

**Welwyn Hatfield Borough Council**  
**Chantry Lane, Hatfield**  
**Chalk Mine Stabilisation Project**

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**Treatment Report**



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# Welwyn Hatfield Borough Council

## Chantry Lane, Hatfield

### Chalk Mine Stabilisation Project

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#### Treatment Report

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# 1 Introduction

## 1.1 Scheme details

Welwyn Hatfield Borough Council (WHBC) has undertaken the treatment of abandoned chalk mines identified beneath houses, roads, areas of public open space and garages along Chantry Lane, Vigors Croft and Bishops Rise surrounding the area of open space known as Chantry Lane Copse. These works have been funded under the Land Stabilisation Programme (LSP), administered by the Homes and Communities Agency (HCA).

The objective of the scheme is to treat ground affected by mine workings.

Hyder Consulting (UK) Limited (Hyder), was appointed by WHBC to manage the investigation and stabilisation of the mine workings including the design and supervision of the treatment works.

Treatment works were undertaken between February 2014 and March 2015 by specialist contractor BAM Ritchies.

## 1.2 Scope of report

This report summarises the work undertaken to stabilise the interpreted mine at Chantry Lane, Hatfield as set out in the Specification for Site Works (Hyder Consulting, 2013).

This report provides:

- a summary of the treatment works undertaken
- evidence that the works have been effective in stabilising mine related disturbed ground and,
- details of any residual risks that remain

Full records of the treatment works are contained in the treatment works factual report (BAM Ritchies, 2015), and an electronic 3-D mine model are provided as appendices.

This report addresses the treatment of chalk mines beneath the site only. Other issues related to pre-existing problems with buildings or the nature of deposits overlying the chalk stratum, have not been addressed.

Details of any remedial works to properties following treatment are outside the scope of this report. The scope of this report is limited to addressing the risks to health and safety and property associated with the current site use. Further assessment and advice will be required for changes in site use or re-development.

This report is a considered a professional opinion. It is not a warranty or guarantee as regards to the works undertaken, and no liability can be accepted, except to the extent of any failure to exercise reasonable skill, care and diligence in the provision of services under Hyder's Terms of Appointment. This report does not in any way increase Hyder's liability beyond that agreed under the Terms of Appointment. This report is not a certificate of design of construction as defined in The Building Act 1984 and The Building (Approved Inspectors, etc.) Regulations.

## 2 Background

### 2.1 Site Description

The site (defined by the Derelict Land Clearance Order site boundary) is located approximately 1km to the southwest of Hatfield town centre. The treatment site and immediate surrounding area comprises the south-eastern part of the open space known as Chantry Lane Copse and adjacent residential properties off Chantry Lane, Vigors Croft and Bishops Rise.

A site location plan and site layout plan are shown in Figures 1 and 2 respectively. The approximate National Grid Reference for the centre of the site is 207975N 521650E.

Chantry Lane Copse is an area of open space consisting of wooded land covered by mature trees and undergrowth with a large depression at the centre. The residential properties generally consist of detached and terraced houses, gardens, roads, garages and areas of open space.

### 2.2 Source Material

#### 2.2.1 Ground investigation reports

- Envirocheck (2009) Check report for site ref. 29459877\_1\_1 LN022793 dated 25-11-09.
- Geotechnology (2010) Microgravity Survey Report Chantry Lane, Hatfield. Report Number 984r2v1d0710.
- Geotechnology (2012) Chantry Lane Chalk Mining Study – Phase II Microgravity Survey. Report No. 1188r1v1d0712.
- Hyder Consulting (2009a) Wider Hatfield Risk Assessment – Risk Review. Report No. GD01151/RT/001.
- Hyder Consulting (2009b) Hatfield Chalk Mining Risk Assessment Manual. Issue 2.0
- Hyder Consulting (2010) Interpretive Ground Investigation Report. Report No. 0002-UA000917-GDR-01.
- Hyder Consulting (2010), Investigation within Mine Areas 8 & 9 Chantry Lane – Hatfield, Hertfordshire, Interpretive Ground Investigation Report. Report No. 0002-UA000917-GDR-01.
- Ian Farmer Associates (2013), Final Factual Report on Ground Investigation at Chantry Lane, Hatfield. Report No. W12/41091.
- Inspectahire (2013), CALS survey, Chantry Lane Copse. Report No. 7100 Issue 01 dated 30 April 2013.
- Norwest Holst Soil Engineering (2010), Report on a Ground Investigation for a Wider Hatfield Risk Assessment Project. Report No. F15853 Document No. D01.

