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A Geodiversity Audit of the City of Glasgow

Geology and Landscape Scotland Programme

Commercial Report CR/13/022

BRITISH GEOLOGICAL SURVEY

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A Geodiversity Audit of the City of Glasgow

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Foreword

A variety of pressures, including environmental and climatic changes, have the potential to affect Scotland's land and resources. To engage with these pressures, local authorities require a good awareness and understanding of the dynamics of our natural world. Geodiversity is an important part of dynamic earth systems and is an environmental asset, but it is one of the least easy to recognise and appreciate. This audit aims to help Glasgow City Council (GCC) better understand the nature of important geological features within the city of Glasgow and to provide GCC staff with an information resource clearly describing the significance and value of a number of geological sites.

In Glasgow, nationally and internationally important geological sites have previously been identified and protected by statutory measures, but these form only a limited part of the area's geodiversity. In order to be able to recognise and protect the full range of Glasgow's geological, geomorphological and landscape features, Glasgow City Council commissioned the British Geological Survey (BGS) to audit and assess the geodiversity of Glasgow.

This report produced by BGS is a systematic inventory and evaluation of an initial list of Geodiversity Sites. As well as providing a useful resource for staff, this audit has the potential to help enlighten plan and policy making, inform planning decisions, and influence the way Glasgow's geodiversity is managed and safeguarded in the future.

Acknowledgements

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Summary

This report describes a geodiversity audit of the city of Glasgow commissioned by Glasgow City Council (GCC) and carried out by the British Geological Survey (BGS). The initial phase of the audit involved a review of the available geodiversity documentation for Glasgow including BGS field maps, databases, digital aerial photography and publications, Scottish Natural Heritage Sites of Special Scientific Interest (SSSI) and Geological Conservation Review (GCR) documentation, and site information from Strathclyde Geoconservation. An initial list of 30 sites with potential for geodiversity value was compiled from this information.

A total of 26 sites were visited during January and February 2013, with 20 sites identified as locally important geodiversity sites in the Glasgow audit. These sites were assessed for their geoscientific merit, accessibility, cultural/heritage/economic importance, site fragility, and potential for enhancement. Information was recorded in the BGS digital data capture system SIGMA Mobile.

A descriptive report is provided for each site, containing location information and maps, a geological summary, a review of the condition of the site and access routes, assessment of the relation of the site to environmental, cultural and historical factors, the geodiversity valuation (Geoscientific Merit) and suggestions for future management of the site.

Many of the locally important geodiversity sites could be enhanced to encourage visitors and students to learn more about how the geology influences the form of the landscape, the economic and cultural history of the Glasgow area, and the ecological habitats of the urban woodlands, Local Nature Reserves and SSSIs.

1 Introduction

The British Geological Survey (BGS) was commissioned by Glasgow City Council (GCC) to carry out a review of sites of geological and geomorphological significance within the local authority area. This geodiversity audit is intended as a resource to inform future planning, development and conservation decisions.

This work was undertaken during January and February 2013 with a desk-top review of BGS records and published literature followed by field visits to gather new geodiversity information. This report describes, illustrates, and ranks 20 sites in Glasgow which together represent the geological diversity of the area. In addition to this report the study has produced a GIS database containing key spatial and attribute information relating to each site, which has been provided to GCC.

1.1 BACKGROUND

1.1.1 A Geodiversity Audit for Glasgow City Council

Prior to the initiation of the audit, a scoping exercise was carried out between the Glasgow City Council, BGS and other interested parties to develop an initial list of geological sites considered worthy of attention. Not all of these sites could be visited but those that were excluded from this first audit have been noted and now form an additional list of sites that may be assessed in future.

This first Geodiversity Audit for Glasgow will give the Council a greater awareness of the geodiversity within its boundary and a greater opportunity to evaluate this local geodiversity in context. It is hoped that, where appropriate, this would also bring greater opportunity to secure benefits for these sites e.g. enhancing the quality of access and contributing to tourism and education.

1.1.2 What is Geodiversity?

Geodiversity has many definitions, but essentially describes the variety of rocks, minerals and fossils, landforms and landscapes, active geological processes and soils and subsoils (Quaternary deposits) of an area. These elements interlink and together determine the character of the natural environment and local wildlife habitats. Rocks, sediments and landforms also underpin the development of settlements and industry, strongly influencing an area's cultural history and local 'character'.

1.1.3 Why conserve geological features?

Geodiversity is an important element of ecosystems, contributing to their health and function and also supporting the ecosystem services they provide. Geodiversity links people, places, rocks, soils, landforms and landscapes. It connects people with their historic landscape, past human activity and natural landscape changes and it continues to shape modern and future landuse. However, the role of geodiversity is perhaps not yet fully recognised and needs to be presented clearly to decision makers.

Geological sites are vulnerable to a wide range of threats e.g. development may remove the interest or access to a site, quarries can be infilled, natural vegetation growth can cover and degrade exposures, riverbank stabilisation measures can obscure outcrops and features in urban environments may be built over.

1.2 OBJECTIVES AND METHODS

The aim of this study was to identify, and formally assess, a network of key sites across Glasgow that represent the diverse geology and geomorphology of the area. The study had five components:

1. Identification of potential sites of geological/geomorphological significance.
2. Delineation of the site boundaries and description of the geological and/or geomorphological features.
3. Assessment of the condition of the sites and access routes.
4. Description of the geoscientific significance of the feature.
5. Consideration of the potential for conservation and/or enhancement with respect to education and public enjoyment.

These objectives have been achieved in three stages of work: an initial desktop review to assess potential sites and to ensure as full a representation as practical of the geology and geomorphology in the area as well as a good geographical spread; a field study to assess geoscientific potential and site condition; and finally analysis and reporting of the site geodiversity valuations.

1.3 REPORT OUTLINE

A brief overview of the geology of the Glasgow area is given in Chapter 2 to provide context to the geodiversity assessment. In Chapter 3, the selection criteria, assessment methodology and details of the information presented in the audit assessment forms are given. The assessment pro-forma for each of the audit sites are presented in Chapter 4. Each of these reports contains; location information and maps, a selection of photographs illustrating key features of the site, a geological summary, information on the condition of the site and access routes, details of environmental, cultural and historical associations, an assessment of Geoscientific Merit and suggestions for future management/enhancement of the site. The results are summarised and discussed in Chapter 5.

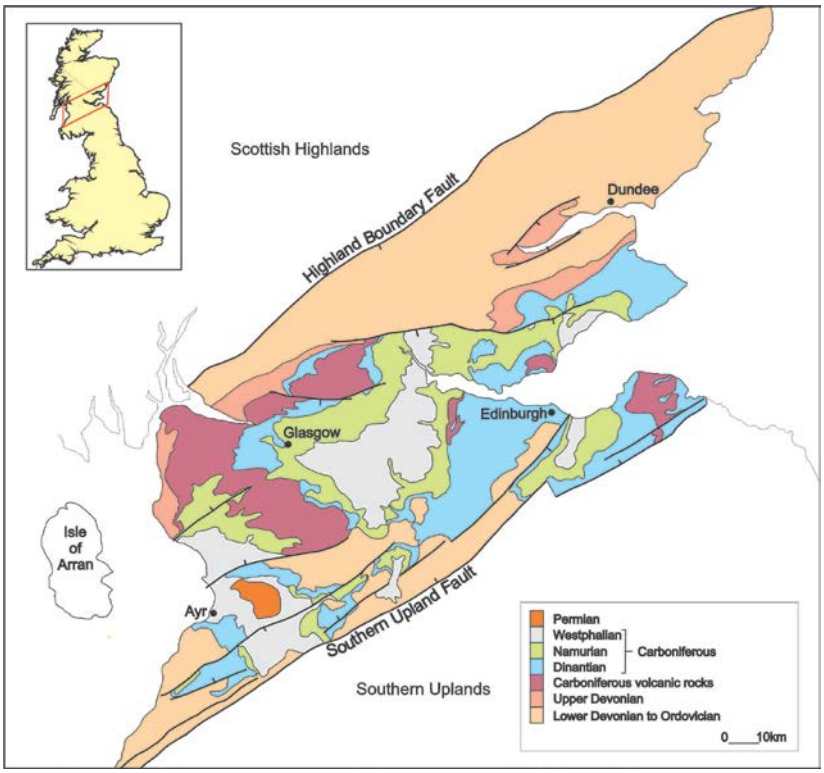
An extended list of potential geodiversity sites that includes boreholes and building stones characteristic of the built heritage of Glasgow, as well as some bedrock exposures and geomorphological features not included in the audit is given in Appendix 1.

2 The Geology of Glasgow

2.1 GEOLOGICAL SUMMARY

2.1.1 Bedrock geology

Glasgow lies within the Midland Valley of Scotland, the name given to the relatively low lying part of central Scotland located between the Scottish Highlands and the Southern Uplands. Geologically it is defined by two faults: the Highland Boundary Fault, which lies to the north and extends from Stonehaven in the northeast to the Firth of Clyde at Helensburgh, and the Southern Upland Fault which extends from Dunbar to Glen App. The downfaulted area between the two faults contains rocks of mainly Carboniferous and Devonian age (Map 1).

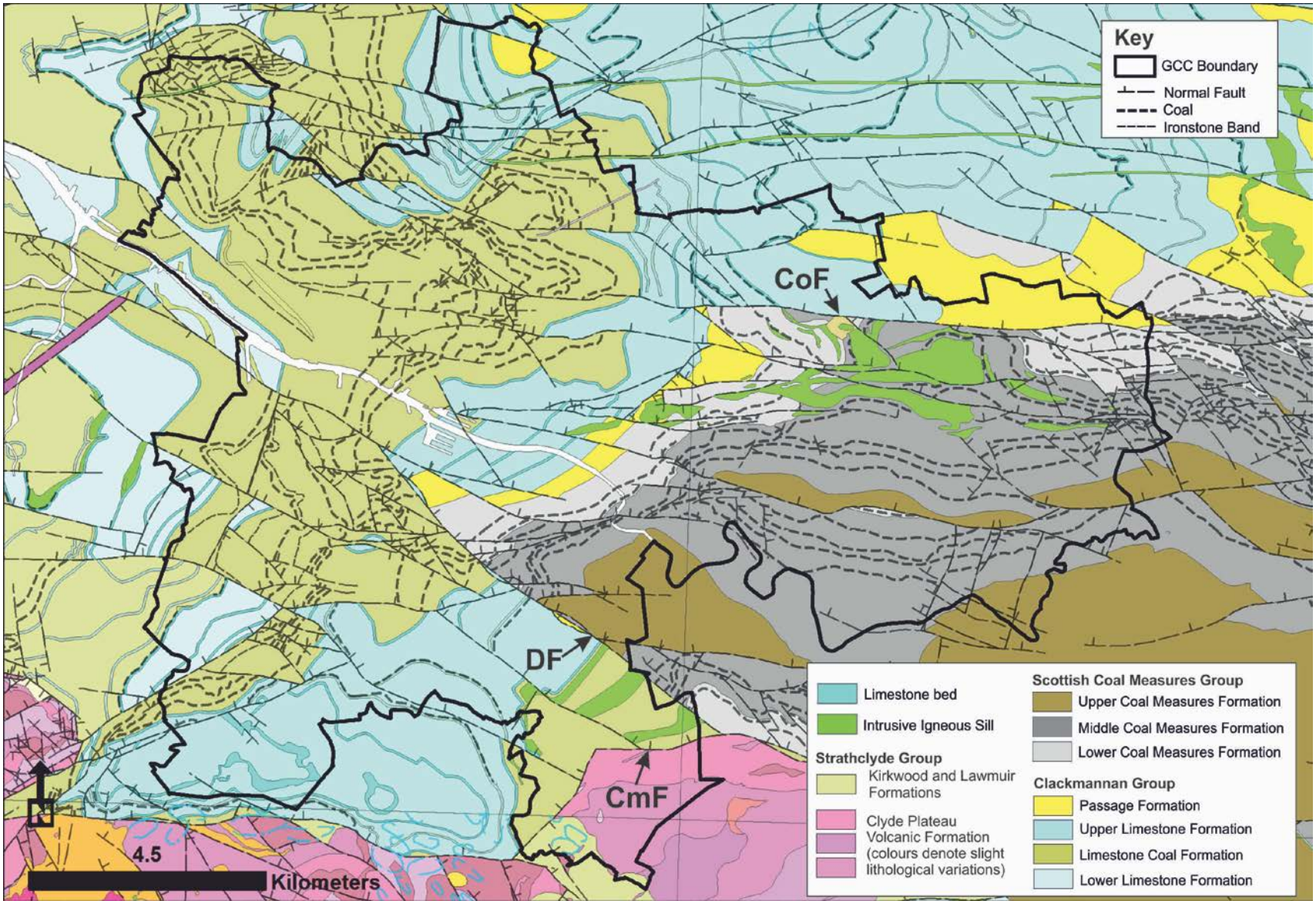


Map 1 Simplified geological map of the Midland Valley of Scotland. Geological faults are shown by a thick black line with a tick on the downthrow side (Source: BGS DiGMapGB data).

The rocks that crop out within the city of Glasgow are all of Carboniferous age (310 – 350 Million years old), belonging to the Strathclyde, Clackmannan and Scottish Coal Measures Groups (Map 2, Table 1). The oldest strata in the region are the basalt rocks of the Clyde Plateau Volcanic Formation, formed by the extrusion of lavas from volcanoes and vents during the early Carboniferous. Erosion and reworking of the lavas resulted in the deposition of volcaniclastic sedimentary rocks of the Kirkwood and Lawmuir Formations. In the later Carboniferous, cessation of volcanic activity allowed fluvial, estuarine and shallow marine environments to be established. During this time, a thick sequence of coal-bearing cyclothems consisting of repeating sequences of marine and non-marine sediments including mudstone, siltstone, sandstone and limestone with coal, ironstone and seatearths were deposited (strata commonly termed ‘measures’). A transition to more terrestrial environments occurred in the late

Carboniferous, marked by the development of sandstones of the Passage Formation prior to a resumption of deposition of coal cyclothems, but this time in more fluviodeltaic environments. These later sedimentary strata contain no limestones with marine horizons marked only by thin, shelly marine bands, and are classified into the Lower, Middle and Upper Coal Measures formations. The Carboniferous sedimentary rocks underlie most of the Glasgow area and have been widely mined for coal and iron ore, and quarried for sandstone and limestone. During the Late Carboniferous and early Permian a series of intrusive igneous sills were emplaced within the sedimentary succession. Strata younger than the early Permian are not found within the Glasgow area.

The Carboniferous strata are dissected by numerous faults, the most prominent of which trend roughly east – west or north-west – south-east. In the south, the Castlemilk West Fault bounds the northern edge of the Clyde Plateau Volcanic Formation rocks of Cathkin Braes, with a throw of ~400m down to the north bringing the lavas to the level of the younger sedimentary rocks of the Limestone Coal Formation. The Dechmont Fault, runs north-west from Castlemilk and also substantially offsets the strata, locally separating the Limestone Coal Formation and Upper Coal Measures (Hall et al., 1998). In the east of the city, the Comedie Fault offsets Coal Measures strata to the south against the Upper Limestone and Passage Formation to the north (Map 2).



Map 2 Bedrock geology of the Glasgow area (Source: BGS DiGMapGB-50 data). Castlemilk Fault (CmF), Dechmont Fault (DF) and Comedie Fault (CoF) are mentioned in the text.

Classification of the Carboniferous strata in the Midland Valley of Scotland

Subsystem	Series		Stage	Lithostratigraphical Units: Formations: Central Coalfield	Ayrshire	Fife	West Lothian	East Lothian	Groups	Old Classifications	
Silesian	Westphalian	C	Bolsovian	Scottish Upper Coal Measures Formation					Scottish Coal Measures	UPPER (BARREN) COAL MEASURES	
		B	Duckmantian	Scottish Middle Coal Measures Formation						MIDDLE COAL MEASURES	PRODUCTIVE COAL MEASURES
		A	Langsettian	Scottish Lower Coal Measures Formation						LOWER COAL MEASURES	
	Namurian		Chokerian-Yeadonian	Passage Formation					Clackmannan Group	PASSAGE GROUP	
			Arnsbergian						Bathgate Group		
			Pendleian	Upper Limestone Formation						UPPER LIMESTONE GROUP	
				Limestone Coal Formation						LIMESTONE COAL GROUP	
Dinantian	Viséan		Brigantian	Lower Limestone Formation						LOWER LIMESTONE GROUP	
				Lawmuir Formation		Pathhead Formation	West Lothian Oil-Shale Formation	Aberlady Formation		UPPER OIL-SHALE GROUP	CALCIFEROUS SANDSTONE MEASURES
			Asbian	Kirkwood Formation		Sandy Craig Formation					
				Clyde Plateau Volcanic Formation		Pittenweem Formation					
			Holkerian to Arundian			Anstruther Formation	Gullane Formation		Strathclyde Group	LOWER OIL-SHALE GROUP	
							Arthur's Seat Volcanic Formation	Garleton Hills Volcanic Formation			
			Chadian			Fife Ness Formation					
	Tournaisian		Courceyan	Clyde Sandstone Formation			Ballagan Formation		Inverclyde Group	CEMENTSTONE GROUP	
				Ballagan Formation							
				Kinnesswood Formation						UPPER OLD RED SANDSTONE (part)	

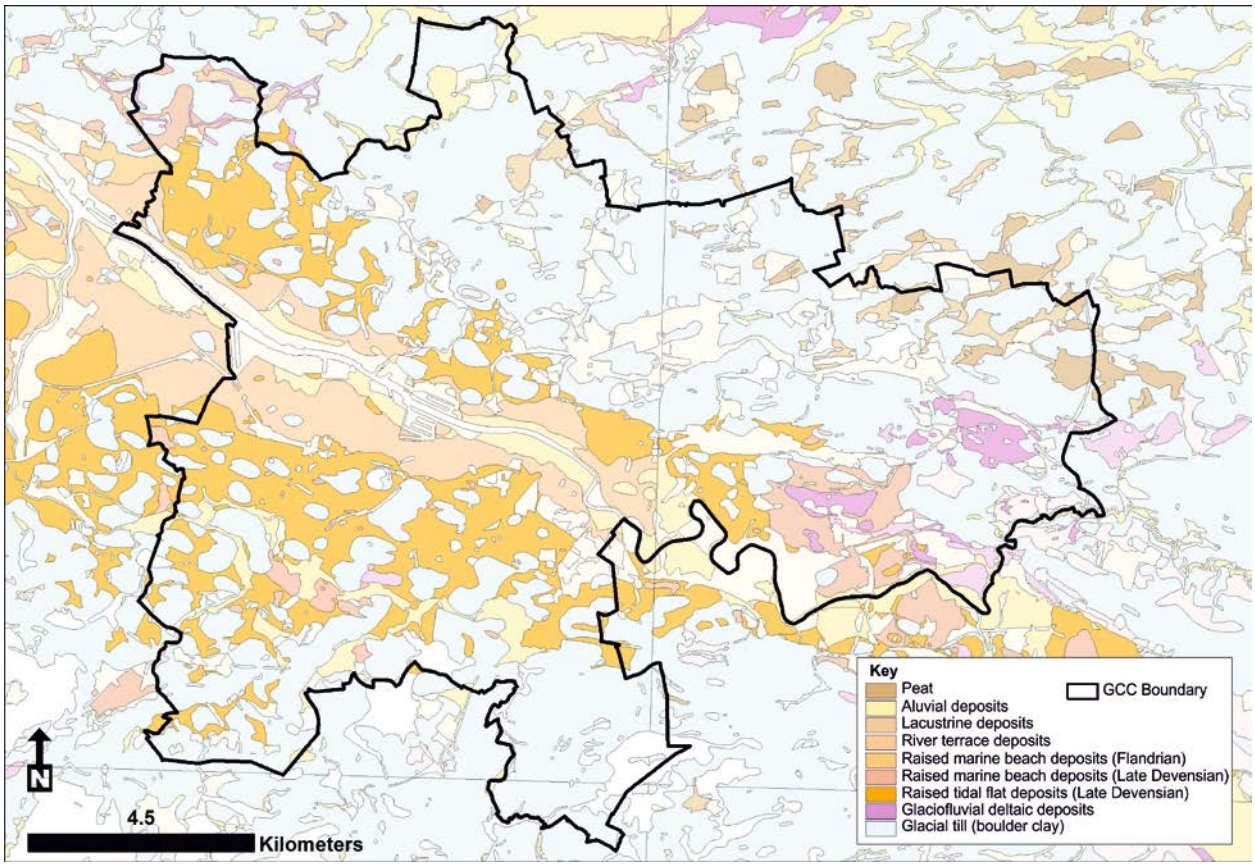
Table 1 Stratigraphy of Carboniferous strata in the Midland Valley of Scotland (From Browne et al., 1999)

2.1.2 Superficial deposits

The broad shape of the landscape in the Glasgow area has been largely produced by glacial erosion of the underlying bedrock during the past two million years and the deposition of sediments following the most recent deglaciation (18 – 12 thousand years ago). Scouring of the terrain by glacial ice has resulted in the preferential erosion of softer sedimentary rocks in the Clyde valley, with more resistant Clyde Plateau Volcanic rocks forming the high ground to the north and south.

Within the Clyde lowlands, the most recent glaciers have deposited sediments that now largely conceal the bedrock (Map 3). The most extensive deposit is glacial till (Wilderness Till Formation), a mixture of clay, sand and silt containing boulders, cobbles and gravel which was laid down beneath the ice. The till has been sculpted into elongate streamlined mounds (drumlins) by the flow of ice. In the Clyde estuary, the glacial deposits have been largely covered by postglacial marine and estuarine clay and silt deposits which were laid down during a period of higher relative sea level following the retreat of glaciers in the Clyde valley. These deposits are responsible for areas of flat topography in west and south-west Glasgow and elsewhere drape drumlins or infill the inter-drumlin hollows up to an elevation of c. 35m above OD (Browne and McMillan, 1989).

Alluvial sediments, peat and lacustrine deposits associated with modern rivers and lakes are the most recent natural deposits. Alluvial sediments are generally associated with the Clyde and Kelvin Rivers and the White Cart and North Calder Waters as well as numerous tributary streams. In places these rivers have eroded through the underlying glacial sediments and exposed bedrock. Peat and lacustrine clay and silt have been deposited in lakes occupying inter-drumlin hollows in the north and east of Glasgow. Peat and peaty soils are also found on poorly drained areas of higher ground in the volcanic upland terrain of Cathkin Braes.



Map 3 Superficial geology of the Glasgow area (Source: BGS DiGMapGB-50 data).

2.1.3 Artificial ground

The development and industrialisation of the Glasgow area has been driven by the extraction and use of the region's natural geological resources. The mining of coal and ironstone as well as the quarrying of sandstone, limestone and igneous rocks underpinned the early growth of the city. These activities, as well as extensive industrial and residential developments have left a legacy of worked ground and man-made deposits throughout Glasgow and in places have dramatically changed the natural topography and, in some areas, have caused pollution and soil contamination.

2.2 GEODIVERSITY AND THE GLASGOW LANDSCAPE

The diverse landscape of Glasgow is a product of the underlying geology and geological processes that have acted upon it. The hard volcanic rocks of the Clyde Plateau Volcanic Formation are resistant to erosion and areas underlain by these rocks are characterised by higher ground. The volcanic terrains of the Campsie Fells and Kilpatrick Hills form a high ridge bounding the Clyde basin to the north, whilst Cathkin Braes and the uplands of Whitelee Forest form high ground to the south. The relatively soft sedimentary rocks in the Clyde valley area (Scottish Coal Measures, Clackmannan and Strathclyde Groups) were preferentially eroded by glaciers during the last ice age, and form the low ground in the Clyde basin. Hard igneous rocks intruded locally into the Carboniferous sedimentary strata commonly form hills which protrude through overlying superficial deposits. Though relatively small, these hills form prominent topographic features within the low terrain of the Clyde valley and many have formed important military, cultural and industrial sites throughout Glasgow's history.

Deposition of sediments by glaciers and sculpting by the flowing ice has produced a hummocky, drumlinised terrain within the central Clyde valley. Along the River Clyde these glacial sediments have been covered by later marine, estuarine and alluvial sediments, but the irregular glacial topography has strongly influenced the urban development of central Glasgow. The glacial topography is also responsible for the development of a range of important ecological habitats, particularly wetlands associated with lochs developed in inter-drumlin hollows.

3 Glasgow Geodiversity Audit Criteria

3.1 SITE SELECTION CRITERIA

In the initial stage of the audit, the designated geological SSSIs in the Glasgow area, Fossil Grove and Waulkmill Glen, were reviewed alongside a range of datasets providing information on potential geodiversity sites in Glasgow. Additional information on the locations of potential bedrock exposures in the Glasgow area was provided by Strathclyde Geoconservation and Dr John Faithfull from the Hunterian Museum. Datasets consulted included:

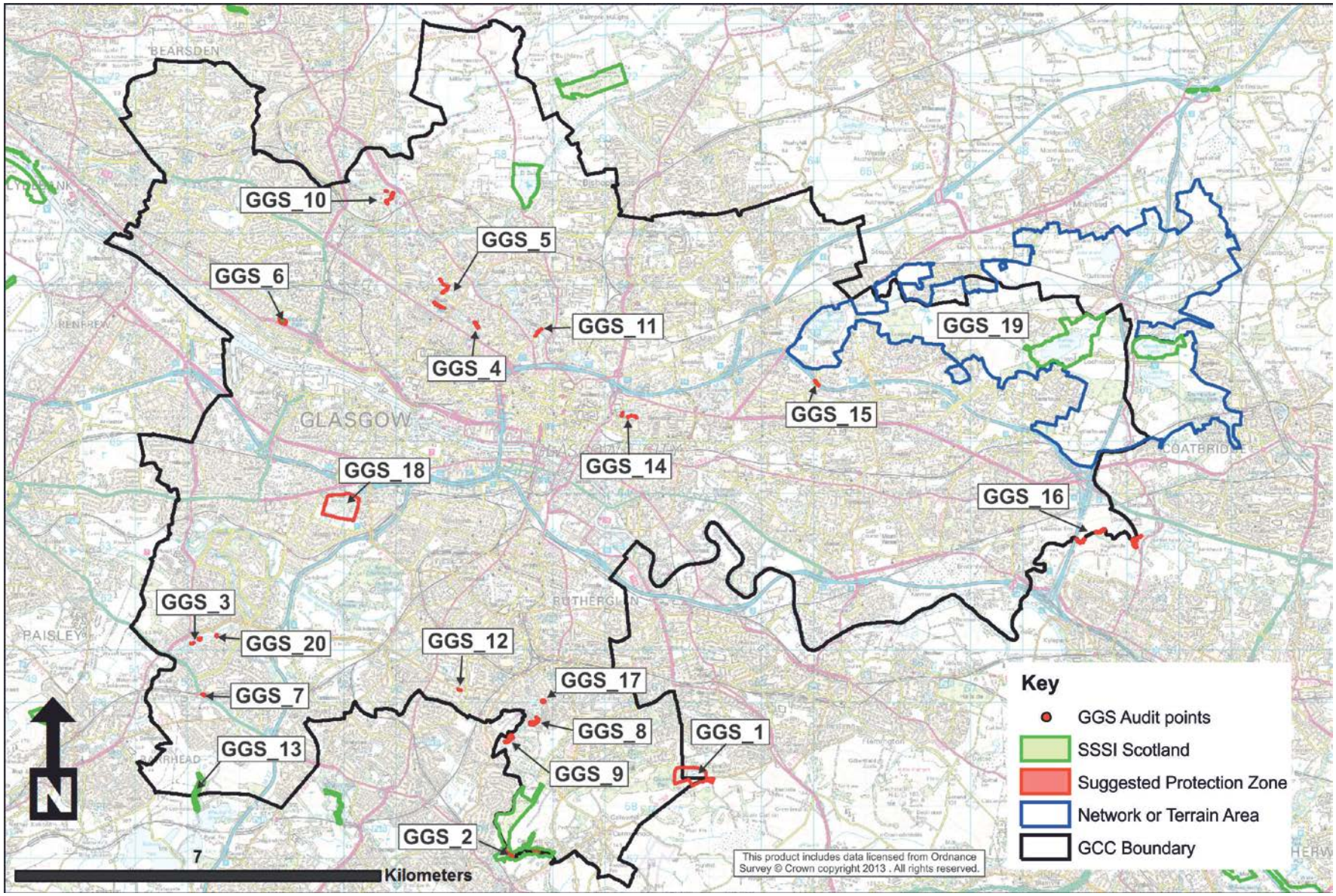
- SSSI and GCR documentation (SNH)
- BGS 1:10 000 standards and field maps
- BGS BritPits database of Mines and Quarries
- BGS Glasgow and Airdrie Memoirs (Hall et al., 1998, Forsyth et al., 1996)
- Geological Excursions around Glasgow and Girvan (Lawson and Weedon, 1992)

A total of 30 potential geodiversity sites were identified within the GCC from the desk study. In addition, a number of boreholes representing key sections of the strata from the region were highlighted along with buildings and quarries displaying characteristic building stones used in the Glasgow area. Boreholes and built heritage sites are not included as geodiversity sites in this audit, which focuses on outcrops and landforms to reflect the strong development pressures in the Glasgow area. However, these features are included in an extended list of geodiversity sites in Appendices 1 to 5.

Twenty-six sites were prioritised for field assessment and auditing. These sites were selected to reflect the highest quality exposures and encompass the main geological units found in the Glasgow area. On field inspection, six of these sites were removed from the audit list due to a lack of exposure or poorly preserved features. A total of 20 locally important geodiversity sites have been identified in the Glasgow area (Table 2, Map 4). Five additional sites that were not visited during the field survey due to time constraints require further investigation to assess whether they should be considered as locally important geodiversity sites. A full list of locally important geodiversity sites, additional sites (both visited and not visited) and further geodiversity features including boreholes and characteristic building stones, is given in Appendix 1.

Site number	Site name	X	Y	Main geological unit and/or features
GGS_1	Cathkin Braes	261814	658558	Clyde Plateau Volcanic Formation and trap topography
GGS_2	Kittock Water	258653	657150	Kirkwood Formation
GGS_3	Levern Water, Househill Park	252234	661206	Lower Limestone Formation
GGS_4	River Kelvin, Belmont Bridge	257539	667238	Limestone Coal Formation
GGS_5	River Kelvin, Botanic Gardens	256903	667861	Limestone Coal Formation
GGS_6	Fossil Grove SSSI and Quarry	253781	667334	Limestone Coal Formation, igneous intrusion and palaeontology
GGS_7	Nitshill Station	252322	660141	Limestone Coal Formation
GGS_8	White Cart Water, Holmwood House	258662	659605	Limestone Coal Formation
GGS_9	Linn Waterfall, White Cart Water	258170	659298	Limestone Coal Formation and igneous intrusion
GGS_10	River Kelvin, Dawsholm Park	255917	669709	Upper Limestone Formation
GGS_11	Possil Road aqueduct	258690	667058	Upper Limestone Formation
GGS_12	Merrylee Road	257220	660235	Upper Limestone Formation
GGS_13	Waulkmill Glen SSSI	252181	658401	Upper Limestone Formation (Calmy Limestone)
GGS_14	Necropolis	260445	665471	Passage Formation and igneous intrusion
GGS_15	M8 Gartcraig Road Bridge	264080	666093	Middle Coal Measures Formation and igneous intrusion
GGS_16	Newlands Glen	269529	663294	Middle Coal Measures Formation
GGS_17	Court Knowe	258814	660016	Igneous intrusion
GGS_18	Bellahouston Park	254935	663803	Quaternary landforms
GGS_19	Seven Lochs Master Plan Area	263874	667214	Quaternary landforms
GGS_20	Househill Fossil Tree	252561	661256	Palaeontology

Table 2 Glasgow Geodiversity Audit Sites.



Map 4 Glasgow Geodiversity Audit Sites (for site names refer to Table 2).

