



Dacorum Borough Council

Highbarns Chalk Mines Project

Cavity Auto Scanning Laser System (C-ALS) Survey Report



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1 SUMMARY

Between September 2009 and October 2010 Hyder Consulting (UK) Ltd have completed several studies for Dacorum Borough Council (DBC) as part of our project management commission for the Highbarns Chalk Mines Project in Hemel Hempstead. These studies have consisted of:

- A geotechnical assessment of the historical chalk mines located around the junction of Highbarns, East Green and Pond Road based on a detailed desk study reported in Hyder's Geotechnical Assessment Report dated February 2010 and a visual structural inspection of the site reported in Hyder's Visual Structural Inspections Report dated April 2010.
- A microgravity survey carried out by Geotechnology Ltd at the site during early 2010 to help determine the extent of the mine the findings of which were reported within Hyder's Geophysical Survey Report dated June 2010.
- An assessment of feasible mine treatment options for the purposes of supporting an application to the Homes & Communities Agency's (HCA) Land Stabilisation Programme for funding, together with an associated Derelict Land Clearance Order submission. Our Feasibility Study Report was issued in July 2010 while our Derelict Land Clearance Order document was issued in October 2010 both of which accompanied the full funding application submitted to the HCA by DBC in October 2010.

In April 2011 Dacorum Borough Council commissioned Hyder to supervise and interpret a Cavity Auto scanning Laser System (C-ALS) survey of open mineworkings within six existing boreholes formed as part of the Peter Brett Associates (PBA) ground investigation in 2008 around the Highbarns/Pond Road/East Green road junction. The main objective of the recent laser survey was to undertake a comparative survey between the findings of the original laser survey with those of the recent survey to help determine whether any changes have occurred to the extent of the voids encountered that could possibly indicate deterioration in the condition of the mine.

Laser surveys were undertaken in five boreholes compared to the eight surveyed in 2008 since one of the boreholes had since been infilled and surveys of two of the remaining boreholes were not possible because of downhole access constraints. A summary of the surveys carried out in 2008 and 2011 is provided below.

Borehole	2008 (PBA)		2011 (Hyder)		Comments on 2011 survey
	HD CCTV	C-ALS	HD CCTV	C-ALS	
CP1A	X	√	X	√	Borehole ID too small for CCTV survey
CP2D	X	√	X	√	Borehole ID too small for CCTV survey
CP1B	X	√	X	√	Borehole ID too small for CCTV survey
CP1D	X	√	X	X	Borehole ID too small for CCTV survey; insufficient room for C-ALS laser head to manoeuvre
CP1C	X	√	X	√	Borehole ID too small for CCTV survey
CP4B	X	√	X	X	Borehole ID too small for CCTV survey; insufficient room for C-ALS laser head to manoeuvre

CP5B	√	√	X	X	Remediated in 2008
CP6B	X	√	X	√	Borehole ID too small for CCTV survey

This report discusses the findings of the recent C-ALS survey carried out by Inspectahire Ltd at the site during May 2011 and compares the results with the data obtained by the previous survey also carried out by Inspectahire in 2008. The findings of the C-ALS survey are reported within Inspectahire's Report No. 5489 dated May 2011 and reproduced in Appendix A.

The key finding of the recent laser survey is that it has not identified any significant changes to the extent of the mineworkings identified by the earlier laser survey carried out within the same five boreholes in 2008, suggesting that no obvious significant deterioration has occurred in that part of the mine surveyed since the previous laser survey.

However, it should be noted that the recent laser survey is limited to the extent of the known mine accessed via five retained boreholes within the immediate vicinity of the Highbarns road junction and therefore does not address the risk from any areas of mine workings not identified to date and the probable/possible extent of the mine indicated on Figure 4: Extent of Known Mineworkings and Interpreted Mine Layout. It should also be noted that although the recent laser survey does not indicate any significant change to the extent of the open mine over the past three years within the five boreholes surveyed, other factors such as the condition and thickness of the mine roof remain unclear as the laser survey is only able to assess the extent of the open void. Furthermore limited monitoring data cannot provide a reliable indicator of mine stability since sudden collapses can occur spontaneously or due to factors such as pipe bursts. The assessed risk of collapse from the workings as set out in Hyder's Geotechnical Assessment Report for the site is therefore unaffected by the results of the monitoring and remains significant. There is however no additional data to suggest imminent collapse of any of the workings surveyed.

This interpretative report necessarily makes frequent reference to the data within the Inspectahire report and thus it will be essential to read the latter in close conjunction with this report. This report also draws upon the findings of Hyder's Geotechnical Assessment Report No 0002-LN01292-GD-01-0 dated February 2010 and our Feasibility Study Report (Report No 0004-LN01292-GD-01-0) which therefore should also be read in close conjunction with this report.

2 INTRODUCTION

2.1 Brief

In September 2009 Hyder Consulting (UK) Limited was commissioned by Dacorum Borough Council (DBC) to undertake the project management of a scheme to investigate historical chalk mines located around the junction of Highbarns, East Green and Pond Road, Hemel Hempstead. This area has been subject to at least two mine related collapses causing damage to properties, followed by subsequent investigation and local mine treatment works.

As part of this commission Hyder has completed investigations to confirm:

- the likely extent of any mineworkings
- the level of risk to residents and road users above or adjacent to the workings
- the mitigations required to address the risk identified
- the need and type of any treatment of mineworkings
- options for funding and developing any treatment scheme.

To date Hyder Consulting have completed the following studies.

- A geotechnical assessment of the historical chalk mines located around the junction of Highbarns, East Green and Pond Road based on a detailed desk study and a visual structural inspection of the site to form the basis for option development as part of a feasibility study. The findings of the geotechnical assessment were reported in Hyder's Geotechnical Assessment Report No 0002-LN01292-GD-01-0 dated February 2010 while the findings of the visual inspection were reported in Hyder's Visual Structural Inspections Report No 3001-LN01292-LNR-F-01 dated April 2010.
- A microgravity survey carried out by Geotechnology Ltd at the site during early 2010 to help determine the extent of the mine and to aid the design of a preliminary targeted intrusive ground investigation. The findings of the geophysical survey were reported within Hyder's Geophysical Survey Report No 0002-LN01292-GD-02-0 dated June 2010.
- An assessment of feasible mine treatment options for the purposes of supporting an application to the Homes & Communities Agency's (HCA) Land Stabilisation Programme for funding, together with an associated Derelict Land Clearance Order submission. Our Feasibility Study Report (Report No 0004-LN01292-GD-01-0) was issued in July 2010 while our Derelict Land Clearance Order document was issued in October 2010 both of which accompanied the full funding application submitted to the HCA by DBC in October 2010.

In April 2011 Dacorum Borough Council commissioned Hyder to supervise and interpret a Cavity Auto scanning Laser System (C-ALS) survey of open mineworkings identified within six existing boreholes formed as part of the Peter Brett Associates (PBA) ground investigation in 2008 around the Highbarns/Pond Road/East Green road junction. The main objective of the recent laser survey was to enable a comparison between the findings of the original laser survey with those of the recent survey to help determine whether any changes have occurred to the extent of the voids encountered that could possibly indicate deterioration in the condition of the mine.

2.2 Scope of report

This report discusses the findings of the recent C-ALS survey carried out by Inspectahire Ltd at the site during May 2011 and compares the results with the data obtained from the earlier laser survey undertaken in 2008. The findings of the C-ALS survey are reported within Inspectahire's Report No. 5489 dated May 2011 and reproduced in Appendix A.

This interpretative report necessarily makes frequent reference to the data within the Inspectahire report and thus it will be essential to read the latter in close conjunction with this report. This report also draws upon the findings of Hyder's Geotechnical Assessment Report No 0002-LN01292-GD-01-0 dated February 2010 and our Feasibility Study Report (Report No 0005-UA000857-GDR-01-0) which therefore should also be read in close conjunction with this report.

2.3 Limitations

This report is based on currently available information and relies in particular on the interpretation of geophysical survey data provided within Inspectahire's Report No. 5489 dated May 2011.

This report is limited solely to a re-assessment of the likely extent of the open mineworkings identified by five boreholes of the previous C-ALS survey carried out in 2008 beneath the Highbarns/Pond Road/East Green road junction. Consideration of mineworkings beyond the identified open voids in the vicinity of the Highbarns junction eg the interpreted mine layout indicated by the microgravity survey carried out last year within the study area and any risks associated with them is beyond the scope of this report.

This report does not address matters of legal responsibility, for which separate advice will be required.

2.4 Use of the report

This report has been prepared for the benefit of Dacorum Borough Council for the purpose of helping to determine whether any changes have occurred to the extent of known mineworkings identified within five boreholes by a C-ALS survey in 2008 (reported within Peter Brett Associates' Interpretative Geotechnical Report – Phase 1 dated July 2008, document ref. 20247/0043/Int01/rev2) beneath the Highbarns/Pond Road/East Green road junction in Hemel Hempstead.

Any other parties relying on the contents of this report do so at their own risk. The report is not intended to address disputes between any parties, the validity of insurance claims, the adequacy of any professional advice or investigations, or to comment on the reasonableness of any professional opinion, the brief for which may have differed from the current investigation.

This report is intended to be read in conjunction with the following reports:

- 1) Peter Brett Associates's Interpretative Geotechnical Report – Phase 1 for the site (dated July 2008, document ref. 20247/0043/Int01/rev2).
- 2) Hyder's Geotechnical Assessment Report No 0002-LN01292-GD-01-0 dated February 2010.
- 3) Hyder's Visual Structural Inspections Report No 3001-LN01292-LNR-F-01 dated April 2010.
- 4) Hyder's Geophysical Survey Report No 0002-LN01292-GD-02-0 dated June 2010.

5) Hyder's Feasibility Study Report No 0005-UA000857-GDR-01-0 dated July 2010.

3 BACKGROUND

In May 2007 the front garden of No. 5 Highbarns collapsed undermining the foundations of the property. Peter Brett Associates (PBA), working on behalf of the insurer, confirmed that the collapse related to chalk mining. Subsequent investigation by Peter Brett Associates (on behalf of Hertfordshire County Council, as Highways Authority) established the presence of chalk workings beneath this property extending beneath the highway of Pond Road, Highbarns and East Green and potentially affecting adjacent properties (see Figure 3). These workings are believed to extend beneath No. 5 Pond Road which was subject to a collapse in 2001. PBA identified voids and evidence of the mineworkings at depths of between approximately 9m and 23m.

The area potentially at risk from chalk mining was defined by PBA. This comprises an Inner Zone of Interest (the Inner Study Area), where PBA considered there was evidence of mineworkings, and an Outer Zone of Interest (the Outer Study Area) extending 100m from this based on PBA's experience of the potential extent of chalk mines from known mine openings.

A summary of known collapses within the study area is provided in Table 3.1 below.

Date of collapse	Location	Details	Treatment	Date of treatment	Proven as related to mining?
1980s	Pavement at 24 Highbarns	A lorry which sank into a hole in the pavement (believed to be a well at the time).	Filled with concrete and tarmaced over.	1980s	N
2000	Front drive of No. 40 Highbarns	Void 1m deep and 1m long beneath left hand corner of garage (facing the front of the house)	Backfilling (no records available) and relocation of soakaway.	Assumed 2000	N
21/11/2001	Front garden of No. 5 Pond Road	4.6m wide, 3.8m deep and 4.8m deep void (assumed at time to be a solution feature)	Compaction grouting and bulk infilling under insurance (by Keller), 50.5m ³ grout pumped.	May 2003	Y
31/05/2007	Front garden of No. 5 Highbarns	5m deep and 6m diameter hole beneath the patio and left hand side of the front of the house, undercutting foundations along the left side of the house by 3m.	Emergency infilling with 80m ³ of foam concrete	June 2007	Y
			Compaction grouting and bulk infilling under insurance (by Keller). 591m ³ of pea gravel, foam concrete and grout injected.	Aug to Oct 2008	Y
19/06/2008	Pavement and highway in front of No.s 5/7 Highbarns (BH CP5B)	Incipient collapse - void migration beneath highway and pavement identified following investigation at No 5 Highbarns. 5m wide void at 6.7m to 10.8m depth.	Emergency compaction grouting and bulk infilling for DBC (by Keller)	Oct and Nov 2008	Y

Table 3.1: Known collapse events affecting properties at the site

The workings beneath No. 5 Highbarns, No. 5 Pond Road and a shallow void adjacent to the highway were subsequently stabilised by grouting. However the potential for untreated workings at the site remains and in December 2008 an outline application to the Land

Stabilisation Programme was made by Dacorum Borough Council as part of the initial stage for funding of a scheme to treat the mineworkings at the site. As part of this process in September 2009 Hyder Consulting were appointed by Dacorum Borough Council to manage the application for funding under the Land Stabilisation Programme.

After the collapse in 2007, the road junctions over the mineworkings were closed. Precautionary monitoring of the highways is also in place and emergency plans in the event of a collapse have been developed. A communications strategy including residents and key stakeholders has been developed and movement/damage reporting procedures put in place.

In late 2009 and early 2010 Hyder produced a Geotechnical Assessment Report setting out the results of a detailed desk study, review of mine stability and risk assessment. This report recommended a microgravity survey be undertaken to confirm the extents of the mine suggested by the historical information. This survey was completed in January and February 2010 and reviewed in Hyder's Geophysical Survey Report.

During the summer of 2010 Hyder produced a Feasibility Study Report which assessed feasible mine treatment options for the purposes of supporting an application to the Homes & Communities Agency's (HCA) Land Stabilisation Programme for funding. In October 2010 Hyder prepared a Derelict Land Clearance Order document which, together with the Feasibility Study Report, accompanied DBC's full funding application to the HCA in October 2010 for a scheme to treat the mineworkings at the site.

Other reports commissioned for the scheme include an ecological survey, an archaeological assessment and building inspections. Available reports commissioned for the scheme are listed in Section 9.

4 SITE DETAILS

The site (the Inner and Outer Study Areas shown on Figure 2) is located approximately 2.5km to the south-east of Hemel Hempstead town centre, within a residential area known as Nash Mills (see Figures 1 and 2). The approximate National Grid Reference for the centre of the site is 507088 204921.

The centre of the site is a crossroads formed from the junction of three residential streets, Highbarns, Pond Road and East Green. Highbarns runs north-west to south-east, Pond Road runs north-eastwards from Highbarns. East Green runs south-westwards from its junction with Highbarns. The site comprises mostly semi-detached and terraced residential properties but a block of flats (Gade Tower) is located off East Green. Nash Mills C of E Primary School and playing fields are located in the south-west corner of the Outer Study Area. There are a number of areas of public open space forming small greens between residential streets, including around the crossroads at the centre of the study area.

