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BETTER DEFINED GEOLOGICAL AND HAZARD MODELS  
FOR BELLAHOUSTON PARK, GLASGOW – EXTENSION  
AUTUMN 2003.

Commissioned Report

CR/03/262N Commercial-in-  
confidence



BRITISH GEOLOGICAL SURVEY

COMMISSIONED REPORT CR/03/262N

BETTER DEFINED GEOLOGICAL AND HAZARD MODELS  
FOR BELLAHOUSTON PARK, GLASGOW– EXTENSION  
AUTUMN 2003.

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# 1 Introduction

## 1.1 BACKGROUND

Glasgow City Council (GCC) would like the key, south-central area of Bellahouston Park to be used for public events and wish to further constrain hazard areas related to old mineworkings. Previous studies and a borehole drilling programme have improved the geological and hazard model related to the workings of the Knightswood Gas and Pollock Stone coals (Rogers and Sowerbutts, 2000; Monaghan, Browne & Culshaw 2003). However a problematic area remained around a 1960's borehole record 'Pollock Borehole 13' that contained a 1.1m void at 22.2m depth (-1.7m OD). The void was interpreted as being at the level of the Banton Rider Coal and the geology of the borehole did not fit well with surrounding boreholes (Monaghan, Browne & Culshaw 2003). The area where this void would be projected to crop out (hazard class D2) was in the centre of the part of the park with least hazard (no recorded mineworkings). Therefore, GCC wished to further resolve the area of hazard class D2 to adequately understand the hazards to public safety in this prime area for future activities.

GCC commissioned the British Geological Survey (BGS) to undertake stratigraphical logging of three additional boreholes and to update the geological and hazard models for southern Bellahouston Park accordingly. Please refer to Monaghan, Browne & Culshaw (2003) along with this report.

## 1.2 AIM OF THE REPORT

This report describes the geological results of the extension to the 2003 borehole drilling programme to further constrain the void recorded in Pollock Borehole 13, and the subsequent improvements to the hazard model.

# 2 Borehole drilling programme

## 2.1 SITING OF THE NEW BOREHOLES

BGS and GCC worked together such that the siting of the new boreholes constrained the hazard related to the void recorded in Pollock Borehole 13 to maximum effect. The core lengths for each borehole were long enough such that the stratigraphy of each could be robustly defined. The borehole locations are shown in Table 1 and Figure 1.

GCC Borehole number	Easting	Northing	Start height, metres above OD	Summary
500_1	254993	663547	22.1	Through BKME, stops just above Banton Rider horizon, KNO 3-4m off rockhead
500_2	255004	663485	20.3	Into BKME with the KNO a metre or so above rockhead
500_3	255012	663461	20.2	Into BKME with the KNO just off at rockhead

Table 1. New borehole numbers, locations and summary of interpreted stratigraphy. See Appendix 2 for explanation of codes used.

\* outcrop is used throughout this report to mean the line where the coal seam reaches the top of the rock surface (rockhead). However superficial deposits up to 25m in thickness obscure the actual position.

## 2.2 BOREHOLE DRILLING AND STRATIGRAPHIC CORRELATION

Ritchies Ltd were contracted to drill the boreholes for GCC. The boreholes were open-holed to just below rockhead, from which 76mm diameter core was obtained to a depth advised by BGS and GCC. Stratigraphical logging of the boreholes was done by Alison Monaghan and Mike Browne of BGS. Fossil specimens were taken to BGS in Edinburgh and identified by Mark Dean. Stratigraphical correlations were made using recognisable lithological sequences, key fossil occurrences and other characteristic features in the interval of the Limestone Coal Formation from below the Black Metals Member to just below the Knott Coal (Figure 2). Logs of the new boreholes are given in Appendix 1.

## 2.3 THE PROBLEMATIC 'POLLOCK BOREHOLE 13'

As noted above, the reason for this extension to the drilling program in Bellahouston Park was the existence of a borehole record that contained a void in an area of the Park otherwise unaffected by mineworkings. Further checks were made on the original GCC and BGS records of Pollock Borehole 13, but the site and existence of a void are noted with certainty on the original Ross & Co. plans.

## 2.4 BOREHOLE RESULTS

The detailed logs of each borehole are given in Appendix 1, see Figure 1 for their locations. Depths are given as drilled depths apart from where labelled as relative to Ordnance Datum (e.g. 2mOD).

### 2.4.1 500\_1

This borehole was drilled to test hazard class area D2 of Monaghan, Browne and Culshaw (2003) i.e. whether the void recorded in Pollock Borehole 13 extended up-dip to outcrop. The borehole reached rockhead at 13.5m depth with 12m of till above rockhead. The stratigraphy of the borehole is well constrained starting in the sandstone beneath the Knott Coal, with the coal off by 3-4m above rockhead when correlated with nearby boreholes. The borehole penetrates into the Black Metals Member mudstone and ironstone succession from about 16m to 35m. The Black Metals Member contains a fossil fauna of *Lingula*, marine shells and trace fossils that is typical for this area. The muddy ironstones below about 27m could be correlated with the 'California Clayband Ironstones' that occur in the bottom part of the Black Metals Member in this area (Hinxman *et al.*, 1920). Below the 0.1m coal marking the base of the Black Metals Member, the borehole penetrates sandstones, siltstones, seatrocks and finishes at a total depth of 46m in siltstones and mudstones interpreted as just above the Banton Rider Coal and thin ironstones. The interval beneath the Black Metals has no characteristic fauna but correlates well lithologically with the same interval in the BGS Corkerhill Borehole (BGS number NS56SW/304) from 1.4km south-west of the Park. It is also similar to that recorded in the problematic Pollock Borehole 13. The interval beneath the Black Metals Member is also similar, though about 3m thicker than that recorded beneath Bellahouston Sports Centre (see Rogers and Sowerbutts, 2000). No evidence of any workings was found in borehole 500\_1.

The stratigraphy of borehole 500\_1 is consistent with a south-easterly dipping succession in the same fault block B as BGS boreholes numbers NS56SW45/18 and NS56SW671 and GCC borehole number 54/63/023, with a low dip of c.5° north of the latter borehole. Due to the depths of the key horizons, a small fault  $F_{BC}$  is interpreted between borehole 500\_1 and boreholes 500\_2, 500\_3 and 55/63/052. The depths of key horizons in borehole 500\_1 are not consistent with the interpretation of Pollock Borehole 13 as beneath the Black Metals Member with no intervening structure.

### 2.4.2 500\_2

This borehole was drilled to test whether the void recorded in Pollock Borehole 13 extended up-dip in fault block C. The new borehole reached rockhead at 10.2m depth with 8.2m of till above rockhead. The stratigraphy of the borehole is well constrained starting in the sandstone beneath the Knott Coal, with the coal off by c.1m above rockhead when correlated with nearby boreholes. The borehole penetrates into the Black Metals Member mudstone and ironstone succession from about 16.5m to the total depth of 31m. The Black Metals Member contains a fossil fauna of *Lingula*, marine shells and trace fossils that is typical for this area. No evidence of any workings was found in this borehole. The core recovery of the borehole was sometimes poor and the broken core with increased dips and polished surfaces from c.22.5-25.7m could be interpreted as a small fault zone. However, the position of ironstones and fossil content beneath this level correlate well with 500\_1 suggesting that any faulting had minimal offset.

The stratigraphy of borehole 500\_2 is not consistent with that previously interpreted for Pollock Borehole 13 that was situated only 13m to the east. The stratigraphy of borehole 500\_2 is consistent with a south-easterly dipping succession at c.7° in the same fault block C as boreholes 500\_3 and 55/63/052.

### 2.4.3 500\_3

This borehole was drilled to test whether the void recorded in Pollock Borehole 13 extended down-dip in fault block C, and given the results of 500\_1 and 500\_2, to re-evaluate the stratigraphy of Pollock Borehole 13. The new borehole reached rockhead at 11.4m depth with 5.6m of till above rockhead. The stratigraphy of the borehole is well constrained starting in the sandstone beneath the Knott Coal, with the coal just above rockhead when correlated with nearby boreholes. The borehole penetrates into the Black Metals Member mudstone and ironstone succession from about 18.55m to the total depth of 26.9m. The Black Metals Member contains a fossil fauna of *Lingula*, marine shells and trace fossils that is typical for this area. No evidence of any workings was found in this borehole. The core recovery of the borehole was sometimes poor and the broken core with increased dips, crushed material and polished surfaces from c.23-25m could be interpreted as a small fault zone. However, the position of ironstones and fossil content beneath this level correlate well with 500\_1 suggesting that any faulting had minimal offset.

The stratigraphy of borehole 500\_3 is not consistent with that previously interpreted for Pollock Borehole 13 that was situated only 26m to the north. The stratigraphy of borehole 500\_3 is consistent with a south-easterly dipping succession at c.7° in the same fault block C as boreholes 500\_2 and 55/63/052.

### 2.4.4 Revised interpretation of Pollock Borehole 13

As a result of the 2003 drilling programme, the site of Pollock Borehole 13 has been closely surrounded by 5 boreholes 500\_1, 500\_2, 500\_3, 54/63/023 and 55/63/049. The stratigraphy of these five boreholes is well constrained by lithological and palaeontological correlations to the strata between the Knott Coal and into the Black Metals Member. A fairly simple geological model with south-easterly dipping strata and minor NNW trending normal faults can be inferred using all new and old boreholes apart from Pollock Borehole 13. The interpretation of Pollock Borehole 13 as beneath the Black Metals Member and the recorded void at the Banton Rider level (as in Monaghan, Browne and Culshaw 2003), or at higher stratigraphical intervals with the void at the Knightswood Gas Coal level (as in Rogers and Sowerbutts (2000) is inconsistent with the new data and simple geological model. The strata now proven in this area of the Park occur within a part of the geological succession that has no documented mineworkings in the vicinity, and thus it is unclear what the void represents. Several alternatives can be proposed for Pollock Borehole 13:

1. The borehole was drilled in a very localised fault block that has throws of a few tens of metres. In the localised upthrown fault block, a trial shaft had been previously sunk and the Banton Rider Coal was extracted in a limited area that can be no more than c.5m to the east or c.11m to the west of Pollock Borehole 13. The void then represents an old mineworking or part of the trial shaft.
2. The upper 16.5m of Pollock Borehole 13 is moderately similar to that recorded in borehole 55/63/049 that is situated 7m to the east i.e. a similar superficial succession and a thin coal underlain by sandstones. It is possible that the upper 16.5m of Pollock Borehole 13 lies on the downthrown side of Fault<sub>CD</sub> with the thin coal correlated with the Knott in 55/63/049. As the

expected Black Metals Member mudstones are not recorded beneath 16.5m in Pollock Borehole 13, some unrecorded faulting would be required to repeat the recorded sandstone/siltstone succession and the void could be interpreted as a void along a fault plane. Such voids along fault planes have been observed very rarely by experienced geologists, where they may have propagated upwards from lower mineworkings.

This seems a very unlikely explanation for the 1.1m void in this case as there are no known mineworkings beneath the Knott Coal near or in Bellahouston Park until the Garsgadden Ironstones that are c.50m below, and these ironstones have not been recorded as being worked in this specific area. Even if the Garsgadden Ironstones has been worked it would be unlikely that the void would have migrated by so many metres.

3. Whilst the site of Pollock Borehole 13 appears certain (see Section 2.3), the original cores or drillers log could have been mislabelled during the 1960's investigation such that this record is from another location.

