16

Inf from Inlr Feb 1962

219

SP52SE5

219/75

Copy.

50-52 Wigmore St.
W.1.

Laboratory report No 71135/2

Sample of water from Bicester Water Works. 21st Oct. 1935.
(D.W. pump)

Results in Parts per 100,000

Appearance —	very slightly opaque
" of solids on ignition —	White
Total solids	30
Chlorine	1.30
Nitrites	nil
Nitrates	0.002
Total hardness	21.4
Poisonous metals	Copper & lead absent
Free ammonia	0.02
Oxygen absorbed	0.56
Albuminoid ammonia	0.001

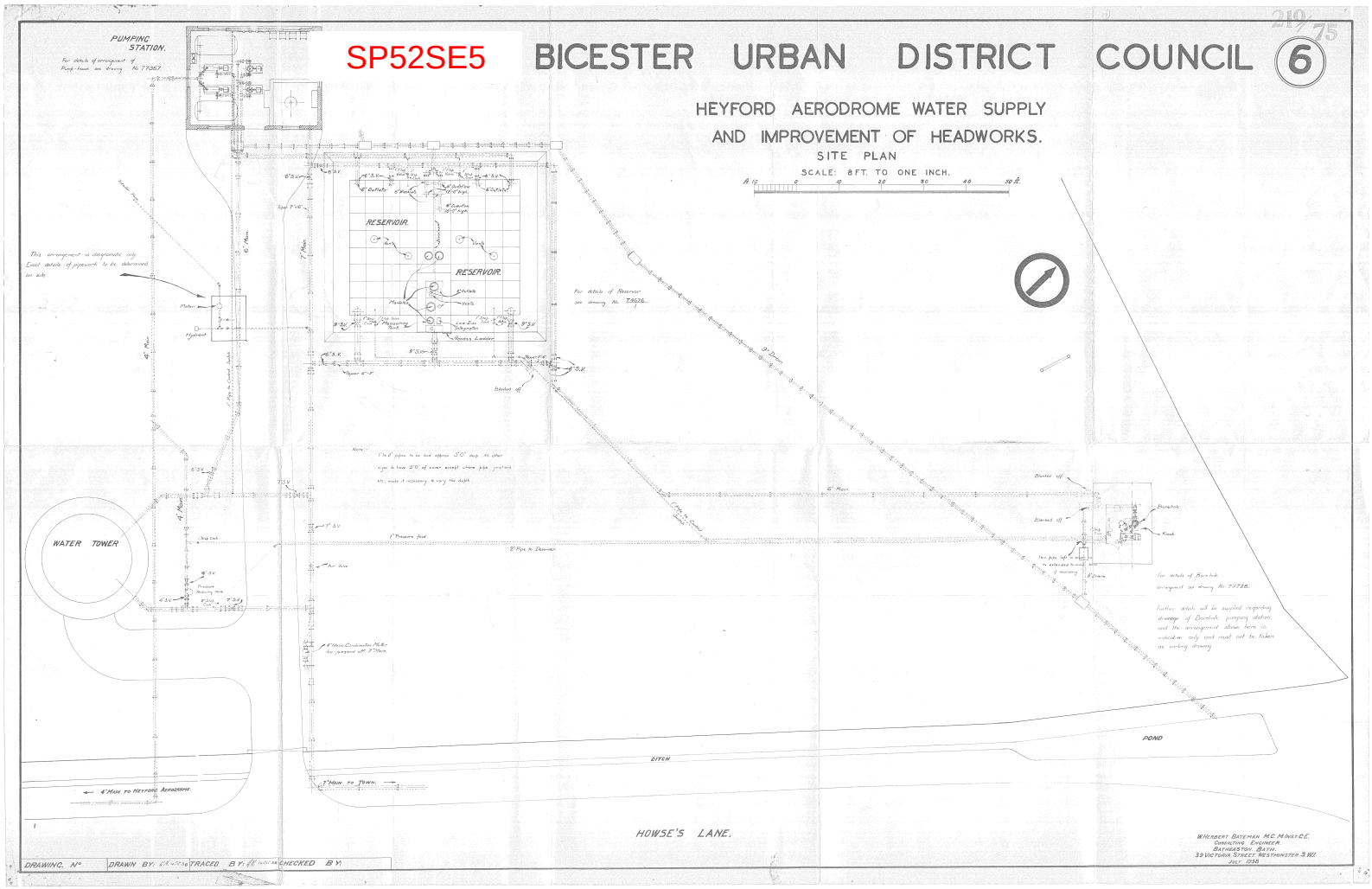
Opinion — a perfectly good sample of drinking water

(signed)
John Bell & Croydon

Bacteriological Examination

No. of organisms capable of growth on gelatine plate at 22°C after 72 hrs. incubation 116 per c.c.
" " " " " " " agar " " 37°C " 48 " " 40 " "

B. coli absent in 100 c.c



SP52SE5

219/75(1)

SP52/19

Bicester Town Supply.

Gowell Farm, near Bicester, 1¼ miles N.W. of Market Place.

Communicated by Mr. Edgar F. Willson, Surveyor to the Urban District Council.

Height above O.D. 277 feet. (84.42m)

A pit, 8 feet square and 11 feet deep, was lined with brickwork and floored with concrete 1 ft. 6 in. thick. A steel tube 11 inches diam. was taken to 112 ft. 4 in. from surface, with perforation at 77 feet. No water worth mentioning was met with until 92 feet, when it rose to the surface. At 105 feet the bulk was struck, and overflowed at the rate of 6,000 gallons per hour when not pumping. The water will rise 3 feet above the surface.

		Thickness. Ft.	Ins.	Depth. Ft	In.
	Surface soil	1	6	1	6
	Grey rock (Cornbrash)	3	0	4	6
	Sandy marl	8	0	12	6
Forest Marble 84 ft.	Blue rock (Forest Marble)	3	0	15	6
	Light shale	2	6	18	0
	Limestone	2	0	20	0
WhL Blisworth	Blue clay or shale	3	6	23	6
	White rock	7	0	30	6
WhL Ardley	Grey shale with hard beds	12	6	43	0
	Grey rock	6	0	49	0
	Dark shale	1	0	50	0
	Rock	0	6	50	6
	Blue binds	2	0	52	6
WhL Shales	Blue shale	1	6	54	0
	Grey rock	3	0	57	0
Great Oolite 84 ft. 6 in.	Grey shale	1	0	58	0
	Grey rock	1	0	59	0
Shipton	Variegated rock	3	6	62	6
	Grey rock...	3	0	65	6
	Dark shale	7	0	72	6
	Rock	2	0	74	6
	Blue clay	5	0	79	6
Rutland Fm	Blue rock	2	6	82	0
	Dark shale with hard beds	3	0	85	0
	Limestone	1	6	86	6
	Limestone with shale beds	3	0	89	6
	Blue shale	1	0	90	6
	Grey sandy shale with water	2	0	92	6
	Grey rock	2	6	95	0
	Dark sandy shale	2	6	97	6
	Light sandy shale	2	0	99	6
Tuyalum Lst	Grey rock	2	6	102	0
	Soft rock, water, bulk here	6	0	108	0
Estuarine Beds 4 ft. 4 in. (penetrated)	Peat	1	3	109	3
	Light sand	0	8	109	11
	Dark clay and sand	2	4	112	3
Sharps Hill Fm	Rock, 1 inch only into it	0	1	112	4

Analysis by Mr. W. W. Fisher in "The Salinity of Water from the Oolites" "*The Analyst*," *February, 1904*. *See* p. 92.

Mr. E. Foster Tanner, Clerk to the Urban District Council, has kindly added the following particulars :—

"The deep well pump has been fixed. Motive power supplied by Crossley's 13-h.p. gas engines in duplicate, either capable of driving the pumping plant, which has the capacity for raising 8,000 gallons per hour. The water is pumped into tanks, constructed of steel, on the top of a tower, immediately adjoining the well. The tanks are in duplicate, *i.e.*, an inner and an outer tank. Their combined holding capacity is about 45,000 gallons. Height from ground to bottom of tanks, 40 feet. There is a 7-inch main from the water tower to the town, and the distribution mains in the town are respectively 6-inch, 5-inch, 4-inch, and 3-inch. The cost of the works was £7,000."

O.D. given as +277 by H.T. Smith Esq. Surveyor to Bicester U.D.C. See Letter in 9509/28.

Bore cased in; pump removed.

Published in

C. ISLER & Co., Ltd.,
ARTESIAN & CONSULTING WELL ENGINEERS,
BEAR LANE, SOUTHWARK, S.E.1.

Telegraphic Address: "ISLER, LONDON."
Telephone No.: Hop 4460 (3 Lines).

BIRMINGHAM BRANCH: 58 Summer Row.

CHART

Showing the Soils passed through at

M Bicester Waterworks
Gowell Farm Bicester

Grey Sandy Shale (with water)	2	0	92	6
Grey Rock.	2	6	95	0
Dark Sandy Shale	2	6	97	6
Light " "	2	0	99	6
Grey Rock.	2	6	102	0
Soft Rock	6	0	108	0
Peat	1	3	109	3
Light Sand		8	109	11
Dark Clay & Sand	2	4	112	4
Rock.	2			

15'6" of 15" 8ft below
97ft 11" Tubes level with surface
15 " 10½" " 97ft below
perforated from 77ft below
perforations ½" on 3½" pitch covered
with fine mesh brass wire gauge

W.L Overflow
12,000 g.p.h. at P.W.L. of 70ft
Dug Well Pumps.

Bored by T. Thom.

SP52SE5

219

SP 5709 2384

BICESTER WATER WORKS.

Well at Gowell Farm. Present supply, 1909.

Yield.—140,000 to 212,000 gallons per day. Water reduced by 14 days test-pumping to 70 feet from surface, but rose again to surface in two hours after cessation of pumping.

Report on analysis of water received 30th September, 1905, at end of pumping test. By Mr. W. W. Fisher, F.I.C.

Description.—The sample is slightly cloudy and contains a little sand. The residue left on evaporation is alkaline and contains a little sodium carbonate.

Odour.—None.

Appearance in two-foot tube.—Pale-yellowish.

The results of the analysis are stated in grains per gallon.

Total dissolved solid matter	26·6
Chlorine in chlorides	1·1
Ammonia, free and saline	·028
„ albuminoid	·003
Nitrogen in nitrates	·014
„ in nitrites	0
Oxygen required to oxidise organic matter (in 3 hours)	·007
Hardness in Clark's degree	14·5

Remarks.—The total dissolved solid constituents are normal for water from the Oolite. The chlorides are not in excess of the natural amount; the nitrates are small, and the proportion of organic matter is extremely small. The water is of a moderate degree of hardness.

Published in
'The Water Supply
of Oxfordshire',
Pages 92, 93

RECORD OF STRATA - BICESTER URBAN DISTRICT COUNCIL'S BOREHOLE.

219

SP52SE5

75-0

Ft.	ins.	
1.	6	Surface Soil
3.	0	Grey Rock.
8..	0.	Sandy Marl
3.	0.	Blue Rock
2.	6	Light Shale
2.	0	Limestone.
3.	6	Blue Shale.
7.	0	White Rock.
12.	6	Grey Shale with hard beds.
6.	0	Grey Rock.
1.	0	Dark Shale.
	6	Rock
2.	0	Blue Binds.
1.	6	Blue Shale.
3.	0	Grey Rock.
1.	0	Grey Shale.
1.	0	Grey Rock.
3.	6	Variegated Shale.
3.	0	Grey Rock.
7.	0	Dark Shale.
2.	0	Rock.
5.	0	Blue Clay.
2.	6	Blue Rock.
3.	0	Blue Shale with hard ribs.
1.	6	Limestone.
3.	0	Limestone with Shale beds.
1.	0	Blue Shale.
2.	0	Grey Sandy Shale.
2.	6	Grey Rock.
2.	6	Dark Sandy Shale.
2.	0	Light Sandy Shale.
2.	6	Grey Rock.
6.	0	Soft Rock.
1.	3	Peat.
	8	Light Sand.
2.	4	Dark Clay and Sand, Rock.

See SP52SE/5

SP52SE5

SP 52 SE/6 [5851 2319] Bicester Station Well (19--) Datum +77.7 (Ground level)

	Depth ft	Thickness m	Depth m
Cornbrash Formation	*8.50*	2.59	2.59
Forest Marble Formation and White Limestone Formation: Bladon Member	*29.75*	6.48	9.07
Ardley Member and Shipton Member	*76.00*	14.10	23.16
Rutland Formation and Taynton Limestone Formation	*100.00*	7.32	30.48
Sharp's Hill Formation, 'White Sands' and Northampton Sand Formation	*120.00*	6.10	36.58

Stratigraphical classification by M G Sumbler, May 1999.

ENGINEER OVE ARUP & PARTNERS

LOGGED BY:
FIELDWORK BY:
LAB. TESTING BY:

SP52NW34

OXFORD TO BIRMINGHAM NEW ROUTE–OXFORD TO BANBURY SECTION

EXCAVATION METHODS Percussion Boring - Pilcon Wayfarer
150 mm diameter hole
146 and 100 mm diameter Rotary Coring from 0.4 to 19.4 m

GROUND LEVEL 108.95 m O.D.
COORDINATES 454971 E 225919 N
DATES 26.6.79 to 2.7.79

HOLE NO. Y3
SHEET 1 OF 2
FIGURE A

Date/Time at Depth	Depth of Casing	Depth to Water*	Piez.	Description of Strata	Strata: Leg.	Reduced Level	Depth	Graphical Representation	Sampling/In situ testing: Depths	Type	No.	Blows	Lab. Testing: % Core/RQD	<425 %	W %	PL %	LL %	γ Mg/m³	C_u kN/m²	Additional Tests and Notes: I_h	d_h	I_v	d_v
27.6.79						108.95	0.00																
18.00	NIL	DRY		TOPSOIL		108.75	0.20																
08.00	NIL	DRY		Subangular to subrounded COBBLES and BOULDERS of white micritic limestone with some firm dark reddish brown silty clay. (Colluvium)					0.40	S										SPT no penetration.			
									0.60	D	1		75							Core diameter 114 mm.			
27.6.79						107.75	1.20						0										
				Moderately strong white highly fractured becoming slightly fractured thinly bedded fine grained fined oolitic and calcarenitic sparry LIMESTONE. (White Limestone - Bladon)					1.30				50										
				From 2.75 to 2.85m weak light orange brown conglomeratic calcareous siltstone.					1.60				0							Core diameter reduced below 1.60m			
				From 2.85 to 2.90m Hardground/erosion layer with rolled micritic pebbles and wispy iron staining.									83										
18.00	1.50	0.00											0										
08.00	1.50	DRY											77										
									2.60				0							2.68	76		
																				3.46	77	3.34	77
				Moderately weak to moderately strong thinly and medium bedded initially moderately fractured fine grained pelletoidal micritic bioturbated LIMESTONE. (White Limestone - Ardley)		106.05	2.90						90										
				From 3.10 to 4.00m irregular vertical solution weathered joint.									19										
				From 3.40 to 3.90m limestone very fine grained almost porcellaneous with thin walled gastropods.					3.80														
				From 3.90 to 6.50m limestone orange and orange brown fine to medium grained very pelletoidal with some sparry walled shells.									95										
28.6.79													34							0.85	75		
									4.80													1.25	78
				Below 6.50m limestone becoming very compact medium to thickly bedded and increasingly siliceous.									95										
				From 7.20 to 7.80m limestone moderately weak orange with solution casts of shells.									45										
				Below 7.80m weak initially weathered orange becoming dark grey very silty calcareous sandstone.					5.80											0.20	75		
																				2.63	75	1.97	74
													93										
													64										
									6.80											2.70	72	2.28	75
													98										
18.00	3.00	DRY											97										
08.00	3.00	6.70		Hard dark grey very silty CLAY and clayey SILT becoming black and carbonaceous. (White Limestone - Shipton)		101.05	7.90		8.00														
						100.65	8.30						95										
29.6.79				Moderately weak to moderately strong grey medium to thickly bedded fine to medium grained pelletoidal micritic LIMESTONE. (White Limestone - Shipton)									40										
				From 8.55 to 8.65m weak to moderately weak clayey pelletoidal calcareous siltstone.					8.80											1.32	77	1.47	67
18.00	3.00	0.00											99										
08.00	3.00	6.70											91										
2.7.79									9.80														

(*Point Load Index < 0.10 MN/m^2)

SP 52NW/34
5496 2592
5497 2592

*WATER ▽ First water strike ▼ Subsequent water strikes

PIEZOMETER Upper seal / Response length / Lower seal

SAMPLE AND TEST KEY: D Small disturbed sample; B Bulk disturbed sample; W Water sample; U Undisturbed sample; Point Load Index I MN/m²; Distance between platens d mm; v = vertical h = horizontal load ‖

R Rotary core recovery to scale; V Insitu vane test; S Standard penetration test; C Cone penetration test; K Permeability test; I Insitu density test

Blows N = N value 26/150, blows for 150mm drive after seating; 26*, blows for part or whole of seating drive only; (26) Undisturbed sample blow count

V Vane strength kN/m² Natural Remould

Cr Core recovery %; RQD Rock quality designation; <425 Sample % passing 425μm sieve

DEPTH All depths, levels and thicknesses in metres

J. Tiplady BSC. C.Eng.FICE,FIHE
Director
Eastern Road Construction Unit,
80/83 Goldington Road, Bedford.

FIG. A

SHEET 2 OF 2

HOLE NO. Y3

ENGINEER: OVE ARUP & PARTNERS

LOGGED BY:

FIELDWORK BY:

LAB. TESTING BY:

SP52NW34

OXFORD TO BIRMINGHAM NEW ROUTE–OXFORD TO BANBURY SECTION

EXCAVATION METHODS Percussion Boring - Pilcon Wayfarer
150 mm diameter hole
146 and 100 mm diameter Rotary Coring from 0.4 m to 19.4 m

GROUND LEVEL 108.95 m O.D.

COORDINATES 454971 E 225919 N

DATES 26.6.79 to 2.7.79

HOLE NO. Y3

SHEET 2 OF 2

FIGURE A

Date/Time at Depth	Depth of Casing	Depth to Water	Piez.	Description of Strata	Strata Leg.	Reduced Level	Depth	Graphical Representation	Sampling/In situ testing Depths	Type	No.	Blows	Cr RQD	Lab. Testing <425 %	W %	PL %	LL %	γ Mg/m³	C_u kN/m²	Additional Tests and Notes I_h	d_h	I_v	d_v
2.7.79				(White Limestone - Shiplon as above) From 10.80 to 11.85m alternating weak to moderately weak clayey calcareous siltstone and fine grained silty limestone. From 11.45 to 11.75m hard dark grey silty clayey with very thin limestone interbeds. From 12.50 to 12.80m hard very dark greenish grey jointed moderately carbonaceous very silty clay with silt and fine sand laminae and abundant small oyster shells at base.					11.30				97/75									
									12.80				93/70	100	15	14	39			0.12	77	0.27	69
				Hard green very silty CLAY and clayey SILT with vertical black carbonized rootlets. (Hampen Marly Beds)		95.60	13.35																
				Moderately weak greenish grey silty very fine grained calcareous SANDSTONE. (Hampen Marly Beds)		95.30	13.65																
				Hard dark grey becoming dark green very silty in places very fossiliferous CLAY. (Hampen Marly Beds)		95.15	13.80		13.80				98/77	100	18	21	48			2.42	76	5.65	58
				From 13.95 to 14.00m hard black very carbonaceous clay (almost jet).									95/62										
				From 14.60 to 14.70m moderately weak greyish green very fine grained silty limestone.					14.80														
													100/83	100	3	20	47			2.93	77	3.31	70
									15.80														
									15.90			67*/75											
				Initially very weak and very muddy becoming moderately weak to moderately strong dark grey medium to thickly bedded fine to medium grained pelletoidal fossiliferous LIMESTONE. (Taynton Stone)		91.95	17.00		16.80				93/64	100	11	17	48						
				From 17.80 to 18.50m limestone thinly to medium false bedded and calcarenitic.					17.80				100/98							1.40	77	1.65	73
													93/66							1.59	77	2.73	62
18.00	3.00	DRY							19.40														
					END	89.55	19.40																

(* Point Load Index < 0.10 MN/m²)

SP 52 NW/34
5496 2592

* WATER ▽ First water strike ▼ Subsequent water strikes

PIEZOMETER Upper seal, Response length, Lower seal

SAMPLE AND TEST KEY: D Small disturbed sample; B Bulk disturbed sample; W Water sample; U Undisturbed sample

Point Load Index I MN/m² Distance between platens d mm v = vertical h = horizontal loading

Rotary core recovery to scale; V Insitu vane test; S Standard penetration test; C Cone penetration test; K Permeability test; I Insitu density test

Blows N = N value 26/150, blows for 150mm drive after seating 26*, blows for part or whole of seating drive only (26) Undisturbed sample blow count

V Vane strength kN/m² Natural, Remould

Cr Core recovery % RQD Rock quality designation <425 Sample % passing 425μm sieve

DEPTH All depths, levels and thicknesses in metres

J. Tiplady BSC. C.Eng.FICE,FIHE
Director
Eastern Road Construction Unit,
56/63 Goldington Road, Bedford.

FIG. A | SHEET 2 OF 2 | HOLE NO. Y3

No 8.

219

5635 2625

March 18th 1925

SP52NE6

90

BOREHOLE SECTION

BORED & COMMUNICATED BY LE GRAND SUTCLIFF & GELL LTD, SOUTHALL

BORED FOR ; Archibald Nicholson Esqr.
Manor Farm,
Bucknell, Nr, Bicester,

DISTRICT : Bicester IN THE COUNTY OF :Oxford.

POSITION OF BORING: At Manor Farm just N.E. of Bucknell
In a field about ½ mile N.W. of the farm.

MAPS: 6" Ordnance Oxford 17
1" Geo. Old Series 45.N.E. O.D.OF SITE : 320'
N.S. 219

WATER LEVEL BELOW SURFACE: 26' 0" YIELD OF WATER: 360 gallons per hour.

TUBING REMAINING IN BOREHOLE. 25' 0" of 4" top 1' 0 below surface
5' 5" of 5" top 1' 6" " "

STRATA	THICKNESS Ft.	Ins.	DEPTH Ft.	Ins.	
Blue Clay.....	5	9	5	9	Wychwood Beds?
Grey Clay.....	3	3	9	0	
Blue Clay.....	1	0	10	0	
Blue Rock.....	4	0	14	0	Kemble Beds?
Grey Rock.....	4	6	18	6	
Green Clay.....		6	19	0	
Grey Rock.....	5	0	24	0	
Coloured Clays & Rock.....	15	6	39	6	
Grey Rock.....	2	6	42	0	
Blue Clay.....	2	0	44	0	White limestone
Blue Rock.....	3	0	47	0	
Green Clay.....	2	0	49	0	
Blue Rock.....	2	0	51	0	
" Clay.....	5	0	56	0	
" Rock	3	0	59	0	
" Clay.....	5	0	64	0	Hampen Marly? Beds
" Rock.....	3	0	67	0	
" Clay (dark).....	4	0	71	0	
" Rock.....	3	0	74	0	
Whitish Clay.....	1	0	75	0	Taynton Stone
White Rock.....	5	0	80	0	
Blue Rock.....	3	0	83	0	
Grey Green Clay.....	6	0	89	0	Upper Estuarine Clay & Smarts Hill Beds?
" " " Stones.....	4	0	93	0	
Black Sandy Clay.....	34	9	127	9	Sherford Hook
Black Rock.....		3	128	0	
Blue Rock.....		3	128	3	Norton Beds?
Green Rock.....	1	3	129	6	
Gault Clay.....	23	6	153	0	Upper Lias
Gault.....	26	0	179	0	
Rock.....	2	9	181	9	
Clay & Shale.....	2	3	184	0	
Bands of Rock & Loamy Shale	4	6	188	6	Middle Lias
Rock, Clay & Pebbles.....	5	0	193	6	
Loamy Clay & Shales.....	21	6	215	0	
C/F	215	0	215	0	

Forest Marble ?

Great Oolite Series ?

2 sht.

SP52NE6

219/90

March 18th 1925

BOREHOLE SECTION

BORED & COMMUNICATED BY LE GRAND SUTCLIFF & GELL LTD. SOUTHALL

BORED FOR : Archibald Nicholson Esq.,
Manor Farm,
Bucknell Nr,Bicester.

DISTRICT : Bicester. IN THE COUNTY OF: Oxford.

STRATA	THICKNESS Ft,	Ins.	DEPTH Ft.	Ins.	
C/F	215	0	215	0	
Loamy Clay & Shales, hard bands.....	6	0	221	0	Middle + Lower Lias
Loamy Clay & Shales.....	6	0	227	0	
White Rock.....		6	227	6	
Loamy Clay & Shales.....	12	6	240	0	
Blue Clay ~~(Gault)~~.....	7	0	247	0	
Rock.....	1	0	248	0	
~~Gault~~.....	3	0	251	0	
Total depth of boring.	251	0	251	0	

Great Oolite Series

Lias? Up

A.W.W. 1.VI.39.

Based on Arkell: Jur. Sys. " QJGS 1931 Richardson GeolMag 1910?

GENERAL REMARKS

Probably not a great deal of water at this site
W.L. dropped considerably during boring about 190-200 ft.

BORING FINISHED: 26th April 1924.

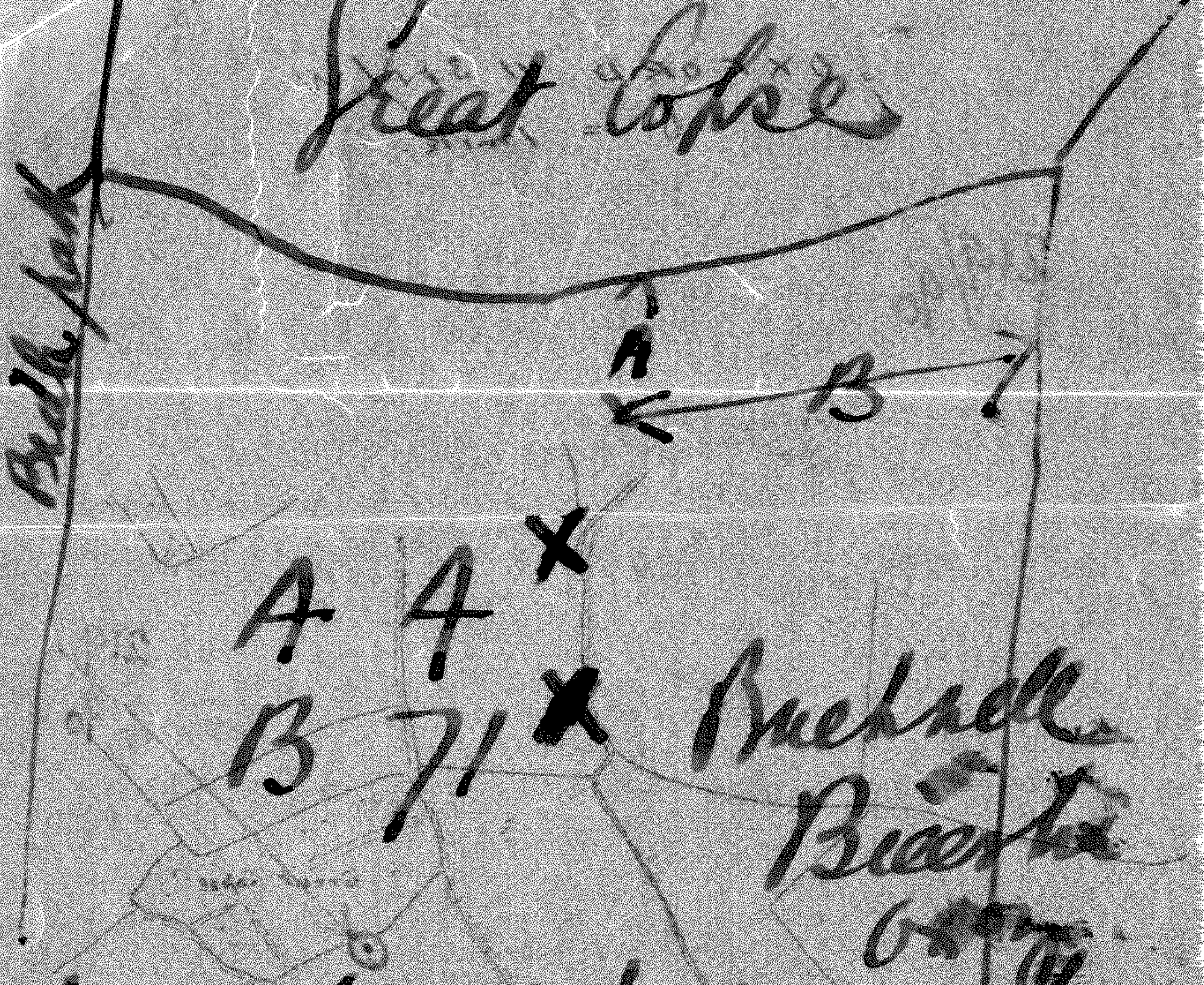
LE GRAND SUTCLIFF & GELL LTD.,

Signature.....

Our Ref,S.B.4/17.
Our Order No. 1150. 23/1/24.

LI/AMP.

3 The well is still in use
Yield unknown. 800 glns per day
when I want it.



I hope this will help. If you
can understand it, it is right
within a foot or two

A Nicholson

11.1.40

SP52NE6

OXFORD II SW/W

6" = 1 mile.

219/10

5635 2625 SP52NE6

90 21

BOREHOLE SECTION

BORED & COMMUNICATED BY LE GRAND SUTCLIFF & GELL LTD, SOUTHALL

BORED FOR ; Archibald Nicholson Esqr. NGR: SP 5635 2625
Manor Farm,
Bucknell, Nr, Bicester,

SP52NE/6.

DISTRICT : Bicester IN THE COUNTY OF : Oxford.

POSITION OF BORING: At Manor Farm just N.E. of Bucknell
In a field about 1 mile N.W. of the farm.

MAPS: 6" Ordnance Oxford 17
1" Geo. Old Series 45.N.E. O.D.OF SITE : 320' (97.53m)
N.S. 219

WATER LEVEL BELOW SURFACE: 26' 0" YIELD OF WATER: 360 gallons per hour.