The centre of the site lies at an approximate elevation of 100m above Ordnance Datum but slopes downhill to the east, south and west towards the valley of the River Gade.

To the south-west and north-west of the Outer Study Area are residential areas, comprising semi-detached and terraced housing. At the southern corner of the Outer Study Area (on the junction between Belswains Lane and Bunkers Lane) is the now closed Nash Mills Paper Mill.

Buried services at the site include telecoms, domestic gas, electricity, water and drainage running along the highway and to individual properties. Electricity supplies to lighting columns are present along pavements as well as overhead telephone cables.

The extent of the Application Area for the Land Stabilisation Programme (LSP) funding application is shown on Figure 5 and covers an area of 1.9ha.

5 SITE HISTORY

Historical maps from 1839 onward provide no direct evidence of mineworkings at the site. However there is a reference to a mine at Highbarns in the memoirs of John Turner (1837-1918 - a Nash Mills resident who emigrated to the USA about 100 years ago), who recalled as a boy having been lowered in "bucket" from windlass down a shaft about 4ft (1.2m) in diameter and 100ft (30m) deep, with tunnels at the base in various directions. The narrative goes on to say that "*The mine was owned by 'mill people' and here they manufactured bricks for their own use, mine chalk for burning and making lime, and pipe clay for use in paper making*".

The relationship between this chalk mine and the Nash Mills Paper Mill seems to be confirmed by the 1839 tithe map of land ownership. This indicates that a plot between Highbarns Farm and Nash Mills Paper Mill and a plot immediately north-west of Highbarns Farm (located just south of the current crossroads at the centre of the site) were owned by John Dickinson. John Dickinson (1782-1869) purchased Nash Mills in 1811 for paper making.

A BGS report commissioned for the site states that the 1912 geological field map and 1949 supplementary notes, identified an old pit in Highbarns road opposite No. 1 Pond Road (which the BGS report states is on the line of a mine tunnel identified by PBA for their investigations at No. 5 Highbarns). It would seem reasonable that this is the mine referred to by John Turner.

No further evidence of mining at the site is recorded until following the collapse of the front garden of No. 5 Highbarns in 2007 when subsequent investigation demonstrated the presence of mine tunnels at the approximate location of the old shaft identified from historical plans.

There is no evidence of structures at the site to suggest very extensive workings and no historical evidence to support suggestions made in a paper by J.R. Hunn and M. Stanyon in 2009 of an adit connection with Nash Mills. On this basis it is concluded that the workings are most likely to be concentrated around the junction of Highbarns with Pond Road and East Green.

A detailed history, including all references, is provided within the Geotechnical Assessment Report for the site. The key features identified by the desk study undertaken are summarised on Figure 2.

6

GROUND CONDITIONS

The general stratigraphy of the site based on the specific BGS report obtained for the site and a review of published geological information (see Geotechnical Assessment Report for details) is summarised in Table 6.1 below.

Unit	Description from BGS report	BGS comments
Head	<p>Head deposits typically are poorly stratified and poorly sorted, and can be variable in composition. Locally, they are probably composed of clay, sand and flint gravel.</p> <p>May contain gently dipping shear surfaces (as a result of periglacial solifluction).</p>	Head deposits may be more extensive than shown on the geological map but are likely to be thin and discontinuous.
Clay-with-Flints	<p>No Clay-with-Flints deposits are noted on the geological maps for the site. However Clay-with-Flints was encountered in several of the boreholes drilled in 2008 by Peter Brett Associates. These deposits comprised sandy, gravelly clay and are considered by the BGS to represent residual soil in-fill to solution pipes and hollows.</p> <p>Clay may be shrinkable.</p>	Deposits up to 7m thick encountered in boreholes.
Seaford Chalk (formerly Upper Chalk)	The Seaford Chalk is composed mainly of soft, smooth, blocky, white chalk with common seams of small to very large nodular flints, and some beds of semi-tabular flint. Thin beds of harder nodular chalk occur near the base. It forms the middle to upper part of what was previously known as the Upper Chalk.	As the Chalk Rock Member lies topographically just below the southern margin of the search area, it seems likely that much of the area is underlain by Lewes Nodular Chalk Formation up to 30 metres thick while only the northern sector may be underlain by the Seaford Chalk Formation.
Lewes Nodular Chalk (formerly Upper Chalk)	The Lewes Nodular Chalk is typically composed of hard to very hard, white to creamy or yellowish white nodular chalk and chalkstone, with interbedded soft to hard, grainy white chalk and sporadic seams of clay-rich chalk (marl seams). It forms the basal part of what was previously known as the Upper Chalk. A notably hard bed of chalk, the Chalk Rock Member, occurs just above the base of the formation in this district.	The BGS memoir for the site notes that <i>"the chalk immediately above the Chalk Rock is especially prized for marling the land probably because it contains phosphatic glauconitic grains"</i> and hence that the floor of the mines is often formed by the hard "Chalk Rock" layer within the chalk.

Table 6.1: Stratigraphy identified by BGS

The ground conditions encountered in exploratory holes advanced at the site are summarised in Table 6.2 below.

Unit	Description from boreholes	Comment
Made Ground	<p>Generally comprised fill material that was likely to have been used as a sub-base for the highway and pavements.</p> <p>Thickest deposits are described as <i>brown sandy clay with gravel of flint, concrete and brick</i>.</p>	<p>The thickness of Made Ground ranged from between 0.15m to 1.0m.</p> <p>Assumed to be related to levelling parts of the site for construction of the current houses and roads.</p>
Clay-with-Flints	<p>Soft to firm to stiff, orange brown, sandy, gravelly CLAY. The gravel content comprises fine to medium, sub-angular to sub-rounded flint.</p>	<p>Occurs throughout most of the area investigated. The thickness of the deposits generally increases in a downhill direction to the south, ranging between 0.4m at the northern edge of the study area to 6.8m at the southern edge of the study area.</p>
Upper Chalk	<p>Recovered as structureless, weak to very weak CHALK composed of calcareous silt with gravel sized fragments of chalk and flint (typically Dm, locally Dc grade).</p> <p>SPT N blow counts range from <5 to up to 20. Hence much of the chalk recovered is likely to have been disturbed.</p>	<p>In places the chalk surface appears to be highly weathered to up to 10m depth suggesting dissolution features.</p> <p>Includes mineworkings (voids and collapsed ground).</p>

Table 6.2: Summary of ground conditions encountered

Groundwater was not recorded during any of the investigations undertaken at the site and is therefore assumed to be below the base of the known workings (i.e. in excess of 25m below surface).

The available BGS memoir for the site notes that the floor of the mines is often formed by the hard "Chalk Rock" layer at the base of the Lewes Nodular Chalk. The Chalk Rock Member is shown outcropping on geological maps along the line of Belswains Road at around 76mAOD. Given that the chalk dip is near horizontal, this amounts to about 24m below surface at the anticipated mine shaft entry. This depth and level provides a likely control to the maximum depth of working which is in line with experience from other similar chalk mining in Hertfordshire. This depth is also close to that ascribed to the mine by John Turner (the accuracy of which is unknown).

7 RECENT C-ALS SURVEY

7.1 Description of Fieldwork

The intrusive ground investigation undertaken by PBA in 2008 for Hertfordshire County Council included 8 No. downhole laser scans (C-ALS surveys) undertaken by Inspectahire Ltd in cable percussion boreholes CP1A, CP1B, CP1C, CP1D, CP2D, CP4B, CP5B and CP6B (see Figure 3 for the locations of these boreholes). C-ALS surveys comprise a rotating laser scanner which can be introduced into boreholes to provide a dimensioned 3D image of open voids.

Inspectahire Ltd were appointed by DBC to carry out the recent C-ALS survey within six of the eight previous boreholes, the exceptions being boreholes CP4B where the previous laser survey was unable to complete a scan due to the smallness of the void and CP5B where the recorded void was remediated later in 2008. Of the six boreholes (CP1A, CP1B, CP1C, CP1D, CP2D and CP6B) where it was planned to undertake repeat laser surveys, it was not possible for Inspectahire to carry out a scan in borehole CP1D due to insufficient space within the void for the laser head to manoeuvre.

The main objective of the recent laser survey was to enable the findings of the original laser survey to be compared with those of the recent survey to help determine whether any changes have occurred to the extent of the voids encountered that could possibly indicate deterioration in the condition of the mine.

It was originally intended for Inspectahire to also undertake CCTV surveys within the six boreholes but due to the smaller than anticipated inside diameter of the plastic standpipes (70mm instead of 100mm apart from CP1B) it was not possible to obtain CCTV footage.

The C-ALS survey was carried out over three days between 11th and 13th May 2011. The C-ALS survey was undertaken by lowering the unit on Carbon Fibre poles and taking one metre measurements following the bore track until it reached the end of the plastic standpipe. The C-ALS unit was then lowered a further approximately 500mm into the void to give sufficient space for the probe head to manoeuvre. A quick scan was then conducted to make sure that the probe had enough room to manoeuvre for a full scan. Once the probe was in position it was locked off and then a full vertical and horizontal scan was undertaken lasting approximately 120 minutes. Inspectahire collected all the data on a laptop for later analysis with the use of Voids Works software.

Inspectahire have advised that due to improvements to the C-ALS unit and software since 2008, the recent survey is more accurate than the survey carried out in 2008.

Further details about how the C-ALS system operates is provided on page 4 of the appended Inspectahire report.

7.2 Survey observations

The objective of the recent C-ALS survey was to provide results that could be compared with the data collected by the earlier C-ALS survey undertaken in 2008. As mentioned above the recent survey was only able to be carried out within five of the six boreholes that were surveyed previously.

Provided below are the findings of the recent survey undertaken within each of the five boreholes based upon the descriptions provided within Inspectahire's report. These findings are compared to the findings of the 2008 survey.

Boreholes CP1A and CP2D

Although boreholes CP1A and CP2D were surveyed separately a direct linkage between the two survey positions was identified. Inspectahire therefore combined the data from these two boreholes similar to the previous survey.

The laser survey revealed the presence of the open mine workings with approximately the same dimensions as the 2008 survey. The tunnel remains approximately 43m long and remains open at the present time, running in a north-east to south-west direction. The depth of the tunnel remains generally at approximately 16m below ground level. The tunnel also remains approximately 1.7m to 2.0m in open vertical height and spans between 4.1m and 6.1m in width.

The five other possible tunnels extending off the main north-east to south-west aligned tunnel also appear to have the same size as previously surveyed. However, it should be noted that the full extents of the five side tunnels may not be indicated in the survey as collapses and changes in orientation of the gallery could place further workings out of site of the laser scanning device.

Survey images obtained in 2008 and 2011 within these two boreholes are shown on pages 8 to 10 of the appended Inspectahire report.

Borehole CP1B

The recent laser survey has revealed the presence of an open void with approximately the same dimensions as those identified by the 2008 survey. The open height of the tunnel appears to have decreased slightly from a maximum height of 3.3m to 2.9m due to the overflow of grout from the remedial works carried out within the vicinity of No 5 Highbarns. The tunnel remains approximately 7.5m in length with a north easterly orientation, at a depth of approximately 16.4m below ground level with an unchanged width of between approximately 2.9m and 3.3m. Survey images obtained in 2008 and 2011 within this borehole are shown on pages 11 to 13 of the appended Inspectahire report.

Borehole CP1C

The recent laser survey has revealed the presence of an open void with approximately the same dimensions as those identified by the 2008 survey. The void remains at a depth of approximately 13.8m below ground level with the tunnel extending in a south-easterly orientation and dropping a further 5m or so. The approximate length of the tunnel remains about 8.6m with the height still ranging between approximately 1.3m and 2.7m and the width remaining at approximately 4.5m. Survey images obtained in 2008 and 2011 within this borehole are shown on pages 14 to 16 of the appended Inspectahire report.

Borehole CP6B

The recent laser survey has revealed the presence of an open void with approximately the same dimensions as those identified by the 2008 survey. The depth to the roof level of the mine is still approximately 16.5m below ground level. The approximate length of the tunnel remains about 10m with the height still ranging between approximately 1.4m and 2.2m and the width still ranging between 1.4m and 2.3m. Survey images obtained in 2008 and 2011 within this borehole are shown on pages 17 to 19 of the appended Inspectahire report.

The main objective of the recent laser survey was to undertake a comparative survey between the findings of the original laser survey carried out in 2008 within the immediate vicinity of the Highbarns/Pond Road/East Green road junction and those of the recent survey to help determine whether any changes have occurred to the extent of the voids encountered that could possibly indicate deterioration in the condition of the mine. The 2008 laser survey was carried out in eight boreholes designated CP1A, CP2D, CP1B, CP1C, CP1D, CP4B, CP5B and CP6B (see Figure 3 for their locations). It was intended to carry out the recent laser survey within six of the eight original boreholes, the exceptions being boreholes CP4B (the previous laser survey was unable to complete a scan of the void encountered by this borehole) and CP5B (the recorded void was remediated later in 2008). However, the recent survey was carried out in five boreholes (CP1A, CP2D, CP1B, CP1C and CP6B) as it was not possible for Inspectahire to carry out a scan in borehole CP1D due to insufficient room for the laser head to manoeuvre.

The key finding of the recent laser survey is that it has not identified any significant changes to the extent of the mineworkings identified by the earlier laser survey carried out within the same five boreholes in 2008 suggesting that no obvious significant deterioration has occurred in those parts of the mine surveyed since the previous laser survey.

However, it should be noted that the recent laser survey is limited to the extent of the known mine accessed via five retained boreholes within the immediate vicinity of the Highbarns road junction and therefore does not address the risk from any areas of mine workings not identified to date and the probable/possible extent of the mine indicated on Figure 4: Extent of Known Mineworkings and Interpreted Mine Layout. It should also be noted that although the recent laser survey does not indicate any significant changes to the extent of the open mine over the past three years within the five boreholes surveyed, other factors such as the condition and thickness of the mine roof remain unclear as the laser survey is only able to assess the extent of the open void. Furthermore limited monitoring data cannot provide a reliable indicator of mine stability since sudden collapses can occur spontaneously or due to factors such as pipe bursts. The assessed risk of collapse from the workings as set out in Hyder's Geotechnical Assessment Report for the site is therefore unaffected by the results of the monitoring and remains significant. There is however no additional data to suggest imminent collapse of any of the workings surveyed.