The geological model presented in Section 3.3 is consistent with, but not dependent on, these alternatives for Pollock Borehole 13. The small localised fault block required by alternative 1 is too small to be shown on Figures 1, 5 and 6, though fault  $F_{CD}$  is shown as running through the borehole. The hazard model presented in section 4 does not rely on the stratigraphical interpretation of Pollock Borehole 13 but does take into account the recorded void at 22.2m depth (-1.7m OD).

## 3 The revised geological model

### 3.1 METHODOLOGY

Contour models were revised for rockhead, drift thickness, most marine bands in the Black Metals Member and the Knott coal seam using the new and pre-existing borehole datasets (Figures 3-7). The resultant structure contour models were also constrained by projecting stratigraphical horizons that were just above rockhead onto boreholes using the standard sequence shown in Figure 2. Coal seam outcrops on the base of the horizon were drawn where structure contours intersected the rockhead surface, calculated using a local dip and borehole thicknesses (Figures 6, 7). Standard intervals between horizons (Figure 2) were used where no borehole data was present. It should be noted that because of the substantial topography on the rockhead surface, that sometimes varies more quickly than the dip of the solid geology, some of the coal seam outcrops are quite sinuous. No edits were made to the geological model for the Knightswood Gas or any higher coal seams.

### 3.2 DRIFT THICKNESS AND ROCKHEAD

Minor adjustments were made to the rockhead and drift thickness models of Monaghan, Browne and Culshaw (2003) to incorporate the new borehole dataset (Figures 3 and 4).

### 3.3 SOLID GEOLOGY

The solid geology model has been edited in the central part of the Park only, around the area of the new boreholes in south-easterly dipping fault blocks B and C. The main changes are that fault block C closes northwards against faults  $F_{BC}$  and  $F_{CD}$ , the outcrop of the Knott Coal in fault block C is more sinuous, and that strata in the northern end of fault block C now dip at a more typical c.7° than the steeper dips of up to 19° required to accommodate Pollock Borehole 13 in Monaghan, Browne and Culshaw (2003; Figures 1,5,6). The throw on faults  $F_{BC}$  and  $F_{CD}$  decrease northwards to a few metres or less in the area around 500\_2. Borehole 500\_1 confirms that dips in the northern part of fault block B decrease to c. 5 degrees.

## 4 Hazard model

The hazard class calculations and areas remain the same for the Knightswood Gas and Pollock Stone Coals (see Monaghan, Browne and Culshaw, 2003; Table 2, Figures 7, 8).

Boreholes 500\_1, 500\_2 and 500\_3 show no evidence for mineworkings. Borehole 500\_1 has proven that the void recorded in Pollock Borehole 13 does not extend up-dip towards rockhead and thus hazard class area D2 of Monaghan, Browne and Culshaw (2003) has been deleted and replaced by hazard class 4.

The stratigraphical interpretation of all boreholes apart from Pollock Borehole 13 forms a consistent geological model such that any feature responsible for the geology in Pollock Borehole 13 would be very localised (see 2.4.4). The strata now proven around the site of Pollock Borehole 13 occur within a part of the geological succession that has no documented mineworkings in the vicinity, and therefore any mineworkings from the problem borehole are thought to be very localised. If the void in Pollock Borehole 13 were along a fault plane, this would also be expected to be very localised. As a result of the restricted spatial extent over which the void is predicted to exist, hazard class E3 has been applied in a buffer zone 20m around the location of Pollock Borehole 13 and clipped where a borehole has been drilled closer to it than 20m. Hazard class E3 is appropriate as whatever the cause of the void as it is greater than 5.25m from rockhead (see Table 2). The possibility for collapse of the void exists, but in Pollock Borehole 13 the void is recorded 9.7m from rockhead with 8m of overlying superficial deposits, so the migration of the void to the surface is unlikely applying the rule-of-thumb of Bell (1978). Any entrance (shaft) to the void identified in Pollock Borehole 13 poses an unlocated, and probably greater hazard.

Hazard Class	Definition	Hazard assessment	Subsidence features
Hazard Class 1 (greatest hazard)	Area with drift thickness less than 9.4m and less than 5.25m of rock between the base KDG and rockhead	Greatest likelihood of voids reaching the surface	Several crown holes have developed in this area
Hazard Class 2	Area with drift thickness greater than 9.4m and less than 5.25m of rock between the base KDG and rockhead	Reduced likelihood of voids reaching the surface due to thicker drift cover	One possible collapse feature in this area
Hazard Class 3	Area where base KDG is greater than 5.25m from rockhead. Coal is at increasing depth with increasing distance from outcrop	Possibility for collapses exists but worked coals at greater depth from rockhead	
Hazard Class 4 (least hazard)	No evidence of worked coal seams beneath this area	No direct evidence for mining related hazard on the up-dip side of the KDG outcrop	
Hazard Class A1	Area with drift thickness less than 9.4m and less than 5.25m of rock between the Pollock Stone Coal and rockhead (using a dip of 12°)	If the Pollock Stone Coal has been worked in the Park then there is a similar likelihood to Hazard Class 1 of voids reaching the surface. If the Pollock Stone Coal has not been worked, the area is of Hazard Class 3.	
Hazard Class B2	Area with drift thickness greater than 9.4m and less than 5.25m of rock between the Pollock Stone Coal and rockhead (using a dip of 12°)	If the Pollock Stone Coal has been worked in the Park then there is a reduced likelihood, similar to Hazard Class 2, of voids reaching the surface. If the Pollock Stone Coal has not been worked, the area is of Hazard Class 3.	
Hazard Class C3	Area with drift thickness greater than 9.4m and more than 5.25m of rock between the Pollock Stone Coal and rockhead (using a dip of 12°)	If the Pollock Stone Coal has been worked in the Park then the possibility for collapses exists but the coal is at increasing depth from rockhead. The hazard is similar to Hazard Class 3 but with the possibility for both Pollock Stone Coal and KDG workings at depth. If the Pollock Stone Coal has not been worked, the area is of Hazard Class 3.	
Hazard Class E3	Area with more than 5.25m of rock between a void and rockhead	Possibility for collapses exists but void 9.7m from rockhead with 8m of overlying superficial deposits in Pollock BH13.	

Table 2. Description of hazard classes for southern Bellahouston Park.

Figures 7 and 8 show the revised hazard model for the southern part of Bellahouston Park. The outcome of this extension to the borehole drilling program has been to increase the area of least hazard class 4 and to restrict the area of hazard class E3 to the immediate vicinity of Pollock Borehole 13. However, the limitations of the geological and hazard model as interpretations of site investigation data must be realised and Figure 7 shows the variable distribution of data points constraining the model. The boundaries of the hazard classes are inherently fuzzy apart from where tightly constrained by good quality data points.

## 5 Conclusions and recommendations

These conclusions of Monaghan, Browne and Culshaw (2003) are reiterated:

- The borehole drilling programme has greatly improved confidence in the geological and hazard models.
- The revised model is consistent with the position of crown holes and other subsidence features developing in areas with a thin drift cover and where the Knightswood Gas Coal is close to the rockhead surface, as described in Rogers and Sowerbutts (2000).
- The detection of voids and solid coal during drilling of the Knightswood Gas Coal confirms that coal was extracted beneath the Park using partial extraction (stoop and room) rather than total extraction methods.
- The presence of abandoned mineworkings under Bellahouston Park does restrict the activities that can be undertaken in the Park.
- Evidence suggests that areas designated hazard classes 1 and 2 represent those at risk from crown hole development from collapse of mineworkings in the Knightswood Gas Coal.
- It is recommended that no temporary or permanent buildings or structures of any kind be installed in hazard classes 1 and 2 zones without further investigation to confirm ground conditions and, if applicable, ground reinforcement. However, the risk of severe injury or death to pedestrian traffic is low.
- It is recommended that only pedestrians be allowed to use areas classified as hazard class 1.
- Pedestrians and cars could use areas classified as hazard class 2, but it is suggested that the Council consider reinforcing the ground to be used for cars with a geofabric.
- The same recommendations for usage apply to hazard class A1 as to hazard class 1. The same recommendations for usage apply to hazard class B2 as to hazard class 2.
- Usage of the areas designated hazard class 3 is more complex. It is recommended that heavy equipment or point-loaded structures are not installed in these zones without further investigation to confirm ground conditions and, if applicable, ground reinforcement. However, hazard class 3 areas may not require ground stabilisation for heavier installations with well-distributed loads or for low loads such as cars. The risk to pedestrian traffic in hazard class 3 is very low and cars may be parked in this area.
- The same recommendations for usage apply to hazard classes C3 and E3 as to hazard class 3.
- The area designated hazard class 4 has been enlarged as a result of the borehole drilling programme. None of the new or pre-existing boreholes in this area showed evidence for mineworkings and, from the geological modelling, the area is assumed not to be undermined. The likelihood of any mining related incident occurring is extremely low. Usage of this area would be subject to foundation conditions appropriate for the drift and man-made deposits (not assessed here).
- The Council should be aware that a slow deterioration of mineworkings is likely to continue over the medium to long term assuming no significant changes are made to the site.

The following conclusions are made as a result of the extension to the drilling programme:

- None of the boreholes surrounding Pollock Borehole 13 showed any evidence for mineworkings. The strata now proven around the site of Pollock Borehole 13 occur within a part of the geological succession that has no documented mineworkings in the vicinity, and therefore any void from Pollock Borehole 13 is likely to be very localised. An area of 20m around Pollock Borehole 13 has been designated hazard class E3 to take account of the recorded void. Any entrance (shaft) to the void identified in Pollock Borehole 13 poses an unlocated, and probably greater hazard than the void itself.

- The same recommendations for usage apply to hazard class E3 as to hazard class 3.
- As the area E3 is small (<300 m<sup>2</sup>) two ways of reducing the hazard further might be considered:
  1. Carry out a geophysical survey of the area around Pollock BH 13 using electromagnetic and magnetic methods. Such a survey is likely to take about a day (plus travel time and interpretation/reporting time) and cost about £2500 – 3000. The Council would need to provide a member of staff for one day to help with laying out survey lines etc. The disadvantage of this approach is that failure to find an anomaly that could be interpreted as a shaft does not prove the absence of any shafts.
  2. The area E3 is reinforced with a geofabric. As this will require the removal of some of the topsoil, it is possible that the presence of any shaft will be revealed, particularly if the in situ superficial deposits are uncovered. Indicators of a shaft include remnants of a shaft lining, the presence of artefacts, a change in soil colour/texture in a limited area, soft ground. A volume of about 100 –150 m<sup>3</sup> of topsoil may need removing and stockpiling. A 20m length of roadway will need to be removed and rebuilt. It should be noted that, while failure to find evidence of a shaft indicates that the presence of a shaft is highly unlikely, it does not remove the hazard entirely. Placing of a geofabric will reduce the hazard even further.