3.2 GEODIVERSITY AUDITING

Field assessment of the sites was carried out in January and February 2013. Specifications for the audit data collection are based on the Local Nature Conservation Site Systems best practise guidance (SNH, 2006), information requirements provided by GCC and standard BGS geodiversity audit procedures and are described in the following sections. Full details of the GCC specifications are given in Appendix 6.

The term 'locally important geodiversity site' is used in this report to refer to the sites included in the audit. This term is used rather than the accepted term 'Local Geodiversity Site' (SNH, 2006) to reflect the fact that the sites are yet to be formally adopted. The sites were audited following best practise procedures outlined in the Local Nature Conservation Site Systems guidance document (SNH, 2006), thus the valuations of Glasgow's 'locally important geodiversity sites' are consistent with those of Local Geodiversity Sites identified in other geodiversity audits.

Information for each site was collected on a tablet PC using a bespoke version of the Geodiversity Audit tool included in the BGS Sigma Mobile data collection system, a Geographic Information System (GIS). The field data were assessed and compiled using ARC GIS.

3.3 DEFINING SITE BOUNDARIES

The site areas have been delineated by the generation of Shapefiles in ARC GIS. These outlines have been classified according to guidelines supplied by GCC (Appendix 6) and summarized here:

1. **Suggested Protection Zone:** Effectively the extent of the locally important geodiversity site, this is the *minimum area anticipated to protect the site*. This area covers the main feature and its immediate access (within ~5 m of an exposure) and at some sites includes several closely spaced outcrops. Where multiple outcrops associated with a particular geodiversity site are large and/or more widely spaced, the suggested protection zone for a single site may consist of several separate sub-areas (e.g. GGS_2a and GGS_2b). These sub-areas have been given a priority classification according to the quality of the outcrop grading from 1 (highest) to 3 (lowest).
2. **Network Areas:** This defines the area of a network of which a locally important geodiversity site may form the whole or part. The network defines a terrain characterised by a suite of landforms indicative of a particular geological unit or past erosion or depositional process.
3. **Buffer Zone:** This is an extended protection zone consisting of areas from which the site may be viewed and accessed. The Buffer Zone may also include areas or features adjacent to the site not considered as the main geodiversity feature/s, but providing additional spatial, economic or historical context for the site.

Shapefiles of these boundaries have been supplied to GCC in conjunction with this report.

3.4 GEOLOGY AND GEOSCIENTIFIC MERIT

The extent of the locally important geodiversity site is considered to be defined by the suggested protection zone described above. The assessment of the site condition and geoscientific merit described in the following sections applies to all components of the site that lie within this suggested protection zone unless otherwise stated on the site form.

The inclusion of multiple outcrop areas within the suggested protection zone reflects the spatial variability in rock strata: a set of outcrops together display vertical and/or horizontal variations in rock characteristics that provide important information regarding past environments and

geological processes. For this reason, for sites where several sub-areas have been defined, the value of the collection of exposures far exceeds the value of any single sub-area.

Where sites consist of multiple sub-areas, all components are considered as intrinsic to the sites' geoscientific merit. However, a priority classification has also been given to indicate the relative contribution of a particular sub-area to the overall site value. This prioritisation reflects either the relative quality of the exposure, and/or the range of features that can be seen within a given sub-area, with poorer exposures and/or exposures displaying fewer features considered as lower priority.

3.4.1 Site type

Geodiversity sites are classified according to the type of exposure or feature and the current use of the site (Table 3, Table 4).

Site type	Description
Natural Section	Natural outcrop of one or more geological features forming a linear exposure (river section, cliff face, shoreline etc.)
Natural Exposure	Natural outcrop of geological feature
Natural Landform	Constructional or erosional geomorphological feature (valley, dune, all Quaternary features etc.)
Natural View	Collection of geological features forming a landscape overview interpretation
Mine Workings	Feature produced by minerals/coal workings (adit, spoil tip etc.)
Quarry Workings	Feature produced by stone/aggregate workings (quarry, pit, waste dumps etc.)
Artificial Section	Section exposure created artificially by work to construct a road/track/path etc.
Excavation	Artificially created exposure (excavation - not related to any of the above)

Table 3 Site Type classification scheme

Current Use	Description
In Use	Feature still used for primary purpose (working quarry etc) as defined by the FEATURE criteria
Disused	Feature no longer used for primary purpose and has no other current use
Urban	Feature is on publicly accessible lands (but not recreational lands) within the urban limits (allotments, road verges etc.)
Open Country	Feature on publicly accessible natural countryside with no unique use (hills, national park land etc.)
Private Country	Feature is on privately owned, natural countryside with limited/no public access (Estate land etc.)
Agricultural land	Feature is used/forms part of land used for agricultural purposes (farm fields and grazing areas etc.)
Recreation	Feature is on land specifically designed or modified for recreational uses (parks, picnic areas etc.)
Industrial	Feature is on land used for industrial purposes (including waste land forming part of/owned by an industrial complex)

Table 4 Current Use classification scheme

3.4.2 Stratigraphy and Rock Types

The chronostratigraphic age (e.g. 'Carboniferous'), lithostratigraphic group and formation (Table 1), as well as the dominant lithology for each site are recorded for reference purposes. More details of the main lithologies, their relation to any subordinate lithologies that may be present, and the nature of geological structures or other features of interest are given in a geological description.

3.4.3 Geoscientific Merit Criteria

The locally important geodiversity sites have been graded according to their Geoscientific Importance which has been assessed in terms of the key geological or geomorphological attributes. The valuation of the site applies to the area defined by the suggested protection zone unless otherwise stated.

The key attributes assessed are:

- **Lithostratigraphy** – features indicative of an important stratigraphic horizon and helping to define the sequence of geological strata,
- **Sedimentology** – features related to depositional processes and settings,
- **Igneous/Mineral/Metamorphic** – intrusive or extrusive igneous rocks, metamorphic rocks and minerals, and mineral vein deposits,
- **Structural geology** – faults, folds, shear zones or other deformation features,
- **Palaeontology** – fossils or trace fossils,
- **Geomorphology** – landforms and features representative of, or demonstrating, key depositional and erosional processes occurring at the earth's surface.

A single site may have more than one attribute, but is very unlikely to have all of them. The attributes have been scaled for their relative rarity and quality using the classification schemes defined in Table 5. The nature and type of literature available on the sites are also described where such material is available.

An overall Geoscientific Importance has also been derived for each site using the same scales used to grade the site attributes. The overall value is based on a summary of the scalings for relevant attributes, but also includes consideration of the relative importance of the site in terms of its uniqueness or conversely, the degree to which it is representative of a larger terrain or unit, the degree of preservation of features, and the potential role of the site as a setting for other sites or as part of a network of sites.

3.5 SITE CONDITION, ACCESS AND SAFETY

3.5.1 Fragility and stability of site

The current condition of each site and the stability of rock exposures were assessed during the field survey. The condition of the exposure or feature was assessed in terms of the degree of weathering and vegetation cover on exposed rock faces as well as artificial degradation including paint, vandalism and fly-tipping. The stability of the exposure was assessed with respect to natural weathering, biological weathering and slope processes as well as the influence of artificial construction and stabilisation measures. Potential future threats to the stability of the site, both natural and man-made, were also highlighted.

Rarity		
Level	**Significance**	**Description**
Very Rare	World Class	Few examples world-wide
Rare	UK/Scottish significance	Few UK examples
Moderately Rare	Regional significance	Few Midland Valley examples
Moderately Common	Clyde Valley Development Plan Area (CVDPA) significance	Several examples in CVDPA
Common	Glasgow significance	Several examples in GCC area
Quality		
Level	**Description**	
Excellent	World Class example	
Very Good	Good UK example	
Good	Good Midland-valley example	
Moderate	Good CVDPA example	
Poor	Moderate to poor CVDPA example	

Table 5 Geoscientific Merit criteria (NB: Midland Valley refers to the region between the Southern Uplands in the south and the Highland Boundary Fault in the north)

3.5.2 Safety and access

The nature of access to the site and the safety of the site area are important considerations, particularly for sites in urban areas. Unstable and steep exposures, rivers and river gorges and waste from fly-tipping represent significant potential hazards at many geological sites. The ease and safety of access, both directly to the feature and to places where the feature may be viewed, were also assessed for each site. Conditions that may restrict access or views of the feature, such as river flow levels, and seasonal vegetation growth were noted.

3.6 CULTURAL, HERITAGE AND ECONOMIC SIGNIFICANCE

The geological or geomorphological features at each site were assessed in terms of their cultural, aesthetic and historical significance using the same 'rarity' scaling system used to assess geoscientific merit (section 3.4.3). The following criteria were reviewed:

- **The history of the Earth Sciences**: historic significance for Earth Sciences, for example, where scientific concepts were first demonstrated by famous geologists.

- **Economic geology**: association with current or former extraction or exploitation of geological materials such as coal, metallic ores, building stone, sand and gravel.

- **Scientific study and education**: significance for teaching of Earth Sciences, geography and/or the history of science.

- **Associations with biodiversity and ecosystems**: relation of geological features to important natural wildlife habitats.

- **Aesthetic, archaeological, historical and cultural associations**: culturally or historically significant sites associated with geological features that condition the landscape, for example where high ground formed by resistant igneous rocks have been historically utilised as military sites.

- **Local communities, visitors and public awareness:** the level of accessibility and community interest in particular sites or features.

4 Audit Site Assessments

This section contains the completed audit forms giving details of each of the 20 sites, geological descriptions and the Geodiversity Value.

GGS_1: Cathkin Braes

Site Description

Physical Context: Upland terrain to the south-east of Glasgow.

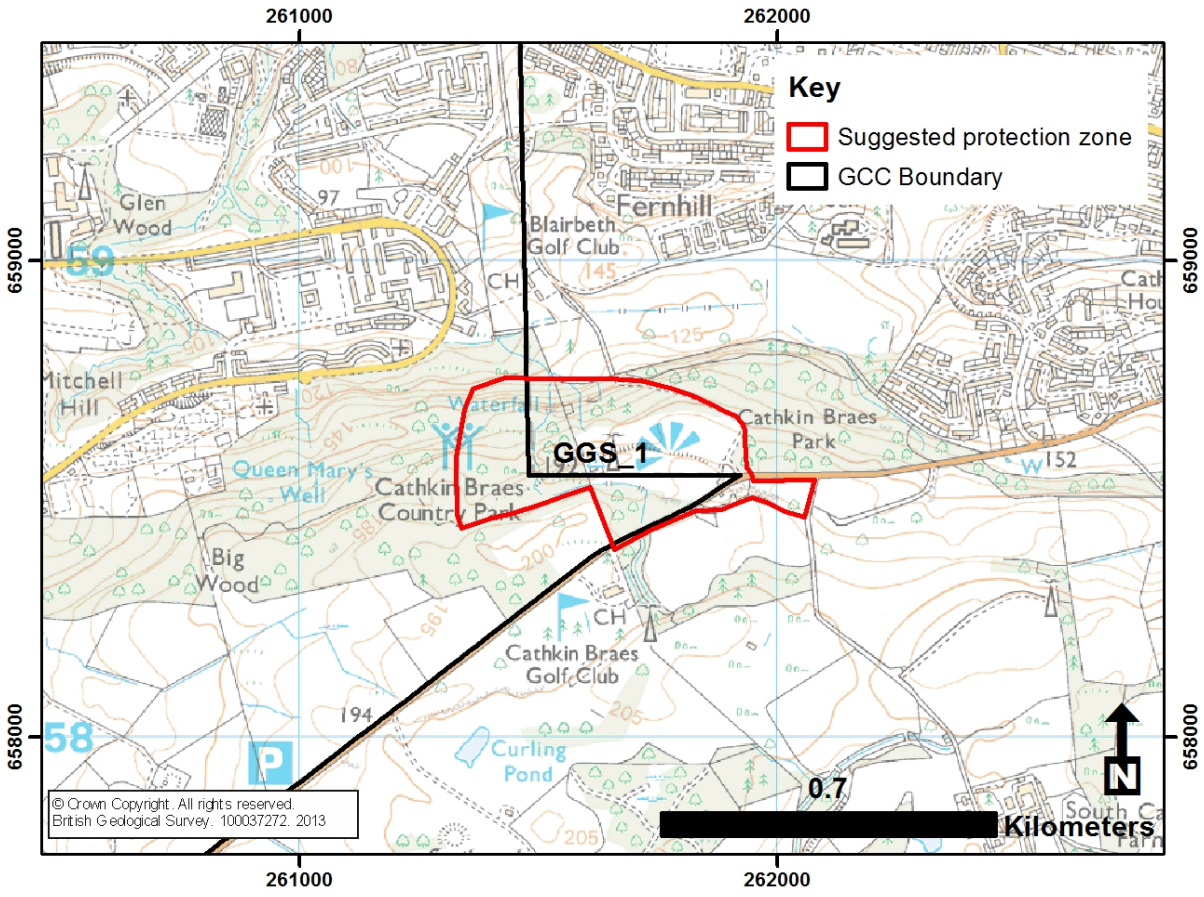
Nearby geodiversity sites or features: None within 1 km

Is the site part of a network or geological terrain: Part of the Clyde Plateau Volcanic Formation upland terrain

Does the site cross or border with another Local Authority Area: Yes, South Lanarkshire

Site Location, any nearby landmarks and access point: Includes Cathkin Braes Country Park. There are a number of access points around the site, parking is only available in lay-bys along the B759 (Cathkin Road).	**Site Type:** • Natural exposure • Natural landform • Natural view • Quarry workings
NGR: 261814 658558	Current use: Open Country
Site ownership: To be confirmed by GCC	Current geological designations: None
Permission to visit required: To be confirmed by GCC	Other designations: Country Park
Field surveyor: Katie Whitbread and Sarah Arkley	Date visited: 1st February, 2013

Map, Location and Boundary Suggestions



MAP GGS_1: Cathkin Braes Location Map. The suggested protection zone (SPZ) comprises a region containing multiple exposures of igneous rocks and landforms associated with upland igneous 'trap topography'. The area defined by the SPZ has been assessed in the following evaluation.

Site Photos

Photo GGS_1 P1: View of a disused road-metal quarry adjacent to the Cathkin Road. Looking S.

Photo GGS_1 P2: Quarry face displays the massive nature of some of the lava flows with sub-vertical joints. Looking SW.

Photo GGS_1 P3: Close-up of the basaltic rock forming one of the lava flows seen in the quarry. The phenocrysts (large crystals) can be identified within a fine-grained groundmass.

Site Photos

Photo GGS_1 P4: View from Queen Mary's Seat. Removed/vandalised signage can be seen in the foreground, development work for the Commonwealth Games Mountain Bike trails is visible in the middle ground. The small escarpment in the middle ground represents a drop to the underlying lava flow. The view overlooks the main escarpment, formed where the Castlemilk Fault brings the resistant volcanic rock into contact with softer Carboniferous sedimentary strata, with a view beyond across the Clyde Basin to the NW.

Photo GGS_1 P5: A stream falls over the fault-bound escarpment at the northern edge of the Cathkin Braes uplands. Looking N.

Photo GGS_1 P6: Close-up of loose rock uncovered by recent excavations. Displaying what appears to be a volcanic bomb within a fine-grained ashy matrix, this is likely to be from one of the beds located between lava flows.

Stratigraphy and Rock Types

Unit 1	Age: Viséan, Lower Carboniferous	Formation: Clyde Plateau Volcanic Formation
	Group: Strathclyde Group	Rock type: Olivine-basalt and Olivine-macrophyric basalt

Geological Description

Numerous relatively small exposures of the basaltic lavas of the Clyde Plateau Volcanic Formation are seen in the Cathkin Braes area. The lavas of the Clyde Plateau Volcanic Formation were formed during a major episode of subaerial volcanicity during the early Carboniferous. The same period of volcanic activity was responsible for the lavas found in the Kilpatrick Hills and the Campsie Fells to the north of the GCC area, and in the Lanarkshire and Renfrewshire Hills to the south. The various lava sequences are all thought to be of a similar age; resulting from one major volcanic episode which took place within a relatively short period of time at the beginning of the Viséan.

The basaltic lavas of Cathkin Braes form a faulted sequence approximately 60m thick, with the lower 30m comprising microporphyritic olivine-basalts, and the upper 30m of macroporphyritic olivine-basalts. In exposure, these upper lavas are commonly vesicular and contain plagioclase, olivine and pyroxene phenocrysts. Some pyroclastic material observed in places and beds of volcaniclastic material may be locally seen between lava flows. The individual lava flows form distinct steps in the landscape, the term 'trap' comes from the Swedish word for 'step'.

Cathkin Quarry, located at GR 262200,658350 is now infilled, but was the largest of a number of road-metal quarries in the volcanic rocks which form the Cathkin Braes. Small exposures of the lavas can be seen in disused quarries close to the B759 which crosses the site.

GeoScientific Merit and Value

	Rarity	Quality	Which if any Literature/ Collections has this been documented in and to what extent?	Primary interest (comment)
Lithostratigraphy	Moderately common	Poor	Hall et al., 1998.	Clyde Plateau Volcanic Formation
Sedimentology				
Igneous/ Mineral/ Metamorphic	Moderately common	Poor	Hall et al., 1998.	Extrusive igneous rocks
Structural geology				
Palaeontology				
Geomorphology (active processes and relict landforms)	Moderately common	Moderate		Trap topography

Assessment of the Overall Relative GeoScientific Importance

The classic trap topography of this upland volcanic terrain is characteristic of areas underlain by rocks of the Clyde Plateau Volcanic Formation within the Midland Valley. This site is an excellent point from which the landscape of the Glasgow area can be viewed and is considered as a **good CVDPA example** of **significance within the CVDPA**.

Safety of Access/ Site Condition/ Fragility/ Threats/ Sensitivities	
Safety of access/ ease and barriers to access into and around the site	There is good access to the viewpoint at Queen Mary's Seat, escarpment features, and bedrock exposures in a small disused quarry from the small parking area on the B759. Elsewhere the terrain is rough and paths are in variable condition. However, new paths and mountain bike trails are under development for the Commonwealth Games (2014) which should improve access. Access is restricted by a golf course in part of the area.
Safety of exposure	Small exposures are generally stable, but exposures on steep escarpments, especially the large northernmost escarpment may be dangerous to access.
Nature of exposure	Landforms and views, with minor bedrock outcrops.
Current conflicting activities or other threats	Some construction and development for 2014 Commonwealth Games Mountain Bike trails.
Restricting conditions	A golf course is located in the southern part of the site.
Ease or permissions needed to visit	Large area of the site is part of a GCC Country Park with public access.
Current condition and how clearly the values can be seen at the moment (close and at a distance)	Features of the trap topography are clearly visible in the area of Queen Mary's Seat but woodland obscures similar features in other areas of the site. Quarry faces are fairly accessible and clear of vegetation but young trees on the quarry floor obscure views from a distance.
Site fragility and sensitivities	Trap topography may be degraded by substantial landscaping of the ground during developments.

Other Current Site Values, Associations or Significance	
History of Earth Sciences	No known association.
Economic geology	A number of 'road-metal' quarries existed in the volcanic rocks of the Cathkin Braes. However, all the quarries are now disused, and the largest of these, Cathkin Quarry, is infilled.
Scientific study and education	No apparent association.
Associations with biodiversity or ecosystem and ecosystem services	The high ground and acidic soils resulting from the underlying volcanic rocks, support flora and fauna not seen elsewhere in the GCC area.
Aesthetic, landscapes, Archaeology, History and cultural associations	Glasgow City Council publish a Cathkin Braes Leaflet describing the history and features of Cathkin Braes, including archaeological associations and different wildlife habitats.
Local Communities/ visitors and promoting public awareness	Cathkin Braes Country Park contains a network of paths and a number of viewpoints to the north across the city, unfortunately the signboards at Queen Mary's Seat have been removed/vandalised.

Potential Opportunities for Using or Enhancing the Site	
Opportunities for Potential Future Uses or enhancing the site	The viewpoints provide ideal sites for explaining how the underlying geology and last glacial period has shaped the landscape across the Clyde Basin and surrounding high ground. Sign boards could be re-instated at the site to highlight this. Alternatively, information could be presented digitally via a webpage or 'geodiversity app'. References to the geology and landscape of the site could be included in leaflets and websites describing the Cathkin Braes Country Park area.

GGS_2: Kittoch Water, near Busby

Site Description

Physical Context: Gorge section along the Kittock Water in south Glasgow.

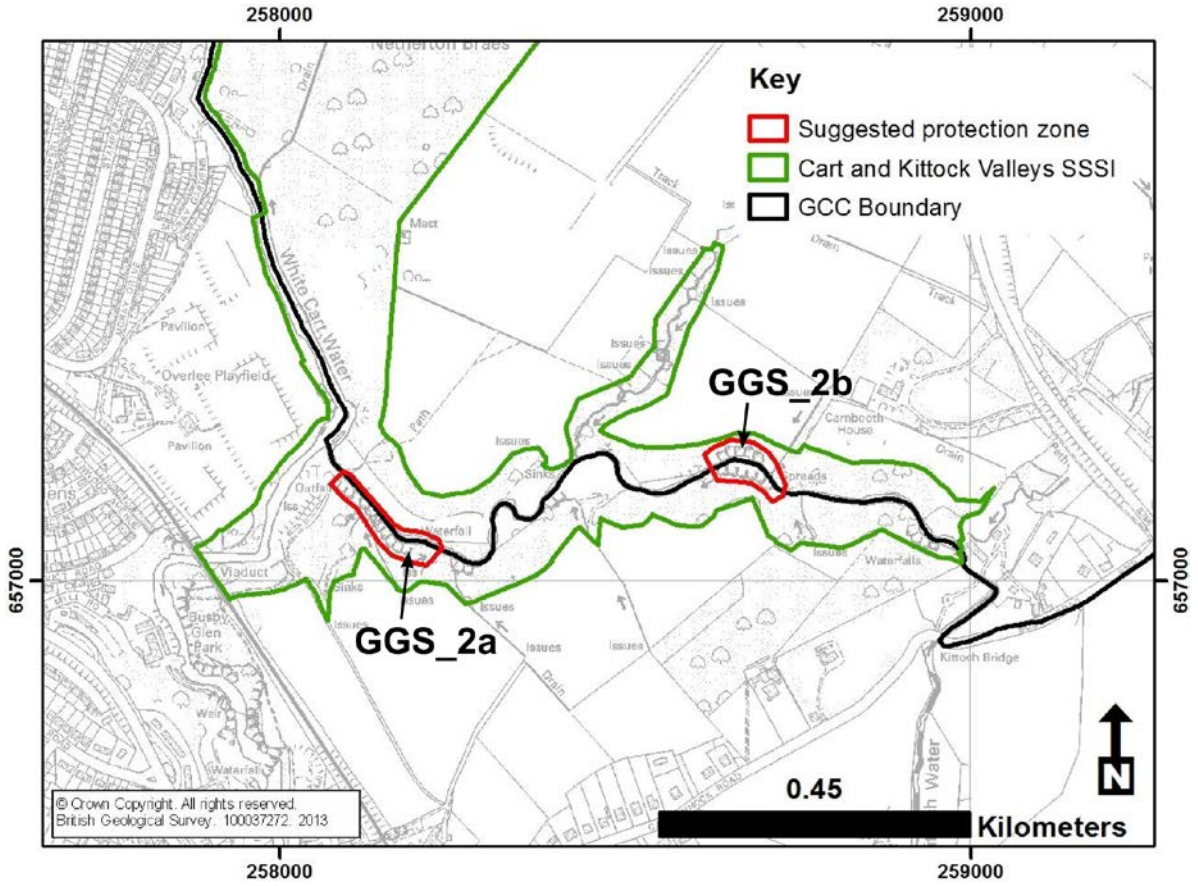
Nearby geodiversity sites or features: Close to Busby Glen Park (East Renfrewshire)

Is the site part of a network or geological terrain: No

Does the site cross or border with another Local Authority Area: Yes, East Renfrewshire

Site Location, any nearby landmarks and access point: Public footpaths from Busby Glen provide access to the confluence of the White Cart and Kittoch Water. There is no path to access exposures upstream of here, along Kittoch Water.	**Site type:** • Natural section
NGR: 258653 657150	Current use: Private Country
Site ownership: To be confirmed by GCC	Current geological designations: None
Permission to visit required: To be confirmed by GCC	Other designations: Biological SSSI
Field surveyor: Katie Whitbread and Sarah Arkley	Date visited: 1st February, 2013

Map, Location and Boundary Suggestions



MAP GGS_2: Kittoch Water Location Map. The suggested protection zone comprises two areas of significant outcrop, GGS_2b contains the most extensive outcrop and is considered the highest priority sub-area due to the quality of the exposure. The site defined by the suggested protection zone and comprising both sub-areas has been assessed in the following evaluation. GGS_2 lies within the area of the Cart and Kessock Valleys SSSI (Woodland). Other bedrock exposures not included in the suggested protection zone can be found within the SSSI area.

Site Photos

Photo GGS_2 P1: Gently dipping bedded strata of the Kirkwood Formation, located on the banks of the Kittock Water (GGS_2b). Looking SW.

Photo GGS_2 P2: Volcaniclastic sedimentary rocks visible in the river section (GGS_2b). Looking W.

Photo GGS_2 P3: Close-up of an agglomerate bed, located in the lower part of the section. The individual grains of volcanic material (eroded from the Clyde Plateau Volcanic Formation) can be clearly seen.

Stratigraphy and Rock Types

Unit 1	Age: Viséan, Lower Carboniferous	Formation: Kirkwood Formation
	Group: Strathclyde Group	Rock type: Volcaniclastic sedimentary rock

Geological Description

The site consists of several sections in the Kirkwood Formation located in the gorge of the Kittock Water. The Kirkwood Formation overlies the lavas of the Clyde Plateau Volcanic Formation and consists dominantly of tuffaceous mudstones and tuffs, derived from erosion of the upstanding volcanic terrain formed by the Clyde Plateau Volcanic Formation during the early Carboniferous. Non-tuffaceous sedimentary rocks occur in places, including sandstones, siltstones, mudstones and some conglomerates. Strata of the Kirkwood Formation only outcrop at the surface in a small region near the southern edge of the GCC area.

In the Kittock Water, sub-vertical sections of 3 to 5m of fine- to coarse-grained volcaniclastic sandstones. The sediments are bedded at 0.5 to 1.5m scales and pebbles of basalt up to 5cm diameter are present in coarser beds.

The Kirkwood Formation is locally faulted against basalts of the Clyde Plateau Volcanic Formation, but the faults are not seen directly and can only be inferred from the juxtaposition of the different lithological units.

GeoScientific Merit and Value

	Rarity	Quality	Which if any Literature/ Collections has this been documented in and to what extent?	Primary interest (comment)
Lithostratigraphy	Moderately common	Moderate		Kirkwood Formation
Sedimentology	Moderately common	Moderate		Volcaniclastic sediments
Igneous/ Mineral/ Metamorphic	Moderately common	Moderate		Extrusive igneous rocks
Structural geology				
Palaeontology				
Geomorphology (active processes and relict landforms)				

Assessment of the Overall Relative GeoScientific Importance

This site contains good exposures of bedded volcaniclastic sediments of the Kirkwood Formation and is therefore an important stratigraphic site and sedimentological site. The Kittock Water is a **good CVDPA example** with **local to regional (CVDPA) significance**.

Safety of Access/ Site Condition/ Fragility/ Threats/ Sensitivities	
Safety of access/ ease and barriers to access into and around the site	Access to the exposures along the Kittock Water is poor, with no paths beyond the northern limit of Busby Glen. Access was gained by following the woodland edge and carefully descending down a steep wooded gorge side. Outcrops on the north side of the river were inaccessible due to a lack of river crossing points. The Kittock Water also appeared to contain some sewage outflow so crossing may be inadvisable.
Safety of exposure	The exposures appear stable but care should taken be if hammering.
Nature of exposure	Natural sections in bedrock along the gorge of the Kittock Water.
Current conflicting activities or other threats	No apparent conflicting activities. The site is difficult to access and is located within a protected woodland SSSI.
Restricting conditions	Difficult access.
Ease or permissions needed to visit	Site is thought to be on private land, but details of ownership are not known.
Current condition and how clearly the values can be seen at the moment (close and at a distance)	The exposures are in moderately good condition, but there is considerable moss and surface algal growth as well as large vegetation. Dense vegetation also restricts views of exposures on the north side of the river.
Site fragility and sensitivities	Further vegetation may degrade the views and exposures.

Other Current Site Values, Associations or Significance	
History of Earth Sciences	No known association.
Economic geology	No apparent association.
Scientific study and education	No known association.
Associations with biodiversity or ecosystem and ecosystem services	The site lies within an existing ecological SSSI, protected as a broad-leaved, mixed and yew woodland.
Aesthetic, landscapes, Archaeology, History and cultural associations	No apparent association.
Local Communities/ visitors and promoting public awareness	No apparent significance.

Potential Opportunities for Using or Enhancing the Site	
Opportunities for Potential Future Uses or enhancing the site	The difficult access to this site means that potential development is limited.

GGS_3: Levern Water, Household Park

Site Description

Physical Context: Sections in the banks and bed of the Levern Water.

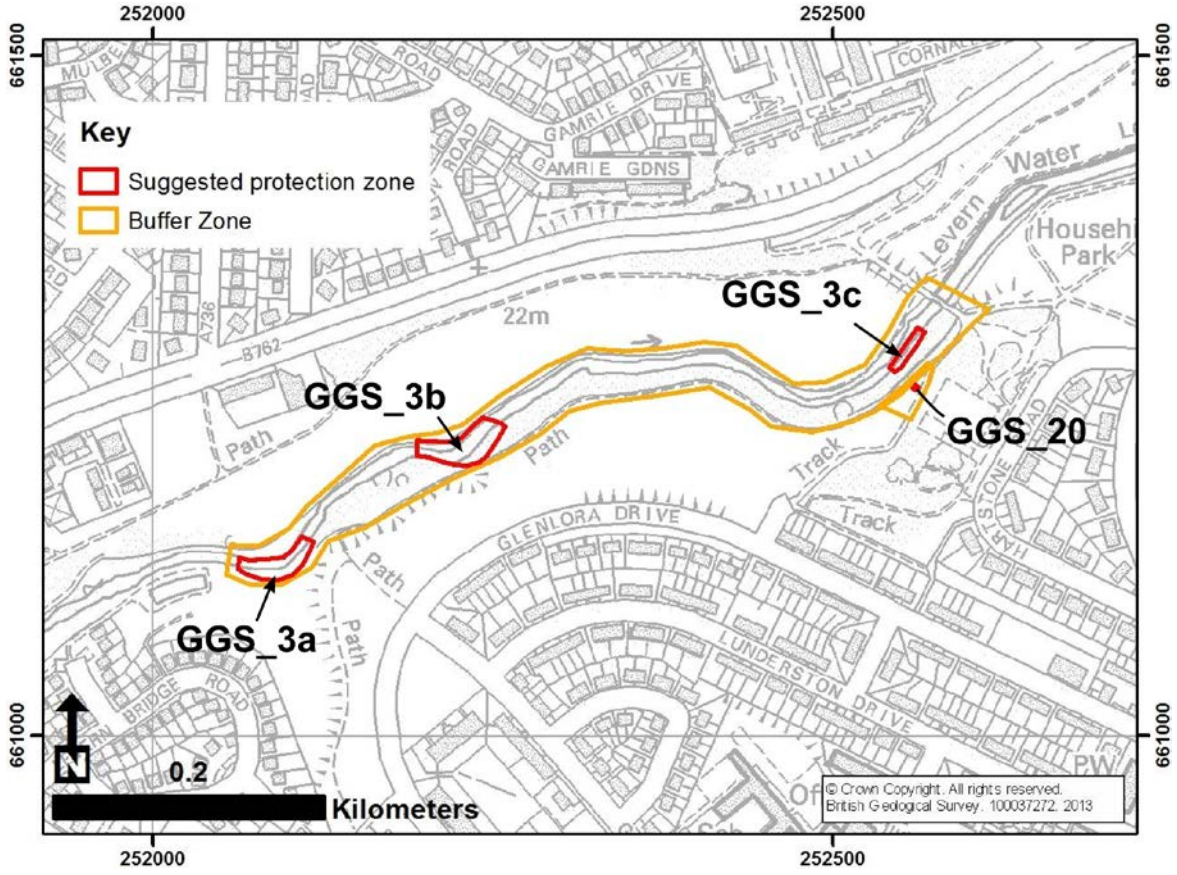
Nearby geodiversity sites or features: GSS_20 - Fossil Tree, Household Park is located adjacent to this site

Is the site part of a network or geological terrain: No

Does the site cross or border with another Local Authority Area: No

Site Location, any nearby landmarks and access point: Household Park has various access points and, street-parking is locally available. A footbridge allows access across the river.	**Site type:** • Natural Section
NGR: 252233 661205	Current use: Urban
Site ownership: Glasgow City Council	Current geological designations: None
Permission to visit required: Public access	Other designations: None known
Field surveyor: Katie Whitbread and Sarah Arkley	Date visited: 20th February 2013

Map, Location and Boundary Suggestions



MAP GGS_3: Levern Water Location Map. The suggested protection zone comprises three areas of significant outcrop, GGS_3b is considered the highest priority sub-area due to the quality of the bedrock exposure and association of bedrock with superficial deposits and made ground. GSS_3a and 3c are intermediate and lower proiority areas respectively but are included because they expose different parts of the bedrock sequence. The site defined by the suggested protection zone and comprising all sub-areas has been assessed in the following evaluation. The Buffer Zone incorporates access routes to the site and viewing areas. The location of adjacent site GGS_20 is also shown.