TUBING REMAINING IN BOREHOLE. 25' 0" of 4" top 1' 0 below surface
5' 5" of 5" top 1' 6" "

STRATA	THICKNESS Ft.	Ins.	DEPTH Ft.	Ins.	
Blue Clay.....	5	9	5	9	Wychwood Be
Grey Clay.....	3	3	9	0	
Blue Clay.....	1	0	10	0	
Blue Rock.....	4	0	14	0	Kemble Bed
Grey Rock.....	4	6	18	6	
Green Clay.....		6	19	0	
Grey Rock.....	5	0	24	0	
Coloured Clays & Rock.....	15	6	39	6	
Grey Rock.....	2	6	42	0	
Blue Clay.....	2	0	44	0	White limest
Blue Rock.....	3	0	47	0	
Green Clay.....	2	0	49	0	
Blue Rock.....	2	0	51	0	
" Clay.....	5	0	56	0	
" Rock	3	0	59	0	
" Clay.....	5	0	64	0	Hampen Marl
" Rock.....	3	0	67	0	Beds
" Clay (dark).....	4	0	71	0	
" Rock.....	3	0	74	0	
Whitish Clay.....	1	0	75	0	
White Rock.....	5	0	80	0	Taynton Ste
Blue Rock.....	3	0	83	0	
Grey Green Clay.....	6	0	89	0	
" " " Stones.....	4	0	93	0	Upper Estuarine = Smarts Hill B
Black Sandy Clay.....	34	9	127	9	
Black Rock.....		3	128	0	Sweeford Ho
Blue Rock.....		3	128	3	Norton Beds
Green Rock.....	1	3	129	6	
Gault Clay.....	23	6	153	0	Upper Lias
Gault.....	26	0	179	0	
Rock.....	2	9	181	9	
Clay & Shale.....	2	3	184	0	
Bands of Rock & Loamy Shale	4	6	188	6	
Rock, Clay & Pebbles.....	5	0	193	6	Middle Lia
Loamy Clay & Shales.....	21	6	215	0	
C/F	215	0	215	0	

SP52NE6

219/90

March 18th 1925

BOREHOLE SECTION

BORED & COMMUNICATED BY LE GRAND SUTCLIFF & GELL LTD. SOUTHALL

BORED FOR : Archibald Nicholson Esq.,
Manor Farm,
Bucknell Nr,Bicester.

SP52NE6

DISTRICT : Bicester. IN THE COUNTY OF: Oxford.

STRATA	THICKNESS Ft,	Ins.	DEPTH Ft.	Ins.	
O/F	215	0	215	0	Middle + Lower Lias
Loamy Clay & Shales,hard bands.....	6	0	221	0	
Loamy Clay & Shales.....	6	0	227	0	
White Rock.....		6	227	6	
Loamy Clay & Shales.....	12	6	240	0	
Blue Clay ~~(Gault)~~.....	7	0	247	0	
Rock.....	1	0	248	0	
~~Gault~~.....	3	0	251	0	
Total depth of boring.	251	0	251	0	

Great Oolite Series

Lias? Cf

A.W.W. 1.VI.39

Based on Arkell: Jur. Sy. " GJGS 19 Richardson Geol. M. 19

GENERAL REMARKS

Probably not a great deal of water at this site
W.L. dropped considerably during boring about 190-200 ft.

BORING FINISHED: 26th April 1924.

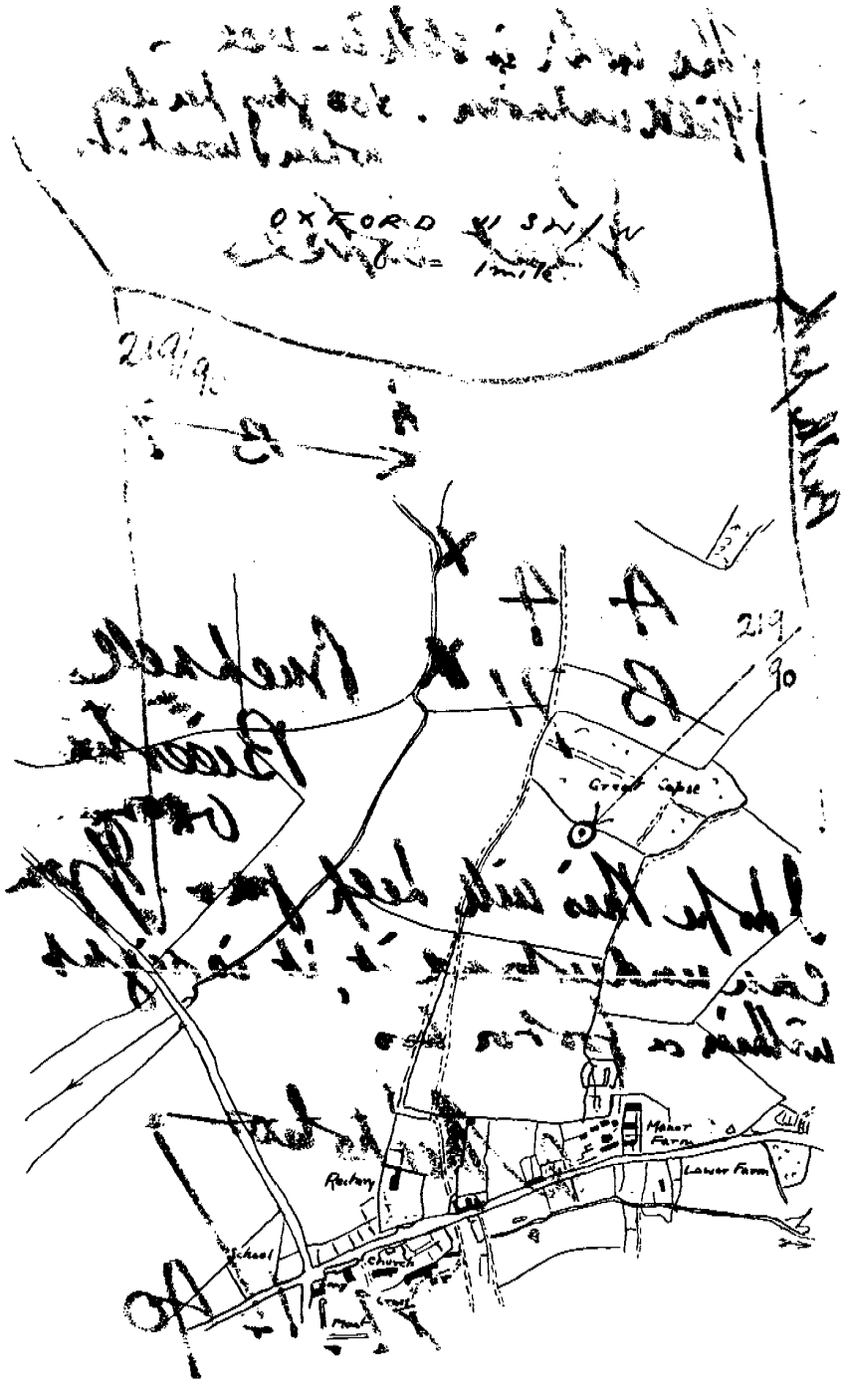
LE GRAND SUTCLIFF & GELL LTD.,

Signature.....

Our Ref,S.B.4/17.
Our Order No. 1150. 23/1/24.

LI/AHP.

SP52NE6



[SP52NE BJ 6 .]

5635 2625 SP52NE6 90 21

BOREHOLE SECTION

BORED & COMMUNICATED BY LE GRANDSUTCLIFF & GELL LTD, SOUTHALL

BORED FOR ; Archibald Nicholson Esqr. NGR SP 5635 2625
Manor Farm,
Bucknell, Nr, Bicester,

SP52NE/6.

DISTRICT : Bicester IN THE COUNTY OF :Oxford.

POSITION OF BORING: At Manor Farm just N.E. of Bucknell
In a field about ¼ mile N.W. of the farm.

MAPS: 6" Ordnance Oxford 17
1" Geo. Old Series 45.N.E. O.D.OF SITE : 320' (97.53m)
N.S. 219

WATER LEVEL BELOW SURFACE: 26' 0" YIELD OF WATER: 360 gallons per hour.

TUBING REMAINING IN BOREHOLE. 25' 0" of 4" top 1' 0 below surface
5' 5" of 5" top 1' 6" " "

STRATA	THICKNESS Ft.	Ins.	DEPTH Ft.	Ins.	
Blue Clay.....	5	9	5	9	FML
Grey Clay.....	3	3	9	0	Wychwood Beds
Blue Clay.....	1	0	10	0	
Blue Rock.....	4	0	14	0	Great Marlstone & L.
Grey Rock.....	4	6	18	6	Kemble Beds
Green Clay.....		6	19	0	
Grey Rock.....	5	0	24	0	
Coloured Clays & Rock.....	15	6	39	6	
Grey Rock.....	2	6	42	0	
Blue Clay.....	2	0	44	0	White limestone
Blue Rock.....	3	0	47	0	
Green Clay.....	2	0	49	0	
Blue Rock.....	2	0	51	0	
" Clay.....	5	0	56	0	
" Rock	3	0	59	0	
" Clay.....	5	0	64	0	Rid Hampen Marly Beds
" Rock.....	3	0	67	0	
" Clay (dark).....	4	0	71	0	
" Rock.....	3	0	74	0	
Whitish Clay.....	1	0	75	0	
White Rock.....	5	0	80	0	Great Oolite Ty Taynton Sta
Blue Rock.....	3	0	83	0	
Grey Green Clay.....	6	0	89	0	ShF
" " " Stones.....	4	0	93	0	Upper Fatturnia C = Swarks Hill Bed
Black Sandy Clay.....	34	9	127	9	HYS
Black Rock.....		3	128	0	NS Sweeford = Hoo
Blue Rock.....		3	128	3	Norton Beds
Green Rock.....	1	3	129	6	
Gault Clay.....	23	6	153	0	Upper Lias
Gault.....	26	0	179	0	
Rock.....	2	9	181	9	
Clay & Shale.....	2	3	184	0	
Bands of Rock & Loamy Shale	4	6	188	6	
Rock, Clay & Pebbles.....	5	0	193	6	Middle Lias
Loamy Clay & Shales.....	21	6	215	0	
C/F	215	0	215	0	

SP52NE6

219/90

March 18th 1925

BOREHOLE SECTION

BORED & COMMUNICATED BY LE GRAND SUTCLIFF & GELL LTD. SOUTHALL

BORED FOR : Archibald Nicholson Esq.,
Manor Farm,
Bucknell Nr,Bicester.

SP52NE6

DISTRICT : Bicester. IN THE COUNTY OF: Oxford.

STRATA	THICKNESS Ft,	Ins.	DEPTH Ft.	Ins.	
C/F	215	0	215	0	
Great Oolite Series: Loamy Clay & Shales, hard bands.....	6	0	221	0	Middle + Lower Lias
Loamy Clay & Shales.....	6	0	227	0	
White Rock.....		6	227	6	
Loamy Clay & Shales.....	12	6	240	0	
Lias? Blue Clay ~~(Gault)~~.....	7	0	247	0	
Rock.....	1	0	248	0	
~~Gault~~.....	3	0	251	0	
Total depth of boring.	251	0	251	0	

A.W.W. 1.11.39.

Based on Arkell: Jur. Sys. " QJGS 1931 Richardson Geol Mag 1910

GENERAL REMARKS

Probably not a great deal of water at this site
W.L. dropped considerably during boring about 190-200 ft.

BORING FINISHED: 26th April 1924.

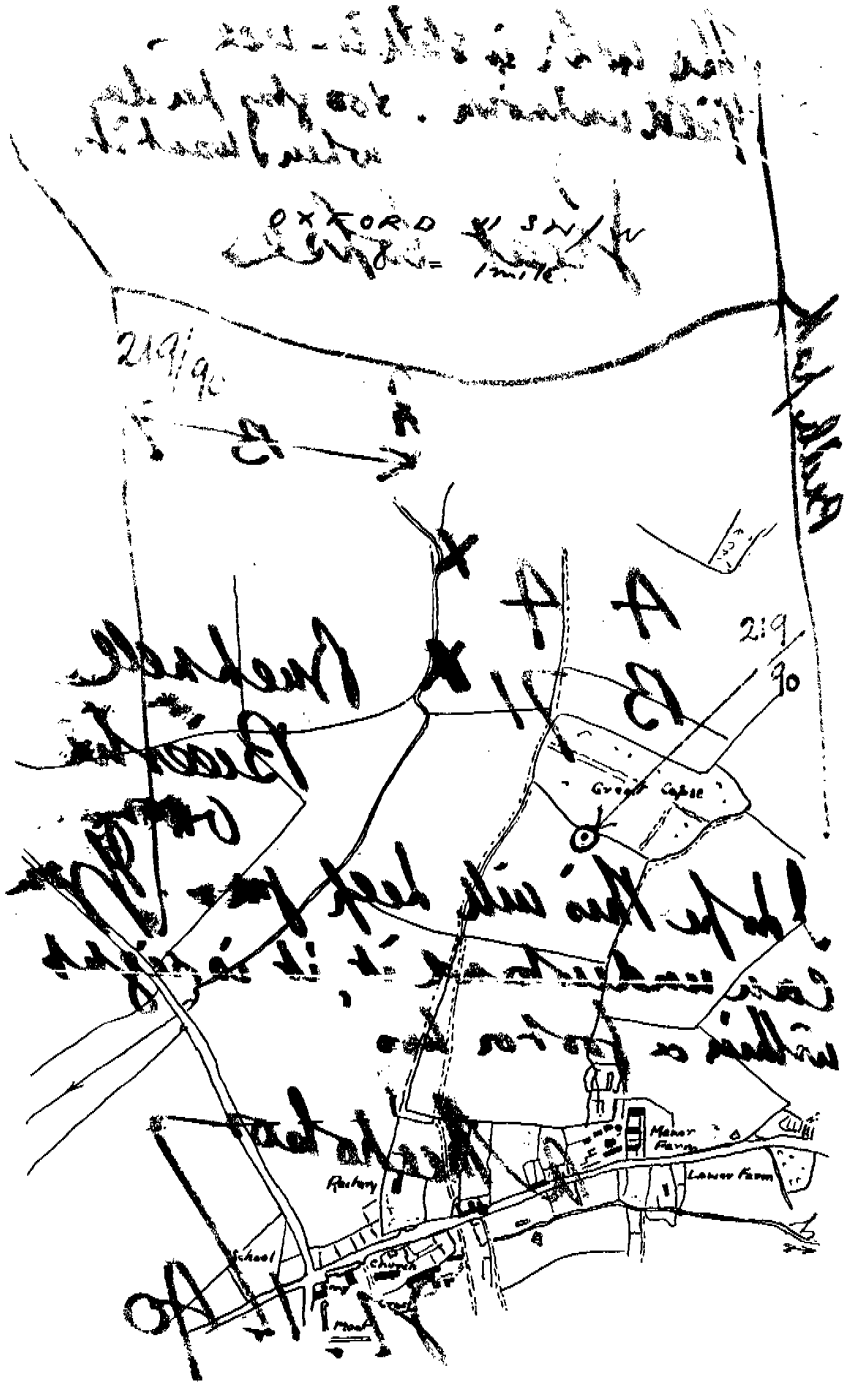
LE GRAND SUTCLIFF & GELL LTD.,

Signature.....

Our Ref,S.B.4/17.
Our Order No. 1150. 23/1/24.

LI/AMP.

SP52NE6



Dr Richard Earl
TurfTrax Ground Management Systems Limited
Unit 1, Highfield Park
Highfield Road
Oakley
Bedfordshire
MK43 7TA

Geological Assessment - Detailed

This report is aimed at customers and clients carrying out preliminary site assessments, who require a detailed assessment of the geology, hydrogeology and any geological hazards around the site.

The report, prepared by BGS geologists, is based on analysis of records and maps held in the National Geoscience Data Centre (NGDC), and includes descriptions of rock types, natural subsidence hazards and mining & quarrying hazard if present. It also contains geological map extracts taken from the BGS Digital Geological Map of Great Britain at the 1:50,000 scale (DiGMapGB-50) and a listing of the key geoscience data sets held in the NGDC for the area around the site. The report also considers radon hazard (in terms of the level of radon protection required in the construction of new dwellings) and the detailed hydrogeology of the site.

Note that for some sites, the latest available records may be quite historical in nature, and while every effort is made to place the analysis in a modern geological context, it is possible in some cases that the detailed geology at a site may differ from that described.

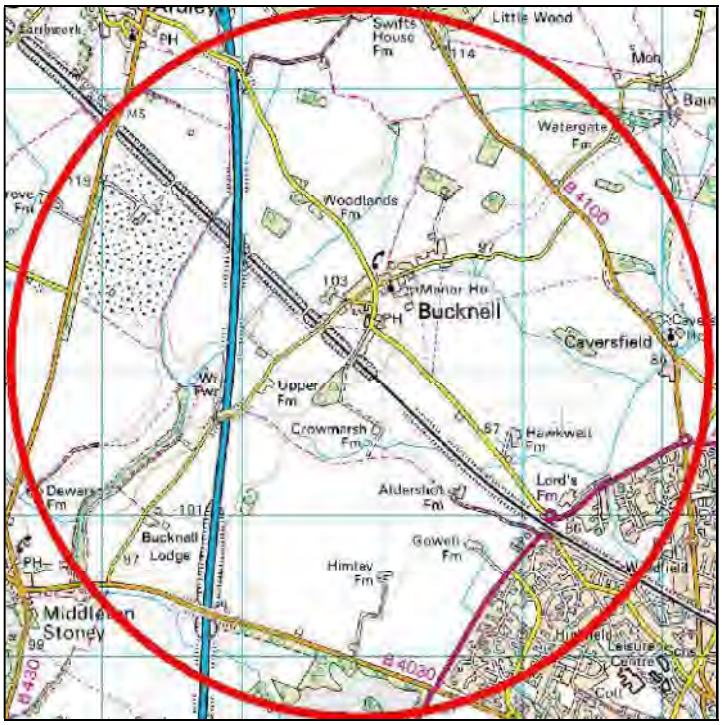
Client's Reference:
NW Bicester

Section 1: Location and extent of report area

Site Address:
Site A: NW Bicester

Area centred at: *455853,225060*
Radius of site area: *2500 metres*

This report is based on the above location details. However, where the client has submitted a site plan, it is used for the assessment in Sections 2, 3 and 4.



Scale: 1:50000 (1cm = 500m)

SITE LOCATION

Section 2: Geological Factors for the site

This table lists some of the principal geological factors that may affect a site, and is based on interpretation of data available to BGS at the time of compilation; additional information may be available in BGS files. The information is designed to act as a checklist and should not be used in place of a detailed site investigation.

Factor	May be significant within site area (Y/N)?	Comments
Shrink-Swell Clay Hazard	No	
Landslide Hazard	Yes	Mudstone beds in the **Bladon Member** and **Forest Marble Formation** may be unstable on steep slopes or in excavations. The **Cornbrash** may be affected by cambering along valley sides, and valley bulging may affect the **Forest Marble** mudstones in valley bottoms.
Ground Dissolution Hazard	Yes	The **White Limestone Formation**, limestone beds in the **Forest Marble Formation** and the **Cornbrash Formation** may be prone to dissolution along joints, leading to minor cavity formation.
Compressible Ground Hazard	Yes	**Alluvium** may include compressible organic-rich layers.
Collapsible Ground Hazard	No	
Running Sand Hazard	Yes	**Alluvium** may include sandy layers with a low running sand hazard potential.
Shallow mining	No	
Aquifer vulnerability		The alluvium and Cornbrash and Forest Marble Formations beneath the site are classified as Minor Aquifers with high soil leaching potential on the Environment Agency's Groundwater Vulnerability map, Sheet 30, Northern Cotswolds. The underlying White Limestone Formation is a Major Aquifer.
Shallow groundwater		Likely within possibly 0.5 m of the ground surface in the Cornbrash; possible artesian conditions in deep boreholes or excavations.
Artificial ground	Yes	Landfill site.
Natural land gas	No	
Level of Radon Protective Measures	Yes	BASIC RADON PROTECTIVE MEASURES ARE REQUIRED FOR THE REPORT AREA.

Section 3: Description of the Geology & Hydrogeology for the site

Topography and surface drainage (see Section 4)**:**
Site elevation ranges from 75 metres above Ordnance Datum (OD) in the stream valley in the south to 120 m in the north-west of the search area.

The slope and principal drainage direction is to the south-east. The drainage is dendritic in pattern and tributaries run in other directions. Two stream networks traverse the search area.

Artificial Ground (see Section 4)**:**
There is an extensive worked ground site in the north-west of the search area, which has been partially backfilled as a landfill site. Elsewhere, there are other small pits, worked mainly for limestone, that are often backfilled. Main roads and railways have cuttings and embankments.

Superficial Deposits (see Section 4)**:**
The streams are flanked by narrow tracts of **alluvium** of late Quaternary age, comprising sandy silty calcareous clay overlying gravelly sandy silty clay, with limestone clasts. The alluvial deposits are up to 150 m wide, are generally between 1 to 2 m in thickness (rarely exceeding 3 m in thickness). They may locally include highly compressible, organic-rich (peaty) layers.

Locally, hollows in these valley sides are floored by thin deposits of **head**, formed by soil creep or hill wash. Their composition reflects that of the local materials from which they were derived, either the bedrock or other types of superficial deposit, or both in combination. Head deposits typically are poorly stratified and poorly sorted, and can be variable in composition. Locally, they are typically composed of variably stony sandy silty clay. Head deposits may be more extensive than shown on the geological map, but if so, probably only as a layer between 0.3 m and 1 m in thickness, and possibly discontinuous.

Rockhead Depth (see Section 4)**:**
Where covered by alluvium or head, rockhead is at 1 to 3 m depth. Its depth beneath the Artificial Ground (especially under landfill sites) is unknown. Over the remainder of the search area, rockhead is close to the surface.

Bedrock Geology (see Section 4)**:**
The search area is underlain at rockhead by various formations and members of the Great Oolite Group, of Mid-Jurassic age, which are dominated by limestones with subordinate mudstone beds.

The oldest exposed formation is the **White Limestone Formation**, forming a broad plateau in the north-west of the search area, and where complete, comprises 10 to 18 m thickness of white to yellow, bedded, peloidal and bioclastic limestone (see **Additional Geological Considerations** below). There may be less than 5 m thickness of beds present in the extreme north-west. Thin calcareous mudstone beds are present in the basal part and dark, carbonaceous mudstones predominate over limestone in the upper part, which is distinguished on the map extracts (see Section 5) as the **Bladon Member**, up to 3 m thick.

The White Limestone Formation is overlain with an erosive contact by the **Forest Marble Formation**, to the extent that the Bladon Member is locally absent. The Forest Marble Formation forms a narrow outcrop between the White Limestone and Cornbrash Formations, and also crops out on the flanks of the stream valleys. The Formation is composed of 3 to 5 m of grey calcareous mudstone with lenticular beds of bioclastic, ooidal limestone, particularly common at the base, where they are widely distinguished on the map extracts.

The **Cornbrash Formation** is the youngest bedrock unit within the site area, cropping out over about half the search area, almost all of the site area, and forming a broad south-east sloping plateau. It comprises about 3 m thick grey to brown bioclastic shelly rubbly-bedded limestone with thin subordinate beds of grey mudstone.

Mudstone beds in the Bladon Member and Forest Marble Formation may be unstable on steep slopes or in excavations.

The limestone-dominated units of the White Limestone, Forest Marble and Cornbrash Formations may be affected by dissolution leading to the widening of joints and the formation of linear vertical voids, which are likely to fill with rubble and soil.

Along valley sides, the Cornbrash Formation outcrops may be affected by cambering. Cambering is a widespread phenomenon in the south and east Midlands, although it is not known whether it affects the strata at this site. Cambering takes place where beds of resistant, permeable rocks such as limestone overlie impermeable clay (or mudstone which weathers and softens to clay) along valley sides and escarpments. The superincumbent load coupled with water movement along the interface causes the soft plastic clay material to squeeze or wash out. Intervening sand beds may exacerbate the effect, but even where such permeable beds are absent, large thicknesses of clay may be lost by squeezing. As a result, the vertical thickness of the clay beds reduces, and the limestone strata are lowered as a 'camber', comprising blocks separated by minor faults parallel to the valley axis. The cambered strata may themselves undergo brittle fracture, so forming blocks separated by vertical joints normal to the direction of movement, on which minor vertical displacements may take place (forming 'dip-and-fault' structures). The displacements on the faults associated with cambering is usually quite small (up to 3 m), and they may be undetectable at the surface other than in excavations. In addition, the spacing may be too close (tens of metres) for them to be distinguishable at 1:10 560 or 1:10 000-scale. Cambering is thought to have been initiated during Pleistocene periglacial conditions. It is probably not an ongoing process here, but may merge into landslide movement downslope and must be considered a potential engineering hazard.

In narrow valleys a consequence of squeezing of the clay strata may be valley bulging, in which the softer material is forced upwards in the floor of the valley, above its normal position, becoming folded and possibly faulted. This may also cause the downslope ends of cambers to be disrupted.

Downhill (lateral) movement of the blocks may cause wide fissures (known as 'gulls') to form. The gulls are likely to fill with loose rock and soil, and in some cases with clay, but can remain as voids. Gulls may also result from the collapse of cavities in limestone formed by dissolution along joints. Such an origin may be evident from a regular pattern or orientation of gulls parallel to local joint sets or not at right angles to the inferred direction of extension. Many gulls develop by a combination of these causes.

Additional Geological Considerations (see Section 4)**:**
The White Limestone Formation is underlain by four further formations of the Great Oolite Group: in ascending order the Horsehay Sand, the mudstone-dominated Sharp's Hill, the Taynton Limestone and the mudstone-dominated Rutland formations, totalling about 20 m in thickness. These are underlain by the 2 to 6 m of the ferruginous sandstones of the Northampton Sand Formation. Beneath these are over 100m of the mudstone-dominated Lias Group.

The bedrock strata dip very gently (less than 0.5°) to the south-east. Faults have been mapped to the north-east of Bucknell, with displacements of up to about 5 m. It is important to understand the nature of geological faults, and the uncertainties which attend their mapped position at the surface. Faults are planes of movement, along which, adjacent blocks of rock strata have moved relative to each other. They commonly consist of zones, perhaps up to several tens of metres wide, containing several to many fractures. The portrayal of such faults as a single line on the geological map is therefore a generalisation. Geological faults in this area are of ancient origin, are today mainly inactive, and are thought to present no threat to property.

Hydrogeology and groundwater vulnerability:
The areas of worked ground, although not within the site area, may contain groundwater that may have an effect on groundwater beneath the site, albeit at depth. The areas of worked ground occur within the White Limestone Formation (see below).

There are small patches of alluvium, and possibly head, within the site area in the floors and flanks of some of the valleys. These deposits are of variable permeability. Groundwater may be present in limited quantities in the less permeable deposits, otherwise it is likely to be in hydraulic conductivity with the Forest Marble Formation bedrock if the bedrock is relatively permeable, or will be perched and drain out if it is more permeable than the bedrock. The deposits are very small in area and thickness and there is no borehole water level information relating to them. However, the water is likely to be in hydraulic continuity with, and at a similar level to, surface water.

The Great Oolite Group limestones transmit water via fractures that can be enhanced by dissolution; water movement through them can therefore be rapid.

With the exception of the Forest Marble Formation cropping out in the floors and sides of the valleys, the whole of the site area is underlain by Cornbrash Formation bedrock. This is a local aquifer and several water strikes have been recorded in shallow, site-investigation boreholes drilled within the site area. The rest water levels are generally slightly higher than the strike levels; both are generally between about 0.5 and 4.0 m below the ground surface.

The Forest Marble Formation, where present beneath the area, may hold small quantities of water in any limestone bands present, but the upper part generally acts as an aquiclude between the Cornbrash Formation and the underlying White Limestone Formation. There are no boreholes drilled through the Forest Marble Formation in the site area that record water strikes within it.

The White Limestone Formation constitutes a major aquifer in the area, with some sources of public supply. There are several boreholes in the wider area, some within the site area, that penetrate this formation. A 34 m deep borehole at Gowell Farm (SP52/19 at SP 5709 2384), drilled pre-1909 to supply Bicester with water, penetrated the complete 25 m thickness of the White Limestone Formation, underlying about 7.2 m of Forest Marble Formation and terminating in the underlying Rutland Formation. Water was struck at 28 m and 32 m below the ground level in the White Limestone Formation. The rest water level rose to the surface after the first strike, and was artesian, with a rest water level about 1 m above ground level (about 88 m above OD) after the second strike. The yield was over 7 l/s. An 80 m deep borehole at Lords Farm (SP52/18 at SP 5746 2424), drilled in 1941, was drilled through a similar sequence and terminated in the Lias. It struck water in the Cornbrash Formation, which was cased out, and at two levels below the White Limestone Formation. The rest water level was at 11 m below ground level (about 68 m above OD) and it yielded 1.7 l/s. Other records of water levels at Lords Farm (SP52/17A, B and C at about SP 569 245) show that the water level was at within 3.6 m below ground level (about 76 m above OD).

There are no water analyses from the Cornbrash and Forest Marble Formations, but anticipate that water from the limestones will be similar to that from the White Limestone Formation. All of the boreholes in the area that have analyses are deeper ones drilled into, and abstracting water from, the White Limestone Formation. A typical analysis, one from 1905 of the water from the Gowell Farm borehole, records total dissolved solids of 380 mg/l, a chloride ion concentration of 16 mg/l, a hardness of 207 mg/l (as $CaCO_3$), and nitrates of 0.2 mg/l. A 1935 analysis of several samples, taken under pumping conditions, record total dissolved solids of about 300-400 mg/l and a chloride ion concentration of 13-32 mg/l. The outcrop, and thus recharge area, of the White Limestone Formation lies to the north-west of the site area, within the search area. There are areas of worked ground in this formation in the search area. Depending upon the unknown depth of the worked ground areas, the water level in the White Limestone Formation may lie above the floor of any quarry or similar excavation. If any such worked ground has been backfilled and it is unlined, it is possible that the backfill material may affect groundwater flow beneath the site and may be in contact with the water within the White Limestone Formation. It is possible that under these conditions, the water in this formation may be, or become, contaminated and may eventually be transmitted down hydraulic gradient to the water in the formation beneath this site.

There are insufficient data to determine a groundwater flow direction, but locally it will probably be towards the nearest stream and regionally, down-dip towards the south-east.

The alluvium, and Cornbrash and Forest Marble Formations beneath the site are classified as Minor Aquifers with high soil leaching potential on the Environment Agency's Groundwater Vulnerability map, Sheet 30, Northern Cotswolds.

Individual sites will always require more detailed assessments to determine the specific impact on groundwater resources. The maps only represent conditions at the surface and where the soil and/or underlying formations have been disturbed or removed, the vulnerability class may have been changed and site specific data will be required.

Natural Land Gas

Section 2 indicates whether or not there is any potential susceptibility of the report area to surface or near-surface emissions of methane and/or carbon dioxide from natural sources or mining. Where methane and carbon dioxide emissions do occur at the surface most appear to be derived from abandoned shallow coal mines although a number of recorded incidences originate from peat and other natural deposits of organic materials, such as in buried ponds or river channels. It should be noted that the exact extent of potential sources of natural land gas, particularly that of peat and other organic deposits, can be difficult to predict.

An indication of potential for gas emissions does not necessarily indicate that there is a problem. That would depend on (1) the quantity of gases in the source rocks or superficial deposits, (2) whether they have been released and (3) whether there are pathways for transmission and locations for accumulation.

