CHALK MINE STABILISATION PROJECT
HIGHBARNS, HEMEL HEMPSTEAD

Treatment Area 11: Nos. 2, 4, 6 and 8 Meadow Road

Report Number: 0013-UA000857-TR-01-TAR-0011

OCTOBER 2015

Incorporating

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1 INTRODUCTION

Dacorum Borough Council (DBC) has commissioned Arcadis Consulting (UK) Ltd (Arcadis) (formerly Hyder Consulting (UK) Limited) to oversee the treatment and validation of abandoned chalk mines identified beneath residential areas in the Nash Mills area of Hemel Hempstead, Hertfordshire. The mine workings identified at the site have been assessed to comprise a single level of chalk mine galleries in the vicinity of Highbarns, Pond Road and East Green Road junction. The mine treatment has been funded under the Land Stabilisation Programme (LSP), administered by the Homes and Communities Agency (HCA).

The background to the scheme, interpretation of the mine, and treatment works are set out in the overarching Treatment Report (Arcadis, 2015). This report forms an addendum to the above report and should be read in conjunction with it.

The objective of this report is to set out the works that were undertaken to treat the mines and provide the results of post mine treatment validation probing. The properties discussed in this report are as follows:

- Nos. 2, 4, 6 and 8 Meadow Road.

The broader site location, treatment areas and interpreted extent of mine workings within the Derelict Land Clearance Order site boundary are shown in the overarching Treatment Report (Arcadis, 2015), Figures 1, 2 and 3 respectively.

This Treatment area, validation probes and extent of grouting work specific to this treatment area are shown on drawings TA0011-01 and 02 in Appendix A.

Factual information relating to the investigative probes, validation probes and extent of grouting work are contained in the BAM Ritchies Sectional Validation Report for the treatment works (BAM Ritchies, 2015).

2 SUBSURFACE INVESTIGATIONS

The subsurface investigations at these properties were undertaken in response to historical subsidence events across the site.

The pre-contract investigations were undertaken by Soil Engineering Ltd in 2012 and included investigative dynamic probes and dynamic windowless sampled boreholes. A review of historical information, the natural topography and the geotechnical investigations were used to identify zones of probable mining related disturbed ground.

Following and during each stage of the treatment works, validation dynamic probing was undertaken to establish the effectiveness of the mine treatment.

The scope of the validation dynamic probing completed during and following the treatment works for Nos. 2, 4, 6 and 8 Meadow Road are summarised in Table1 below.

Table 1: Summary of Validation Testing

Type of Investigations	Number
Total No. of External Validation Dynamic Probes (VP)	95
Total No. of Internal Validation Dynamic Probes (VP)	3

The results of the validation dynamic probes undertaken during and after treatment works are presented in the relevant sectional factual report VR011 for this treatment area (BAM Ritchies, 2015). For the purposes of this report, additional dynamic probes undertaken concurrently with the grouting works in order to further investigate the extent of mine workings are designated validation probes.

Findings of the pre-contract design phase ground investigation undertaken by Soil Engineering and subsequent interpretations are contained in the Interpretive Ground Investigation Report for the site (Hyder, 2012a).

3 TREATMENT RECORDS

Mine treatment works have been undertaken in accordance with the Specification for Site Works (Hyder, 2012b). The techniques of mine treatment adopted at the site consisted of bulk infilling of open voids and compaction grouting of collapsed ground.

A summary of the treatment works are set out in Table 2 below.