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### **Note on Monaghan, Browne and Culshaw (2003)**

As a result of recent work, the naming of laterally impersistent coals between the Knightswood Gas and Knott Coals should be modified from Monaghan, Culshaw and Browne (2003; see Figure 2) such that in the GCC borehole 55/63/53 the KRIC at 9-9.66m should be the Knightswood Gas Under Coal position, the revised KRIC level is at 16.11-16.2m. Similarly in GCC borehole 55/63/51 the KRIC at 11.16-11.26m should be the Knightswood Gas Under Coal, the revised KRIC level is at 17.72-17.9m. In GCC borehole 55/63/50 the KRIC can now be identified at 16.95-17.07m

## **Appendix 1**

### **Borehole logs – enclosed**

## Appendix 2

### Terminology used in the report and logs

*From the BGS Rock Classification Scheme*

SDST=sandstone

SLST=siltstone

MDST=mudstone

CMDST= carbonaceous mudstone

CANL= cannel

COAL=coal

FEST=ironstone

FEMDST=ironstone, mud grade

VOID =open void, coal working

DMTN=diamicton (used for boulder clay)

SANDU=sand

CLAY=clay

SOIL=soil

*From the BGS stratigraphic Lexicon*

JF=Jubilee Coal

KDG=Knightswood Gas Coal

KRIC=Knott Rider Coal

KNO=Knott Coal

BKME=Black Metals Member

MGR= made ground

DRFT=drift undifferentiated

BNRC= Banton Rider Coal

PMA=Possil Main Coal

PSTC= Pollock Stone Coal

*Other terms*

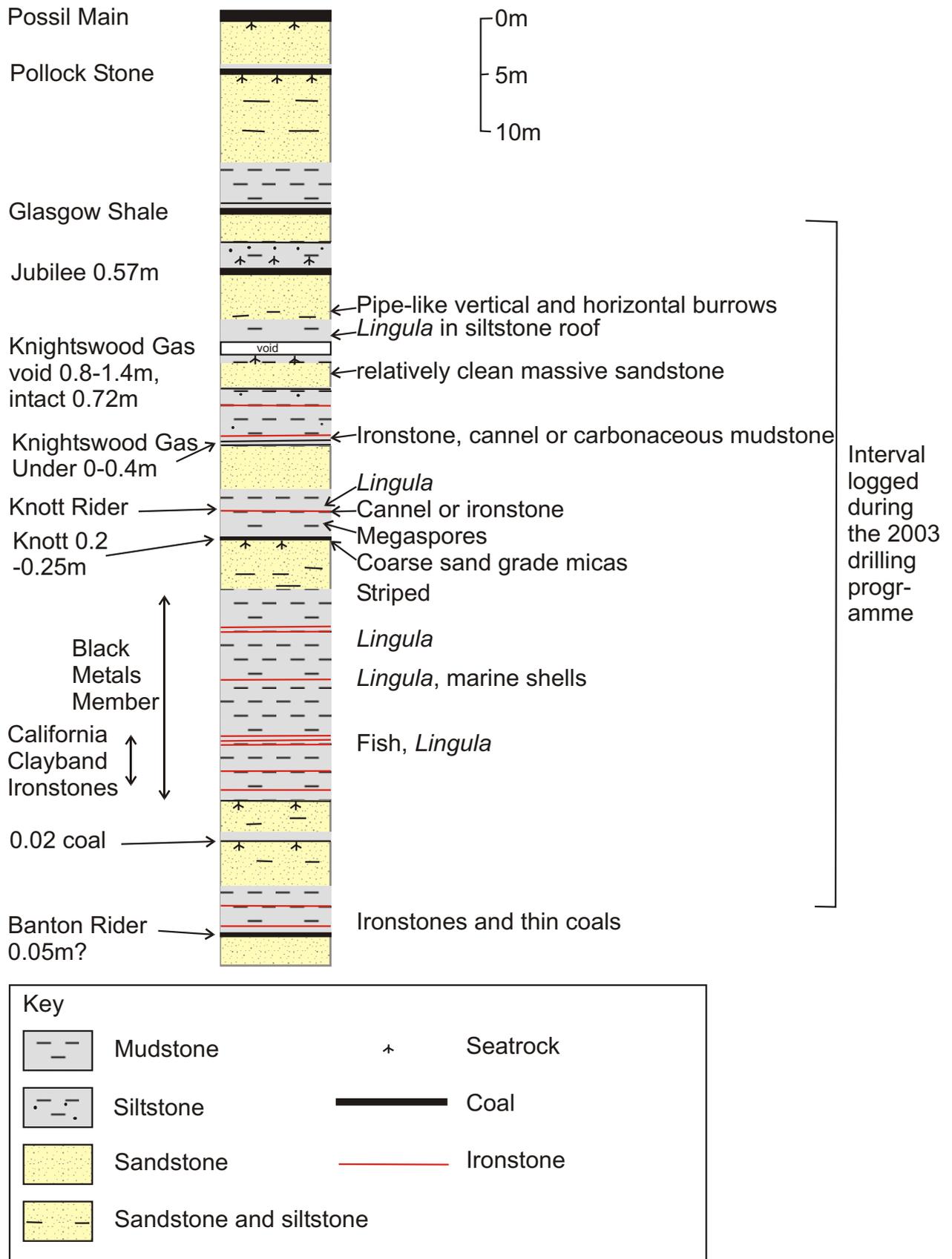
carb-mic-sid= carbonaceous-micaceous-sideritic

PDI = passes down into, ES = erosional surface, FT = fault, RH = rockhead, TD = total depth of the borehole

## Appendix 2. Explanation of automatic keys on figures generated in ArcView

	Revisedfaults2003.shp	Faults, tick on downthrow side
	Revcoalcrops2003v2.shp	Coal outcrops
	Revknocontours2003.shp	Knott contours relative to OD
	Knott3bh.shp	Boreholes penetrating Knott Coal
	Bkmebh2003.shp	Boreholes penetrating Black Metals Member
	Marinebkme.shp	Black Metals Member contours relative to OD
	Updatedboreholes2003.shp	Boreholes from BGS database
	Revdriftbh2003v3.shp	Drift boreholes labelled with drift thickness or rockhead
	Revisedrockhead2003.shp	Rockhead contours in metres relative to OD
	0	
	5	
	10	
	15	
	20	
	23	
	2.5	
	Reviseddrthickness2003.shp	Drift thickness contours in metres
	1	
	5	
	10	
	15	
	20	
	25	
	2.5	
	Newboreholes.shp	Location of new boreholes, label described in figure
	NA	blue dot=borehole in strata below KDG
	NO	black dot=borehole encounters intact KDG
	YES	dark red dot= borehole encounters void of KDG
	Hazardareas2003v2.shp	Hazard class areas
	Hazard Class 1	
	Hazard Class 2	
	Hazard Class 3	
	Hazard Class 4	
	Hazard Class A1	
	Hazard Class B2	
	Hazard Class C3	
	Hazard Class E3	



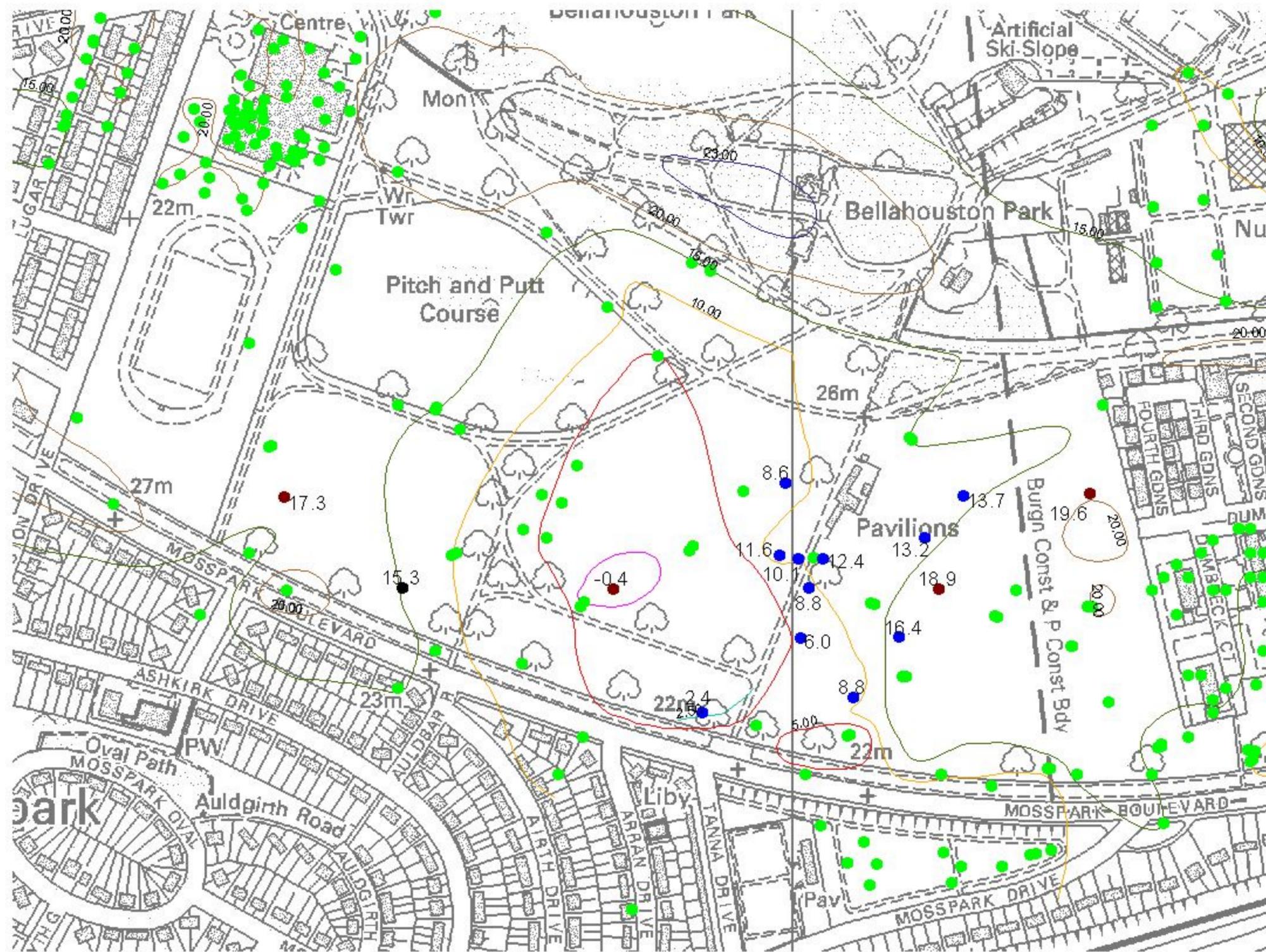


**Figure 2. Summary log for the southern part of Bellahouston Park and features used for stratigraphical correlation in this study**



# Bellahouston Park Extension 2003

## Figure 3. Rockhead contour model



### KEY

Rockhead contours in metres relative to Ordnance Datum, colours as shown below, in metres. Constrained by existing boreholes in green and new boreholes in blue, dark red and black. New boreholes labelled with height relative to OD.

