



CHALK MINE STABILISATION PROJECT HIGHBARNNS, HEMEL HEMPSTEAD

Treatment Area 3: Nos. 5, 7, 9, 11, 13 and 15 Highbarns

Report Number: 0013-UA000857-TR-01-TAR-0003

OCTOBER 2015



Incorporating

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Drawing TA03-02 – Treatment Area Plan for TAR0003 with Validation Probes

1 SUMMARY

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 5, 7, 9, 11, 13 and 15 Highbarns

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

This Treatment area, validation probes and extent of grouting work specific to this treatment area are shown on Drawings TA0003-01 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 Nos. 5, 7, 9, 11, 13 and 15 Highbarns, (BAM, 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. 5, 7, 9, 11, 13 and 15 Highbarns are summarised in Table 1 below.

Table 1: Summary of Validation Investigations

Type of Investigations	Number
Total No. of External Validation Dynamic Probes (VP)	57
Total No. of Internal Validation Dynamic Probes (VP)	6

The results of the validation dynamic probes undertaken during and after treatment works are presented in the relevant sectional factual report VR003 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 MINE TREATMENT

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. 5 Highbarns (Total Grout Holes = 12, Total Grout Volume = 33.875m ³)	Front of property	Vertical compaction grout holes	1	3.248 (CGV133)	3.248
	Rear garden	Vertical compaction grout holes	11	0.756 (CGV638) to 5.372 (CGV098A).	30.627
	Beneath the property	Inclined compaction grout holes	24	0.839 (CGI182) to 55.326 (CGI184)	151.847
No. 7 Highbarns (Total Grout Holes = 47, Total Grout Volume = 336.224m ³)	Front of property	Bulk grout holes	1	20.9 (BG024)	20.9
	Front of property	Vertical compaction grout holes	5	3.251 (CGV138) to 49.8 (CGV136)	106.617
	Rear garden	Vertical compaction grout holes	17	0.889 (CGV152) to 12.800 (CGV605)	56.86
No. 9 Highbarns (Total Grout Holes = 36, Total Grout Volume = 152.209m ³)	Beneath the property	Inclined compaction grout holes	15	0.524 (CGI205) to 7.058 (CGI204)	61.322
	Front of property	Vertical compaction grout holes	5	0.02 (CGV222) to 5.38 (CGV177)	19.29
	Rear garden	Vertical compaction grout holes	16	0.218 (CGV163) to 7.5 (CGV176)	71.601
No. 11 Highbarns (Total Grout Holes = 16, Total Grout Volume = 79.87m ³)	Adjacent the property	Vertical compaction grout holes	4	0.7 (CGV179) to 5.388 (CGV182)	12.39
	Beneath the property	Inclined compaction grout holes	12	0.499 (CGI199) to 17.771 (CGI198)	67.480
No. 13 Highbarns (Total Grout Holes = 15, Total Grout Volume = 68.173m ³)	Beneath the property	Inclined compaction grout holes	12	1.471 (CGI233) to 11.06 (CGI216)	51.182
	Adjacent the property	Vertical compaction grout holes	3	1.852 (CGV185) to 11.128 (CGV186)	16.991
No. 15 Highbarns (Total Grout Holes = 17, Total Grout Volume = 96.553m ³)	Beneath the property	Inclined compaction grout holes	12	0.02 (CGI230) to 8.967 (CGI225)	53.826
	Adjacent the property	Vertical compaction grout holes	5	3.198 (CGV604) to 12.578 (CGV624)	42.727

Notes:

The above extract is based on data from BAM Ritchies' Sectional Validation Report for Nos. 5, 7, 9, 11, 13 and 15 Highbarns (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).

The grout volumes recorded during treatment at 5, 7, 9, 11, 13 and 15 Highbarns are generally comparable to the expected volumes as indicated by the pre-contract ground investigation and microgravity surveys. Grout volumes across the treatment area generally ranged between a minimum of 0.02m³ and a maximum of 55.326m³ indicating the presence of mine passages. The majority of the highest grout volumes were recorded in inclined holes located in the front gardens of Nos. 5 to 15 Highbarns. Following the interpretation of the site data, the layout of the mine under property Nos 5, 7 and 9 appears more complex than originally thought from the interpretation of pre-contract investigations.