Relevant information from the ground investigations completed prior to the treatment works is included in the electronic mine model for the site (see Appendix C).

#### 2.2.2 Design and feasibility documentation

- Hyder Consulting (2011), Feasibility Study Report. Report No. 0004-UA009172-GDR-01-O.
- Hyder Consulting (2013), Specification for Site Works. Report No. 0003-UA004620-GDR-01.

The specification for the mine treatment works is included in electronic format as Appendix D.

### 2.2.3 Mine model

An electronic version of the post-completion version of the mine model in RockWare Rockworks v16 is included in electronic format as Appendix C.

### 2.2.4 Contractor's Reports

- BAM Ritchies (2015), Chantry Lane Factual Geotechnical Report. Ref. BBK706E, VR-001 to 012. April 2015

An electronic version of the contractor's factual reports for mine treatment works containing the factual version of the mine model is included as Appendix E.

## 3 Ground conditions

### 3.1 Site Geology

The sequence of natural deposits encountered beneath the site are consistent in both ground investigations carried out in 2010 and 2012 and the final treatment works.

Investigations generally indicate glacial deposits interpreted as Kesgrave Catchment Subgroup (KCS) consisting of interbedded sand, gravel and clay overlying rock. The rock encountered in the investigations has been identified as Cretaceous-age Lewes Nodular Chalk Formation and Seaford Chalk Formation. The depth to the top of the rock increased sharply towards the east of the site, with the area around the open space of Vigors Croft having the thickest layer of glacial deposits above the chalk.

These natural deposits are generally covered by a relatively thin veneer of Made Ground, the exception being in the vicinity of No. 23 Chantry Lane and No. 6 Bishops Rise, where 2.40m and 3.80m of Made Ground was encountered.

There were no observations during construction that identified any significant variations from the original geological model identified during the pre-treatment phases.

Refer to the Geotechnical Interpretive Report (Hyder, 2010) for further information relating to the stratigraphy, strength and stiffness information of the deposits at the site.

### 3.2 Groundwater

The site is underlain by the Lewes Nodular Chalk Formation and Seaford Chalk Formation which is classified as a Principal Aquifer. Superficial deposits at the site (where present) are classified as a Secondary 'A' aquifer. The site at Chantry Lane is situated in a Zone I Groundwater Source Protection Zone associated with a groundwater abstraction point to the southeast of the site.

The groundwater level within the Chalk has been recorded throughout the mine stabilisation works in four monitoring wells. Monitoring has indicated groundwater levels to be between 22.45m and 31.75m below ground level with an elevation range between 54.98m Above Ordnance Datum (AOD) and 55.76m AOD. These have recorded only small variations in groundwater level through the year and during the treatment works.

## 4 Stabilisation Works

### 4.1 Design basis

The scope of the mine stabilisation design is limited to addressing the risk of subsidence and settlement of structures due to historic chalk mining within the DCLO boundary. Other factors that might affect the stability/condition of properties are considered outside the scope of the stabilisation works.

The design basis is summarised in the feasibility report (Hyder, 2011) and identified the most suitable option for mine treatment to be a cement-based grout to stabilise the workings identified during the investigations and treatment works. Bulk grout infilling was used where large voids or shafts were identified and compaction grouting in areas of collapsed chalk mine workings.

Treatment was limited to the zone from the base of mine workings up to the bottom of any intact chalk above the mining related disturbed ground. No treatment of superficial deposits (i.e. within 5m of surface) has been undertaken except where evidence of collapse features extended to the surface.