Site Photos

Photo GGS_3 P1: Gently dipping (towards the SE), bedded strata of the Lower Limestone Formation, located on the banks of the Levern Water (GGS_3b). The strata observed here are thought to be located stratigraphically between the Blackhall Limestone and Main Hosie Limestone. The sequence consists dominantly of dark-coloured mudstones with ironstone bands/nodules. Looking SW.

Photo GGS_3 P2: Sequence of well-jointed, thinly-bedded, dark-grey mudstones (GGS_3b). Looking SE.

Photo GGS_3 P3: Close-up of mudstone pebbles on the river bed, the small, disc-like nature of the pebbles reflects the thinly-bedded and well-jointed nature of the mudstones from which they were derived.

Site Photos

Photo GGS_3 P4: Tipped waste adjacent to outcrops along the southern bank of the Levern Water (GGS_3b). Dumping /fly-tipping is significant along this stretch of the river. Looking SE.

Photo GGS_3 P5: Made ground, consisting of loosely consolidated mudstone clasts, (likely to be waste material from local mining) overlying natural superficial deposits in a river bank section along the Levern water (GGS_3b). Looking SE.

Photo GGS_3 P6: Close-up showing the irregular nature of the base of the made ground and how it cuts down into the underlying natural superficial deposits (GGS_3b). Looking NW.

Stratigraphy and Rock Types

Unit 1	Age: Viséan-Namurian, Carboniferous	Formation: Lower Limestone Formation
	Group: Clackmannan Group	Rock type: Sedimentary rock cycles, Clackmannan Group type

Geological Description

The site contains several exposures of strata of the Lower Limestone Formation exposed in the bed and banks of the Levern Water in south-west Glasgow. A 20m long section in the middle of the site exposes 1 to 1.5m of iron-stained shaly mudstone with 5 to 10cm thick sandstone beds and ironstone nodules up to 30cm diameter and 10cm thick.

The mudstone is overlain by sandy clay with stones, thought to be glacial till, in the river bank. The till has been locally excavated and overlain by spoil material consisting of coarse fragments of mudstone (made ground), with sharp cut-fill contacts between the made ground and the underlying till seen in the banks of the Levern Water.

Geological fieldslips and historic OS maps indicate that the Lower Limestone strata were formerly worked for ironstone in several local mines. It is likely that the spoil forming the made ground was derived from this local mining.

GeoScientific Merit and Value

	Rarity	Quality	Which if any Literature/ Collections has this been documented in and to what extent?	Primary interest (comment)
Lithostratigraphy	Moderately common	Poor		Lower Limestone Formation strata
Sedimentology	Moderately common	Poor to moderate		Marine environments
Igneous/ Mineral/ Metamorphic				
Structural geology				
Palaeontology				
Geomorphology (active processes and relict landforms)				

Assessment of the Overall Relative GeoScientific Importance

The site provides a good example Lower Limestone Formation strata and of the relation between bedrock, superficial deposits and made ground. It is considered to be a **good CVDPA example** with **significance in the CVDPA**.

Safety of Access/ Site Condition/ Fragility/ Threats/ Sensitivities	
Safety of access/ ease and barriers to access into and around the site	There is good network of paths within Household Park, but access to the river sections generally requires descent of vegetated river banks of moderate slope. Exposures can be easily viewed from the playing fields on the opposite river bank. In some areas the river depth prevents access to bank sections. Tipped waste impedes access in places.
Safety of exposure	Natural exposures are generally stable but substantial amounts of rubbish in the river and on slopes may be hazardous. Care must be taken in the river sections, especially during higher flow conditions.
Nature of exposure	River bank and river bed exposures.
Current conflicting activities or other threats	Significant tipping along the banks of the river obscures outcrops and locally impedes access.
Restricting conditions	Access may be restricted during high river flow conditions and may be affected by seasonal vegetation growth.
Ease or permissions needed to visit	No permissions required.
Current condition and how clearly the values can be seen at the moment (close and at a distance)	Exposures are generally in good condition but are locally degraded by vegetation growth and obscured by tipped waste.
Site fragility and sensitivities	Continued tipping of waste along the river may substantially degrade exposures and limit access to the site.

Other Current Site Values, Associations or Significance	
History of Earth Sciences	No known association.
Economic geology	There has been extensive local mining, most probably of blackband and clayband ironstone, with spoil forming an extensive tract of made ground either side of the river.
Scientific study and education	No apparent association.
Associations with biodiversity or ecosystem and ecosystem services	Household Park contains areas of woodland and river habitats.
Aesthetic, landscapes, Archaeology, History and cultural associations	Household Park was formerly part of the grounds of Household House, now demolished.
Local Communities/ visitors and promoting public awareness	The site is part of a recreational park area.

Potential Opportunities for Using or Enhancing the Site	
Opportunities for Potential Future Uses or enhancing the site	Information relating aspects of the geology seen in the park to local mining history and landscape heritage could be included on websites providing information about the park area.

GGS_4: River Kelvin, Belmont Bridge

Site Description

Physical Context: River cliff in the Kelvin gorge.

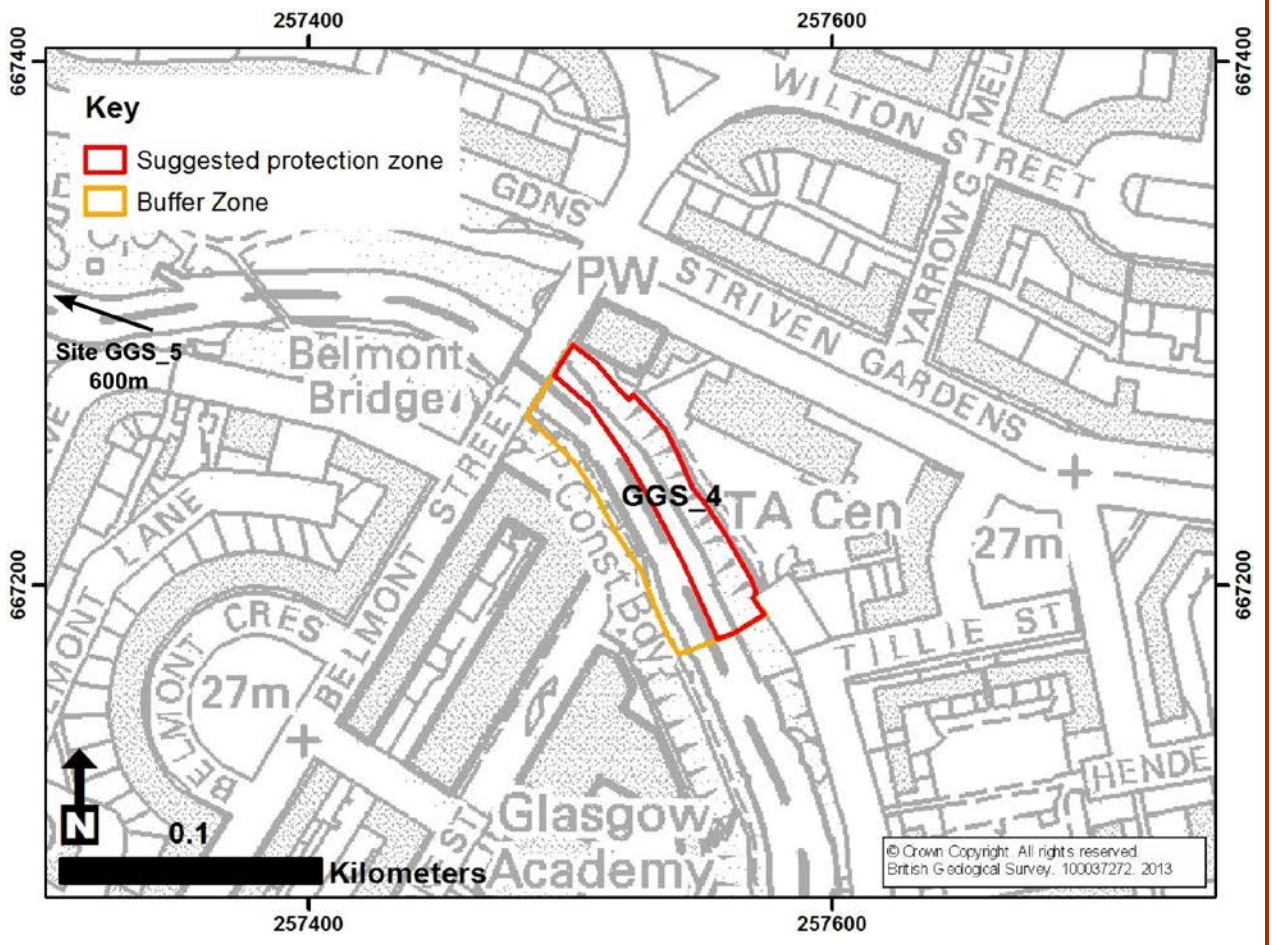
Nearby geodiversity sites or features: Part of series of exposures along the Kelvin gorge. GGS_5 (Kelvin, Botanic Gardens) is located approximately 600m upstream to the north-west.

Is the site part of a network or geological terrain: Part of the Kelvin gorge network.

Does the site cross or border with another Local Authority Area: No

Site Location, any nearby landmarks and access point: Belmont Street, Belmont Bridge	**Site type:** • Natural Section
NGR: 257538 667238	Current use: Urban
Site ownership: Glasgow City Council	Current geological designations: None
Permission to visit required: Public access	Other designations: None known
Field surveyor: Katie Whitbread and Sarah Arkley	Date visited: 20th February 2013

Map, Location and Boundary Suggestions



MAP GGS_4: River Kelvin, Belmont Bridge Location Map. The suggested protection zone comprises bedrock section exposed along the bank of the River Kelvin. The Buffer Zone incorporates the site together with the main viewing point on the Kelvin Walkway.

Site Photos

Photo GGS_4 P1: The eastern bank of the River Kelvin, immediately downstream of Belmont Bridge has been stabilised with a concrete facing which prevents erosion occurring on the outside of the river meander, but obscures any potential bedrock exposures. However, further downstream (opposite the people in the photo above) rock outcrops are visible in the bank side, displaying a sequence through the Limestone Coal Formation. Looking SE.

Photo GGS_4 P2: Gently dipping (east) sedimentary sequence of the upper part of the Limestone Coal Formation, approximately at the stratigraphic position of the Ashfield Coking Coal and Nitshill Sandstone. This part of the sequence consists of coal cyclothems averaging 6-7m in thickness. The outcrop here appears to display a typical coarsening upward sequence, with mudstones/siltstones at the base coarsening upwards to a thick sandstone unit. Looking NE.

Site Photos

Photo GGS_4 P3: The weir and sluice located immediately downstream of the Queen Margaret Bridge was formerly used to control water entering the mill lade, which carried water to the North Woodside Flint Mill. The bridge, built 1926-1929 is made from concrete but faced with red Corncockle sandstone and solid red Peterhead granite parapets (according to the GCC leaflet on the Botanic Gardens). Looking NW.

Photo GGS_4 P4: The mill lade which channelled water from the River Kelvin to power the flint mill. The lade bed was cleaned, lined with stone and the walls cut down for safety in the 1970's. The site now forms part of the Kelvin Walkway and lies within the boundaries of the Glasgow Botanic Gardens. Looking NW.

Photo GGS_4 P5: The site of North Woodside Flint Mill. The millstones shown in the photo came from another mill within Glasgow (according to the on-site information board) and the only remaining millstone from the North Woodside Mill forms the base of the sundial in the Botanic gardens, Looking E towards Belmont Bridge and Kelvin Stevenson Memorial Church. The Belmont Street Bridge was constructed in 1870 (according to the GCC Glasgow Botanic Gardens Heritage Trail leaflet).

Photo GGS_4 P6: The remains of North Woodside Flint Mill, preserved by Glasgow Corporation in the 1970's for archaeological and historical interest. Looking SW.

Stratigraphy and Rock Types

Unit 1	Age: Namurian, Upper Carboniferous	Formation: Limestone Coal Formation
	Group: Clackmannan Group	Rock type: Sedimentary rock cycles, Clackmannan Group type

Geological Description

A section through two coal cyclothems in the Limestone Coal Formation between the Glasgow Shale Coal and the Possil Main Coal is exposed in a 30m long section along the River Kelvin south of Belmont Bridge. Although not directly accessible due to the river, the strata can be readily viewed from the walkway on the opposite river bank.

The section exposes 3 to 4m of strata in which thinly bedded siltstones at the river level grade upwards into flaggy-bedded sandstone and then thicker bedded (20 to 50cm) sandstone. In the thickest part of the exposure, at the north end of the section, two coarsening-up cycles are partially visible. A minor fault can also be seen in the centre of the section as indicated by a small offset on a sandstone beds.

The site lies within the Kelvin gorge network, this feature and its importance is described in more detail in the review of site GGS_5.

GeoScientific Merit and Value

	Rarity	Quality	Which if any Literature/ Collections has this been documented in and to what extent?	Primary interest (comment)
Lithostratigraphy	Moderately common	Poor		Limestone Coal Formation strata
Sedimentology	Moderately common	Moderate to poor		Fluvial and deltaic environments
Igneous/ Mineral/ Metamorphic				
Structural geology				
Palaeontology				
Geomorphology (active processes and relict landforms)	Moderately common	Moderate		River gorge, mixed bedrock and alluvial river landforms

Assessment of the Overall Relative GeoScientific Importance

The site comprises a relatively thick section highlighting the cyclic nature of the coal-bearing strata of the Limestone Coal Formation which has been extensively mined throughout the Glasgow area. The site is considered to be a **moderate CVDPA example** with **significance in the CVDPA area**.

The site lies within the Kelvin gorge network, and the significance of this landform system is discussed in more detail in the assessment of GGS_5.

Safety of Access/ Site Condition/ Fragility/ Threats/ Sensitivities

Safety of access/ ease and barriers to access into and around the site	There is no direct access to section due to the river and near-vertical slope of the gorge wall. However, there are good views of the full length of section from the opposite river bank, from the Kelvin Walkway.

Safety of exposure	Not applicable as exposure is inaccessible.
Nature of exposure	River bank section.
Current conflicting activities or other threats	Rock falls caused by river erosion undercutting of the bank have obscured some of the lower parts of the exposure in places.
Restricting conditions	A high river levels, the base of the exposure may not be visible. Seasonal vegetation growth may restrict the view of the exposure.
Ease or permissions needed to visit	No permissions required.
Current condition and how clearly the values can be seen at the moment (close and at a distance)	The exposure is in moderately good condition in places, but is degraded by overhanging tree branches and vegetation growth in others.
Site fragility and sensitivities	Future rocks falls may obscure parts of the exposure. However, new exposures may also be created by this process. Any bank stabilisation measures required to stabilise the river bank could degrade the exposure.

Other Current Site Values, Associations or Significance

History of Earth Sciences	No known association.
Economic geology	The Limestone Coal Formation strata have been extensively mined for coal throughout the Glasgow area. The North Woodside Flint Mill was built just to the north of the site to exploit the flow of the Kelvin for the grinding of flint.
Scientific study and education	No apparent association.
Associations with biodiversity or ecosystem and ecosystem services	The Kelvin gorge contains areas of woodland and a range of wildlife habitats.
Aesthetic, landscapes, Archaeology, History and cultural associations	The site of the former flint mill, just upstream of Belmont Bridge has been preserved as a local archaeological site.
Local Communities/ visitors and promoting public awareness	The Kelvin gorge walkway is frequently used for recreation and the wider River Kelvin area is the focus for the community group the ‘Friends of the River Kelvin’ which aims to support the protection and management and of the Kelvin gorge.

Potential Opportunities for Using or Enhancing the Site

Opportunities for Potential Future Uses or enhancing the site	The geological features of the site could be described in an information board located on the Kelvin Walkway. The site could form part of a Kelvin geology walk.

GGS_5: Kelvin River, Botanics

Site Description

Physical Context: Exposures in the gorge of the River Kelvin.

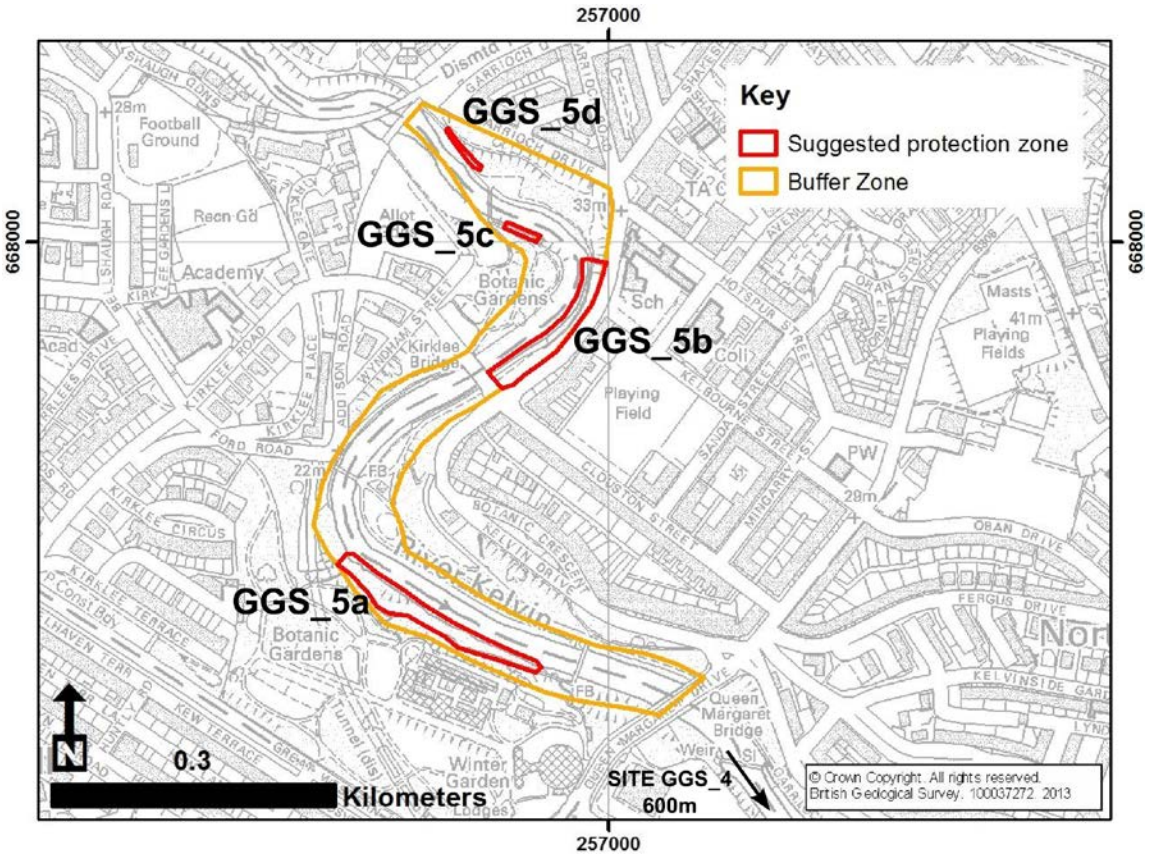
Nearby geodiversity sites or features: GGS_4 (River Kelvin, Belmont Bridge) is located approximately 600m downstream (to the south-east).

Is the site part of a network or geological terrain: Part of the River Kelvin gorge network.

Does the site cross or border with another Local Authority Area: No

Site Location, any nearby landmarks and access point: The site extends along the Kelvin from Queen Margaret Drive in the south to the disused railway bridge at the northern end of the Botanic Gardens. There are various access points to the Kelvin gorge via the Botanic Gardens and surrounding streets.	**Site type:** • Natural Section
NGR: 256902 667861	Current use: Recreation
Site ownership: Glasgow City Council	Current geological designations: None
Permission to visit required: Public access	Other designations: None known
Field surveyor: Katie Whitbread and Sarah Arkley	Date visited: 20th February 2013

Map, Location and Boundary Suggestions



MAP GGS_5: River Kelvin, Botanic Gardens Location Map The suggested protection zone comprises four areas of significant outcrop, GGS_5b is considered the highest priority sub-area due to the quality of the bedrock exposure. GSS_5a is intermediate priority and small exposures in sub-areas GGS_5c and d are lower proiority but are included because they expose different parts of the bedrock sequence. The site defined by the suggested protection zone and comprising all sub-areas has been assessed in the following evaluation. The Buffer Zone incorporates access routes to the site and viewing areas.

Site Photos

Photo GGS_5 P1: Rock outcrops are visible high in the eastern bank of the River Kelvin, immediately upstream of Kirklee Bridge, beneath Garrioch Road (GGS_5b). The outcrop displays a gently dipping sedimentary sequence through the upper part of Limestone Coal Formation, approximately at the stratigraphic position of the Jubilee Coal and Glasgow Shale Coal. This part of the sequence consists of coal cyclothems averaging 6-7m in thickness. The outcrop here appears to display a typical coarsening upward sequence, with siltstones at the base coarsening upwards to a thick, bedded sandstone unit. Looking NE.

Photo GGS_5 P2: Close-up showing the parallel laminated nature of some of the sandstone beds.

Photo GGS_5 P3: Close-up highlighting the ripple- laminated nature of some of the sandstone beds.

Photo GGS_5 P4: Close-up illustrating how some of the sandstone blocks at this site are hanging very precariously, daylight can be seen through this vertical joint (GGS_5b).

Site Photos

Photo GGS_5 P5: Laterally extensive section along the bank of the River Kelvin, displaying gently dipping sedimentary rocks of the Limestone Coal Formation (GGS_5b). The Kelvin Walkway lies halfway up the slope, with further rock outcrops exposed above the path (as described in photographs P1- P4 Looking E.

Photo GGS_5 P6: The Kirklee Bridge, built 1899-1900, is constructed of red sandstone with polished pink granite columns and balustrades. In the foreground a number of boulders cemented into the ground form an interesting feature, no explanation for their existence was found. Looking E.

Photo GGS_5 P7: Close-up of iron-stained groundwater seeping from the bankside adjacent to the Kelvin Walkway path. ?mine water. Looking NW.

Stratigraphy and Rock Types

Unit 1	Age: Namurian, Upper Carboniferous	Formation: Limestone Coal Formation
	Group: Clackmannan Group	Rock type: Sedimentary rock cycles, Clackmannan Group type

Geological Description

The site consists of a series of exposures of cyclothems of the Limestone Coal Formation along the Kelvin river and gorge. The sequence extends from below the level of the Knightswood Gas Coal to above the Glasgow Shale Coal.

In sections to the east of the river, just north of Kirklee Bridge near the centre of the site, a sandstone bluff up to 4m high is exposed. The sandstone is buff to orange coloured and flaggy bedded at the base with the bed thickness increasing upwards to10 - 50cm. The sandstone is laminated and ripple laminated in places with small-scale cross-bedded ripples. No coal is seen at the base of the exposure, but the site is recorded on old fieldslips as the position of the Jubliee Coal. Sandstone from an underlying cycle can be seen in the river bank below this section (viewed from the opposite river bank).

Sandstone and siltstone from other coal-cycles are exposed in smaller exposures throughout the site. Access to exposures on the western bank of the river is restricted due to an unstable slope caused by a recent landslip.

The gorge of the River Kelvin follows an irregular course from the region of the Garscube Estate south to the River Clyde in Partick. In this area, the river descends a relatively steep channel through a confined, wooded gorge, containing a mixture of bedrock and alluvial river channel features. The modern course of the Kelvin through Glasgow appears to be the result of a diversion from an original south-west draining channel system and the route of the Kelvin through the incised Kelvin gorge in Glasgow is thought to be due to diversion of the river during deglaciation of the area at the end of the last glaciation (13 to 10,000 years ago).

GeoScientific Merit and Value

	Rarity	Quality	Which if any Literature/ Collections has this been documented in and to what extent?	Primary interest (comment)
Lithostratigraphy	Moderately common	Moderate		Limestone Coal Formation strata
Sedimentology	Moderately common	Moderate		Fluvial and deltaic environments
Igneous/ Mineral/ Metamorphic				
Structural geology				
Palaeontology				
Geomorphology (active processes and relict landforms)	Moderately common	Moderate		River gorge, mixed bedrock and alluvial river landforms

Assessment of the Overall Relative GeoScientific Importance

The site contains good exposures of coal-cyclic sequences characteristic of strata that have been extensively mined in the Glasgow area. The sandstones display sedimentological evidence for rapid deposition in fluvio-deltaic environments. The site is considered to be a **good CVDPA example** of **significance in the CVDPA area.**

GGS_5, together with sites GGS_4 and GGS_10 forms a set of sites located within the Kelvin gorge network, an example of a glacially diverted drainage system. Erosion of the river, initially supplied by glacial meltwater, in to superficial deposits and bedrock has resulted in the confined gorge and produced numerous exposures of bedrock along its length. The relation of bedrock exposures at the three sites to gorge and river landforms is considered to enhance their GeoScientific importance. Due to the extent of the Kelvin gorge, this feature has not been given a separate assessment in this audit but the special context of the gorge is considered to provide added GeoScientific importance to the three sites that lie within it.

Safety of Access/ Site Condition/ Fragility/ Threats/ Sensitivities

Safety of access/ ease and barriers to access into and around the site	The exposures can be readily viewed from the Kelvin Walkway, but direct access requires traversing of steep, slippery vegetated slopes.
Safety of exposure	Parts of the exposure near the Kirklee Bridge appear to be unstable with small to medium sized blocks becoming detached from the rock face through weathering. Rock falls could also pose a risk to passers-by on the Kelvin Walkway below. Extreme care should be taken at the outcrop and hammering is discouraged.
Nature of exposure	Vertical crag on the side of the Kelvin gorge.
Current conflicting activities or other threats	Landslips or rockfalls may obscure parts of the exposure, but may also generate new exposures.
Restricting conditions	Summer vegetation growth would restrict viewing from the path.
Ease or permissions needed to visit	No permissions required.
Current condition and how clearly the values can be seen at the moment (close and at a distance)	The exposures are in good condition, with local surface algae and moss and partial vegetation cover. Biological weathering is responsible for some destabilisation of exposure faces.
Site fragility and sensitivities	The sites may be affected by landslips and further vegetation growth. Exposures may be destabilised by hammering and sample collecting should be kept to a minimum.

Other Current Site Values, Associations or Significance

History of Earth Sciences	No known association.
Economic geology	There is evidence for former mining in the form of adits and shafts in parts of the site area, including iron-rich groundwater seepage. Historical geological fieldslips indicate numerous shafts in the surrounding area from with coal seams within the Limestone Coal Formation strata, including the Knightswood Gas, Glasgow Shale and Possil Main, have been worked. The Kelvin river has provided power for paper and textile mills, and chemical and dye works. Evidence for some of this former industry is preserved within the Kelvin gorge, notably downstream of the site at the North Woodside Flint Mill.
Scientific study and education	No apparent association.

Associations with biodiversity or ecosystem and ecosystem services	The Kelvin gorge and Botanic gardens contain areas of managed and semi-natural woodland hosting a wide variety of wildlife.
Aesthetic, landscapes, Archaeology, History and cultural associations	The River Kelvin in Glasgow was formerly a focus for considerable industrial development. Closure of mills, chemical and dye works and abandonment of railway yards and sidings that formerly followed the river in the 1950's and 60's has allowed the biodiversity to regenerate and enabled the River Kelvin to become an important ecological area as well as a place of recreation within inner Glasgow.
Local Communities/ visitors and promoting public awareness	The Botanic Gardens and the Kelvin gorge walkway are frequently used for recreation. The wider River Kelvin area is the is the focus for the community group the 'Friends of the River Kelvin' which aims to support the protection and management of the River Kelvin gorge and associated ecological habitats.

Potential Opportunities for Using or Enhancing the Site

Opportunities for Potential Future Uses or enhancing the site	The geological features of the site area could be described in information boards located on the Kelvin Walkway as well as in leaflets or other media providing information for users of the Kelvin Walkway and Botanic Gardens. The site could form part of a Kelvin geology walk.

GGS_6: Fossil Grove SSSI and quarry, Victoria Park

Site Description

Physical Context: Disused quarry now forming part of Victoria Park in western Glasgow.

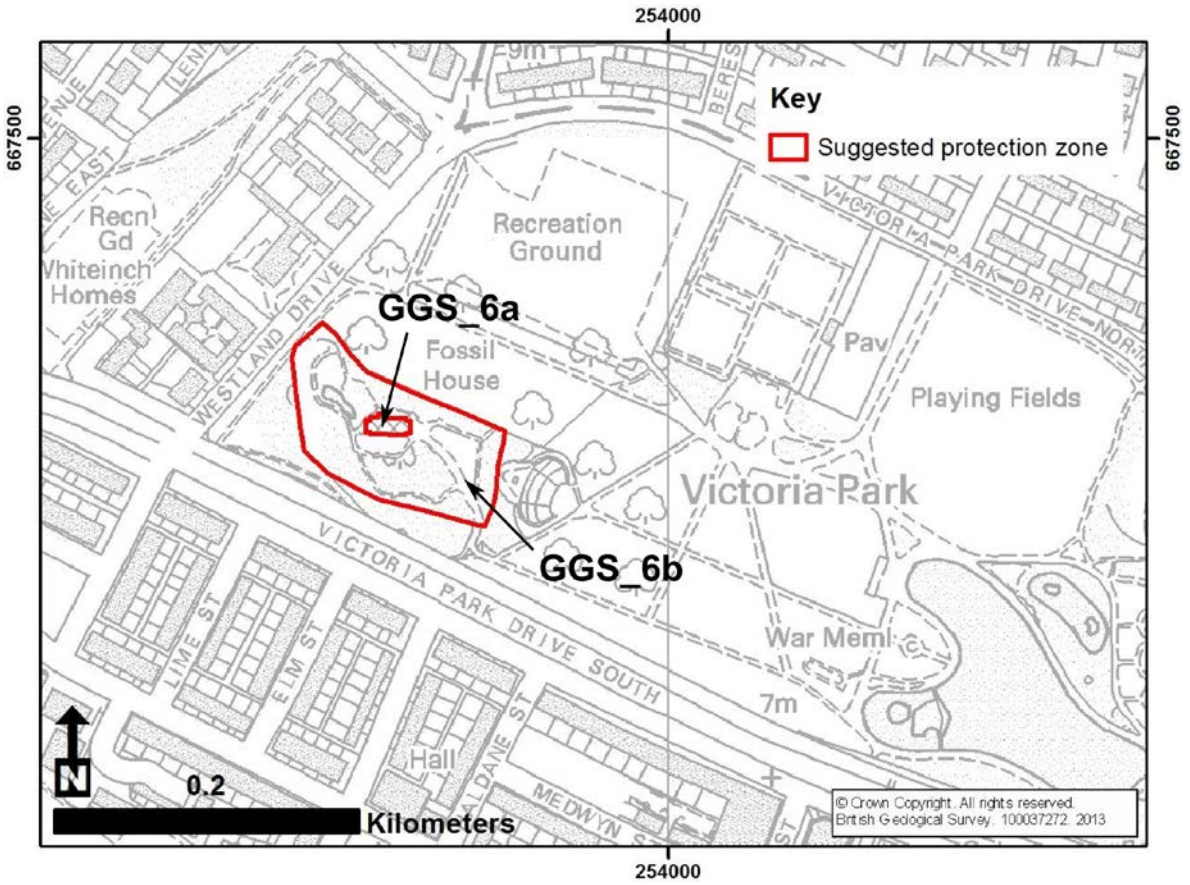
Nearby geodiversity sites or features: None within 1km.