In our opinion, whilst we believe the known highest risk areas have been addressed by the emergency works carried out to date, we are not in a position to discount the potential for collapse from any of the remaining areas of open mineworkings identified by PBA. We are not convinced that for these areas a sensible prioritisation of risk could be arrived at because of uncertainties such as the condition and thickness of the mine roof.

Our risk assessment assumes that by the end of 2012 treatment would have been completed and that before this time appropriate further intrusive ground investigation works would have confirmed the extent of workings. Pending treatment we would therefore recommend that the intrusive ground investigation works included within our Feasibility Study Report are undertaken. In the meantime continued visual monitoring and reporting at the site, supplemented as required by building inspection and level surveys, should be undertaken as set out in our Geotechnical Assessment Report. A further review of risks at the site will be required in the event that any evidence of ground movements is detected.

Ultimately we would stress that monitoring is unlikely to be a suitable approach to address the risks at the site in the long term because of the issues of coverage and the potentially sudden nature of crownhole development.

9 RELEVANT REPORTS

The following reports have been produced for the project and should be referred to as required when reading this report:

1. British Geological Survey Report for site: Geological Assessment - Standard dated 11-09-09.
2. Envirocheck report for site (2009) ref. 29459877_1_1 LN022793 dated 25-11-09.
3. Geotechnology (2010), *Microgravity Survey Report* Highbarns, Hemel Hempstead. Report Number 926r1v1d0310, March 2010. Geotechnology, Neath.
4. Hertfordshire Biological Records Centre (2009) Ecological Survey of the Highbarns Area, Hemel Hempstead, July 2009.
5. Hunn, J. R. & Stanyon, M. (2009) Nash Mills Chalk Mine, *The Quarterly* 72, October 2009.
6. Hyder Consulting (2010), Highbarns Chalk Mines Project Geotechnical Assessment Report, No 0002-LN01292-GD-01-0, February 2010.
7. Hyder Consulting (2010), Highbarns Chalk Mines Project Visual Structural Inspections Report, No 3001-LN01292-LNR-F-01, April 2010.
8. Hyder Consulting (2010), Highbarns Chalk Mines Project Geophysical Survey Report No 0002-LN01292-GD-02-O, June 2010.
9. Hyder Consulting (2010), Highbarns Chalk Mines Project Feasibility Study Report No 0005-UA000857-GDR-01-0, July 2010.
10. Inspectahire Ltd (2011), Report No 5489 Dacorum Borough Council, Highbarns, Hemel Hempstead, C-ALS & CCTV Inspection of Voids, May 2011.
11. Peter Brett Associates (2008), Interpretative Geotechnical Report – Phase 1 No 20247/0043/Int01/rev2, July 2008.

The Envirocheck report for the site and other desk study references are provided within the Hyder Geotechnical Assessment Report for the site.

The Geotechnology microgravity survey report is included within the Hyder Geophysical Survey Report.

Figures

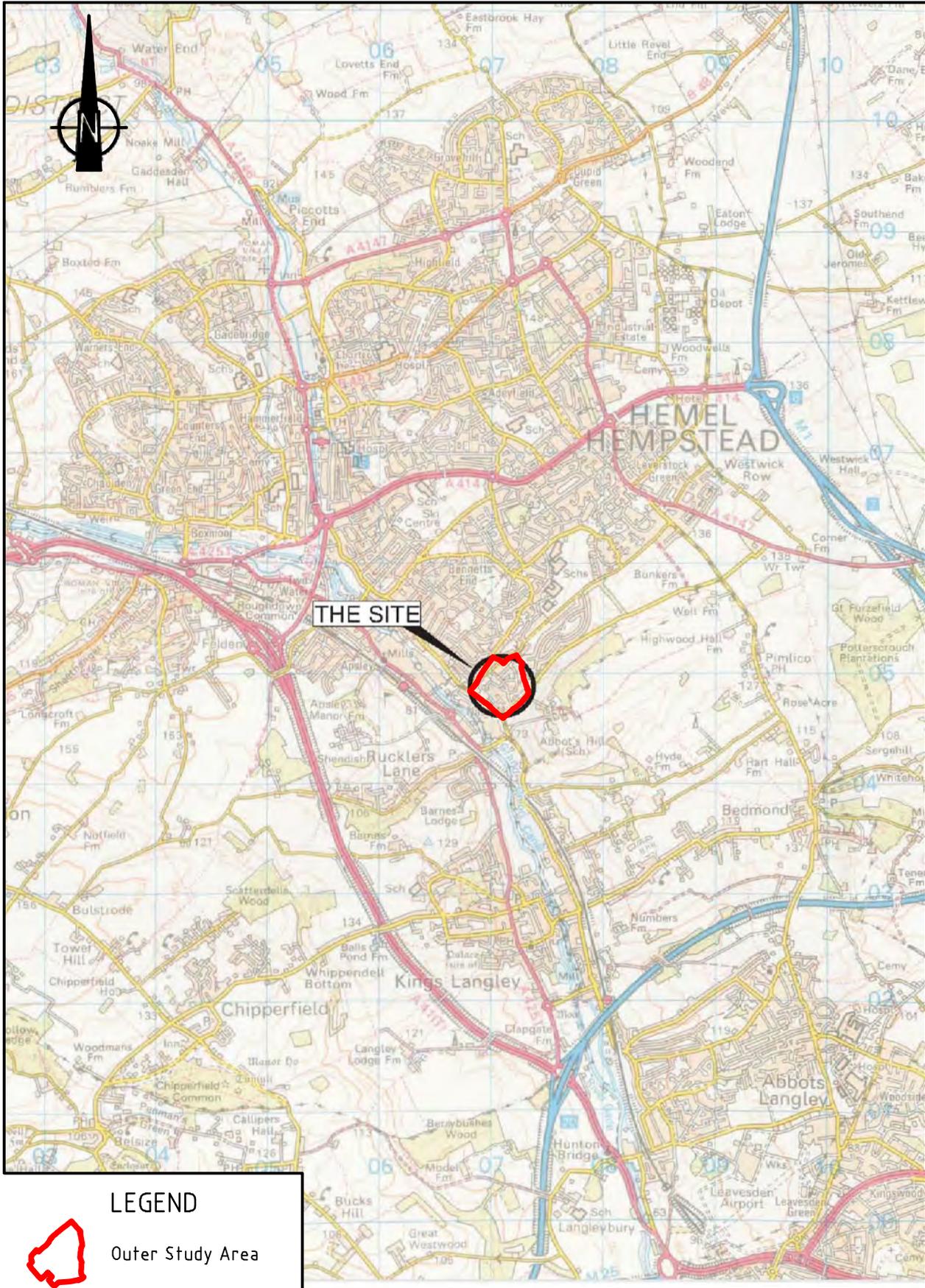
Figure 1: Site Location Plan

Figure 2: Site Plan and Desk Study Results

Figure 3: Plan Showing the Extent of Known Mineworkings at the Site (and Previous Exploratory Holes)

Figure 4: Extent of Known Mineworkings and Interpreted Mine Layout

Figure 5: LSP Funding Application Area Showing Distribution of Housing, Highways and Public Open Spaces



Status
PRELIMINARY
 NOT TO BE USED FOR CONSTRUCTION

Scales	1:50000	Original Size	A4
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Height Datum	Grid
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Filename: **FIGURE1-LN01292-GD-00.dwg**

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Project
**HIGHBARNES CHALK
 MINES PROJECT**

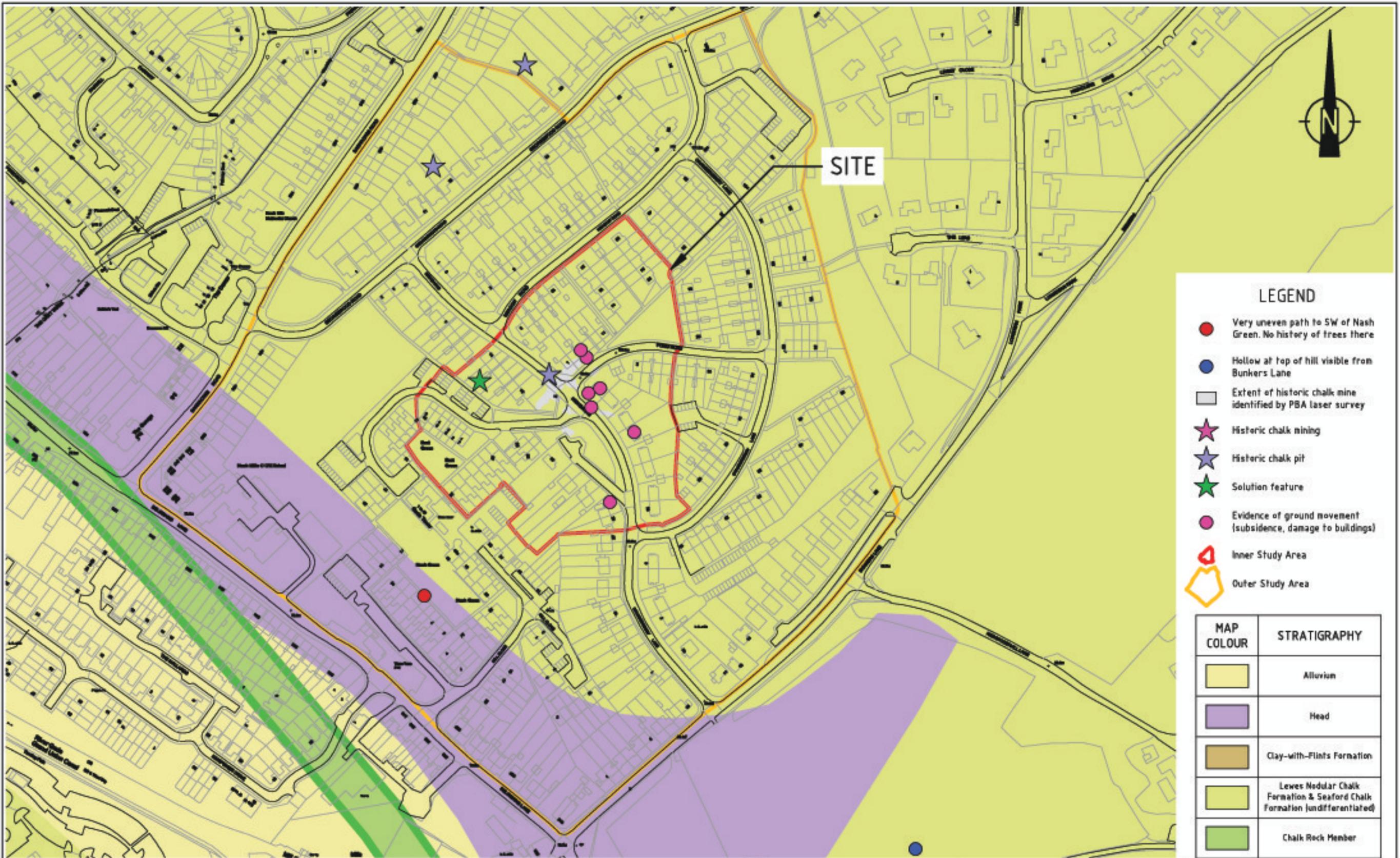
Title
SITE LOCATION PLAN

Hyder Consulting Ltd

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 GU2 7AR

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 Fax: +44 (0)1753 331515

Drawing No.	Project No.	Issue
FIGURE 1	UA000857	01



LEGEND

- Very uneven path to SW of Nash Green. No history of trees there
- Hollow at top of hill visible from Bunkers Lane
- Extent of historic chalk mine identified by PBA laser survey
- ★ Historic chalk mining
- ★ Historic chalk pit
- ★ Solution feature
- Evidence of ground movement (subsidence, damage to buildings)
- Inner Study Area
- Outer Study Area

MAP COLOUR	STRATIGRAPHY
	Alluvium
	Head
	Clay-with-Flints Formation
	Lewes Nodular Chalk Formation & Seaford Chalk Formation (undifferentiated)
	Chalk Rock Member

Issue	Description	And	Apr	Date

Client
DACORUM BOROUGH COUNCIL

Station
PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

Scales	1:20000	Current Issue Signatures
Original Size	A3	Author D.RIDDELL
Height Datum		Checker M.SKITTRALL
Grid		Approver
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Filename:	FIGURE3-LN#1292-GD-#0.DWG	

Project
HIGHBARNS CHALK MINES PROJECT

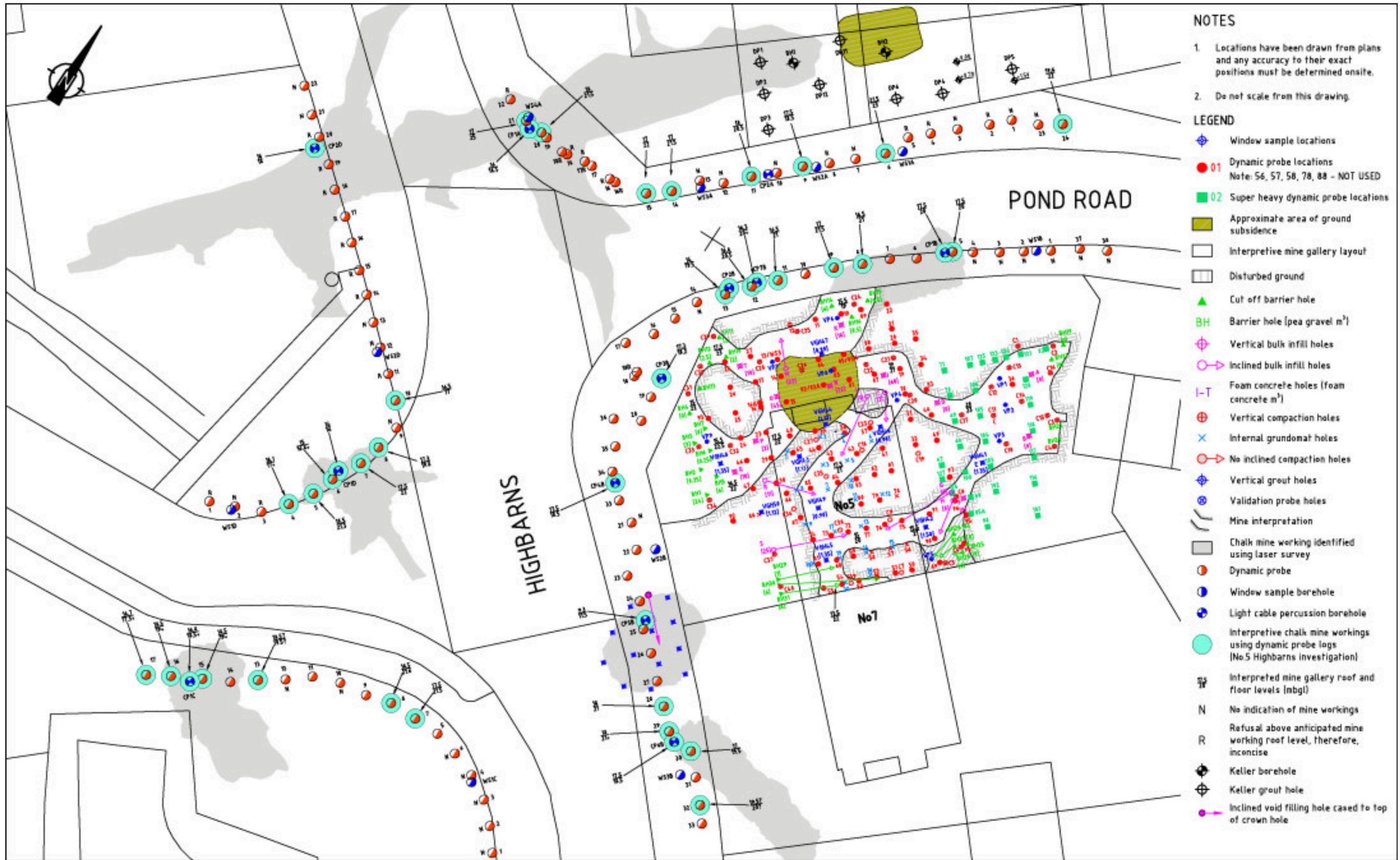
Title
SITE PLAN AND DESK STUDY RESULTS

Hyder Consulting Ltd

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Drawing No. **FIGURE 2** | Project No. **UA000857** | Issue **01**



NOTES

- Locations have been drawn from plans and any accuracy to their exact positions must be determined onsite.
- Do not scale from this drawing.