The relatively small number of gas emission incidents from coal mining and natural sources recorded in most areas of the UK suggests that the hazard is relatively minor and of local significance compared, for example, with the extensive problems associated with mining related subsidence or gas problems associated with landfill sites. However, in some parts of the coal fields, such as in parts of Northumberland, a relatively high number of gas emission sites have been identified, so the gas hazard is correspondingly greater. Whereas specific problems with methane and carbon dioxide from natural sources and mining can cause severe and, sometimes, expensive or dangerous problems, most gas emissions from natural sources and mining can usually be dealt with readily if they do arise.

A Residential Property or Non-Residential Property, Commercial or Development Site (maximum of 25 hectares) coal mining search from the Coal Authority (http://www.ppsearches.co.uk/coal_mining_searches.htm) will indicate whether any shafts or adits, which may act as pathways for gas, are located within 20 m of the boundary of the property or site. Where the Coal Authority is aware that a property or site being the subject of a search has been affected by mine gas, this information will be included in the Coal Mining Search Report.

If the report area is potentially susceptible to surface or near-surface emissions of methane and/or carbon dioxide from natural sources or mining, (1) caution should be exercised in forward planning on the basis that hazards from natural methane and carbon dioxide impose a constraint on development by virtue of public health or safety implications; (2) developers need to be aware that potential problems may be associated with gas emissions; (3) employers at some places of work may have responsibilities under the Health and Safety at Work etc Act 1974 to monitor gas levels; and (4) there may be a need to consult an appropriate specialist or to seek further information through desk studies and/or site investigations.

The information in this report should not be used in place of a site investigation. The existence of gas emissions at specific sites can only be established by detailed site investigation. The level of risk from methane or carbon dioxide in a particular building or underground cavity can only be established by monitoring the spaces in which it may accumulate.

Radon

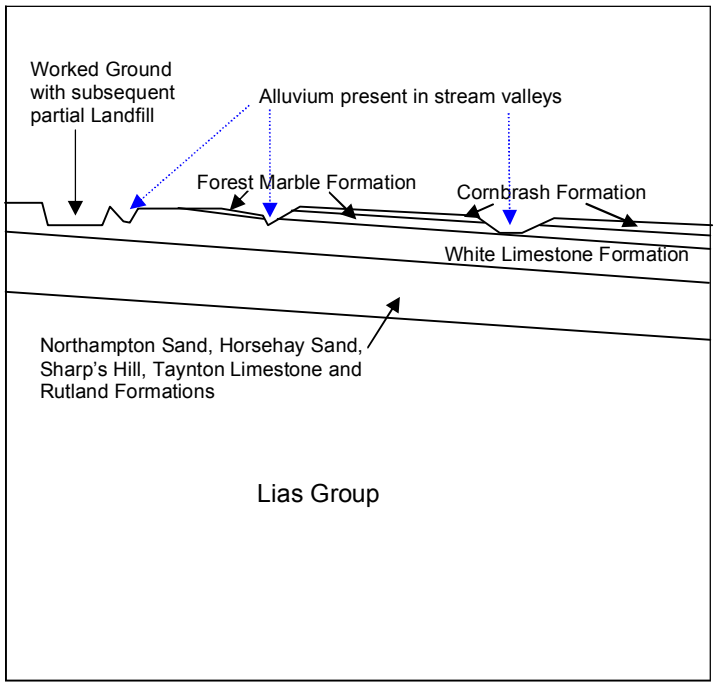
Section 2 describes the level of Radon Protective Measures required during the construction of new buildings or extensions to existing buildings, at the site. This determination complies with information set out in *BR211 Radon: Guidance on protective measures for new dwellings (2007edition)*, which also provides guidance on what to do if the result indicates that protective measures are required (please see BRE Website for more details: www.bre.co.uk/radon). This assessment is based on the Radon Potential Dataset produced jointly by the BGS and the Health Protection Agency (for more information please see the BGS website at www.bgs.ac.uk/radon).

Section 4: Schematic Geological Cross-Section of the Site

Not to scale

grid ref of north-west side of site [4]5385 [2]2653

grid ref of south-east side of site [4]5775 [2]2335



This sketch represents an interpretation of the geometrical relationships of the main rock units described in the text. Not to scale.

Section 5: Geological maps

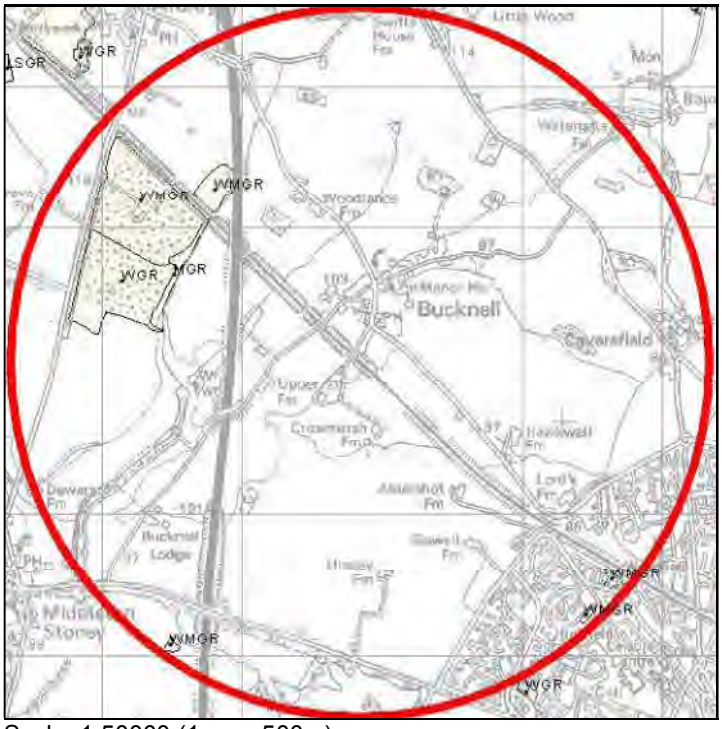
Extracts of geology maps around your site are provided in this section, taken from the BGS Digital Geological Map of Great Britain at the 1:50,000 scale (DiGMapGB-50). The first four maps show separately the four main layers of geology that may be present in an area – **artificial (man-made) deposits**, **landslip deposits**, **superficial deposits** and **bedrock**. The fifth 'combined geology' map shows all four rock layers superimposed on the same map, to show the rocks that occur at the surface just beneath the soil.

More information on DiGMapGB-50 and how the various rock layers are classified can be found on the BGS website (www.bgs.ac.uk), under the DiGMap and BGS Rock Classification Scheme areas. Further descriptions of the rocks listed in the map keys can also be obtained by searching against the Computer Code on the *BGS Lexicon of named Rock Units*, which is also on the BGS Website at by following the 'GeoData' link. The computer codes are labelled on the maps to try and help in their interpretation (with a dot at the bottom left hand corner of each label). However, please treat this with caution in areas of complex geology, where some of the labels may overlap several geological formations. If in doubt, please contact BGS enquiries.

The geological formations are listed broadly in order of age in the map keys (youngest first) but only to the formation level (a formation is a package of related rocks). Within formations, please be aware that individual members may not be ordered by age.

Artificial deposits

These include deposits moved and disturbed by man.



Scale: 1:50000 (1cm = 500m)

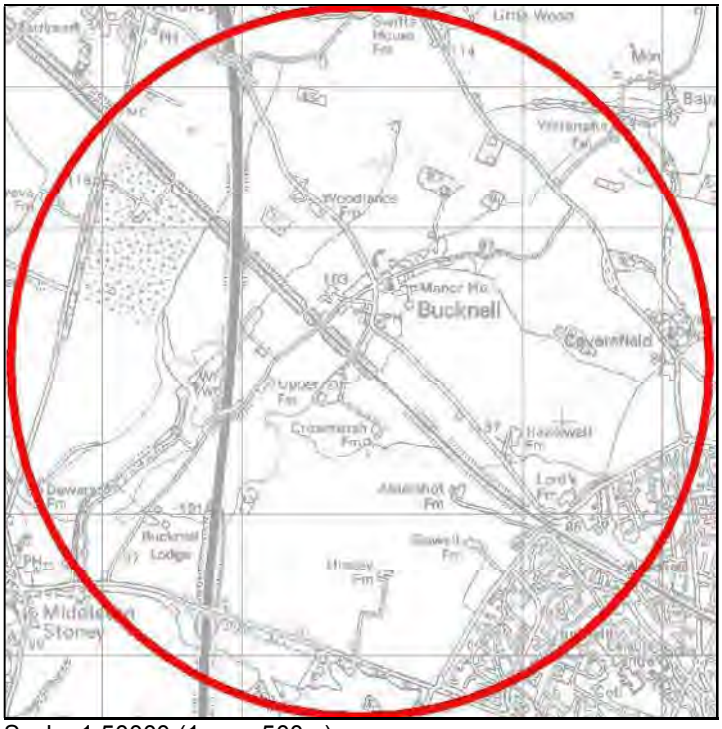
SITE LOCATION

Key to Artificial deposits:

Map colour	Computer Code	Rock name	Rock type
	LSGR	LANDSCAPED GROUND (UNDIVIDED)	UNKNOWN/UNCLASSIFIED ENTRY
	MGR	MADE GROUND (UNDIVIDED)	ARTIFICIAL DEPOSIT
	WGR	WORKED GROUND (UNDIVIDED)	VOID
	WMGR	INFILLED GROUND	ARTIFICIAL DEPOSIT

Landslip deposits

These include natural deposits formed by sliding and mass-movement of soils and rocks on hill slopes (an alternative term for Landslip deposits is 'Mass Movement Deposits')



Scale: 1:50000 (1cm = 500m)

SITE LOCATION

Key to Landslip deposits:

No deposits are mapped in the search area

Superficial deposits

These include fairly recent geological deposits, such as river sands and gravels, or glacial deposits, which lie on the bedrock in many areas (an alternative term for Superficial deposits is 'Drift Deposits')

Scale: 1:50000 (1cm = 500m)

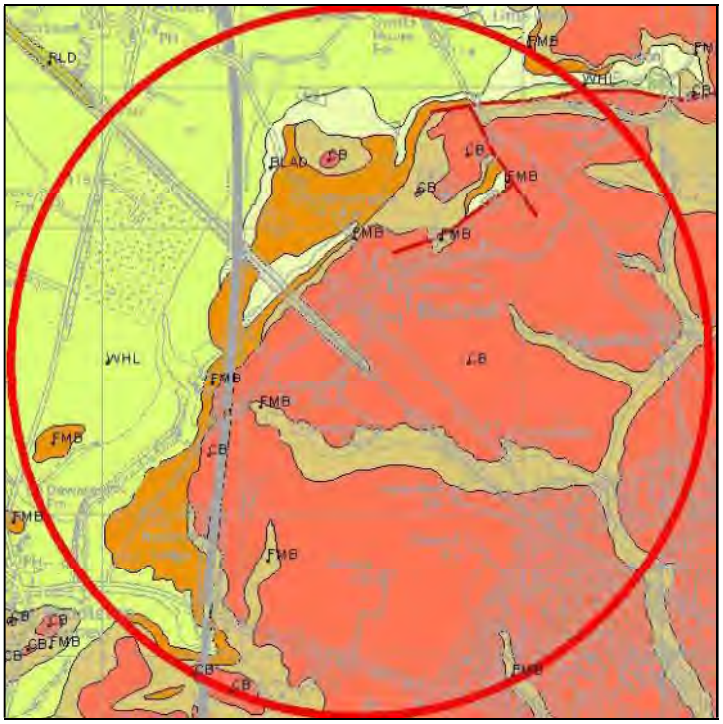
SITE LOCATION

Key to Superficial deposits:

Map colour	Computer Code	Rock name	Rock type
	ALV	ALLUVIUM	CLAY, SILT, SAND AND GRAVEL
	HEAD	HEAD	CLAY, SILT, SAND AND GRAVEL

Bedrock

Bedrock forms the ground underlying the whole of an area, upon which the other geological layers listed above may lie (an alternative term for Bedrock is 'Solid Geology')



Scale: 1:50000 (1cm = 500m)

SITE LOCATION

Fault

Coal, ironstone or other mineral vein

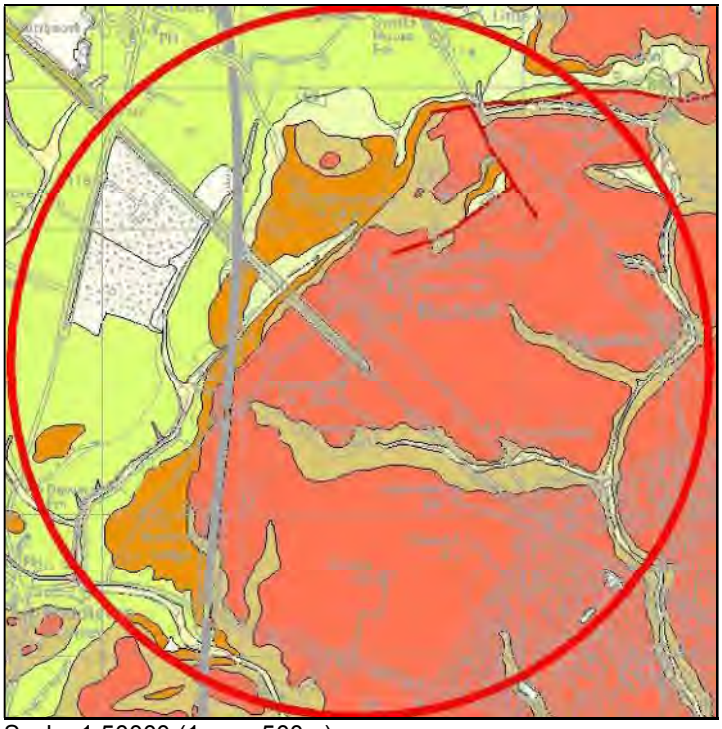
Note: Faults and Coals, ironstone & mineral veins are shown for illustration and to aid interpretation of the map. Not all such features are shown and their absence on the map face does not necessarily mean that none are present

Key to Bedrock geology:

Map colour	Computer Code	Rock name	Rock type
	CB	CORNBRASH FORMATION	LIMESTONE
	FMB	FOREST MARBLE FORMATION	LIMESTONE
	FMB	FOREST MARBLE FORMATION	LIMESTONE AND MUDSTONE, INTERBEDDED
	WHL	WHITE LIMESTONE FORMATION	LIMESTONE
	BLAD	BLADON MEMBER	MUDSTONE AND LIMESTONE, INTERBEDDED
	RLD	RUTLAND FORMATION	MUDSTONE

Combined 'Surface Geology' Map

This map shows all four rock layers overlaid from the previous maps.



Scale: 1:50000 (1cm = 500m)

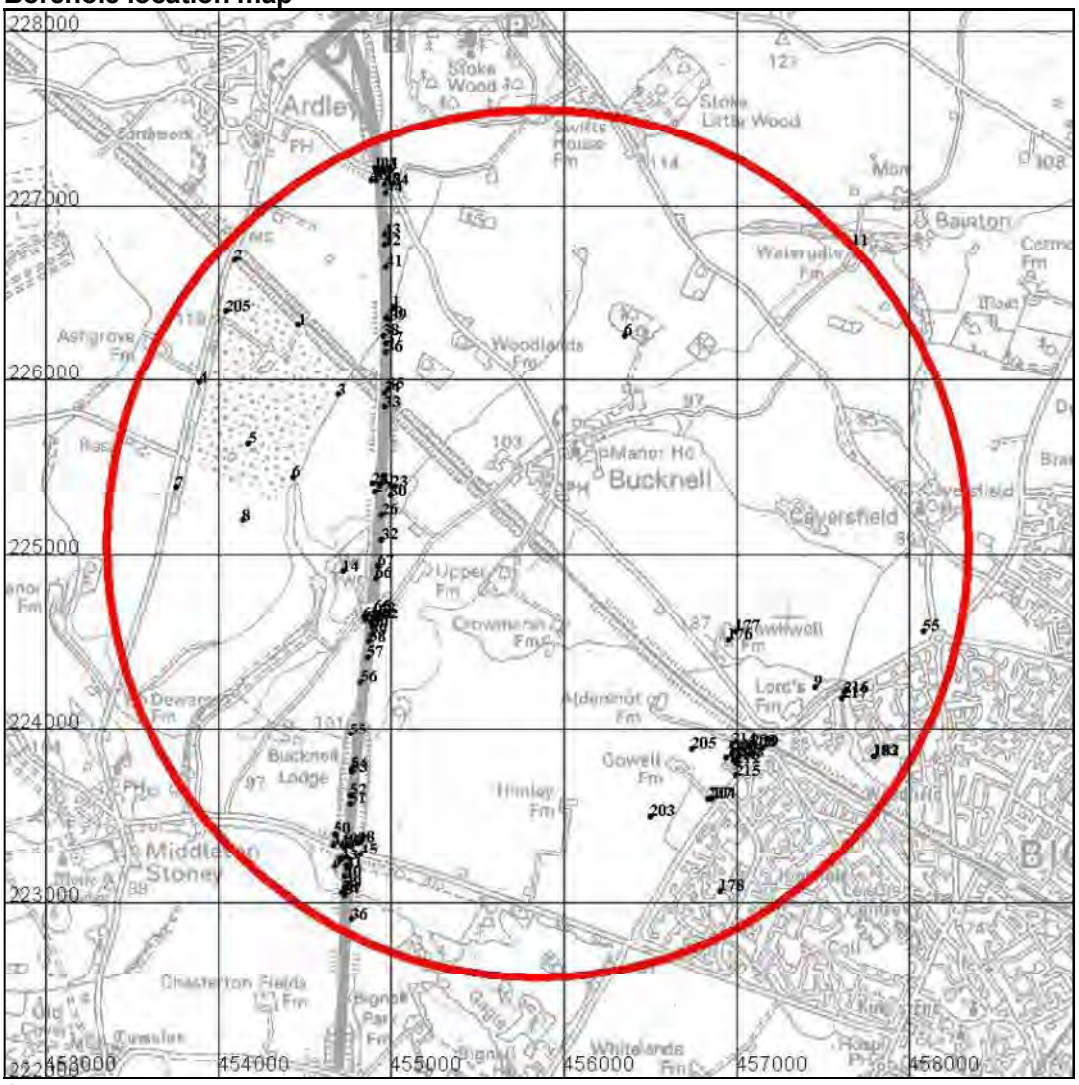
SITE LOCATION

Please see the Keys to the Artificial, Landslip, Superficial and Bedrock geology maps.

Section 6: List of geological data available around the site

This section lists the principal data sets held in the National Geoscience Records Centre that are relevant to the site. Descriptions of the data sets and how to obtain copies of records from them are given in Sections 7 and 8. Users with access to computing facilities can make their own index searches using the BGS Internet Geoscience Data Index, accessible through the BGS website at www.bgs.ac.uk

Borehole location map



Scale: 1:40000 (1cm = 400m)

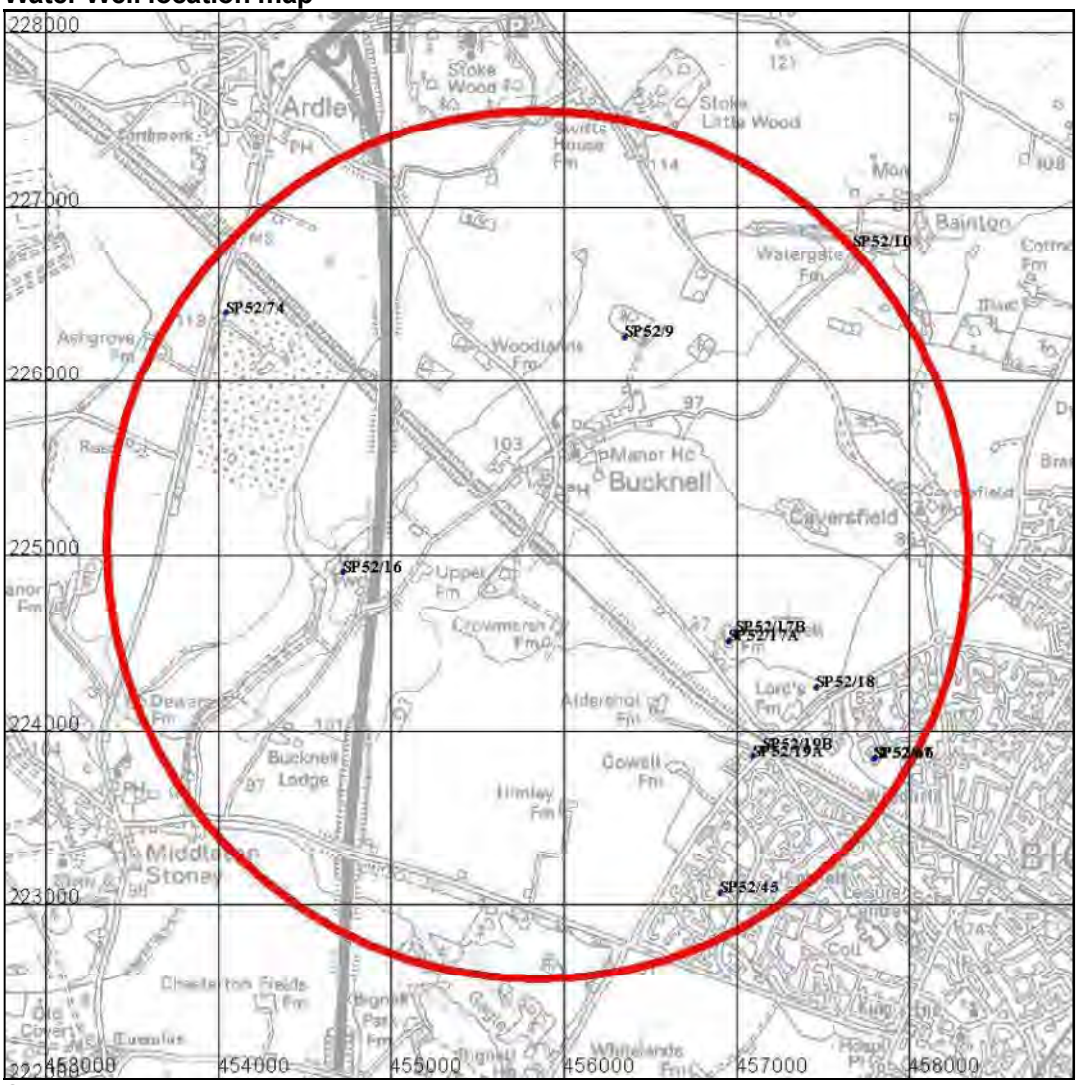
Borehole records
(A blank Length field indicates the borehole is confidential or no depth has been recorded digitally.)
Total number of records: 98

The 'Office' column shows the office at which the records are held and from where copies can be obtained (see contact details later in the report). KW=Keyworth, MH & MW=Murchison House, WL=Wallingford, EX=Exeter

Regno	Grid_reference	Name	Length	Office	SIR
SP52NE1	SP 55010 26410	ARDLEY FIELDS NO.10		KW	
SP52NE6	SP 56350 26250	MANOR FARM BUCKNELL	76.50	WLKW	
SP52NE11	SP 57670 26770	LODGE FARM BAINTON	40.84	WLKW	
SP52NE23	SP 55000 25381	OXFORD-BANBURY SECTION 529	1.00	KW	
SP52NE24	SP 55004 27117	OXFORD-BANBURY SECTION 547	1.00	KW	
SP52NW1	SP 54460 26310	ARDLEY FIELDS NO.1		KW	
SP52NW2	SP 54090 26680	ARDLEY FIELDS NO.2		KW	
SP52NW3	SP 54690 25910	ARDLEY FIELDS NO.3		KW	
SP52NW4	SP 53890 25980	ARDLEY FIELDS NO.4		KW	
SP52NW5	SP 54170 25630	ARDLEY FIELDS NO.5		KW	
SP52NW6	SP 54430 25440	ARDLEY FIELDS NO.6		KW	
SP52NW7	SP 53750 25380	ARDLEY FIELDS NO.7		KW	
SP52NW8	SP 54140 25190	ARDLEY FIELDS NO.8		KW	
SP52NW12	SP 54930 27200	M40 ARDLEY 274P	4.00	KW	
SP52NW26	SP 54940 25220	BUCKNELL EMBKMENT E11 24000-24570 TP527	2.30	KW	313
SP52NW27	SP 54900 25350	BUCKNELL EMBKMENT E11 24000-24570 TP525	2.90	KW	313
SP52NW28	SP 54890 25400	BUCKNELL EMBKMENT E11 24000-24570 TP528	3.40	KW	313
SP52NW30	SP 54996 25329	BUCKNELL EMBKMENT E11 24000-24570 TP526	1.00	KW	313
SP52NW31	SP 54930 25390	BUCKNELL EMBKMENT E11 24000-24570 BHY2	20.00	KW	313
SP52NW32	SP 54940 25080	BUCKNELL EMBKMENT E11 24000-24570 TP524	1.00	KW	313
SP52NW33	SP 54960 25840	BUCKNELL EMBKMENT E11 24000-24570 TP531	4.00	KW	313
SP52NW34	SP 54960 25920	BUCKNELL EMBKMENT E11 24000-24570 BHY3	19.00	KW	313
SP52NW35	SP 54980 25940	BUCKNELL EMBKMENT E11 24000-24570 TP534	1.00	KW	313
SP52NW36	SP 54970 26160	BUCKNELL EMBKMENT E11 24000-24570 BH069	20.00	KW	313
SP52NW37	SP 54970 26210	BUCKNELL EMBKMENT E11 24000-24570 TP537	1.00	KW	313
SP52NW38	SP 54950 26250	BUCKNELL EMBKMENT E11 24000-24570 TP536	1.00	KW	313
SP52NW39	SP 54990 26340	BUCKNELL EMBKMENT E11 24000-24570 TP540	1.00	KW	313
SP52NW40	SP 54970 26350	BUCKNELL EMBKMENT E11 24000-24570 TP538	1.00	KW	313
SP52NW41	SP 54970 26640	BUCKNELL EMBKMENT E11 24000-24570 TP541	1.00	KW	313
SP52NW42	SP 54960 26770	ARDLEY CUTTING C10 25780-27040 TP542	1.00	KW	313
SP52NW43	SP 54960 26830	ARDLEY CUTTING C10 25780-27040 TP543	1.00	KW	313
SP52NW44	SP 54970 27070	ARDLEY CUTTING C10 25780-27040 TP545	2.00	KW	313
SP52NW45	SP 54880 27140	ARDLEY CUTTING C10 25780-27040 TP544	1.00	KW	313
SP52NW46	SP 54920 27180	ARDLEY CUTTING C10 25780-27040 TP546	1.00	KW	313
SP52NW48	SP 54960 27120	ARDLEY CUTTING C10 25780-27040 BH070	25.00	KW	313
SP52NW49	SP 54910 27140	ARDLEY CUTTING C10 25780-27040 BH070A	15.00	KW	313
SP52NW111	SP 54903 27210	M40 OXFORD-BIRMINGHAM M/W BH075	12.00	KW	3322
SP52NW205	SP 54040 26390	ARDLEY FIELDS	10.20	WLKW	
SP52SE5	SP 57090 23840	GOWELL FARM BICESTER	43.28	WLKW	
SP52SE9	SP 57450 24230	BICESTER	79.85	WLKW	
SP52SE29	SP 57150 23880	GOWELL FARM 2	43.00	WLKW	
SP52SE55	SP 58080 24550	CAVERSFIELD SEWER BICESTER BH370/5	6.00	KW	
SP52SE176	SP 56950 24500	LORDS FARM		WL	
SP52SE177	SP 56990 24550	LORDS FARM		WL	
SP52SE178	SP 56900 23060	KINGS END FARM BICESTER		WL	
SP52SE182	SP 57800 23830	SLADE FARM CAVERSFIELD	28.96	WL	
SP52SE183	SP 57790 23830	WRETCHWICK FARM BICESTER		WL	
SP52SE203	SP 56500 23490	GOWELL FARM BICESTER 1	2.25	KW	37679
SP52SE204	SP 56850 23590	GOWELL FARM BICESTER 2	1.75	KW	37679
SP52SE205	SP 56740 23870	GOWELL FARM BICESTER 3	1.37	KW	37679
SP52SE206	SP 56970 23850	GOWELL FARM BICESTER 4	1.75	KW	37679
SP52SE207	SP 56830 23590	GOWELL FARM BICESTER TP 2	1.65	KW	37679
SP52SE208	SP 57080 23890	GOWELL FARM BICESTER TP 4	1.61	KW	37679
SP52SE209	SP 56980 23860	GOWELL FARM BICESTER 2	4.22	KW	37680
SP52SE210	SP 56940 23820	GOWELL FARM BICESTER 3	4.06	KW	37680
SP52SE211	SP 56980 23810	GOWELL FARM BICESTER 4	3.49	KW	37680
SP52SE212	SP 56990 23790	GOWELL FARM BICESTER 5	4.10	KW	37680
SP52SE213	SP 57010 23820	GOWELL FARM BICESTER 6	3.66	KW	37680
SP52SE214	SP 56970 23900	GOWELL FARM BICESTER 7	3.56	KW	37680

Regno	Grid_reference	Name	Length	Office	SIR
SP52SE215	SP 56990 23720	GOWELL FARM BICESTER TP 1	0.88	KW	37680
SP52SE216	SP 57620 24200	LORDS LANE BICESTER OXFORDSHIRE 1	2.95	KW	37773
SP52SE217	SP 57610 24170	LORDS LANE BICESTER OXFORDSHIRE 2	2.80	KW	37773
SP52SW1	SP 54880 24600	M40 CARDINGTON 248P	6.00	KW	
SP52SW5	SP 54730 23310	M40 BUCKNELL LODGE 235P	8.00	KW	
SP52SW14	SP 54720 24900	TROWPOOL WELL BICESTER	7.62	WLKW	
SP52SW36	SP 54770 22900	MIDDLETON STONEY SOUTH CUTTING C8 TP495	1.00	KW	313
SP52SW37	SP 54730 23040	EAGLE BROOK EMBANKMENT E10 TP496	3.00	KW	313
SP52SW38	SP 54710 23050	EAGLE BROOK EMBANKMENT E10 BHY5	10.20	KW	313
SP52SW39	SP 54730 23080	EAGLE BROOK EMBANKMENT E10 TP498	2.00	KW	313
SP52SW40	SP 54730 23140	EAGLE BROOK EMBANKMENT E10 TP499	1.00	KW	313
SP52SW41	SP 54740 23190	EAGLE BROOK EMBANKMENT E10 TP500	2.00	KW	313
SP52SW42	SP 54670 23200	EAGLE BROOK EMBANKMENT E10 TP501	2.00	KW	313
SP52SW43	SP 54710 23240	MIDDLETON STONEY NORTH CUTTING C9 TP502	2.00	KW	313
SP52SW44	SP 54660 23330	MIDDLETON STONEY NORTH CUTTING C9 TP503	1.00	KW	313
SP52SW45	SP 54820 23270	MIDDLETON STONEY NORTH CUTTING C9 TP504	0.00	KW	313
SP52SW46	SP 54740 23330	MIDDLETON STONEY NORTH CUTTING C9 TP505	3.00	KW	313
SP52SW47	SP 54770 23320	MIDDLETON STONEY NORTH CUTTING C9 BH066	19.00	KW	313
SP52SW48	SP 54810 23340	MIDDLETON STONEY NORTH CUTTING C9 TP507	1.00	KW	313
SP52SW49	SP 54710 23330	MIDDLETON STONEY NORTH CUTTING C9 BH065	14.00	KW	313
SP52SW50	SP 54670 23390	MIDDLETON STONEY NORTH CUTTING C9 TP506	2.00	KW	313
SP52SW51	SP 54760 23560	MIDDLETON STONEY NORTH CUTTING C9 TP508	2.00	KW	313
SP52SW52	SP 54760 23610	MIDDLETON STONEY NORTH CUTTING C9 TP509	3.00	KW	313
SP52SW53	SP 54770 23740	MIDDLETON STONEY NORTH CUTTING C9 TP510	2.00	KW	313
SP52SW54	SP 54770 23760	MIDDLETON STONEY NORTH CUTTING C9 BHY1	2.00	KW	313
SP52SW55	SP 54760 23960	MIDDLETON STONEY NORTH CUTTING C9 TP511	3.00	KW	313
SP52SW56	SP 54820 24260	BUCKNELL EMBANKMENT E11 TP513	3.00	KW	313
SP52SW57	SP 54860 24400	BUCKNELL EMBANKMENT E11 TP514	3.00	KW	313
SP52SW58	SP 54870 24490	BUCKNELL EMBANKMENT E11 TP515	3.00	KW	313
SP52SW59	SP 54880 24530	BUCKNELL EMBANKMENT E11 TP516	3.00	KW	313
SP52SW60	SP 54890 24570	BUCKNELL EMBANKMENT E11 TP517	2.00	KW	313
SP52SW61	SP 54840 24630	BUCKNELL EMBANKMENT E11 TP518	3.00	KW	313
SP52SW62	SP 54940 24620	BUCKNELL EMBANKMENT E11 TP519	2.00	KW	313
SP52SW63	SP 54850 24610	BUCKNELL EMBANKMENT E11 BH067	10.00	KW	313
SP52SW64	SP 54910 24620	BUCKNELL EMBANKMENT E11 BH068	20.00	KW	313
SP52SW65	SP 54900 24670	BUCKNELL EMBANKMENT E11 TP520	1.00	KW	313
SP52SW66	SP 54910 24860	BUCKNELL EMBANKMENT E11 TP522	0.00	KW	313
SP52SW67	SP 54920 24930	BUCKNELL EMBANKMENT E11 TP523	0.00	KW	313
SP52SW68	SP 54928 24655	M40 OXFORD-BRMHAM OXFORD-BANBURY BH0685	10.00	KW	3322

Water Well location map



Scale: 1:40000 (1cm = 400m)

Water Well Records
Total number of records: 12

All these records are registered in the main Borehole Records collections (see Borehole Records Table and map above), and duplicate, or partial duplicate copies may be held at other sites (at Keyworth KW, Exeter EX or Murchison House MH). These represent records that are held in the National Well Record Archive of water wells and boreholes held at Wallingford (WF) or Murchison House (MW). The Well Registration number is used to index records in the National Well Record Archive please quote this if applying for copies of water wells (see contact details later in the report).