Is the site part of a network or geological terrain: No

Does the site cross or border with another Local Authority Area: No

Site Location, any nearby landmarks and access point: The site lies within Victoria Park, located in the Glasgow's West End. There are two main road routes, the A814 and A739 (near the Clyde tunnel) providing access to the park, which has several access points. Street parking is locally available.	**Site type:** • Quarry workings
NGR: 253781 667333	Current use: Recreation
Site ownership: Glasgow City Council	Current geological designations: SSSI, GCR
Permission to visit required: Public access (restricted access to Fossil Grove).	Other designations: None known
Field surveyor: Katie Whitbread and Sarah Arkley	Date visited: 7th February, 2013

Map, Location and Boundary Suggestions



Map GGS_6: Fossil Grove and Quarry Location Map. The suggested protection zone has been divided into two parts, consisting of the Fossil Grove paleontological SSSI (GGS_6a) and the surrounding quarry area (GGS_6b). Because the Fossil Grove exposure within the site (GGS_6a) has already been designated a SSSI, the following valuation focuses on the surrounding quarry area (GGS_6b) and the context it provides for the Fossil Grove paleontogogical site.

Site Photos

Photo GGS_6 P1: A 'grove' of fossil tree stumps preserved in sandstone of the Limestone Coal Formation was discovered during quarrying excavations in 1887 (GGS_6a)**.** In1889, in one of the first instances of Geodiversity conservation, it was decided that the fossil stumps should be preserved in situ as a public attraction rather than taken to a museum. A specially erected building (designed by the famous architect Peter Macgregor Chalmers) opened on January 1st 1890, later renovated to form the current building. The site is now managed by Glasgow City Council.

Photo GGS_6 P2: Close-up showing one of the posters displayed on the outside of the building which houses the fossil stumps. The poster illustrates improvements made to the building to enhance the visitor experience and protect the fossils.

Photo GGS_6 P3: Close-up of the interpretation board which exists at the south-western entrance to the park.

Site Photos

Photo GGS_6 P4: View into the former quarry in Victoria Park (GGS_6b), looking NW. A number of rock faces can be easily accessed, primarily exposing the microgabbro sill which was once extracted here for road stone and ultimately led to the discovery of the fossil stumps.

Photo GGS_6 P5: Photo showing the contact between the sill and underlying sedimentary strata. The bottom of the hammer is resting on the contact between the microgabbro and underlying sandstone (GGS_6b).

Photo GGS_6 P6: Close-up showing the chilled margin and basal contact of the sill (GGS_6b).

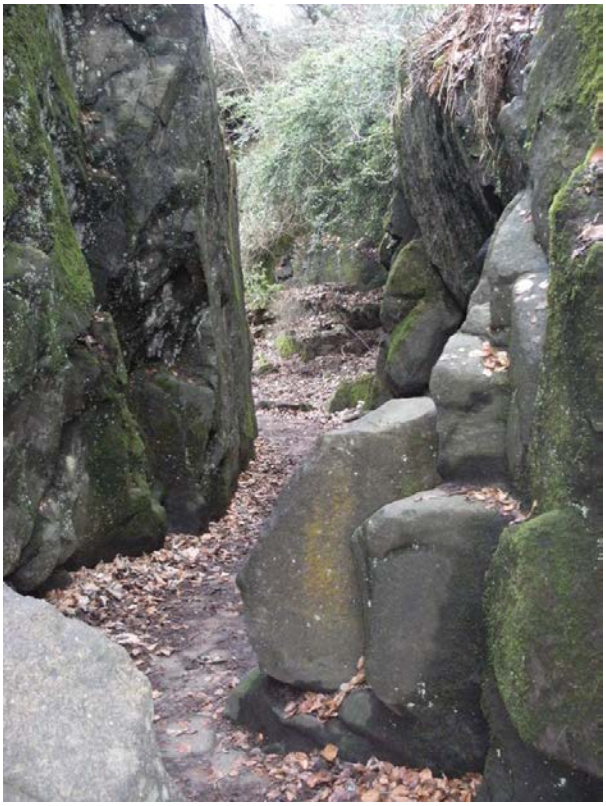


Photo GGS_6 P7: Pathways through the micrgabbro quarry allow good access to a number of exposure faces (GGS_6b).

Stratigraphy and Rock Types

Unit 1	Age: Westphalian-Early Permian	Formation: Western Midland Valley Westphalian to Early Permian Sills
	Group: Midland Valley Carboniferous to Early Permian Alkaline Basic Sill Suite	Rock type: Olivine-microgabbro
Unit 2	Age: Namurian, Upper Carboniferous	Formation: Limestone Coal Formation
	Group: Clackmannan Group	Rock type: Sedimentary rock cycles, Clackmannan Group type

Geological Description

At Fossil Grove, the stumps and upper roots of eleven *Lepidodendron* (Lycopod) are preserved *in situ* in strata of the Carboniferous Limestone Coal Formation (Cleal and Thomas, 1995). The *in situ* preservation of the trees means that the nature of the soil in which they grew, the characteristics of the Carboniferous forest environment, and the processes responsible for their burial and preservation can be ascertained. The forest was growing on a palaeosol consisting of silt and mud, now a silty mudstone containing plant material, and the tree spacing indicates that the Carboniferous forest may have had a density of approximately 4500 trees per square kilometre. The forest in this area was swamped by sediment during flooding of local rivers which ultimately caused the death of the trees and the burial and replacement of the wood, resulting in the preservation of the Lycopod stumps as sandstone casts within the strata of the lower Limestone Coal Formation, possibly just above the Johnstone Clayband Ironstone.

Immediately above the horizon in which the Lycopod stumps are preserved an igneous sill, recorded to be part of the Hosie Sill, of the alkali dolerite Midland Valley Sill Suite has been intruded. The resistant olivine-microgabbro of the sill was formerly quarried at the site, leading to the discovery of Fossil Grove during the quarrying excavations in 1887. Radiometric dates of between 270Ma and 273Ma (Mid Permian), have been obtained from biotite and hornblende for the intrusions in the region (Hall et al., 1998).

The microgabbro is dominantly medium-grained, grey to dark grey in colour, and displays little internal structure. Up to 8m of the sill are exposed in the quarry faces, however, local boreholes have proved 45m of microgabbro in several sill sheets within sedimentary strata. The base of the sill at the contact with the underlying sedimentary strata is exposed in the lower part of the quarry near the pond to the west of Fossil Grove. A thin chilled margin is visible in the sill where the hot magma cooled rapidly on contact with the surrounding rocks during emplacement. In this area the underlying sedimentary rocks consist of sandstone with beds ranging from 3 to 50 cm thick. The contact with the overlying sedimentary strata is not visible. Sub-vertical, columnar jointing, which formed perpendicular to the cooling surfaces, is fairly well developed in parts of the sill exposed within the quarry.

Fossil Grove has geological SSSI status, but the SSSI does not include the surrounding quarry area.

GeoScientific Merit and Value

	Rarity	Quality	Which if any Literature/ Collections has this been documented in and to what extent?	Primary interest (comment)
Lithostratigraphy	Moderately common	Moderate	Hall et al., 1998	Limestone Coal Formation strata
Sedimentology	Moderately common	Excellent		Fluvial and deltaic environments

Igneous/ Mineral/ Metamorphic	Moderately common	Good		Intrusive igneous sill
Structural geology				
Palaeontology	Rare	Excellent	Hall et al., 1998	Plant fossils
Geomorphology (active processes and relict landforms)				

Assessment of the Overall Relative GeoScientific Importance

The site is famous for the exceptionally preserved *in situ* Lycopod stumps and the Fossil Grove site have been protected by SSSI status. However, the very good exposures of the sill and contact with underlying sedimentary rocks in the surrounding quarry are also important features of the site area and provide fundamental context for the Fossil Grove SSSI. The Fossil Grove SSSI is a World Class palaeontological site with national (UK/Scottish) significance. The surrounding quarry area is a **good Midland Valley example** and its context in relation to the Fossil Grove site gives it **regional (Midland Valley) significance.**

Safety of Access/ Site Condition/ Fragility/ Threats/ Sensitivities

Safety of access/ ease and barriers to access into and around the site	Victoria Park has good road connections and a number of access points. There is a network of metalled and well maintained footpaths throughout the park, including the quarry area. Quarry exposures are directly next to paths and easily accessed. Fossil Grove is protected within a purpose-built building but the opening hours vary seasonally. Information on opening hours can be found on the Glasgow City Council website.
Safety of exposure	The quarry faces appear stable but should be assessed when approaching for any loose material that may be present above head height.
Nature of exposure	Vertical faces in a disused quarry forming part of an attractive garden setting.
Current conflicting activities or other threats	No conflicting activities or threats were noted in the quarry area.
Restricting conditions	Closure of the Fossil Grove building restricts access to the SSSI site. Victoria Park is open from 7am until dusk, allowing access to the quarry area.
Ease or permissions needed to visit	No permission is required for access to the quarry or Fossil Grove SSSI, but private arrangement of a tour of the SSSI may be needed if the building is shut.
Current condition and how clearly the values can be seen at the moment (close and at a distance)	Exposures are in good condition with moderate weathering some vegetation growth in places. Vegetation is clearly trimmed and maintained.
Site fragility and sensitivities	Fossil Grove is of national importance and is appropriately protected as a SSSI. There appear to be no issues with fragility of the surrounding quarry site.

Other Current Site Values, Associations or Significance	
History of Earth Sciences	The preservation of Fossil Grove in situ is an early example of geoconservation in which the scientific and cultural value of the geological features was recognised by key individuals prompting efforts to conserve and protect the features. The building protecting the fossils may be the world's first fossil visitor centre.
Economic geology	The microgabbro sill was formerly quarried for roadstone material.
Scientific study and education	The study of Fossil Grove has provided many important insights into Carboniferous environments and processes as documented in a range of scientific and general interest publications. The discovery and history of the site is also well documented in a range of media.
Associations with biodiversity or ecosystem and ecosystem services	The site lies within a managed recreational park area.
Aesthetic, landscapes, Archaeology, History and cultural associations	The discovery and preservation of the Fossil Grove site was an important act of geoconservation and the site is one of the earliest examples of geotourism. Fossil Grove has been a tourist attraction since the late 19th century, and highlights how, with proper management, extractive industries can play an important role in enhancing our Geodiversity.
Local Communities/ visitors and promoting public awareness	Victoria Park is frequently used for recreation. Victoria Park is the is the focus for the community group the 'Friends of Victoria Park' which aims to support the protection and management of the park.

Potential Opportunities for Using or Enhancing the Site	
Opportunities for Potential Future Uses or enhancing the site	Clearance of some vegetation from quarry faces would greatly enhance views of the sill and its basal contact with the underlying sedimentary strata. Information boards relating the sill to the Fossil Grove site and inclusion of more geological information in existing leaflets and website descriptions would add to the educational potential of the site.

GGS_7: Nitshill Road Cutting, Nitshill Station

Site Description

Physical Context: Road cutting into bedrock below railway bridge.

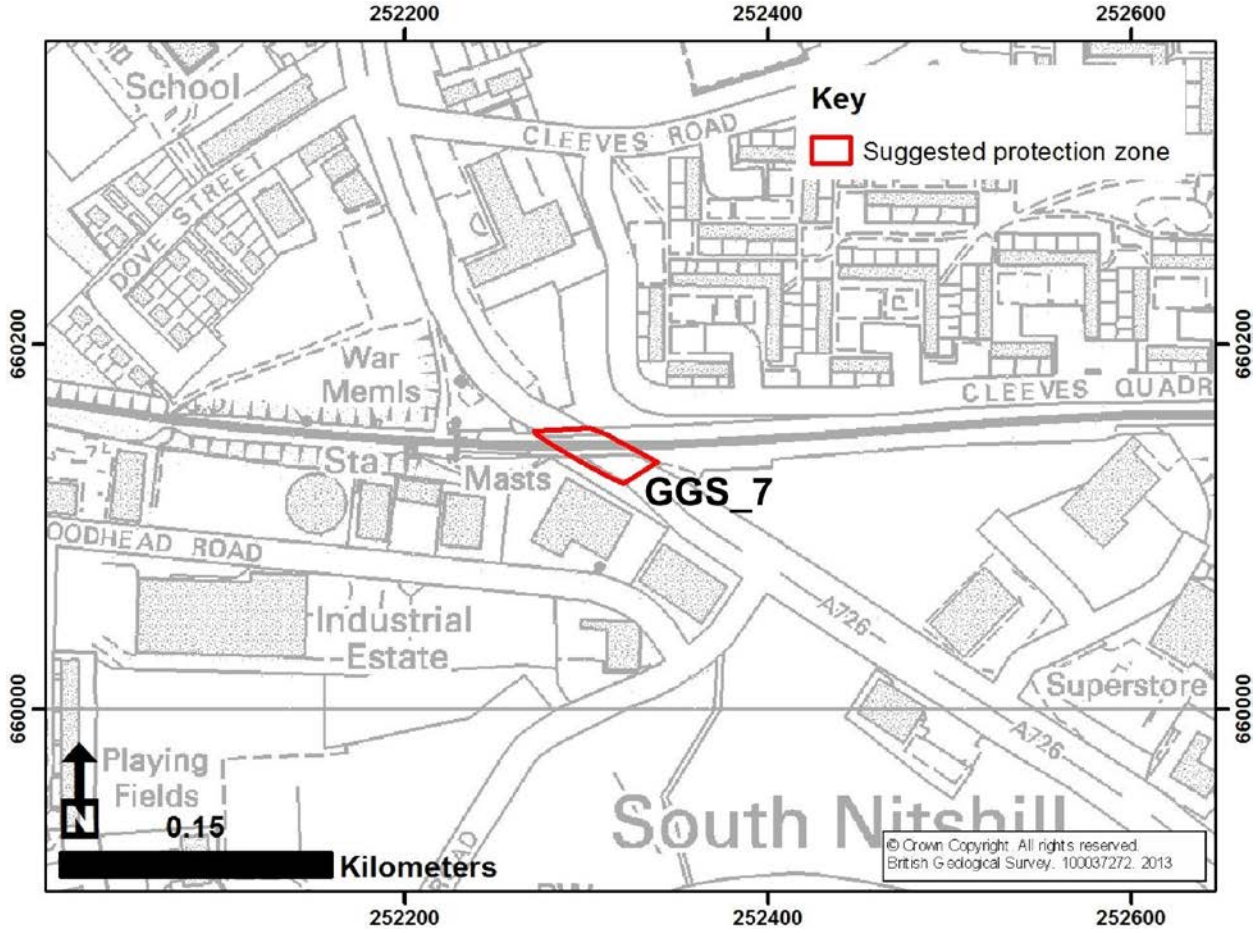
Nearby geodiversity sites or features: GGS_3 (Household Park) and GGS_20 (Fossil tree Household Park) are located approximately 1 km to the north

Is the site part of a network or geological terrain: No

Does the site cross or border with another Local Authority Area: No

Site Location, any nearby landmarks and access point: Tunnel allowing the A726 to pass beneath the railway line, located east of Nitshill Station, in the southern part of the city	**Site type:** • Artificial Section
NGR: 252321 660140	Current use: Urban
Site ownership: To be confirmed by GCC	Current geological designations: None
Permission to visit required: Public access	Other designations: None known
Field surveyor: Katie Whitbread and Sarah Arkley	Date visited: 20th February, 2013

Map, Location and Boundary Suggestions



MAP GGS_7: Nitshill Road Cutting Location Map. The suggested protection zone comprises bedrock sections exposed along both sides of a road cutting beneath the railway bridge.

Site Photos

Photo GGS_7 P1: The southern entrance to the tunnel where the Nitshill Road passes beneath the railway line, looking NE. The lower portion of the cutting is in sandstone bedrock, thought to be the Nitshill Sandstone (Limestone Coal Formation). The sandstone unit is described as reaching 20m thick at its maximum, and was extensively quarried in the Nitshill area as a building stone.

Photo GGS_7 P2: Close-up showing iron-rich laminae in the sandstone.

Photo GGS_7 P3: Close-up showing iron-rich nodules in the sandstone.

Photo GGS_7 P4: Nitshill was rich in mineral resources, coal and ironstone were mined extensively, and the area prospered for nearly 200 years, but these activities were not without risk. A mining disaster at the Victoria Pit was one of the most tragic in the industrial history of Scotland, 61 miners lost their lives.

Stratigraphy and Rock Types

Unit 1	Age: Namurian, Upper Carboniferous	Formation: Limestone Coal Formation
	Group: Clackmannan Group	Rock type: Sandstone

Geological Description

Bedrock is exposed in the lower portion of the of stone built railway bridge/tunnel along the A726. The dressed sandstone faces are up to1.5m high, along a 50m length, either side of the road. A natural exposure of the sandstone is located under the westernmost arch of the railway bridge. The sandstone is thought to be part of the Nitshill Sandstone, stratigraphically located in the upper part of the Limestone Coal Formation, between the Ashfield Coking Coal and Possil 14-inch Coal. The sandstone is massive, with beds more than 1m thick, and medium- to coarse-grained. Weathered surfaces indicate some internal laminations but sedimentary structures are not clear. Iron-rich nodules and fissure fills are seen in places. Tool marks are preserved on the face of the exposure.

The Nitshill Sandstone was a valuable freestone and extensively quarried at Nitshill, where it consisted of two main units. The thicker upper bed lay between the Quarry and Satturland Coals; while the lower bed lay between the Satturland and Stone Coals. The lower unit was of such excellent quality that it was also mined underground (Hall et al., 1998). The quarries, which lay to the northeast of this site, north of the railway line are now infilled and built over.

GeoScientific Merit and Value

	Rarity	Quality	Which if any Literature/ Collections has this been documented in and to what extent?	Primary interest (comment)
Lithostratigraphy	Moderately common	Poor	cf. Hall et al., 1998	Limestone Coal Formation strata
Sedimentology	Common	Poor		Fluvial environments
Igneous/ Mineral/ Metamorphic				
Structural geology				
Palaeontology				
Geomorphology (active processes and relict landforms)				

Assessment of the Overall Relative GeoScientific Importance

The sandstone exposed at this site displays few sedimentary features, but has some stratigraphic importance as an example of the Nitshill Sandstone. The exposure has therefore been graded as a **moderate to poor CVDPA example** of strata with **significance in the CVDPA.**

Safety of Access/ Site Condition/ Fragility/ Threats/ Sensitivities

Safety of access/ ease and barriers to access into and around the site	The exposures are easily accessed from footpaths either side of the road, with safety railings present between the path and the road. Some parking is available on waste ground to the north of the railway bridge. The Nitshill Road is a busy two-lane road and is the only significant hazard associated with site access.

Safety of exposure	Exposures are part of a low well-dressed rock face, and have no safety issues. The outcrop is adjacent to a busy road and although railings are present care should be taken at all times. Visitors to the site should also be aware of exhaust fumes which collect beneath the bridge and can be unpleasant.
Nature of exposure	Vertical road cutting in the lower part of a stone railway bridge.
Current conflicting activities or other threats	Ground water was observed seeping out of the bridge wall at the boundary between the bedrock and the built stone wall, resulting in algal growth over much of the dressed sandstone faces. In time this is likely to increase and obscure more of the face. Salt used on footpaths and roads in the winter can have a detrimental effect on the sandstone face.
Restricting conditions	None apparent.
Ease or permissions needed to visit	No permissions required.
Current condition and how clearly the values can be seen at the moment (close and at a distance)	The outcrop is moderately well exposed, although algae and moss obscure the rock face in places. Some litter was present at the base of the section but does not affect the earth science interest of the site.
Site fragility and sensitivities	Human impacts or natural processes are not thought to pose a major risk to the site.

Other Current Site Values, Associations or Significance	
History of Earth Sciences	No apparent association.
Economic geology	The Nitshill Sandstone was extensively quarried in this area and used locally for building stone. The Limestone Coal Formation strata were also mined locally for coal and ironstone (both blackband and clayband). A tragic mine accident in the Nitshill area, which occurred in 1851 is commemorated by the memorial at the northern entrance to the railway bridge. Accounts of the Nitshill Colliery explosion, in which 61 miners lost their lives have been recorded in several online reported in several reports.
Scientific study and education	No apparent association.
Associations with biodiversity or ecosystem and ecosystem services	No association.
Aesthetic, landscapes, Archaeology, History and cultural associations	Tool marks produced during construction of the bridge are preserved on the exposure surface.
Local Communities/ visitors and promoting public awareness	The footpaths either side of the road provide excellent access to the exposures and are regularly used by pedestrians in a residential area.

Potential Opportunities for Using or Enhancing the Site	
Opportunities for Potential Future Uses or enhancing the site	Although geological/geomorphological features are limited at this site, its link to the Nitshill Sandstone and the building stone industry give it some economic significance which could be highlighted.

GGS_8: Holmwood House section, White Cart Water

Site Description

Physical Context: River cliff located on the eastern bank of the White Cart Water. Observed from the former Millholm Paper Mill site in Linn Park.

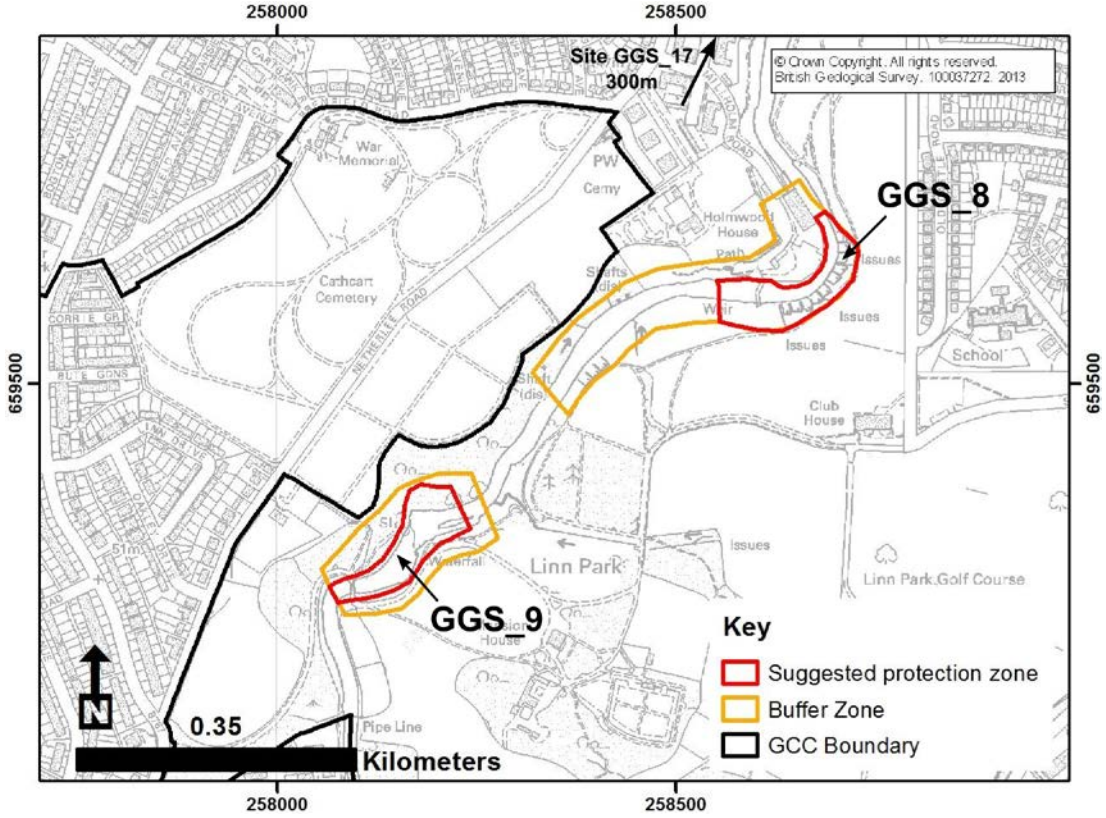
Nearby geodiversity sites or features: This is the middle site of three located along the White Cart Water in Linn Park: GGS_9 (Linn Waterfall) is located approximately 600m downstream (south-west), and GGS_17 (Court Knowe Quarry) is located approximately 500m to the north – north-east.

Is the site part of a network or geological terrain: Part of a series of bedrock exposures along the White Cart Water.

Does the site cross or border with another Local Authority Area: No

Site Location, any nearby landmarks and access point: Site is located within Linn Park opposite the former Millholm Paper Mill, located below Holmwood House. Linn Park is located in the south of Glasgow, with a number of access points.	**Site type:** • Natural Section • Natural Landform • Mine workings
NGR: NS 258662 659604	Current use: Open country/recreation
Site ownership: Glasgow City Council	Current geological designations: None
Permission to visit required: Public access	Other designations: None known
Field surveyor: Katie Whitbread and Sarah Arkley	Date visited: 23rd January, 2013

Map, Location and Boundary Suggestions



MAP GGS_8: Location map of Holmwood House section on the White Cart Water in Linn Park. The suggested protection zone for GGS_8 comprises a continuous bedrock section exposed in the river bank and gorge and is the area considered in the following valuation. The Buffer Zone includes areas from which the site may be viewed, further minor bedrock outcrops and features related to former mining. GGS_9 (Linn Waterfall) is located to the south-west and GGS_17 (Court Knowe Quarry) is located 500m to the north – north-east.

Site Photos

Photo GGS_8 P1: Viewed from the site of the former Millholm Paper Mill, a sedimentary sequence within the Limestone Coal Formation can be observed on the east side of the White Cart Water (looking SE). The section consists of c. 15m of sandstone and is partly obscured by rockfall material at the base.

Photo GGS_8 P2: A river cliff section immediately upstream of the main site, displays a small fault at river level (bottom left-hand corner of the image) and a possible entrance into old mine workings towards the top of the section.

Photo GGS_8 P3: Bedded sandstones within the Limestone Coal Formation can also be seen in the eastern bank of the river at the weir (immediately upstream of the paper mill).

Photo GGS_8 P3: Close-up showing what appears to be void within the sedimentary strata which may be a disused adit in the centre of the image.

Photo GGS_8 P4: Well maintained footpaths allow good access along the White Cart Water. However the site of the former paper mill is fenced off, making these sections inaccessible to the public.

Stratigraphy and Rock Types

Unit 1	Age: Namurian, Upper Carboniferous	Formation: Limestone Coal Formation
	Group: Clackmannan Group	Rock type: Sedimentary rock cycles, Clackmannan Group type

Geological Description

The section exposes an approximately 15m high section through strata of the Limestone Coal Formation. The gently dipping sedimentary sequence consists of relatively thick sandstone bodies with mudstones and siltstones. Some larger sandstone units are channelised with erosional bases that truncate lower units. Some thin coal seams are visible in places in the strata. Small faults and weak folding of strata is visible in the section near the south of the site.

Evidence for mine workings is visible high in the river section with probable adits driven into the cliff face into a 20-25 cm coal seam. Four 'Shafts' are recorded on the geological fieldslips upstream of the weir on the western bank of the river. Although evidence for these was not observed, these features indicate that the strata were locally mined.

Debris from a significant rockfall lies at the base of the main section. The deposit obscures some of the bedrock exposure but is a good example of landslip processes occurring due to erosional undercutting of the river cliff on the outer side of an entrenched meander bend. The landslip is thought to have occurred within the past 20 years.

GeoScientific Merit and Value

	Rarity	Quality	Which if any Literature/ Collections has this been documented in and to what extent?	Primary interest (comment)
Lithostratigraphy	Moderately common	Moderate		Limestone Coal Formation strata
Sedimentology	Moderately common	Moderate		Fluvial and fluvio-deltaic environments
Igneous/ Mineral/ Metamorphic				
Structural geology	Common	Poor		Minor faulting
Palaeontology				
Geomorphology (active processes and relict landforms)	Moderately Rare	Moderate		Fluvial erosion and slope processes

Assessment of the Overall Relative GeoScientific Importance

The site provides a relatively extensive section through several coal cyclothems in the Limestone Coal Formation with evidence for local mining of coal. The sedimentological and stratigraphic significance of the bedrock exposures is augmented by good examples of active geomorphic processes and the site is considered to be **good CVDPA example** with **regional (Midland Valley) significance**.

Safety of Access/ Site Condition/ Fragility/ Threats/ Sensitivities

Safety of access/ ease and barriers to access into and around the site	Access to the site is poor. Direct access to the vertical cliff face is not possible and viewing from the opposite bank, at the site of the former Millholm Paper Mill is discouraged. The area is fenced off with a locked gate, presumably due to the presence of

	unstable buildings and foundations. The section can be seen from the White Cart Water Walkway near Holmwood House and Millholm Road, but view is relatively distant, partial and may be obscured by vegetation in summer.
Safety of exposure	The cliff section is evidently prone to rock fall and landslip related to undercutting by the river. Signs and fencing warning the public of unstable ground have been installed on the eastern banks of the gorge above the sections. Viewing of the sections from the former mill site is hazardous and great care is required over uneven and unstable ground. The section can be safely viewed from the White Cart Water Walkway near Holmwood House.
Nature of exposure	River cliff, approximately 15m high and sub-vertical. The exposure is almost continuous along a 250m stretch of river.
Current conflicting activities or other threats	Further vegetation growth on cliff faces will obscure and degrade the sections. If any bank stability work was to take place along the river it could further obscure bedrock exposures and degrade the earth science interest of the site.
Restricting conditions	View from the White Cart Water Walkway will be significantly obscured by summer vegetation. Access restrictions to the disused mill site, the best viewpoint, need to be addressed for this to be developed as an educational geodiversity site.
Ease or permissions needed to visit	Access to the former Millholm Paper Mill site, where the best views of the sections are gained, is prevented by high fencing and a large padlocked gate. However, the area is clearly accessed unofficially via gaps in the fencing.
Current condition and how clearly the values can be seen at the moment (close and at a distance)	Exposures in the cliff face are in good condition, and despite partial vegetation cover, sedimentary strata and associated geological/geomorphological features are visible.
Site fragility and sensitivities	Outcrops may be degraded by vegetation growth but is free from vandalism due to its inaccessibility. Landslips caused by natural river erosion may obscure parts of the exposure, particularly towards the base, but this process may also improve exposure in other areas. Tipping of waste was observed in the old mill site providing additional hazards to access.

Other Current Site Values, Associations or Significance	
History of Earth Sciences	No apparent association.
Economic geology	The Limestone Coal Formation is the principle source of coal and ironstone within the district. At least 13 coal seams have been mined, some of them extensively, such as the Knightswood Gas and Possil Main Coals, and both blackband and clayband ironstones have been worked throughout Glasgow. The site contains evidence for former working of coal seams and possibly ironstone in the form of adits worked directly into the gorge walls, and shafts which were recorded on historic geological fieldslips near the site. The narrow river gorge was exploited in the construction of the mill and associated weir, by which the flow of the White Cart Water was harnessed to power the paper mill.
Scientific study and education	No apparent association.
Associations with biodiversity or ecosystem	Linn Park diverse wildlife habitats and plant life including open grassland, scrub land, deciduous and coniferous woodland and

and ecosystem services	riverbank environments.
Aesthetic, landscapes, Archaeology, History and cultural associations	The former Millholm Paper Mill and Holmwood House are described in an existing social history leaflet (Cathcart Heritage Trail). Holmwood House, now a National Trust for Scotland property, lies directly above the gorge. It was built at the request of James Couper, in 1857-58 who owned the paper mill with his brother.
Local Communities/ visitors and promoting public awareness	The park is regularly used for recreation and is the focus for the community group the 'Friends of Linn Park' which aims to protect the environmental amenity of the park and promote environmental education, events and recreation.