LEGEND

- Window sample locations
- 01 Dynamic probe locations
Note: 56, 57, 58, 78, 88 - NOT USED
- 02 Super heavy dynamic probe locations
- Approximate area of ground subsidence
- Interpretive mine gallery layout
- Disturbed ground
- Cut off barrier hole
- Barrier hole (pea gravel m³)
- Vertical bulk infill holes
- Inclined bulk infill holes
- Foam concrete holes (foam concrete m³)
- Vertical compaction holes
- Internal groutomat holes
- No inclined compaction holes
- Vertical grout holes
- Validation probe holes
- Mine interpretation
- Chalk mine working identified using laser survey
- Dynamic probe
- Window sample borehole
- Light cable percussion borehole
- Interpretive chalk mine workings using dynamic probe logs (No.5 Highbarns investigation)
- Interpreted mine gallery roof and floor levels (mbgl)
- No indication of mine workings
- Refusal above anticipated mine working roof level, therefore, inconclusive
- Keller borehole
- Keller grout hole
- Inclined void filling hole cased to top of crown hole

Issue	Description	And	Apr	Date

Client
DACORUM BOROUGH COUNCIL

Status
PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

Scales
1:200

Original Size
A3

Height Datum

Grid

Filename
FIGURES-LN#1292-GD-09.DWG

Project
HIGHBARNS CHALK MINES PROJECT

Title
PLAN SHOWING THE EXTENT OF KNOWN MINEWORKINGS AT THE SITE

Current Issue Signatures

Author D.RIDDELL
Checker M.SKITTRALL
Approver

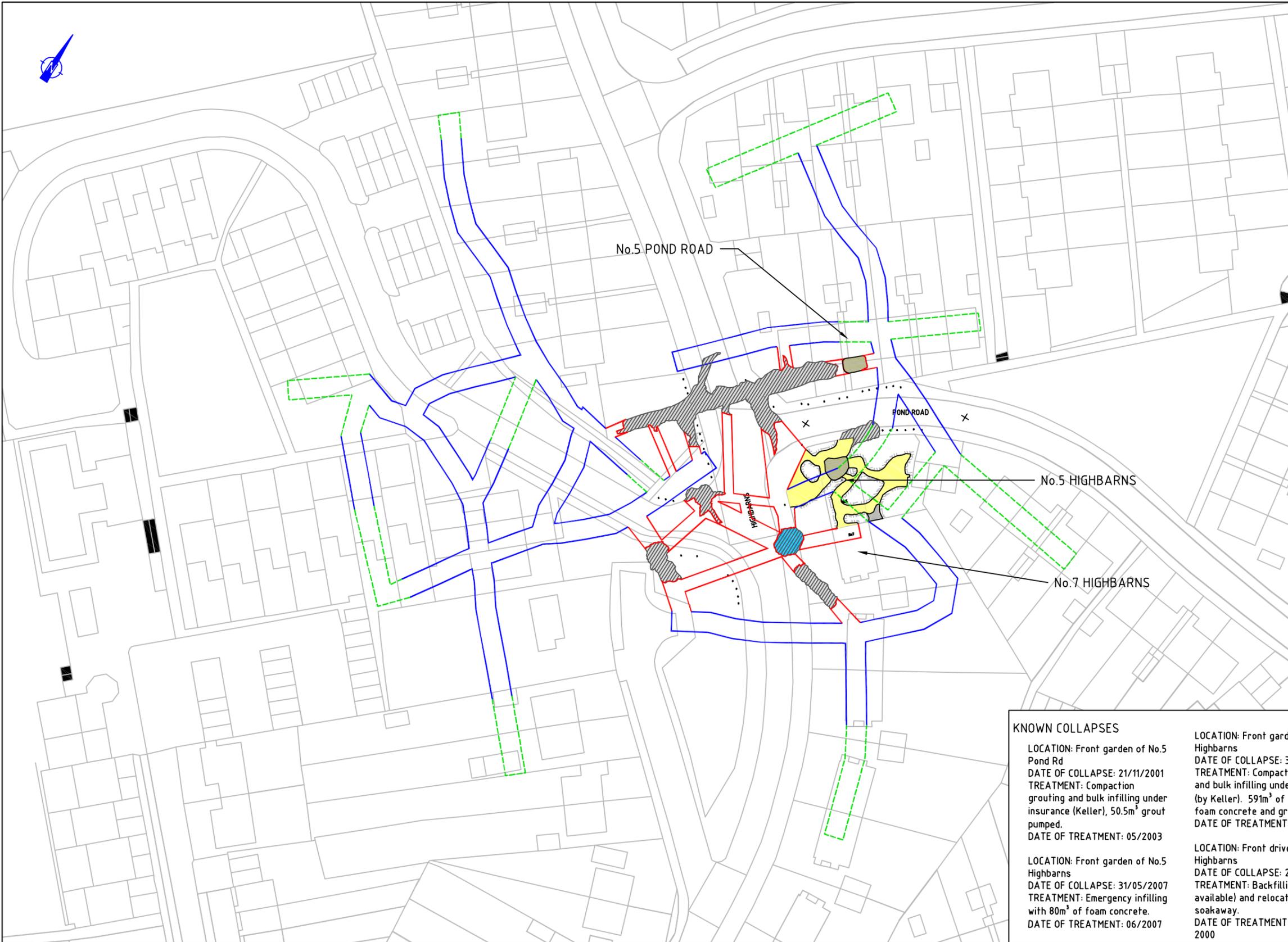
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Drawing No. **FIGURE 3** Project No. **UA000857** Issue **01**



NOTES

1. Locations have been drawn from plans and any accuracy to their exact positions must be determined onsite.
2. Do not scale from this drawing.

LEGEND

- Possible extents of mines based upon Negative Microgravity anomalies shown on Figure 7 - Microgravity Interpretation plan within Geotechnology's Microgravity Survey Report No 926r1v1d0310
- Probable extents of mines based upon significant Negative Microgravity anomalies shown on Figure 7 - Microgravity Interpretation plan within Geotechnology's Microgravity Survey Report No 926r1v1d0310
- Probable extents of mines extrapolated from the voids identified by Laser Survey from PBA report Ref 20247 - Interpretative Geotechnical Report Rev2 - Highbarns
- Approximate area of ground subsidence detected at surface - From PBA report Ref 20247 - Interpretative Geotechnical Report Rev2 - Highbarns
- Interpretive mine gallery layout - From PBA report Ref 20247 - Interpretative Geotechnical Report Rev2 - Highbarns
- Mine interpretation - Chalk Pillar
- Chalk mine working identified using laser survey (VOID) From PBA report Ref 20247 - Interpretative Geotechnical Report Rev2 - Highbarns
- Chalk mine working identified using laser survey (VOID) at higher level From PBA report Ref 20247 - Interpretative Geotechnical Report Rev2 - Highbarns

KNOWN COLLAPSES

<p>LOCATION: Front garden of No.5 Pond Rd DATE OF COLLAPSE: 21/11/2001 TREATMENT: Compaction grouting and bulk infilling under insurance (Keller), 50.5m³ grout pumped. DATE OF TREATMENT: 05/2003</p>	<p>LOCATION: Front garden of No.5 Highbarns DATE OF COLLAPSE: 31/05/2007 TREATMENT: Emergency infilling with 80m³ of foam concrete. DATE OF TREATMENT: 06/2007</p>	<p>LOCATION: Front garden of No.5 Highbarns DATE OF COLLAPSE: 31/05/2007 TREATMENT: Compaction grouting and bulk infilling under insurance (by Keller). 591m³ of pea gravel, foam concrete and grout injected. DATE OF TREATMENT: 08-09/2008</p>
<p>LOCATION: Front garden of No.5 Highbarns DATE OF COLLAPSE: 31/05/2007 TREATMENT: Emergency infilling with 80m³ of foam concrete. DATE OF TREATMENT: 06/2007</p>	<p>LOCATION: Front drive of No. 40 Highbarns DATE OF COLLAPSE: 2000 TREATMENT: Backfilling (no records available) and relocation of soakaway. DATE OF TREATMENT: Assumed 2000</p>	<p>LOCATION: Pavement at 24 Highbarns DATE OF COLLAPSE: 1980's DETAILS: A lorry sank into a hole in the pavement (believed to be a well at the time). TREATMENT: Filled with concrete and farmed over. DATE OF TREATMENT: 1980's</p>
		<p>LOCATION: Pavement and highway in front of No.s 5/7 Highbarns (BH CP5B) DATE OF COLLAPSE: 19/06/2008 TREATMENT: Emergency compaction grouting and bulk infilling for DBC (by Keller). DATE OF TREATMENT: Oct/Nov 2008</p>

Issue	Description	Amd	Apr	Date

Client
DACORUM BOROUGH COUNCIL

Status	PRELIMINARY	
	NOT TO BE USED FOR CONSTRUCTION	
Scales	1:750	Current Issue Signatures
Original Size	A3	Author I. TURNER
Height Datum		Checker D. BARRIE
Grid		Approver M. SKITTRALL
Filename:	FIGURES-LN01292-GD-00_IT_V2.DWG	
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Project
HIGHBARNS CHALK MINES PROJECT

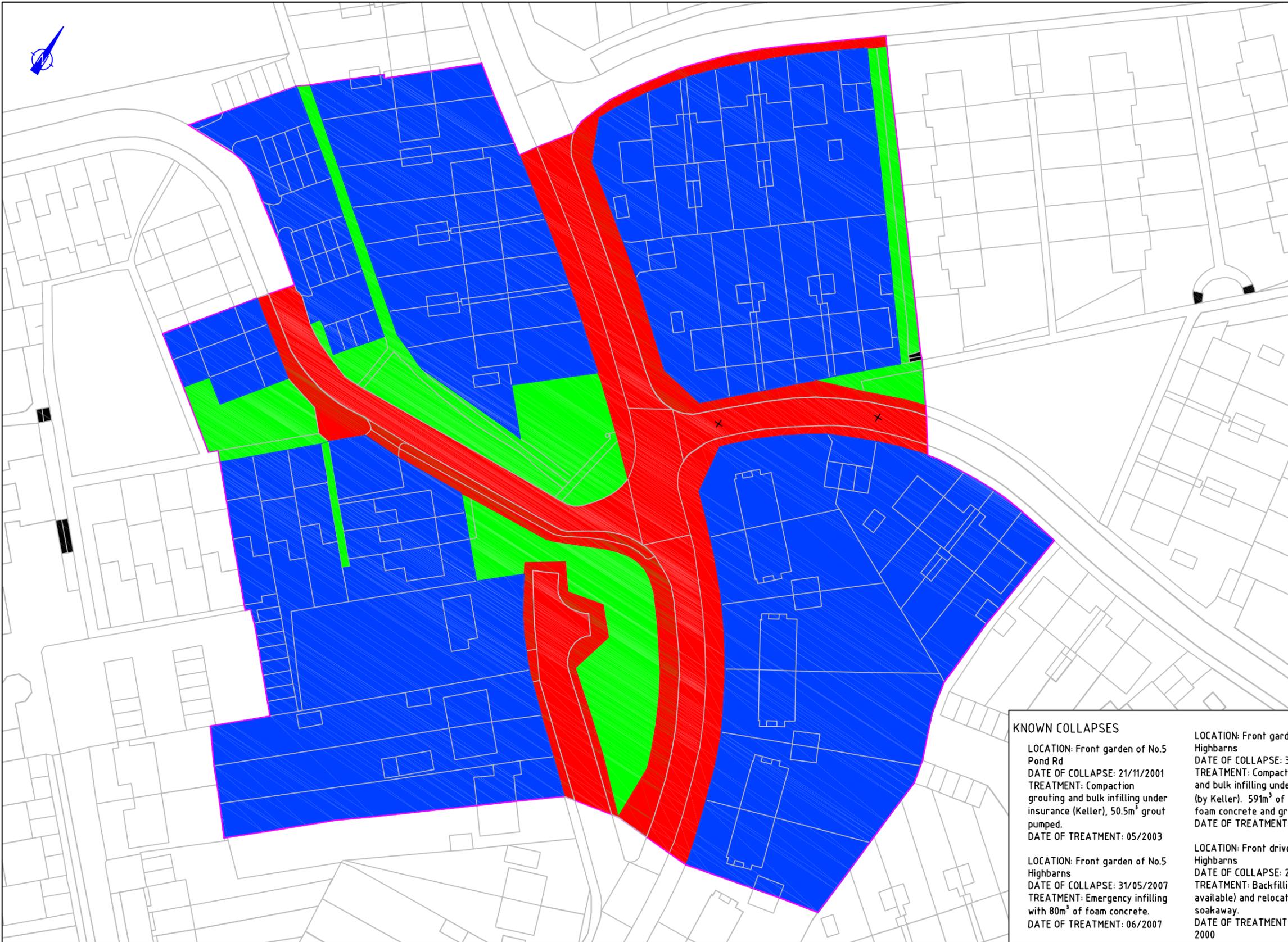
Title
EXTENT OF KNOWN MINE WORKINGS AND INTERPRETED MINE LAYOUT

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Drawing No.	Project No.	Issue
FIGURE 4 - UA000857	01	01



NOTES

1. Locations have been drawn from plans and any accuracy to their exact positions must be determined onsite.
2. Do not scale from this drawing.

