP4	489313.968	511487.066	26.988	12.612	
MP5	489315.765	511498.358	21.652	11.665	
MP6	489314.795	511508.928	16.825		

Scalby Ness					
	Easting	Northing	Height (mAOD)	Slope Distance	Remarks
MP1	503417.846	490962.702	35.853	3.15	Monitor point co-ordinates derived directly from GPS observations. Distances to edge measured with tape measure.
MP2	503425.536	490962.701	36.059	4.30	
MP3	503429.459	490952.269	35.509	2.65	
MP4	503434.045	490941.940	34.969	4.18	

Scarborough South Cliff (North Section)					
H4	Easting	Northing	Height (mAOD)	Slope Distance	Remarks
MP1	504353.903	487885.382	48.508	7.206	Monitor point co-ordinates derived directly from GPS observations. Slope distances calculated from separate TPS observations.
MP2	504359.701	487888.093	45.197	6.081	
MP3	504364.788	487888.922	41.974	9.114	
MP4	504372.839	487890.600	38.039	10.320	
MP5	504381.799	487893.850	34.090	9.246	
MP6	504389.334	487897.564	30.228		

Ongoing Coastal Monitoring of Survey Points – 24th August 2009 (Continued)

Scarborough South Cliff (Central Section)					
E3	Easting	Northing	Height (mAOD)	Slope Distance	Remarks
MP1	504549.325	487431.090	54.322	10.724	Monitor point co-ordinates derived directly from GPS observations. Slope distances calculated from separate TPS observations.
MP2	504559.474	487434.499	53.691	12.983	
MP3	504571.837	487437.291	50.847	10.260	
MP4	504579.847	487440.336	45.212	13.855	
MP5	504592.579	487444.628	41.856		

Scarborough South Cliff (South Section)					
BH2	Easting	Northing	Height (mAOD)	Slope Distance	Remarks
MP1	504754.082	487134.614	55.305	12.050	Monitor point co-ordinates derived directly from GPS observations. Slope distances calculated from separate TPS observations.
MP2	504764.242	487137.096	49.350	5.997	
MP3	504769.607	487136.013	46.881	7.236	
MP4	504775.961	487137.850	44.007		

Ongoing Coastal Monitoring of Survey Points – 21st September 2009

Whitby West Cliff					
BH2	Easting	Northing	Height (mAOD)	Slope Distance	Remarks
MP1	489306.567	511468.127	40.840	8.310	Monitor point co-ordinates derived directly from GPS observations. Slope distances calculated from separate TPS observations.
MP2	489308.298	511474.546	35.879	7.870	
MP3	489310.263	511481.188	32.156	8.643	
MP4	489313.967	511487.050	26.974	12.617	
MP5	489315.744	511498.361	21.666	11.658	
MP6	489314.790	511508.925	16.801		

Scalby Ness					
	Easting	Northing	Height (mAOD)	Slope Distance	Remarks
MP1	503417.839	490962.717	35.822	3.15	Monitor point co-ordinates derived directly from GPS observations. Distances to edge measured with tape measure.
MP2	503425.535	490962.710	36.027	4.30	
MP3	503429.464	490952.274	35.489	2.65	
MP4	503434.037	490941.924	34.953	4.18	

Scarborough South Cliff (North Section)					
H4	Easting	Northing	Height (mAOD)	Slope Distance	Remarks
MP1	504353.945	487885.398	48.508	7.207	Monitor point co-ordinates derived directly from GPS observations. Slope distances calculated from separate TPS observations.
MP2	504359.739	487888.114	45.193	6.082	
MP3	504364.829	487888.943	41.968	9.112	
MP4	504372.873	487890.619	38.039	10.323	
MP5	504381.838	487893.883	34.086	9.241	
MP6	504389.366	487897.596	30.221		

Ongoing Coastal Monitoring of Survey Points – 21st September 2009 (Continued)