Potential Opportunities for Using or Enhancing the Site	
Opportunities for Potential Future Uses or enhancing the site	Increasing access by partial opening of the disused mill site would allow viewing of the northern end of the cliff section whilst maintaining restrictions to unstable mill buildings. Information on the local geology and its relation to the economic and social history of the Linn Park and Cathcart area could be included in existing leaflets and other media that provide information on the history of the area.

GGS_9: Linn Waterfall, White Cart Water

Site Description

Physical Context: A waterfall in the White Cart Water in Linn Park located downstream of the Halfpenny Bridge.

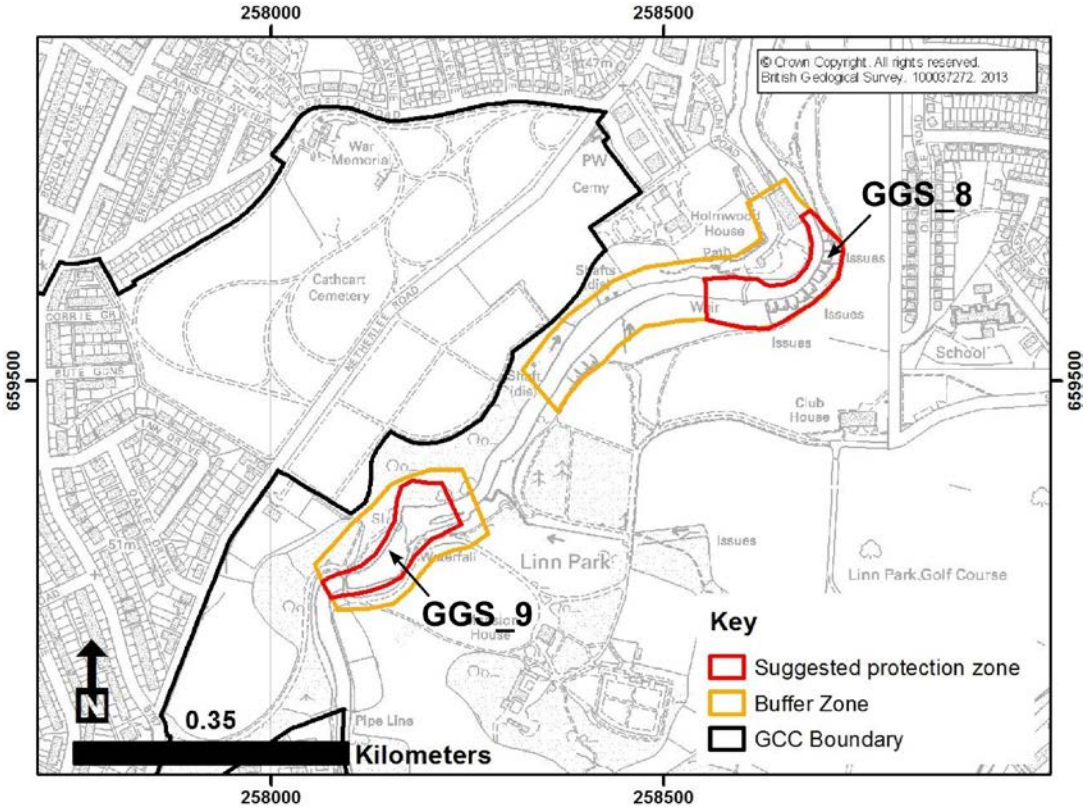
Nearby geodiversity sites or features: GGS_8 (Holmwood House, White Cart Water) is located approximately 600m to the north-east and GGS_17 (Court Knowe Quarry) is located approximately 1km to the north-east.

Is the site part of a network or geological terrain: The site is one of a series of bedrock outcrops exposed by river erosion along the White Cart Water.

Does the site cross or border with another Local Authority Area: No

Site Location, any nearby landmarks and access point: Site is located along the White Cart Water in Linn Park, approximately 100m to the north-east of the Halfpenny Bridge. Linn Park is located in the south of Glasgow, with a number of access points.	**Site type:** • Natural Landform • Natural Section
NGR: 258169 659298	Current use: Recreation
Site ownership: Glasgow City Council	Current geological designations: None
Permission to visit required: Public access	Other designations: None known
Field surveyor: Katie Whitbread and Sarah Arkley	Date visited: 23rd January 2013

Map, Location and Boundary Suggestions



MAP GGS_9: Location map of geodiversity site at Linn Waterfall, White Cart Water in Linn Park. The suggested protection zone for GGS_9 comprises a bedrock expsoures in the river bed and banks include a waterfall. The Buffer Zone includes areas from which the site may be viewed. GGS_8 (Holmwod House) is located to the north-east and GGS_17 (Court Knowe Quarry) is located 1 km to the north-east.

Site Photos

Photo GGS_9 P1: The Linn Waterfall in the White Cart Water is formed by the resistant Cathcart Sill which intruded through the sedimentary strata of the Limestone Coal Formation. Looking W.

Photo GGS_9 P2: The top of the igneous intrusion is well exposed in the river, gently dipping upstream (towards the WSW), parallel to the adjacent sedimentary strata. It displays a network of closely-spaced joints (sub-vertical fractures) formed as the hot magma cooled quickly against the cold sedimentary strata it was intruding. Looking N.

Photo GGS_9 P3: Sedimentary strata of the Limestone Coal Formation, which underlie the sill, can be seen in the eastern river bank.

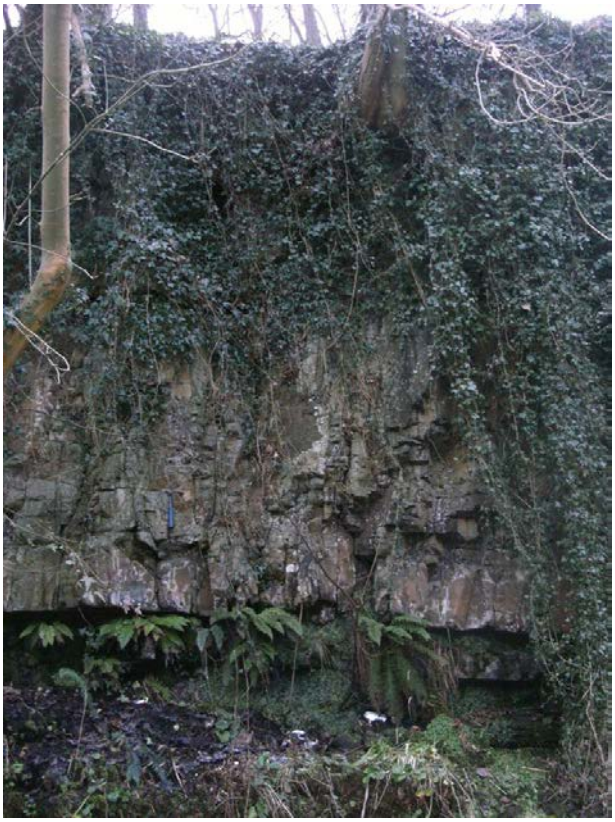


Photo GGS_9 P4: The contact between the sill and underlying sedimentary strata can be seen on the eastern bank. Removal of ivy hanging over the face would greatly enhance the exposure.

Site Photos

Photo GGS_9 P5: View from the western bank of the White Cart Water, looking upstream to the waterfall (to the south). This view could be greatly enhanced by the removal of some branches and visitor experience enriched by adding an interpretation board explaining why this picturesque feature exists.

Photo GGS_9 P6: Point bars located on the western side of the White Cart Water, immediately upstream of the waterfall, are the results of active river processes. These banks of sediment have formed on the inside curve of the river meander where the water flow slows down and sediment is dropped. Looking NNE.

Stratigraphy and Rock Types

Unit 1	Age: Westphalian-Early Permian	Formation: Western Midland Valley Westphalian to Early Permian Sills
	Group: Midland Valley Carboniferous to Early Permian Alkaline Basic Sill Suite	Rock type: Olivine-microgabbro
Unit 2	Age: Namurian, Upper Carboniferous	Formation: Limestone Coal Formation
	Group: Clackmannan Group	Rock type: Sedimentary rock cycles, Clackmannan Group type

Geological Description

The Linn Waterfall has formed due to the presence of a resistant igneous sill intruded within the softer sedimentary strata of the Limestone Coal Formation. The sill, known as the Cathcart Sill, is part of the Midland Valley Carboniferous to Early Permian Alkaline Basic Sill Suite and is thought to be approximately 270Ma (Hall et al., 1998). The sill is approximately 3m thick and composed of olivine-microgabbro with fairly well developed sub-vertical, columnar jointing which formed perpendicular to the cooling surfaces exposed at the top of the waterfall. The sill dips gently to the west-south-west, consistent with the surrounding strata.

The basal contact between the sill and underlying sedimentary strata is visible in the section on the eastern bank of the river. The underlying sediments consist of bedded micaceous sandstones belonging to the uppermost part of the Limestone Coal Formation. The upper contact between the sill and the country rocks is not seen directly, but overlying strata are seen further upstream, in the river banks and bed in the vicinity of Halfpenny Bridge. These strata consist of very flaggy-bedded sandstones, and are probably stratigraphically close to the upper boundary of the Limestone Coal Formation, marked by the base of the Index Limestone. This unit is not seen in the river, but ‘old limestone quarries’ are recorded on historic geological fieldslips to the north – north-west of the waterfall.

The surrounding area of Linn Park consists of undulating drumlinised terrain with smooth rounded drumlins typical of ice moulding of glacial till (Wilderness Till Formation). The glacial sediments have been eroded by the river along the gorge of the White Cart Water, resulting in the formation of the Linn Waterfall where the resistant igneous sill crops out. A plunge pool has been excavated by river erosion at the base of the waterfall. Depositional features associated with the river in the vicinity of the waterfall can also be seen. A ‘push bar’ of boulders deposited at the downstream edge of the waterfall plunge pool during high flow events is visible downstream from the falls, and point bars formed by deposition of gravel and sand on the inside of a meander bend where the flow is slower can be seen upstream.

GeoScientific Merit and Value

	Rarity	Quality	Which if any Literature/ Collections has this been documented in and to what extent?	Primary interest (comment)
Lithostratigraphy	Moderately common	Moderate		Limestone Coal Formation strata
Sedimentology	Moderately common	Poor		Fluvio-deltaic environments
Igneous/ Mineral/ Metamorphic	Moderately common	Good		Intrusive igneous sill
Structural geology				
Palaeontology				
Geomorphology (active processes and relict landforms)	Moderately common	Good		Fluvial processes

Assessment of the Overall Relative GeoScientific Importance

The Linn Waterfall site contains a range of geological and geomorphological features that include good exposures of Limestone Coal Formation strata, the microgabbro sill and the contact between them. A range of fluvial features and processes can also be seen at the site, making this an important geomorpholgical site in which the relation between the geology and active river process can be clearly seen. The site is a **good Midland Valley** example with **regional (Midland Valley) significance**.

Safety of Access/ Site Condition/ Fragility/ Threats/ Sensitivities

Safety of access/ ease and barriers to access into and around the site	Linn Park has a number of access points and a good network of metalled and well maintained footpaths. Fencing is present along steep banks of the river, but access points have been constructed to allow direct access to the riverside near Linn Waterfall. Direct access to the top of the sill is moderately difficult and access to sediments below the sill requires traversing of steep vegetated slope, with some river debris and litter at the base. The waterfall can be easily and safely viewed from well-maintained foot paths either side of river and the river can be crossed at Halfpenny Bridge.
Safety of exposure	Direct access to any part of the waterfall should be assessed on approach as the river would be very dangerous in moderate to high flows. The amount of sill top exposed will vary depending on the volume of water flowing in the river. The top of the sill has an uneven, slippery surface, there is a risk of falling (potentially 3-4m into the river below). The section exposing the underlying sedimentary strata appears stable but should be assessed when approaching for any loose material above head height and care should be taken if hammering.
Nature of exposure	River section with waterfall.
Current conflicting activities or other threats	Further tree growth on the river banks will restrict views of the waterfall, particularly in summer. Ivy significantly obscures the section along the river bank in which the contact with the underlying sedimentary strata is exposed. If any bank stability work was to take place along the river upstream or downstream of the waterfall the context of the sill could be compromised.
Restricting conditions	Direct access of the exposures would be dangerous during high flow conditions on the river.
Ease or permissions needed to visit	None required as the exposures are located within a public park.
Current condition and how clearly the values can be seen at the moment (close and at a distance)	The sill is well exposed in the river and in both river banks, although vegetation obscures the outcrop in some areas. Clearance of some lower tree branches would enhance the view of the waterfall from the western bank.
Site fragility and sensitivities	Outcrops and views may be degraded by further vegetation growth. The site is largely free from litter or vandalism and paths and access points are well maintained.

Other Current Site Values, Associations or Significance

History of Earth Sciences	No apparent association.
Economic geology	Disused quarries in the Index Limestone are recorded close to the site and can still be seen a depressions, but contain no exposures.
Scientific study and education	Samples from the Cathcart Silll have been radiometrically dated yielding an age 270 Ma for the emplacement of the sill (cf. Hall et al., 1998).

Associations with biodiversity or ecosystem and ecosystem services	The park has a great diversity of wildlife habitats and plant life, including open grassland, scrub land, deciduous and coniferous woodland to the riverbank environment.
Aesthetic, landscapes, Archaeology, History and cultural associations	'Linn' is the old Scots word meaning waterfall indicating that Linn Park is named after this geological/geomorphological feature. The Halfpenny Bridge, immediately upstream of the, is described in an existing social history leaflet (Cathcart Heritage Trail).
Local Communities/ visitors and promoting public awareness	The park is regularly used for recreation and is the focus for the community group the 'Friends of Linn Park' which aims to protect the environmental amenity of the park and promote environmental education, events and recreation.

Potential Opportunities for Using or Enhancing the Site	
Opportunities for Potential Future Uses or enhancing the site	The aesthetic appeal of the waterfall and a range of available sources of information on the social, economic and cultural history of the area suggest that there is considerable potential for development of educational material that describe nature of the geology and geomorphological features of the site and its relation to the history of the park and local area. Recent woodland management works have identified a 'recommended interpretation point' on the western bank of the river just downstream of the waterfall, which would be an ideal place to describe the geology and geomorphology of this site.

GGS_10: River Kelvin, Dawsholm Park

Site Description

Physical Context: The site is located along the gorge of the River Kelvin in the vicinity of Dawsholm Park

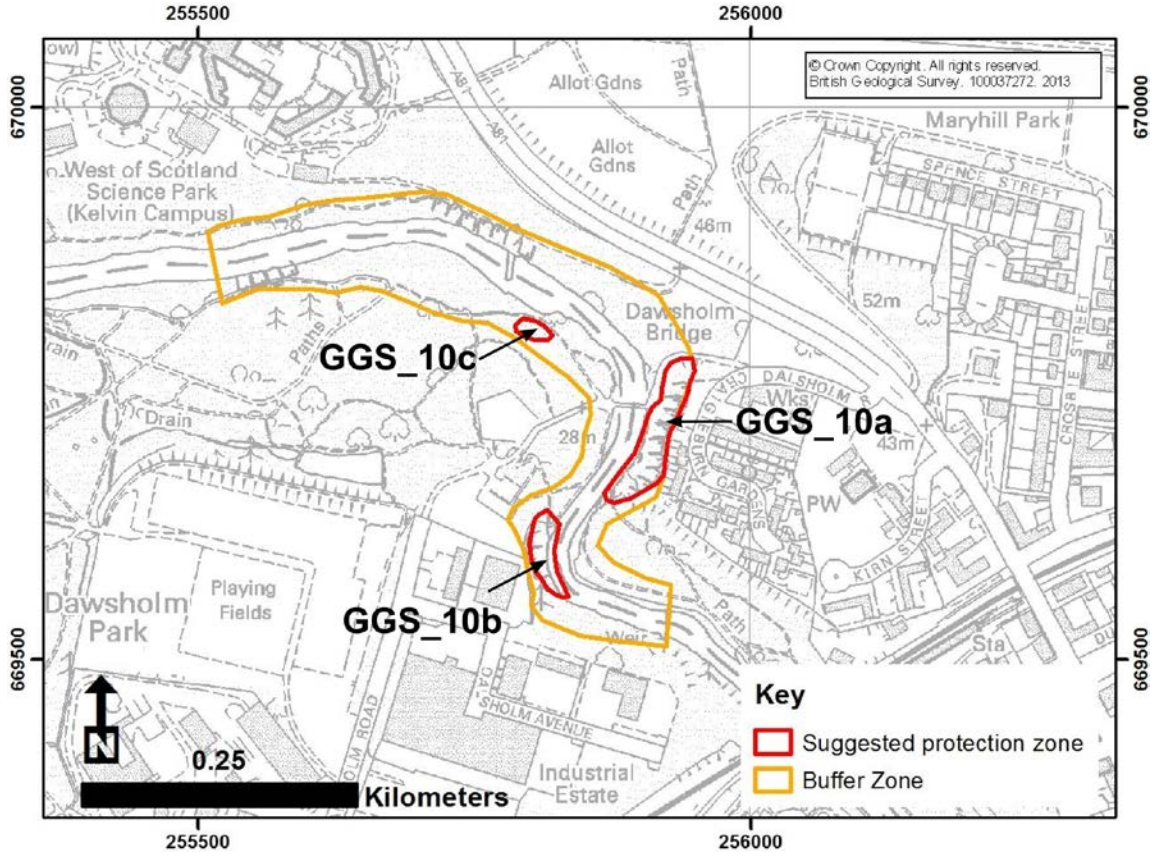
Nearby geodiversity sites or features: None within 1 km.

Is the site part of a network or geological terrain: Part of the River Kelvin gorge network.

Does the site cross or border with another Local Authority Area: No

Site Location, any nearby landmarks and access point: The sites is within Dawsholm Park, Kelvindale. Numerous access points into the park.	**Site type:** • Natural Section • Quarry workings
NGR: 255916 669709	Current use: Recreation
Site ownership: Glasgow City Council	Current geological designations: None
Permission to visit required: Public access	Other designations: Dawsholm Park has City Wide SINC & LNR status
Field surveyor: Katie Whitbread and Sarah Arkley	Date visited: 31st January, 2013

Map, Location and Boundary Suggestions



MAP GGS_10: River Kelvin, Dawsholm Park Location Map. The suggested protection zone comprises three areas of significant bedrock outcrop. All areas are considered to have the same level of priority for protection because they expose different parts of the bedrock sequence. The site defined by the suggested protection zone and comprising all sub-areas has been assessed in the following valuation. The Buffer Zone incorporates access routes to the site and viewing areas as well as further areas of bedrock outcrop located along the River Kelvin.

Site Photos

Photo GGS_10 P1: Bedrock exposure located on the western bank of the River Kelvin beneath Dawsholm Industrial Estate (GGS_10b). The outcrop consists of sedimentary strata belonging to the Upper Limestone Formation and displays a good example of a channelized sandstone unit with an erosive base. Looking W.

Photo GGS_10 P2: Beneath an overhang, towards the base of a quarry face, a thin bed of coal is visible (GGS_10a). This is a rare feature, particularly of urban areas and its location is very accessible.

Photo GGS_10 P3: Close-up of the pale-coloured, sandstone at the quarry.

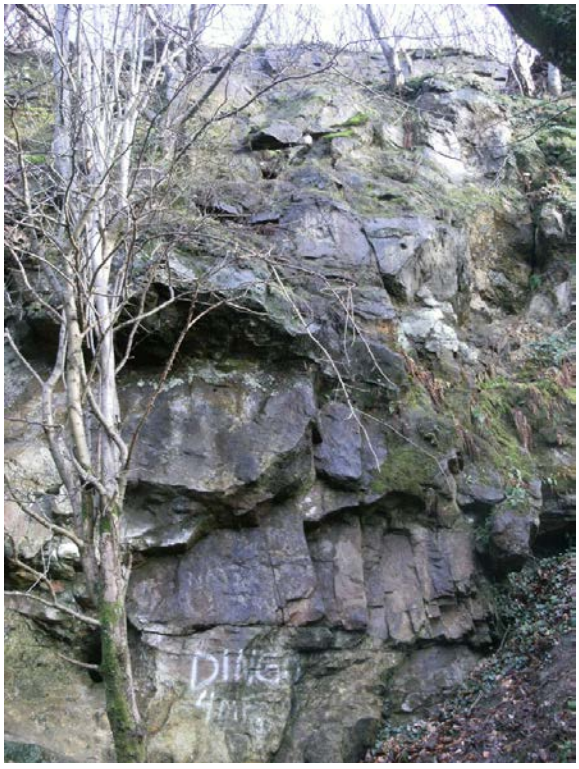


Photo GGS_10 P4: A disused quarry on the eastern side of the River Kelvin, close to Dawsholm Bridge extracted sandstone from the Upper Limestone Formation (GGS_10a). Despite some graffiti in the lower part of the quarry face, the section is generally in good condition. Looking ESE.

Stratigraphy and Rock Types

Unit 1	Age: Namurian, Upper Carboniferous	Formation: Upper Limestone Formation
	Group: Clackmannan Group	Rock type: Sedimentary rock cycles, Clackmannan Group type
Unit 2	Age: Namurian, Upper Carboniferous	Formation: Limestone Coal Formation
	Group: Clackmannan Group	Rock type: Sedimentary rock cycles, Clackmannan Group type

Geological Description

A number of outcrops are visible along this section of the Kelvin gorge, they are of variable quality and accessibility but together provide relatively extensive sections in the upper part of the Limestone Coal Formation and basal strata of the Upper Limestone Formation.

The southernmost exposures consist of 5-10m thickness of channelized sandstone seen in the western bank of the River Kelvin. The almost vertical section can be easily viewed from the opposite bank, but not accessed directly as the base of the outcrop is in the river.

The best of the four outcrop points at the site is at Bells Crag, possibly the site of a former quarry, on the eastern side of the Kelvin gorge, close to the Dawsholm Bridge. The exposure displays an 8 to 10m high section, predominantly in massive channelised sandstone units with erosive bases. A thin coal (c. 10cm) and seatearth (~ 50cm) are exposed below the sandstone unit in places. The sandstone is medium- to coarse-grained, and bedded on 1 to 3m scale. Some beds are pebbly or gritty towards the base, containing rounded quartz pebbles in a coarse sandstone matrix. Some flaggy cross-bedded bands of coarse-grained, micaceous and organic-rich sandstone are also seen. In places the sandstone displays calcareous weathering patterns.

Towards the north end of the site gently dipping flaggy sandstones and siltstones of the Limestone Coal Formation are exposed on the western side of the Kelvin gorge, these are locally inaccessible due to dense vegetation and steep gorge slopes.

The site lies within the Kelvin gorge network, and the significance of this landform system is discussed in more detail in the assessment of GGS_5.

GeoScientific Merit and Value

	Rarity	Quality	Which if any Literature/ Collections has this been documented in and to what extent?	Primary interest (comment)
Lithostratigraphy	Moderately common	Good		Limestone Coal Formation and Upper Limestone Formation strata
Sedimentology	Moderately common	Good		Fluvial and deltaic environments
Igneous/ Mineral/ Metamorphic				
Structural geology				
Palaeontology				

Geomorphology (active processes and relict landforms)	Moderately common	Moderate		River gorge, mixed bedrock and alluvial river landforms

Assessment of the Overall Relative GeoScientific Importance

The site contains substantial exposures of strata from the Limestone Coal and Upper Limestone Formations with coal seams and clear sedimentary features. The site is a **good Midland Valley example** with **local to regional (CVDPA) significance**.

The site lies within the Kelvin gorge network and the gorge and river landforms seen within the site and associated with bedrock exposures are considered to enhance the sites geoscientific importance. This is discussed in more detail in the assessment of GGS_5.

Safety of Access/ Site Condition/ Fragility/ Threats/ Sensitivities

Safety of access/ ease and barriers to access into and around the site	A network of well maintained footpaths provides good access to, and view of, the bedrock exposures on both sides of the Kelvin gorge. The river can be crossed easily at Dawsholm Bridge, located in the middle of the site. Dense vegetation, steep slopes and the River Kelvin prevent access to many of the river bank exposures.
Safety of exposure	Most of the exposures appear to be generally stable but there may be some risk of rockfall in places due to weathering of exposures. Care should be taken if hammering.
Nature of exposure	River/gorge sections and a vertical quarry face provide a variety of exposures.
Current conflicting activities or other threats	Vegetation restricts access to, and views of some outcrops.
Restricting conditions	Seasonal growth of vegetation will further restrict views of and access to some of the exposures. Some exposures extend into the River Kelvin, this is a substantial river and care should be taken if attempting to view river bank sections.
Ease or permissions needed to visit	None required as the exposures are located within a public park.
Current condition and how clearly the values can be seen at the moment (close and at a distance)	Outcrops are generally in a good condition, although some exposures are quite vegetated with lichens, rushes and ferns or partly obscured by tree saplings and rhododendron bushes. Large-scale features visible in Bells Crag (e.g. channel bases) are difficult to view from any distance due to the significant number of young and fallen trees on the quarry floor.
Site fragility and sensitivities	All outcrops are subject to degradation with further vegetation cover. Graffiti was found on some exposures, but the sites and paths are largely free from litter. Rock falls caused by under-cutting of river bank exposures could lead to the loss of some exposures but this process may also expose new sections.

Other Current Site Values, Associations or Significance

History of Earth Sciences	No apparent association.
Economic geology	Sandstone may formerly have been quarried in part of the site, presumed to be for local use.

Scientific study and education	No apparent association.
Associations with biodiversity or ecosystem and ecosystem services	Most of Dawsholm Park was declared a LNR by GCC in 2007.The park is recorded as consisting mostly of policy and plantation woodland, and is principally important for the birdlife the woodland habitat supports. Grassland and hedgerows along the River Kelvin provide additional wildlife habitats for a variety of flora and fauna.
Aesthetic, landscapes, Archaeology, History and cultural associations	The sites are part of Dawsholm Park and the Kelvin gorge, these are attractive green areas of Glasgow. Kelvin Viaduct immediately south of the sites was built c.1858 for the Glasgow, Dumbarton and Helensburgh Railway. It's a masonry structure, with seven semicircular arches, carrying a double line of railway over the River Kelvin.
Local Communities/ visitors and promoting public awareness	The park is regularly used for recreation and the wider River Kelvin area is the is the focus for the community group the 'Friends of the River Kelvin' which aims to support the protection and management and of the Kelvin gorge.

Potential Opportunities for Using or Enhancing the Site	
Opportunities for Potential Future Uses or enhancing the site	Wildlife interpretation boards are installed in Dawsholm Park and the addition of a 'rocks and landscape' board would further enhance the visitor experience and understanding of the area. Information on the geology of the area could also be included in other sources of information regarding the Dawsholm Park and the Kelvin, such as websites and leaflets.

GGS_11: Possil Road cutting

Site Description

Physical Context: Road cutting (c. 80m long) in bedrock.

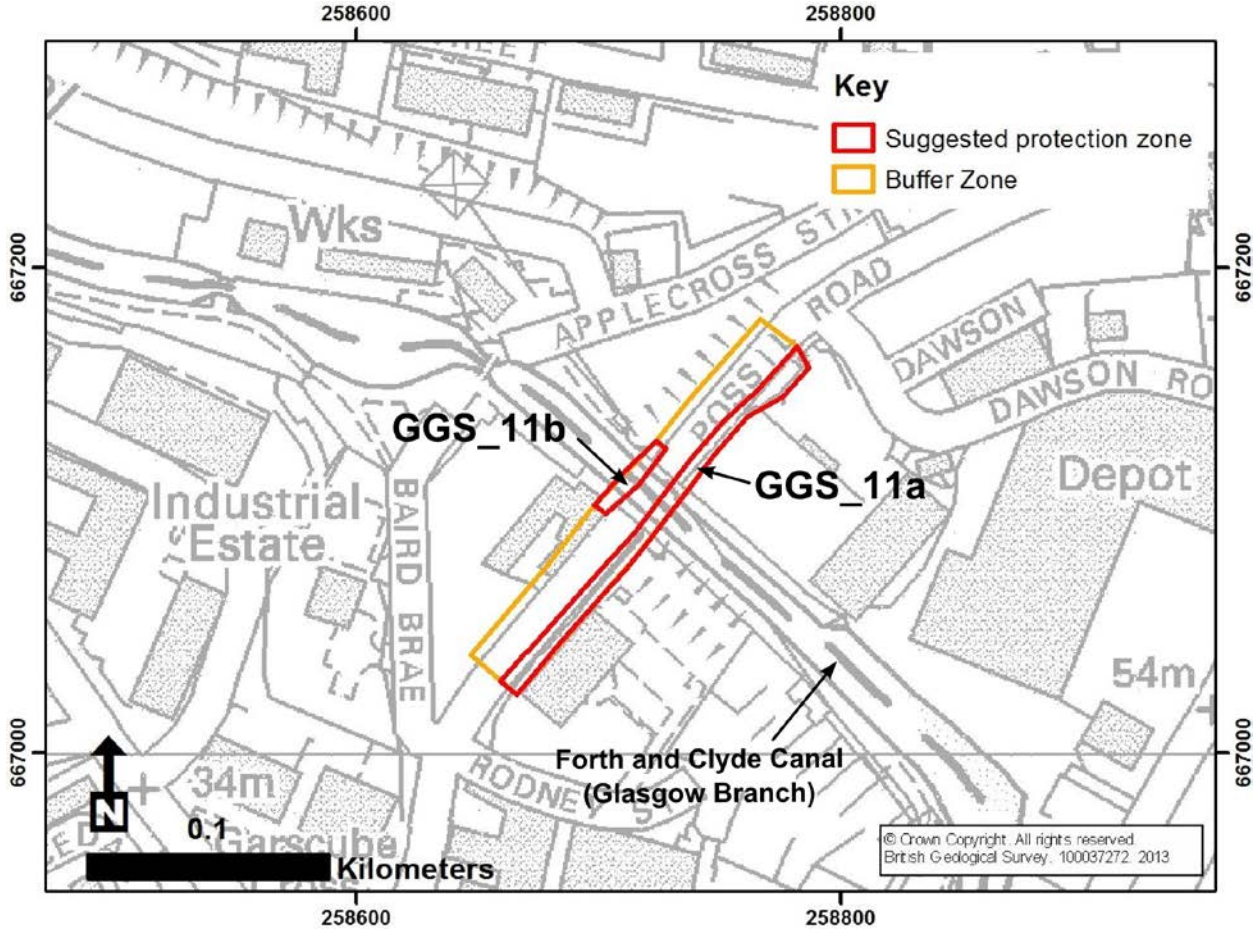
Nearby geodiversity sites or features: None within 1km

Is the site part of a network or geological terrain: No

Does the site cross or border with another Local Authority Area: No

Site Location, any nearby landmarks and access point: Possil Road at the canal aqueduct	**Site type:** • Artificial Section
NGR: 258690 667058	Current use: Urban
Site ownership: To be confirmed by GCC	Current geological designations: None
Permission to visit required: None	Other designations: None known
Field surveyor: Katie Whitbread and Sarah Arkley	Date visited: 31st January, 2013

Map, Location and Boundary Suggestions



MAP GGS_11: Possil Road Location Map. The suggested protection zone comprises two areas of bedrock outcrop located along both sides of a road cutting beneath the aquduct carrying the Forth and Clyde Canal at Possil Road. GGS_11a comprises the most extensive exposure and is considered the highest priority sub-area. The site defined by the suggested protection zone and comprising both sub-areas has been assessed in the following valuation. The Buffer Zone incorporates the pavement from which the site can be viewed.