Table 2: Summary of Treatment Works

Property	Location	Type of Hole	Number of Holes	Range of Grout volumes[1] (m^3)	Total Grout volume[1] (m^3)
No. 2 Meadow Road (Total Grout Holes = 17, Total Grout Volume = 91m^3)	Beneath the property	Inclined compaction grout holes	9	1.6 (CG8) to 7.6 (CG10)	29.7
	Front Garden	Compaction grout holes	3	1.9 (CG39) to 4 (CG2B)	9.4
	Rear Garden	Compaction grout holes	5	0.1 (CG9) to 32.8(CG17)	51.9
No. 4 Meadow Road (Total Grout Holes = 10, Total Grout Volume = 42.3m^3)	Beneath the property	Inclined compaction grout holes	4	2.7 (CG7) to 7.4 (CG6)	20.4
	Front of property	Compaction grout holes	4	2.8 (CG38) to 4.7(CG37)	14.9
	Rear garden	Compaction grout holes	2	2.3 (CG11) to 4.7 (CG18)	6.9
No. 6 Meadow Road (Total Grout Holes = 1, Total Grout Volume = 4.9m^3)	Front of property	Compaction grout holes	1	4.9 (CG32)	4.9
No. 8 Meadow Road (Total Grout Holes = 23, Total Grout Volume = 240.5m^3)	Beneath the property	Inclined compaction grout holes	4	5.1 (CGI637) to 10.9 (CGI702)	30.4
	Front of property	Compaction grout holes	4	2.0 (CGI634) to 3.8 (CG645)	12.5
	Rear garden	Compaction grout holes	15	1.4 (CGI701) to 19.8 (CGI047)	197.5
Highbarns Garages (Total Grout Holes = 1, Total Grout Volume = 3.9m^3)	In Front of Garages	Compaction grout holes	1	3.9 (CG22)	3.9

Notes:

The above extract is based on data from BAM Ritchies' Sectional Validation Report for Nos. 2, 4, 6 and 8 Meadow Road (BAM, 2015). The factual report should be referenced for further details of treatment works including the volumes of grout injected and injection pressures per grout hole.

The treatment was undertaken in a phased approach with several stages of grouting and validation dynamic probe testing. Additional stages of grouting and validation testing were completed where validation testing raised doubts as to the extent of the grout penetration beneath properties or where additional mining related disturbed ground was identified.

4 VALIDATION

Validation of the treatment works has been based upon a combination of factors including a comparison of pre-treatment investigations, validation probing and grout volumes recorded during treatment. The number of grout holes, their location and the phasing of the grouting was adjusted as the work proceeded in order to accommodate the findings of the treatment works. Experience gained from other chalk mine projects has identified that dynamic probe blow counts of less than 3 per 100mm penetration is indicative of the presence of mine workings. Consequently, treatment was only considered complete where validation probes proved blow counts greater than 3 per 100mm penetration at the level of the suspected mine as interpreted from the pre-contract investigations.

A detailed scope of validation procedures adopted during the treatment works is presented in the Highbarns Chalk Mine Stabilisation Treatment Report (Arcadis, 2015).

Two principal areas of mined ground to be treated were identified during the pre-contract ground investigations and as part of further pre-treatment investigations completed in the vicinity of Highbarns and Meadow Road junction. A known area of mine connections was interpreted to be present partly beneath the property and rear gardens of No. 6 and No. 8 Meadow Road. A secondary area of mine workings was suspected to be present partly beneath No. 2 and No. 4 Meadow Road and connecting with the workings beneath Meadow Road. Specific observations for each property are set out in the subsequent sections.

The total volumes of grout injected into the ground at Nos. 2, 4, 6 and 8 Meadow Road are generally comparable to the expected volumes as indicated by the pre-treatment ground investigations. However a number of locations were treated with greater than expected volumes of grout as explained in the following sections.

4.1 No. 2 Meadow Road

Dynamic probes were undertaken in the front and rear gardens of No. 2 prior to treatment in late 2014 They were used to investigate the extent of the mine workings initially identified in the Meadow Road and Highbarns Junction. These probes indicated possible mining related disturbed ground extending from the road junction to the garages at the back of the property

A total grout volume of 91.0m^3 was injected into seventeen inclined and vertical compaction grout holes located in the front and rear gardens of No. 2 Meadow Road. This confirmed the presence of mined ground beneath the property. A maximum grout volume of 32.7m^3 was injected into CG17 located in the rear garden of No. 2. This was one of the first grout holes to be completed in the area with volumes seen to consistently reduce in subsequent grout holes as the treatment progressed. This was the expected outcome of the grouting works demonstrating that treatment of the mined ground was taking place.