### 4.2 Validation procedure

A detailed validation process was adopted that included a review of pre and post treatment dynamic probing, and a review of grout volumes against a 3-D model of the mine workings. This review process was undertaken continuously during the works to allow additional treatment and validation testing to be undertaken if any inconsistent results were detected.

The validation procedure comprised the following steps:

1. A review of drilling and borehole CCTV records to confirm the absence of any large voids
2. Confirmation that grout/infill takes were in excess of the drill hole volume, thereby demonstrating that voids are being infilled and/or compaction of poor ground is occurring.
3. A review of the vertical distribution of grout/infill takes compared against the 3D mine model to confirm treatment of anticipated mine features.
4. A review of post-treatment dynamic probing data compared with pre-treatment data to confirm that areas of weak ground have been improved.

Survey monitoring was completed during the works to ensure ground surface movements stayed within tolerances to minimise the risk of damage to existing properties and services. Details of monitoring undertaken can be found in the Specification for Site Works contained in Appendix D.

### 4.3 Treatment Areas

The site was divided into the following 12 discrete treatment areas to manage the assessment of the investigation, treatment and validation testing data:

- Treatment Area 1: Nos. 2-6 Chantry Lane (evens only)
- Treatment Area 2: Nos. 5-9 Chantry Lane (odds only)
- Treatment Area 3: No. 11 Chantry Lane
- Treatment Area 4: No. 15 Chantry Lane
- Treatment Area 5: Nos. 17-27 Chantry Lane (odds only)
- Treatment Area 6: No. 29 Chantry Lane

- Treatment Area 7: Nos. 31-37 Chantry Lane (odds only)
- Treatment Area 8: Nos. 1-5 Vigors Croft (odds only)
- Treatment Area 9: Nos. 2-8 Bishops Rise (evens only)
- Treatment Area 10: No. 19 Roe Green Close
- Treatment Area 11: Chantry Lane and Vigors Croft
- Treatment Area 12: Chantry Lane Copse

A summary of the treatment works for each Treatment Area (numbered TAR01 to TAR12) is presented in Appendix B. The factual data used in the assessment can be found in the contractor's Sectional Validation Reports (numbered VR0001 to VR0012) contained in Appendix E.

## 4.4 Amendments to the Construction Method

The original construction method, extent of treatment, and quality control and validation procedures are set out in detail within the feasibility report (Hyder, 2011) and the project specification for site works (Hyder, 2013).

The following sections indicate where departures from the original construction method were used in the completion of the treatment works and also indicate limitations with the drilling and grouting process encountered during the works.

### 4.4.1 Drilling

Drill holes were generally dry and stable during the works, though some re-drilling was required, particularly following periods of heavy rainfall or where the hole had been left open for several days. Chalk recovered was highly disturbed by the drilling process but the drill returns provided sufficient information to assess the stratigraphy.

Borehole CCTV (predominantly using a small drainage camera) was undertaken immediately following drilling holes. This was sufficient to confirm the presence of large voids but for smaller voids the smearing of chalk along the borehole made observation difficult.

### 4.4.2 Bulk infilling and Compaction Grouting

BAM Ritchies developed a grout mix for use in treating the chalk mines based on their experience on chalk mines at Briars Lane (Hatfield) and Highbarns (Nash Mills).

The specification for the works required the use of a thick cementitious grout for compaction grouting. The stiffer mix used by BAM Ritchies allowed the same grout mix to be used for compaction grouting as well as bulk infilling. This provided sufficient flexibility in the treatment method to be able to adapt to the variable condition of the ground within and around the interpreted mine workings.

Final Grout mix designs are presented in the factual report (BAM Ritchies, 2015).

Grouting stage lengths of 2m were utilised although in some areas where various difficulties were encountered increased stage lengths were necessary. No pressurised injection of grout was carried out within the top 5m of ground unless any voids were uncovered to minimise the potential for grout to enter properties and services.

### 4.4.3 Monitoring

Prior to commencement of the design treatment works, building and ground movement monitoring procedures were agreed with the Contractor. During the course of works, there was no evidence of building movements exceeding the agreed monitoring levels that required emergency procedures to be implemented.