Additional index information may be held for the Water Well Records as indicated below, indicating the information that can be found on the well record itself. If fields are blank, then the well record has not been examined and its contents are unknown. A Yes or a No indicates that the well record has been examined and the information as indicated is, or is not, present. This information should help you when requesting copies of Records.

KEY:
Aquifer = The principal aquifer recorded in the borehole
G = Geological Information present on the log
C = Borehole construction information present on the log
W = Water level or yield information present on the log
Ch = Water chemistry information present on the log

Well Reg No.	BH Reg No.	Name	Grid Easting	Grid Northing	Depth (m)	Date	Aquifer	G	C	W	Ch
SP52/74	SP52NW205/BJ	ARDLEY FIELDS (LAND FILL SITE)	454040	226390	10.20		GREAT OOLITE GROUP	Yes	Yes	Yes	No
SP52/9	SP52NE6/BJ	MANOR FARM BUCKNELL	456350	226250	76.50	1924	UNKNOWN	Yes	Yes	Yes	No
SP52/10	SP52NE11/BJ	LODGE FARM BAINTON	457670	226770	41.00	1949	UNKNOWN	Yes	Yes	Yes	No
SP52/16	SP52SW14/BJ	BUCKNELL P.S.	454720	224900	7.60		GREAT OOLITE GROUP	Yes	Yes	Yes	Yes
SP52/19A	SP52SE5/BJ	BICESTER P.S.	457090	223840	34.20	1905	GREAT OOLITE GROUP	Yes	Yes	Yes	Yes
SP52/17A	SP52SE176/BJ	LORDS FARM, BICESTER	456950	224500	3.70		GREAT OOLITE GROUP	No	Yes	No	No
SP52/67	SP52SE183/BJ	WRETCHWICK FARM BICESTER	457790	223830			UNKNOWN	No	Yes	No	No
SP52/17B	SP52SE177/BJ	LORDS FARM, BICESTER	456990	224550	3.70		GREAT OOLITE GROUP	No	Yes	No	No
SP52/45	SP52SE178/BJ	KINGS END FARM BICESTER	456900	223060			UNKNOWN	No	Yes	No	No
SP52/66	SP52SE182/BJ	SLADE FARM CAVERSFIELD	457800	223830	29.00	1909	GREAT OOLITE GROUP	Yes	Yes	Yes	No
SP52/18	SP52SE9/BJ	LORDS FARM BICESTER	457460	224240	79.90		UNKNOWN	Yes	Yes	Yes	No
SP52/19B	SP52SE29/BJ	BICESTER P.S.	457150	223880	42.80	1936	UNKNOWN	Yes	Yes	Yes	Yes

Boreholes with water level readings
Total number of records: 1

Reference	Easting	Northing	Location	Start_date	End_date	Readings
SP52/19	457130	223870	EX BICESTER P.S.			

There are no records for Locations with aquifer properties in the selected area

Site investigation reports
Total number of records: 26

Number	Office	Title
313	KW	OXFORD TO BIRMINGHAM NEW ROUTE WENDLEBURY TO SOULDERN SECTION
1440	KW	BICESTER RAF PROJECT NRS 84-0177 AND 87-0234 REPLACEMENT OF WATER MAINS
2438	KW	UPPER HEYFORD RAF CONSOLIDATED SUPPORT CENTRE
3310	KW	M40 OXFORD TO BIRMINGHAM MOTORWAY BANBURY BY PASS
3322	KW	M40 OXFORD TO BIRMINGHAM MOTORWAY OXFORD TO BANBURY SECTION
6285	KW	OXFORD TO BIRMINGHAM M40 MOTORWAY
6292	KW	BICESTER SOUTHERN BYPASS INTERPRETATIVE REPORT EMBANKMENT DESIGN SUPPLEMENT LONDON-BIRMINGHAM-BIRKEHEAD TRUNK ROAD A41
6293	KW	BICESTER SOUTHERN BYPASS INTERPRETATIVE REPORT EMBANKMENT DESIGN SUPPLEMENT LONDON-BIRMINGHAM-BIRKEHEAD TRUNK ROAD A41
6812	KW	A43: M40 TO B4031 IMPROVEMENT
7811	KW	RAF UPPER HEYFORD BASE THEATR
17835	KW	A43:M40 TP B4031 IMPROVEMENT
17836	KW	A43:M40 TO B4031 IMPROVEMENT
17838	KW	A43:M40 TO B4031 IMPROVEMENT SUPPLEMENTARY GROUND INVESTIGATION
19905	KW	BICESTER SOUTHERN BY-PASS
27597	KW	LANGFORD VILLAGE BICESTER
35484	KW	FEWCOTT ROAD FRITWELL
37469	KW	LAUNTON ROAD BICESTER OXFORD
37552	KW	TELFORD ROAD BICESTER
37595	KW	RAF UPPER HEYFORD OXFORDSHIRE
37679	KW	GOWELL FARM BICESTER OXFORDSHIRE
37680	KW	GOWELL FARM BICESTER OXFORDSHIRE
37773	KW	LORDS LANE BICESTER OXFORDSHIRE
37835	KW	MAIN STREET STOKE LYNE
37884	KW	EURO 5 DISTRIBUTION CENTRE ARDLEY OXFORDSHIRE
37988	KW	ROYAL ORDNANCE BICESTER OXFORDSHIRE
43801	KW	RAF BASE UPPER HEYFORD

National Grid geological maps (1:10,000 and 1:10,560 scale)
Total number of records: 4

Map	Type	Survey	Published	Revision
SP52NE	C	2000	2000	
SP52NW	C	2000	2000	2000
SP52SE	C	1999	2000	
SP52SW	C	1999	2000	

There are no records for County Series geological maps (1:10,560 scale) in the selected area

New Series medium scale geological maps (1:50,000 and 1:63360 scale)
Total number of records: 1

Sheet	Title	Type	Survey	Published	Revision
219	Buckingham	C	2000	2002	

Old Series one inch geological maps (1:63360 scale)
Total number of records: 3

Sheet	Title	Type	Survey	Published	Revision
45NE	Buckingham	D		1873	
45NE	Buckingham	S		1871	
45SE	Bicester	S		1863	

There are no records for Hydrogeological maps (various scales) in the selected area

Geological Memoirs
Total number of records: 1

Title	Date
Buckingham	2002

There are no records for Technical reports in the selected area

There are no records for Waste sites in the selected area

Mining plans
Total number of records: 3

Record Type	Plan No.	Title
KP	12374	OXFORDSHIRE/BANBURY PROSPECT 1984-1985 VIBROSEIS PLANING MAP
KP	12375	OXFORDSHIRE/BANBURY PROSPECT NCB & OIL COMPANY DATA TRADED & UNTRADED 1984
KP	18191	WESTPHALIAN A & B OF THE COALFIELDS OF ENGLAND & WALES (INCLUDING CANONBIE)

Section 7: Descriptions of BGS databases

Note that this report is not a definitive listing of all data held in BGS.

Borehole Records and Water Wells

Records of boreholes, shafts and wells from all forms of drilling and site investigation work. Some 900,000 records dating back over 200 years and ranging from one to several thousand metres deep. Currently some 50,000 new records are being added to the collection each year.

A small percentage of the borehole records are held commercial-in-confidence for various reasons and cannot be released without the written permission of the originator. If any of the records you need are listed as confidential apply in the normal way. BGS Enquiry Service staff will release the data where this is possible or provide you with the information needed to contact the originator.

Where records are held in more than one office, the contents may differ. Enquiries principally requiring water related information should contact the Wallingford or Edinburgh office.

Water levels

These represent a subset of records within the National Well Record Archive of water wells and boreholes where there are either digital or analogue time series of water levels, or where available water level data span multiple years. Time series data are held for approximately 1500 boreholes distributed nationally. Other water level data is available where records have been inspected and digitised. Record's, are identified by the Well Registration number used for water wells (see above). Please contact our Wallingford office to discuss your specific requirements and to obtain costs.

Aquifer properties

These are locations where data on aquifer physical properties (transmissivity, specific yield, storage, porosity or hydraulic conductivity) are held. The data include raw data from field and laboratory investigations, and site-specific summaries of the data. Coverage is limited to aquifers in England and Wales. Records are identified by an aquifer property identifier, which should be quoted when ordering data. This data should be ordered separately, but will normally be provided and charged for as part of the relevant borehole records.

Site investigation reports

Additional laboratory and test data may be available in these reports, subject to any copyright and confidentiality conditions. The grid references used are based on an un-refined rectangle and therefore may not be applicable to a specific site. Borehole records in these reports will be individually referenced within the borehole records collection, described above.

Geological maps

- **National Grid maps (1:10,000 and 1:10560 scale) -** Since the 1960s the standard large-scale map for recording geological information has been the Ordnance Survey (OS) quarter sheet covering a 5km square area. The maps are supplied in different formats depending on their age and the method of reproduction used. Only the latest most up-to-date version is listed.

- **County Series map sheets (1:10,560 scale) -** Maps produced on OS County Series sheets between approximately 1860 and 1960. The list indicates distinct examples of maps from separate surveys or revisions. It is advisable to discuss your requirements before ordering or travelling to view these maps.

- **New Series medium scale maps (1:50,000 and 1:63360 scale)** - Maps at either scale covering the OS New Series one-inch map sheet areas used by BGS. Please note that the sheet numbering is not the same as used for current OS 1:50,000 topographic maps.

- **Old Series medium scale one-inch maps (1:63,360 scale) -** Early geological mapping covering the OS Old Series one-inch map sheet areas. Applies to England and Wales only.

While there may be information relevant to your enquiry on older maps, you will generally want the latest

edition, and National Grid maps will be preferred to County Series maps, and New Series to Old Series.

Memoirs

Explanatory sheet memoirs describing the geology of the areas covered by either the medium scale (1:50,000 and 1:63,360) map series.

Technical reports

The open file reports listed are mainly from the Onshore Geology Series. These include descriptions of the geology for the National Grid series geological sheets. Please note that the location details in the database are not yet complete so it is possible that not all the relevant reports available will be listed.

Waste sites

Listing of some 3500 waste sites for England and Wales identified by BGS as part of a survey carried out on behalf of the Department of the Environment in 1973. Later information is available from the Environment Agency.

Mine Plans

Plans of various types, principally relating to mining activity and including abandonment plans. For mine plans, the coverage is not comprehensive, but that for Scotland is the most complete. The search includes the collection of Plans of Abandoned Mines (Other than Coal & Oil Shale) for Scotland and the non-coal plans in the BGS Land Survey Plans collection, (mainly Scotland). Microfilm copies of the Plans of Abandoned Mines (Coal & Oil Shale) for Scotland and the Coal Authority's catalogues are available for consultation by prior appointment.

The mine plans listed for the rest of England and Wales (excluding SW England, which is not covered) include working copies, compilations and interpretations, which may be copyright or confidential and therefore not be available for purchase. The general nature of some of the plans means that they may not be applicable to a specific site. However, the presence of mining data could indicate that further specialist advice or interpretation is required. Large-scale plans produced for site investigations or other purposes are also included for completeness.

Section 8: How to access or inspect data

Borehole Records – *contact BGS Enquiry Service (see end of section)*

Copies of borehole records can be supplied (order form enclosed) at the flat rate of £13 (+VAT) per log with a minimum charge £26 (+VAT). Normal first class postage within the UK is included. Next day recorded delivery or express parcel dispatch is available on request and charged at cost. Copies of documents can be forwarded by facsimile transmission at an additional charge of £0.50 (+VAT) per A4 sheet. Records with additional detailed geological information derived from BGS examination of borehole material may be charged at the current 'value-added' rate. If you have a need for data with particular geological characteristics, then please contact the enquiries office to discuss your requirements (additional charges may apply).

Alternatively you can make an appointment to visit the relevant enquiry office and examine the records yourself. The Commercial User Ticket (see below) covers inspection of the borehole logs and includes access to a set of relevant documents for one unit area (typically a 5 km x 5 km area). A further charge of £19 (+ VAT) is due for each additional set examined. Data can be freely extracted from the records but any copies requested will be charged as above.

Water wells – *contact BGS Enquiry Service*

Copies of records can be supplied (order form enclosed) at the flat rate of £13 (+VAT) per log with a minimum charge £26 (+VAT). Normal first class postage within the UK is included. Next day recorded delivery or express parcel dispatch is available on request and charged at cost. Copies of documents can be forwarded by facsimile transmission at an additional charge of £0.50 (+VAT) per A4 sheet.
If you have a need for data with particular hydrogeological characteristics, then please contact the relevant enquiries office (England and Wales =Wallingford, Scotland=Edinburgh) to discuss your

requirements (additional charges may apply).

Alternatively you can make an appointment to visit the relevant enquiry office and examine the records yourself.

Records for England and Wales are held at Wallingford where the visitor charge is £9.50/hour (+VAT, with a minimum charge of £19 (+VAT).

Records for Scotland are held with the borehole records at our Edinburgh office the above Borehole Record charges cover them and apply.

BGS Memoirs, maps and open file reports – *contact BGS Sales (details below)*

BGS Memoirs, maps and open file reports relevant to your area can be examined in the appropriate BGS Library. Copies can be ordered from our main Sales Desk: Sales Desk, British Geological Survey, Keyworth, Nottingham NG12 5GG Tel: 0115 936 3241, Fax: 0115 936 3488, E-mail: sales@bgs.ac.uk.

Sales Desks are also located in Edinburgh; Tel: 0131 650 0358, Fax: 0131 667 2785, E-mail: scotsales@bgs.ac.uk, and London; Tel: 020 7589 4090, Fax: 020 7584 8270, E-mail: bgslondon@bgs.ac.uk. BGS London also maintains a reference collection of all BGS publications.

Please check price and P&P before ordering.

Waste Sites – *contact BGS Enquiry Service*

Copies of register entries, containing a variety of levels of data recording, can be obtained from the BGS Enquiry Service (price on application). The registers can also be inspected by visit (see above)

Mine Plans – *contact BGS Enquiry Service*

Mine Plans are available for consultation by prior appointment. Copies can also be obtained - price on application.

Commercial User Ticket – *contact BGS Enquiry Service*

A combined day ticket for commercial visitors to the National Geological Data Centre and the Library is £55 (+VAT) and there is a £33 (+VAT) day ticket for visitors who only wish to use the Library. Frequent visitors can purchase an annual subscription at £275 (+VAT) for access to the NGDC and the Library or £155 (+VAT) for use of the Library only. Further details can be provided on request.

BGS ENQUIRY SERVICE Contact Details:

Keyworth (KW) Office
For Borehole and other records (excluding water well records & hydrogeological data) in England & Wales (excluding Northern England, and Devon & Cornwall):
Records & Data Enquiries
Kingsley Dunham Centre
Keyworth
Nottingham
NG12 5GG
Tel: 0115 9363143
Fax: 01159 363276

Exeter (EX) Office
For Borehole and other records (excluding water well records & hydrogeological data) in Devon & Cornwall:
Records & Data Enquiries
BGS Exeter Business Centre
Forde House
Park Five Business Centre
Harrier Way
Sowton
Exeter
Devon
EX2 7HU
Tel: 01392 445271
Fax: 01392 445371

Wallingford (WL) Office
For water well records and hydrogeological data (water levels, water chemistry and aquifer properties) in England & Wales:
Records & Data Enquiries
British Geological Survey,
Maclean Building,
Wallingford,
Oxford
OX10 8BB.
United Kingdom
Tel: 01491 838800
Fax: 01491 692345
Email: hydroenq@bgs.ac.uk

Murchison House (MH or MW) Office:
For water well records and hydrogeological data for Scotland, and all other records in Scotland & Northern England:
Records & Data Enquiries
Murchison House
West Mains Road
Edinburgh
EH9 3LA
Tel: 0131 650 0282
Fax: 0131 650 0252
Email: boreholesnorth@bgs.ac.uk

Section 9: More detailed geological reports available from BGS

This report forms part of the GeoReports range offered by the BGS Enquiry Service, including reports describing site geology, hydrogeology and geological hazards. For details on these please contact:

BGS Central Enquiries Desk
British Geological Survey
Kingsley Dunham Centre
Keyworth
Nottingham
NG12 5GG
Tel: 0115 936 3143
Fax: 0115 936 3276
Email: enquiries@bgs.ac.uk

Or visit the GeoReports online shop at www.bgs.ac.uk/georeports

Section 10: Supporting Information

- The geological map extracts in Section 5 of this report are extracted from the BGS 1:50,000 scale Digital Geological Map of Great Britain (DiGMapGB-50). More information on DiGMapGB-50 can be found on the BGS website at http://www.bgs.ac.uk/products/digitalmaps/digmapgb_50.html
- Further descriptions of the rocks listed in the map keys in Section 4 can be obtained by searching against the Computer Code (in the map Key) on the *BGS Lexicon of named Rock Units*, which can be found on the BGS Website at www.bgs.ac.uk by following the 'GeoData' link
- Descriptions of how the various rock layers identified on the maps are classified can be found in the BGS Rock Classification Scheme.

Section 11: Terms and Conditions

General Terms & Conditions

This report is supplied in accordance with the GeoReports Terms & Conditions available on the BGS website at www.bgs.ac.uk/georeports and also available from the BGS Central Enquiries Desk at the above address.

Important notes about this report

- The data, information and related records supplied in this report by BGS can only be indicative and should not be taken as a substitute for specialist interpretations, professional advice and/or detailed site investigations. You must seek professional advice before making technical interpretations on the basis of the materials provided.
- Geological observations and interpretations are made according to the prevailing understanding of the subject at the time. The quality of such observations and interpretations may be affected by the availability of new data, by subsequent advances in knowledge, improved methods of interpretation, and better access to sampling locations.
- Raw data may have been transcribed from analogue to digital format, or may have been acquired by means of automated measuring techniques. Although such processes are subjected to quality control to ensure reliability where possible, some raw data may have been processed without human intervention and may in consequence contain undetected errors.
- Detail, which is clearly defined and accurately depicted on large-scale maps may be lost when small-scale maps are derived from them.
- Although samples and records are maintained with all reasonable care, there may be some deterioration in the long term.
- The most appropriate techniques for copying original records are used, but there may be some loss of detail and dimensional distortion when such records are copied.
- Data may be compiled from the disparate sources of information at BGS's disposal, including material donated to BGS by third parties, and may not originally have been subject to any verification or other quality control process.
- Data, information and related records, which have been donated to BGS, have been produced for a specific purpose, and that may affect the type and completeness of the data recorded and any interpretation. The nature and purpose of data collection, and the age of the resultant material may render it unsuitable for certain applications/uses. You must verify the suitability of the material for your intended usage.
- If a report or other output is produced for you on the basis of data you have provided to BGS, or your own data input into a BGS system, please do not rely on it as a source of information about other areas or geological features, as the report may omit important details.
- The topography shown on any map extracts is based on the latest OS mapping and is not necessarily the same as that used in the original compilation of the BGS geological map, and to which the geological linework available at that time was fitted.

Report issued by:

BGS Enquiry Service

Appendix G

TurfTrax Report

A report to Bicester Town Council on a Tier 1 hydrological risk assessment of an area of land identified for development as a new cemetery on the NW outskirts of Bicester.

6th March 2008

Directors: AF Mills, Dr. R Earl and N Green
TurfTrax Ground Management Systems Limited
Registered Office: Chequers Court
31 Brown Street • Salisbury • SP1 2AS
Company Registration Number: 4135392

Bicester Town Council

A report to Bicester Town Council on a Tier 1 hydrological risk assessment of an area of land identified for development as a new cemetery on the NW outskirts of Bicester.

Table of Contents

1 Executive summary

Peter Mitchell Associates, on behalf of TurfTrax Ground Management Systems Limited, have completed a Tier 1 hydrological risk assessment of land being considered for development as a new cemetery for Bicester. The key issues that have been identified are summarised below.

The Council has identified broad areas of land on the outskirts of the town. This report is an initial assessment of the identified site to the NW to establish its suitability for use as a cemetery. In order to study independent data concerning the site, a Detailed Geological Assessment report was commissioned from the British Geological Survey (BGS). This Assessment is attached as an appendix to this report and extracts from it have been incorporated into the text below.

The vulnerability ranking assigned to this site is 'Moderate', and the numbers of anticipated annual burials gives a Risk Rating of 'High'.

The site characteristics that raised the vulnerability score were:

- Absence of superficial deposits
- High water table
- Aquifer – the area is underlain by a minor aquifer

Subject to appropriate site investigations and agreement with the EA, it may be possible to either adjust the risk rating of the site or to design measures, such as drainage or specifications for burials, to mitigate risk to groundwater.

It is recommended that this report and the accompanying BGS report be sent to the EA, and dialogue should be established with the EA, to ascertain it's requirements for further assessment of this site's suitability for development as a cemetery.

Subject to the outcome of this dialogue, if detailed site investigations were thought desirable, it is proposed that a specific area for development is identified and that this should be subject to the following site investigative works:

1. A topographic survey to provide a basis for designing the cemetery and any necessary drainage infrastructure.

2. An electro-magnetic induction (EMI) survey to provide a basis for establishing the most appropriate locations for excavating test pits down to a maximum depth of 3.5 m and installing a minimum of three dip wells (up to 10 m deep) to monitor ground water depth. The EMI data would be shown on the site plan to two different depths (200 mm and 1.2 m).

3. Assessment of the soil profile pits, and to 'window sample' material removed during the boring of the dip wells, in terms of the type, condition and physical properties of the soil exposed. The results will be used to determine factors that may influence the appropriateness of the site for burial purposes and the vulnerability of the environment to contamination from the proposed development.

4. Monitor the groundwater levels in the dip wells over a winter period, i.e. during the period of highest rainfall.

5. Determine any appropriate options for mitigating risk to ground and surface water by improving the surface and subsurface drainage status.

Depending upon the results of this sampling and analysis, it may be possible to use the site as a cemetery subject to certain restrictions such as the installation of an appropriate drainage scheme.

2 Introduction

This report is an initial assessment of a broad area of land on the NW outskirts of Bicester with respect to it's suitability for use as a cemetery.

Whilst definitive data regarding the pollution from cemeteries is scarce, any planning application for a new cemetery will be assessed by the local Environment Agency (EA) team against their Research and Development Technical Report P223 published in 1999 entitled 'Pollution Potential of Cemeteries – Draft Guidance'. The approach to risk assessment adopted by the report can be summarised by the following excerpt:

"in order to be able to provide guidance which will enable Environment Agency staff to adopt a consistent approach when assessing the risks associated with the development of human or animal burial grounds. The guidance is directed principally at the potential threats to groundwater resources, but account is taken also of possible risks to surface waters, soils and the atmosphere"[1]

The report provides a framework for assessing the risks associated with cemeteries. The first stage is a 'Tier One' preliminary site assessment that provides an initial review of the potential pathways for contamination and receptors in proximity to the site.

The P233 report sets out the likely types and quantities of pollutants released by the burial of human bodies. The key to whether a site would be considered suitable is the rate at which such pollutants would be transported through the ground to enter water supplies:

"Pathways which pose the greatest threat to groundwaters from dissolved and particulate contaminants are those where hydrogeological factors allow rapid movement of pollutants from the source to the groundwater...

Consequently, coarse granular or heavily fractured sub-soils, fissured aquifer materials, or those of restricted mineralogy, are unlikely to offer significant opportunities for attenuation by many of the processes...By contrast, aquifers composed of sediments or rocks of mixed mineralogy and in which groundwater flows are irregular, provide more effective protection of groundwater from surface derived pollution."[2]

The EA's Technical Report P223 identifies that the number of burials in a proposed cemetery will affect the overall assessment of the environmental risk. Thus a site considered low risk in terms of groundwater vulnerability, automatically becomes a high risk proposal if more than 100 burials are anticipated each year. This relationship between vulnerability class, burial rates and level of risk is shown schematically in Figure 5.2 of P223, featured later in this report.

[1] P223 page 1
[2] P223 page 30

The first step in considering any proposed cemetery site at Bicester should therefore be to assess it against a groundwater vulnerability ranking chart (Table 1):

Table 1. Groundwater Vulnerability Ranking Chart (Table 5.1 in P223)

Ranking	**Very Low**	**Low**	**Moderate**	**High**	**Very High**
Drift type	Clay	Silt	Silty sand	Sand / gravel	Absent
Drift thickness	>5m	>3 – 5m	3m	0 – 3m	Absent
Depth to water table	>25m	11 – 25m	10m	5 – 9m	< 5m
Flow mechanism	Intergranular				Fissured
Aquifer	Non-aquifer		Minor aquifer		Major aquifer
Abstraction and Source Protection Zone	Outside Zone 111	Within Zone 111	Close to boundary of Zones 11 & 111	Within Zone 11	Within Zone 1 or <250m from private source
Watercourses and springs	>100m	>70 <100m	>50 <70m	>30m <50m	<30m
Drains	>100m	>40 <100m	30 – 40m	>10 <30m	<10m

A scoring scheme (Table 2) is used to provide a comparison mechanism:

Table 2. Scoring scheme for Tier 1 risk assessments

Vulnerability	Element score	Total score (Range)
Very low	2 – 1	16 – 8
Low	4 – 3	32 -24
Moderate	6 – 5	48 – 40
High	8 – 7	64 – 56
Very high	10 – 9	80 – 72

Using this system, a total score (range) for vulnerability class can be obtained for each site:

Table 3. Vulnerability class for Tier 1 risk assessments

Low vulnerability	8 – 32
Moderate vulnerability	32 – 56
High Vulnerability	56 – 80

The vulnerability class is then considered in the light of burial rates and an overall level of risk projected. In order to study independent data concerning the site, a Detailed Geological Assessment report was commissioned from the British Geological Survey (BGS). This Assessment is attached as an appendix to this report and diagrams and text extracts from it have been incorporated into the text below.

3 Site location and description

There are two potential sites located on the NW outskirts of Bicester as shown below:

Figure 1. Site location plan.

Figure 2. Site aerial view.

The land is predominantly under agricultural use with a relatively small area occupied by buildings. It is traversed by a stream and a railway line. The slope and principal drainage direction is to the south-east. The drainage is dendritic in pattern and tributaries run in other directions.

Site elevation ranges from 75 metres above Ordnance Datum (OD) in the stream valley in the south to 120 m in the north-west of the search area.

4 Site geology and hydrogeology

The geology of the site is summarised in Figures 3 and 4.