Validation probes (VPM91 to VPM190) to depths ranging between 9.6m and 18.0m were undertaken in the front and rear gardens of No. 2 Meadow Road. The validation probe results did not show any residual weak ground that would be indicative of untreated collapsed mine workings.

4.2 No. 4 Meadow Road

Dynamic probes were undertaken down the side and in the rear gardens of No. 4 prior to treatment in late 2014. They were used to investigate the extent of the mine workings initially identified in the Meadow Road and Highbarns Junction. These probes indicated possible mining related disturbed ground beneath the front garden of

the property that suggested a mine passageway extending between Meadow Road and No. 2 Meadow Road. No mining related disturbed ground was identified extending beneath No.6 Meadow Road.

A total grout volume of 42.295m^3 was injected into ten inclined and vertical compaction grout holes located in the front and rear gardens of No. 4 Meadow Road or drilled from adjacent properties. The volumes of grout injected into these holes were not considered indicative of significant open mine workings. CG06 had the highest grout volume (7.3m^3) and was within the interpreted mine layout beneath the property.

Validation probes to depths ranging between 9.0m and 20.7m were undertaken in the front and rear gardens of No. 4 Meadow Road following treatment. The validation probe results did not show any residual weak ground that would be indicative of untreated collapsed mine workings.

4.3 No. 6 Meadow Road

A total of twenty dynamic probes were undertaken down the side, front and rear gardens of No. 6 Meadow Road prior to treatment in late 2013. They were used to investigate the extent of the mine workings found in Nos 4 and 8 Meadow Road. These probes indicated possible mining related disturbed ground beneath the front garden of the property that suggested the mine passageway from Nos 4 and 8 extended into No. 6.

A grout volume of 4.921m^3 was injected into a single vertical compaction grout hole CG32 located in the front garden of No. 6. The grout volumes were not indicative of open mine workings.

Subsequent validation probes VP768-VP770 completed following treatment in December 2013 did not show any mining related disturbed ground. Following further treatment at adjacent properties, a further five validation probes were completed within the area of the interpreted mine layout and these did not show any weak ground that may be mining related.

4.4 No. 8 Meadow Road

Probing was undertaken down the side (adjacent to No.10, VP492 to VP495) and rear gardens of No. 8 Meadow Road to investigate the extent of the mine workings. The probes were completed prior to treatment in late 2013. The probes indicated mining related disturbed ground in the back garden associated with the mine gallery extending beneath No.6 Meadow Road. No mine workings were identified extending in the direction of No. 10 Meadow Road. A subsequent phase of grouting was undertaken to treat the identified mining related disturbed ground.

A maximum grout volume of 77.4m^3 was injected into CGV046A located in the rear garden of No. 8. This was one of the first grout holes to be completed in the area with volumes seen to consistently reduce in subsequent grout holes as the treatment progressed. Overall a total of 240.5m^3 of grout was injected into twenty three inclined and vertical compaction grout holes located in the front and rear gardens of No. 8 Meadow Road. This confirmed the presence of mined ground beneath the property. Validation probes completed in the front and back gardens and one internal probe within the house did not reveal residual weak ground that would be indicative of untreated collapsed mine workings.

4.5 Highbarns Garages

A grout volume of 3.9m^3 was injected into vertical compaction grout hole CG22 located in front of Highbarns Garages, in the southern corner of the treatment area. A total of five validation probes (VPM144 to VPM193) to depths ranging between 11.9m

and 19.0m were subsequently undertaken adjacent to Highbarns Garages. The validation probe did not indicate any residual weak ground that may be indicative of untreated mine workings.