Site Photos

Photo GGS_11 P1: View of Possil Road cutting (GGS_11a) looking NE, aqueduct located in far left. Massive medium to coarse-grained channelized sandstone unit. Base of channel scours can be seen c. 0.5m and c. 2.5m from the base of the exposure. Tool marks are well preserved on the rock face.

Photo GGS_11 P2: Large fossil wood fragments and mud rip-up clasts within the sandstone are preferentially weathered. Tool marks can also be seen on the exposure surface. Looking E.

Photo GGS_11 P3: Close up view of coarse grained sandstone with quartz pebbles from the erosive base of a channel unit.

Photo GGS_11 P4: Cast of fossilised bark in coarse-grained sandstone in the Possil Road cutting.

Stratigraphy and Rock Types

Unit 1	Age: Namurian, Upper Carboniferous	Formation: Upper Limestone Formation
	Group: Clackmannan Group	Rock type: Sandstone

Geological Description

The Possil Road cutting is a 6 to 8m high vertical section in sandstone from the lower part of the Upper Limestone Formation. The sandstone is channelized and may be either the Upper Drumbreck or Cadgers Loan Sandstone (equivalent to the Barrhead Grit found to the south of the River Clyde), located between the Huntershill Cement Limestone and the Lyoncross Limestone.

The sandstone is massive, medium to very coarse grained, pebbly in places and contains 20 cm to 1m long rip-up clasts of organic rich laminated mudstone and coaly material. The unit also contains fossilised wood fragments commonly exceeding 10 cm in length. In places bark patterns are highlighted by sandstone casts where wood material has weathered in the outcrop face.

The rip-up clasts and some wood fragments are aligned along the irregular bases of channel scours that can be followed along the length of the exposure. The channel bases are undulating, erosional features and mark boundaries between at least four separate sandstone units. In places some large-scale cross-bedding is evident in the higher parts of the channel units. The sandstone retains abundant tool marks from excavation of the cutting, and the softer mudstone clasts and wood fragments are preferentially weathered.

GeoScientific Merit and Value

	Rarity	Quality	Which if any Literature/ Collections has this been documented in and to what extent?	Primary interest (comment)
Lithostratigraphy	Moderately common	Moderate		Upper Limestone Formation strata
Sedimentology	Moderately common	Good		Fluvial environments
Igneous/ Mineral/ Metamorphic				
Structural geology				
Palaeontology	Moderately common	poor		Plant fossils
Geomorphology (active processes and relict landforms)				

Assessment of the Overall Relative GeoScientific Importance

The site contains a relatively large section in a Upper Limestone Formation channel sandstone displaying clear sedimentary features produced by deposition in a high energy, fluvial environment.

Exposures of sandstones within the Upper Limestone Formation are moderately common within the CVDPA, but the size and quality of the exposure, the sedimentological structures and the presence of fossil wood material mean that this site is a **good Midland Valley example** with **regional significance**.

Safety of Access/ Site Condition/ Fragility/ Threats/ Sensitivities

Safety of access/ ease and barriers to access into and around the site	The outcrop can be easily accessed directly from the pavement along Possil Road, with good views of the exposure from the western side of the road. Limited on-street parking is available within c. 100m to 200m of the site. Possil Road is a busy two-lane road and is the only significant hazard associated with site access.
Safety of exposure	The exposure appears stable with no loose or weathered material apparent.
Nature of exposure	The exposure is a vertical faced road cutting up to 8m high.
Current conflicting activities or other threats	The site lies directly below the canal aqueduct and the extensive growth of algae on the exposure surface suggests there may be associated ground water flow through the porous sandstone. Continued algal growth on the exposure surface is expected but key features at the site should remain visible. Graffiti and methods for its removal have potential to obscure or otherwise damage some features of the site.
Restricting conditions	None apparent.
Ease or permissions needed to visit	No permissions required. The site has public access.
Current condition and how clearly the values can be seen at the moment (close and at a distance)	The exposure is in good condition. There is extensive surface cover of algae and lichen, and some graffiti was seen on the exposure surface but the features of the site are clearly visible. Minor amounts of rubbish were found around parts of the exposure and on pavements providing access to the site but do not impede access or affect the earth science interest.

Site fragility and sensitivities	The fossils at the site are not considered to be appealing to collectors, however, any hammering or sample collection has the potential to damage key features of the site.

Other Current Site Values, Associations or Significance	
History of Earth Sciences	The famous Scottish geologist James Hutton was involved in the management and development of the Forth and Clyde Canal between 1767 and 1774 and is reported to have made extensive site inspections, making it possible that Hutton visited this site. However, this has not been confirmed.
Economic geology	The sandstone exposed in Possil Road Quarry has been locally quarried and may have been used in the building of the aqueduct
Scientific study and education	No apparent association
Associations with biodiversity or ecosystem and ecosystem services	No apparent association
Aesthetic, landscapes, Archaeology, History and cultural associations	The Possil Road cutting may have been cut during the construction of the Glasgow branch of the Forth and Clyde Canal which opened in 1790. It is not known if the cutting was part of a pre-existing quarry area or road cutting prior to the construction of the canal.
Local Communities/ visitors and promoting public awareness	The footpath providing access to the site is regularly used by members of the public.

Potential Opportunities for Using or Enhancing the Site	
Opportunities for Potential Future Uses or enhancing the site	Educational use of the site may be developed by the installation of a plaque or signboard describing the nature and significance of the sedimentological features as well as providing information on the former extractive industries in the local area. Additionally, site information could be provided via a website or 'geodiversity app'.

GGS_12: Merrylee Road

Site Description

Physical Context: Roadside section (c.50m long) along Merrylee Road in Newlands, south Glasgow.

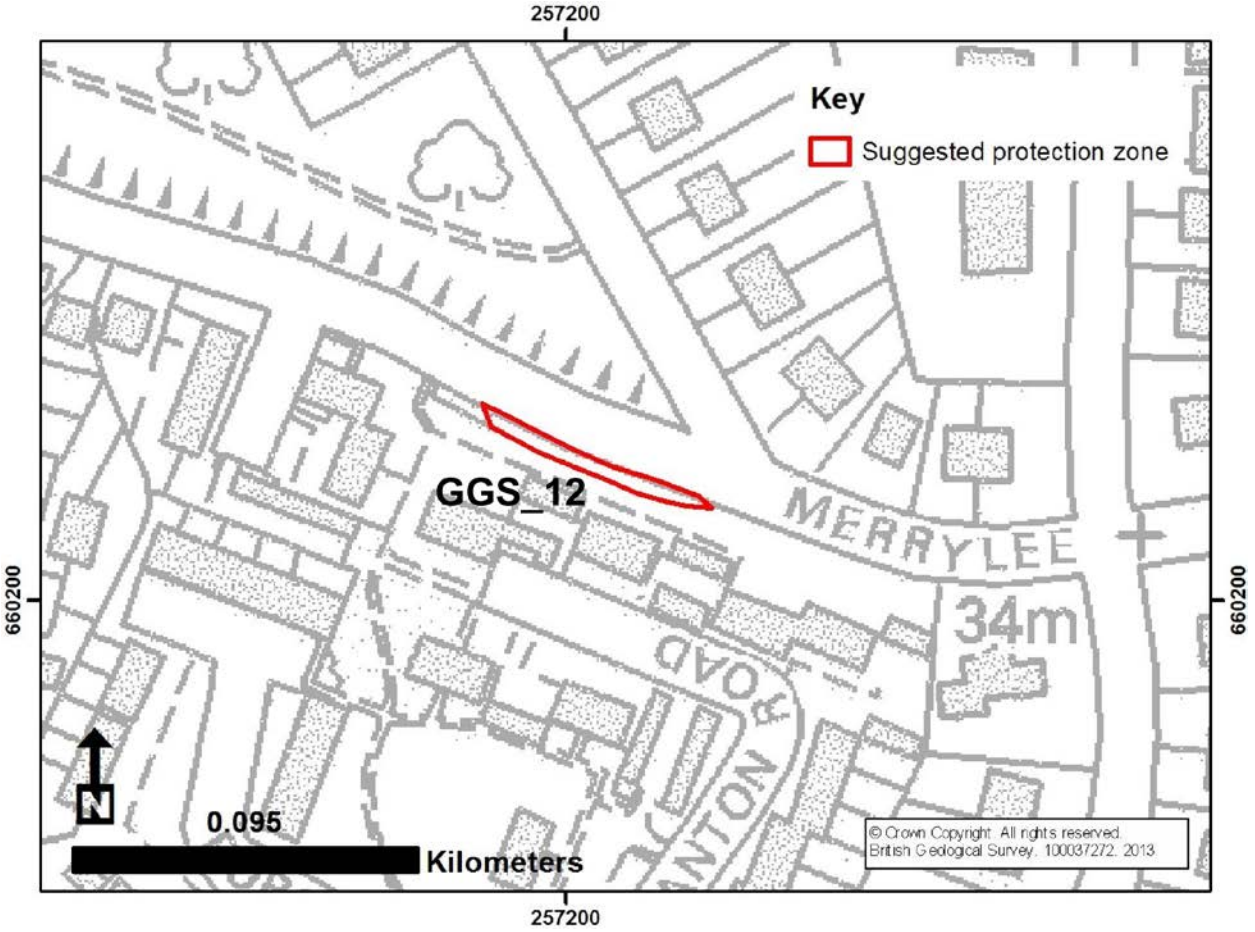
Nearby geodiversity sites or features: None within 1km

Is the site part of a network or geological terrain: No

Does the site cross or border with another Local Authority Area: No

Site Location, any nearby landmarks and access point: Merrylee Road near junction with Lubnaig Road	**Site type:** • Natural/Artificial Section
NGR: 257219 660234	Current use: Urban
Site ownership: To be confirmed by GCC	Current geological designations: None
Permission to visit required: Public access	Other designations: None known
Field surveyor: Katie Whitbread and Sarah Arkley	Date visited: 23rd January, 2013

Map, Location and Boundary Suggestions



MAP GGS_12: Merrylee Road Site Location Map. The suggested protection zone comprises a bedrock section exposed in a road cutting.

Site Photos

Photo GGS_12 P1: Sandstone section along Merrylee Road, looking W. Possibly Giffnock Sandstone from the Upper Limestone Formation.

Photo GGS_12 P2: Medium- to fine-grained sandstone with biological weathering. Looking S.

Stratigraphy and Rock Types

Unit 1	Age: Namurian, Upper Carboniferous	Formation: Upper Limestone Formation
	Group: Clackmannan Group	Rock type: Sandstone

Geological Description

The site consists of a 1m high section in sandstone from the Upper Limestone Formation. The unit may be the Giffnock Sandstone, located in strata between the Lyoncross Limestone and the Orchard Limestone. The sandstone is medium to fine-grained with 20 – 40 cm scale beds which are gently dipping to the east – north-east. Some cross bedding is visible in places.

GeoScientific Merit and Value

	Rarity	Quality	Which if any Literature/ Collections has this been documented in and to what extent?	Primary interest (comment)
Lithostratigraphy	Moderately common	poor		Upper Limestone Formation strata
Sedimentology	Moderately common	poor		Fluvial environments
Igneous/ Mineral/ Metamorphic				
Structural geology				
Palaeontology				
Geomorphology (active processes and relict landforms)				

Assessment of the Overall Relative GeoScientific Importance

The sandstone section is a relatively rare exposure of Upper Limestone Formation strata in south east Glasgow and is a **moderate to poor CVDPA example** with **Local (Glasgow) significance**.

Safety of Access/ Site Condition/ Fragility/ Threats/ Sensitivities

Safety of access/ ease and barriers to access into and around the site	The exposure can be directly accessed from the pavement adjacent to Merrylee Road. Limited on-street parking is available within c. 100m to 200m of the site. Merrylee Road is a busy two-lane road and is the only significant hazard associated with site access.
Safety of exposure	There are no issues with the safety of the exposure.
Nature of exposure	The exposure is a roadside section approximately 1m high.
Current conflicting activities or other threats	Vegetation growth and biological weathering may result in degradation of the exposure over time.
Restricting conditions	None apparent.
Ease or permissions needed to visit	No permissions required. The site has public access.
Current condition and how clearly	The site is in moderately good condition with some moss and

the values can be seen at the moment (close and at a distance)	algae on exposed surfaces and local vegetation growth.
Site fragility and sensitivities	Weathering and vegetation growth may cause degradation of some parts of the exposure over time but the effect on the earth science interest is likely to be limited due to the length of the exposure.

Other Current Site Values, Associations or Significance	
History of Earth Sciences	No apparent association.
Economic geology	Sandstone, including the Giffnock Sandstone, was formerly quarried for building stone.
Scientific study and education	No apparent association.
Associations with biodiversity or ecosystem and ecosystem services	No apparent association
Aesthetic, landscapes, Archaeology, History and cultural associations	No apparent association
Local Communities/ visitors and promoting public awareness	The site has good pedestrian access and is located in residential area.

Potential Opportunities for Using or Enhancing the Site	
Opportunities for Potential Future Uses or enhancing the site	The location of and lack of clear sedimentological features at the site means that there is little potential for development with respect to access and education.

GGS_13: Waulkmill Glen SSSI

Site Description

Physical Context: Waulkmill Glen SSSI is a steep wooded river gorge on the Brock Burn, located downstream from Waulkmill Glen Reservoir.

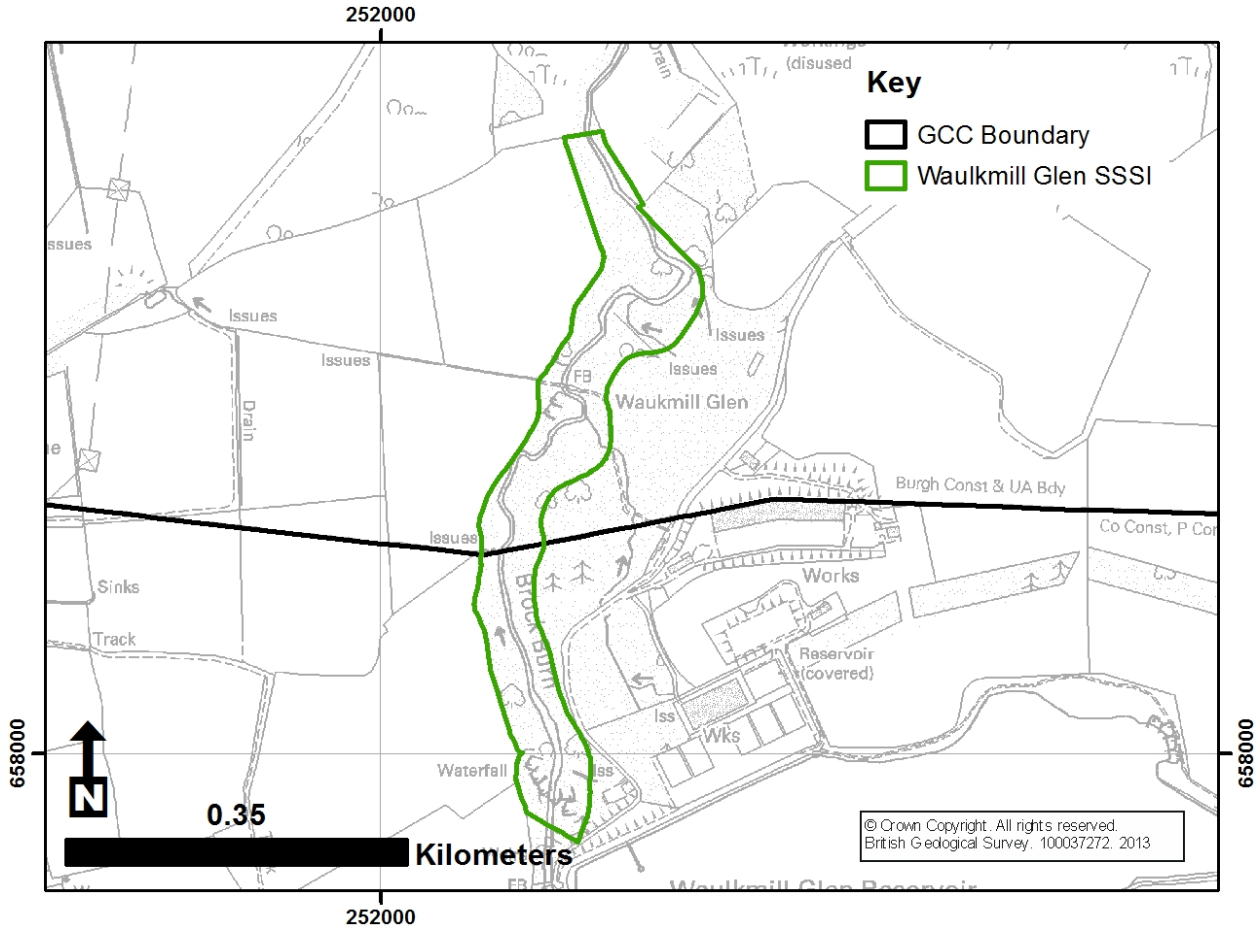
Nearby geodiversity sites or features: None within 1km.

Is the site part of a network or geological terrain: The site, along with Rouken Glen (East Renfrewshire), are designated geological SSSI.

Does the site cross or border with another Local Authority Area: Yes; East Renfrewshire.

Site Location, any nearby landmarks and access point: Waulkmill Reservoir	**Site type:** • Natural Sections
NGR: 252180 658401	Current use: Open Country, Recreation
Site ownership: To be confirmed by GCC	Current geological designations: SSSI, GCR
Permission to visit required: To be confirmed by GCC	Other designations: None known
Field surveyor: Katie Whitbread and Sarah Arkley	Date visited: 1st February, 2013

Map, Location and Boundary Suggestions



MAP GGS_13: The suggested protection zone for the geodiversity site is coincident with the Waulkmill Glen SSSI boundary. There are numerous areas of bedrock outcrop exposed throughout the glen. The suggested protection zone/SSSI comprises the area assesed in the following evaluation.

Site Photos

Photo GGS_13 P1: View of upper part of Waulkmill Glen highlighting dense vegetation which restricts access and views of exposures. Looking N.

Photo GGS_13 P2: Footbridge across Brock Burn in state of disrepair. This is the only access to sections on the west side of the Glen. Looking W.

Photo GGS_13 P3: Mudstone and siltstone section in the Upper Limestone Formation along Brock Burn. Looking NW.

Photo GGS_13 P4: Exposure of the Calmy Limestone. Looking W.

Stratigraphy and Rock Types

Unit 1	Age: Namurian, Lower Carboniferous	Formation: Upper Limestone Formation
	Group: Clackmannan Group	Rock type: Sedimentary rock cycles, Clackmannan Group type

Geological Description

Waulkmill Glen is a steep, wooded river gorge containing a number of sections and exposures of strata of the Upper Limestone Formation between the Index Limestone, which marks the base of the formation, and the Calmy Limestone. The limestones are important marker beds and, along with associated mudstone sequences, contain a rich marine fossil fauna (Hall et al., 1998).

Sections in coal cyclothems consisting of sandstone, siltstone, mudstone and limestone with seatearths and coal seams are present throughout the glen, but those located in the upper glen are largely inaccessible due to the river, steep slopes and vegetation. The Lyoncross Limestone (up to 1.8m thick) is reported to have been worked in the upper part of the glen (Hall et al., 1998).

In the lower part of the glen, 1.5 to 2m thick sections in shaly mudstone and siltstone are exposed in the banks of Brock Burn and 1.5 to 2m thickness of Calmy Limestone is exposed at higher levels in the gorge. The Calmy Limestone is very fine grained and dark grey and is weathering to a creamy yellow – grey.

Minor faults cut the strata in places throughout the gorge. A more substantial fault running north-west to south-east bisects the lower part of Waulkmill Glen and can be seen offsetting strata in the west side of the gorge. In this area, the Calmy Limestone is faulted against a 2 to 3m thick sandstone unit. The fault itself is not seen, being obscured by soil and vegetation, but the sequence of strata indicates that the fault has downthrown the Calmy Limestone some 10 to 20m to the north, bringing it to the level of strata lying above the Orchard Limestone.

GeoScientific Merit and Value

	Rarity	Quality	Which if any Literature/ Collections has this been documented in and to what extent?	Primary interest (comment)
Lithostratigraphy	Moderately rare	Good	Hall et al., 1998 Whyte, 2004	Upper Limestone Formation strata
Sedimentology	Moderately common	Good	Hall et al., 1998 Whyte, 2004	Shallow marine, deltaic and fluvial environments
Igneous/ Mineral/ Metamorphic				
Structural geology	Moderately common	Moderate		Minor faulting
Palaeontology	Moderately common	Moderate	Hall et al., 1998 Wilson, 1967	Fossiliferous limestone and mudstone
Geomorphology (active processes and relict landforms)				

Assessment of the Overall Relative GeoScientific Importance

Waulkmill Glen and Rouken Glen together display rare and relatively extensive exposures of the Upper Limestone Formation, including key limestone beds. Together, these sites comprise the most comprehensive section through the Upper Limestone Formation in the Midland Valley region and are considered essential lithostratigraphic sites, for which they have been designated SSSI (Whyte, 2004).

The exposures in Waulkmill Glen provide examples of depositional features from a range of sedimentary environments and contain fossil faunas and evidence of faulting. The range and quality of the geological features seen, as well as the lithostratigraphic significance, mean that the site is a **good to very good Midland Valley example** with **regional to national significance**.

Safety of Access/ Site Condition/ Fragility/ Threats/ Sensitivities

Safety of access/ ease and barriers to access into and around the site	Access is variable within the glen, with new and/or well maintained footpaths in places but poor path access towards the head of the glen. Considerable vegetation growth restricts access in places and the terrain is steep and ground uneven. Footbridges providing the only means of crossing the Brock Burn are in very poor condition. The river level is controlled by outflow from Waulkmill Glen Reservoir and crossing of the Brock Burn is not advisable.
Safety of exposure	Numerous exposures are located along the steep gorge walls. Some of these are unstable in places where surfaces are weathering and degraded by vegetation growth.
Nature of exposure	River and gorge sections with generally steep to vertical exposures.
Current conflicting activities or other threats	Vegetation growth restricts both direct access to and views of the outcrops. It may be responsible for some degradation of the exposures. However, the vegetation may also stabilise the soil on the steep gorge slopes.
Restricting conditions	Seasonal growth of vegetation will further restrict views and site access. Raised river flow levels following periods of heavy rain may restrict direct access to river bank sections.
Ease or permissions needed to visit	No permissions required.
Current condition and how clearly the values can be seen at the moment (close and at a distance)	Vegetation growth and fallen trees are responsible for some degradation of exposures locally and these factors together with poorly maintained bridges restrict access to features of interest in the site.
Site fragility and sensitivities	The relatively limited range of fossil fauna means that fossil collecting is unlikely to be a substantial risk to the site. However, fossil and sample collection from intact exposures should be restricted and conducted in accordance with the Geologists Code (SNH, 2009).

Other Current Site Values, Associations or Significance

History of Earth Sciences	No apparent association.
Economic geology	The site comprises a section though strata that has been worked for coal, limestone and sandstone in Glasgow and the wider Midland Valley region.
Scientific study and education	The site has been assessed as part of the Geological Conservation review (Whyte, 2004).

Associations with biodiversity or ecosystem and ecosystem services	Waulkmill Glen is an area of semi-natural woodland and plantation forest.
Aesthetic, landscapes, Archaeology, History and cultural associations	Waulkmill Glen lies within the Dams to Darnley Country Park, a new recreational area created by Glasgow and East Renfrewshire.
Local Communities/ visitors and promoting public awareness	Existing paths are used recreationally by walkers.

Potential Opportunities for Using or Enhancing the Site	
Opportunities for Potential Future Uses or enhancing the site	Improvement of access paths in the upper glen and clearing of vegetation would help to maintain some exposures, enable greater access to the geological features and improve views. Information boards could be installed and leaflets produced highlighting key aspects of the geology for which this site has been designated an SSSI, and providing details of the economic importance of the strata in the Midland Valley region.

GGS_14: Necropolis

Site Description

Physical Context: Victorian garden cemetery in central Glasgow.

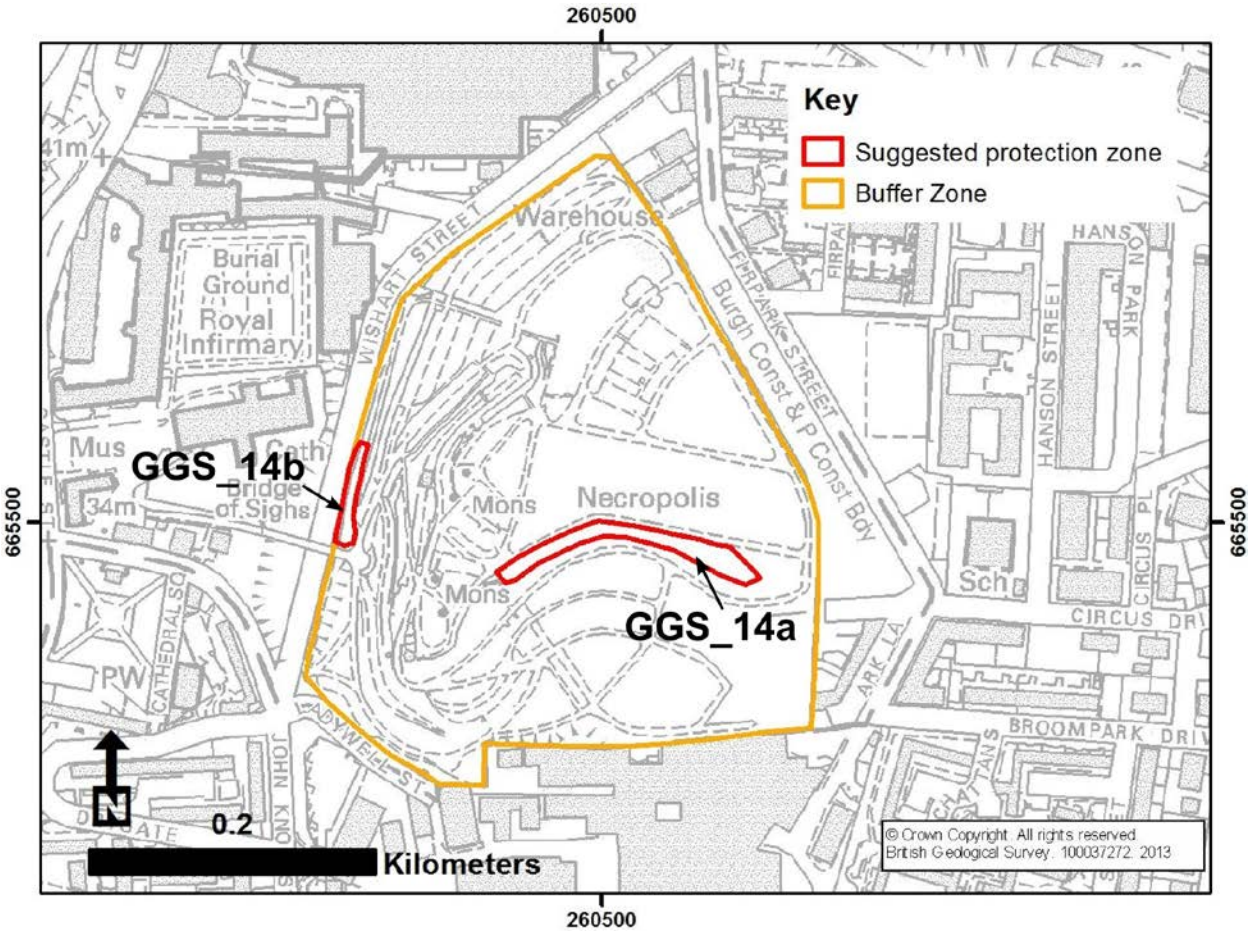
Nearby geodiversity sites or features: None within 1km

Is the site part of a network or geological terrain: Midland Valley Sill Suite

Does the site cross or border with another Local Authority Area: No

Site Location, any nearby landmarks and access point: Just to the east of Glasgow city centre, close to the M8, A8, Glasgow Royal Infirmary and Glasgow Cathedral.	**Site type:** • Natural and artificial sections • Disused quarry
NGR: 260445 665470	Current use: Cemetery, Urban
Site ownership: Glasgow City Council	Current geological designations: None
Permission to visit required: Public access	Other designations: None known
Field surveyor: Katie Whitbread and Sarah Arkley	Date visited: 20th February, 2013

Map, Location and Boundary Suggestions



MAP GGS_14: Glasgow Necropolis Location Map. The site comprises two main bedrock outcrop areas, GGS_14a is located in the site of a former quarry in intrusive igneous rocks, GGS_14b is found adjacent to Wishart Street and consists of an exposure of sandstone. Both sub-areas are considered to have equal priority as together they highlight the relationship between the intrusive igneous sill and the surrounding sedimentary rocks. The following evaluation encompasses the area defined by the suggested protection zone, including both sub-areas. The Buffer Zone includes the prominent and the hill on which the Necropolis is sited as well as access and viewing areas.

Site Photos

Photo GGS_14 P1: Disused quarry in the microgabbro sill that forms the hill on which the Necropolis has been built. The former quarry face is now mostly covered with ivy and other vegetation (GGS_14a). Looking NE.

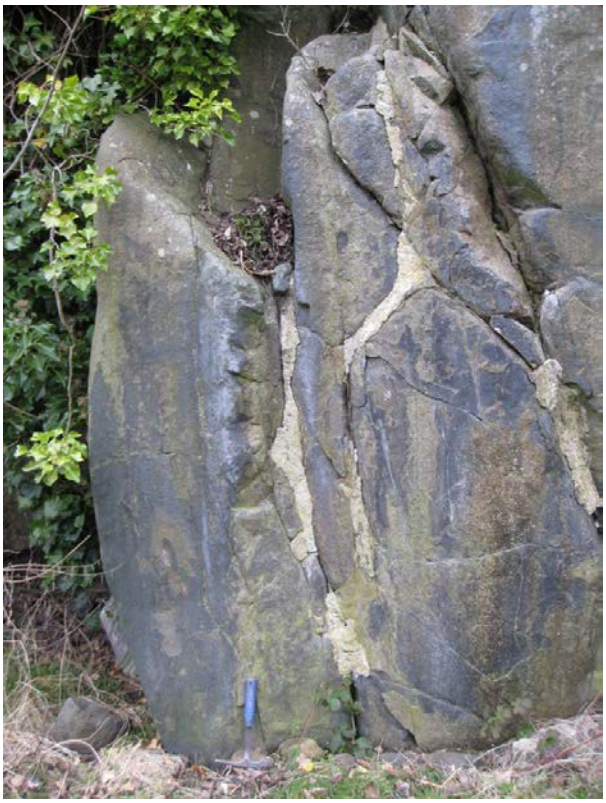


Photo GGS_14 P2: Exposed section of disused quarry face in microgabbro sill. Looking N.

Photo GGS_14 P3: Spheroidal weathering of microgabbro. Looking N.

Photo GGS_14 P4: Passage Formation sandstone displaying cross-bedding. The exposure has been partially faced in stone to stabilise the rock face (GGS_14b). Looking E.

Photo GGS_14 P5: Passage Formation sandstone showing soft sediment deformation structures (GGS_14b). Looking E.

Stratigraphy and Rock Types

Unit 1	Age: Westphalian-Early Permian	Formation: Western Midland Valley Westphalian to Early Permian Sills
	Group: Midland Valley Carboniferous to Early Permian Alkaline Basic Sill Suite	Rock type: Olivine-microgabbro
Unit 2	Age: Namurian-Westphalian, Upper Carboniferous	Formation: Passage Formation
	Group: Clackmannan Group	Rock type: Sandstone

Geological Description

The Necropolis is sited on a hill formed from the resistant igneous rocks of the Western Midland Valley alkaline basic sill suite, locally intruded into Carboniferous strata at the level of the Passage Formation. The hill has been formed due to preferential erosion of the surrounding, softer sedimentary rocks by glaciers. The harder igneous rocks of the sill have resisted erosion and form an upstanding feature with a steep western face caused by scouring by east-flowing ice.