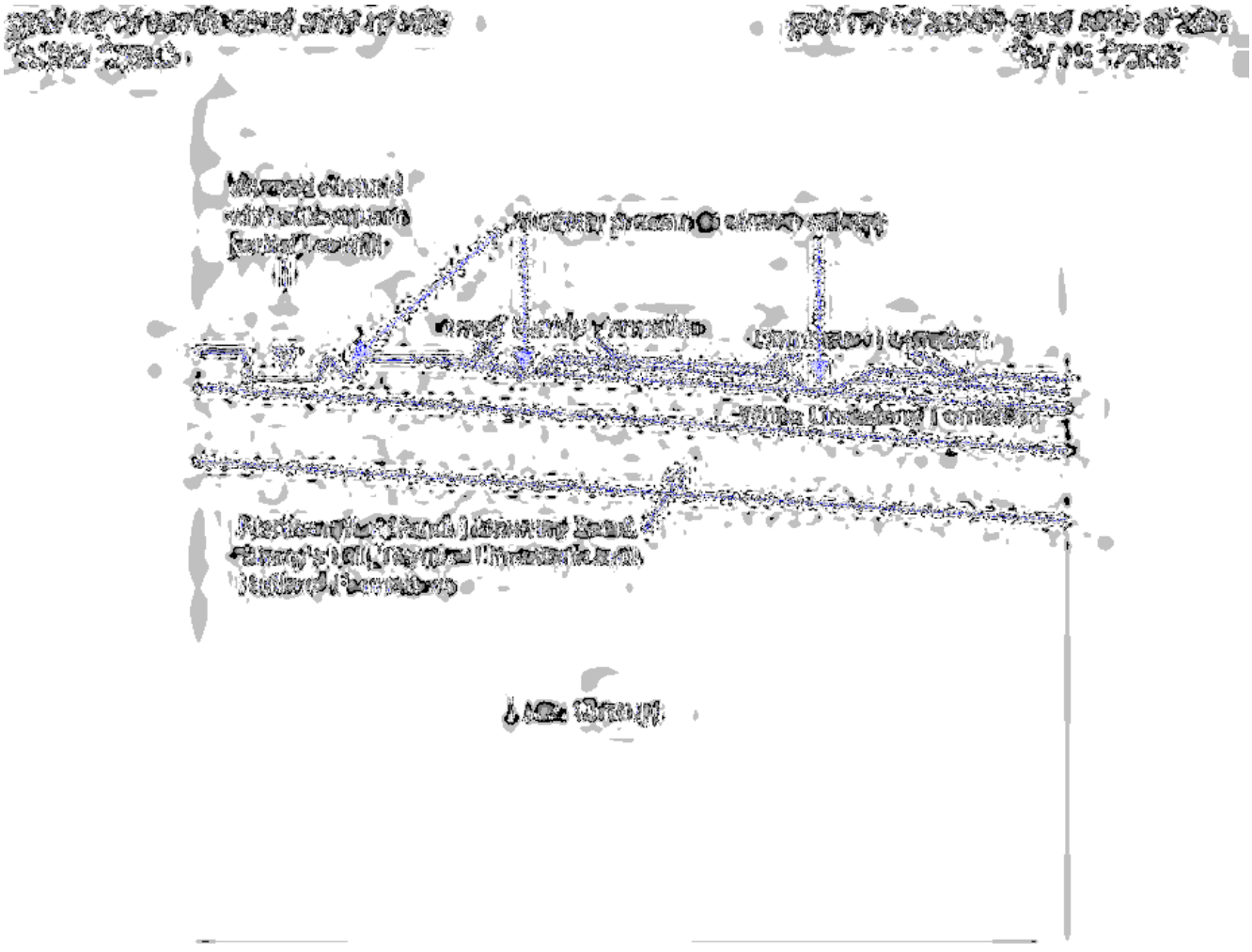


Figure 3. Schematic diagram of NW site geology.

The site identified for potential cemetery development only occupies approximately the middle third of the surface, i.e. situated on the Forest Marble Formation.

4.1 Superficial deposits (Drift)

Figure 4a. Superficial geology in the NW area.

The BGS report covers a wider area than that for the proposed cemetery development and includes land to the west of the M40 motorway and the built up area to the east of the site, hence its reference to two streams.

The streams are flanked by narrow tracts of **alluvium** of late Quaternary age, comprising sandy silty calcareous clay overlying gravelly sandy silty clay, with limestone clasts. The alluvial deposits are up to 150 m wide, are generally between 1 to 2 m in thickness (rarely exceeding 3 m in thickness). They may locally include highly compressible, organic-rich (peaty) layers.

Locally, hollows in these valley sides are floored by thin deposits of **head**, formed by soil creep or hill wash. Their composition reflects that of the local materials from which they were derived, either the bedrock or other types of superficial deposit, or both in combination. Head deposits typically are poorly stratified and poorly sorted, and can be variable in composition. Locally, they are typically composed of variably stony sandy silty clay. Head deposits may be more extensive than shown on the geological map, but if so, probably only as a layer between 0.3 m and 1 m in thickness, and possibly discontinuous.

It can be appreciated that the location of any cemetery development would not include either stream. There are thus effectively no superficial deposits within the search area.

4.2 Rockhead depth

Rockhead is close to the surface.

4.3 Bedrock geology:

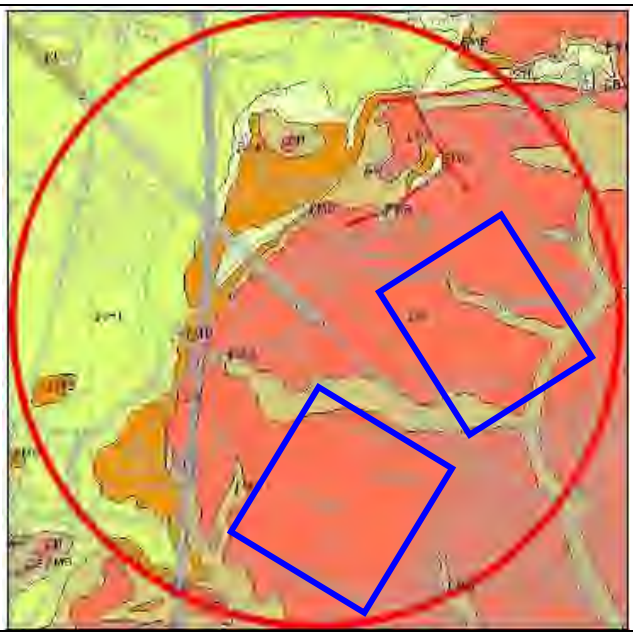


Figure 4. Bedrock geology in the NW area.

Key to bedrock geology maps:

The search area is underlain at rockhead by various formations and members of the Great Oolite Group, of Mid-Jurassic age, which are dominated by limestones with subordinate mudstone beds.

The **White Limestone Formation**, forms a broad plateau to the north-west of the proposed cemetery. This comprises 10 to 18 m thickness of white to yellow, bedded, peloidal and bioclastic limestone (see **Additional Geological Considerations** below).

The White Limestone Formation is overlain with an erosive contact by the **Forest Marble Formation**. The Forest Marble Formation forms a narrow outcrop between the White Limestone and Cornbrash Formations, and also crops out on the flanks of the stream valleys. The Formation is composed of 3 to 5 m of grey calcareous mudstone with lenticular beds of bioclastic, ooidal limestone, particularly common at the base, where they are widely distinguished on the map extracts.

The **Cornbrash Formation** is the youngest bedrock unit within the site area, cropping out over most of the area proposed as cemetery and forming a broad south-east sloping plateau. It

comprises about 3 m thick grey to brown bioclastic shelly rubbly-bedded limestone with thin subordinate beds of grey mudstone.

Mudstone beds in the Forest Marble Formation may be unstable on steep slopes or in excavations.

The limestone-dominated units of the White Limestone, Forest Marble and Cornbrash Formations may be affected by dissolution leading to the widening of joints and the formation of linear vertical voids, which are likely to fill with rubble and soil.

Additional geological considerations:

The White Limestone Formation is underlain by four further formations of the Great Oolite Group: in ascending order the Horsehay Sand, the mudstone-dominated Sharp's Hill, the Taynton Limestone and the mudstone-dominated Rutland formations, totalling about 20 m in thickness. These are underlain by the 2 to 6 m of the ferruginous sandstones of the Northampton Sand Formation. Beneath these are over 100 m of the mudstone-dominated Lias Group.

The bedrock strata dip very gently (less than 0.5°) to the south-east. Faults have been mapped to the north-east of Bucknell, beyond the proposed cemetery development, with displacements of up to about 5 m. It is important to understand the nature of geological faults, and the uncertainties which attend their mapped position at the surface. Faults are planes of movement, along which, adjacent blocks of rock strata have moved relative to each other. They commonly consist of zones, perhaps up to several tens of metres wide, containing several to many fractures. The portrayal of such faults as a single line on the geological map is therefore a generalisation. Geological faults in this area are of ancient origin, are today mainly inactive, and are thought to present no threat to property.

4.4 Hydrogeology:

With the exception of the Forest Marble Formation cropping out in the floors and sides of the valleys, the whole of the site area is underlain by Cornbrash Formation bedrock. This is a local aquifer and several water strikes have been recorded in shallow, site-investigation boreholes drilled within the site area. The rest water levels are generally slightly higher than the strike levels; both are generally between about 0.5 and 4.0 m below the ground surface.

The Forest Marble Formation, where present beneath the area, may hold small quantities of water in any limestone bands present, but the upper part generally acts as an aquiclude between the Cornbrash Formation and the underlying White Limestone Formation. There are no boreholes drilled through the Forest Marble Formation in the site area that record water strikes within it.

The White Limestone Formation constitutes a major aquifer in the area, with some sources of public supply. There are several boreholes in the wider area, some within the site area, that penetrate this formation:

- A 34 m deep borehole at Gowell Farm (SP52/19 at SP 5709 2384), drilled pre-1909 to supply Bicester with water, penetrated the complete 25 m thickness of the White Limestone Formation, underlying about 7.2 m of Forest Marble Formation and terminating in the underlying Rutland Formation. Water was struck at 28 m and 32 m below the ground level in the White Limestone Formation. The rest water level rose to the surface after the first strike, and was artesian, with a rest water level about 1 m above ground level (about 88 m above OD) after the second strike. The yield was over 7 l/s.

- An 80 m deep borehole at Lords Farm (SP52/18 at SP 5746 2424), drilled in 1941, was drilled through a similar sequence and terminated in the Lias. It struck water in the Cornbrash Formation, which was cased out, and at two levels below the White Limestone Formation. The rest water level was at 11 m below ground level (about 68 m above OD) and it yielded 1.7 l/s.

- Other records of water levels at Lords Farm (SP52/17A, B and C at about SP 569 245) show that the water level was at within 3.6 m below ground level (about 76 m above OD).

There are insufficient data to determine a groundwater flow direction, but locally it will probably be towards the nearest stream and regionally, down-dip towards the south-east.

The alluvium, and Cornbrash and Forest Marble Formations beneath the site are classified as Minor Aquifers with high soil leaching potential on the Environment Agency's Groundwater Vulnerability Map, Sheet 30, Northern Cotswolds.

5 Boreholes

The plan below shows the location of boreholes relative to the proposed cemetery development:

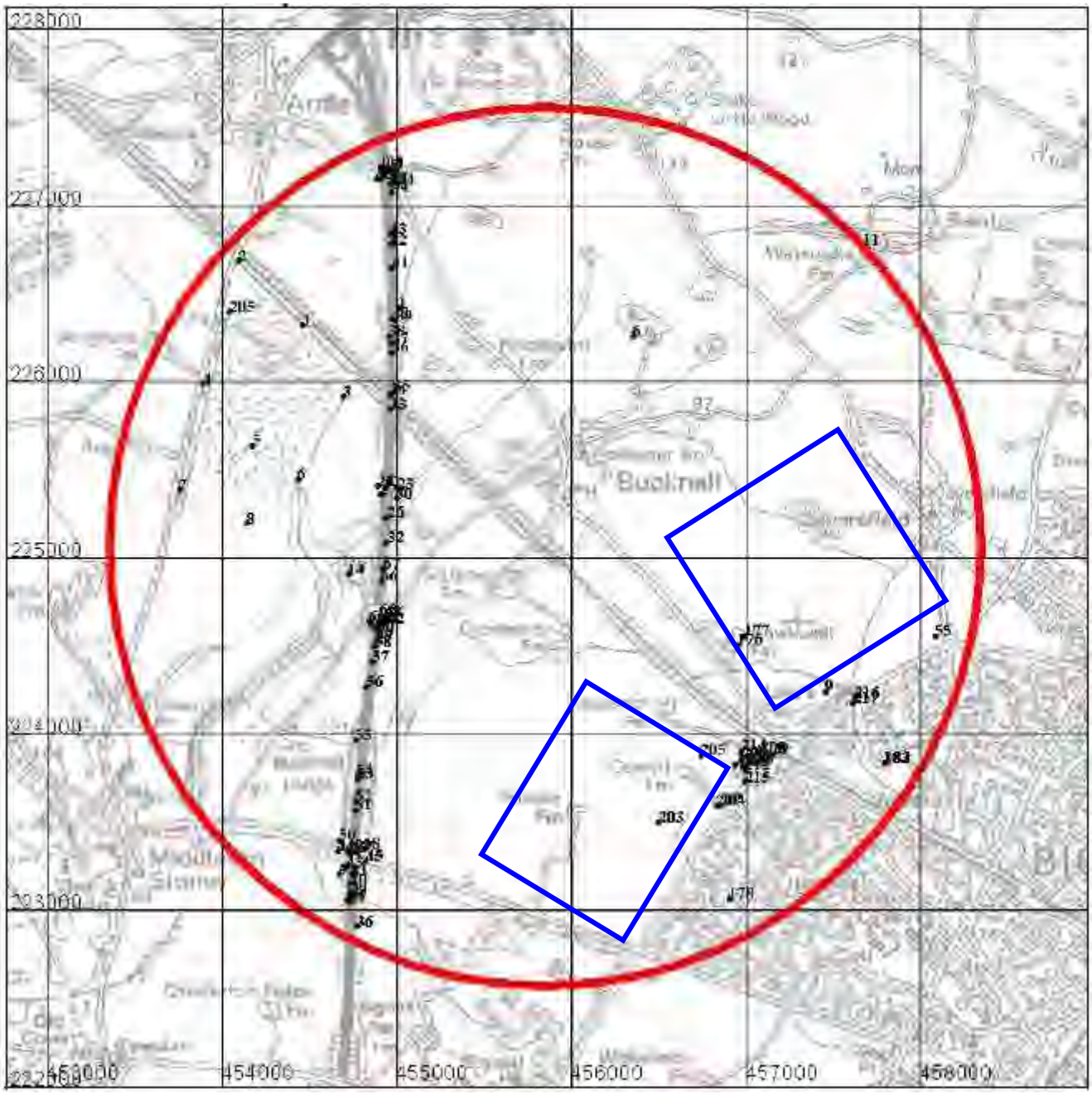


Figure 5. Site location, boreholes and watercourses.

The BGS report includes an extensive table referring to these boreholes.

6 Water wells

The plan below shows the location of water wells relative to the proposed cemetery development:

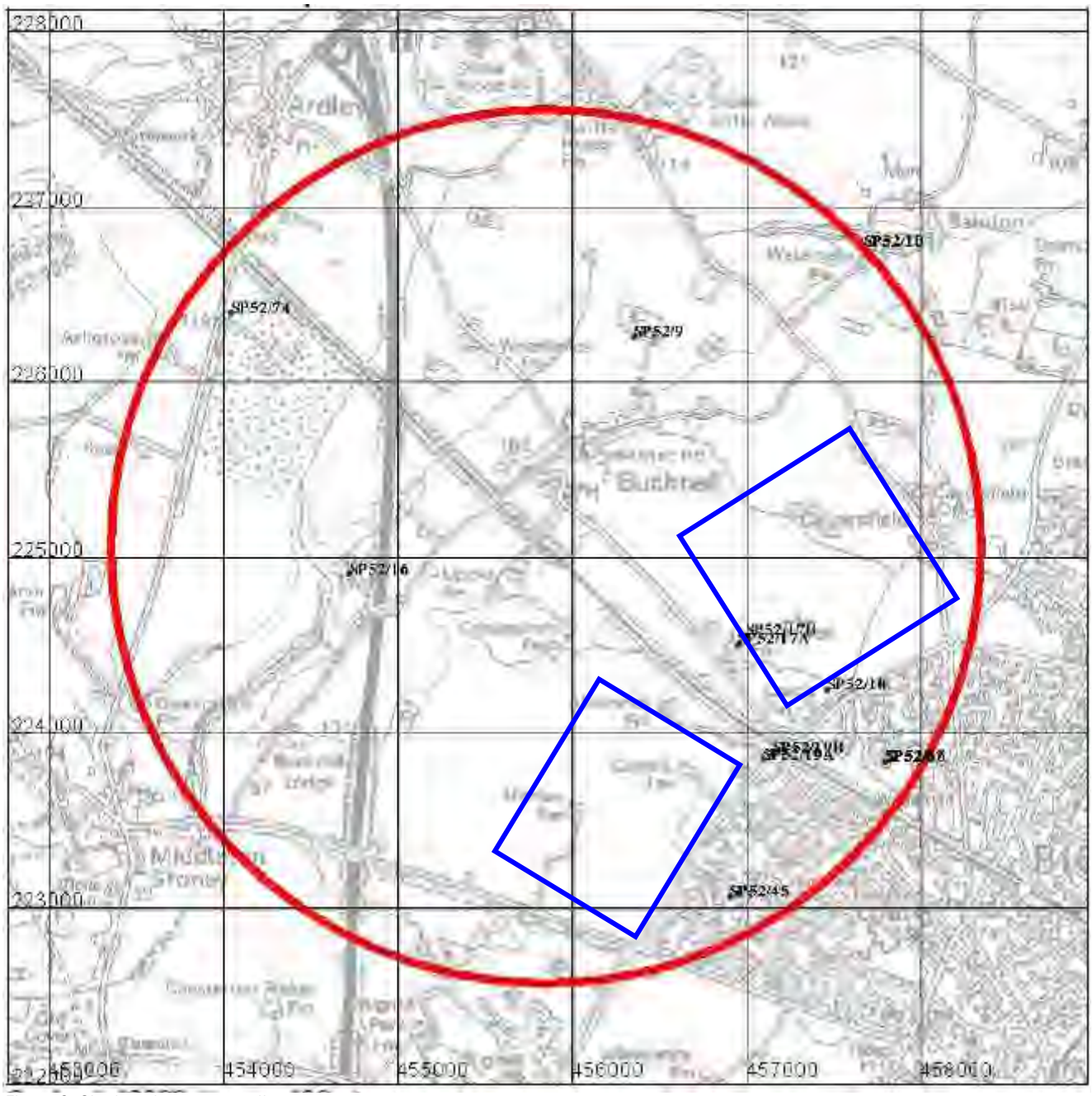


Figure 6. Site location, water wells.

The BGS report includes an extensive table referring to these water wells.

7 Indicative flood plains

According to the EA's website, the NW of Bicester lies outside any indicative flood plain (Figure 6).

Figure 6. Environment Agency website flood risk map.

8 Groundwater source protection zones (SPZs)

The Environment Agency (EA) has defined Source Protection Zones (SPZs) for 2000 groundwater sources such as wells, boreholes and springs used for public drinking water supply. These zones show the risk of contamination from any activities that might cause pollution in the area. The closer the activity, the greater the risk.

Zone 1 (Inner protection zone)
Any pollution that can travel to the borehole within 50 days from any point within the zone is classified as being inside zone 1. This applies at and below the water table. This zone also has a minimum 50 metre protection radius around the borehole. These criteria are designed to protect against the transmission of toxic chemicals and water-borne disease.

Zone 2 (Outer protection zone)
The outer zone covers pollution that takes up to 400 days to travel to the borehole, or 25% of the total catchment area – whichever area is the greatest. This travel time is the minimum amount of time that we think pollutants need to be diluted, reduced in strength or delayed by the time they reach the borehole.

Zone 3 (Total catchment)
The total catchment is the total area needed to support removal of water from the borehole, and to support any discharge from the borehole.

According to the EA's website, the Bicester area lies outside Zone 3 (Figures 7a & 7b):

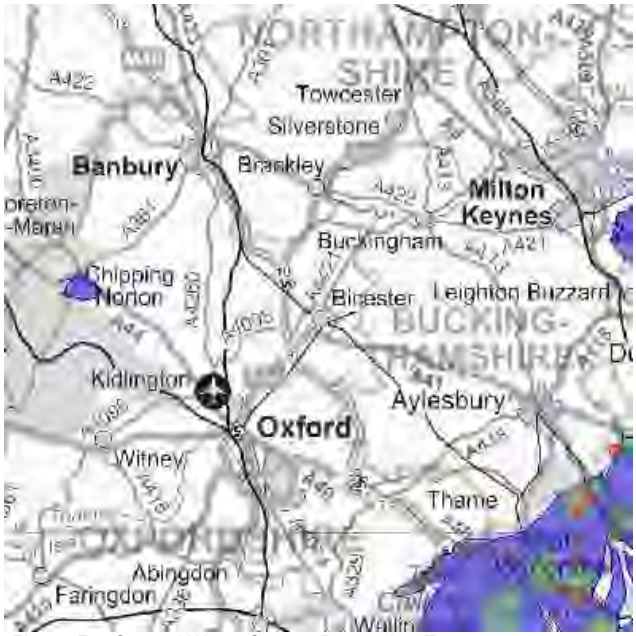


Figure 7a. Ground Water Source Protection Zones
Key: Purple = Total catchment, Green = Outer Zone, Red = Inner Zone. Taken from Environment Agency website SPZ map.

Figure 7b. Ground Water Source Protection Zones
Taken from Environment Agency website SPZ map.

9 Risk assessment

9.1 Site Vulnerability Assessment

Pertinent criteria, associated comment and assigned score are presented in Tables 4 and 5.

Table 4. Site vulnerability criteria and comment

Criteria	Comment
Drift Type	Absent
Drift Thickness	N/A
Depth to Water Table	0.5m to 4m
Flow Mechanism	Fracture Flow
Aquifer	Minor aquifer
Abstraction and SPZ	Outside SPZ 3
Watercourses and springs	>100 (subject to precise location within the identified area
Drains	None known to be present

Table 5. Site vulnerability assessment score sheet

Factor	Site Characteristics	Ranking	Score		
Drift type	Absent	Very High	10	-	9
Drift thickness	N/A	Very High	10	-	9
Depth to water table	0.5m to 4m	Very High	10	-	9
Flow mechanism	Fracture Flow	Very High	10	-	9
Aquifer	Minor aquifer	Moderate	6	-	5
Abstraction and Source Protection Zone	Outside SPZ 3	Very Low	2	-	1
Watercourses and springs	>100m	Very Low	2	-	1
Land Drains	None known to be present	Very Low	2	-	1
Total (range)			52	-	44

Vulnerability	Range	Actual
Low vulnerability	8 – 32	
Moderate vulnerability	32 – 56	44 - 52
High Vulnerability	56 – 80	

9.2 Vulnerability Class

Based upon the total ranking score indicated, the site may be classified with a vulnerability class of:

Low: [ ] Moderate: [X] High: [ ]

9.3 Scale of Development

The anticipated number of annual full earth burials, as opposed to cremated remains, is 50.

9.4 Level of Risk

The EA level of risk to the number of anticipated burial rates and groundwater vulnerability using a nomograph reproduced in Figure 8.

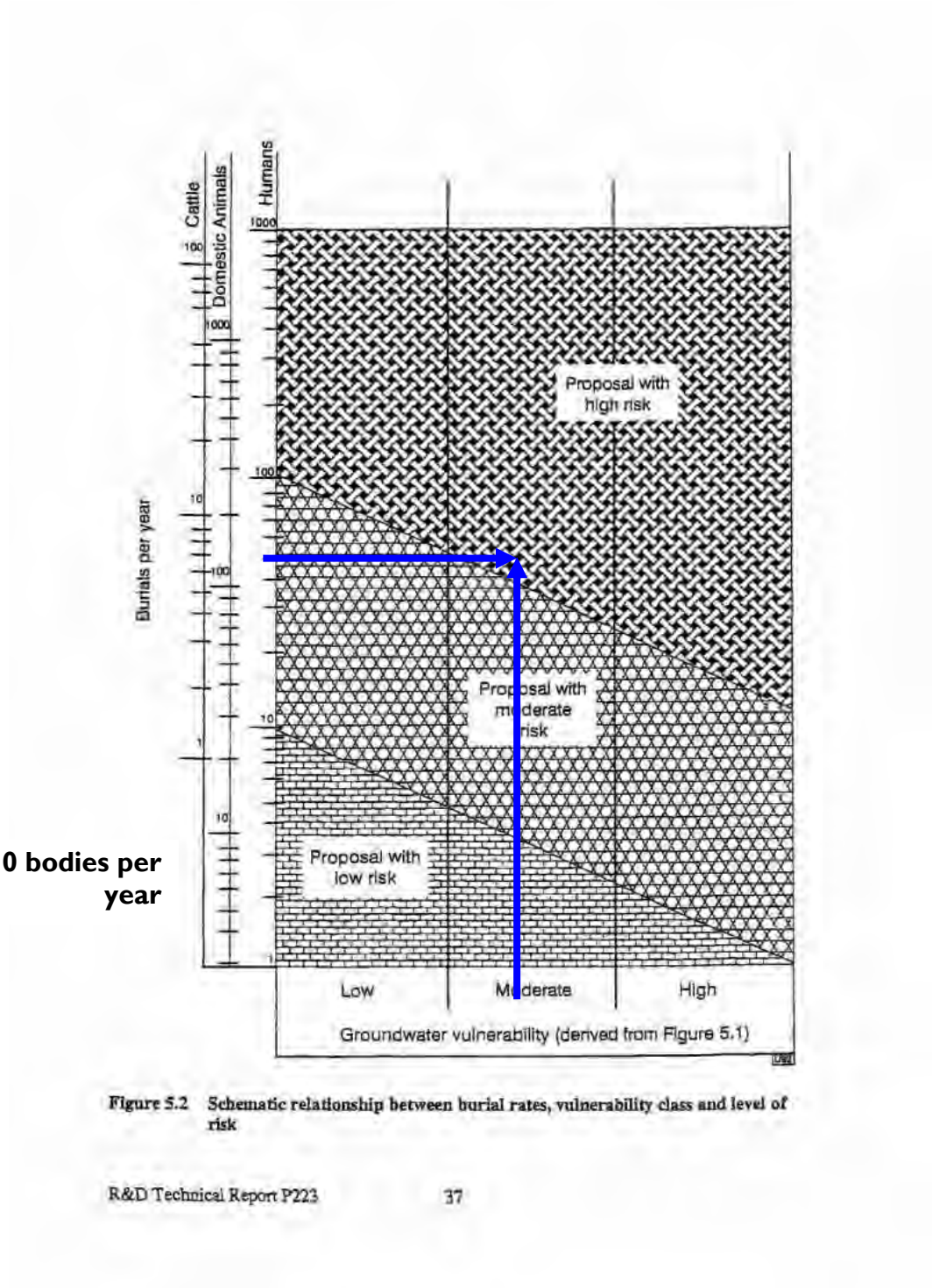


Figure 8. Schematic relationship between burial rates, vulnerability class and level of risk (from EA R & D Technical Report P223 (1999).

With reference to Figure 8, the level of risk at this site is considered to be 'High'.

10 Discussion and conclusions

The vulnerability ranking assigned to this site is 'Moderate', however the numbers of anticipated annual burials gives rise to a Risk Rating of 'High'.

The site characteristics that raised the vulnerability score were:

- Absence of superficial deposits
- High water table
- Aquifer – the site is underlain by a minor aquifer

Applied Geotechnical Engineering excavated a number of trial pits around the Bicester ring road during June 2006. Two trial pits were located near Lords Farm and revealed rubbly, very thinly bedded limestone with a clayey, sandy matrix down to 1.2 m with a stronger limestone beneath to 1.9 m (grave depth). Groundwater was not encountered in either trial pit.

There may be significant seasonal fluctuation in groundwater levels as the BGS report indicates that the watertable may be encountered between 0.5 m and 4 m. It would therefore be appropriate to install dipwells within the chosen area and monitor groundwater levels through a winter period to monitor levels and possibly reduce the risk rating of the site.

Subject to appropriate site investigations and agreement with the EA, it may be possible to either adjust the risk rating of the site or to design measures, such as drainage or specifications for burials, to mitigate any risk to groundwaters.

11 Recommendations

It is recommended that this report and the accompanying BGS report be circulated to the EA and dialogue established to ascertain requirements for further assessment of this site's suitability for development as a cemetery.

Subject to the outcome of this dialogue, if detailed site investigations were thought desirable, it is proposed that the site investigation should consist of the following:

1. A topographic survey to provide a basis for designing the cemetery and any necessary drainage infrastructure.

2. An electro-magnetic induction (EMI) survey to provide a basis for establishing the most appropriate locations for excavating soil profile pits down to a maximum depth of 3.5 m and installing a minimum of three dip wells (up to 10 m deep) to monitor ground water depth. The EMI data would be shown on the site plan to two different depths (200 mm and 1.2 m).

3. Assessment of the soil profile pits, and to 'window sample' material removed during the boring of the dip wells, in terms of the type, condition and physical properties of the soil exposed. The results will be used to determine factors that may influence the appropriateness of the site for burial purposes and the vulnerability of the environment to contamination from the proposed development.

4. Monitor the groundwater levels in the dip wells over a winter period, i.e. during the period of highest rainfall.

5. Determine any appropriate options for mitigating risk to ground and surface water by improving the surface and subsurface drainage status.

Depending upon the results of this sampling and analysis, it may be possible to use the site as a cemetery subject to certain restrictions such as the installation of an appropriate drainage scheme.

Confidentiality

This presentation is confidential and is only for the use of officers of Bicester Town Council and Cherwell District Council (and their representatives). Without the specific consent in writing of TurfTrax Ground Management Systems Limited, no copies of this presentation are to be made and information contained herein should not be communicated to any third party. At the request of TurfTrax Ground Management Systems Limited all copies of this document, in whatever form, are to be returned.

12 Contact details

Commercial Office
Chequers Court
31 Brown Street
Salisbury
Wiltshire
SP1 2AS

Tel: 01722 434000
Fax: 01722 434040

Technical Office
Unit 1, Highfield Parc
Highfield Road
Oakley
Bedfordshire
MK43 7TA

Tel: 01234 821750
Fax: 01234 821751
Email: richard.earl@turftrax.com

13 Appendices

Publications by key staff

A guide to better soil structure. Booklet based on MAFF funded project SP0305 "A national soil vulnerability-based framework for the provision of farm-specific guidance on the management of soil structure". National Soil Resources Institute, Cranfield University, Silsoe, Bedfordshire, MK45 4DT, September 2001.

Alexandrou, A. & **Earl, R**. (1998). The relationship between the pre-compaction stress, volumetric water content and initial dry bulk density of soil. Journal of Agricultural Engineering Research 71, 75-80.

Alexandrou, A & **Earl, R**. (1997). Development of a technique for assessment the behaviour of soil under load. Journal of Agricultural Engineering Research 68, 169- 180.

Alexandrou, A. & **Earl, R**. (1995). In situ determination of the pre-compaction stress of a soil. Journal of Agricultural Engineering Research 61, 67-72.

Bulson, H.A.J., **Welsh, J.P**., Stopes, C.E. & Woodward, L. (1996). Agronomic viability and potential economic performance of three organic four year rotations without livestock, 1988-1995. Aspects of Applied Biology 47: Rotations and cropping systems, 277-286.

Churcher, D.W., Greenwood, J.R., **Vickers, A.W**. Morgan, R.P.C., Coppin, N.J. & Norris, J.E. (1999). A bioengineering demonstration trial, Kent, England. In: Proceedings 2nd International Conference on Landslides, Slope Stability and the Safety of Infrastructures. ISBN 981-04-1537-0.

S.K. Cook, W.F. Cormack, M. Green, J.M. Holland, A.R. Leake and **J.P. Welsh**. (2000). Farming systems for the new Millennium. Aspects of Applied Biology 62. AAB, Wellesbourne, UK.

Davies, D.H.K. & **Welsh, J.P**. (2002). Weed control in organic cereals and pulses. In: Organic cereals and pulses (eds) D Younie, BR Taylor, JP Welsh and JM Wilkinson. Chalcombe Publications, Lincoln, UK. 77-114.