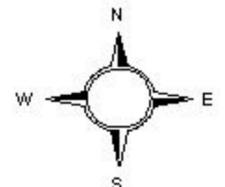
● Revdriftbh2003v3.shp  
 Revisedrockhead2003.shp

- 0
- 5
- 10
- 15
- 20
- 23
- 2.5

Newboreholes.shp

- NA
- NO
- YES

200 0 200 400 Meters

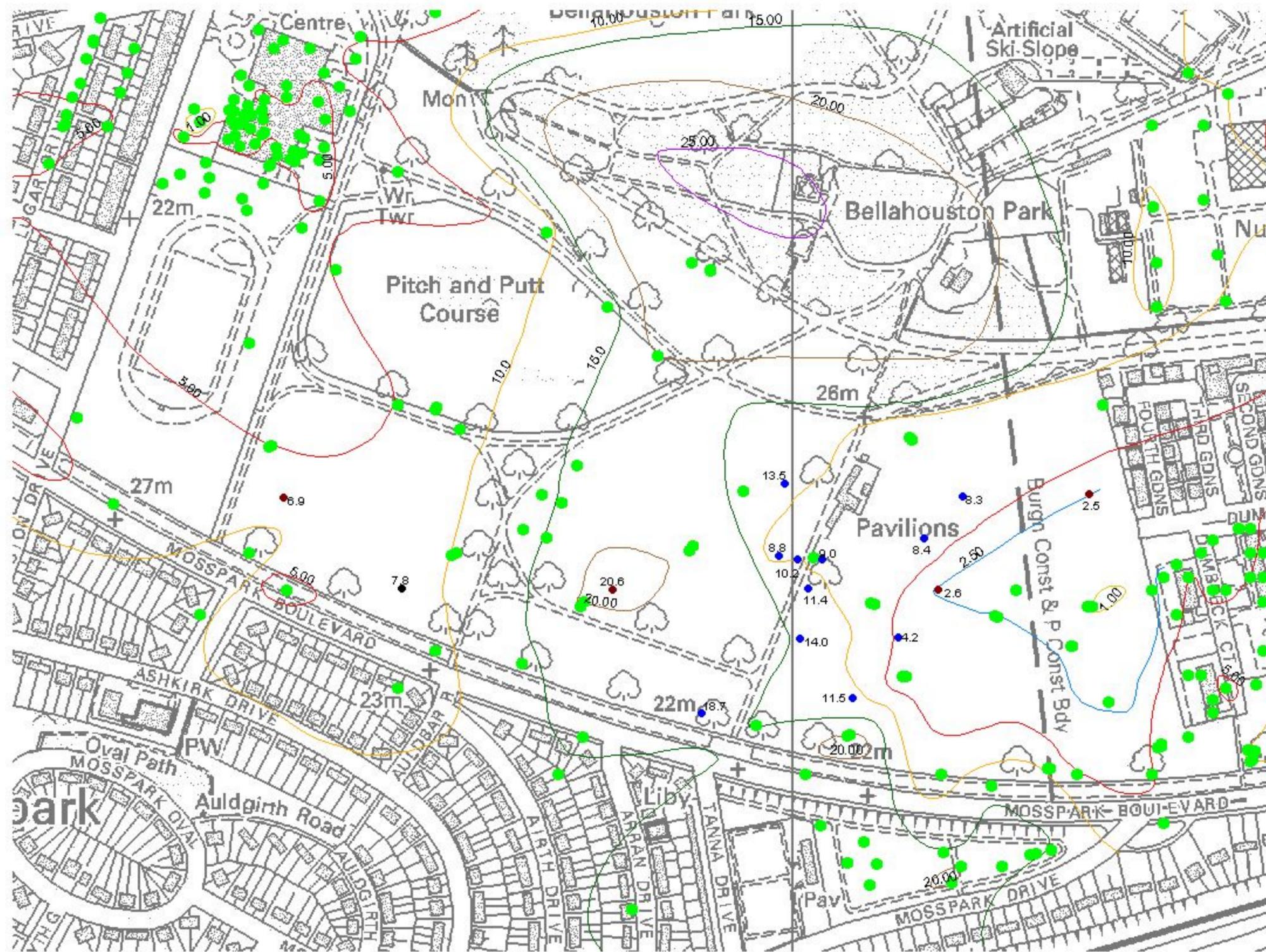


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# Bellahouston Park Extension 2003

## Figure 4. Drift thickness contour model



### KEY

Drift thickness contours coloured as in shown below, in metres. Constrained by pre-existing boreholes in green. New boreholes in blue, dark red and black, labelled with drift thickness in metres.

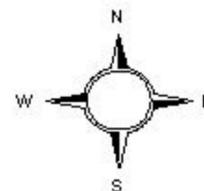
### Newboreholes.shp

- NA
- NO
- YES
- Revdriftbh2003v3.shp

### Reviseddrthickness2003.shp

- 1
- 5
- 10
- 15
- 20
- 25
- 2.5

200 0 200 400 Meters

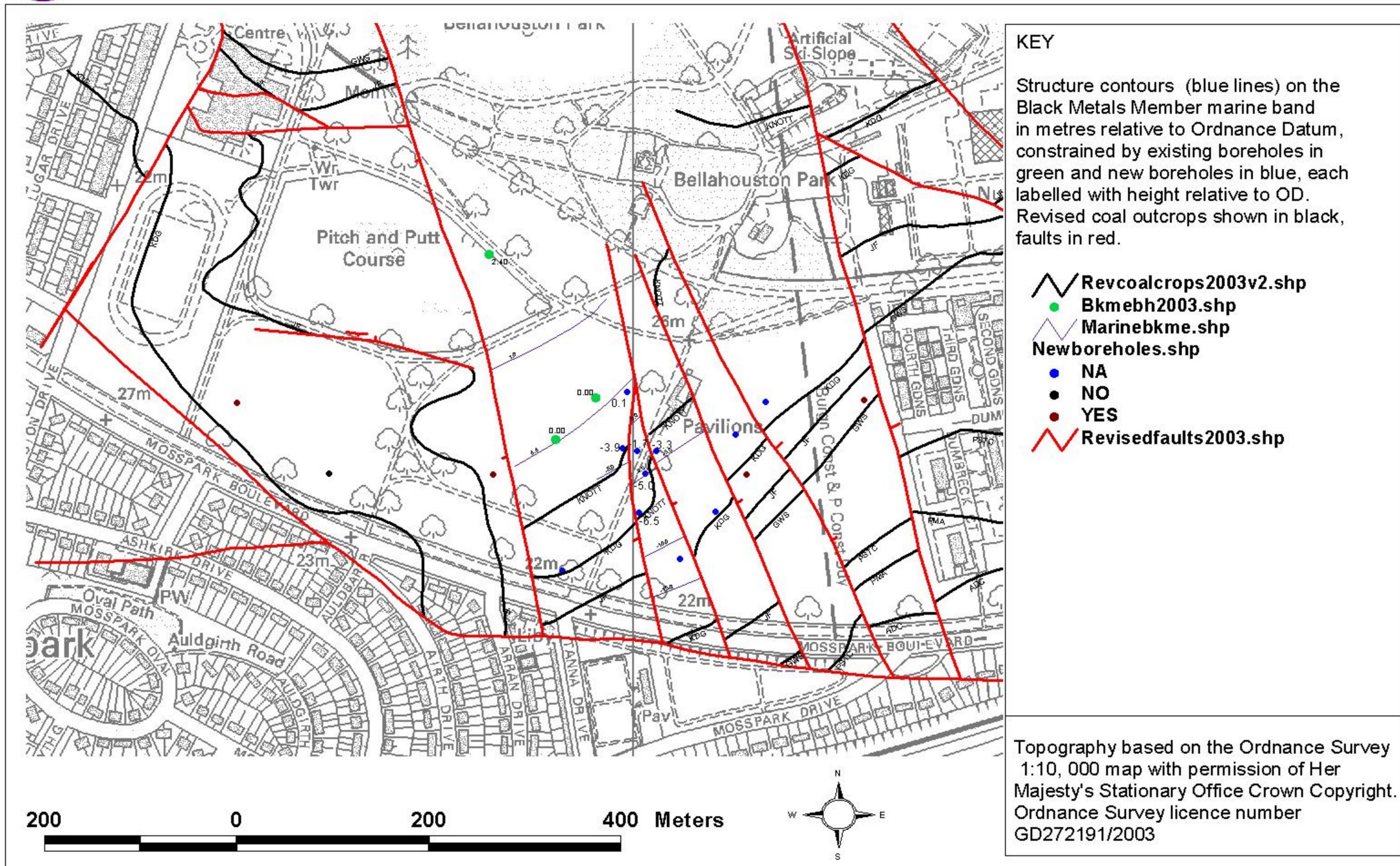


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# Bellahouston Park Extension 2003

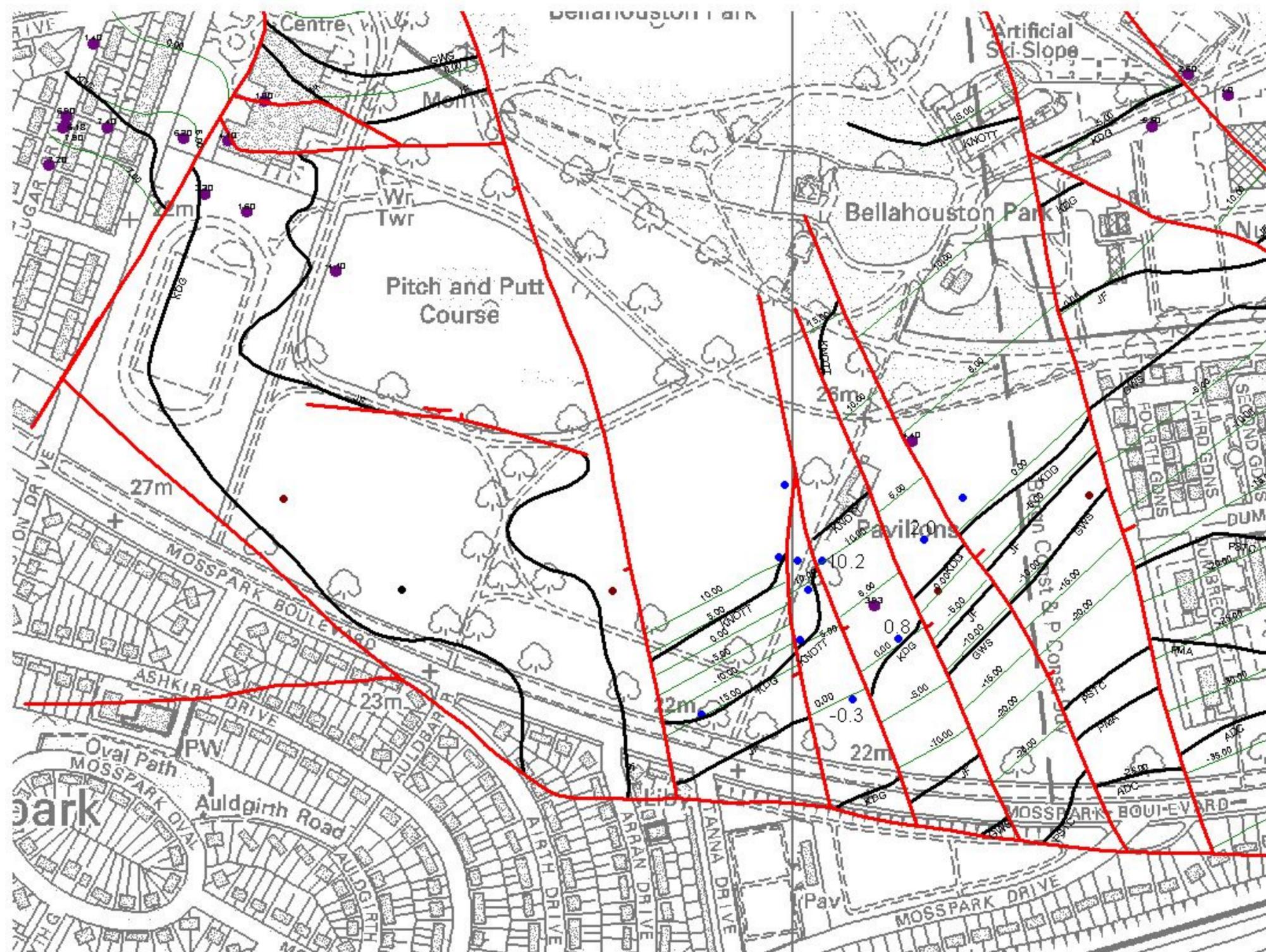
## Figure 5. Black Metals Member marine band contour model





# Bellahouston Park Extension 2003

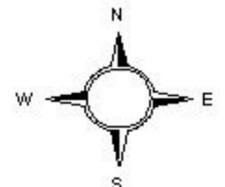
## Figure 6. Knott Coal (KNO) contour model



### KEY

Structure contours (green lines) on the Knott Coal seam in metres relative to Ordnance Datum, constrained by existing boreholes in purple and new boreholes in blue, each labelled with height relative to OD. Revised coal outcrops shown in black, faults in red.