Scarborough South Cliff (Central Section)					
E3	Easting	Northing	Height (mAOD)	Slope Distance	Remarks
MP1	504549.295	487431.105	54.318	10.719	Monitor point co-ordinates derived directly from GPS observations. Slope distances calculated from separate TPS observations.
MP2	504559.441	487434.504	53.688	12.990	
MP3	504571.812	487437.273	50.852	10.264	
MP4	504579.833	487440.319	45.218	13.848	
MP5	504592.569	487444.599	41.863		

Scarborough South Cliff (South Section)					
BH2	Easting	Northing	Height (mAOD)	Slope Distance	Remarks
MP1	504754.076	487134.606	55.300	12.039	Monitor point co-ordinates derived directly from GPS observations. Slope distances calculated from separate TPS observations.
MP2	504764.241	487137.088	49.346	6.000	
MP3	504769.602	487136.004	46.879	7.219	
MP4	504775.963	487137.837	44.999		

Ongoing Coastal Monitoring of Survey Points – 12th October 2009

Whitby West Cliff					
BH2	Easting	Northing	Height (mAOD)	Slope Distance	Remarks
MP1	489306.567	511468.127	40.840	8.313	Monitor point co-ordinates derived directly from GPS observations. Slope distances calculated from separate TPS observations.
MP2	489308.298	511474.546	35.879	7.870	
MP3	489310.263	511481.188	32.156	8.657	
MP4	489313.967	511487.050	26.974	12.613	
MP5	489315.744	511498.361	21.666	11.656	
MP6	489314.790	511508.925	16.801		

Scalby Ness					
	Easting	Northing	Height (mAOD)	Slope Distance	Remarks
MP1	503417.839	490962.717	35.822	3.15	Monitor point co-ordinates derived directly from GPS observations. Distances to edge measured with tape measure.
MP2	503425.535	490962.710	36.027	4.30	
MP3	503429.464	490952.274	35.489	2.65	
MP4	503434.037	490941.924	34.953	4.18	

Scarborough South Cliff (North Section)					
H4	Easting	Northing	Height (mAOD)	Slope Distance	Remarks
MP1	504353.973	487885.396	48.512	7.211	Monitor point co-ordinates derived directly from GPS observations. Slope distances calculated from separate TPS observations.
MP2	504359.771	487888.116	45.197	6.079	
MP3	504364.855	487888.946	41.970	9.110	
MP4	504372.897	487890.625	38.032	10.319	
MP5	504381.858	487893.891	34.092	9.247	
MP6	504389.389	487897.611	30.225		

Ongoing Coastal Monitoring of Survey Points – 12th October 2009 (Continued)

Scarborough South Cliff (Central Section)					
E3	Easting	Northing	Height (mAOD)	Slope Distance	Remarks
MP1	504549.310	487431.103	54.320	10.726	Monitor point co-ordinates derived directly from GPS observations. Slope distances calculated from separate TPS observations.
MP2	504559.463	487434.503	53.688	12.978	
MP3	504571.821	487437.280	50.859	10.262	
MP4	504579.839	487440.330	45.227	13.848	
MP5	504592.573	487444.612	41.868		

Scarborough South Cliff (South Section)					
BH2	Easting	Northing	Height (mAOD)	Slope Distance	Remarks
MP1	504754.075	487134.604	55.300	12.050	Monitor point co-ordinates derived directly from GPS observations. Slope distances calculated from separate TPS observations.
MP2	504764.249	487137.102	49.345	5.997	
MP3	504769.605	487136.013	46.878	7.225	
MP4	504775.968	487137.847	43.989		

Ongoing Coastal Monitoring of Survey Points – 16th November 2009

Whitby West Cliff					
BH2	Easting	Northing	Height (mAOD)	Slope Distance	Remarks
MP1	489306.563	511468.127	40.911	8.315	Monitor point co-ordinates derived directly from GPS observations. Slope distances calculated from separate TPS observations.
MP2	489308.307	511474.548	35.933	7.871	
MP3	489310.278	511481.208	32.181	8.655	
MP4	489313.954	511487.061	26.987	12.618	
MP5	489315.753	511498.365	21.685	11.663	
MP6	489314.803	511508.927	16.838		