5 CONCLUSIONS

Grouting has been completed under 2, 4, 6 and 8 Meadow Road to stabilise mining related disturbed ground due to former chalk mining. From the investigations and treatment work undertaken and the subsequent validation testing it can be reasonably concluded that;

- based upon the evidence, all mined ground encountered has been treated and that compaction and consolidation of void | collapsed voids has taken place;
- as a result of the above assessment, the risk of settlement from chalk mine workings within the treatment area has reduced to an acceptably low level following treatment;
- there is no evidence of any adverse impacts on groundwater quality beneath the site as a consequence of the work;
- there is no evidence of any significant movement or other adverse effects on buildings or infrastructure during the works; and
- the risks from further untreated workings in the treatment area is considered to be no higher than elsewhere in Hemel Hempstead.

The grouting work undertaken has only targeted the treatment of mined ground for the current site use and building layout. It is still the responsibility of the land owner to seek appropriate design advice prior to future development.

Dacorum Borough Council Building Control should be informed if any evidence of mine workings (such as shafts, voids or collapsed ground) is found during any future works undertaken as part of redevelopment.

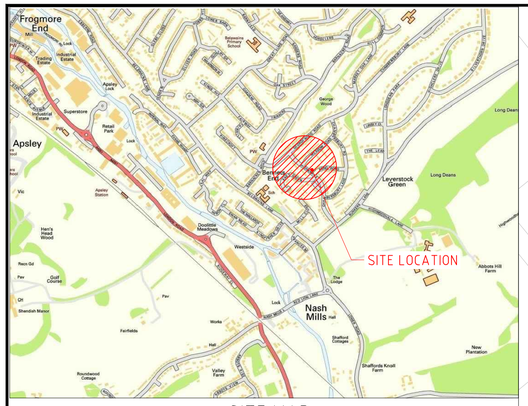
6 REFERENCES

1. Arcadis Consulting (UK) Limited (2015), Chalk Mine Stabilisation Project, Highbarns, Hemel Hempstead, Treatment Report, No 0013-UA000857-TR-01, October 2015.
2. BAM Ritchies (2015), *Highbarns Sectional Validation Reports ref*. BBK704U, VR-001 to 012. March 2015.
3. Hyder Consulting (UK) Limited (2012a), *Highbarns Chalk Mines Project, Interpretive Ground Investigation Report,* No 0010-UA000857-GDR-01, September 2012.
4. Hyder Consulting (UK) Limited (2012b), Highbarns, Hemel Hempstead, Chalk Mine Stabilisation Project, Specification for Site Works, No 0007-UA000857-GDR-01, September 2012.

APPENDIX A

Drawing TA0011-01 – Treatment Area Plan for TAR0011 with Grout Holes

Drawing TA0011-02 - Treatment Area Plan for TAR0011 with Validation Probes



SITE MAP

NTS

TREATMENT AREA PLAN

SCALE 1:150

NOTES:

1. ALL DIMENSIONS IN MILLIMETRES UNLESS NOTED OTHERWISE.
2. ALL LEVELS IN METRES UNLESS NOTED OTHERWISE.
3. VALIDATION AND GROUTING DATA BASED ON BAM RITCHIES' SECTIONAL VALIDATION REPORT (BBK706E VR0001 TO VR00012) AND DATED APRIL 2015.
4. VOIDS IDENTIFIED BY LASER SURVEYS UNDERTAKEN IN 2008 AND REMEDIATED IN 2008 ARE BASED ON PETER BRETT ASSOCIATES (2008), INTERPRETATIVE GEOTECHNICAL REPORT - PHASE 1, NO 20247/0043/INT01/REV2, JULY 2008.
5. VOIDS IDENTIFIED BY LASER SURVEYS UNDERTAKEN IN 2012 ARE BASED ON INSPECTAHIRE (2012), CALS AND CCTV INSPECTION OF VOIDS REPORT NO 6658, ISSUE 02, AUGUST 2012.