Earl, R. (1998). Tillage - soil, plant and implement considerations. Landwards 53, 17-23.

Earl, R. (1998). Principles of traction and compaction. Landwards 53, 14-16.

Earl, R. (1997). Prediction of trafficability and workability from soil moisture deficit. Soil and Tillage Research 40, 155-168.

Earl, R. (1997). Assessment of the behaviour of field soils during compression. Journal of Agricultural Engineering Research 68, 147- 158.

Earl, R. (1996). Prediction of trafficability and workability using tensiometers. Journal of Agricultural Engineering Research 63, 27-34.

Earl, R., Taylor, J.C., Wood, G.A., Bradley, I.T., Waine, T., **Welsh, J.P**., Godwin, R.J. & Knight, S.M. (2003). Soil factors and their influence on within-field crop variability, Part I: Field observation of soil variation. Biosystems Engineering 84(4), 425-440.

Earl, R. & Alexandrou, A. (2001). Deformation processes below a plate sinkage test on sandy loam: theoretical approach. Journal of Terramechanics 38, 153-162.

Earl, R. & Alexandrou, A. (2001). Deformation processes below a plate sinkage test on sandy loam: experimental approach. Journal of Terramechanics 38, 163-183.

Earl, R. & Carter, A.D. (1991). The sampling of water in an unsaturated soil. The Agricultural Engineer 46, 50-51.

Earl, R. and Wheeler, P.N. Lined moles cut drainage costs. Arable Farming, June 1993, p 27-32.

Earl, R., Wheeler, P.N., Blackmore, B.S. & Godwin, R.J. (1996). Precision farming - the management of variability. Landwards 51(4), 18-23.

Godwin, R.J., Richards, T.E., Wood, G.A., **Welsh, J.P**. & Knight, S.M. (2003). An economic analysis of the potential for precision farming in UK cereal production. Biosystems Engineering 84(4), 533-545.

Godwin, R.J., Wood, G.A., Taylor, J.C., Knight, S.M. & **Welsh, J.P**. (2003). Precision farming of cereal crops: A review of a six year experiment to develop management guidelines. Biosystems Engineering 84(4), 375-391.

Greenwood, J.R., **Vickers, A.W**., Morgan, R.P.C., Coppin, N.J. & Norris, J.E. (2001). Bioengineering: The Longham Wood Cutting field trial. CIRIA Project report 81. ISBN 0 86017 881 1.

Gregory, A.S., Kendall, B.A., **Earl, R**. & **Vickers, A.W**. (2002). The effects of engineering practices and incorporation of amendments on soil structural development in a clay soil-forming material used as a landfill restoration cap. A report for shanks first fund.

Gregory, A.S. & **Vickers, A.W**. (2004). The effects of amendments on soil structural development in a clay soil-forming material used as a landfill restoration cap. Soil Use and Management.

Kendall, B.A., Gregory, A.S., **Earl, R**., & **Vickers, A.W**. (2001). The effects of engineering practices and amendments on soil structural development in a clay landfill restoration cap. In: Eighth International Waste Management and Landfill Symposium. 1st - 5th October 2001. Sardinia, Italy. Proceedings. Volume 4. pp 371-380.

Morgan, R.P.C., Mcintyre, K., **Vickers., A.W.V**., Quinton, J.N. & Rickson, R.J. (1997). A rainfall simulation study of soil erosion on rangeland in Swaziland. Soil Technology 11, 291-299.

Pearce, B.D., Wolfe, M.S. & **Welsh, J.P**. (2002). Review of knowledge of the potential impacts of genetically modified organisms (GMO) on organic agriculture. In: Proceedings of the 14th IFOAM World Congress, Canada.

Philipps, L., **Welsh, J.P**., Bulson, H.A.J. & Woodward, W. (1999). Agronomic viability and potential economic performance of three organic four year rotations without livestock, 1988-1998. Proceedings of the 12th IFOAM Conference - Organic Agriculture: Credible Solutions for the 21st Century, Argentina. 109-115.

J Powell, G Davies, S Fowler, M Hovi, N Lampkin, M Lennartsson, S Padel, B Pearce, L Philipps, J Robertson, E Stockdale, C Watson, R Weller, **J Welsh** and M Wolfe. (2002). Proceedings of the UK Organic Research 2002 Conference. Organic Centre Wales, Aberystwyth, UK.

Reeve, M.J. and **Earl, R**. (1990). The effect of soil strength on agricultural and civil engineering field operations. Soil Survey Report, MAFF Contract 3806.

Schmidt, H., Philipps, L., **Welsh, J.P**. & Fragstein, P.V. (1999). Legume breaks in stockless organic farming rotations: Nitrogen accumulation and influence on the following crops. Biological Agriculture and Horticulture 17, 159-170.

Spoor, G., **Earl, R.** and Wheeler, P.N. (1992). Development of lower cost drainage systems for heavy soils. HGCA Project Report No 64.

Spoor, G, **Hann, M J**, Godwin, R J, Leeds-Harrison, P B, Miller, S M. (1987). Machinery Developments for Reducing Draught and Improving the Grading Characteristics of Mole Ploughs. ASAE 5th National Drainage Symposium.

Taylor, J.C., Wood, G.A., **Earl, R**. & Godwin R.J. (2003). Soil factors and their influence on within-field crop variability, Part II: Spatial analysis and determination of management zones. Biosystems Engineering 84(4), 441-453.

Taylor, J.C., Wood, G.A., **Welsh, J.P**. & Knight S. (2000). Exploring management strategies for precision farming of cereals assisted by remote sensing. Aspects of Applied Biology 60: Remote Sensing in Agriculture, 53-60.

Thomasson, A.J., Carter, A.D., Jones, R.J.A., Leverton, R.E., **Earl, R**., Bouma, J., Van Wijk, A.L.M., Feddes, R.A., Van Lanen, H.A.J., Kabat, P. And Hack-ten Broeke, M.J.D. (1989). Use of modern physical field methods and computer simulation for land evaluation purposes. Report to EC DG VI, Research Contract No 5711.

Toyne, K. & **Vickers, A.W**. (2003). Critical evaluation of the ASTM method of measuring percolation rates of rootzones materials. Paper presented at National Turfgrass Foundation National Conference, Southport. November 2003.

Vickers, A.W. & James, I.T. (2003). Management of cracking in clay soils used for cricket pitches. Paper presented at the Institute of Groundsmanship Annual Conference, Leicester, April 2003.

Vickers, A.W. (2002). Experimental Design for evaluation of products for sportsturf. Paper presented at National Turfgrass Foundation National Conference, Southport. November 2002.

Vickers, A.W. (2001). Optimisation of rolling on cricket pitches. Paper presented at the 2001 Institute of Groundsmanship Annual Conference, Haydock.

Vickers, A.W. (2001). Soil water management for sports surfaces. Paper presented at the 2001 Institute of Groundsmanship Annual Conference, Haydock.

Vickers, A.W. & Morgan, R.P.C. (1999). Soil water monitoring to assess the effectiveness of three bioengineering treatments on an unstable Gault Clay cutting in Southern England. In: Proceedings 2nd International Conference on Landslides, Slope Stability and the Safety of Infrastructures. ISBN 981-04-1537-0

Vickers, A.W. (1994). A simple field erodibility index based on some English soils. In: Conserving Soil Resources, European Perspectives. Edit. R.J. Rickson. CAB International. pp 70 - 78.

Welsh, J.P., Philipps, L. & Cormack, W.F. (2002). The long-term agronomic performance of organic stockless rotations. In: Proceedings of the UK Organic Research 2002 Conference. Organic Centre Wales, Aberystwyth, UK. 47-50.

Welsh, J.P., Wolfe, M.S. & Pearce, B.D. (2002). The performance of cereal varieties under organic systems in on-farm trials in England. In: Proceedings of the 14th IFOAM World Congress, Canada.

Welsh, J.P., Wolfe, M.S., Snape, J. & Pearce, B.D. (2002). Generating and evaluating a novel genetic resource in wheat in diverse environments. In: Proceedings of the 14th IFOAM World Congress, Canada. 311.

Welsh, J.P. & Wolfe, M.S. (2002). The performance of variety mixtures and the potential for population breeding in organic farming systems. Proceedings of the ECO-PB Symposium: Organic seed production & plant Breeding – strategies, problems and perspectives, Berlin.

Welsh, J.P., Wood, G.A., Godwin, R.J., Taylor, J.C., **Earl, R**., Blackmore, S. & Knight, S.M. (2003). Developing strategies for spatially variable nitrogen application in cereals, Part I: Winter barley. Biosystems Engineering 84(4), 481-494.

Welsh, J.P., Wood, G.A., Godwin, R.J., Taylor, J.C., **Earl, R**., Blackmore, S. & Knight, S.M. (2003). Developing strategies for spatially variable nitrogen application in cereals, Part II: Wheat. Biosystems Engineering 84(4), 495-511.

Welsh, J.P., Bulson, H.A.J., Stopes, C.E., Froud-Williams, R.J. & Murdoch, A.J. (1999). The critical weed-free period in organically-grown winter wheat. Annals of Applied Biology 134, 315-320.

Welsh JP, Bulson H A J, Philipps L and Wolfe M. (1999). Weed control strategies for organic cereal crops. Proceedings of the 1999 Brighton Crop Protection Conference – Weeds. 945-950.

Welsh JP, Bulson H A J, Stopes C E, Froud-Williams R J and Murdoch A J. (1997). Mechanical weed control in organic winter wheat. Aspects of Applied Biology 50: Optimising Cereal Inputs - Its Scientific Basis. 375-384.

Welsh JP, Bulson H A J, Stopes C E, Murdoch A J and Froud-Williams R J. (1997). The critical period of weed competition and its application in organic winter wheat. Proceedings of the 1997 Brighton Crop Protection Conference - Weeds. 105-110.

Welsh JP, Bulson H A J, Stopes C E, Froud-Williams R J and Murdoch A J. (1996). Weed control in organic winter wheat using a spring-tine weeder. Proceedings of the Second International Weed Control Congress, Copenhagen. 1127-1132

Wood, G.A., **Welsh, J.P**., Godwin, R.J., Taylor, J.C., **Earl, R**. & Knight, S.M. (2003). Real-time measures of canopy size as a basis for spatially varying nitrogen applications to winter wheat sown at different seed rates. Biosystems Engineering 84(4), 513-531.

D. Younie, B.R. Taylor, **J.P. Welsh** & J.M. Wilkinson. (2002). Organic Cereals and Pulses. Chalcombe Publications, Lincoln, UK.

Zimbone, S.M., **Vickers, A.W**., Morgan, R.P.C. & Vella, P. (1996). Field investigations of different techniques for measuring soil surface shear strength. Soil Technology. 9. pp 101 – 111.

Standard Terms and Conditions

Turftrax Ground Management Systems Limited
Terms and Conditions for the Supply of Services
Interpretation
In these Conditions
AGREED FEE means the charges agreed between TurfTrax and the Client in relation to the Specified Service
CLIENT means the person named on the Specification Sheet for whom TurfTrax has agreed to provide the Specified Service in accordance with these Conditions
CONTRACT means the contract for the provision of the Specified Service
DOCUMENT includes, in addition to a document in writing, any map, plan, graph, drawing or photograph, any film, negative, tape or other device embodying visual images and any disc, tape or other device embodying any other data
INPUT MATERIAL means any Documents or other materials, and any data or other information provided by the Client relating to the Specified Service
OUTPUT MATERIAL means any Documents or other materials, and any data or other information provided by TurfTrax relating to the Specified Service
SPECIFICATION SHEET means the sheet to which these Conditions are appended
SPECIFIED SERVICE means the service relating to geophysical surveys of land to be provided by TurfTrax for the Client and referred to in the Specification Sheet
TURFTRAX means TurfTrax Ground Management Systems Limited (registered in England under number 4135392) or its subsidiary as stated on the Specification Sheet
The headings in these Conditions are for convenience only and shall not affect their interpretation.
Supply of the Specified Service
TurfTrax shall provide the Specified Service to the Client subject to these Conditions. Any changes or additions to the Specified Service or these Conditions must be agreed in writing by TurfTrax and the Client.
The Client shall allow TurfTrax adequate access to its property at reasonable times and for so long as is necessary to enable TurfTrax to provide the Specified Service in accordance with the Contract.
The Client shall at its own expense supply TurfTrax with all necessary Documents or other materials, and all necessary data or other information relating to the Specified Service, within sufficient time to enable TurfTrax to provide the Specified Service in accordance with the Contract. The Client shall ensure the accuracy of all Input Material.
TurfTrax shall have no liability for any loss or damage, however caused, to the Input Material. All Output Material shall be at the sole risk of the Client from the time of delivery to or to the order of the Client.
The Specified Service shall be provided in accordance with the Specification Sheet subject to these Conditions.
Further details about the Specified Service, and advice or recommendations about its provision or utilisation, which are not given in TurfTrax's brochure or other promotional literature, may be made available on written request.
TurfTrax may correct any typographical or other errors or omissions in any brochure, promotional literature, quotation or other document relating to the provision of the Specified Service without any liability to the Client.
TurfTrax may at any time without notifying the Client make any changes to the Specified Service which are necessary to comply with any applicable safety or other statutory requirements, or which do not materially affect the nature or quality of the Specified Service.
Charges
Subject to any special terms agreed, the Client shall pay the Agreed Fee and any additional sums which are agreed between TurfTrax and the Client for the provision of the Specified Service or which, in TurfTrax's sole discretion, are reasonably incurred as a result of the Client's instructions or lack of instructions, the inaccuracy of any Input Material or any other cause attributable to the Client.
All charges quoted to the Client for the provision of the Specified Service are exclusive of any Value Added Tax, for which the Client shall be additionally liable at the applicable rate from time to time.
TurfTrax shall be entitled to invoice the Client on completion of the Specified Service.
The Agreed Fee and any additional sums payable shall be paid by the Client (together with any applicable Value Added Tax, and without any set-off or other deduction) within 30 days of the date of TurfTrax's invoice.
If payment is not made on the due date, TurfTrax shall be entitled, without limiting any other rights it may have, to charge interest on the outstanding amount (both before and after any judgment) at the rate of 4 % above the base rate from time to time of Barclays Bank plc from the due date until the outstanding amount is paid in full.
Rights in Input Material and Output Material
The property and any copyright or other intellectual property rights in:
any Input Material shall belong to the Client
any Output Material and any amendments or variations to the Input Material made by TurfTrax shall, unless otherwise agreed in writing between the Client and TurfTrax, belong to TurfTrax, subject only to the right of the Client to use the Output Material for the purposes of utilising the Specified Service.
Any Input Material or other information provided by the Client which is so designated by the Client and any Output Material shall be kept confidential by TurfTrax, and all Output Material or other information provided by TurfTrax which is so designated by TurfTrax shall be kept confidential by the Client; but the foregoing shall not apply to any Documents or other materials, data or other information which are public knowledge at the time when they are so provided by either party, and shall cease to apply if at any future time they become public knowledge through no fault of the other party.
The Client warrants that any Input Material and its use by TurfTrax for the purpose of providing the Specified Service will not infringe the copyright or other rights of any third party, and the Client shall indemnify TurfTrax against any loss, damages, costs, expenses or other claims arising from any such infringement.
Warranties and Liability
TurfTrax warrants to the Client that the Specified Service will be provided using reasonable care and skill and, as far as reasonably possible, in accordance with the Specification and at the intervals and within the times referred to in the Specification Sheet. Where TurfTrax supplies in connection with the provision of the Specified Service any goods (including Output Material) supplied by a third party, TurfTrax does not give any warranty, guarantee or other term as to their quality, fitness for purpose or otherwise, but shall, where possible, assign to the Client the benefit of any warranty, guarantee or indemnity given by the person supplying the goods to TurfTrax.
TurfTrax shall have no liability to the Client for any loss, damage, costs, expenses or other claims for compensation arising from any Input Material or instructions supplied by the Client which are incomplete, incorrect, inaccurate, illegible, out of sequence or in the wrong form, or arising from their late arrival or non-arrival, or any other fault of the Client.
Except in respect of death or personal injury caused by TurfTrax's negligence, or as expressly provided in these Conditions, TurfTrax shall not be liable to the Client by reason of any representation (unless fraudulent), or any implied warranty, condition or other term, or any duty at common law, or under the express terms of the Contract, for any loss of profit or any indirect, special or consequential loss, damage, costs, expenses or other claims (whether caused by the negligence of TurfTrax, its servants or agents or otherwise) which arise out of or in connection with the provision of the Specified Service or their use by the Client, and the entire liability of TurfTrax under or in connection with the Contract shall not exceed the amount of TurfTrax's charges for the provision of the Specified Service, except as expressly provided in these Conditions.
TurfTrax shall not be liable to the Client or be deemed to be in breach of the Contract by reason of any delay in performing, or any failure to perform, any of TurfTrax's obligations in relation to the Specified Service, if the delay or failure was due to any cause beyond TurfTrax's reasonable control.
Termination
Either party may (without limiting any other remedy) at any time terminate the Contract by giving written notice to the other if the other commits any breach of these Conditions and (if capable of remedy) fails to remedy the breach within 30 days after being required by written notice to do so.
Insolvency of Client
This clause applies if:
the Client makes any voluntary arrangement with its creditors or (being an individual or firm) becomes bankrupt or (being a company) becomes subject to an administration order or goes into liquidation (otherwise than for the purposes of amalgamation or reconstruction); or
an encumbrance takes possession, or a receiver is appointed, of any of the property or assets of the Client; or
the Client ceases, or threatens to cease, to carry on business; or
TurfTrax reasonably apprehends that any of the events mentioned above is about to occur in relation to the Client and notifies the Client accordingly.
If this clause applies then, without prejudice to any other right or remedy available to TurfTrax, TurfTrax shall be entitled to cancel the Contract or suspend any further provision of services under the Contract without any liability to the Client, and if the Services have been provided but not paid for the price shall become immediately due and payable notwithstanding any previous agreement or arrangement to the contrary.
General
These Conditions (together with the terms, if any, set out in the Specification Sheet) constitute the entire agreement between the parties, supersede any previous agreement or understanding and may not be varied except in writing between the parties. All other terms and conditions, express or implied by statute or otherwise, are excluded to the fullest extent permitted by law.
Any notice required or permitted to be given by either party to the other under these Conditions shall be in writing addressed to the other party at its registered office or principal place of business or such other address as may at the relevant time have been notified pursuant to this provision to the party giving the notice.
No failure or delay by either party in exercising any of its rights under the Contract shall be deemed to be a waiver of that right, and no waiver by either party of any breach of the Contract by the other shall be considered as a waiver of any subsequent breach of the same or any other provision.
If any provision of these Conditions is held by any competent authority to be invalid or unenforceable in whole or in part, the validity of the other provisions of these Conditions and the remainder of the provision in question shall not be affected.
Any dispute arising under or in connection with these Conditions or the provision of the Specified Service shall be referred to arbitration by a single arbitrator appointed by agreement or (in default) nominated on the application of either party by the President for the time being of Institute of Arbitrators.
English law shall apply to the Contract, and the parties agree to submit to the non-exclusive jurisdiction of the English courts.

Author:	Peter Mitchell Dr Richard Earl
Released by:	Dr James Welsh
Signed:	
Date:	6th March 2008

Appendix H

BGS BR211 Radon Report

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

GeoReports

Dylan Thomas
Hyder Consulting (UK) Ltd
HCL House
St Mellons Business Park
Cardiff
CF3 0EY

BR211 Radon Report:

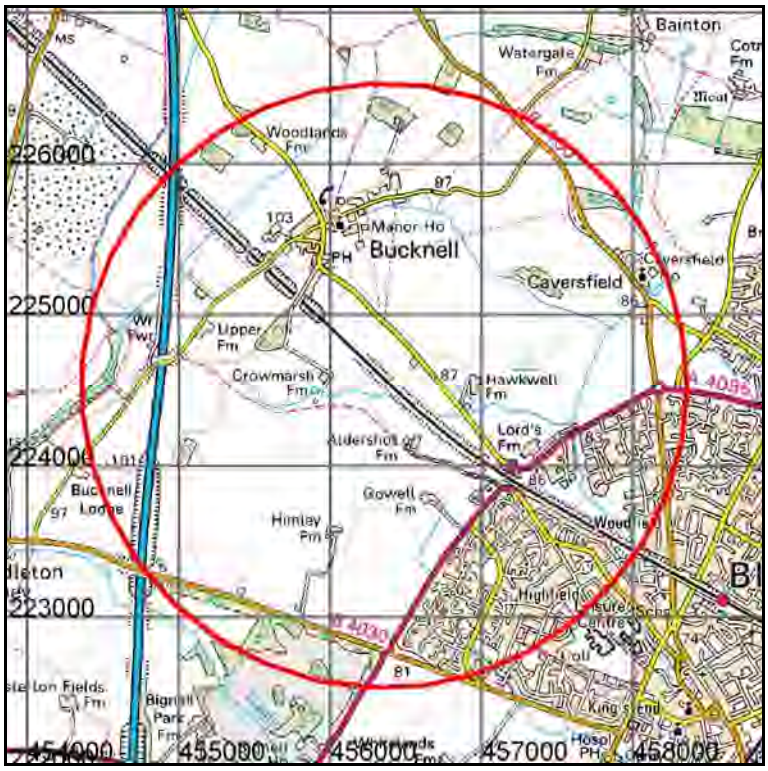
Advisory report on the requirement for radon protective measures in new buildings and extensions.

Report Id: ***GR_200946/1***

Client reference:

Location and extent of site

This report describes a site located at National Grid Reference 456358, 224534. Note that for sites of irregular shape, this point may lie outside the site boundary. Where the client has submitted a site plan the assessment will be based on the area given.



Scale: 1:50 000 (1cm = 500 m)

Search area indicated in red

BR211 Radon Report

This is an advisory report on the requirement for radon protective measures in new buildings and extensions.

Requirement for radon protective measures

The determination below follows advice in *BR211 Radon: Guidance on protective measures for new buildings (2007 edition)*, which also provides guidance on what to do if the result indicates that protective measures are required.

BASIC RADON PROTECTIVE MEASURES ARE REQUIRED FOR THE REPORT AREA.

The BGS is not able to provide advice on the technical specifications of 'basic' and 'full' radon protective measures. This information is detailed in **BRE Report BR211 :Radon: Protective measures for new buildings** which may be purchased from **brebookshop.com.** BR211 offers guidance on the technical solutions that are required to satisfy Building Regulations requirements. Summary guidance is available on the web at: http://www.bre.co.uk/radon/protect.html.

If you require further information or guidance, you should contact your local authority building control officer or approved inspector.

Contact 020 7944 5758 or Email: partsac.br@communities.gsi.gov.uk for advice on the interpretation of guidance contained in BRE Report BR211 (2007).

What is radon ?

Radon is a naturally occurring radioactive gas, which is produced by the radioactive decay of radium which, in turn, is derived from the radioactive decay of uranium. Uranium is found in small quantities in all soils and rocks, although the amount varies from place to place. Radon released from rocks and soils is quickly diluted in the atmosphere. Concentrations in the open air are normally very low and do not present a hazard. Radon that enters enclosed spaces such as some buildings (particularly basements), caves, mines, and tunnels may reach high concentrations in some circumstances. The construction method and degree of ventilation will influence radon levels in individual buildings. A person's exposure to radon will also vary according to how particular buildings and spaces are used.

Inhalation of the radioactive decay products of radon gas increases the chance of developing lung cancer. If individuals are exposed to high concentrations for significant periods of time, there may be cause for concern. In order to limit the risk to individuals, the Government has adopted an Action Level for radon in homes of 200 becquerels per cubic metre (Bq m^{-3}). The Government advises householders that, where the radon level exceeds the Action Level, measures should be taken to reduce the concentration.

Radon in workplaces

The Ionising Radiation Regulations, 1999, require employers to take action when radon is present above a defined level in the workplace. Advice may be obtained from your local Health and Safety Executive Area Office or the Environmental Health Department of your local authority. The BRE publishes a guide (BR293)**: Radon in the workplace.** BRE publications may be obtained from The BRE Bookshop, I H S Technical Indexes Ltd., Willoughby Road, Bracknell, Berkshire RG12 8DW. Tel: 01344 404407, Fax: 01344 714440, website: www.brebookshop.com

Radon in existing buildings
Useful information is given in the following free publications which can be obtained by writing to:
Radon Studies, Radiation Protection Division, Health Protection Agency, Chilton, Didcot, Oxfordshire OX11 0RQ

Radon - A Householder's Guide
Radon - You Can Test for it
Radon - A Guide for Homebuyers and Sellers
Radon - A Guide to Reducing Levels in Your Home
Information in the booklets is also available on the DEFRA website at:
http://www.defra.gov.uk/environment/radioactivity/background/radon.htm

Householders are recommended to follow advice in **Radon - a householder's guide.** The guide outlines simple solutions for dealing with the radon problem depending on whether or not the home has been tested for radon. In radon affected homes, the problem of radon can usually be tackled with simple, effective and relatively inexpensive measures. These measures are comparable in cost to work such as damp-proofing and timber treatment. You can get practical advice about construction work to reduce radon levels from the Building Control Officer at your local council.

Is this property in a radon affected area – YES

The answer to the standard enquiry on house purchase known as **CON29 Standard Enquiry of Local Authority 3.13 Radon Gas: Location of the Property in a radon Affected Area is YES** this property is in a Radon Affected Area as defined by the Health Protection Agency (HPA).

The estimated probability of the property being above the Action Level for radon is: 3-5%.

In addition to the search area, the radon data includes a 75 metre zone around the site to allow for uncertainties in location data and geological line work.

The result informs you of the estimated probability that this particular property is above the Action Level for radon. This does not necessarily mean there is a radon problem in the property. The only way to determine whether it is above or below the Action Level is to carry out a radon measurement within the existing property.

Radon Affected Areas are designated by the HPA. They advise that radon gas should be measured in all properties within Radon Affected Areas.

If you are buying a currently occupied property in a Radon Affected Area you should ask the present owner whether radon levels have been measured in the property. If they have, ask whether the results were above the Radon Action Level and if so whether remedial measures were installed, radon levels were retested, and the that the results of re-testing confirmed the effectiveness of the measures.

For further information, advice about radon, its health risks and details of how to order the radon test, please contact the HPA Radon Helpline on 01235 822622 or go online at www.ukradon.org or write to Radon Studies at the Health Protection Agency, address above. You can obtain an information pack from the HPA free Radon answer phone on 0800 614529.

Contact Details

Keyworth (KW) Office
British Geological Survey
Kingsley Dunham Centre
Keyworth
Nottingham
NG12 5GG
Tel: 0115 9363143
Fax: 0115 9363276
Email: enquiries@bgs.ac.uk

Wallingford (WL) Office
British Geological Survey
Maclean Building
Wallingford
Oxford
OX10 8BB
Tel: 01491 838800
Fax: 01491 692345
Email: hydroenq@bgs.ac.uk

Murchison House (MH) Office
British Geological Survey
Murchison House
West Mains Road
Edinburgh
EH9 3LA
Tel: 0131 650 0282
Fax: 0131 650 0252
Email: enquiry@bgs.ac.uk

Terms and Conditions

General Terms & Conditions

This Report is supplied in accordance with the GeoReports Terms & Conditions available on the BGS website at www.bgs.ac.uk/georeports and also available from the BGS Central Enquiries Desk at the above address.

Important notes about this Report

- The data, information and related records supplied in this Report by BGS can only be indicative and should not be taken as a substitute for specialist interpretations, professional advice and/or detailed site investigations. You must seek professional advice before making technical interpretations on the basis of the materials provided.
- Geological observations and interpretations are made according to the prevailing understanding of the subject at the time. The quality of such observations and interpretations may be affected by the availability of new data, by subsequent advances in knowledge, improved methods of interpretation, and better access to sampling locations.
- Raw data may have been transcribed from analogue to digital format, or may have been acquired by means of automated measuring techniques. Although such processes are subjected to quality control to ensure reliability where possible, some raw data may have been processed without human intervention and may in consequence contain undetected errors.
- Detail, which is clearly defined and accurately depicted on large-scale maps, may be lost when small-scale maps are derived from them.
- Although samples and records are maintained with all reasonable care, there may be some deterioration in the long term.
- The most appropriate techniques for copying original records are used, but there may be some loss of detail and dimensional distortion when such records are copied.
- Data may be compiled from the disparate sources of information at BGS's disposal, including material donated to BGS by third parties, and may not originally have been subject to any verification or other quality control process.
- Data, information and related records, which have been donated to BGS, have been produced for a specific purpose, and that may affect the type and completeness of the data recorded and any interpretation. The nature and purpose of data collection, and the age of the resultant material may render it unsuitable for certain applications/uses. You must verify the suitability of the material for your intended usage.
- If a report or other output is produced for you on the basis of data you have provided to BGS, or your own data input into a BGS system, please do not rely on it as a source of information about other areas or geological features, as the report may omit important details.
- The topography shown on any map extracts is based on the latest OS mapping and is not necessarily the same as that used in the original compilation of the BGS geological map, and to which the geological linework available at that time was fitted.
- Note that for some sites, the latest available records may be quite historical in nature, and while every effort is made to place the analysis in a modern geological context, it is possible in some cases that the detailed geology at a site may differ from that described.

Report issued by
BGS Enquiry Service

P3Eco (Bicester) Ltd and A2Dominion Group

NW Bicester Eco Development

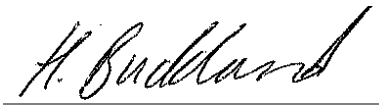
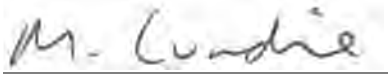
Geotechnical Interpretative Report - Exemplar Site

Hyder Consulting (UK) Limited
2212959
29 Bressenden Place
London
SW1E 5DZ
United Kingdom
Tel: +44 (0)20 3014 9000
Fax: +44 (0)20 7828 1794
www.hyderconsulting.com

P3Eco (Bicester) Ltd and A2Dominion Group

NW Bicester Eco Development

Geotechnical Interpretative Report - Exemplar Site

Author	Harriet Buckland	
Checker	M Lundie	
Approver	C Plumb	

Report No 2505-UA001881-UP33R-01

Date November 2010

This report has been prepared for P3Eco (Bicester) Ltd and A2Dominion Group in accordance with the terms and conditions of appointment for NW Bicester Eco Development contract, dated May 2010. Hyder Consulting (UK) Limited (2212959) cannot accept any responsibility for any use of or reliance on the contents of this report by any third party.

CONTENTS

Figures

Appendices

1 INTRODUCTION

Hyder Consulting (UK) Limited (HCL) has been instructed by P3Eco (Bicester) Ltd. (P3Eco) and A2Dominion Group Ltd. (A2Dominion) to undertake a Geotechnical and Geo-Environmental intrusive investigation with subsequent factual and interpretative reports for a proposed new eco development on the north-western periphery of the town of Bicester, Oxfordshire.