LEGEND

- Study Area
- Housing - Including full curtilage of each property including front and back gardens, garages and driveways.
- Highways - Including all carriageways and associated pavements
- Public Open Space - Including all open areas used by the public including footways and alleys.

KNOWN COLLAPSES

<p>LOCATION: Front garden of No.5 Pond Rd DATE OF COLLAPSE: 21/11/2001 TREATMENT: Compaction grouting and bulk infilling under insurance (Keller), 50.5m³ grout pumped. DATE OF TREATMENT: 05/2003</p>	<p>LOCATION: Front garden of No.5 Highbarns DATE OF COLLAPSE: 31/05/2007 TREATMENT: Emergency infilling with 80m³ of foam concrete. DATE OF TREATMENT: 06/2007</p>	<p>LOCATION: Front garden of No.5 Highbarns DATE OF COLLAPSE: 31/05/2007 TREATMENT: Compaction grouting and bulk infilling under insurance (by Keller). 591m³ of pea gravel, foam concrete and grout injected. DATE OF TREATMENT: 08-09/2008</p>	<p>LOCATION: Front drive of No. 40 Highbarns DATE OF COLLAPSE: 2000 TREATMENT: Backfilling (no records available) and relocation of soakaway. DATE OF TREATMENT: Assumed 2000</p>	<p>LOCATION: Pavement at 24 Highbarns DATE OF COLLAPSE: 1980's DETAILS: A lorry sank into a hole in the pavement (believed to be a well at the time). TREATMENT: Filled with concrete and farmed over. DATE OF TREATMENT: 1980's</p>	<p>LOCATION: Pavement and highway in front of No.s 5/7 Highbarns (BH CP5B) DATE OF COLLAPSE: 19/06/2008 TREATMENT: Emergency compaction grouting and bulk infilling for DBC (by Keller). DATE OF TREATMENT: Oct/Nov 2008</p>
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Issue	Description	Amd	Apr	Date

Client
DACORUM BOROUGH COUNCIL

Status	PRELIMINARY NOT TO BE USED FOR CONSTRUCTION	
Scales	1:750	Current Issue Signatures
Original Size	A3	Author I. TURNER
Height Datum		Checker M.SKITTRALL
Grid		Approver M.SKITTRALL
Filename:	FIGURE9-LN01292-GD-00_IT.DWG	

Project	HIGHBARNES CHALK MINES PROJECT	
Title	LSP FUNDING APPLICATION AREA SHOWING DISTRIBUTION OF HOUSING, HIGHWAYS AND PUBLIC OPEN SPACES	
Plot Date:	26/Jul/2010 9:41:31 AM	

Project
HIGHBARNES CHALK MINES PROJECT

Title
LSP FUNDING APPLICATION AREA
SHOWING DISTRIBUTION OF HOUSING,
HIGHWAYS AND PUBLIC OPEN SPACES

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Drawing No. **FIGURE 5 - UA000857** | Project No. **01** | Issue

Appendix A

Inspectahire's Report No 5489 C-ALS & CCTV Inspection of Voids dated May 2011



inspectahire

THE INSPECTION SPECIALISTS

**5489 Dacorum Borough Council
Highbarns
Hemel Hempstead
CAL-S & CCTV Inspection of Voids
May 2011
Issue 1**

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2.	PROJECT DETAILS	3
3.	OPERATING ENVIRONMENT	3
4.	DESCRIPTION OF C-ALS, CAVITY MONITORING SYSTEM	4
5.	OPERATIONAL INSPECTION METHODS	5-6
6.	OBSERVATIONS AND COMMENTS	5-7
7.	IMAGES OF VOID	8-19

1. INTRODUCTION

In 2008 Inspectahire Ltd were retained by Peter Bret Associates to help investigate whether historical chalk mines encountered within properties in the vicinity of the junction of High Barns, Pond road and East Green presented a potential stability hazard to the adjacent highway.

This report represents a comparative survey of the findings of a Cavity Auto scanning Laser System (C-ALS) of six retained bore holes with the data collected in 2008.

2. PROJECT DETAILS

Project Name:	5489 Highbarns
Date:	May 2011
Project No.:	5489
Report Ref:	5489/DHall
Report Author:	Daniel Hall Inspectahire
Site Address:	High Barns, Nash Mills
Personnel:	Daniel Hall Inspectahire Mark Ronaldson Inspectahire
Site Brief:	To carry out a CAL-S survey & CCTV of Voids
Site Conditions:	Outdoors open to elements
Equipment Used:	CAL-S and Ca-ZOOM camera

3. OPERATING ENVIRONMENT

The site comprises of three two-lane residential streets two of which have now being closed off to traffic.

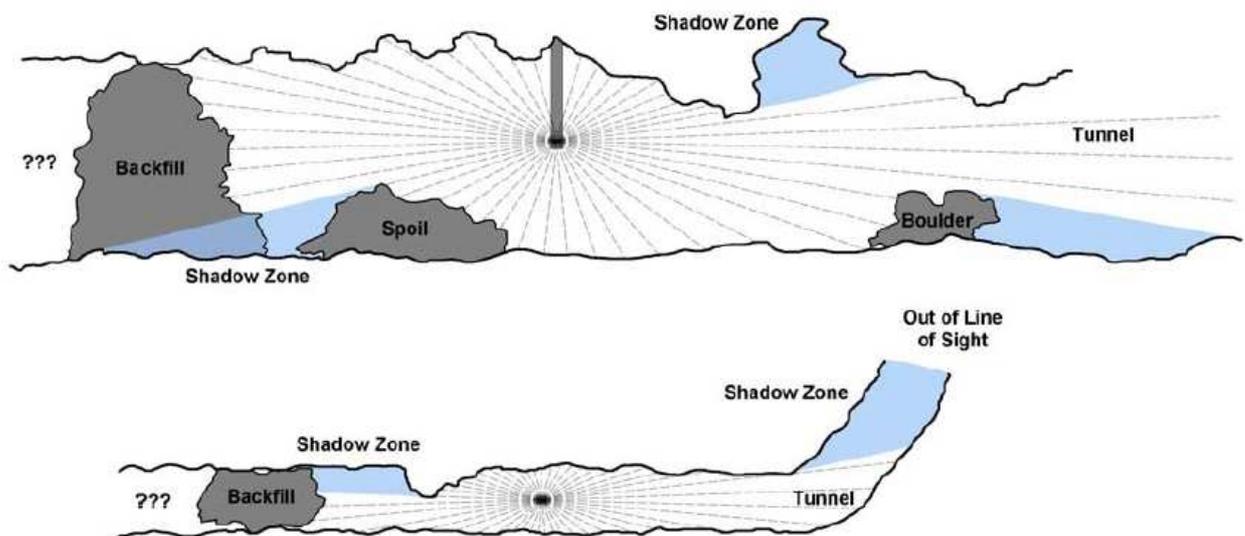
Access to the voids was via Lined and capped access points on pavements and grass verges.

All work was carried out in accordance to Dacorum Borough Councils procedures.

4. DESCRIPTION OF C-ALS, CAVITY MONITORING SYSTEM

Measurement Devices Ltd (MDL) has developed a Robotic Laser Surveying System capable of being inserted into voids and cavities via predrilled boreholes to quickly and safely survey old workings. This system is known as the Cavity Auto scanning Laser System (C-ALS).

MDL's C-ALS cavity monitoring system is a self-navigating, 'motorised' robotic probe designed to enter & survey dry abandoned mine workings or cavities. With a diameter of just 50mm, the unit can be deployed down pre-drilled boreholes of 65mm or more, from where it employs a miniaturised laser scanner to measure the three-dimensional shape of the void together with its surface reflectivity.



As indicated in the image above, the results from the laser survey are dependent on the condition of the void being surveyed. Obstructions such as boulders will create 'shadows' or blind spots which cannot be surveyed. Blockages will also limit the extent of the survey as will changes in orientation of a tunnel, such as the tunnel passes beyond the line of site of the laser scanner.

5. OPERATIONAL INSPECTION METHODS

Access to all Voids was via capped, dry and lined bore holes at varying depths

The CAL-S unit was lowered on Carbon Fibre poles taking one meter measurements following the bore track until it reached the end of the Liner.

The CAL-S unit was then introduced into the Void approximately 500mm further to create enough room for the probe head to move

A quick scan was then conducted from this point to make sure the probe had enough room to manoeuvre for a full scan.

The probe was then locked off once in position and then a full vertical and horizontal scan (approximately 120 minutes)

All the data was collected on a laptop to be analysed later with the use of Void Works software.

6. OBSERVATIONS AND COMMENTS

Upon removal of borehole caps it was discovered that Liners were 70mm id apart from CP1B and not 100mm id as instructed. No CCTV footage was taken because of this and restricted access.

Due to improvements in the CAL-S unit and software the 2011 survey is more accurate than the survey carried out in 2008.

Borehole CP1A and CP2D

Although boreholes **CP1A** and **CP2D** were surveyed separately a direct linkage between the two survey positions was identified. Therefore the information obtained from both of these boreholes has been combined.

The laser survey revealed the presence of the open mine working with approximately the same dimensions as the 2008 survey. The tunnel remains approximately 43m long and remains open at the present time, running in a north east to south west direction. The depth of the tunnel remains generally around 16m below ground level. The tunnel also remains approximately 1.7 to 2.0m in open vertical height and spans between 4.1m and 6.1m in width.

The 5 other possible tunnels extending off the main north east tunnel also remain the same in size.

It should be noted that the full extents of the 5 side tunnels may not be indicated in the survey as collapses and changes in orientation of the gallery could place further workings out of site of the laser scanning device.

2008 Survey Data

Approx Length	Approx Height	Approx Width
43m	1.7m to 2.0m	6.1m

2011 Survey Data

Approx Length	Approx Height	Approx Width
43m	1.7m to 2.0m	6.1m

Borehole CP1B

The laser survey revealed the presence of the open mine working with approximately the same dimensions as the 2008 survey. The open height of the tunnel has being slightly decreased from a maximum height 3.3m to 2.9m due to an overflow of grout from remedial works carried out in zone B.

The tunnel remains approximately 7.5m in length with a north easterly orientation, 16.4m below ground level and between 2.9m and 3.3m in width.

The survey suggests that the gallery is in filled / collapsed or changes in orientation such that the line of sight is lost by the laser device beyond the boundary fence of **No.5** Highbarns.

2008 Survey Data

Approx Length	Approx Height	Approx Width
7.5m	3.3m	2.9m to 3.3m

2011 Survey Data

Approx Length	Approx Height	Approx Width
7.5m	2.9m	2.9m to 3.3m

Borehole CP1D

No scan could be taken in this void due to insufficient room for the laser head to manoeuvre.

Borehole CP1C

The laser survey revealed the presence of an open void with approximately the same dimensions as the 2008 survey. It remains 13.8m below ground level with tunnel extending in a south easterly orientation and dropping a further 5m or so the tunnel still extends for approximately 8.6m below the grass area on the junction of Highbarns and East green it still spans approximately 4.5m and has an open height of between 1.3 and 2.7m

2008 Survey Data

Approx Length	Approx Height	Approx Width
8.6m	1.3m to 2.7m	4.5m

2011 Survey Data

Approx Length	Approx Height	Approx Width
8.6m	1.3m to 2.7m	4.5m

Borehole CP6B

The laser survey revealed the presence of the open mine working with approximately the same dimensions as the 2008 survey. It remains approximately 10m long with an easterly orientation. the depth to the roof level of the gallery is still approximately 16.5m below ground level. the general span of the tunnel is still between 1.4 and 2.3m across and the open height still varies between 1.4 and 2.2m