Individual cases where minor cracking were observed were dealt with on a case by case basis and are discussed further in the treatment area reports.

There was no evidence of hazardous gasses detected during drilling and no significant impacts on groundwater levels and quality were recorded.

## 4.5 As Built information

The design specification for the works is included in Appendix D. The anticipated and actual scope of the treatment works are summarised in the table below.

**Table 1: Proposed and actual principal treatment quantities**

<b>Item</b>	<b>Proposed quantity</b>	<b>Actual quantity</b>
Grout holes	544 No.	1026 No.
Bulk grout infill volume	1461m <sup>3</sup>	111m <sup>3</sup>
Compaction grout volume	3189m <sup>3</sup>	2013.7m <sup>3</sup>
Investigation Dynamic probes (DP)	62 No.	606 No.
Validation Dynamic probes (VP)	520 No.	624 No.

The above is an extract of data from BAM Ritchies' factual report (BAM, 2015). The factual report should be referenced for further details of treatment works including as built details for the locations of the drilled and grouted holes, the volumes of grout injected and injection pressures per grout hole.

# 5 Findings

## 5.1 Pre-Treatment investigations

The pre-treatment ground investigations had indicated that predominantly open mine workings were located at the Chantry Lane Copse with partially or fully collapsed (or infilled with backfill material) mine workings extending towards the properties. The notable areas where suspected open mine workings were identified were:

**Table 2: Mining related disturbed ground identified from the pre-treatment investigations.**

Location	Investigative probe Number	Depths of Voids (m below ground level)
No. 2 Bishops Rise	DP58-43	between 4.7m and 12.1m
No. 6 Bishops Rise	BH37	between 9.0m and 9.4m
No. 8 Bishops Rise	DP47-14 and DP47-26	between 7.0m and 10.7m and 18.1m and 20.2m
No. 1 Vigors Croft	DP43-03	between 7.6m and 10.8m and 17.8m and 21.7m
No. 11 Chantry Lane	DP35-21	consistently low blow counts down to a depth of 11.2m
No. 11 Chantry Lane	DP48-02 and DP48-04	between 6.2m and 8.6m
No. 29 Chantry Lane	DP49-42 and DP49-56	between 16.1m and 19.0m
No. 37 Chantry Lane	DP33-02	between 10.1m and 13.4m

## 5.2 Drilling and Grouting

The method of boring grout holes (open hole auguring) allowed basic logging of the soils encountered. This allowed disturbed ground and voids to be recorded to a sufficient degree of accuracy to support the validation process. In addition, it was possible to identify grout in the drill samples where areas of previous treatment were encountered. This provided an indication of the lateral extent of the grout permeation achieved during the treatment process.

Generally collapsed mine workings were uncovered during the treatment works with only localised evidence of open mine workings identified during an additional phase of treatment in the vicinity of Bishops Rise properties and at Nos. 9-11 Chantry Lane. This resulted in higher grout takes in these areas. CCTV and laser scanning surveys were used at several locations to identify the size and orientation of voids and helped locate additional dynamic probing to confirm the extent of the mine workings.

In general, treatment was limited to the zone from the base of mine workings up to the bottom of any intact chalk above the mining related disturbed ground. No treatment of superficial deposits (i.e. within 5m of surface) has been undertaken except where evidence of collapse features extended to the surface.

Possible shafts identified across site during investigative probing and borehole records appeared to have been backfilled with superficial material or chalk. During investigation and treatment, no surface expressions of shafts were noted outside Chantry Lane Copse. Shaft locations confirmed following investigations were treated by grouting.

A comparison of grout takes relative to the mine layout are set out in Hyder's individual treatment area reports numbered TAR01 to 12 in Appendix B.

## 5.3 Validation Testing

The evidence from validation testing confirms that the treatment works were effective at improving disturbed ground associated with former chalk mining. Subsequent phases of grouting and validation testing were completed if weak ground was still identified within a treatment area.