The olivine microgabbro of the sill is exposed on the south side of the Necropolis in a 100m long, and approximately 10 m high section at the back of a former quarry. The exposure is overgrown with ivy along most of its length. The sill consists of fine- to medium-grained crystals of pyroxene (augite) and plagioclase with altered olivine and lesser amounts of biotite, magnetite, apatite and analcime. The Necropolis Sill also displays segregation veins of fine-grained olivine basalts and a feldspathic type containing phenocrysts of hornblende, formed by internal differentiation of the magma during emplacement of the sill. The microgabbro exhibits spheroidal weathering in places.

A radiometric date from biotite derived from the Necropolis Sill yields an age of 273 Million years indicating a lower to mid-Permian age of emplacement (cf. Hall et al., 1998).

The microgabbro sill overlies strata of the Passage Formation which are exposed at the base of a wall along the western edge of the site (near the Bridge of Sighs). The contact between the sill and underlying sandstone is not seen.

The Passage Formation is a dominantly fluvial sedimentary sequence consisting mainly of sandstone with few mudstone beds deposited in channels and on adjacent flood plains. In the small exposures at the Necropolis, the sandstone is medium-grained and relatively poorly cemented, displaying cross bedding as well as contorted bedding indicating soft sediment deformation in saturated, unlithified sediments during or soon after deposition.

GeoScientific Merit and Value

	Rarity	Quality	Which if any Literature/ Collections has this been documented in and to what extent?	Primary interest (comment)
Lithostratigraphy	Moderately common	Moderate to poor	Hall et al., 1998	Passage Formation
Sedimentology	Moderately common	Moderate	Hall et al., 1998	Fluvial environments
Igneous/ Mineral/ Metamorphic	Common	Moderate	Hall et al., 1998	Intrusive igneous sill
Structural geology				
Palaeontology				
Geomorphology (active processes and relict landforms)	Common	moderate		Landforms and weathering

Assessment of the Overall Relative GeoScientific Importance

The importance of the Necropolis as a historical and cultural site is due to the prominent topographic feature created by the resistant igneous sill. The site contains exposures of both the sill and the Passage Formation and although the contact between the units cannot be seen directly, their relation can be readily inferred from the topography. The range of geological and geomorphological features at the site makes this a **good CVDPA example** of the Midland Valley sill suite with **significance in the CVDPA.**

Safety of Access/ Site Condition/ Fragility/ Threats/ Sensitivities

Safety of access/ ease and barriers to access into and around the site	Access to and around the Necropolis is very good, with road access, local parking and a network of metalled paths throughout the site. There is direct access to the exposed rock face in the area of the former quarry, but access to other exposures in other areas is restricted by monuments and stone walls. Access to exposures of the Passage Formation is more restricted. Outcrops can be seen from the road-side pavement along the western boundary of the site area, but direct access is restricted by fencing and a very steep slope.
Safety of exposure	The vertical face of the former quarry appears to be stable. Exposures of the Passage Formation are apparently less stable and have been partially walled over to prevent degradation of the rock face. However, the walled sections appear to be locally unstable.
Nature of exposure	The main sill exposure is a 10m high vertical quarry face. There are also small exposures of the sill and Passage Formation in steeper slopes around the west of the Necropolis.

Current conflicting activities or other threats	The former quarry face and some other small exposures are overgrown with ivy. Some clearing of vegetation may be needed to preserve access to the exposure. Stabilisation of rock faces by facing with stone has obscured parts of the Passage Formation outcrop and outcrops of the microgabbro sill away from the quarry face.
Restricting conditions	Access to some rock exposures is locally restricted by monuments.
Ease or permissions needed to visit	The site is a public park operated by Glasgow City Council and open daily from 7am until dusk.
Current condition and how clearly the values can be seen at the moment (close and at a distance)	Exposures of the sill are locally good, but the extensive ivy cover obscured much of the rock face. Exposures of the Passage Formation sandstones are partially obscured by vegetation and walls.
Site fragility and sensitivities	Collection of samples has the potential to damage rock faces and monuments at this historic site and should be discouraged.

Other Current Site Values, Associations or Significance

History of Earth Sciences	No apparent association.
Economic geology	The microgabbro sill was formerly quarried for roadstone (cobbles) on the southern side of the Necropolis site at Ladywell Quarry. Many of the stone walls built around the Necropolis have been built using stone from this quarry.
Scientific study and education	The site has provided samples for radiometric dating that have helped to constraining the timing of emplacement of the Midland Valley Carboniferous and Permian sill suites.
Associations with biodiversity or ecosystem and ecosystem services	No apparent association.
Aesthetic, landscapes, Archaeology, History and cultural associations	A possible interpretation of the name Glasgow is “the place of the grey rock”. The Grey Rock is a former name given to the hill that now forms the site of the Glasgow Necropolis, suggesting that the name of Glasgow may be derived from this prominent outcrop of the microgabbro sill. The ‘Grey Rock’ has a considerable historical association as a religious and military site dating to before the 6th century, and was developed during the Victorian period as a garden cemetery. The monuments within the Necropolis also contain a rich variety of rock types.
Local Communities/ visitors and promoting public awareness	The site attracts many local visitors and tourists, and is the focus for the community group Friends of the Necropolis, a registered charity. There are guided tours, web pages and leaflets available, providing substantial detail on the history and cultural significance of the site.

Potential Opportunities for Using or Enhancing the Site

Opportunities for Potential Future Uses or enhancing the site	Information on the geological features of the site may be readily included in existing webpages and leaflets that provide information on the history of the site. In particular, the relation of the geological factors that control the site and form of the ‘Grey Rock’ to the cultural and economic history of the site could be stressed. Sign boards or plaques may also provide a means to highlight the importance of the geological features of the site to visitors. Clearing of some vegetation and maintenance of exposed rock faces will enhance the views and accessibility of exposures.

GGS_15: M8, Gartcraig Road bridge

Site Description

Physical Context: Roadside cutting on the M8 to the west of Gartcraig Road bridge.

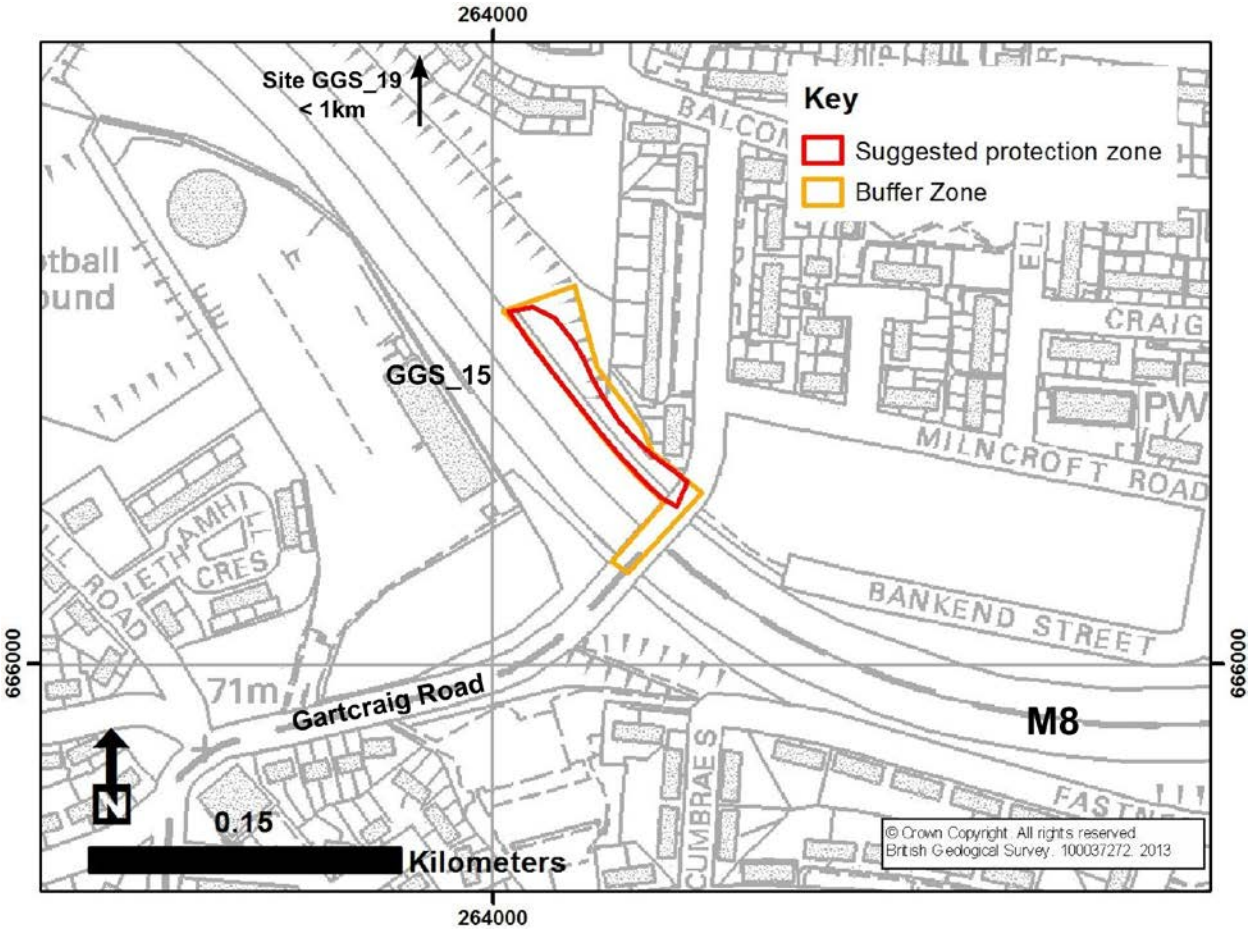
Nearby geodiversity sites or features: GGS_19 Seven Lochs Master Plan Area is less than 1km to the north of the site.

Is the site part of a network or geological terrain: Midland Valley Sill Suite

Does the site cross or border with another Local Authority Area: No

Site Location, any nearby landmarks and access point: M8 at Gartcraig Road	**Site type:** • Artificial Section
NGR: 264080 666092	Current use: Urban
Site ownership: To be confirmed by GCC	Current geological designations: None
Permission to visit required: Yes - for direct access; can be view from publically accessible areas.	Other designations: None known
Field surveyor: Katie Whitbread and Sarah Arkley	Date visited: 31st January, 2013

Map, Location and Boundary Suggestions



MAP GGS_15: M8 Gartcraig Road Location Map. The site comprises a bedrock section exposed in a road cutting. The Buffer Zone includes the slope above the bedrock exposure as activity in this area may impact the exposure below, and the pavement along Gartcraig Road from which the site can be viewed.

Site Photo

Photo GGS_15_P1: View of M8 road cutting from Gartcraig Road Bridge. Looking NW. Microgabbro sill overlies sedimentary strata of the ScottishMiddle Coal Measures Formation. (Note that the exposures can be seen in Street View images on Google Earth)

Stratigraphy and Rock Types

Unit 1	Age: Westphalian-Early Permian	Formation: Western Midland Valley Westphalian to Early Permian Sills
	Group: Midland Valley Carboniferous to Early Permian Alkaline Basic Sill Suite	Rock type: Olivine-microgabbro
Unit 2	Age: Westphalian, Upper Carboniferous	Formation: Scottish Middle Coal Measures Formation
	Group: Scottish Coal Measures Group	Rock type: Sedimentary rock cycles, Coal Measure type

Geological Description

The site consists of a 20 m long, approximately 8 m high section through an intrusive igneous sill overlying sedimentary strata of the Scottish Middle Coal Measures Formation. The contact between the olivine microgabbro sill and the underlying bedded sandstone and siltstone of the Middle Coal Measures occurs in the lower part of the exposure and dips gently to the west.

GeoScientific Merit and Value

	Rarity	Quality	Which if any Literature/ Collections has this been documented in and to what extent?	Primary interest (comment)
Lithostratigraphy	Moderately common	Moderate		Scottish Middle Coal Measures Formation strata

Sedimentology	Moderately common	Poor		Deltaic environments
Igneous/ Mineral/ Metamorphic	Common	Good		Intrusive igneous sill
Structural geology				
Palaeontology				
Geomorphology (active processes and relict landforms)				

Assessment of the Overall Relative GeoScientific Importance

The site is one of few examples of the contact between the intrusive sill and underlying sedimentary rocks, particularly in eastern Glasgow where the sill is intruded within strata of the ScottishLower and Middle Coal Measures Formations. This site is a **good CVDPA example** of **significance within the CVDPA**.

Safety of Access/ Site Condition/ Fragility/ Threats/ Sensitivities

Safety of access/ ease and barriers to access into and around the site	Direct access to the outcrop is heavily restricted due to its location adjacent to the M8 motorway. Access would require police permission and high visibility clothing. The section can be viewed from the pavement on Gartcraig Road bridge. Gartcraig Road is a busy two-lane road and is the main hazard associated with site access (viewing only). Although there is a rail at chest-height, care should be taken when viewing the site from the bridge.
Safety of exposure	The rocks are jointed, but the rock face appears stable.
Nature of exposure	20m long, 8m high vertical rock face in a road cutting. Smaller sections are located along the M8 to the east.
Current conflicting activities or other threats	If required, future measures to stabilise the cutting face through netting or concreting would degrade the exposure and restrict the view from Gartcraig Road. Vegetation and algal growth on the rock face is likely to increase with time and may make geological features difficult to view from the bridge.
Restricting conditions	Direct access to the section is restricted by the M8 Motorway.
Ease or permissions needed to visit	Permissions would need to be obtained to gain direct access to the site. No permissions are required to view the site from Gartcraig Road.
Current condition and how clearly the values can be seen at the moment (close and at a distance)	The exposure is in moderately good condition, with some algal growth and minor vegetation cover. To the east, under Gartcraig Road, the continuation of the cutting has been concreted over. A smaller section is also seen along the road side approximately 100m to the east of Gartcraig Road bridge
Site fragility and sensitivities	The site is relatively stable and in good condition, but the lack of safe direct access means that factors affecting the view of the site are of increased importance with respect to its geodiversity value. Vegetation growth and any future netting or concreting will adversely affect the clarity of features in the exposure.

Other Current Site Values, Associations or Significance	
History of Earth Sciences	No known association.
Economic geology	Both the coal measures strata and the intrusive sill have been mined or quarried within the Glasgow area.
Scientific study and education	No apparent association.
Associations with biodiversity or ecosystem and ecosystem services	No association.
Aesthetic, landscapes, Archaeology, History and cultural associations	No association.
Local Communities/ visitors and promoting public awareness	No current association.

Potential Opportunities for Using or Enhancing the Site	
Opportunities for Potential Future Uses or enhancing the site	The site has limited potential for development due to its location. Production of a drawn section to highlight the relationship between the sill and the underlying rocks would enhance the educational value of the site and could be made available through digital media such as a website or app.

GGS_16: Newlands Glen

Site Description

Physical Context: The site is wooded glen along the North Calder Water in eastern Glasgow.

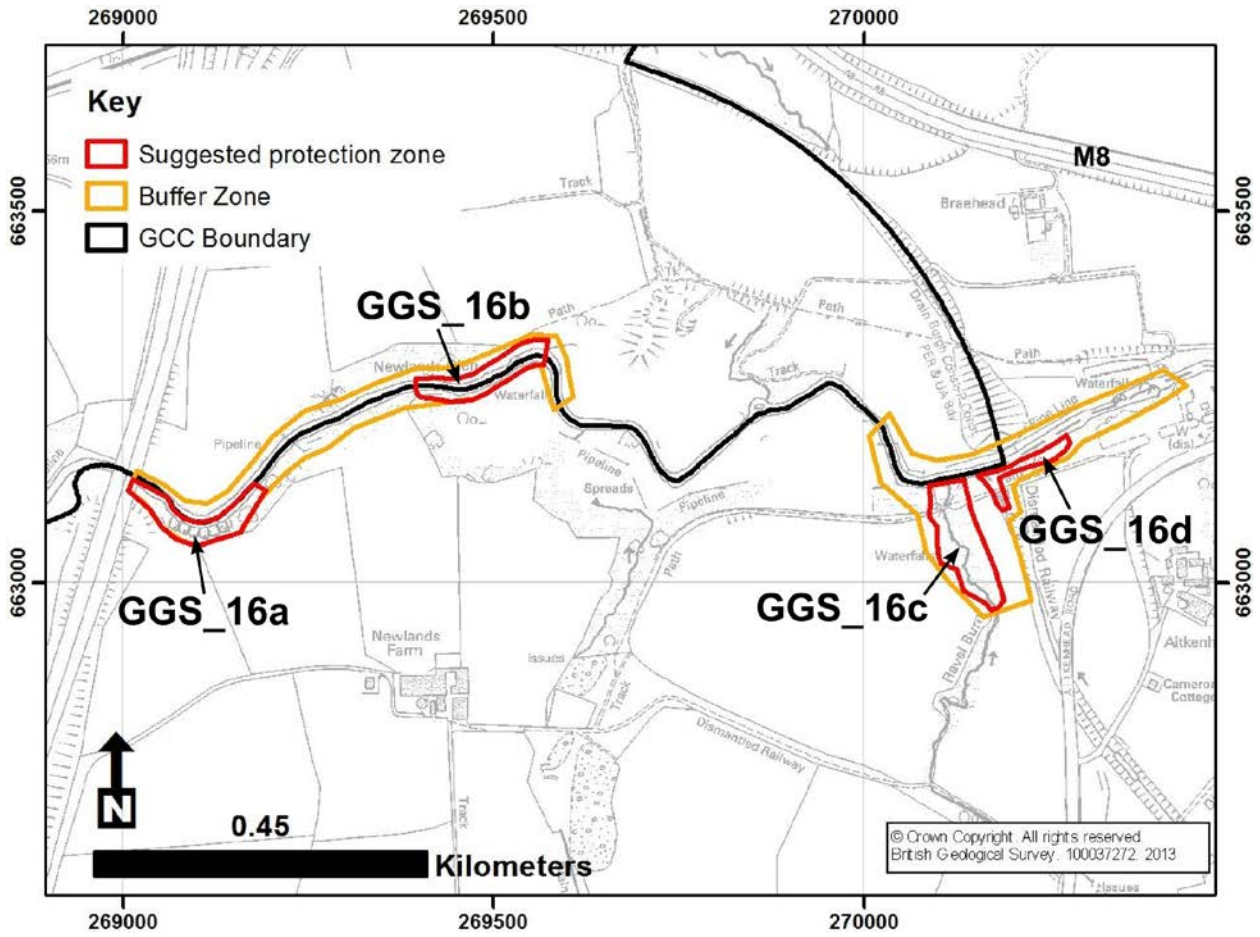
Nearby geodiversity sites or features: None within 1km.

Is the site part of a network or geological terrain: No

Does the site cross or border with another Local Authority Area: Yes, North Lanarkshire

Site Location, any nearby landmarks and access point: The site is located along the North Calder Water between the M73 and M8.	**Site type:** • Natural Sections
NGR: 269528 663293	Current use: Private Country
Site ownership: To be confirmed by GCC	Current geological designations: None
Permission to visit required: To be confirmed by GCC	Other designations: None known
Field surveyor: Katie Whitbread and Sarah Arkley	Date visited: 7th February, 2013

Map, Location and Boundary Suggestions



MAP GGS_16: Newlands Glen Location Map. The suggested protection zone comprises four areas of significant bedrock outcrop, GGS_16 a, b and c are all considered as high priority sub-areas as they expose different sets of geological features. GSS_16d is a high quality exposure but contains features that can be viewed in the other sub-area; therefore it is considered to have intermediate priority. The site defined by the suggested protection zone and comprising all sub-areas has been assessed in the following evaluation. The Buffer Zone incorporates access routes to the site, viewing areas and some additional areas of outcrop.

Site Photos

Photo GGS_16_P1: Exposure of sandstone towards the western end of the Newlands Glen site approximately 150m east of the M73 bridge (GGS_16a). The exposure consists of c. 3m of bedded and cross-bedded sandstone overlying coal and seatearth (at the level of the laptop). Looking E.

Photo GGS_16_P2: Coal streaks in a mudstone unit within the Scottish Middle Coal Measures Formation.

Photo GGS_16_P3: Faulted sandstone highlighted by a brecciated section of river cliff and waterfall in the North Calder Water in Newlands Glen (GGS_16b). Looking N.

Photo GGS_16_P4: Fossilised leaves preserved in a siltstone seatearth near the outlet of the Ravel Burn (GGS_16c).

Photo GGS_16_P5: Thinly bedded sandstone unit from Scottish Middle Coal Measures Formation, exposed along the banks of the Ravel Burn (GGS_16c).

Photo GGS_16_P6: Diamicton (glacial till) overlying siltstone of the Scottish Middle Coal Measures Formation in the Ravel Burn. Contact just above the handle of the hammer. The diamicton is in turn overlain by made ground deposits, visible at the top of the photograph (GGS_16c)

Stratigraphy and Rock Types

Unit 1	Age: Westphalian, Upper Carboniferous	Formation: Scottish Middle Coal Measures Formation
	Group: Scottish Coal Measures Group	Rock type: Sedimentary rock cycles, Coal Measure type
Unit 2	Age: Devensian, Pleistocene, Quaternary	Formation: Wilderness Till Formation
	Group: Midland Valley Glacigenic Subgroup	Rock type: Diamicton (glacial till)

Geological Description

Newlands Glen is a 1.5km wooded valley cut by the North Calder Water into superficial deposits and sedimentary bedrock. A series of exposures of sections of coal cyclothems in the Scottish Middle Coal Measures Formation are seen in the gorge, river and tributary streams. These strata fall within the upper part of the Scottish Middle Coal Measures Formation between the Glasgow Upper Coal and the Aegiranum Marine Band that marks the base of the overlying Scottish Upper Coal Measures Formation.

To the west of the site, a series of sections in the side of the gorge expose sandstones, siltstones and mudstones with thin coal-bearing beds and organic rich mudstones and seatearths. The sandstone units occur as relatively thin, planar beds within mudstone/siltstone sequences and as thicker channel sandstone bodies marked by erosive bases and large scale cross bedding. These channel sandstones are fine to medium grained, and ripple bedded in places, indicating rapid deposition, and contain abundant organics and mica giving an almost black appearance. The channel sandstones overly organic rich mudstone with coal streaks and thin coal beds which are underlain by organic rich grey silty seatearths with abundant plant fossils.

Towards the middle section of Newlands Glen, a 7 to 8m high sandstone section has been cut by the North Calder Water, which also has a small waterfall in the stream. The waterfall is orientated oblique to the channel banks and forms the continuation of a fracture in the sandstone gorge wall indicating the presence of a small north-east to south-west trending fault zone c. 5m wide with limited vertical offset.
In the east of the site a section of near continuous outcrop of mudstone, siltstone and sandstone with thin coaly horizons is exposed for ~150m in the bed and banks of Ravel Burn. The proportion of sandstone increases upwards and exposures display clear cross-bedding. In the banks of Ravel Burn and other small, incised tributary streams in the area, the sedimentary rocks are overlain by silty till with gravel and small cobbles, which is overlain in places by head deposits and made ground.

Newlands Glen also highlights features related to river deposition and erosion (fluvial geomorphology), including sections of alluvial reach with active bank erosion, and erosional bedrock reaches in which geological features such as faults and variations in bedrock lithology have cause the formation of waterfalls and small, steep steps.

GeoScientific Merit and Value

	Rarity	Quality	Which if any Literature/ Collections has this been documented in and to what extent?	Primary interest (comment)
Lithostratigraphy	Moderately common	Moderate to good	Forsyth et al., 1996	Scottish Middle Coal Measures Formation strata
Sedimentology	Moderately common	Moderate to good	Forsyth et al., 1996	Deltaic and shallow marine environments
Igneous/ Mineral/ Metamorphic				

Structural geology	Moderately common	Poor		Minor faulting
Palaeontology	Moderately common	Moderate		Plant fossils
Geomorphology (active processes and relict landforms)	Moderately common	Poor		Fluvial landforms and processes

Assessment of the Overall Relative GeoScientific Importance

The site contains a range of depositional features that are characteristic of deposition in deltaic and fluvio-deltaic environments and the relatively extensive exposure contributes to its lithostratigraphic importance. Fossils, geomorphological features and sections through the overlying superficial deposits add to the geodiversity value of the site, making it a **good Midland Valley example** of **regional (Midland Valley) importance**

Safety of Access/ Site Condition/ Fragility/ Threats/ Sensitivities

Safety of access/ ease and barriers to access into and around the site	The site can be accessed on footpaths, although direct access to sections, particularly in the east of the site requires traversing of steep to very steep, vegetated gorge slopes with no footpath access. Access to river bank exposures and sections along the North Calder Water is restricted as the river is too deep to cross and there are no footbridges in the site area. There are substantial amounts of tipped waste in parts of the site which pose a hazard for access to some exposures.
Safety of exposure	Exposures in the east of the site are commonly overhanging and are locally unstable due to the steep gorge sides. The slopes and vegetation along the gorge walls make access to the base of some sections hazardous. In Ravel Burn, exposures are moderately stable and more readily accessible.
Nature of exposure	The exposures consist of a series of gorge and river sections.
Current conflicting activities or other threats	Tipping of waste, particularly towards the west of the site restricts access to some sections along the river and obscures outcrops in some areas.
Restricting conditions	Seasonal vegetation growth may further restrict direct access to some exposures, and high river flow levels may restrict access to river bed and bank sections.
Ease or permissions needed to visit	The site can be accessed on mapped footpaths, but permission from landowners is advised.
Current condition and how clearly the values can be seen at the moment (close and at a distance)	Exposures throughout the site are in moderately good condition, but thick vegetation in the eastern part of the site mean that the features in this area are more difficult to view.
Site fragility and sensitivities	Continued tipping of waste may obscure exposures or prevent access to some parts of the site. Collection of samples and fossils has the potential to degrade exposures in some areas, but limited sampling should not substantially affect the geological features of the site. Clearing of some vegetation and fallen trees may help to preserve some exposures.

Other Current Site Values, Associations or Significance	
History of Earth Sciences	No apparent association.
Economic geology	The site is a good example of strata that have been mined extensively for coal in the Midland Valley.
Scientific study and education	No apparent association.
Associations with biodiversity or ecosystem and ecosystem services	Newlands Glen is an area of semi-natural woodland.
Aesthetic, landscapes, Archaeology, History and cultural associations	No apparent association.
Local Communities/ visitors and promoting public awareness	No apparent association.

Potential Opportunities for Using or Enhancing the Site	
Opportunities for Potential Future Uses or enhancing the site	Improvements to access and preparation of leaflets or other media explaining the geological features may enhance the education potential of the site area.

GGS_17: Court Knowe Quarry

Site Description

Physical Context: Small disused quarry near northern edge of Linn Park just south of Court Knowe.

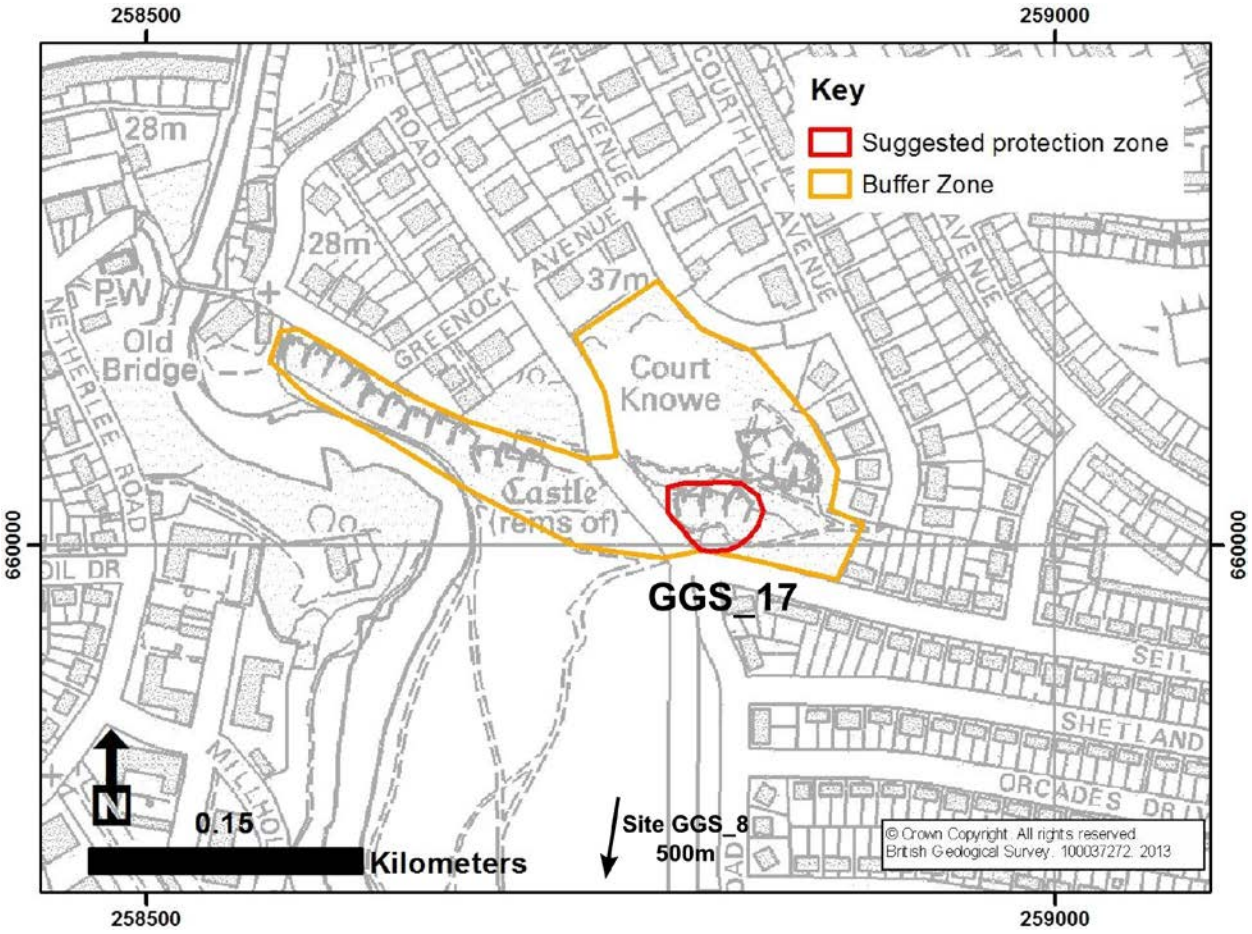
Nearby geodiversity sites or features: GGS_8 is located c. 500m to the south-east and GGS_9 is c. 1km to the south east along the White Cart Water.

Is the site part of a network or geological terrain: Midland Valley sill suite.

Does the site cross or border with another Local Authority Area: No

Site Location, any nearby landmarks and access point: Near junction of Old Castle Road and Seil Drive at the north end of Linn Park.	**Site type:** • Artificial Section
NGR: 258813 660016	Current use: Disused Quarry
Site ownership: Glasgow City Council	Current geological designations: None
Permission to visit required: Public access	Other designations: None known
Field surveyor: Katie Whitbread and Sarah Arkley	Date visited: 23rd January, 2013

Map, Location and Boundary Suggestions



MAP GGS_17: Court Knowe Quarry location map. GGS_8 and GGS_9 are located 400 and 900m respectively to the south-west along the White Cart Water in Linn Park.The suggested protection zone comprises bedrock exposures in the disused quarry at Court Knowe. The Buffer Zone includes acess routes and adjacent areas of bedrock expsoure and historical interest related to hill formed from the igneous sill exposed in the quarry.

Site Photos

Photo GGS_17 P1: Disused quarry at Court Knowe in microgabbro sill. Rectilinear joint sets can be seen. Looking N.

Photo GGS_17 P2: Close up view of Microgabbro.

Photo GGS_17 P3: Root penetrating joint in microgabbro in Court Knowe Quarry.