Scalby Ness					
	Easting	Northing	Height (mAOD)	Slope Distance	Remarks
MP1	503417.830	490962.730	35.860	3.15	Monitor point co-ordinates derived directly from GPS observations. Distances to edge measured with tape measure.
MP2	503425.526	490962.706	36.066	4.30	
MP3	503429.456	490952.269	35.520	2.65	
MP4	503434.022	490941.926	34.975	4.18	

Scarborough South Cliff (North Section)					
H4	Easting	Northing	Height (mAOD)	Slope Distance	Remarks
MP1	504353.978	487885.391	48.529	7.200	Monitor point co-ordinates derived directly from GPS observations. Slope distances calculated from separate TPS observations.
MP2	504359.768	487888.104	45.218	6.082	
MP3	504364.856	487888.946	41.992	9.112	
MP4	504372.898	487890.614	38.050	10.318	
MP5	504381.859	487893.876	34.111	9.251	
MP6	504389.392	487897.598	30.241		

Ongoing Coastal Monitoring of Survey Points – 16th November 2009 (Continued)

Scarborough South Cliff (Central Section)					
E3	Easting	Northing	Height (mAOD)	Slope Distance	Remarks
MP1	504549.296	487431.089	54.307	10.723	Monitor point co-ordinates derived directly from GPS observations. Slope distances calculated from separate TPS observations.
MP2	504559.463	487434.491	53.673	12.989	
MP3	504571.811	487437.268	50.844	10.265	
MP4	504579.828	487440.319	45.206	13.856	
MP5	504592.567	487444.614	41.852		

Scarborough South Cliff (South Section)					
BH2	Easting	Northing	Height (mAOD)	Slope Distance	Remarks
MP1	504754.080	487134.589	55.312	12.047	Monitor point co-ordinates derived directly from GPS observations. Slope distances calculated from separate TPS observations.
MP2	504764.252	487137.084	49.359	6.000	
MP3	504769.608	487135.997	46.882	7.223	
MP4	504775.975	487137.827	44.004		

Ongoing Coastal Monitoring of Survey Points – 14th December 2009

Whitby West Cliff					
BH2	Easting	Northing	Height (mAOD)	Slope Distance	Remarks
MP1	489306.570	511468.135	40.864	8.309	Monitor point co-ordinates derived directly from GPS observations. Slope distances calculated from separate TPS observations.
MP2	489308.301	511474.548	35.863	7.870	
MP3	489310.275	511481.195	32.104	8.657	
MP4	489313.963	511487.086	26.918	12.623	
MP5	489315.748	511498.376	21.605	11.657	
MP6	489314.790	511508.950	16.764		

Scalby Ness					
	Easting	Northing	Height (mAOD)	Slope Distance	Remarks
MP1	503417.829	490962.715	35.861	3.15	Monitor point co-ordinates derived directly from GPS observations. Distances to edge measured with tape measure.
MP2	503425.527	490962.707	36.077	4.30	
MP3	503429.466	490952.282	35.546	2.65	
MP4	503434.021	490941.941	34.985	4.18	

Scarborough South Cliff (North Section)					
H4	Easting	Northing	Height (mAOD)	Slope Distance	Remarks
MP1	504353.925	487885.364	48.513	7.207	Monitor point co-ordinates derived directly from GPS observations. Slope distances calculated from separate TPS observations.
MP2	504359.724	487888.078	45.204	6.078	
MP3	504364.808	487888.912	41.979	9.112	
MP4	504372.852	487890.587	38.039	10.320	
MP5	504381.815	487893.847	34.098	9.252	
MP6	504389.352	487897.569	30.233		

Ongoing Coastal Monitoring of Survey Points – 14th December 2009 (Continued)

Scarborough South Cliff (Central Section)					
E3	Easting	Northing	Height (mAOD)	Slope Distance	Remarks
MP1	504549.289	487431.079	54.292	10.721	Monitor point co-ordinates derived directly from GPS observations. Slope distances calculated from separate TPS observations.
MP2	504559.438	487434.479	53.670	12.999	
MP3	504571.816	487437.252	50.829	10.266	
MP4	504579.838	487440.302	45.195	13.849	
MP5	504592.573	487444.589	41.841		