Localised variations in ground conditions and the effectiveness of the treatment can mean that some dynamic probe holes record isolated post-treatment blow counts less than the minimum set for adequate treatment (3 blows per 100 mm penetration). However, the effectiveness of the treatment is assessed on the basis of all of the data obtained from the works, including grouting volumes, and the relevant validation probing at individual properties in relation to the updated mine map (see Section 5.4) and not solely on individual probes.

Furthermore, weak ground was often encountered within the made ground layer, KCS and natural weathering and softening of the chalk at the interface with the KCS. These zones of weaker ground were not stabilised as part of the works.

## 5.4 Revised Mine Layout

The site works have confirmed that the mine workings form a single network of interconnected galleries and shafts. The presence of these interconnected mines reflects the unplanned way in which chalk workings were developed around a series of shafts rather than through a complex and extensive network of galleries.

Mine workings were encountered between depths of approximately 4.5m and 18.6m. The shallowest confirmed workings were identified using the laser scanning survey at DP19-04A along the Chantry Lane Copse with a mined depth of 2.4m. Possible mining related relaxed ground was also identified as shallow as 4.5m bgl at DP03-08 at the rear garden of Nos. 17-27 Chantry Lane.

A number of refinements have been made to the pre-treatment mine model following the interpretation of the site data. The key modifications made to the model include;

1. Additional mine galleries extending from No. 15 Chantry Lane along Nos. 5, 7, 9 and 11 Chantry Lane.
2. Based on grout takes and review of all the available data, two additional shafts were uncovered. A mine shaft was uncovered along the side plot at No. 11 Chantry Lane (adjacent to Chantry Lane) while an additional mine shaft was uncovered along the back garden of No. 9 Chantry Lane. Following further investigations in the area, two distinct mine galleries were found to terminate at Nos. 5 and 7 Chantry Lane respectively.
3. Extension of mine workings beneath the property at No. 37 Chantry Lane terminating beneath the property.
4. Re-alignment of the mine gallery at No. 31 Chantry Lane closer to the front of the property. This was subsequently extended into adjacent property at No. 29 Chantry Lane before linking up with previously known mine workings at the front of No. 29 Chantry Lane.
5. Extension of mine workings at the back of the terraced properties at Nos. 17, 19, 21, 23, 25 and 27 Chantry Lane resulting into two distinct mines along the back garden which were treated up to the site boundary.
6. Extension of mine workings at No. 5 Vigors Croft along the front of the property before terminating along the adjacent open space.
7. Extension of mine workings at Nos. 1 and 3 Vigors Croft terminating at a mine shaft location at the back garden of No. 6 Bishops Rise.
8. Extension of mine workings at the end of the back garden of No. 1 Vigors Croft uncovered following works at No. 4 Bishops Rise connecting to a known shaft location at Chantry Lane Copse.
9. Extension of mine workings at Nos. 2, 4, 6 and 8 Bishops Rise following additional investigation and grouting works carried out.

Full details of the revised mine layout are presented in Figure 3, Appendix A and contained in the Rockworks model in Appendix C.

## 5.5 Drainage

Drainage surveys were conducted during and following the works confirms that there has been not been any deterioration in the drainage condition as a result of the works.

## 6 Limitations of the Treatment

While the treatment in the area of Chantry Lane has reduced the risk of ground subsidence from collapsing mines, there remains the possibility that settlement from uncharted / un-investigated mines and other causes of subsidence that has not been addressed by these works could result in future building damage such as:

- Weak ground associated with the natural condition of the surficial soils and the weathered nature of the chalk at the rock head still exist. These areas were outside of the scope of the treatment works;
- Shallow foundations and effects of swelling / shrinkage of near surface soils; and
- Foundations being affected by leaking pipes

Whilst the risks from further untreated workings is considered to be no higher than elsewhere in Hatfield, professional advice should be sought for any unexpected ground movements or any evidence of mine workings.

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## Appendix A

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Figure 1: Site Location Plan

Figure 2: Site Plan (showing treatment areas)

Figure 3: Interpreted Mine Plan

## Appendix B

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### Treatment Area Reports TAR0001 to TAR0012

## Appendix C

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