This geotechnical interpretative report presents a summary of data collected during an initial preliminary ground investigation undertaken at the proposed Exemplar site in August 2010 and provides advice relating to the physical and chemical nature of the ground based on interpretation of this data. Prior to undertaking the ground investigation, a desk study report (Ref. 1) and following completion of the investigation a factual report (ref. 2) were produced by HCL, which should be read in conjunction with this document.

1.1 Background to the Proposed Development

Land at NW Bicester is identified in the Supplement to Planning Policy Statement 1 (PPS1) entitled 'Eco Towns' (July 2009) as a potential location for an Eco Town. PPS1 sets out the Government's overarching planning policies on the delivery of sustainable development through the planning system. The Supplement to PPS1 sets out a range of criteria against which Eco Town proposals should be assessed.

The development of land at NW Bicester as an Eco Town has been promoted by P3Eco. P3Eco have selected A2Dominion as its development partner for the promotion and implementation of the Exemplar scheme (see Figure 1 – site location plan for land proposed for the Exemplar Scheme) and also as its affordable housing partner in respect of the wider Masterplan scheme.

The proposed development is still in the preliminary design stage and as such, the ground investigation was designed based on the information provided within the desk study to provide the assessment of general ground conditions and parameters from a geotechnical, hydrogeological and geo-environmental perspective.

The purpose of this report therefore is to identify the geotechnical, environmental, geological, hydrogeological and hydrological conditions and constraints to the proposed eco development present at the Exemplar site. In additionally to use the information gathered during the investigation and desk study phases, including the historic land use knowledge, to develop an understanding of any potential contamination risks that might arise from current or potential future use of the site.

1.2 Objectives of the Report

The principal objective of the report is to provide an assessment of the current geotechnical and geo-environmental conditions of the proposed Exemplar site. To this end, this report aims to:

- Establish ground and groundwater conditions beneath the site;
- Identify the presence of contaminants within the soil;
- Identify health and safety issues arising as a result of the ground conditions; and
- Discuss materials management and waste disposal issues.

In order to meet these objectives, a preliminary site-specific intrusive ground investigation was undertaken by HCL's in –house SI contracting division, using CJ Associates Ltd. (CJA) as the specialist drilling subcontractor, with all technical direction and supervised provided by HCL.

2 THE EXEMPLAR SITE SETTING

2.1 Site Location

The town of Bicester lies approximately 24km to the north east of Oxford and 28km to the south east of Banbury. The M40 motorway lies 2km to the south west, with ready access to the town from Junction 9. The proposed eco development site will comprise approximately 5,000 homes with supporting employment and education infrastructure, and will be situated on the north-western periphery of Bicester, beyond the A4095 (which forms part of the Bicester Ring Road), approximately 1.5km from the town centre.

The whole of the development site covers an area of approximately 416ha and at present, comprises Grade 3 agricultural land with a number of farmhouses and other buildings, as well as a small commercial area on the western side of Howes Lane (A4095). Immediately beyond the Site to the north-west is the village of Bucknell, with Caversfield located on the north-eastern Site boundary, beyond the B4100 highway.

This geotechnical interpretative report is restricted to the Exemplar site, which extends over an area of approximately 21.1ha, situated within the north eastern boundary of the whole development site, to the south of Caversfield. The sole landowner of the Exemplar development site is Mr Phipps.

The location of the site is presented in Figure 1 with the proposed site development plan included in Figure 3; and comprises of predominantly two storey houses, although this is subject to change and was current at the time of writing.

2.2 Site Description

The Exemplar site is predominantly flat, arable farmland and the agricultural land value is Grade 3 (good to moderate quality) which is currently being used as grazing land for livestock at the time of the ground investigation. Fields are bounded either by post and wire fences or by dense hedges with some large trees. Most fields were surrounded by drainage ditches approximately 0.5m to 0.75m deep, though all were dry at the time of the Site walkover and Ground Investigation.

The site is dissected from east to west by a low flow watercourse/stream, with ground level dropping at a low grade to the river. There is one stream on the Exemplar site (flowing in a NW to SE direction), which feed the N to S flowing River Bure.

Existing buildings within the Site boundary comprise those at Home Farm. The buildings here contain grade 2 listed buildings.

2.3 Public Register and Historical Information

Public register information relating to the Site and the surrounding area has been obtained mainly from the Landmark Information Group Ltd. A full review of public register and historical information can be seen in the desk study report (Ref. 1).

2.4 Geology and Hydrology

The following section contains extracts from the accompanying desk study report (Ref. 1) and supplemented by information gained from the recent ground investigation.

2.4.1 Superficial Deposits

Late Quaternary age superficial deposits of Alluvium flank the streams in narrow tracts, typically some 20m wide (locally up to 80m wide) and some 1m to 3m in thickness. The Alluvium typically comprises sandy, calcareous clay overlying gravelly clay with limestone clasts and may locally include highly compressible, organic-rich (peaty) layers.

Head deposits may be present near the streams where the erosive action of the water has carved small valleys. These deposits are formed by soil creep or hill wash and their composition reflects that of the local materials from which they were derived, either the bedrock or other types of superficial deposits (or both). They are typically poorly stratified and poorly sorted and are not expected to be present in thicknesses much greater than 1m.

Beneath the topsoil, the remainder of the Site has only a thin cover (approximately 1m) of superficial deposits, mainly derived from the partial to complete weathering of the underlying solid geology.

2.4.2 Solid Geology

The landscape of the Site follows the underlying geology, which dips in a south-easterly direction at a very gentle ~0.7°. The Site area is underlain at rock head by various formations and members of the Great Oolite Group, of Mid-Jurassic age, which are dominated by limestone's with subordinate mudstone beds.

There are no geological faults shown on Site; however some minor faults have been mapped to the north-east of Bucknell village, with ground displacements of up to 5m. Faults are planes of movement, along which, adjacent blocks of rock strata have moved relative to each other. They commonly consist of zones, perhaps up to several tens of metres wide, containing several to many fractures. The portrayal of such faults as a single line on the geological map is therefore a generalisation. The geological faults in the Bicester area are ancient in origin and are today mainly inactive, therefore are not thought to present a threat to the proposed development.

Sequence of Strata

The Cornbrash Formation (CB) is the youngest bedrock unit represented and dominates the outcrop within the Site area. It comprises approximately 5m of thick grey to brown, bioclastic, rubbly-bedded limestone with thin subordinate beds of grey mudstone.

The older, underlying Forest Marble Formation (FMB) is exposed as a narrow outcrop on the flanks of the three stream valleys in the area where the Cornbrash Formation has been eroded. The FMB comprises approximately 5m to 10m of grey calcareous mudstone with lenticular beds of bioclastic, ooidal limestone (particularly common at the base).

Although not represented in outcrop on Site, the FMB is underlain at an erosive contact by the White Limestone Formation (WHL), which crops approximately 2km to the north-west. The WHL comprises up to 25m of white to yellow, bedded, peloidal and bioclastic limestone (see Additional Geological Considerations below).

The White Limestone Formation is underlain by four further formations of the Great Oolite Group: in ascending order the Horsehay Sand, the mudstone-dominated Sharp's Hill, the Taynton Limestone and the mudstone-dominated Rutland formations, totalling approximately 20m in thickness. These are then underlain by 2m to 6m of the ferruginous sandstones of the Northampton Sand Formation before the 100m+ of the mudstone-dominated Lias Group is encountered.

2.5 Hydrogeology

With the exception of the Forest Marble Formation cropping out in the floors and sides of the valleys, the whole of the Site area is underlain by the Cornbrash Formation. This is a local aquifer and water strikes have been recorded in shallow boreholes drilled within the Site area. The standing water levels are generally between 0.5m and 4.0m below the ground surface.

The Forest Marble Formation may hold small quantities of water in any limestone bands present, but the upper part generally acts as an aquiclude, i.e. an essentially impermeable barrier between the Cornbrash Formation and the underlying White Limestone Formation. None of the boreholes drilled at the Exemplar Site reached the Forest Marble Formation.

The White Limestone Formation constitutes a major aquifer in the area, which provides some sources of public supply. There are several boreholes in the wider area, some within the Site area, that penetrate this formation:

- A 34m deep borehole at Gowell Farm (SP52/19 at SP 5709 2384), drilled pre-1909 to supply Bicester with water. This penetrated the complete 25m thickness of the White Limestone Formation, underlying about 7.2m of Forest Marble Formation and terminating in the underlying Rutland Formation. Water was struck at 28m and 32m below the ground level in the White Limestone Formation. The rest water level rose to the surface after the first strike, and was artesian, with a rest water level about 1m above ground level (about 88m AOD) after the second strike. The yield was over 7 l/s.

- An 80 m deep borehole at Lords Farm (SP52/18 at SP 5746 2424), drilled in 1941, was drilled through a similar sequence and terminated in the Lias. It struck water in the Cornbrash Formation, which was cased out, and at two levels below the White Limestone Formation. The rest water level was at 11m below ground level (about 68m AOD) and it yielded 1.7 l/s.

Other records of water levels at Lords Farm (SP52/17A, B and C at about SP 569 245) show that the water level was at approximately 3.6m below ground level (about 76m AOD).

In addition to the available geological information, the Environment Agency (EA) Groundwater Vulnerability Map on the EA website has been reviewed to determine the vulnerability of the groundwater underlying the Site with the following conclusions:

- The superficial deposits are not classified as an aquifer. The underlying Cornbrash Formation is classified as a Secondary 'A' Aquifer, which comprises "permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers."

This designation corresponds with the geological interpretation given above.

There is insufficient data to determine a groundwater flow direction, but locally it will probably be towards the nearest stream and regionally, down-dip towards the south-east.

2.5.1 Groundwater Source Protection Zones

The Environment Agency (EA) has defined Source Protection Zones (SPZs) for groundwater sources such as wells, boreholes and springs used for public drinking water supply. The SPZs show the risk of contamination from any activities that might cause pollution in the area.

Source protection zones are defined as follows:

A Source Protection Zone III is the total area needed to support removal of water from a borehole, and to support any discharge from the protected borehole/well/spring used for public drinking water supply.

A Source Protection Zone II (outer protection zone) covers pollution that takes up to 400 days to travel to the abstraction point, or 25% of the total catchment area – whichever area is the biggest.

A Source Protection Zone I (inner protection zone) defines an area where pollution can travel from the source to the extraction point within 50 days. A Source Protection Zone I also has a minimum 50m protection radius around a public supply borehole.

According to the EA website, the Site does not lie within a SPZ.

2.6 Flooding

Information contained within the desk study report (Ref. 1) indicates that the site is not within the zone of potential flooding from fluvial watercourses. According to the Environment Agency Flood Maps included within the Envirocheck Report, the Site does not generally lie within a zone susceptible to flooding; however, the River Bure that flows to the south east of the site in a roughly north-easterly to south-westerly direction is shown to present a risk of flooding from Rivers or Sea without Defences (Zone 3)" to an area confined to the stream's valley (i.e. its natural floodplain).

Note that EA flood maps are based upon coarse DTM and JFLOW modelling and are not considered suitable to delineate the flood plain to support a planning application. The stream that flows across the site in a west to east direction has not been modelled by the EA, as it is too small. As such, a separate, Site-specific hydraulic model should be developed in order to confirm the flood plain extents across the Site.

2.7 Drainage Soakaways

As part of the development, the suitability of the ground for accepting soakaways for surface water drainage will need to be considered. Based on the available documented evidence on the geology and visual evidence from the Site walkover (where the superficial deposits were typically loamy and all field drainage ditches and the stream that feeds the River Bure were dry), it is considered at this stage that the ground will likely be suitable for some form of soakaway, this is discussed in more detail within the Hyder Exemplar Site Drainage Strategy Report (Ref.3).

3 GROUND INVESTIGATION

The preliminary ground investigation for the whole site was carried out between 2nd August and 16th August 2010 and included the investigation of the Exemplar site. The investigation was undertaken and supervised by HCL on behalf of A2Dominion and P3Eco.

The site specific ground investigation at the Exemplar site was designed to address the objectives identified within Section 1.2 of this report. The findings of the ground investigation, GI are summarised below and are detailed in the HCL Factual Report (Ref. 2)

3.1 Site Works

The completed scope of the ground investigation at the Exemplar site is as follows:

- 3 no. window sample boreholes with rotary follow on to maximum depth of 7m below ground level (bgl) with Standard Penetration test (SPTs) at 1m interval to 5m and at 1.5m intervals thereafter. Gas and groundwater monitoring standpipes were installed within two of the three boreholes;
- 2 no. in-situ permeability tests within selected boreholes;
- 6 no. machine excavated trial pits to depths of up to 2.9m bgl; and
- 3 no. in-situ soakaway tests within selected machine-excavated trial pits.

The depth, thickness and descriptions of the strata (including depths of sampling points) are given on the relevant exploratory logs, presented within the HCL Factual Report (Ref. 2).

Upon their completion, the trial pits were safely backfilled and compacted and the ground re-instated, as far as practicable. Selected rotary boreholes were completed with gas and groundwater monitoring installations for monitoring purposes with raised locking covers.

3.2 Sampling

A Geotechnical Engineer from HCL logged the boreholes and trial pits in accordance with the recommended procedures provided by document BS5930:1999 “Code of Practice for Site Investigations” (Ref. 4). Disturbed, undisturbed and environmental samples were collected from the exploratory holes, which were subsequently sent for geotechnical, chemical and contamination analysis with the testing scheduled by HCL.

Water was added to all boreholes to assist drilling so groundwater inflows were not apparent. Groundwater was recorded in TP1 at a depth of 2.9m, but there was insufficient inflow to allow sampling.

Furthermore boreholes BH1 and BH5 have been installed with groundwater and gas monitoring standpipes and an ongoing programme of monitoring is currently taking place over a three month period to allow the groundwater and gas levels to stabilise and to be recorded over a range of (short-term) climatic variations.

The full results of the gas and groundwater monitoring will be issued as a separate addendum to this interpretative report.

3.3 Laboratory Testing

Geotechnical and chemical laboratory testing was undertaken on selected samples taken from the boreholes and trial pits and are summarised in Table 3.1 below. Testing of all samples was scheduled by HCL and undertaken by an HCL appointed laboratory. The test results are discussed within Sections 5 to 8 of this report and are presented in full within the HCL Factual Report (Ref. 2). Asbestos presence was analysed as a precautionary health and safety measure due to the desk study identifying possible ACMs (Asbestos Containing Materials) as being present on site, and possibly residing in the ground following demolition of former buildings.

Table 3.1: Summary of Analysis Undertaken on Scheduled Samples

Type of Test	Standard	Number of Samples
Geotechnical Testing on Soil Samples		
Soil Moisture Content	BS1377:1990 Part 2:3	11
Atterberg tests	BS1377:1990 Part 2:4 & 5	11
Particle Size Distribution tests (PSDs)	BS1377:1990 Part 2:9	8
Consolidation Tests	BS1377:1990 Part 5	3
Point Load Tests	International Journal of Rock Mechanics, Science and Geomechanics, Abstract volume 22, No.2 pp 51 to 60, 1985	5
Unconfined Compressive Strength	ISRM Suggested Methods pp 111 to 116 1981	3
Compaction testing, 2.5kg rammer	BS1377:1990 Part 4	2
BRE Sulphate Suite	BRE Special Digest 1:2005	7
Type of Test	**Standard**	**Number of Samples**
Contamination Tests		
Soil		
arsenic, barium, beryllium, cadmium, chromium, nickel, lead, copper, zinc, mercury, lithium, magnesium, phosphorous, potassium, selenium, sodium, strontium, zinc	MCERTS Accredited	7
Total, complex and free cyanide, total phenols, sulphide and pH.	MCERTS Accredited	7
Speciated PAH (USEPA 16)	MCERTS Accredited	6
TPH GRO/DRO/MRO	MCERTS Accredited	6
TPH (Total Petroleum Hydrocarbons) 6 banded	MCERTS Accredited	6
Total pheols	MCERTS Accredited	6
PAH	MCERTS Accredited	6
Asbestos screen	MCERTS Accredited	1

4 GROUND CONDITIONS ENCOUNTERED

4.1 Summary of Strata Sequence

The typical strata sequence encountered across the proposed Exemplar Site has been summarised in Table 4.1, with the full exploratory hole logs presented within the HCL Factual Report (Ref 2). The material properties and engineering considerations of the strata encountered are discussed respectively in Section 5 of this report and the contamination testing is discussed in Section 6.

The strata sequence generally comprises of Topsoil overlying an orange-brown, superficial head deposits comprising of gravelly, sandy Clay with many cobbles and / or orange-brown, sandy, clayey Gravel and Cobbles. Below this superficial layer, yellow-grey, sandy Gravel, and in places yellow grey Clay was encountered. This layer is thought to be a completely weathered layer derived from the underlying limestone as it grades into a limestone rock with depth. Below this level, the stratum alternates between generally a moderately strong to strong limestone, interbedded with stiff Clay and Mudstone layers. The weathered and strong limestone rock with interbedded clay and mudstone layers combine to form part of the cornbrash formation.

The strata descriptions used in the factual report (Ref. 2) are in accordance with BS 5930:1999 (Ref. 4).

Table 4.1: General Sequence of Strata across Site

Stratum	General description of Stratum	Typical Depth Range (m bgl)
Topsoil	Topsoil	GL to 0.2m (Max. 0.3m)
Superficial/Head deposits	Red brown, clayey sandy gravel with cobbles, or in places gravelly sandy Clay with cobbles	To 0.6m (max 0.8m)
Completely Weathered Limestone	Recovered as yellow-grey, sandy Gravel and in places yellow grey Clay	To 1.9m, maximum 2.9m
Interbedded Limestone and Clays	Interbedded moderately strong to strong Limestone and stiff or hard Clay and mudstone	1.9 to >7m

4.2 Groundwater and Ground Gas

During the ground investigation at the Exemplar site, water was added to the boreholes to assist the rotary drilling process within the limestone rock to keep the drill bit cool and limit the rock dust generated. It was therefore not possible to carry out groundwater monitoring of the boreholes during the investigation. All of the six trial pits excavated were found to be dry apart from trial pit, TP 1 which struck water at a depth of 2.9m bgl, located immediately above what is thought to be the top of the interbedded Limestone/Clay. Water entered the TP1 pit as a slow trickle that was not sampled due to the low rate of inflow.

Gas and groundwater monitoring results following completion of the ground investigation at the Exemplar site are ongoing. A further two visits will be carried out as part of monitoring over the next three months of monitoring. Available results are presented within Table 4.2; the remaining monitoring results will be reported separately as an addendum report.

Table 4.2: Groundwater Levels from Monitoring Visit on 13/08/10

Borehole	Eastings	Northings	13/08/2010 (m bgl)
BH1	457493	225428	3.1
BH5	457618	224855	6.3

The results show that borehole, BH1 recorded a standing water level at 3.1m bgl and borehole, BH5 recorded a standing water level at 6.3m bgl. The 13th August monitoring visit suggests that excavations for foundations will not encounter groundwater as the excavation required for the proposed development will typically be limited to a depth of less than 2m bgl.

However, excavations during the ground investigation within the surrounding area were carried out following heavy rain and encountered shallower groundwater inflows above the limestone. Therefore, where foundations are based at shallow level on top of the limestone, some water inflow may be expected following heavy rain where the water is perched above the limestone.

During the ground water monitoring visit, gas measurements were taken from the boreholes, with the results showing that no methane was present and only a small concentration of carbon dioxide was present (max. 3.6% in BH5). The complete set of three month gas and ground water monitoring results will be issued as an Addendum report once the results have been obtained.

5 GEOTECHNICAL PROPERTIES

5.1 Introduction

A testing programme for soil samples recovered from the exploratory hole locations was scheduled by HCL and carried out by a designated laboratory, as specified by document BS1377:1990 “Methods of Tests for Soils for Civil Engineering Purposes” (Ref. 5). The results are summarised in this Section and included in full in the factual report (Ref. 2).

5.2 Superficial Deposits/Head

The superficial deposits/Head are generally consistent across the Exemplar site with a typical subsoil depth of 0.6m. The deposits predominantly comprise of a reddish/orange, brown clayey Gravel with cobbles, or in places a gravelly Clay with cobbles. Based on inspection of the trial and archaeological pits, the material composition varies with depth. When the ground level drops towards the streams or water courses, the granular content of the subsoil decreases and vice versa. Therefore at a higher elevation there is a much higher content of granular material, with increasing cobble content.

5.2.1 Laboratory Testing on Superficial Deposits/Head

One atterberg limits test and one moisture content test was carried out on a cohesive sample of the superficial deposits in trial pit, TP5. The material was found to be of intermediate plasticity with a plasticity index, PI value of 20%. The moisture content testing for the same material indicates a mc of 22%.

Five particle size distribution tests were carried out on the subsoil and indicate this material to comprise mainly silty/clayey, sandy gravel and some cobbles; although in places the cobble fraction is more dominant. Two compaction tests at 0.5m depth were carried out in the superficial deposits and the maximum dry density ranged from 1.65 mg/m^3 to 1.83mg/m^3 and optimum moisture content of between 13% and 16%.

In accordance with BRE Special Digest SD1 (Ref. 9), sulphate content and pH value testing was carried out on selected soil samples and the test results lie within the limit of Sulphate Design Class DS-1, as defined within the BRE guidelines. The minimum pH value is 6.4 and the maximum sulphate value is 100mg/l. The groundwater regime is considered as mobile, therefore an Aggressive Chemical Environment for Concrete (ACEC) classification of AC-1 is considered appropriate.

5.2.2 In Situ Testing in the Superficial Deposits

Two standard penetration tests, SPT’s were carried out within the superficial deposits both giving SPT values in excess of 50 blows, suggesting that the superficial deposits are very dense (Ref. 6).

5.3 Completely Weathered Limestone

The completely weathered Limestone was generally recovered as a yellow-grey, sandy Gravel and yellow grey Clay. This material grades to a moderately weathered limestone with depth.

5.3.1 Laboratory testing on the completely weathered Limestone

Two atterberg Limit tests were carried out on the completely weathered limestone in trial pit, TP1 at 2.6m and in TP3 at 1.5m. Both tests indicate a high plasticity within this stratum, with PI values of 31% recorded for both samples. Moisture content testing carried out on these samples give mc values of 22% and 24%.

Three particle size distribution tests were carried out on the weathered limestone in TP1, TP4 and TP6. Tests indicate that the material is a silty /clayey, sandy Gravel with some cobbles.

5.3.2 In situ testing in the completely weathered Limestone

One SPT test was carried out within the completely weathered Limestone and gives an SPT value in excess of 50.

5.4 Interbedded Limestone

The Limestone was encountered in all exploratory holes, however due to the high strength of the material, excavation of the Limestone was not possible with the JCB 3CX. Rotary coring was used to investigate the limestone strata to depths of up to 7m.

The Limestone was generally moderately strong to strong, oolitic and frequently fossiliferous and grey, interbedded at medium spaced intervals with a stiff to very stiff or hard grey, silty Clay.

5.4.1 Laboratory testing on the interbedded Limestone

Eight atterberg limit tests were carried out on the Clays that are interbedded within the limestone at various depths in order to get a moisture content/Atterberg Limit profile. The tests indicate that the material is generally of intermediate plasticity, with PI values of between 23% and 26% recorded. One test result at depth gives a lower plasticity of 14%, chart 5.1 shows the mc/PI profile for Clays within the interbedded Limestone:

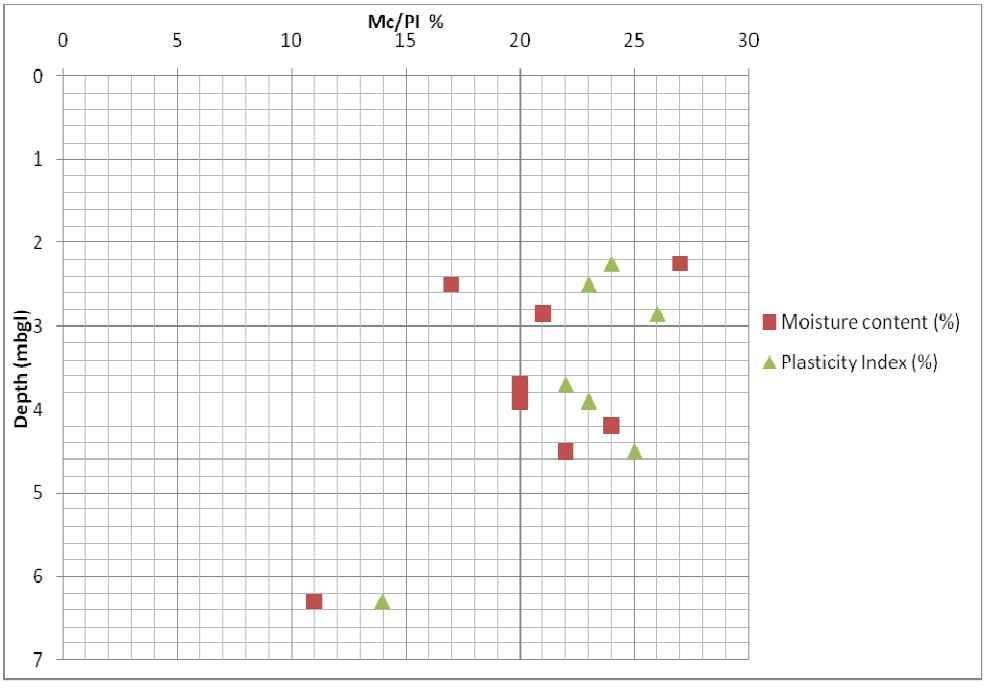


Chart 5.1 mc/PI profile for the interbedded Limestone

Moisture content testing was carried out on all of the samples tested for Atterberg Limits and give mc values of between 11% and 27%. One dimensional consolidation testing was carried out on three clay samples from the interbedded Limestone, from borehole BH1 at 4.5m, BH5 at 2.25m and from BH5 at 3.9m. Test results indicate a coefficient of volume compressibility (Mv) values ranging from 0.013 m^2/MN to 1.119 m^2/MN and coefficient of consolidation (Cv) values ranging from 0.678 m^2/yr to11.6 m^2/yr.

The minimum pH value in the interbedded Limestone is 6.4. and the maximum sulphate value is 240mg/l.

Point load tests indicate Point Load Indices ($I_{s(50)}$) of between 0.09MPa and 4.14MPa in a diametral direction and 0.22MPa and 3.98MPa in an axial direction.

Testing to determine the Unconfined Compressive Strength (UCS) of the limestone was carried out and indicates a UCS of between 19.3mpa and 39.8MPa.

5.4.2 In situ testing in the interbedded Limestone

Fourteen SPT tests have been carried out within the Limestone bands, thirteen of these giving results in excess of 50 blows. One anomalous result gives an SPT count of 28.

One SPT result is available within a Clay band within BH5 at a depth of 4.1m. This gives an SPT value of 38 which gives an undrained shear strength of 171kN/m^2 and indicates that this material is very stiff.

5.5 General

Geotechnical Parameters for each principal stratum type encountered within the boreholes are summarized in Table 5.1. These are based on available test results or published data. It is important that the accompanying notes and previous reports are read in detail when using this data for design and the construction process.

Table 5.1 – Summary of geotechnical properties

	Plasticity Indices			Natural Moisture Content	Undrained Cohesion	Effective angle of Shearing Resistance	Unconfined Compressive Strength	Standard Penetration Test	Concrete Class	Coefficient of volume compressibility /Coefficient of Consolidation
Strata	LL (%)	PL (%)	PI (%)	%	Cu (kPa)	Phi' (degrees)	UCS (MPa)	('N') value	DC/ACEC	(m^2/MN)/(m^2/year)
Superficial deposits cohesive	49	29	20	22	150 based on description	30 based on PI value	-	>50	AC-1	N/A
Superficial deposits Granular	-	-	-	-	-	40 (based on description SPT and BS 8002)	-	>50	AC-1	N/A
Weathered Limestone Granular	-	-	-	-	-	40 (based on description , SPT and BS 8002)	-	>50	AC-1	N/A
Weathered Limestone Cohesive	54-58	23 - 27	31	22-24	>150 based on description and SPT result	28	-	>50	AC-1	N/A
Interbedded Limestone Rock						40 (based on values published by Hoek and Bray)	19-40	>50	AC-1	
Interbedded Limestone Clay	29-46	15 - 23	14 - 26	11-24	>150 based on description and SPT result	28	-	38	AC-1	0.013 to 1.119 / 0.678 to11.6

5.6 Foundations

The exploratory hole logs indicate that shallow strip or pad foundations will be suitable for the proposed residential two storey site development shown in Figure 3.

Based on Atterberg testing, the cohesive strata on the Exemplar site are generally of between low and medium volume change potential. Foundation design should be carried out in conjunction with landscaping design and in accordance with the guidance provided in NHBC chapter 4.2 (Ref. 7) to ensure that no damage to foundations results from shrinkage/swelling of clays.

Due to the potential presence of medium volume change potential Clay beneath the Superficial Deposits, it is recommended based on NHBC chapter 4.2 that foundations are located at a

minimum of 0.9m below ground level (where roots are noted / present then foundations should be extended below the level of the roots – see section 5.8.1), unless limestone is encountered at shallower depth.

There is some variability in the depth to the interbedded limestone across the site, so that when considering foundation types and loadings, consideration of differential settlement should be taken between those areas where limestone might lie directly beneath the foundation and where foundations are underlain by cohesive weathered limestone or Clays. Based on this variability in likely founding strata, strip foundations are not recommended for long rows of terraced houses without the inclusion of flexible movement joints and/or frequent gaps.

No Made Ground was recorded in any of the exploratory holes, however if Made Ground or soft material is encountered in any of the excavations for foundations then this material should be excavated and replaced with suitably compacted, granular fill. All shallow foundations should be inspected by a suitably qualified Geotechnical Engineer, to confirm that a suitable founding stratum is available.

5.7 Excavations

Prior to excavation, any utilities services are to be disconnected and removed under the footprints of the proposed areas of works. Excavations for foundations although slow in the dense gravel, should prove straightforward with a standard backhoe machine excavator, as proven by the trial pitting during the ground investigation.

All pits were stable during the ground investigation, water ingress occurred in one exploratory hole, TP1, however this was below the proposed depth of foundation excavation. Excavations for ground investigation within the surrounding area were carried out following heavy rain and encountered shallower groundwater inflow, above the limestone. Where foundations are based at shallow level on top of the limestone, some water inflow may be expected following heavy rain where the water is perched above the limestone, and some form of dewatering during temporary works may be required.

If any excavations for other infrastructure are required to greater depth, there is an increased possibility of encountering groundwater.

5.8 General Construction Issues

Should significant changes in ground level be required as part of the proposed development of the Exemplar site, the excavatability of the limestone must be considered, as the ground investigation proved that this material is extremely difficult to dig. The overlying superficial and weathered deposits also present difficult/slow digging conditions. Excavations for drains, services and infrastructure may also prove difficult and time consuming, particularly where the limestone is at a shallower depth.