LEGEND	
PATTERN	DETAIL
	TREATMENT AREA BOUNDARY
	DERELICT LAND CLEARANCE ORDER BOUNDARY
	INTERPRETED MINE EXTENTS FOLLOWING TREATMENT
	VOIDS IDENTIFIED BY LASER SURVEYS UNDERTAKEN IN 2012 (SEE NOTE 5)
	VOIDS IDENTIFIED BY LASER SURVEYS UNDERTAKEN IN 2008 AND REMEDIATED IN 2008 (SEE NOTE 4)
	INTERPRETED SHAFT LOCATION FOLLOWING TREATMENT
	COLLAPSED GROUND RECORDED DURING TREATMENT
CGV138 / CGVM138	COMPACTION VERTICAL GROUT HOLES
CGI138 / CGIM138	COMPACTION INCLINED GROUT HOLES (ORIENTATION INDICATED BY DASHED LINE WHERE INFORMATION PROVIDED IN FACTUAL REPORT (SEE NOTE 3))
CG138	COMPACTION GROUT HOLES (INCLINED OR VERTICAL (SEE NOTE 3))
BG138 / BGHM138	BULK GROUT INFILL HOLES (SEE NOTE 3)

GROUTING LEGEND	
PATTERN	DETAIL
CGV138 CGI108	COMPACTION GROUT HOLES (0.0-1.0m³)
CGV138 CGI108	COMPACTION GROUT HOLES (1.0-2.0m³)
CGV138 CGI108	COMPACTION GROUT HOLES (2.0-5.0m³)
CGV138 CGI108	COMPACTION GROUT HOLES (5.0-10.0m³)
CGV138 CGI108	COMPACTION GROUT HOLES (>10.0m³)

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Project:

HIGHBARNS
CHALK MINE STABILISATION PROJECT

Drawing status:

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Drawing title:

TREATMENT AREA PLAN
FOR TAR0011
WITH GROUT HOLES

Drawn by:	Date:	Author:	Date:
SANDIP P	15.10.15	A.BLAKE	15.10.15
Checker:	Date:	Approver:	Date:
A.HOPE	15.10.15	R.BARSBY	15.10.15