2008 Survey Data

Approx Length	Approx Height	Approx Width
10m	1.4m to 2.2m	1.4m to 2.3m

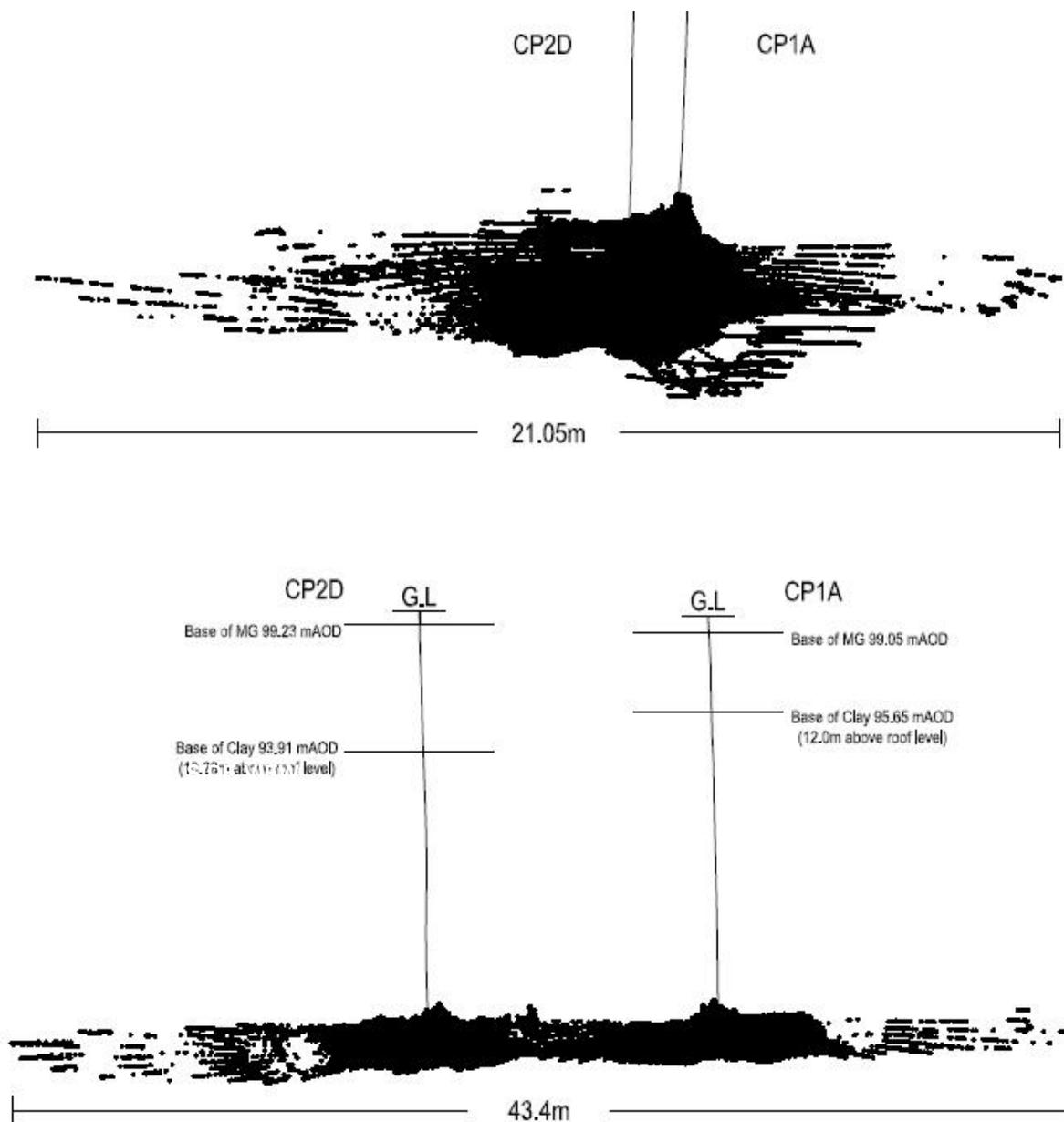
2011 Survey Data

Approx Length	Approx Height	Approx Width
10m	1.4m to 2.2m	1.4m to 2.3m

7. VOID IMAGES

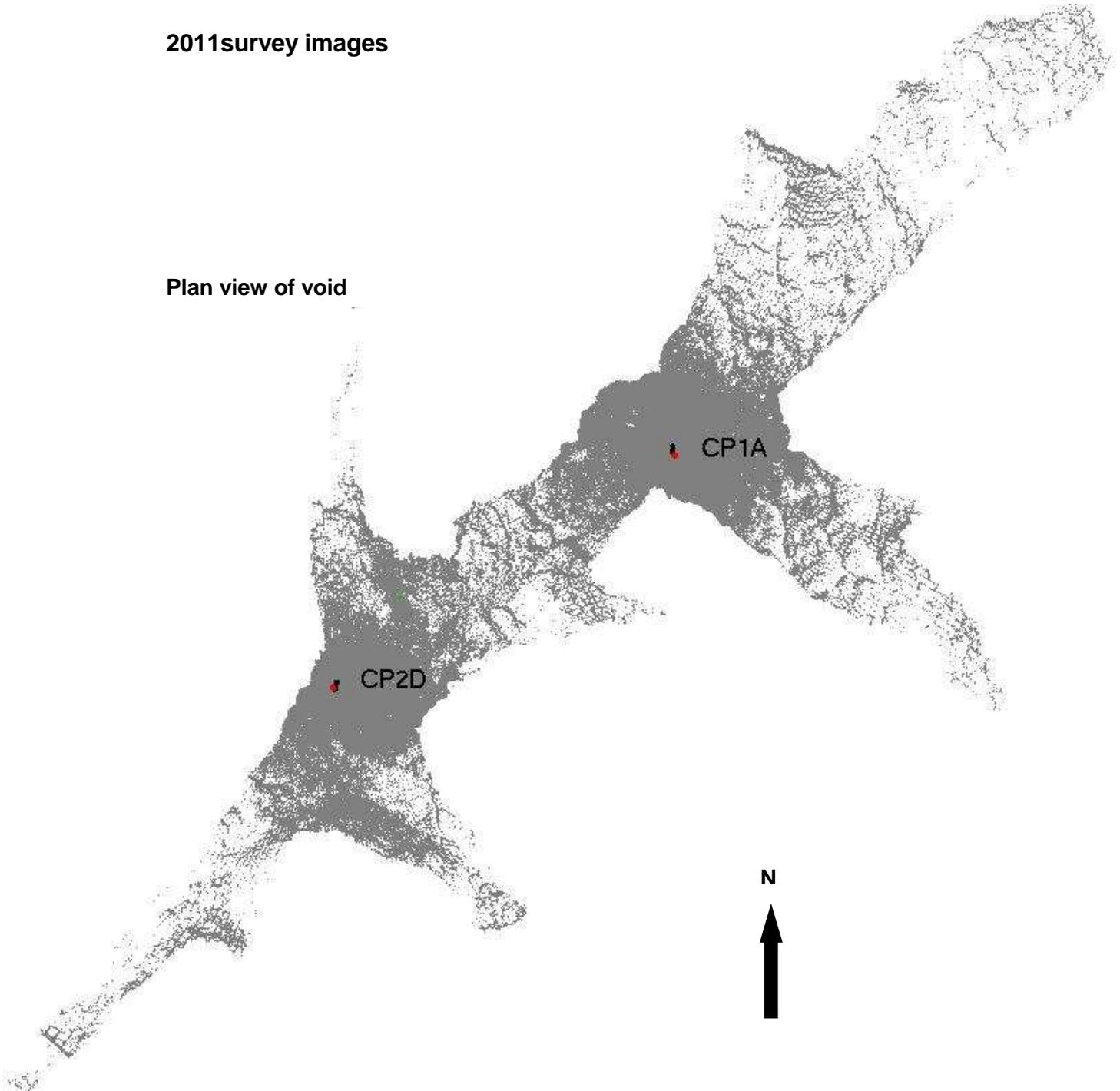
Borehole CP1A and CP2D

2008 survey images

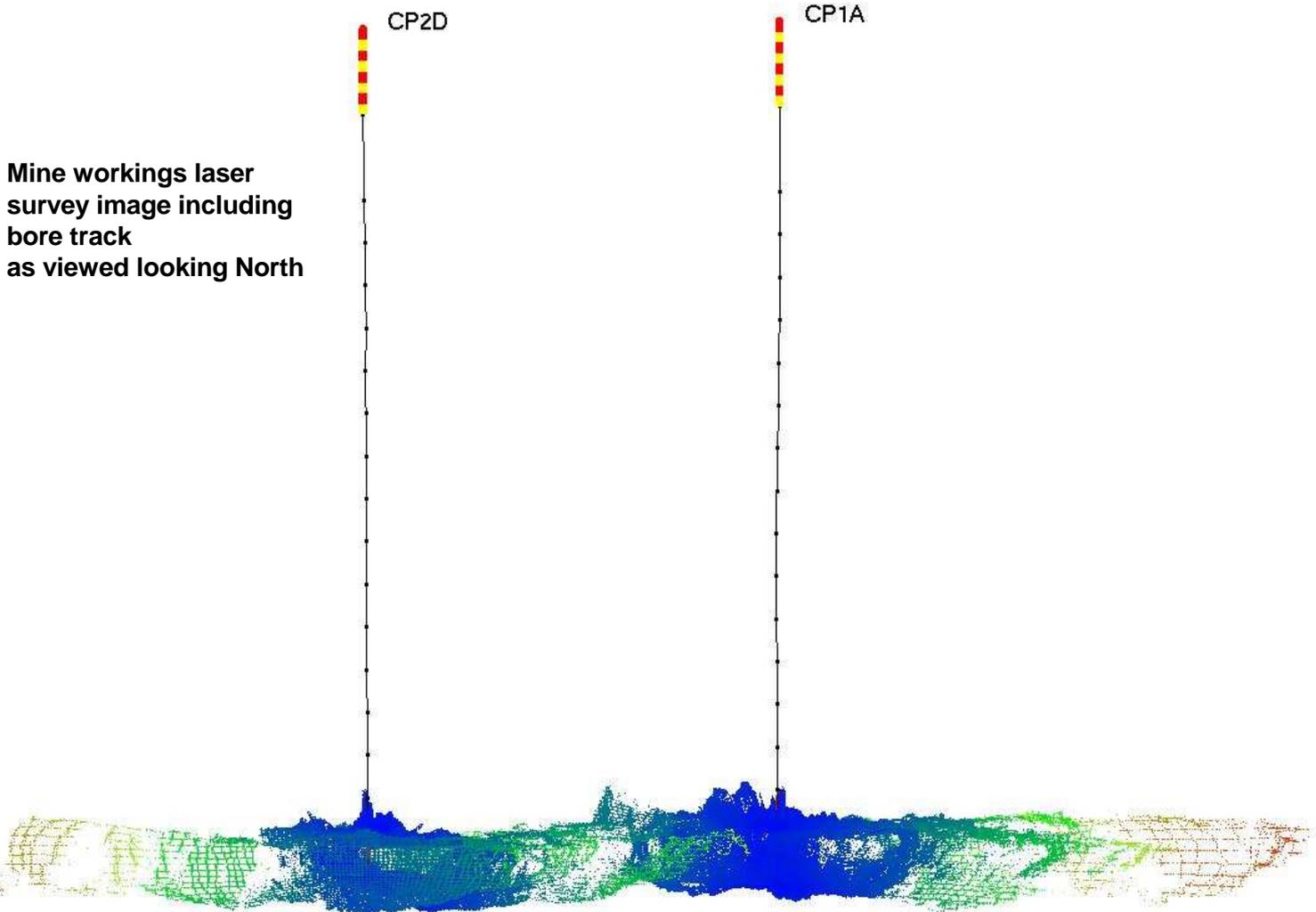


2011 survey images

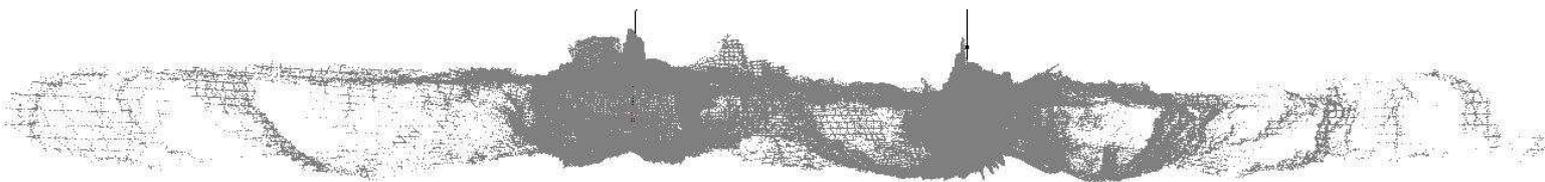
Plan view of void



**Mine workings laser survey image
as viewed looking East**

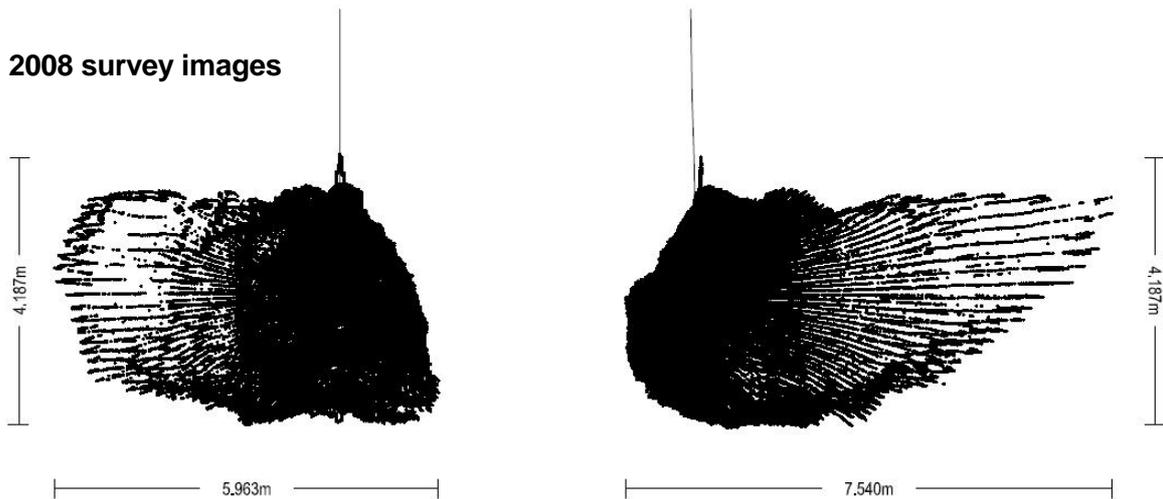