Specific observations for each property are set out in the subsequent sections.

4.1 No. 5 Highbarns

Grouting and validation works at No. 5 Highbarns were designed to investigate the extent of previous treatment works undertaken in 2008 and to carry out further treatment in case of any residual weak ground around the building.

Initially, validation probes were undertaken across No. 5 Highbarns to maximum depths ranging between 11.7m and 20.0m bgl to investigate the extent of the previous treatment. The results of these probe generally indicated an absence of weak ground suggesting the previous grouting works had been effective in treating the mine.

It was, however, considered prudent to undertake validation grouting around the property and a total grout volume of 33.875m³ was injected from twelve vertical holes located in the front and rear gardens of No. 5. Grout volumes ranged between 0.756m³ (indicating no weak ground) and an average maximum of approximately 4.0m³ (indicating possible untreated collapse mining) but the absence of any open mine workings.

Eight validation probes were undertaken following grouting none of which detected weak ground that would have suggested untreated mine workings.

4.2 No. 7 Highbarns

Grouting at No. 7 Highbarns was designed to treat the possible mine passage trending northeast-southwest beneath the whole property including the house that appears to be an extension of the interconnected mine passages extending from No. 5 Highbarns.

Grout treatment at No.7 Highbarns initially commenced with a bulk infill grout hole located in the front garden to treat a known void as identified from laser scanning. A total grout volume of 21m³ was injected into BG024 indicating treatment of an open mine working.

Phase 1 grout treatment commenced in March and April 2013 with a cluster of grout holes located in the front garden of No. 7 Highbarns (CGV134-CGV137 and CGI181-CGI186) followed by grout treatment within the rear garden (CGV141A, CGV144-CGV148, CGV151-CGV154, CGV158-CGV161 and CGI175-CGI180) during the same phase of treatment. A grout volume of 55.326m³ was recorded in CGI184 indicating the presence of an open void which prompted a second phase of grout treatment beneath the south-eastern half of the building.

Prior to the second phase of treatment, validation probes (VP406, VP407, VP408 and VP409) were undertaken adjacent to No. 7 Highbarns to investigate the presence of mining disturbed ground beneath the driveway as well as the potential extent of mining disturbed ground extending towards No. 9 Highbarns. Results showed competent ground and did not indicate the presence of mined ground. Additional rows (VP420, VP421 and VP422) and (VP466, VP467 and VP468) were undertaken which also showed competent ground with no indication of mine ground at the boundary between No. 7 and No. 9 Highbarns. However, during drilling of CGV176 within No. 9 Highbarns, a void was identified between depths of 19.5m and 21.5m bgl. This is explained in more detail in the following section. Two internal validation probes (VP455 and VP127) were undertaken to 9.8m and 18.5m bgl inside the building. Results showed competent ground with no indication of mined ground.

Further grout treatment (CGI605, CGI606 and CGI607) was undertaken from the rear garden of No. 7 Highbarns to treat beneath the building. Grout volumes ranged between 2.104m³ and 3.414m³ indicating treatment of weak ground. Treatment works then concentrated on the south-eastern half of the building to complete the treatment of the potential mine beneath the building. Grout holes CGI608 to CGI619 recorded grout volumes between 2.337m³ and 16.088m³ indicating treatment of weak and voided ground. A notable reduction in grout volumes as grouting proceeded during this phase of work indicated treatment of the mined ground.

4.3 No. 9 Highbarns

Grouting at No. 9 Highbarns was designed to treat the possible mine passage trending southeast-northwest beneath the building that appears to be a mine passage extending from a junction beneath the boundary between No. 7 and No. 9 Highbarns.

Grout treatment was predominantly undertaken as a single phase of work and consisted of a series of inclined and vertical grout holes across the property. Inclined grout holes (CGI203 to CGI214) located in the front garden recorded grout volumes ranging between 0.524m³ and 6.996m³ indicating treatment of mining disturbed ground. Similarly, inclined grout holes located in the rear garden to treat beneath the house recorded grout volumes of between 1.494m³ and 3.516m³.