Where the ground slopes steeply towards the water course that passes across the site in an east – west orientation, consideration of slope stability is required to ensure that no instability of the superficial deposits is induced through foundation loading, and/or cuttings for roads and other infrastructure. It is recommended that the foundations to proposed properties in steeply sloping areas are deepened to found below any potential zone of influence to the slope.

A badger sett is located in the centre of the site. The development must follow current guidelines, and the recommendations of the appointed ecologist when constructing in the vicinity of this habitat.

Any soft material encountered should not be re-used as backfill beneath any planned structures, road pavements, hard standing areas or other areas that may be sensitive to future settlement.

5.8.1 Building Near Trees

Where the development is proposed adjacent to existing or proposed planting, foundations should comply with the requirements of NHBC Guidelines Chapter 4.2 (Ref. 7). In which case, it may be necessary to extend the foundation depths quoted in Section 5.5.

5.8.2 Solution Cavities/Swallow Holes

Although no evidence of solution cavities or swallow holes were recorded during the preliminary ground investigation, these features may be present within the site, particularly in the limestone deposits. Any evidence of such features discovered during excavations should be investigated further by an experienced Geotechnical Engineer, and an appropriate remediation scheme adopted if deemed necessary.

5.9 Roads

The roads on site should be constructed in accordance with Design Manual for Roads and Bridges (DMRB) Volume 4, Section 1, Part 1 (HA44/91), (Ref 8) and Volume 7, Section 2, Part 2 (HD25/94). Further ground investigation should include CBR testing, once founding levels and layouts for the roads are known, in order to assist in the design of roads and bridges.

Particular care should be taken to avoid excessive trafficking in areas of proposed roads, and pavements should be constructed soon after excavation in order to limit deterioration and softening of the formation.

5.10 Radon Protection

As part of the Desk Study Report (Ref. 1), a detailed BR 211 Radon Report was obtained from the British Geological Survey (BGS), which states that basic radon protection measures are required for the site area as the estimated probability of a property being above the Action Level for radon is 3-5%.

Details on the technical specifications for basic radon protection measures are given in document BRE Report BR211 (Ref. 9).

5.11 Protection of Buried Concrete

The pH values tested in the superficial material are greater than 6.4 and the groundwater regime is considered as ‘mobile’ water. The laboratory testing for sulphate and pH has recorded results indicative of ACEC Class AC-1 as described in BRE Special Digest 1 3rd Edition, (2005).

5.12 Permeability Testing

Two falling head tests were undertaken within boreholes BH1 and BH2 at the Exemplar site.

Soakaway testing was undertaken in TP3, TP4 and TP6 within the limestone rock and indicates a coefficient of permeability (K) between 0 (failed test with limited or no soakage) and $3.95 \times 10^{-5} ms^{-1}$.

The full permeability test results are shown in the Hyder factual report (Ref. 2) and the Hyder Exemplar Site Drainage Strategy Report (Ref.3).

6 CONTAMINATED LAND

6.1 Introduction

This Section of the report relates to the potential risks to human health and controlled waters that development of the site may represent. This Section also describes:

- The current baseline conditions at the Exemplar site;
- Any potential impacts and the mitigation measures required to prevent, reduce or offset any potentially significant adverse effects; and
- The likely residual effects after these measures have been implemented.

To assist the understanding of the principles of this subject and their particular application within the context of the proposed development, it is recommended that the reader refers to the associated Hyder Consulting (UK) Ltd. (HCL) Desk Study Report (Ref. 1).

Establishment of Baseline Conditions

The baseline conditions for the Exemplar site and vicinity have been determined based on the Phase 1 Desk Study Report and from laboratory testing results obtained from the follow-up preliminary intrusive ground investigation undertaken on site in August 2010.

Assessment of Effects

The potential effects on the identified receptors from contaminants at baseline conditions at the Exemplar site have been assessed under the headings 'Human Health Risk Assessment', 'Ground Gas Risk Assessment' and 'Controlled Waters Risk Assessment'.

6.2 Human Health Risk Assessment

The Statutory Guidance on Part IIA of the Environmental Protection Act 1990, as set out in DEFRA Circular 01/2006, and Contaminated Land Report 11 (CLR 11) form the basis on which this contaminated land assessment has been undertaken.

Current legislation and guidance on the assessment of potentially contaminated sites acknowledges the need for a tiered risk based approach comprising:

- Tier 1 Assessment: Comparison of site contaminant levels against generic standards and compliance criteria including an assessment of risk using a source-pathway-receptor model.
- Tier 2 Assessment: Derivation of site-specific risk assessment criteria and calculation of site-specific clean-up goals.

The assessment has therefore been undertaken in a phased approach, focussing initially on the Tier 1 Assessment. The Tier 1 assessment includes the following stages, which were completed where applicable:

- Zoning of data/site averaging areas;
- Maximum Concentration Assessment - comparison of maximum detected concentrations against relevant Generic Assessment Criteria (GAC);
- Mean and Maximum Value Statistical Analysis – consideration of statistical outliers and 95% Upper Confidence Levels (UCLs) against relevant GAC;

- Risk Evaluation/Assessment of Significant Results; and
- Identification of the need for Tier 2 Assessment and derivation of Site Specific Assessment Criteria (SSAC).

The current philosophy in the assessment and remediation of contaminated land in the UK is to adopt an 'end use' approach whereby the significance of contamination at a site is evaluated according to either the existing use or to a proposed development end use.

For the Tier 1 Assessment, Environment Agency published generic Soil Guideline Values (SGVs) derived using the Agency's CLEA model, was used. Where these are not available, GAC published by LQM/CIEH were utilised (Ref 11).

The assessment criteria relevant to the standard sensitive receptor setting within the CLEA model has been used i.e. a female receptor aged 1 to 6 years, a residential building (small terraced house) and a sandy loam soil with a pH7 and SOM 1%. Given the proposed site end use, the stringent "residential with plant uptake" land use scenario has been adopted.

Zoning of Data/Site Averaging Areas

The development is expected to comprise predominantly residential properties, therefore the site has been considered to comprise one zone and averaging area for the purposes of this assessment.

Tier 1 Assessment

In order to focus on contaminants of potential concern (COPC), the laboratory testing results have been compared with the respective SGVs/GAC. The results and respective screening criteria are presented in Tables 6.1 to 6.4.

Any contaminants that exceed the SGVs/GAC are considered to be COPC. Those that do not exceed the respective SGVs/GAC are not considered to be COPC and do not require further assessment in relation to the proposed development of the site.

Table 6.1 Summary of Analytical Chemical Testing Results (Inorganic)

Determinand	Number of Samples Tested	Minimum Concentration (mg/kg)	Maximum Concentration (mg/kg)	SGV/GAC (mg/kg) Res. with Plant Uptake	No. of Exceedances
Arsenic	7	10.5	21	32[(1)]	0
Barium	7	21	221	1300[(2)]*	0
Beryllium	7	0.4	3.7	51[(2)]	0
Cadmium	7	<0.2	0.4	10[(1)]	0
Chromium	7	11.3	31	3000[(2)]	0
Copper	7	7.1	17.1	2330[(2)]	0
Lead	7	7	68.8	450[(3)]	0
Mercury	7	<0.5	<0.5	1[(1)]	0
Nickel	7	16.4	28.9	130[(1)]	0
Selenium	7	<0.5	0.6	350[(1)]	0

Zinc	7	18.5	65	3750[2]	0
Cyanide (free)	7	<0.5	<0.6	53[2]	0
Cyanide (complex)	7	<0.5	<0.6	266[2]	0
Asbestos	1	Not detected	N/A	N/A	N/A

1 EA published SGV
2 LQM/CIEH published GAC (2nd Edition)
3 Previous EA published SGV (currently withdrawn)
*Residential without plant uptake scenario

Table 6.2 Summary of Analytical Chemical Testing Results (PAH)

Determinand	Number of Samples Tested	Minimum Concentration (mg/kg)	Maximum Concentration (mg/kg)	GAC (mg/kg) Res. with Plant Uptake	No. of Exceedances
Naphthalene	6	<0.1	<0.1	1.5[1]	0
Acenaphthylene	6	<0.1	<0.1	170[1]	0
Phenanthrene	6	<0.1	1.6	92[1]	0
Benzo(a)anthracene	6	<0.1	2.3	3.1[1]	0
Benzo(b)fluoranthene	6	<0.1	1.9	5.6[1]	0
Benzo(k)fluoranthene	6	<0.1	1.1	8.5[1]	0
Benzo(ghi)perylene	6	<0.1	2.0	44[1]	0
Pyrene	6	<0.1	4.5	560[1]	0
Benzo(a)pyrene	6	<0.1	<0.1	0.83[1]	0
Fluorene	6	<0.1	0.2	160[1]	0
Fluoranthene	6	<0.1	4.9	260[1]	0
Acenaphthene	6	<0.1	<0.1	210[1]	0
Anthracene	6	<0.1	0.6	2300[1]	0
Chrysene	6	<0.1	2.4	6[1]	0
Dibenzo(ah)anthracene	6	<0.1	0.3	0.76[1]	0
Indeno(123cd)pyrene	6	<0.1	1.6	3.2[1]	0
Total PAH (USEPA 16)	6	<1.40	<1.53	No value	N/A

1 LQM/CIEH published GAC (2nd Edition)

Table 6.3 Summary of Analytical Chemical Testing Results (TPH)

Determinand	Number of Samples Tested	Minimum Concentration (mg/kg)	Maximum Concentration (mg/kg)	GAC (mg/kg) Res. with Plant Uptake	No. of Exceedances
Gasoline Range Organics (GRO)					
C5-6	6	<0.2	<0.2	30[(1)]	0
C6-7	6	<0.2	<0.2	73[(1)]	0
C7-8	6	<0.2	<0.2	73[(1)]	0
C8-10	6	<0.2	<0.2	19[(1)]	0
Aliphatic Fractions					
C8-10	6	<4	<5.25	19[(1)]	0
C10-12	6	<4	<5.25	93 (48) [(1)]	0
C12-16	6	<4	5.03	740 (24) [(1)]	0
C16-21	6	<4	<5	45000 (8.48) [(1)]	0
C21-35	6	<9.61	<10.43	45000 (8.48) [(1)]	0
Aromatic Fractions					
C8-10	6	<4	<5	27[(1)]	0
C10-12	6	<4	<5	69[(1)]	0
C12-16	6	<4	<5	140[(1)]	0
C16-21	6	<4	<5	250[(1)]	0
C21-35	6	<9.61	<10.43	890[(1)]	0

Table 6.4 Summary of Analytical Chemical Testing Results for Soils (BTEX)

Determinand	Number of Samples Tested	Minimum Concentration (mg/kg)	Maximum Concentration (mg/kg)	GAC (mg/kg) Res. with Plant Uptake	No. of Exceedances
BTEX					
Benzene	6	<0.01	<0.01	0.33[(1)]	0
Toluene	6	<0.01	<0.01	610[(1)]	0
Ethyl Benzene	6	<0.01	<0.01	350[(1)]	0
m/p-Xylene	6	<0.01	<0.01	230[(1)]	0
o-Xylene	6	<0.01	<0.01	250[(1)]	0

1 LQM/CIEH published GAC (2nd Edition)

Values in blue are solubility saturation limits. Values in green are vapour saturation limits.

Contaminants of Potential Concern

There are no contaminants that exceed the respective SGVs/GAC.

Human Health Risk Assessment Conclusions

None of the contaminants tested returned values greater that the respective SGVs/GAC, therefore the soil that has been tested is deemed suitable for use in gardens (including growing edible plants) without the need for treatment or other remedial action.

During site construction works, site workers should remain vigilant to the possible risk of encountering isolated areas of contaminated material. Should potentially contaminated material be encountered, further testing will be required to assess the risks to the health and safety of site workers and the environment. All persons engaged in site construction works should be made aware of the findings of the intrusive investigation and the hazards associated with handling potentially contaminated materials. It is recommended that all works are conducted in accordance with the Health and Safety Executive publication entitled "Protection of Workers and the General Public during the Development of Contaminated Land" (Ref. 13).

6.3 Ground Gas Risk Assessment

It should be noted that, in accordance with current best practice and guidance, the number and frequency of ground gas monitoring rounds is dependent on the sensitivity of the development and the generation potential of any ground gas source. In this case, the ground gas monitoring programme has been devised in order to establish a preliminary indication of the ground gas regime at the site.

Monitoring of the ground gas regime is to be undertaken on 4 occasions between August and November 2010. The full results are to be included in the associated Addendum to the Hyder Consulting Factual Report (Ref. 2).

The results of monitoring have and will be assessed using the current guidance document: CIRIA C665 "Assessing Risks Posed by Hazardous Ground Gases to Buildings" and BS8485:2007 "Code of Practice for the Characterization and Remediation from Ground Gas in Affected Developments".

Gas Screening Values (GSV)/hazardous gas flow rates for methane and carbon dioxide have been calculated and are summarised in Table 6.5. The corresponding Characteristic Gas Situation (CGS) is also presented in this table. It is understood that the proposed development is to comprise mainly residential houses and therefore the CGS for 'Situation A', defined in the guidance as '*all development types except those in Situation B*' has been considered (Situation B is defined as '*low rise housing with a ventilated underfloor void*').

Table 6.5 Maximum Gas Concentrations (Borehole 5) and GSVs

Max. CH_4 (v/v %)	Max. CO_2 (v/v %)	Max. Flow Rate (l/h)	Max. CH_4 GSV (l/h)	Max. CO_2 GSV (l/h)	Characteristic Gas Situation A
0	3.6	0.3	0	0.0108	1

Radon Gas

The above gas situation does not account for radon. As such, as part of the Desk Study Report, a detailed BR 211 Radon Report was obtained from the British Geological Survey (BGS), which states that basic radon protection measures are required for the site area. This is because the estimated probability of a property being above the Action Level for radon is 3-5%.

Details on the technical specifications for basic radon protection measures are given in document BRE Report BR211: Radon – Guidance on Protective Measures for New Buildings (Ref. 9).

Ground Gas Risk Assessment Conclusions

The results of the gas monitoring to date indicate a very low risk classification for the proposed development from methane and carbon dioxide. However, basic radon protection measures will be necessary in the construction of all new dwellings or extensions on site. Once the addendum report is available for the gas monitoring and risk assessment, the recommendations in the addendum should supersede the guidance in this section.

6.4 Controlled Waters Risk Assessment

The Controlled Waters Risk Assessment (CWRA) has been undertaken in accordance with the guidance suggested in the Model Procedures for the Management of Land Contamination (Contaminated Land Report 11, CLR 11) and comprised a staged approach (referred to as 'Levels'). A Level 2 Assessment has been undertaken for the purposes of this CWRA. For information, all Levels (1 to 4) are summarised in Table 6.6 below.

Table 6.6 – Quantitative Risk Assessment Levels

Level	Soil	Groundwater
1	Pore water contamination compared directly to receptor target concentration	Not applicable
2	Attenuation in unsaturated zone and dilution at the water table	Groundwater below source - groundwater data is compared directly to target concentrations
3	Attenuation in the aquifer	Attenuation and down gradient receptor or compliance point – groundwater concentration at the receptor/compliance point is predicted using numerical modelling
4	Dilution in the receptor	Dilution in the receptor - dilution in a receiving watercourse or pumping abstraction borehole (only with approval of EA)

The basis for the screening criteria is to ensure that the selected screening values are protective of the identified receptor. For groundwater the general approach is to use an environmental standard as experience shows that remediation of contaminated groundwater to background quality is not achievable (Environment Agency 2006a). The standard should be relevant to the current and future receptors and the standards compliance criteria should be considered.

Standards that are applicable to this study are:

- UK Environmental Quality Standards (EQS) for the protection of aquatic life (in both freshwater and saline environments);
- UK Water Supply (Water Quality) Regulations, 2000 and 1989.

The groundwater beneath the site is considered to be the receptor in the first instance and therefore the UK Drinking Water Standards (UKDWS) have been selected as the appropriate screening criteria for the Level 2 Assessment.

Level 2 Assessment

The Level 2 Assessment has been undertaken assuming that there is one hydrogeological unit (at a depth affected by the development) underlying the site (groundwater within the Cornbrash Formation Secondary 'A' Aquifer).

There are no contaminants that exceed their respective UKDWS.

Controlled Waters Risk Assessment Conclusions

As noted none of the contaminants tested returned values greater that the respective UKDWS, therefore the waters that has been tested indicate that no remedial action with regards to ground water is required.

7 Description of Existing Baseline Conditions

The Desk Study Report (Ref. 1) was undertaken for the entire NW Bicester Masterplan eco development site (which encompassed the Exemplar site) to determine likely soil, groundwater and contamination conditions.

A summary of the findings from the Desk Study Report and ground investigation, as relevant to the Exemplar site, is as follows:

- Since the earliest available historical map of 1881 to the present day, the site has been dominated by agricultural activity.
- There are two streams on site; one minor, unnamed stream (flowing in a NW to SE direction), which feeds the N to S flowing River Bure in the southern part of the site.
- Geologically, the site is summarised as follows:
    - 0-0.2m thickness of Topsoil;
    - 0.2-0.6m (up to 0.8m deep in places) of Subsoil, comprising an orange/brown gravelly/sandy Clay or sandy clayey Gravel;
    - 0.6m to 1.9m (up to 2.9m deep in places) of yellow sandy Gravel and in places yellow/grey Clay, grading to completely weathered Limestone (Cornbrash Formation);
    - From 1.9 to 7m depth, alternating Limestone and Clay bands of the Cornbrash Formation are represented.
- No water strikes were recorded within the Cornbrash formation or superficial deposits during drilling. Follow-up groundwater monitoring recorded groundwater standing at in excess of 3m depth on average.
- There are no historic or current sources of industrial activity; farming being the only use of the land. If contamination is present on site, it is not expected to be widespread or significant. However, naturally occurring radon is present and basic radon protection measures will be required for the construction of new dwellings and extensions.

The intrusive ground investigation undertaken on site confirms that there are no contaminants present above the relevant human health and controlled waters assessment criteria, therefore the baseline conditions on site are such that remedial action in terms of contamination is not necessary prior to redevelopment.

7.1 Design and Mitigation

In the following section, the criteria used to define the significance of the effects, both adverse and beneficial, are:

- Major impact – where the development would cause a large change to the existing environment;
- Moderate impact – where the development would cause a noticeable change to the existing environment;
- Minor impact – where the development would cause a small change to the existing environment; and
- Neutral – where no impact will occur on the environment.

7.1.1 Construction

Effects likely to arise on-site through construction activities are outlined below. All construction works have the potential to generate the following potential effects relevant to this assessment:

- Creation of areas of contamination e.g. through spillage;
- Waste generation;
- Dust generation;
- Risk to contamination of workers; and
- Mobilisation of contamination and migration into controlled waters.

As the contamination testing has not identified any COPC, it is not considered that construction work will lead to exposure of construction workers and members of the public to any existing contamination present within soils, nor is it expected that the work will mobilise existing contaminants into ground or controlled water (surface water and groundwater). However, the scale of the site is such that complete coverage of all land area during the ground investigation was uneconomical and impractical, and as such, there is always a possibility that contaminants may be present in previously unexplored areas. These possibilities are discussed below in the context of existing site conditions, i.e. pre-remediation:

7.1.2 Dust

Whilst likely not contaminated, dust and silt can result from ground disturbance during construction, which can lead to accidental ingestion, dermal contact or inhalation of particles by site workers and possibly the general public. In some cases, generation of dust and silt may also lead to deposition on nearby surface waters. These risks would be most severe in the event that construction works were to take place on contaminated land, however, as previously stated it is considered unlikely that the site is contaminated.

As no significant contamination sources have been identified, **the impact is assessed to be neutral to minor adverse**. Nevertheless, mitigation measures such as damping down, covering of stockpiles, use of wheel washes and covering of lorries during transportation will be implemented as part of a general, good site management plan to ensure that the potential effects associated with airborne dust are minimised.

7.1.3 Water

Construction activities can result in the mobilisation of contaminants within the soil and the creation of a pathway for contaminants to migrate to underlying groundwater. Pathways can also be created for the transport of contaminants to surface water via airborne dust and through overland flow from poorly managed stockpiles. However, as previously stated, negligible contaminant concentrations in the soil and groundwater have been measured in the explored areas of the site, therefore it is considered unlikely that the construction works will introduce new contamination from the shallow soil to the underlying Secondary ‘A’ Aquifer (Cornbrash Formation) and the two on-site streams. **The impact is assessed to be neutral**.

7.1.4 Work in Previously Unexplored Areas

In the event that construction activities are undertaken in areas where previously unknown contamination is encountered during construction, a management strategy would be devised to ensure that any risks associated with its mobilisation are minimised. If required, suitable arrangements for stockpiling will be implemented to minimise the potential for the leaching of

contaminated liquids and run-off of sediment through loading and exposure to rainwater. Mitigation measures will include stockpiling in bunded areas underlain by impermeable material away from watercourses. Stockpiles will be covered to prevent leaching of the material.

If excavation works are undertaken in areas where locally contamination water is identified, water may enter the excavations and lead to contaminants migrating vertically and horizontally. Abstraction of potentially contaminated water from excavations will need to be controlled to prevent cross contamination of soils and potential impact upon the Secondary 'A' Aquifer. Mitigation could include the abstraction and disposal of water to a foul sewer or to surface water following appropriate treatment (and with the appropriate consent in place).

It is prudent in unexplored areas for a suitably qualified Geo-environmental Engineer to be present during the construction works tasked with a watching brief, in order to ensure that correct measures are taken if unexpected contamination is encountered.

7.1.5 Waste

In general, material removed from an excavation will not normally be regarded as waste if:

- It is intended to be reused on site and meets risk based values;
- It is suitable for use as backfill and meets risk based values; and
- It does not need to be processed before it can be reused.

In such cases, the material is unlikely to be subject, at that point in time, to the duty of care for waste and environmental permitting. This should be agreed with the Environment Agency Waste Officer prior to works commencing. The document published by CL:AIRE The Definition of Waste: Development Industry Code of Practice provides further details about the criteria which should be meet for re-use of soils on site.

If it is not possible to reuse excavated material on site, then off-site disposal to an appropriately licensed landfill may be required. In this case, due consideration should be given to the UK Landfill Directive. Furthermore, any materials without a defined use on site can be considered as waste.

As of July 2009, the final phase of the landfill regulations from 2002 came into force and developers should be aware of the impact that it could have on their developments.

With measures already in place, the final phase of the regulations means that specified wastes can no longer be disposed off site to landfill and all wastes intended for landfill must receive prior treatment. Options for treatment (which include chemical, biological, mechanical separation and sorting) exist for most wastes and exemptions to this requirement are only limited to: inert wastes where treatment is not technically possible and wastes where viable treatment would not reduce the quality or the hazard(s) posed to human health or the environment.

The basic Government policy applies in the management of waste, and sites should adhere to the following protocol:

I. Reduction of the waste generated by managing the development to keep the amount of 'waste soil' to a minimum;

II. Re-use or re-distribution of soil on site (this will require the necessary authorisation);

III. Recovery or recycling by way of treatment on site (this will require the necessary authorisation); and finally

IV. Disposal, following pre-treatment (with necessary authorisation) to landfill.

If, having followed the above hierarchy, off-site disposal of soil is necessary; there is a requirement to determine whether the waste soil is “hazardous” or “non-hazardous”. This is undertaken by means of CATWASTE^{SOIL}, as described below.

CATWASTESOIL

The results of the investigation have been input into CATWASTE^{SOIL} (Ref. 14), which has determined from the total contaminant concentrations that the soil is non-hazardous.

Disposal

The geology identified at the site indicates that shallow spread foundations may be suitable for all anticipated low-load structures; therefore, the generation of spoil is expected to be minimal.

It is anticipated that any spoil generated may be reused on site for landscaping or other purposes, therefore it is expected that only minimal volumes of material may require disposal off-site.

In general, for offsite disposal, Waste Acceptance Criteria (WAC) testing is necessary once a waste has been characterised as hazardous or if a non-hazardous waste is to be disposed at an “inert” landfill site. Non-hazardous waste does not require WAC testing unless disposal to an “inert” landfill is being considered.

In the event that large volumes of material will require off-site disposal, WAC testing is recommended to confirm whether the material is inert and can therefore be disposed at an “inert” landfill (thereby attracting less landfill tax).

7.1.6 Accidental Spillage of Construction Related Material

During any construction work, there always some potential for accidental spillage of contaminated materials. The main source of spillages is considered to be from construction plant and materials stored on site, particularly fuel and lubricating hydrocarbons. **The impact is assessed as neutral to minor adverse** depending on the nature, frequency and volume of the spillage. Mitigation measures will include the storage of chemicals and contaminative material in accordance with the Environment Agency guidance; regular servicing and inspection of vehicles used on-site; restriction of refuelling of vehicles to bunded areas underlain by hard standing, or other impermeable materials and the restriction of vehicle movements within close proximity of the surface watercourses.

Overall, it is considered that the effect during construction will be neutral to minor adverse.

7.1.7 Operation

For the proposed primarily housing end use, it is expected that receptors will come into regular contact with the soil, therefore potential for accidental ingestion, dermal contact or inhalation of dust particles exists. However, as no contaminant sources have been identified from the historical or current use of the site (confirmed by laboratory testing of the soil and groundwater) **the impact is assessed as neutral**. If contaminated material were discovered in previously unexplored areas of the site, remedial measures would be implemented where a complete pollution linkage would be possible, e.g. if contaminated soil were discovered in an area earmarked for residential gardens, then appropriate remedial action would occur, such as

excavating the soil and replacement by clean material. Alternatively, a cover system could be employed.

It is anticipated that a small proportion of the site may contain retail/leisure facilities. During operation, there may be limited potential for accidental spillage of potentially contaminating materials from delivery locations and plant operational locations. Due to the expected hard standing in these areas with appropriate drainage infrastructure and the adoption of standard materials handling and storage procedures, **the impact is assessed as neutral**.

Overall, it is considered that the effect during operation would be neutral.

7.2 Assessment of Residual Effects

7.2.1 Construction and Operation

In those areas of the site covered by the intrusive ground investigation, no contaminated soil or groundwater was discovered. In those unexplored areas of the site, it cannot be conclusively stated that there are no contaminants present. However, should localised contaminated areas be encountered, the degree of contamination is not expected to be significant, and it is considered that the previously described mitigation measures would significantly reduced or completely mitigated any potential impacts. No residual effects are identified.

7.3 Summary

The intrusive ground investigation has demonstrated that no elevated concentrations of contaminants are present in the soil or groundwater in explored areas of the site. In unexplored areas of the site, the Desk Study Report indicates that it is unlikely that contaminants will be present in significant concentrations.

Construction impacts are considered to be neutral to minor adverse and will be mitigated thorough the use of appropriate PPE and good site management practices.

Operational impacts are considered to be neutral and therefore require no mitigation measures.

Overall, the contamination risks associated with the Exemplar site are considered to be very low, though the risks from naturally occurring radon gas require basic radon protection measures to be incorporated in the construction of new dwellings and extensions.

8 CONCLUSIONS

8.1 Ground and Groundwater Conditions

The ground investigation generally confirms the expected geology, the site being underlain by Topsoil overlying granular and in places cohesive superficial/head deposits to a depth of 0.6m, with weathered limestone (Possibly the Cornbrash formation) to depths of up to 2.9m and interbedded Limestone and Clay below the weathered layer. Laboratory and in situ testing of the soils has been carried out and are discussed in section 5.

Groundwater was encountered in exploratory hole TP1 at a depth of 2.9m within the Limestone beds, and following heavy rain, in other trial pits carried out in the surrounding area, groundwater was encountered as a perched water table above the limestone.

In subsequent monitoring visits, ground water was encountered at depths of 3.1m and 6.3m in BH1 and BH5 respectively.

8.2 Engineering Considerations

Shallow foundations are expected to be a suitable option for residential and low rise structures proposed at the site, however suitable precautions should be taken in line with NHBC Foundation guidance with respect to the presence of medium volume change potential cohesive strata. In areas of low grade sloping ground, slope stability must be considered when assessing structural loadings and any road cuttings.

Excavations for foundations and infrastructure should prove straightforward, though if deeper excavations are required, extremely difficult digging conditions are likely to be encountered below the top of the interbedded Limestone/Clay strata. Excavation sides are expected to remain stable, except following heavy rain and are expected to be dry up to <2m below ground existing level.

Excavations should be inspected by a suitably qualified geotechnical engineer to confirm that a suitable formation is present. Any soft or Made Ground materials should be removed to prevent differential settlement. Due to the variable depth to the interbedded Limestone and Clays, it is recommended that strip foundations be designed to prevent differential settlement, with movement joints incorporated. Test results for concrete classification to BRE standards for sulphate and pH testing has recorded results indicative of ACEC Class AC-1.

8.3 Contamination

None of the soil or water samples analysed contained contaminant concentrations above the relevant, corresponding screening values and no noteworthy elevated ground gas concentrations were observed. As such, the risks posed to human health and the environment is considered to be very low and no remedial action is required.

The risks posed to humans including site and maintenance workers are considered to be very low from pre-construction contamination. However, contamination from materials brought on to site during the construction phase must also be considered as harmful to human health and the environment.

9 REFERENCES

1 Hyder Consulting Limited, Desk Study, A2 Dominion Housing Group Ltd & P3Eco Ltd, NW Bicester Eco Development, July 2010, Report No.: 2501-UA001881-UP33R-01.

2 Hyder Consulting Limited, Factual Report, A2 Dominion Housing Group Ltd & P3Eco Ltd, NW Bicester Eco-Town – Exemplar Site, September 2010, Report No.: 2505-UA001881-UP33R-01

3 Hyder Consulting Limited, Factual Report, A2 Dominion Housing Group Ltd & P3Eco Ltd, NW Bicester Eco-Town – Exemplar Site Drainage, September 2010, Report No.: 2505-UA001881-UP33R-01

4 British Standards Institution (BSi), (1999). BS5930:1999, Code of Practice for Site Investigations. BSi, London.

5 British Standards Institution (BSi)., (1990). BS1377:1990, Methods of Test for Soils for Civil Engineering Purposes. BSi, London.

6 CIRIA, 1995. Report 143: The Standard Penetration Test (SPT): Methods and Use. CIRIA, London.

7 NHBC, 2010. NHBC Standards, Part 4: Foundations.

8 Highways Agency (HA) Volume 4 Section 1 Part 1 HA 44/91.

9 BRE Report BR211: Radon – Guidance on Protective Measures for New Buildings

10 Concrete in aggressive ground, Special Digest 1:2005, 3rd Edition, The Concrete Centre, BRE Construction Division.

11 Land Quality Management (LQM) and Chartered Institute of Environmental Health (CIEH), 2007. Generic Assessment Criteria for Human Health Risk Assessment.

12 CIRIA, C552, Contaminated land risk assessment - a guide to good practice, 2001.

13 HSE, 1991: Protection of workers and the general public during development of contaminated land, guidance. HMSO, London.

14 European Commission, 1991. Council Directive 91/689/EEC of 12 December 1991 on hazardous waste. Official Journal L 377, 31/12/1991 P. 0020–0027