- Revcoalcrops2003v2.shp
- Revknocontours2003.shp
- Knott3bh.shp
- Newboreholes.shp
- NA
- NO
- YES
- Revisedfaults2003.shp

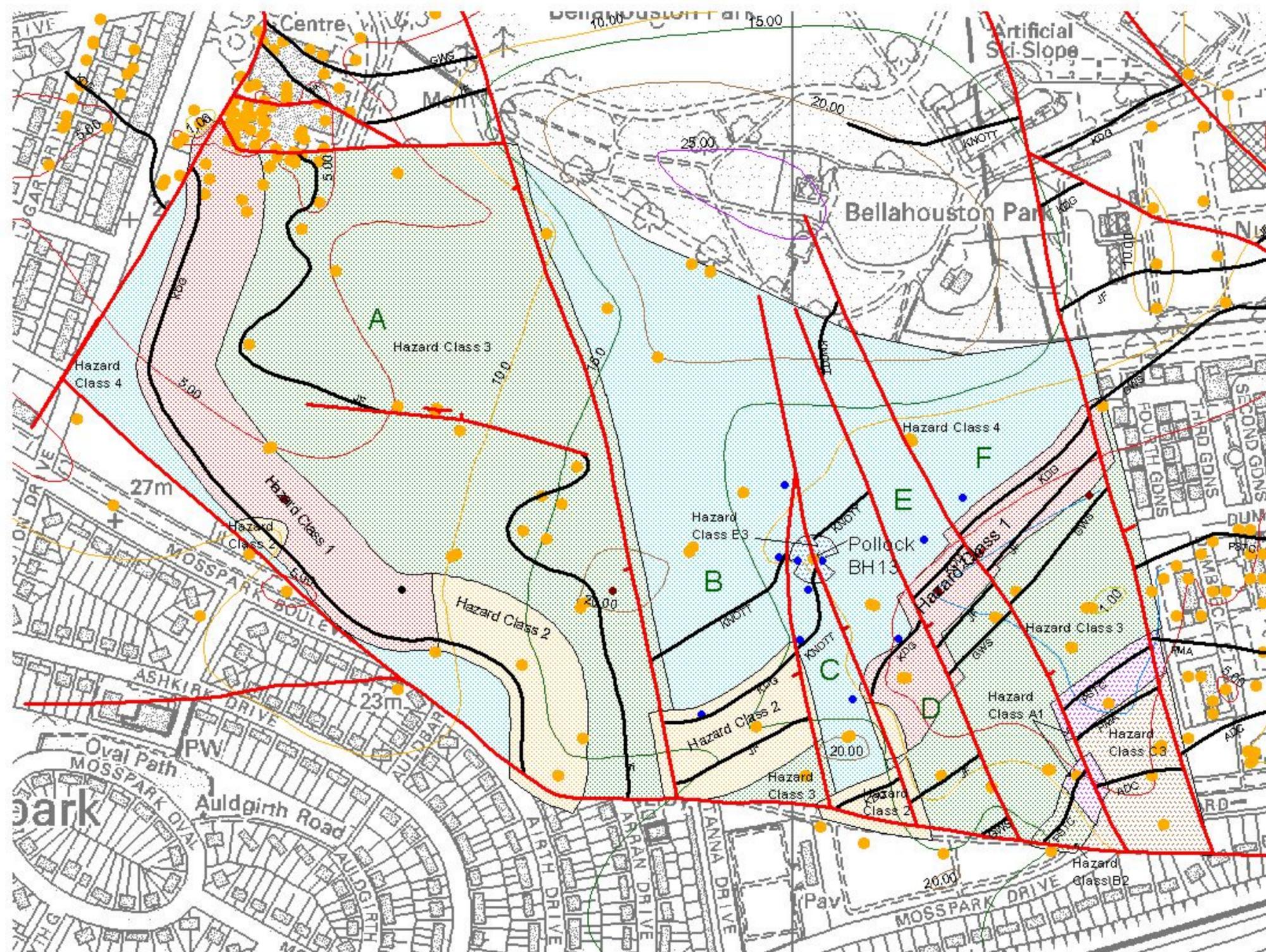


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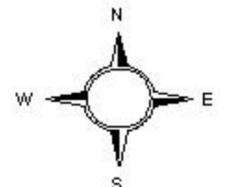
# Bellahouston Park Extension 2003

## Figure 7. Hazard class areas with geological model constraints



**KEY**  
 Hazard class areas shown with coal outcrops and drift thickness. Borehole constraints on solid geology shown as dots.  
 Faults in red, drift thickness contours as in shown below. Fault blocks are labelled with green letters A-F.  
 For the KDG, Hazard class 1 has the highest likelihood of hazard, hazard class 4 the lowest. See text for discussion.

- Revisedfaults2003.shp
- Revcoalcrops2003v2.shp
- Reviseddrthickness2003.shp**
- 1
- 5
- 10
- 15
- 20
- 25
- 2.5
- Newboreholes.shp**
- NA
- NO
- YES
- Hazardareas2003v2.shp**
- Hazard Class 1
- Hazard Class 2
- Hazard Class 3
- Hazard Class 4
- Hazard Class A1
- Hazard Class B2
- Hazard Class C3
- Hazard Class E3

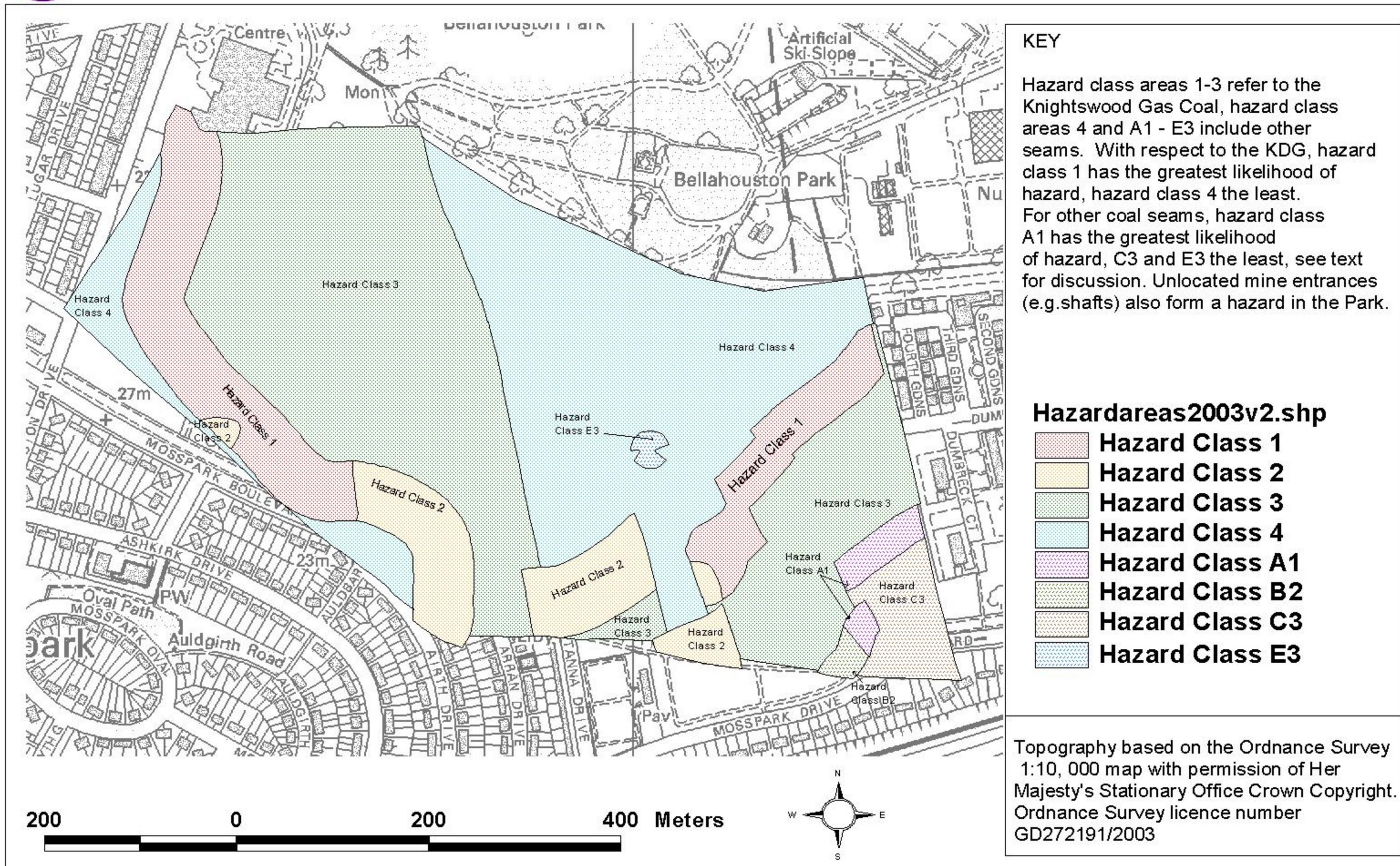


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# Bellahouston Park Extension 2003

## Figure 8. Hazard class areas



## **Appendix 1**

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BORE_NAME	QS	RT	NUMB	BSUFF	BNG_EASTING	BNG_NORTH	START_HEIGHT	STA	LOGGED_B	DRILLED_	DRILL_	DRILL_
Bellahouston Park 500_1	NS56SW	BJ	979	.	254993	663547	22.11	S	ALS/MAEB	RITCHIES	GCC	8/10/03
TOP	BASE	LITHOLOGY	BB	LITHOSTRATIC	UNIT DESCRIPTION							
0	0.1	SOIL		DRFTU	Top soil, drillers log							
0.1	0.5	CLAY		DRFTU	Sandy clay, drillers log							
0.5	1.5	SANDU		DRFTU	Sand, drillers log							
1.5	13.5	DMTN	RH	DRFTU	Boulder clay, drillers log							
13.5	13.7	SDST		LSC	Mudstone and sandstone, drillers log							
13.7	14.8	SDST	PDI	LSC	Offwhite to pale grey, fine grained, micaceous- carbonaceous with many plant fragments in layers, bedded, with slst, grey, laminae and thin bands, mainly flat bedded but some ripple laminations, dip 8 degrees, fining down. Weathered top 25cm, full recovery.							
14.8	15.2	SLST	PDI	LSC	Grey, thinly bedded with pale grey very fine grained sdst laminae, plant rich layers, finely micaceous, full recovery							
15.2	16.3	SLST	PDI	LSC	Grey, thinly bedded, finely micaceous, layers rich in plant fragments becoming less abundant downwards, fining downwards, full recovery							
16.3	17.65	MDST		BKME	Silty, grey, bedded, slightly finely micaceous, small flattish Fe nodules associated with polished surfaces, some pyritous patches							
17.65	17.77	FEST		BKME	Slst grade, grey, massive							