Mine workings laser survey image as viewed looking East

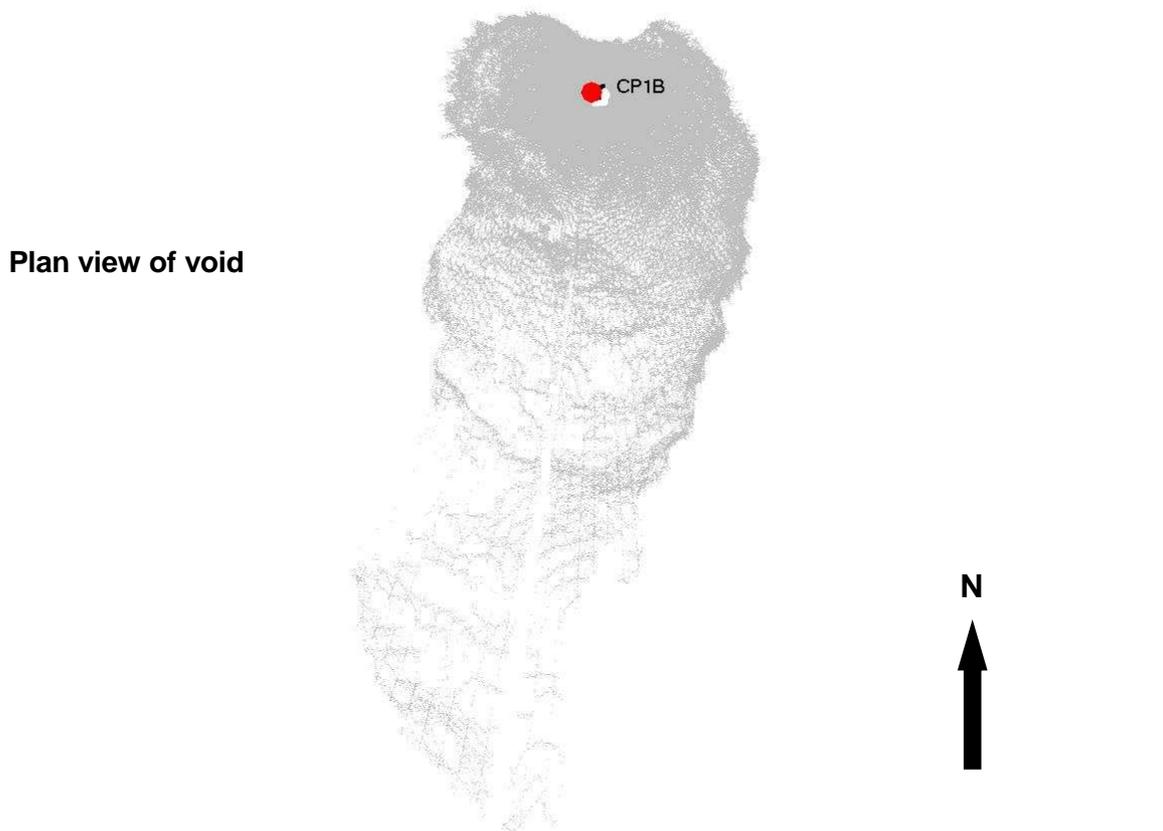


Borehole CP1B

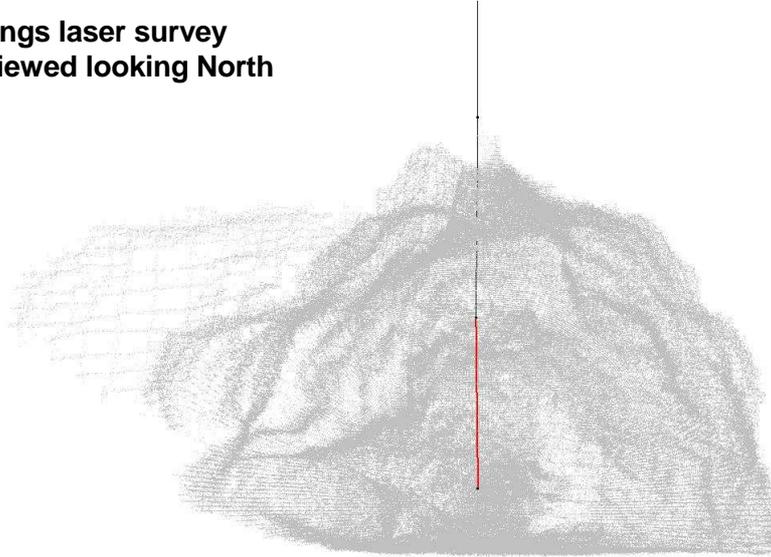
2008 survey images



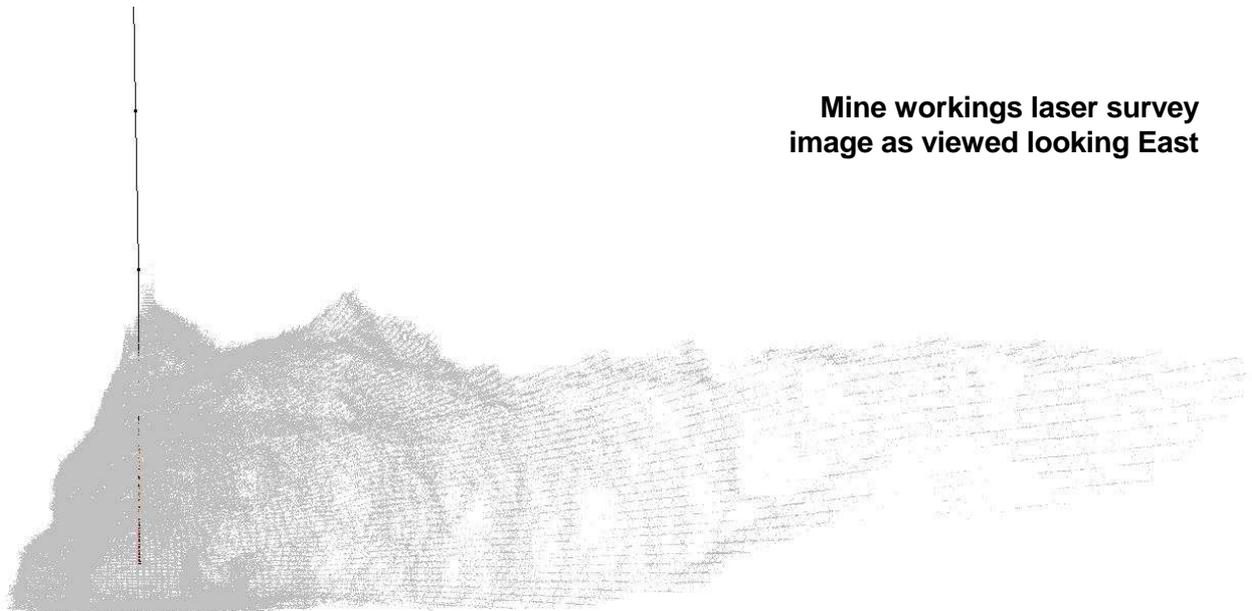
2011 survey images



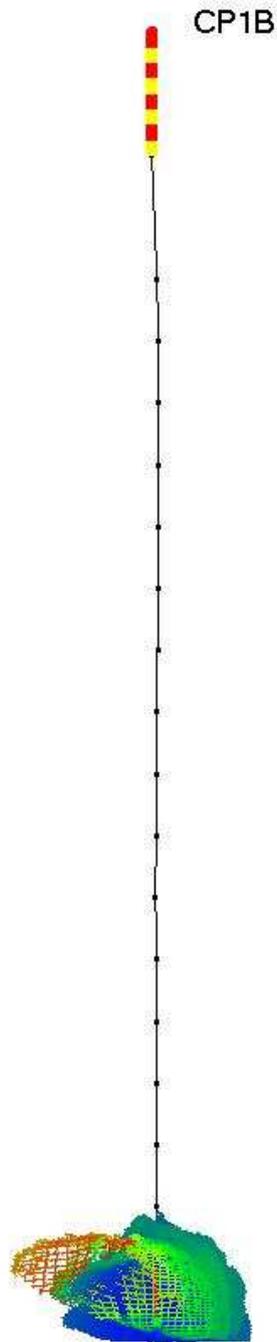
**Mine workings laser survey
image as viewed looking North**



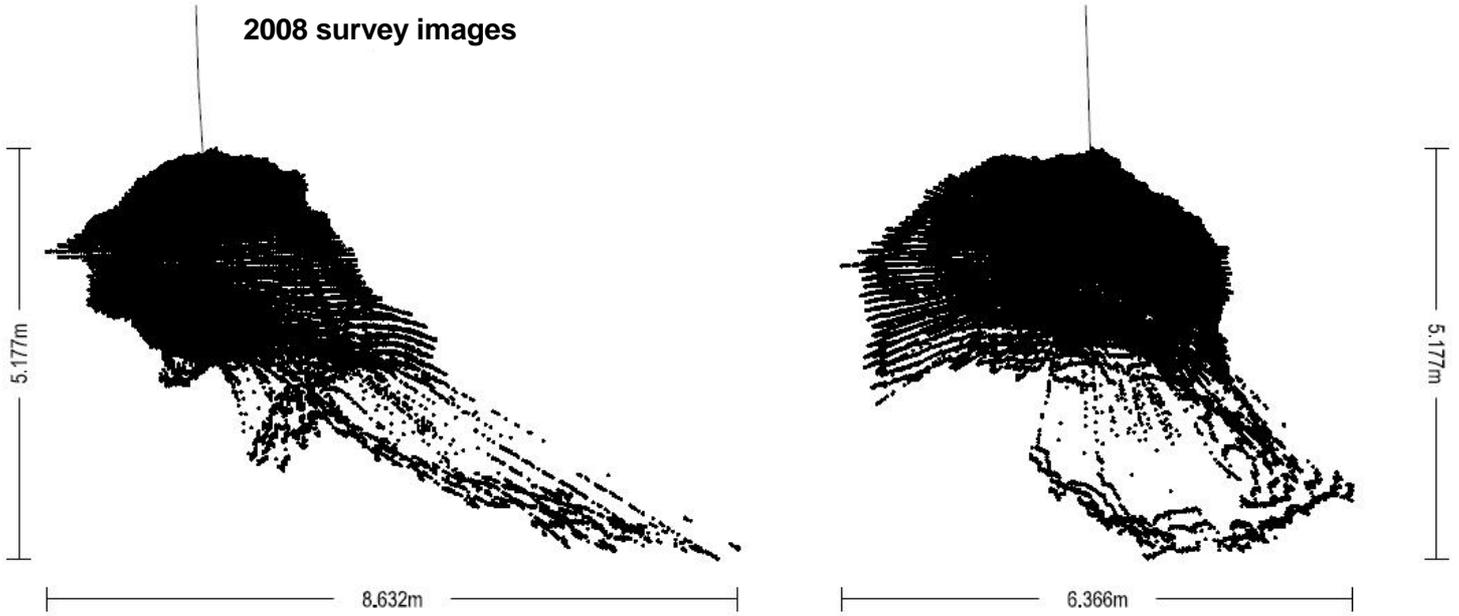
**Mine workings laser survey
image as viewed looking East**



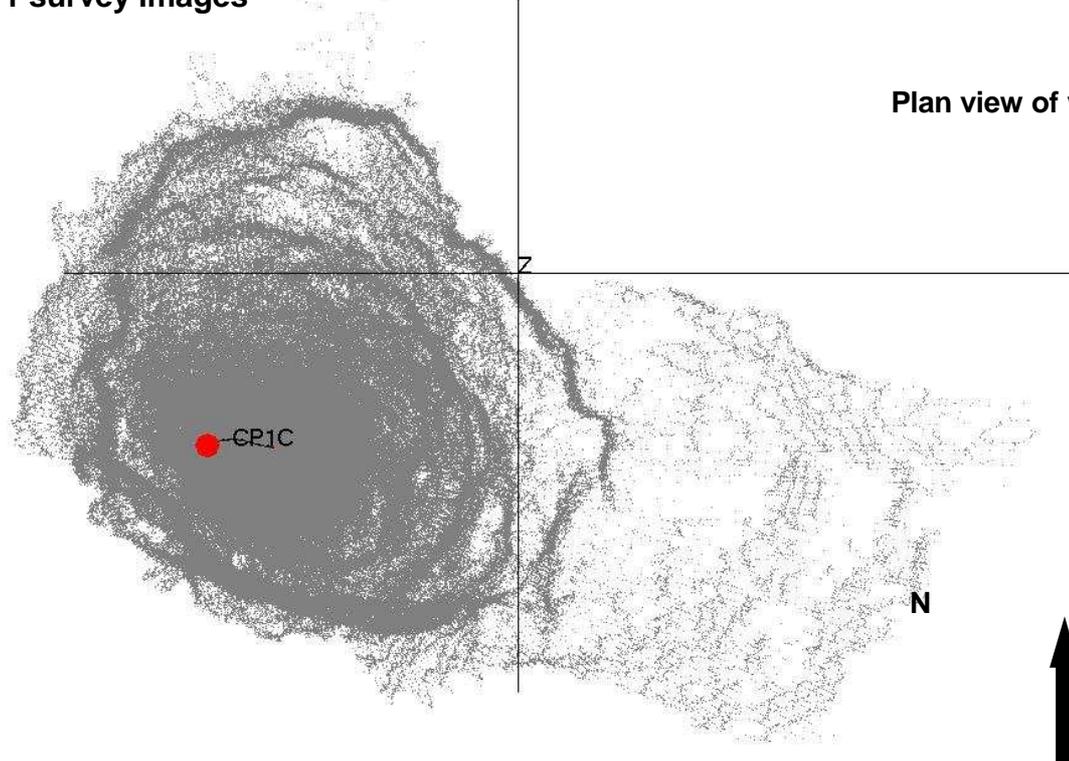
**Mine workings laser survey
image including bore track
as viewed looking North**