Vertical grout holes (CGV162 to CGV175) located in the rear garden to treat the suspected curved mine passage leading into No. 7 Highbarns recorded grout volumes between 0.218m³ and 7.417m³.

Validation probes carried out following treatment works were undertaken to depths of between 16.5m and 19.9m bgl did not record any weak ground that would be indicative of untreated mining.

A row of validation probes (VP420, VP421 & VP422) were undertaken in response to the identification of a void between depths of 19.5m and 21.5m bgl during drilling of CGV176 located on the boundary of No. 7 and No. 9 Highbarns. Results of this validation probing indicated competent ground to 21.7m bgl. However it was considered prudent to grout this area and a grout volume of 4.264m³ was injected into CGV601.

4.4 No. 11 Highbarns

Grouting at No. 11 Highbarns was designed to treat the possible mine passage trending southeast-northwest beneath the property that appears to be an extension of the mine passage beneath No. 9 Highbarns.

Grout treatment was undertaken as a single phase of work and comprised a number of vertical and inclined treatment holes located across the property. Inclined grout holes (CGI194 to CGI202) located in the front garden recorded grout volumes ranging between 0.499m³ and 17.771m³ (CGI198) indicating potentially a partially open mine. Similarly, inclined grout holes (CGI191, CGI192 & CGI193) located in the rear garden to treat beneath the house recorded grout volumes of between 0.99m³ and 3.085m³ indicating treatment of collapsed ground only.

Vertical grout holes (CGV178 to CGV182) located in the driveway between No. 11 and No. 13 recorded grout volumes between 0.7m³ and 5.388m³ indicating treatment of collapsed ground only. A gradual reduction in grout volumes was noted during the treatment works which allowed the total number of grout holes to be reduced by two.

Following the treatment works, validation probes (VP163, VCGV179, VCGV181 and VCGV183) were undertaken to maximum depths ranging between 16.5m and 17.4m bgl. Results of the validation testing generally indicated an overall improvement of the relative density of the ground following treatment works.

4.5 No. 13 Highbarns

Grouting at No. 13 Highbarns was designed to treat the possible mine passage trending southeast-northwest beneath the property that appears to be an extension of the mine passage beneath No. 11 Highbarns.

Grout treatment was undertaken as a single phase of work and comprised a number of vertical and inclined treatment holes located across the property. Inclined grout holes (CGI215 to CGI223) located in the front garden recorded grout volumes ranging between 1.634m³ and 11.06m³ (CGI216) indicating treatment ranging between collapsed mine workings to potentially an open void. Similarly, inclined grout holes (CGI232, CGI233 & CGI234) located in the rear garden to treat beneath the house recorded grout volumes of between 1.471m³ and 6.078m³.

Vertical grout holes (CGV184 to CGV186) located in the driveway between No. 11 and No. 13 recorded grout volumes between 1.852m³ and 11.128m³ indicating treatment of collapsed mine workings and possible open voids.

Following the treatment works, validation probes (VP166, VP165 and VCGV185) were undertaken to maximum depths ranging between 16.7m and 17.4m bgl. Results of the validation testing generally indicated an overall improvement of the relative density of the ground following treatment works.

4.6 No. 15 Highbarns

Grouting at No. 15 Highbarns was designed to treat and determine the extent of the possible mine passage trending southeast-northwest beneath the property that appears to be an extension of the mine passage beneath No. 13 Highbarns.

Grout treatment initially comprised inclined grout holes (CGI224 to CGI229) located in the front garden (grout volumes ranging between 2.78m³ and 8.967m³) and inclined grout holes (CGI230 and CGI231) located in the rear garden to treat beneath the house (grout volumes of between 3.797m³ and 6.695m³) all of which indicated the treatment of mining disturbed ground.

Additional treatment works were undertaken to treat the suspected termination point of the mine beneath the property. Grout volumes between 2.829m³ and 6.695m³ were recorded in CGI611, CGI612 and CGI613.

Grouting was undertaken in the driveway adjacent to the house. These treatment holes marked the end of the southeast-northwest trending mine passage and recorded grout volumes of between 3.198m³ and 12.578m³.