					Silty, darker grey, bedded, slightly finely micaceous, Naiadites sp. and fish material between 16.85-17.9m, Paracarbonicola sp. at 19.1m, small flattish Fe nodules, rare sinous burrow trace on bedding, more silty between 18.35-18.75m, some thin silty laminae from 19.12-19.60m, dip 7 degrees. Lingula squamiformis? at 19.86 and 20.23m. Core broken between 19.86-20.12m. 4cm silty ironstone at 20.85m								
17.77	20.95	MDST		BKME									
20.95	21.02	FEST		BKME	Slst grade, massive								
					Silty, darker grey, bedded, slightly finely micaceous, core broken with core loss especially between 21.60-22m (c. 10cm recovered), with many polished patches. Lingula at 21.90m. Between 21.9-25.75m, Serpuloides sp., Buxtonia sp., Lingula mytilloides, Orbiculoidea sp., Euphemites urii?, Edmondia sp., Myalina sp.,nuculid, Streblochondria anisota, ?Reticycloceras sp., fish material, burrow traces. Typical fauna of the Black Metals Marine Band.								
21.02	22	MDST		BKME									
					Fine grained, grey, calcareous, with marine shells, Serpuloides,Lingula, pyritic growths, hard, compact, massive								
22	22.2	FEST		BKME									
					Fine grained, grey, irony, shell fragments, cone-in-cone texture								
22.2	22.31	LMST		BKME									
					Fine grained, grey, calcareous, with marine shell scraps and pyritic growths								
22.31	22.42	FEST		BKME									

22.42	22.65	MDST		BKME	Silty, darker grey, bedded, marine shells								
22.65	22.77	FEST		BKME	Slst grade, grey, massive, scattered shell fragments,pyritic fragments								
22.77	23.55	MDST		BKME	Silty, grey, slightly finely micaceous, bedded, core broken in places, Lingula at 22.87m, Serpuloides at 23.23m, up to 3mm pyritic nodules and patches								
23.55	23.65	FEST		BKME	Muddy slst grade, grey, with large calcite filled septarian joints								
23.65	25	MDST		LSC	No core recovered, drillers log records weak shaley mudstone								
25	26.38	MDST		BKME	Silty, grey, bedded, slightly finely micaceous, dip 7 degrees, scattered shells and Serpuloides with small Fe nodules and pyritic grains, carbonaceous-micaceous basal 10cm. Fish material, Lingula squamiformis?, ostracods from 26.37-26.44m								
26.38	26.52	FEST		BKME	Slst grade, grey, scattered shell fragments (Lingula), bedded, finely micaceous								
26.52	26.88	MDST		BKME	Silty, darker grey, bedded, slightly finely micaceous, slightly carbonaceous in places, low angle polished surfaces near base, a few plants								
26.88	27	FEMDST		BKME	Silty mdst grade, grey, massive, carbonated plant scraps								
27	27.8	MDST		BKME	Silty, grey, bedded, slightly finely micaceous, some more micaceous layers, polished patches, microfractures in places								
27.8	27.9	FEST		BKME	Slst grade, grey, massive, finely micaceous								
27.9	28.1	MDST		BKME	Sility, grey, bedded, slightly finely micaceous, irony								

28.1	28.18	FEST		BKME	Slst grade, grey, massive								
					Silty, grey, bedded, slightly finely micaceous, jointed at moderate angle to bedding, slightly carbonaceous in places especially basal 10cm, 11 degree dip, Spirorbis sp., ?Naiadites sp., ostracods and fish material between 29-29.35m.								
28.18	29.35	MDST		BKME									
29.35	29.62	FEMDST		BKME	Silty mdst grade, grey, bedded, Lingula								
29.62	29.85	MDST		BKME	Silty, grey, bedded, slightly finely micaceous, silty top 20cm								
29.85	30	FEST		BKME	Slst grade, grey, massive, finely micaceous, small carbonated plant fragments								
30	30.35	MDST		BKME	Silty, grey, bedded, slightly finely micaceous, dip 12 degrees, rare pyritic plant remains								
30.35	30.5	FEMDST		BKME	Silty mdst grade, grey, bedded, fish scraps								
30.5	31.75	MDST		BKME	Silty, grey, bedded, slightly finely micaceous, slightly carbonaceous and very broken 30.85-31m, a few fish scales and sub-horizontal polished surfaces								
31.75	32	FEST		BKME	Slst grade, grey, massive, sandy top, a few carbonated plant remains								
32	32.28	SLST	PDI	BKME	Grey, bedded, finely micaceous								
32.28	33.33	MDST		BKME	Silty, grey, bedded, slightly finely micaceous Lingula at 32.7m and large fish scale at 32.8m, scattered slst laminae and bands, polished surfaces towards base. Somewhat carbonaceous in places. Lingula mytilloides, L. squamiformis, ostracods, fish material and coprolites between 32.7-33.4m								

33.33	33.45	FEMDST		BKME	Silty mdst grade, brownish grey bedded, a few ostracods?								
33.45	33.9	MDST		BKME	Silty, darker grey, slightly finely micaceous, slst layers and thin bands increasing in frequency towards base, possible sinous burrows								
33.9	34	FEST		BKME	Slst grade, grey, massive								
34	35.26	SLST		BKME	Grey, finely micaceous, bedded, hard, crushed weak zone 34.3-34.45m, scattered plant remains, carbonaceous and micaceous down to 34.9m, fining down below								
35.26	35.32	FEMDST		BKME	Silty mdst grade, brownish-grey, massive								
35.32	35.37	MDST		BKME	Silty, dark grey, finely micaceous, bedded								
35.37	35.6	SLST		BKME	Grey, bedded, fish remains, finely micaceous, muddy, carbonaceous at base								
35.6	35.7	COAL		BKME	Bright banded, fusainous layers, ankerite and pyrite in cleat								
35.7	35.87	SEAT		LSC	Fine grained sdst grade, pale grey, carbonaceous-micaceous laminae as remnants of bedding, carbonaceous roots								
35.87	37.43	SDST		LSC	Offwhite, medium to coarse grained, massive to bedded, hair rootlets down to 36.5m generally upward coarsening								
37.43	37.7	SDST	ES	LSC	Offwhite, fine grained, ripple laminated, carbonaceous-micaceous, sharp base								
37.7	38.6	SDST	PDI	LSC	Offwhite, fine grained, bedded, rooty in top 10cm, coarsening up from sdst with many carb-mic and silty layers up to 38.22m, some ripple or wavy lamination								

38.6	39.22	SLST	PDI	LSC	Grey, bedded with many thin sandy laminae decreasing in frequency below 38.95m, water escape deformation, plant fragments, slightly micaceous								
39.22	39.9	SLST		LSC	Grey, bedded finely micaceous, a few sometimes pyritic plant remains, fines downwards to muddy slst at base								
39.9	40.24	SEAT	ES	LSC	Offwhite, medium grained sdst grade, silty wisps, many dark roots, traces of bedding, sharp base								
40.24	40.65	SEAT	ES	LSC	Slst grade, grey, rooty, with some sandy bands throughout, sharp base in 8cm sdst								
40.65	41.2	SDST	ES	LSC	Offwhite, fine grained, bedded with grey slst laminae and bands(70/30), plant remains and some roots,sideritic, flat and ripple lamination								
41.2	43.6	SDST		LSC	Offwhite, fine to medium grained, sideritic, carbonaceous-micaceous, wavy sometimes ripple laminated, massive in places, sharp base								
43.6	44	SLST		LSC	Grey, bedded, finely micaceous with offwhite fine grained sdst laminae and thin beds, planty, fines down into								
44	44.22	SLST		LSC	Grey, thinly bedded, finely micaceous, plant remains, fish scales								
44.22	46	MDST	TD	LSC	Very silty, grey, thinly bedded, small pyritic patches locally, some zones with moderately dipping joints with polished surfaces 44.5-45m. Dip below 5 degrees, scattered plant remains								

BORE_NAME	QS	RT	NUMB	BSUFF	BNG_EASTING	BNG_NORTH	START_HEIGHT	STATUS	LOGGED_BY	DRILLED_BY	DRILL_DATE	
Bellahouston Park 500_2	NS56SE	BJ	1302		255004	663485	20.32	S	ALS/MAEB	RITCHIES	GCC	21/10/03
TOP	BASE	LITHOLOGY	BB	LITHOSTRATIC	UNIT DESCRIPTION							
0	0.1	SOIL		DRFTU	Soil, drillers log							
0.1	0.6	SANDU		DRFTU	Sand, drillers log							
0.6	2	CLAY		DRFTU	Sandy clay, drillers log							
2	10.2	DMTN	RH	DRFTU	Sandy boulder clay, drillers log							
10.2	11	SLST	PDI	LSC	Siltstone, drillers log							
11	13.75	SDST	PDI	LSC	Fine grained, offwhite, bedded with numerous carbonaceous, coarsely micaceous laminae, with grey slst laminae and bands, coaly plant remains, dip 6 degrees, striped bedding 12-12.5m, at least 0.5m of core loss between 11-13m, 0.62m core lengths>10cm from 11-14m. Unstained, hardly weathered, 40cm assessed core loss near the base.							
13.75	14.6	SLST	PDI	LSC	Grey, bedded, coarsely micaceous and carbonaceous plant remains, sandy laminae decreasing in frequency downwards							
14.6	16.5	SLST		LSC	Grey finely micaceous, thinly bedded, carbonaceous, plant remains, only 0.22m>10cm core lengths between 13-16m, assessed 50cm core loss at base							
16.5	17.6	MDST		BKME	Silty, grey, thinly bedded, somewhat finely micaceous, some polished patches, Lingula mytilloides?, Lingula squamiformis, fish material, ?coprolite at 17.14 and 19.90m							
17.6	17.7	FEMDST		BKME	Very silty mdst grade, grey, rare carbonated plant fragments							

17.7	18.85	MDST		BKME	Silty, darker grey, thinly bedded with 3cm silty ironstone near top, rare pyritic coprolite, slightly finely micaceous, traces of burrowing, some polished joints, some small nodules, locally silty								
18.85	19	MDST		BKME	Silty, grey, bedded with pale grey slst laminae and thin bands (75mm). Only 1.05m>10cm core lengths between 16-19m depth.								
19	21.65	MDST		BKME	Silty, grey, slightly finely micaceous, thinly bedded, Lingula at 19.45-20m, burrowed (small pipes). Loss of 40cm assessed at top of item. Slightly harder and more silty in places between 20.4-20.6m, rare fish scale, brown streak locally, dip 5 degrees. 1.61m of core lengths>10cm from 19-22m.?Naiadites sp. at 20.75m.								
21.65	22	FEMDST		BKME	Hard, silty mdst grade, shelly, cone-in-cone 3cm thick at 21.97m, Productids. Buxtonia sp., ?Lingula sp., ?Liralingua sp.,?Streblochondria sp., fish material, burrow traces from 21.72-22.25m								
22	22.25	MDST		BKME	Silty, darker grey, bedded, marine shells Productids								
22.25	22.5	FEST		BKME	Slst grade, massive, rare ?marine fossil								

22.5	26.1	MDST		BKME	Silty, darker grey, thinly bedded with small nodules, dip 26 degrees, core loss of 1.8m assessed in this unit, 0.22m of core lengths>10cm between 22-25m, polished irregular subvertical to steeply dipping joints, shell fragments, 6cm silty ironstone. 0.6m core loss assessed at 25-25.6m, 0.58m of core lengths>10cm between 25-28m. Dip 9 degrees at 25.70m. ?Lingula sp., Euphemites urii? at 24.62-25.65m.								
26.1	27	MDST		BKME	Silty, dark grey, thinly bedded, small concretions, very finely micaceous, Lingula fragments, basal 15cm very micaceous and carbonaceous. Lingula squamiformis, ostracods, fish material, ?burrow traces, coprolites between 26.70-27.06m.								
27	27.12	FEST		BKME	Slst grade, grey, bedded, large Lingulae								
27.12	27.4	MDST		BKME	Silty, dark grey finely micaceous, thinly bedded, small iron concretions, carbonaceous								
27.4	27.52	FEMDST		BKME	Mdst grade, grey, small carbonated plant remains, massive								
27.52	27.86	MDST		BKME	Silty, dark grey, very finely micaceous with small nodules, carbonaceous, dip 10 degrees								
27.86	28	FEST		BKME	Slst grade, grey, bedded								
28	29	MDST		BKME	Silty, dark grey, finely micaceous, bedded, loss of 0.92m assessed here. ?Naiadites sp., ostracods at 28.80m.								