Scarborough South Cliff (South Section)					
BH2	Easting	Northing	Height (mAOD)	Slope Distance	Remarks
MP1	504754.082	487134.597	55.319	12.046	Monitor point co-ordinates derived directly from GPS observations. Slope distances calculated from separate TPS observations.
MP2	504764.252	487137.083	49.361	6.006	
MP3	504769.616	487135.994	46.888	7.219	
MP4	504775.976	487137.828	44.007		

Ongoing Coastal Monitoring of Survey Points - Monthly Comparison

Whitby West Cliff						
BH2	Slope Distance 22/07/09	Slope Distance 24/08/09	Slope Distance 21/09/09	Slope Distance 12/10/09	Slope Distance 16/11/09	Slope Distance 14/12/09
MP1	8.319	8.311	8.310	8.313	8.315	8.309
MP2	7.869	7.874	7.870	7.870	7.871	7.870
MP3	8.655	8.657	8.643	8.657	8.655	8.657
MP4	12.623	12.612	12.617	12.613	12.618	12.623
MP5	11.657	11.665	11.658	11.656	11.663	11.657
MP6						

Scalby Ness						
	Distance to Edge 22/07/09	Distance to Edge 24/08/09	Distance to Edge 21/09/09	Distance to Edge 12/10/09	Distance to Edge 16/11/09	Distance to Edge 14/12/09
MP1	3.15	3.15	3.15	3.15	3.15	3.15
MP2	4.30	4.30	4.30	4.30	4.30	4.30
MP3	2.66	2.65	2.65	2.65	2.65	2.65
MP4	4.18	4.18	4.18	4.18	4.18	4.18

Scarborough South Cliff (North Section)						
H4	Slope Distance 22/07/09	Slope Distance 24/08/09	Slope Distance 21/09/09	Slope Distance 12/10/09	Slope Distance 16/11/09	Slope Distance 14/12/09
MP1	7.206	7.204	7.207	7.211	7.200	7.207
MP2	6.079	6.081	6.082	6.079	6.082	6.078
MP3	9.117	9.114	9.112	9.110	9.112	9.112
MP4	10.317	10.320	10.323	10.319	10.318	10.320
MP5	9.246	9.246	9.241	9.247	9.251	9.252
MP6						

Ongoing Coastal Monitoring of Survey Points - Monthly Comparison (Continued)

Scarborough South Cliff (Central Section)						
E3	Slope Distance 22/07/09	Slope Distance 24/08/09	Slope Distance 21/09/09	Slope Distance 12/10/09	Slope Distance 16/11/09	Slope Distance 14/12/09
MP1	10.724	10.724	10.719	10.726	10.723	10.721
MP2	12.989	12.983	12.990	12.978	12.989	12.999
MP3	10.254	10.260	10.264	10.262	10.265	10.266
MP4	13.849	13.855	13.848	13.848	13.856	13.849
MP5						

Scarborough South Cliff (South Section)						
BH2	Slope Distance 22/07/09	Slope Distance 24/08/09	Slope Distance 21/09/09	Slope Distance 12/10/09	Slope Distance 16/11/09	Slope Distance 14/12/09
MP1	12.050	12.050	12.039	12.050	12.047	12.046
MP2	6.004	5.997	6.000	5.997	6.000	6.006
MP3	7.211	7.236	7.219	7.225	7.223	7.219
MP4						