A row of validation probes (VP423, VP424, VP425 and VP426) located in the driveway of No. 15 Highbarns were undertaken to depths ranging between 15.5m and 16.8m bgl. Results of the validation testing did not indicate residual untreated mined ground and confirmed the termination of the southeast-northwest trending mine passage within the DLCO boundary.

Additional validation testing was undertaken to investigate the possible extent of mine workings extending beyond the DLCO boundary, beneath Nos. 17 and 19 Highbarns. Additional rows of dynamic probes were undertaken adjacent to the northern boundary of No. 17 Highbarns (VP633 to VP637 and VP726) and southern boundary of No. 19 Highbarns (VP605 to VP611 and VP640, VP641, VP643 and VP644). Dynamic probes were also undertaken to the south of No. 19 Highbarns adjacent to Chambersbury Lane (VP705 to VP708). A validation dynamic probe was also carried out inside No. 17 Highbarns. Results of validation testing are indicative of competent natural ground and evidence of mined or weak ground was not identified.

5 CONCLUSIONS

Grouting has been completed under Nos. 5, 7, 9, 11, 13 and 15 Highbarns 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 collapsed voids has taken place;
- as a result of the above assessment, significant risk from chalk mine workings within the treatment area has reduced to an acceptably low level following treatment;
- there was no recorded evidence in the results of dynamic probes that the mine extended beyond the DLCO boundary or beneath Nos. 17 and 19 Highbarns.
- 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 proper advice regarding foundation design prior to any 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.