Scale: AS SHOWN ON DRAWING

Sheet No.: 01

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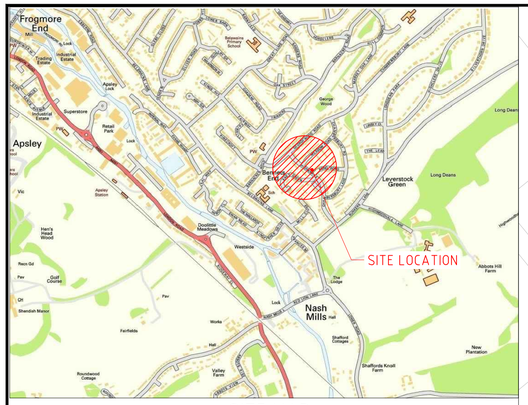
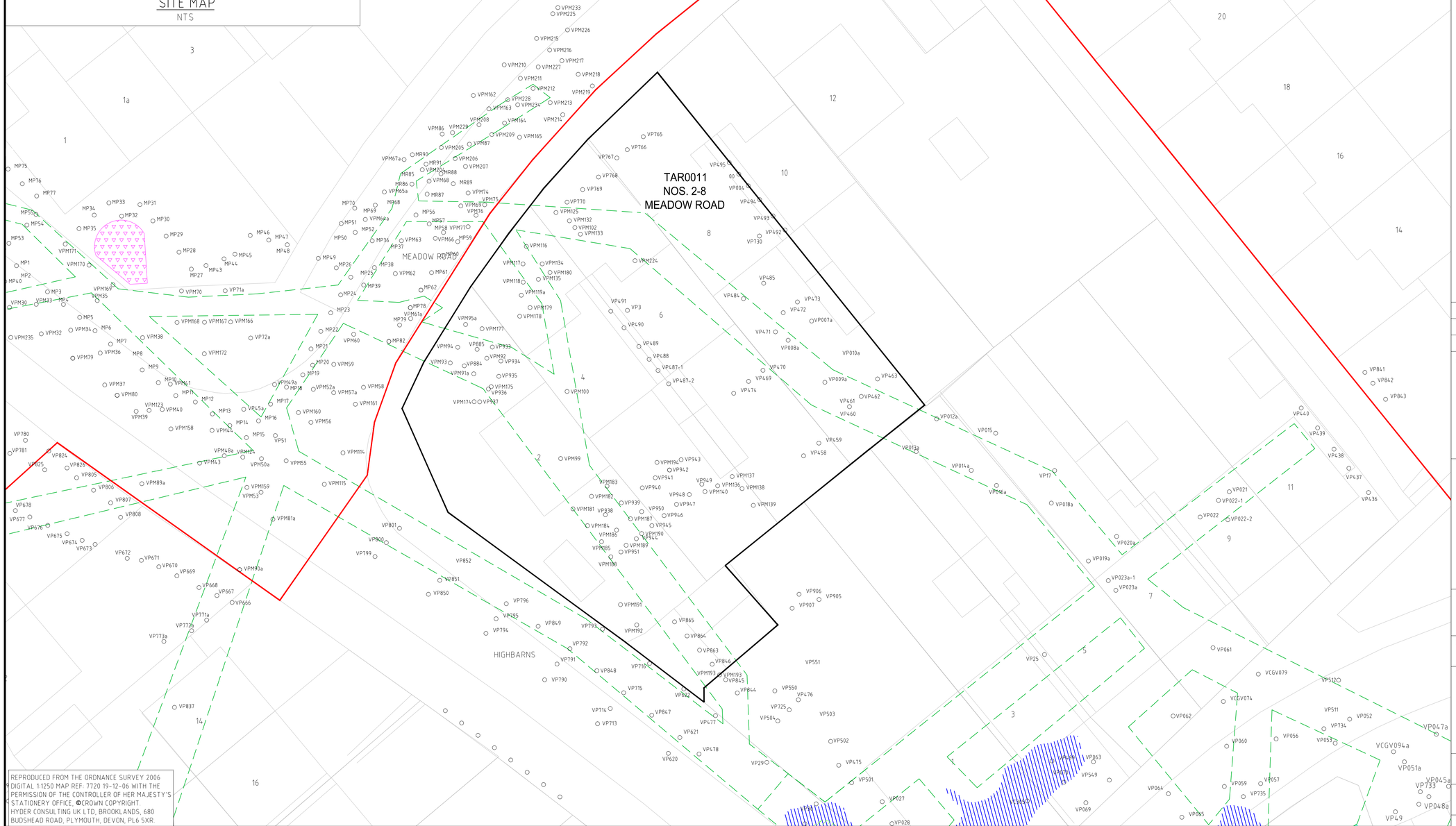


SITE MAP

NTS



TREATMENT AREA PLAN

SCALE 1:150

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1. ALL DIMENSIONS IN MILLIMETRES UNLESS NOTED OTHERWISE.
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	VOIDS IDENTIFIED BY LASER SURVEYS UNDERTAKEN IN 2008 AND REMEDIATED IN 2008 (SEE NOTE 4)
	INTERPRETED SHAFT LOCATION FOLLOWING TREATMENT
	COLLAPSED GROUND RECORDED DURING TREATMENT
VP249/VPM249/ DPM249/VPP249	VALIDATION DYNAMIC PROBES

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TREATMENT AREA PLAN
FOR TAR0011
WITH VALIDATION PROBES

Drawn by:	Date:	Author:	Date:
SANDIP P	15.10.15	A.BLAKE	15.10.15
Checker:	Date:	Approver:	Date:
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