Appendix E Installation Photographs

Plate 1 Runswick Bay A001

Plate 2 Runswick Bay A002

Plate 3 Runswick Bay A003

Plate 4 Runswick Bay A004

Plate 5 Whitby West Cliff Bh2

Plate 6 Scalby Ness MP1

Plate 7 Scalby Ness MP2

Plate 8 Scalby Ness MP3

Plate 9 Scalby Ness MP4

Plate 10 Scalby Ness I1

Plate 11 Scalby Ness I2

Plate 12 Scalby Ness I3

Plate 13 Scalby Ness P1

Plate 14 Scalby Ness P2

Plate 15 Scalby Ness P3

Plate 16 Scalby Ness P4

Plate 17 Scalby Ness B6

Plate 18 Scalby Ness B9

Plate 19 Scalby Ness Sn1

Plate 20 Scalby Ness Sn2

Plate 21 Scarborough North Bay L1

Plate 22 Scarborough North Bay L11

Plate 23 Scarborough North Bay L12

Plate 24 Scarborough North Bay L3

Plate 25 Scarborough North Bay L4

Plate 26 Scarborough North Bay L5

Plate 27 Scarborough North Bay L6

Plate 28 Scarborough North Bay (Oasis Café) BH1I

Plate 29 Scarborough North Bay (Oasis Café) BH1P

Plate 30 Scarborough North Bay (Oasis Café) BH2P

Plate 31 Scarborough North Bay (Oasis Café) BH3I

Plate 32 Scarborough North Bay (Oasis Café) BH3P

Plate 33 Scarborough North Bay (Oasis Café) BH4I

Plate 34 Scarborough North Bay (Oasis Café) BH4P

Plate 35 Scarborough South Cliff I1 (AA01)

Plate 36 Scarborough South Cliff H4 (AA02)

Plate 37 Scarborough South Cliff BH1 Prom

Plate 38 Scarborough South Cliff H6 (AA03)

Plate 39 Scarborough South Cliff G2 (AA04)

Plate 40 Scarborough South Cliff F2 (AA10)

Plate 41 Scarborough South Cliff F4 (AA11)

Plate 42 Scarborough South Cliff E3 (AA09)

Plate 43 Scarborough South Cliff E5 (AA05)

Plate 44 Scarborough South Cliff D3 (AA08)

Plate 45 Scarborough South Cliff D1 (AA06)

Plate 46 Scarborough South Cliff Bh2 (AA07)

Plate 47 Scarborough South Cliff I2

Plate 48 Scarborough South Cliff I2A

Plate 49 Scarborough South Cliff H2

Plate 50 Scarborough South Cliff H1

Plate 51 Scarborough South Cliff H5

Plate 52 Scarborough South Cliff 1 Spa

Plate 53 Scarborough South Cliff 2 Spa

Plate 54 Scarborough South Cliff 3 Spa

Plate 55 Scarborough South Cliff 4 Spa

Plate 56 Scarborough South Cliff G3

Plate 57 Scarborough South Cliff 5 Spa

Plate 58 Scarborough South Cliff F5

Plate 59 Scarborough South Cliff F3

Plate 60 Scarborough South Cliff E2

Plate 61 Scarborough South Cliff E1

Plate 62 Scarborough South Cliff E4

Plate 63 Scarborough South Cliff D2

Plate 64 Scarborough South Cliff Bh3

Plate 65 Scarborough South Cliff Bh4

Plate 66 Scarborough South Cliff Bh1

Plate 67 Scarborough South Cliff A1 (AA12)

Plate 68 Scarborough South Cliff H4 (AA02) Survey Points

Plate 69 Scarborough South Cliff H4 (AA02) Survey Points

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Plate 74 Scarborough South Cliff BH2 (AA12) Survey Points

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Plate 76 Scarborough South Cliff. Promenade showing signs of subsidence.

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Plate 78 Scarborough South Cliff. Pavement cracking above the Clock Café (Sept 2008)

Plate 79 Scarborough South Cliff. Pavement cracking above the Clock Café (Dec 2008)

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Plate 82 Footpath degradation around Holbeck Gardens.

Plate 83 Filey Town BH01

Plate 84 Filey Town BH02

Plate 85 Filey Town BH03

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Plate 87 Filey Town BH05B

Plate 88 Filey Town BH06

Plate 89 Filey Flat Cliffs A2 (BB02)

Plate 90 Filey Flat Cliffs B1

Plate 91 Filey Flat Cliffs D1

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Appendix F Site Photographs of Runswick Bay

Plate 1 Site view looking towards access road into village.

Plate 2 Site view looking over village up towards Topman End.

Appendix G Site Photographs of Whitby West Cliff

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Plate 10 Site view of mid-slope back rotated block and surface tension crack development (January 2010).

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(Dated 27th Nov 2008)

Plate 33 Site view of repair to tension cracks in lower section of access road

(Dated 12th Jan 2010).