29	29.17	FEST		BKME	Slst grade, dark grey, massive, coaly plant fragments, some mdst layers near top								
29.17	30.35	MDST		BKME	Dark grey, silty, thinly bedded, finely micaceous, polished irregular moderatley dipping joints, small nodules, carbonaceous, 6cm silty ironstone at 20.9m								
30.35	30.65	FEMDST		BKME	Brownish grey, silty mdst grade, carbonated plant remains, pelleted texture and subvertical mineral filled joints								
30.65	30.87	MDST		BKME	Silty, dark grey, bedded, finely micaceous, 2-3cm ironstone nodules, core broken and polished								
30.87	31	FEMDST	TD	BKME	Silty mdst grade, grey, massive, carbonated plant scraps. 1m or core lengths > 10cm between 28-31m.								

BORE_NAME	QS	RT	NUMB	BSUFF	BNG_EASTING	BNG_NORTH	START_HEIGHT	STA	LOGGED_B	DRILLED_	DRILL_	DRILL_
Bellahouston Park 500_3	NS56SE	BJ	1303	.	255012	663461	20.18	S	ALS/MAEB	RITCHIES	GCC	23/10/03
TOP	BASE	LITHOLOGY	BB	LITHOSTRATIC	UNIT DESCRIPTION							
0	0.2	SOIL		DRFTU	Soil, drillers log							
0.2	0.9	CLAY		DRFTU	Sandy clay, drillers log							
0.9	1.5	SANDU		DRFTU	Sand, drillers log							
1.5	5.8	CLAY		DRFTU	Sandy clay, drillers log							
5.8	11.4	DMTN	RH	DRFTU	Boulder clay, drillers log							
11.4	12	SDST		LSC	Sandstone/siltstone (to 26.9m) drillers log							
12	14.05	SDST	ES	LSC	Offwhite fine to medium grained, bedded, some carbonaceous- micaceous silty layers and wisps, traces of cross-beds, full core recovery, sharp flat base							
14.05	16.25	SDST	PDI	LSC	Offwhite to pale grey, fine grained, bedded with carbonaceous, micaceous silty laminae and beds, sometimes sideritic, ripple and flat laminated, striped beds, full recovery, 0.6m of core lengths>10cm from 12-15m.							
16.25	17	SLST	PDI	LSC	Grey, bedded with sandy laminae and thin beds, micaceous, plant fragments, dip 5 degrees, flat bedded							
17	18.35	SLST	PDI	LSC	Grey, thinly bedded micaceous, abundant plant fragments, carbonaceous. 1m core lengths>10cm 15-18m with full recovery, core loss of 0.35m assessed at base unit							
18.35	18.55	SLST	PDI	LSC	Grey, thinly bedded, finely micaceous, scattered plant fragments							

18.55	19.85	MDST		BKME	Very silty at top, grey, thinly bedded, finely micaceous, vague sinous burrow traces, rare shell fragments, polished striated patches. <i>Lingula mytilloides</i> , <i>Lingula squamiformis</i> ?, <i>L. cf. squamiformis</i> , burrow traces? at 18.6-22.50m.								
19.85	19.94	FEMDST		BKME	Mdst grade, grey, massive								
19.94	22.85	MDST		BKME	Silty, darker grey, thinly bedded. 10cm core loss at 20m, rare thin ironstone and slst bands up to 2cm, dip 6 degrees. ).0.13m of core lengths>10cm from 18-21m and 0.45 of core loss. Sinous burrow traces, from 21m onwards polished surfaces and irregular dipping joints quite common, 1.02m of core lengths>10cm from 21-23.9m. Rare <i>Lingulae</i> 22.2-22.5m.								
22.85	22.95	FEST		BKME	Muddy slst grade, brownish grey, finely micaceous, massive								
22.95	25	MDST		BKME	Silty, darker grey, finely micaceous, thinly bedded, slst beds near top, dip 17 degrees at 23m, strongly jointed and dip 22 degrees at 23.7-23.9m, much core loss 75cm taken at 23.9-24.65m, 0.55m of core lengths>10cm between 23.9-26.9m. Dip 12 degrees near base with crushed material in basal 3cm. <i>Serpuliodes</i> sp., <i>Buxtonia</i> sp., <i>Lingula</i> sp., <i>Pleuropugnoides</i> sp., ? <i>Sanguinolites</i> sp., ? <i>Streblochondria</i> sp., fish fragment, burrow traces from 23.35-25.60m.								

25	25.16	FEMDST		BKME	Silty mdst grade, brownish grey, bedded, marine shells Productids								
25.16	25.25	MDST		BKME	Silty, darker grey, thinly bedded, marine shells								
25.25	25.35	FEMDST		BKME	Silty mdst grade, brownish grey, bedded, marine shells Productids								
25.35	25.7	MDST		BKME	Silty, darker grey thinly bedded, finely micaceous, soft and broken in places, marine shells and small Serpuloides								
25.7	25.9	FEMDST		BKME	Mdst grade, grey, massive, calcite filled subvertical fractures, 4cm mdst band near base								
25.9	26.9	MDST	TD	BKME	Silty, darker grey, thinly bedded, Lingula, marine shells, Serpuloides, core heavily broken and jointed (cored in pieces), 3cm ironstone band, slightly finely micaceous. Core soft in places but not water stained. Lingula squamiformis?, burrow trace at 26m, ?Naiadites sp. at 26.88m.								

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Bore Name: Bellahouston Park 500\_1



Quarter sheet NS56SW BNG easting 254993.00 Logged by ALS/MAEB  
 Record Type BJ BNG northing 663547.00 Drilled by RITCHIES  
 Number 979 Start Height 22.11 Drilled for GCC  
 Suffix Start Height type S Chart Scale 1:50