Borehole CP1C

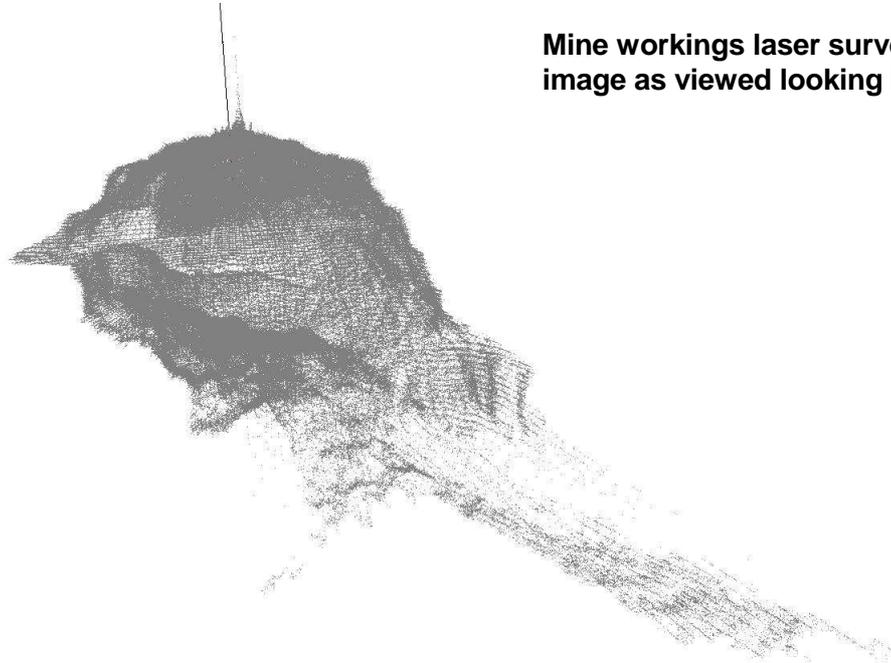


2011 survey images

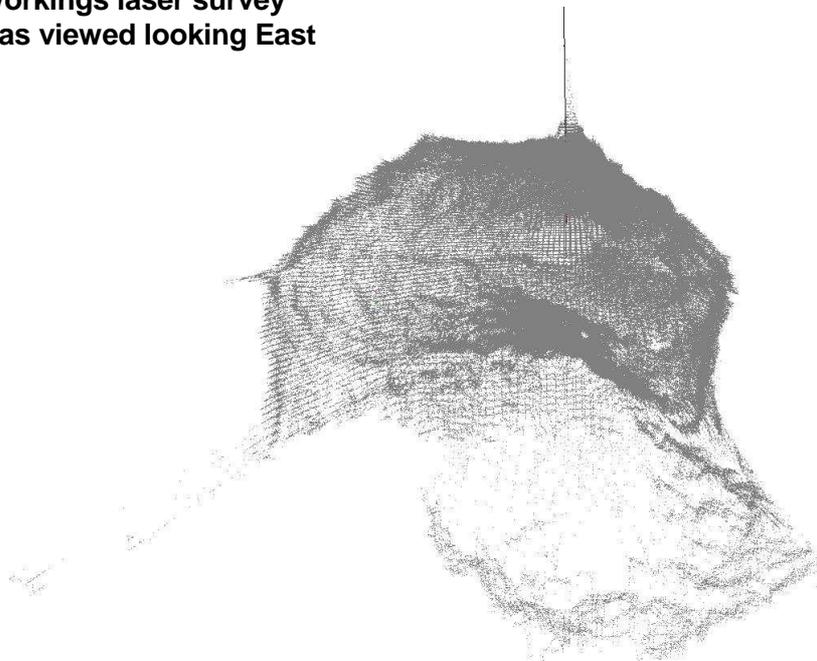


Plan view of void

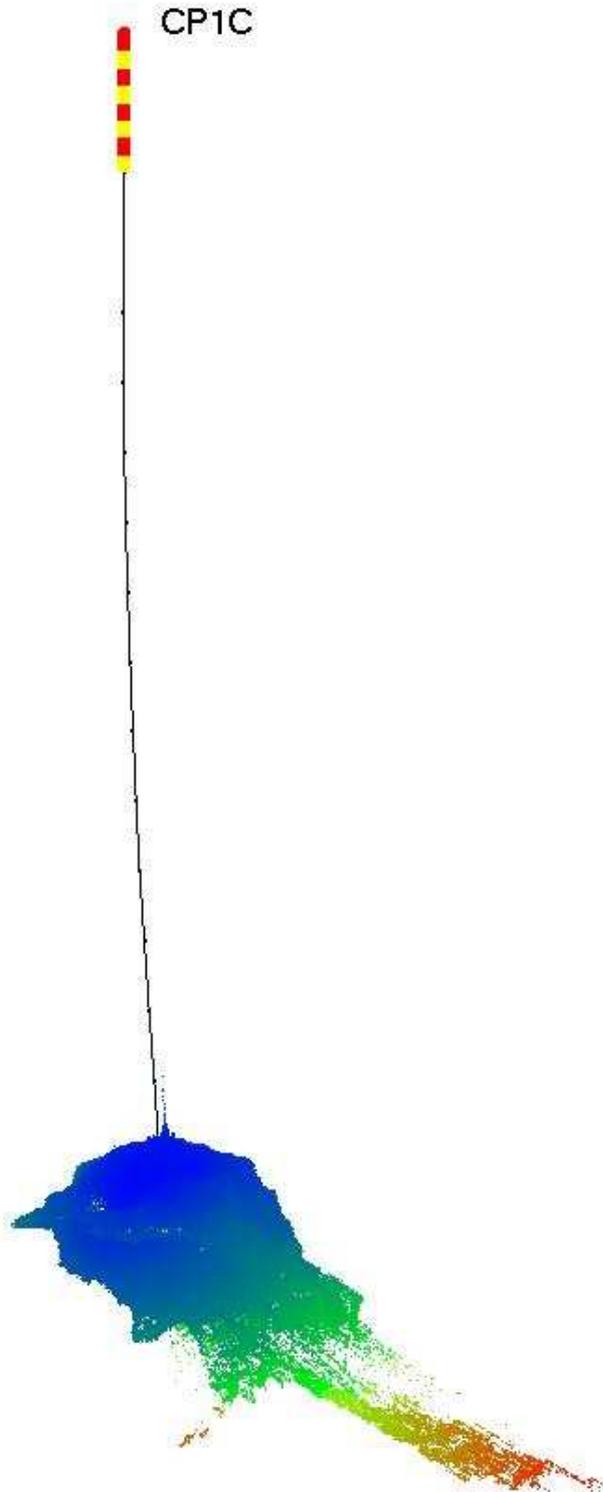
**Mine workings laser survey
image as viewed looking North**



**Mine workings laser survey
image as viewed looking East**

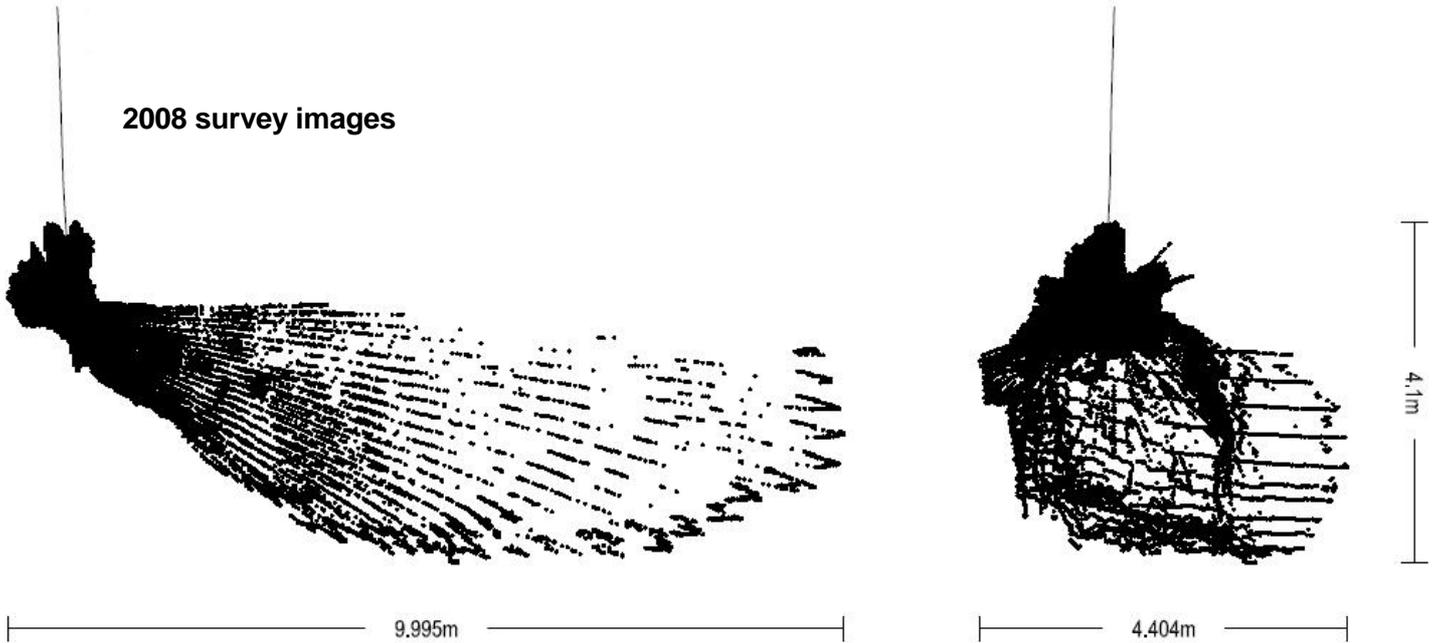


**Mine workings laser survey
image including bore track
as viewed looking North**



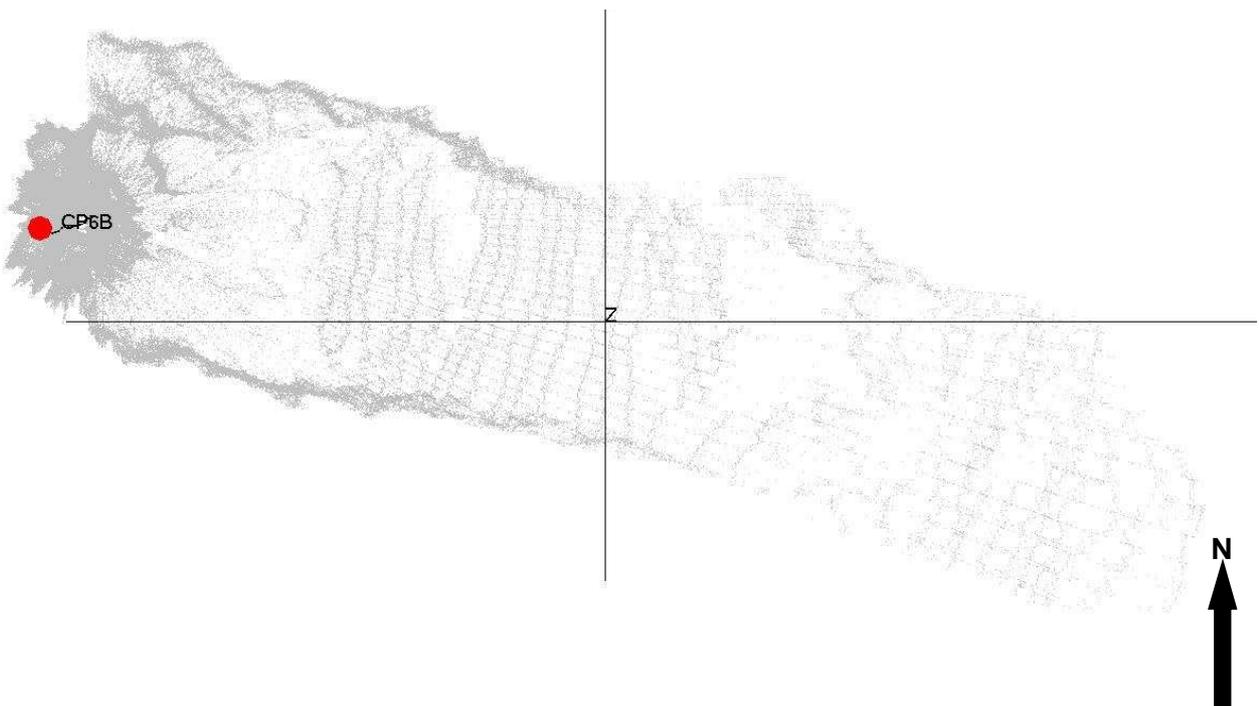
Borehole CP6B

2008 survey images



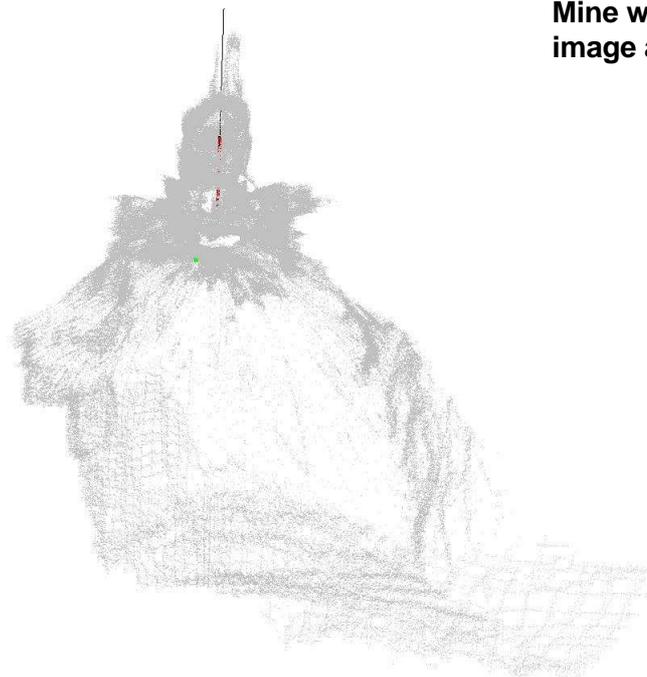
2011 survey images

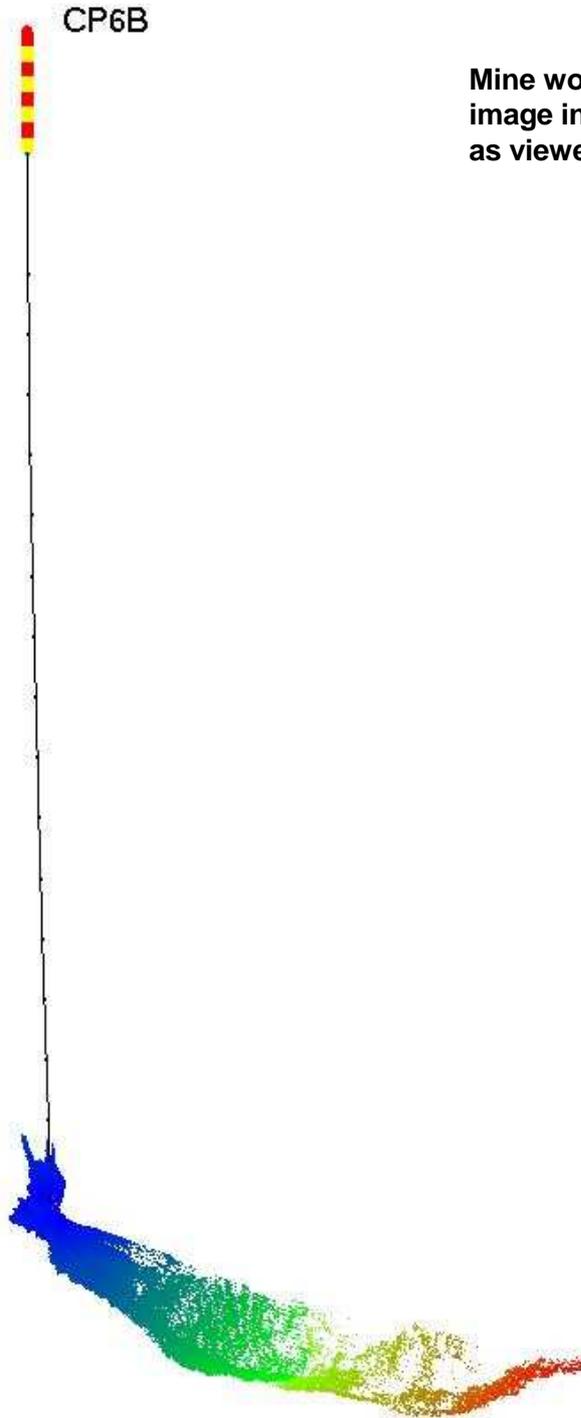
Plan view of void





**Mine workings laser survey
image as viewed looking East**





**Mine workings laser survey
image including bore track
as viewed looking North**