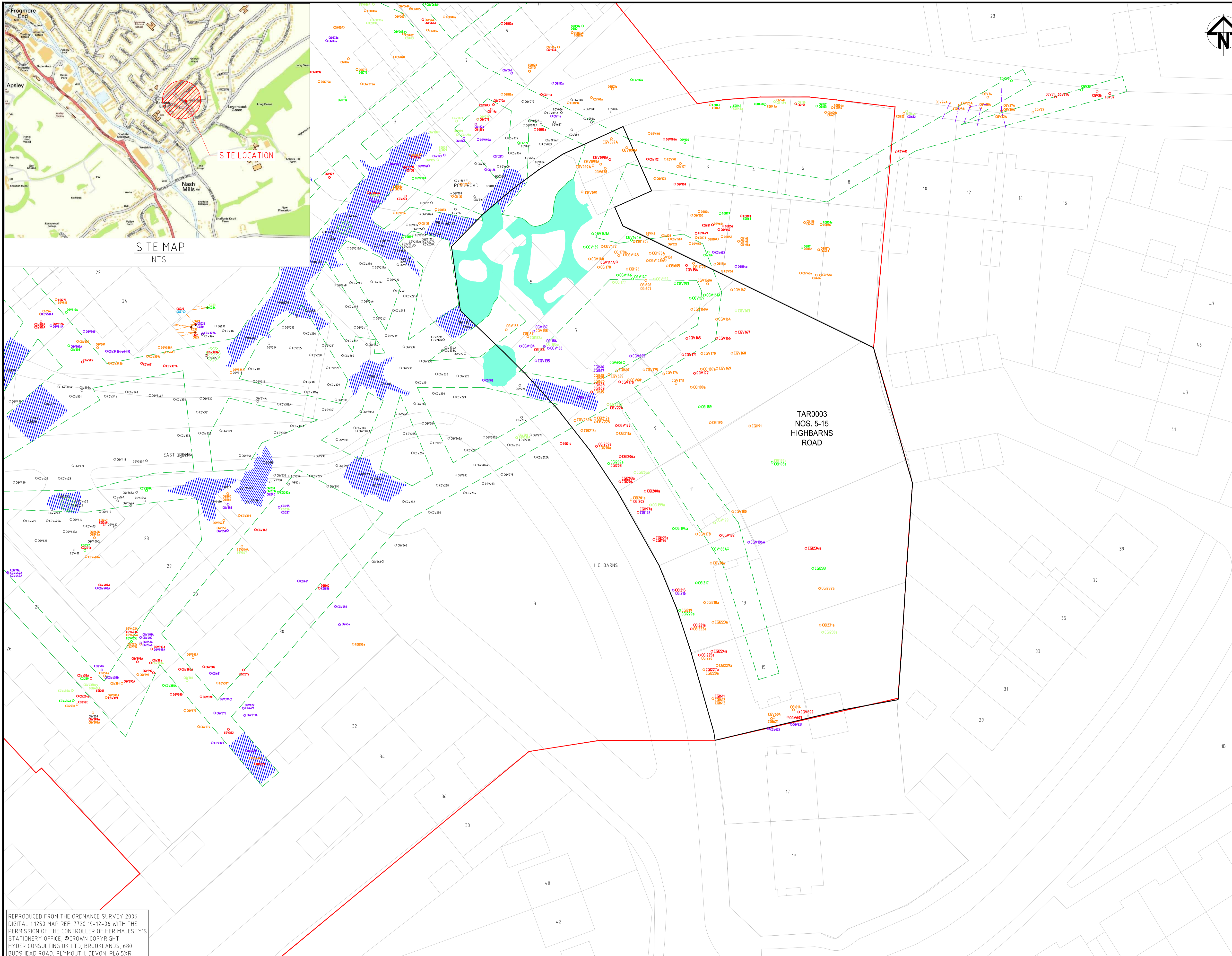
6 REFERENCES

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 TA03-01 – Treatment Area Plan for TAR0003
with Grout Holes**

**Drawing TA03-02 – Treatment Area Plan for TAR0003
with Validation Probes**



SITE MAP
NTS

- 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 (IBK706E 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 2024.7/004.3/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
	COMPACTION VERTICAL GROUT HOLES
	COMPACTION INCLINED GROUT HOLES (ORIENTATION INDICATED BY DASHED LINE WHERE INFORMATION PROVIDED IN FACTUAL REPORT (SEE NOTE 3))
	COMPACTION GROUT HOLES (INCLINED OR VERTICAL (SEE NOTE 3))
	BULK GROUT INFILL HOLES (SEE NOTE 3)

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

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A01	20.10.15	AB	FIRST ISSUE	AH	RB



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Drawing title: TREATMENT AREA PLAN FOR TAR0003 WITH GROUT HOLES

Drawn by: D.MORE	Date: 20.10.15	Author: A.BLAKE	Date: 20.10.15
Checker: A.HOPE	Date: 20.10.15	Approver: R.BARSBY	Date: 20.10.15