DEPTH (m)	LITHOLOGY	BED BASE	LITHOLOGY CODE	STRATIGRAPHY CODE	TOP (m)	BASE (m)	Thickness (m)	DESCRIPTION
0			SOIL CLAY	DRFTU	0.000	0.100	0.1	Top soil, drillers log
0.1			SANDU	DRFTU	0.100	0.500	0.4	Sandy clay, drillers log
0.5			SANDU	DRFTU	0.500	1.500	1	Sand, drillers log
1.5			DMTN	DRFTU	1.500	13.500	12	Boulder clay, drillers log
13.5		RH	SDST	LSC	13.500	13.700	0.2	Mudstone and sandstone, drillers log
13.7			SDST	LSC	13.700	14.800	1.1	Offwhite to pale grey, fine grained, micaceous-carbonaceous with many plant fragments in layers, bedded, with silt, grey, laminae and thin bands, mainly flat bedded but some ripple laminations, dip 8 degrees, fining down. Weathered top 25cm, full recovery.
14.8		PD	SLST	LSC	14.800	15.200	0.4	Grey, thinly bedded with pale grey very fine grained sdst laminae, plant rich layers, finely micaceous, full recovery
15.2		PD	SLST	LSC	15.200	16.300	1.1	Grey, thinly bedded, finely micaceous, layers rich in plant fragments becoming less abundant downwards, fining downwards, full recovery
16.3		PD	MDST	BKME	16.300	17.650	1.35	Silty, grey, bedded, slightly finely micaceous, small flatfish Fe nodules associated with polished surfaces, some pyritic patches
17.65			FEST MDST	BKME	17.650	17.770	0.12	Silt grade, grey, massive
17.77			FEST MDST	BKME	17.770	20.950	3.18	Silty, darker grey, bedded, slightly finely micaceous, Naiaidites sp. and fish material between 16.85-17.8m. Paracarbonicola sp. at 19.1m, small flatfish Fe nodules, rare sinuous burrow trace on bedding, more silty between 18.35-18.75m, some thin silty laminae from 19.12-19.60m, dip 7 degrees. Lingula squamiformis? at 19.86 and 20.23m. Core broken between 19.86-20.12m. 4cm silty ironstone at 20.85m
20.95			FEST MDST	BKME	20.950	21.020	0.07	Silt grade, massive
21.02			FEST MDST	BKME	21.020	22.000	0.98	Silty, darker grey, bedded, slightly finely micaceous, core broken with core loss especially between 21.60-22m (c. 10cm recovered), with many polished patches. Lingula at 21.90m.
22.00			FEST MDST	BKME	22.000	22.200	0.2	Fine grained, grey, calcareous, with marine shells, Serpuloidea, Lingula, pyritic growths, hard, compact, massive
22.20			LMST	BKME	22.200	22.310	0.11	Fine grained, grey, iron, shell fragments, cone-in-cone texture
22.31			FEST MDST	BKME	22.310	22.420	0.11	Fine grained, grey, calcareous, with marine shell scraps and pyritic growths
22.42			FEST MDST	BKME	22.420	22.770	0.23	Silty, darker grey, bedded, marine shells
22.77			FEST MDST	BKME	22.770	23.550	0.78	Silt grade, grey, massive, scattered shell fragments, pyritic fragments
23.55			FEST MDST	BKME	23.550	23.650	0.1	Silty, grey, slightly finely micaceous, bedded, core broken in places, Lingula at 22.87m, Serpuloidea at 23.23m, up to 3mm pyritic nodules and patches
23.65			FEST MDST	BKME	23.650	25.000	1.35	Muddy silt grade, grey, with large calcite filled septarian joints
25.00			MDST	BKME	25.000	26.380	1.38	No core recovered, drillers log records weak shaley mudstone
26.38			FEST MDST	BKME	26.380	26.520	0.14	Silt grade, grey, scattered shell fragments (Lingula), bedded, finely micaceous
26.52			FEST MDST	BKME	26.520	26.880	0.36	Silty, darker grey, bedded, slightly finely micaceous, slightly carbonaceous in places, low angle polished surfaces near base, a few plants
26.88			FEST MDST	BKME	26.880	27.000	0.12	Silty mdst grade, grey, massive, carbonated plant scraps
27.00			FEST MDST	BKME	27.000	27.600	0.8	Silty, grey, bedded, slightly finely micaceous, some more micaceous layers, polished patches, microfractures in places
27.60			FEST MDST	BKME	27.600	27.900	0.1	Silt grade, grey, massive, finely micaceous
27.90			FEST MDST	BKME	27.900	28.100	0.2	Silty, grey, bedded, slightly finely micaceous, iron
28.10			FEST MDST	BKME	28.100	28.180	0.08	Silt grade, grey, massive
28.18			FEST MDST	BKME	28.180	28.350	1.17	Silty, grey, bedded, slightly finely micaceous, jointed at moderate angle to bedding, slightly carbonaceous in places especially basal 10cm, 11 degree dip, Spirorbis sp., ?Naiaidites sp., ostracods and fish material between 29-29.35m
29.35			FEST MDST	BKME	29.350	29.620	0.27	Silty mdst grade, grey, bedded, Lingula
29.62			MDST	BKME	29.620	29.850	0.23	Silty, grey, bedded, slightly finely micaceous, silty top 20cm
29.85			FEST MDST	BKME	29.850	30.000	0.15	Silt grade, grey, massive, finely micaceous, small carbonated plant fragments
30.00			FEST MDST	BKME	30.000	30.350	0.35	Silty, grey, bedded, slightly finely micaceous, dip 12 degrees, rare pyritic plant remains
30.35			FEST MDST	BKME	30.350	30.500	0.15	Silty mdst grade, grey, bedded, fish scraps
30.50			FEST MDST	BKME	30.500	31.750	1.25	Silty, grey, bedded, slightly finely micaceous, slightly carbonaceous and very broken 30.85-31m, a few fish scales and sub-horizontal polished surfaces
31.75			FEST MDST	BKME	31.750	32.000	0.25	Silt grade, grey, massive, sandy top, a few carbonated plant remains
32.00			SLST	BKME	32.000	32.280	0.28	Grey, bedded, finely micaceous
32.28		PD	MDST	BKME	32.280	33.330	1.05	Silty, grey, bedded, slightly finely micaceous Lingula at 32.7m and large fish scale at 32.8m, scattered silt laminae and bands, polished surfaces towards base. Somewhat carbonaceous in places. Lingula mytilloides, L. squamiformis, ostracods, fish material and coprolites between 32.7-33.4m
33.33			FEST MDST	BKME	33.330	33.450	0.12	Silty mdst grade, brownish grey bedded, a few ostracods?
33.45			FEST MDST	BKME	33.450	33.900	0.45	Silty, darker grey, slightly finely micaceous, silt layers and thin bands increasing in frequency towards base, possible sinuous burrows
33.90			FEST SLST	BKME	33.900	34.000	0.1	Silt grade, grey, massive
34.00			SLST	BKME	34.000	35.260	1.26	Grey, finely micaceous, bedded, hard, crushed weak zone 34.3-34.45m, scattered plant remains, carbonaceous and micaceous down to 34.9m, fining down below
35.26			FEST MDST	BKME	35.260	35.370	0.08	Silty mdst grade, brownish-grey, massive
35.37			FEST MDST	BKME	35.370	35.600	0.23	Silty, dark grey, finely micaceous, bedded
35.60			COAL SEAT	BKME	35.600	35.700	0.1	Grey, bedded, fish remains, finely micaceous, muddy, carbonaceous at base
35.70			COAL SEAT	BKME	35.700	35.870	0.17	Bright banded, fusainous layers, ankerite and pyrite in cleat
35.87			SDST	LSC	35.870	37.430	1.56	Fine grained sdst grade, pale grey, carbonaceous-micaceous laminae as remnants of bedding, carbonaceous roots
37.43			SDST	LSC	37.430	37.700	0.27	Offwhite, medium to coarse grained, massive to bedded, hair rootlets down to 36.5m generally upward coarsening
37.70		ES	SDST	LSC	37.700	38.600	0.9	Offwhite, fine grained, ripple laminated, carbonaceous-micaceous, sharp base
38.60		ES	SDST	LSC	38.600	39.220	0.62	Offwhite, fine grained, bedded, rooty in top 10cm coarsening up from sdst with many carb-mic and silty layers up to 38.22m, some ripple or wavy lamination
39.22		PD	SLST	LSC	39.220	39.900	0.68	Grey, bedded with many thin sandy laminae decreasing in frequency below 38.95m, water escape deformation, plant fragments, slightly micaceous
39.90		PD	SLST	LSC	39.900	39.900	0.00	Grey, bedded finely micaceous, a few sometimes pyritic plant remains, fines downwards to muddy silt at base
39.90		ES	SEAT	LSC	39.900	40.240	0.34	Offwhite, medium grained sdst grade, silty wisps, many dark roots, traces of bedding, sharp base
40.24		ES	SEAT	LSC	40.240	40.650	0.41	Silt grade, grey, rooty, with some sandy bands throughout, sharp base in 8cm sdst
40.65		ES	SDST	LSC	40.650	41.200	0.55	Offwhite, fine grained, bedded with grey silt laminae and bands (70/30), plant remains and some roots, sideritic, flat and ripple lamination
41.20		ES	SDST	LSC	41.200	43.600	2.4	Offwhite, fine to medium grained, sideritic, carbonaceous-micaceous, wavy sometimes ripple laminated, massive in places, sharp base
43.60			SLST	LSC	43.600	44.000	0.4	Grey, bedded, finely micaceous with offwhite fine grained sdst laminae and thin beds, planty, fines down into
44.00			SLST	LSC	44.000	44.220	0.22	Grey, thinly bedded, finely micaceous, plant remains, fish scales
44.22		TD	MDST	LSC	44.220	46.000	1.78	Very silty, grey, thinly bedded, small pyritic patches locally, some zones with moderately dipping joints with polished surfaces 44.5-45m. Dip below 5 degrees, scattered plant remains



Quarter sheet NS56SE BNG easting 255004.00

Logged by ALS/MAEB

Record Type BJ BNG northing 663485.00

Drilled by RITCHIES

Number 1302 Start Height 20.32

Drilled for GCC

Suffix . Start Height type S

Date drilled 21/10/03

Chart Scale 1:50

DEPTH (m)	LITHOLOGY	BED BASE	LITHOLOGY CODE	STRATIGRAPHY CODE	TOP (m)	BASE (m)	Thickness (m)	DESCRIPTION
0			SOIL SANDU	DRFTU	0.000	0.100	0.1	Soil, drillers log
0.1			CLAY	DRFTU	0.100	0.600	0.5	Sand, drillers log
1			CLAY	DRFTU	0.600	2.000	1.4	Sandy clay, drillers log
2			DMTN	DRFTU	2.000	10.200	8.2	Sandy boulder clay, drillers log
3								
4								
5								
6								
7								
8								
9								
10		RH	SLST	LSC	10.200	11.000	0.8	Siltstone, drillers log
11		PD	SDST	LSC	11.000	13.750	2.75	Fine grained, offwhite, bedded with numerous carbonaceous, coarsely micaceous laminae, with grey silt laminae and bands, coaly plant remains, dip 6 degrees, striped bedding 12-12.5m, at least 0.5m of core loss between 11-13m, 0.62m core lengths>10cm from 11-14m. Unstained, hardly weathered, 40cm assessed core loss near the base.
12								
13								
14		PD	SLST	LSC	13.750	14.600	0.85	Grey, bedded, coarsely micaceous and carbonaceous plant remains, sandy laminae decreasing in frequency downwards
15		PD	SLST	LSC	14.600	16.500	1.9	Grey finely micaceous, thinly bedded, carbonaceous, plant remains, only 0.22m>10cm core lengths between 13-16m, assessed 50cm core loss at base
16								
17			MDST	BKME	16.500	17.600	1.1	Silty, grey, thinly bedded, somewhat finely micaceous, some polished patches. Lingula mytiloides?, Lingula squamiformis, fish material, ?coprolite at 17.14 and 19.90m
18			FEMDST MDST	BKME BKME	17.600 17.700	17.700 18.850	0.1 1.15	Very silty mdst grade, grey, rare carbonated plant fragments
19			MDST MDST	BKME BKME	18.850 19.000	19.000 21.650	0.15 2.65	Silty, grey, bedded with pale grey silt laminae and thin bands (75mm). Only 1.05m>10cm core lengths between 16-19m depth.
20								Silty, grey, slightly finely micaceous, thinly bedded, Lingula at 19.45-20m, burrowed (small pipes). Loss of 40cm assessed at top of item. Slightly harder and more silty in places between 20.4-20.6m, rare fish scale, brown streak locally, dip 5 degrees. 1.61m of core lengths>10cm from 19-22m. ?Naiaidites sp. at 20.75m.
21								
22			FEMDST	BKME	21.650	22.000	0.35	Hard, silty mdst grade, shelly, cone-in-cone 3cm thick at 21.97m. Productids Buxtonia sp., ?Lingula sp., ?Liralingua sp., ?Streblochondria sp., fish material, burrow traces from 21.72-22.25m
23			MDST	BKME	22.000	22.250	0.25	Silty, darker grey, bedded, marine shells Productids
24			FEST	BKME	22.250	22.500	0.25	Silt grade, massive, rare ?marine fossil
25			MDST	BKME	22.500	26.100	3.6	Silty, darker grey, thinly bedded with small nodules, dip 26 degrees, core loss of 1.8m assessed in this unit, 0.22m of core lengths>10cm between 22-25m, polished irregular subvertical to steeply dipping joints, shell fragments, 6cm silty ironstone. 0.6m core loss assessed at 25-25.6m, 0.58m of core lengths>10cm between 25-28m. Dip 9 degrees at 25.70m. ?Lingula sp., Euphemites urii? at 24.62-25.65m.
26								
27			MDST	BKME	26.100	27.000	0.9	Silty, dark grey, thinly bedded, small concretions, very finely micaceous, Lingula fragments, basal 15cm very micaceous and carbonaceous. Lingula squamiformis, ostracods, fish material, ?burrow traces, coprolites between 26.70-27.06m.
28			FEST MDST	BKME BKME	27.000 27.120	27.120 27.400	0.12 0.28	Silt grade, grey, bedded, large Lingulae
29			FEMDST MDST	BKME BKME	27.400 27.520	27.520 27.860	0.12 0.34	Silty, dark grey finely micaceous, thinly bedded, small iron concretions, carbonaceous
30			FEST MDST	BKME BKME	27.860 28.000	28.000 29.000	0.14 1	Mdst grade, grey, small carbonated plant remains, massive Silty, dark grey, very finely micaceous with small nodules, carbonaceous, dip 10 degrees
31			FEST MDST	BKME BKME	28.000 28.000	28.000 29.000	0.14 1	Silt grade, grey, bedded Silty, dark grey, finely micaceous, bedded, loss of 0.92m assessed here. ?Naiaidites sp., ostracods at 28.80m.
32			FEST MDST	BKME BKME	29.000 29.170	29.170 30.350	0.17 1.18	Silt grade, dark grey, massive, coaly plant fragments, some mdst layers near top
33								Dark grey, silty, thinly bedded, finely micaceous, polished irregular moderately dipping joints, small nodules, carbonaceous, 6cm silty ironstone at 20.9m
34			FEMDST	BKME	30.350	30.650	0.3	Brownish grey, silty mdst grade, carbonated plant remains, pelleted texture and subvertical mineral filled joints
35			MDST	BKME	30.650	30.870	0.22	Silty, dark grey, bedded, finely micaceous, 2-3cm ironstone nodules, core broken and polished
36		TD	FEMDST	BKME	30.870	31.000	0.13	Silty mdst grade, grey, massive, carbonated plant scraps. 1m or core lengths>10cm between 28-31m.