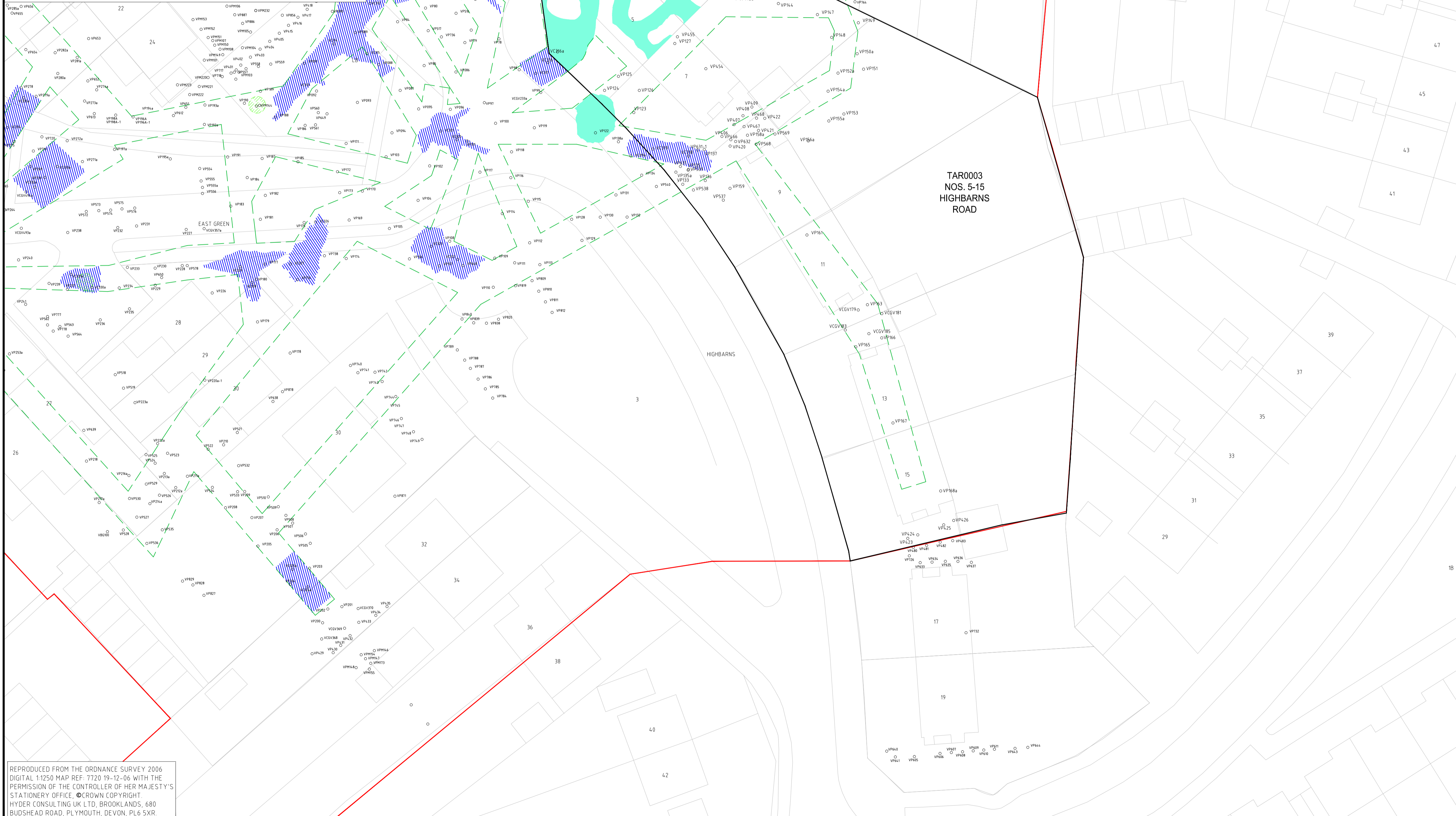
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TREATMENT AREA PLAN
SCALE 1:250

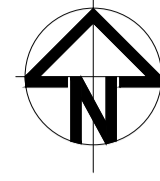


SITE MAP
NTS



TREATMENT AREA PLAN

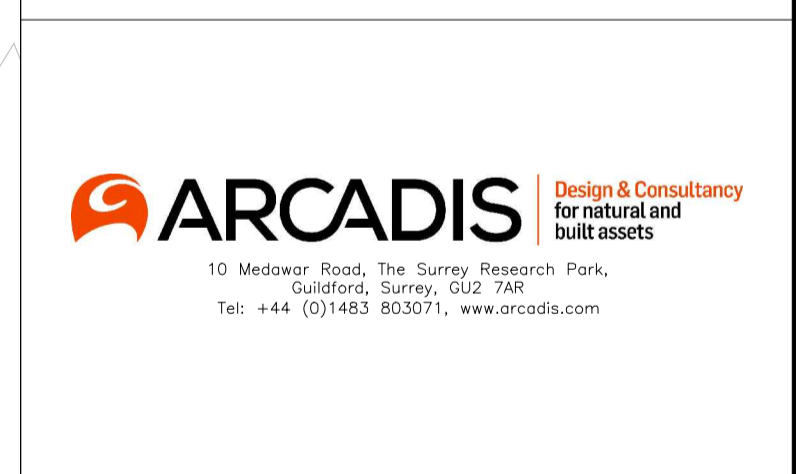
SCALE 1:250



- 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 (IBK7066 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 2024.7/004.3/INT01/REV2, JULY 2008.
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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
	VP249/VP249/DPM249/VP249
	VALIDATION DYNAMIC PROBES

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A01	20.10.15	AB	FIRST ISSUE	AH	RB



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Checker: A.HOPE	Date: 20.10.15	Approver: R.BARSBY	Date: 20.10.15

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