Stratigraphy and Rock Types

Unit 1	Age: Westphalian-Early Permian	Formation: Western Midland Valley Westphalian to Early Permian Sills
	Group: Midland Valley Carboniferous to Early Permian Alkaline Basic Sill Suite	Rock type: Olivine-microgabbro

Geological Description

The site contains 4 to 6 m high vertical exposures of the Cathcart Sill, part of the Western Midland Valley Sill Suite, consisting of olivine-microgabbro. Olivine phenocrysts, mm to sub-mm sized, are visible in some fresh exposures. The unit is strongly jointed at .5 to 1.5m scale, and contains some sub-horizontal layers, but the top and base of the sill are not seen. Drill holes produced during quarrying are visible in places in the rock face.

The outcrop of the sill continues along an escarpment to the west of the Quarry that forces a meander in the White Cart Water just above the Old Bridge at Cathcart. This escarpment follows the line of a north-west trending fault which downthrows to the north-east bringing the sill against strata from the Limestone Coal Formation across the line of the river. The fault is not seen directly but can be inferred from the topography and the juxtaposition of strata.

GeoScientific Merit and Value

	Rarity	Quality	Which if any Literature/ Collections has this been documented in and to what extent?	Primary interest (comment)
Lithostratigraphy				
Sedimentology				
Igneous/ Mineral/ Metamorphic	Common	Moderate	Hall et al., 1998	Intrusive igneous sill
Structural geology	Common	Poor		Faulting
Palaeontology				
Geomorphology (active processes and relict landforms)	Common	Moderate		Landforms and weathering

Assessment of the Overall Relative GeoScientific Importance

This site displays a good exposure of the medium to fine grained olivine microgabbro that is typical of the intrusive sills of the area. The geomorphological context of the locality, with the hill formed by the resistant sill protected to the south by the river is responsible for its use as a former military site. The site is a **good CVDPA example** with **significance in the Glasgow area**.

Safety of Access/ Site Condition/ Fragility/ Threats/ Sensitivities

Safety of access/ ease and barriers to access into and around the site	Access to the quarry area is very good, with local parking and well maintained paths in the quarry and on the adjacent hill of Court Knowe.
Safety of exposure	The vertical rock face appears to be stable, with no loose material evident. The top of the outcrop can be accessed and there is a 5-6m vertical drop.
Nature of exposure	Vertical rock face in disused quarry site.
Current conflicting activities or other threats	None apparent.

Restricting conditions	Seasonal vegetation growth may restrict access to some parts of the quarry.
Ease or permissions needed to visit	No permissions required.
Current condition and how clearly the values can be seen at the moment (close and at a distance)	The exposures are in very good condition, with limited surface weathering.
Site fragility and sensitivities	There is some scratching of the rock face related to climbing activities at the site, but this has not affected the earth science interest.

Other Current Site Values, Associations or Significance

History of Earth Sciences	No known association.
Economic geology	The microgabbro has been quarried, probably for road stone. Drill holes can still be seen in the rock face
Scientific study and education	No association apparent
Associations with biodiversity or ecosystem and ecosystem services	The site lies within a small area of woodland on Court Knowe.
Aesthetic, landscapes, Archaeology, History and cultural associations	The ruined remains of Cathcart Castle are located on the top of the escarpment formed by the extension of the sill to the west of the quarry. Court Knowe is thought to have been the viewpoint used by Mary Queen of Scots to observe the Battle of Langside in 1568. A monument commemorating the battle has been built on the north side of the hill.
Local Communities/ visitors and promoting public awareness	Court Knowe quarry is currently used recreationally as an outdoor climbing site and forms part of the small heritage area developed on Court Knowe.

Potential Opportunities for Using or Enhancing the Site

Opportunities for Potential Future Uses or enhancing the site	Continued management of vegetation will help to maintaining the exposures and integrity of the rock faces for geological interest and climbing. The good access makes this a suitable educational site for observing igneous rock *in situ* and a signboard may help to highlight some of the key features of the geology as well as its relation to the historical aspects of the site.

GGS_18: Bellahouston Park

Site Description

Physical Context: Bellahouston Park is a recreational park area.

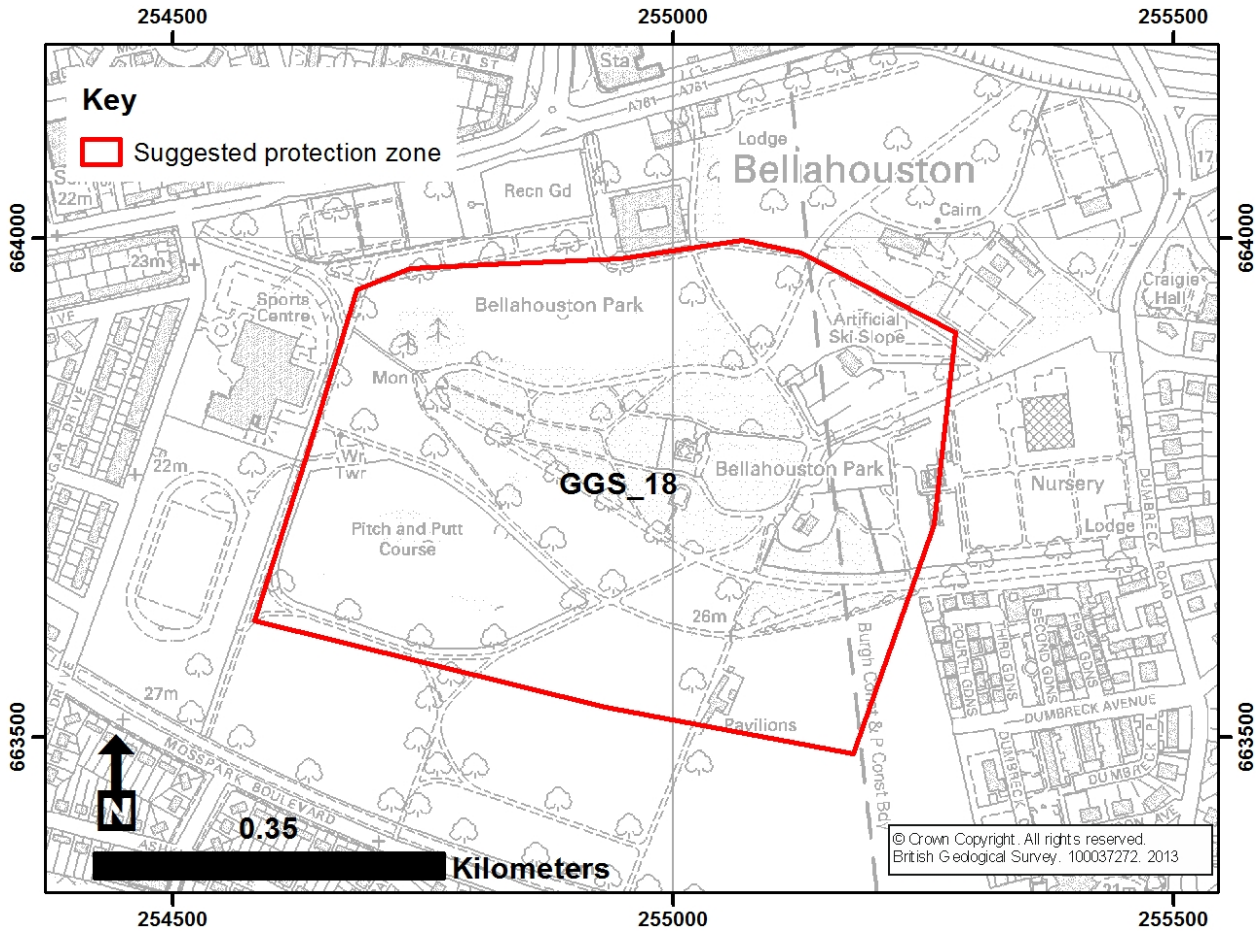
Nearby geodiversity sites or features: None

Is the site part of a network or geological terrain: The site forms part of the drumlin field that characterises much of the city of Glasgow area

Does the site cross or border with another Local Authority Area: No

Site Location, any nearby landmarks and access point: Bellahouston Park is just off Junction 1 of the M77 and close to Mosspark, to the south of Glasgow city centre.	**Site type:** • Natural Landform
NGR: NS 254934 663802	Current use: Recreation
Site ownership: Glasgow City Council	Current geological designations: None
Permission to visit required: Public access	Other designations: None known
Field surveyor: Katie Whitbread and Sarah Arkley	Date visited: 1st February, 2013

Map, Location and Boundary Suggestions



MAP GGS_18: Bellahouston Park Location Map. The site comprises glacial landform features.

Site Photos

Photo GGS_18_P1: Bellahouston Park looking north towards the drumlin (hill topped with trees) from a flat inter-drumlin area underlain by raised glaciomarine sediments. The Glaciomarine clays have low permeability and the area in the bottom left is poorly drained after heavy rain.

Stratigraphy and Rock Types

Unit 1	Age: Devensian, Pleistocene, Quaternary	Formation: Wilderness Till Formation
	Group:	Rock type: Diamicton (glacial till)
Unit 2	Age: Devensian, Pleistocene, Quaternary	Formation: Clyde Clay Formation
	Group:	Rock type: Raised marine intertidal and subtidal deposits – clay and silt

Geological Description

Bellahouston Park is centred on a drumlin that forms a smooth, elongate hill and is flanked by flat ground. The drumlin is formed of glacial till of the Wilderness Till Formation, deposited and moulded by Late Devensian glaciers that occupied the Clyde Valley between 30 – 16 thousand years ago and forms part of the inner Clyde drumlin field. The flat ground surrounding the drumlin is underlain by a thin deposit of raised glaciomarine clay laid down during a period of higher sea level during and soon after deglaciation at the close of the Late Devensian. At this time the drumlin would have been an island in the then flooded Clyde estuary.

The top two meters of the superficial deposits are likely to have been extensively reworked during construction and subsequent demolition of the Empire Exhibition in 1938 but this is not thought to have affected the nature of the landforms. Shallow mining formerly occurred in the southern part of the park area where several coal seams are located close to rockhead beneath thin superficial deposits.

GeoScientific Merit and Value

	Rarity	Quality	Which if any Literature/ Collectionshas this been documented in and to what extent?	Primary interest (comment)
Lithostratigraphy				
Sedimentology				
Igneous/ Mineral/ Metamorphic				
Structural geology				
Palaeontology				
Geomorphology (active processes and relict landforms)	Common	Moderate		Glacial landforms

Assessment of the Overall Relative GeoScientific Importance

The features in Bellahouston Park highlight the nature of glacial landforms that are typical of the central Glasgow area. Although the surface deposits may have been landscaped in places in the past, the main drumlin feature is generally well preserved making this a **moderate CVDPA example** with **significance in the Glasgow area**.

Safety of Access/ Site Condition/ Fragility/ Threats/ Sensitivities

Safety of access/ ease and barriers to access into and around the site	Access to the site is very good with major road routes and local parking areas. There is a network of metalled paths throughout the site.
Safety of exposure	Not applicable.
Nature of exposure	The site is a landform feature consisting of a smooth-sided hill surrounded by flat ground
Current conflicting activities or other threats	None apparent.
Restricting conditions	Views of the terrain from the top of the drumlin are largely obscured by trees. Some removal of trees may enhance views over the drumlin-field in central Glasgow.
Ease or permissions needed to visit	No permissions required.
Current condition and how clearly the values can be seen at the moment (close and at a distance)	The site is in good condition and key features are clearly visible.
Site fragility and sensitivities	Future construction and further planting of trees may affect the visual impact of and views from of the site area.

Other Current Site Values, Associations or Significance

History of Earth Sciences	No associations apparent.
Economic geology	Shallow mining of coal seams has occurred in parts of the park area, although there is little modern evidence for this historic activity.
Scientific study and education	No associations apparent.

Associations with biodiversity or ecosystem and ecosystem services	The site is part of a recreational park area with small amounts of woodland.
Aesthetic, landscapes, Archaeology, History and cultural associations	Approximately 180 drumlins form a large drumlin 'field' within the inner Cyde valley. These rounded hills have influenced the development of the City of Glasgow, including the alignment of roads and railways, and many form city landmarks, for example Garnethill, Park Circus, Partickhill and Queens Park.
Local Communities/ visitors and promoting public awareness	Bellahouston Park is a recreational area.

Potential Opportunities for Using or Enhancing the Site

Opportunities for Potential Future Uses or enhancing the site	Signboards highlighting the main features of the park landscape and providing information on the glacial history of the inner Clyde area could be produced to inform the public about the nature of the terrain.

GGS_19: Seven Lochs Master Plan Area (as of spring 2013)

Site Description

Physical Context: The Seven Lochs Master Plan Area is a proposed park area extending for ~ 6 to 8 km across the north-east edge of the GCC boundary, including Hogganfield Loch, Cardowan Moss and Bishops Loch.

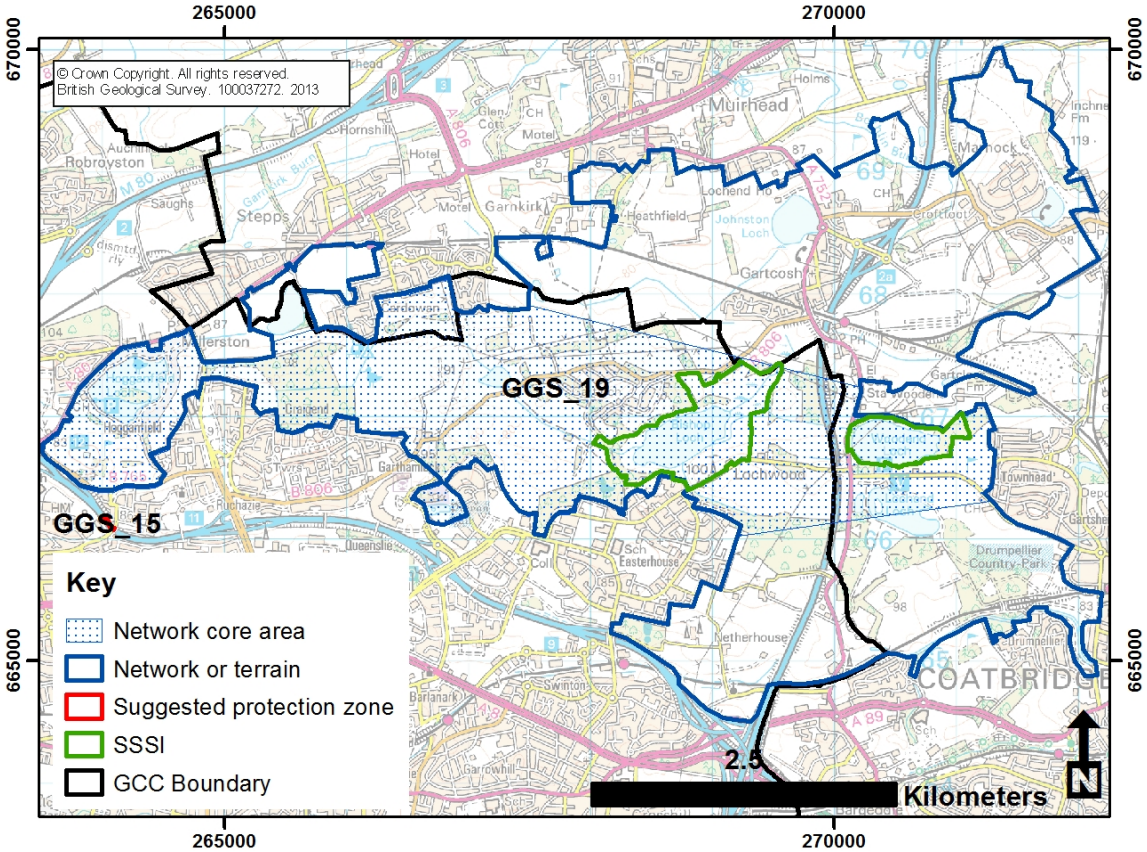
Nearby geodiversity sites or features: GGS_15 (M8 Gartcraig Road) is located less than 1km to the south

Is the site part of a network or geological terrain: Yes, the site is a lowland glacial terrain.

Does the site cross or border with another Local Authority Area: Yes, North Lanarkshire

Site Location, any nearby landmarks and access point: Site can be accessed from the M73 and M8 via the A80 and B806. The site is large and there are various access points.	**Site type:** • Natural Landforms
NGR: 263870 667210	Current use: Open Country, Recreation
Site ownership: Various; includes publically accessible council parks and nature reserves as well as some private land.	Current geological designations: None
Permission to visit required: Permission may be required for areas of private land	Other designations: biological SSSI, LNR
Field surveyor: Katie Whitbread and Sarah Arkley	Date visited: 31st January, 2013

Map, Location and Boundary Suggestions



MAP GGS_19:Seven Lochs Master Plan Area location map.The network boundary is based on the proposed Seven Lochs Master Plan Area at the time of the audit. No protection zone has been suggested due to the size of the site area, however, a core area including Hogganfield Loch and the designated bioloigcal SSSIs of Bishops Loch and Woodend Loch has been highlighted as a priority area.

Site Photos

Photo GGS_19 P1: Hogganfield Loch from near the landing stage at western end of the loch.

Photo GGS_19 P2: View of western area of Seven Lochs Master Plan Area. Looking north from disused quarry at Garthamlock towards Cardowan (within the core area).

Stratigraphy and Rock Types

Unit 1	Age: Devensian, Pleistocene, Quaternary	Formation: Wilderness Till Formation
	Group: Midland Valley Glacigenic Subgroup	Rock type: Diamicton (glacial till)
Unit 2	Age: Flandrian, Holocene, Quaternary	Formation: N/A
	Group: N/A	Rock type: Peat
Unit 3	Age: Flandrian, Holocene, Quaternary	Formation: N/A
	Group: N/A	Rock type: Lacustrine deposits: silty clay and silt

Geological Description

The site contains a series of landforms that are characteristic of a lowland glacial terrain. The undulating landscape contains a series of drumlins with inter drumlin hollows containing lochs, some of which have been partially or wholly filled by lacustrine sediments (clay, silt and organic matter) and peat. The wetlands and peatlands form important habitats for birds and other wildlife.

The bedrock underlying the southern half of the site area consists of sedimentary rocks of the Scottish Middle and Scottish Lower Coal Measures formations intruded with igneous sills, whilst to the north the Passage Formation and Upper Limestone Formation underlie the superficial deposits. In some parts of the park area, notably in Todd's Well (**MAP GGS_19**), subsidence features related to shallow mining of coal seams can be seen, and small disused quarries in the microgabbro sill are found, for example at Garthamlock (GR 266150 666925).

GeoScientific Merit and Value

	Rarity	Quality	Which if any Literature/ Collections has this been documented in and to what extent?	Primary interest (comment)
Lithostratigraphy				
Sedimentology				
Igneous/ Mineral/ Metamorphic				
Structural geology				
Palaeontology				
Geomorphology (active processes and relict landforms)	Common	Moderate to good		Landforms

Assessment of the Overall Relative GeoScientific Importance

The Seven Lochs Master Plan Area is a **good CVDPA to Midland Valley example** of a lowland glacial terrain with **significance in the Glasgow area**.

Safety of Access/ Site Condition/ Fragility/ Threats/ Sensitivities	
Safety of access/ ease and barriers to access into and around the site	Access to parts of the site is good, with parking and networks of paths in public park areas and designated Local Nature Reserves. Proposals for development of the Seven Lochs Master Plan Area include the construction of a network of paths throughout the site area.
Safety of exposure	Not applicable.
Nature of exposure	The site consists of a series of landforms comprising the glacial terrain. Local exposures of bedrock are also seen in a disused quarry.
Current conflicting activities or other threats	Residential developments adjacent to and within the proposed park area have the potential to affect some views of the terrain and topography.
Restricting conditions	None apparent.
Ease or permissions needed to visit	Some areas of the site may be privately owned, but designated LNR's and SSSI are publically accessible.
Current condition and how clearly the values can be seen at the moment (close and at a distance)	Wetlands, lochs and peatlands are in generally good condition, although tipping of waste may affect some areas
Site fragility and sensitivities	Residential developments, if extensive, may affect restrict some views of the terrain and affect the character of the landscape.

Other Current Site Values, Associations or Significance	
History of Earth Sciences	No apparent association.
Economic geology	Local shallow mining has resulted in subsidence in the area of Todd's Well. Igneous intrusive rocks have been mined locally.
Scientific study and education	Local Nature Reserves and SSSI have nature trails and signboards for ecological habitat and wildlife information.
Associations with biodiversity or ecosystem and ecosystem services	Wetlands and peatlands are important wildlife habitats. The area also provides important ecosystem services as management of the wetlands may help to control flood risk in other areas, and healthy peatlands are significant carbon stores.
Aesthetic, landscapes, Archaeology, History and cultural associations	The wetland habitats are important ecological sites. Bishops Loch and Woodend Loch (North Lanarkshire) have been designated ecological SSSI, and a number of Local Nature Reserves (LNR's) have been established in the region. These wetland sites are to be linked by the creation of the proposed Seven Lochs Master Plan Area. The Park is being developed through collaboration between the GCV Green Network and various planning authorities and local councils to maintain the environment of, and around, the City of Glasgow.
Local Communities/ visitors and promoting public awareness	The area has a wide range of recreational users. A series of trails and sign boards providing ecological information.

Potential Opportunities for Using or Enhancing the Site	
Opportunities for Potential Future Uses or enhancing the site	There is potential that information on the nature of the relationship between the geological history, landscape and wildlife could be added to existing or new signboards to highlight the importance of the glacial history in the formation of this terrain.

GGS_20: Fossil Tree, Household Park

Site Description

Physical Context: Geological feature located Household Park.

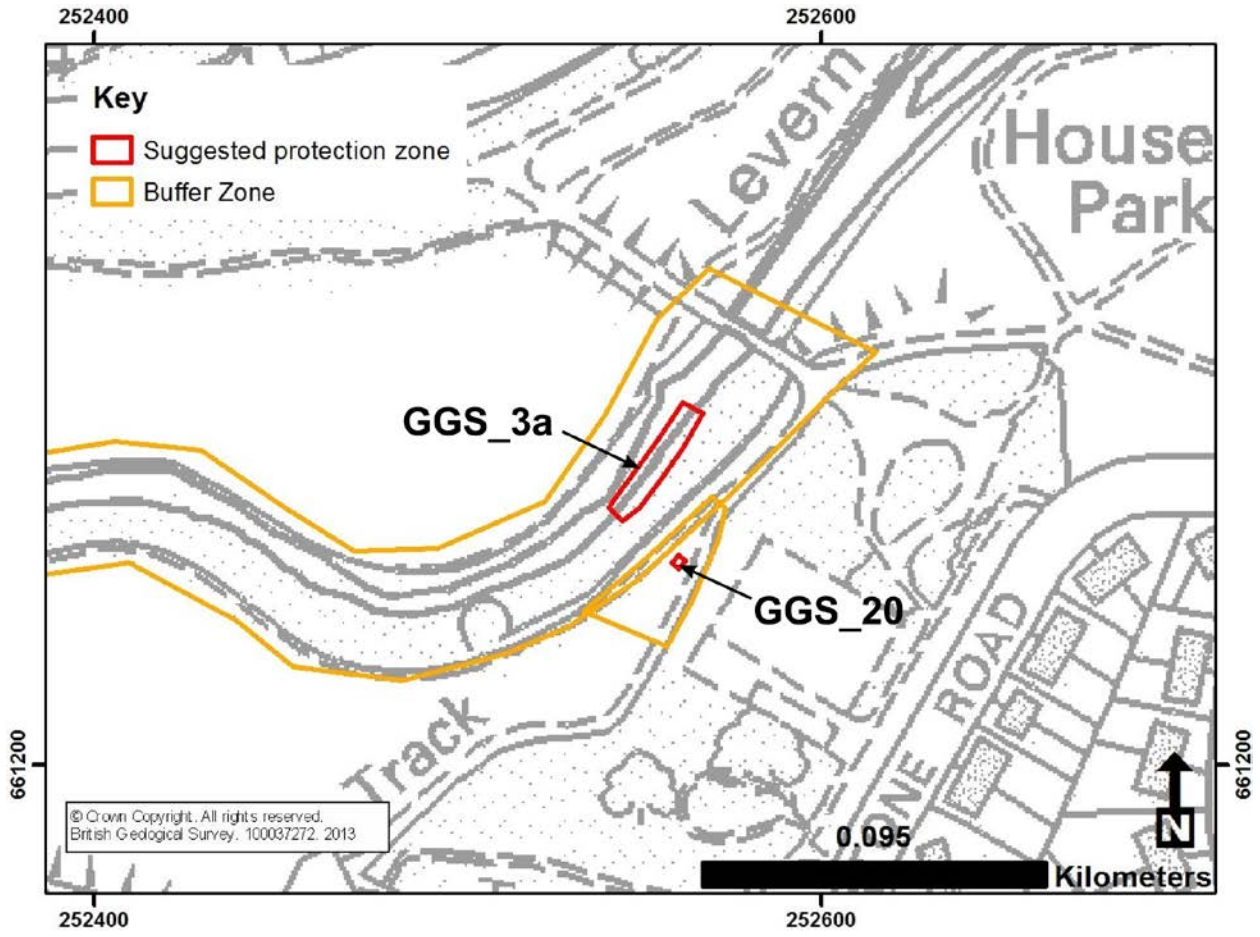
Nearby geodiversity sites or features: GGS_3 Household Park (sections along the Levern Water) is located just to the west of the site

Is the site part of a network or geological terrain: No

Does the site cross or border with another Local Authority Area: No

Site Location, any nearby landmarks and access point: Household Park, near Householdwood between the A726 and B762 in south-west Glasgow.	**Site type:** • Other: Fossil Feature (not *in situ*)
NGR: 252561 661256	Current use: Recreation
Site ownership: Glasgow City Council	Current geological designations: None
Permission to visit required: No	Other designations: None known
Field surveyor: Katie Whitbread and Sarah Arkley	Date visited: 20th February, 2013

Map, Location and Boundary Suggestions



MAP GGS_20: Fossil tree, Household Park. The adjacent site along the Levern Water is GGS_3 (Household Park). The Buffer Zone incorporates access and viewing areas surrounding the site. The following evaluation refers the to the suggested protection zone.

Photo GGS_20 P1: Fossil Tree in Household Park. Looking E.

Photo GGS_20 P2: Fossil Tree in Household Park. Looking NW.

Photo GGS_20 P3: Detail of longitudinal groves on the surface of the fossil tree in Household Park.

Stratigraphy and Rock Types

Unit 1	Age: Namurian, Upper Carboniferous	Formation: Origin not confirmed
	Group: Clackmannan Group	Rock type: Sandstone

Geological Description

Household Park exhibits a petrified arborescent 'tree' stump reportedly extracted from a Carboniferous sandstone unit quarried in the area of Household or Nitshill. The location of the quarry, and consequently the stratigraphic horizon in which the stump was preserved, is not known, however as the feature is reportedly locally derived, it is most probably from a sandstone bed in the Lower Limestone Formation or the lower part of the Limestone Coal Formation.

The 'tree' stump stands approximately 1.5m tall and has a diameter of 0.4 – 0.6m. Parts of the upper root system and longitudinal surface grooves are still preserved. It is likely to be a sandstone cast of the trunk and upper root system of a Lepidodendron, similar to those seen at Fossil Grove, but considerably more of the trunk is seen in this example.

GeoScientific Merit and Value

	Rarity	Quality	Which if any Literature/ Collections has this been documented in and to what extent?	Primary interest (comment)
Lithostratigraphy				
Sedimentology				
Igneous/ Mineral/ Metamorphic				
Structural geology				
Palaeontology	Moderately rare	Good		Plant fossils
Geomorphology (active processes and relict landforms)				

Assessment of the Overall Relative GeoScientific Importance

The fossil is not *in situ* but is a relatively large example of a petrified tree of Carboniferous age thus the site is considered to be a **good Midland Valley example** with **regional significance**. (However, verification of the origin of the tree is recommended to validate this assessment).

Safety of Access/ Site Condition/ Fragility/ Threats/ Sensitivities

Safety of access/ ease and barriers to access into and around the site	Access to the site is good, with local on-street parking and a network of metalled paths throughout the park area.
Safety of exposure	There are no safety issues at the site.
Nature of exposure	The feature is a fossil 'tree' stump and is not *in situ*
Current conflicting activities or other threats	It has been reported that there were originally two trees in the park area but that one has been 'lost', possibly having been rolled into the river gorge adjacent to the site. Graffiti and vandalism are evident on the feature.

Restricting conditions	None apparent.
Ease or permissions needed to visit	No permissions required.
Current condition and how clearly the values can be seen at the moment (close and at a distance)	The fossil 'tree' has been somewhat degraded by vandalism, but is clearly visible close to the footpath and can be compared directly with adjacent modern trees.
Site fragility and sensitivities	The reported loss of a second tree suggests that the site may be vulnerable to further damage and vandalism. Cleaning and maintenance may be needed to improve the trees condition. Hammering and sample collection would damage the feature and should be prevented.

Other Current Site Values, Associations or Significance

History of Earth Sciences	No known association.
Economic geology	The tree was reportedly discovered during quarrying activities in the local area.
Scientific study and education	No association apparent.
Associations with biodiversity or ecosystem and ecosystem services	No association.
Aesthetic, landscapes, Archaeology, History and cultural associations	The fossil tree(s) was (/were) reportedly originally installed in the gardens or grounds of Househill House. The house has since been demolished and the area now forms Househill Park, managed by Glasgow City Council.
Local Communities/ visitors and promoting public awareness	The fossil tree has been mentioned in correspondences on the local area forum site "hiddenglasgow" and incidentally in local newspaper features on the Nitshill area. But, there is little information available regarding the 'tree' and its history.

Potential Opportunities for Using or Enhancing the Site

Opportunities for Potential Future Uses or enhancing the site	A small plaque or sign board giving information on the tree and its historical association would be informative to local visitors. Consideration should be given whether the fossil tree might be rehoused in a museum.

5 Summary

The City of Glasgow has considerable geodiversity and much of its social and economic history is intrinsically linked to the rocks, sediments and landforms that underlie the area. Two of the most significant geological sites in the GCC area have already been designated as SSSI, giving them protected status. In addition to these sites, 18 further locally important geodiversity sites have been identified during this Audit. These sites are dominated by natural and artificial bedrock exposures and Quaternary landforms, reflecting the need to consider the preservation of Glasgow Geodiversity in the face of ongoing development pressure. The geological and geomorphological features range from moderate local examples of fairly common features to excellent examples of features that have national significance (Table 6).

5.1 BEDROCK EXPOSURES

In total 17 locations where bedrock is exposed have been identified as locally important geodiversity sites. These exposures together display a broad range of features characteristic of the Carboniferous sedimentary strata and igneous rocks that underlie Glasgow and the wider Midland Valley area.

Important lithostratigraphic horizons and good examples of the coal cyclothems that have been mined and quarried for coal, ironstone, limestone and sandstone throughout Glasgow are seen in several river gorge sections. The oldest sedimentary strata, the volcaniclastic sediments of the Kirkwood Formation are exposed along the Kittock Water at the southern edge of the GCC area (GGS_2). Coal and ironstone bearing strata of the Lower Limestone Formation are seen along the Levern Water in Househill Park (GGS_3). Coal-bearing sandstone and mudstone strata of the Limestone Coal Formation are well exposed along the gorge of the River Kelvin (GGS_4, 5 and 10). Several key limestone horizons of the Upper Limestone Formation, as well as intervening strata, can be seen in Waulkmill Glen SSSI (GGS_13). The youngest well-exposed sedimentary strata seen in the area are the coal bearing mudstone, siltstone and sandstone of the Scottish Middle Coal Formation measures exposed in Newlands Glen (GGS_16) at the eastern edge of the GCC area.

The microgabbro of the Midland Valley Sill Suite is exposed in numerous places within Glasgow as the resistant rocks form topographic high points that protrude through overlying superficial deposits. The contact between these intrusive igneous rocks and underlying sedimentary strata is exposed at Fossil Grove quarry (GGS_6), Linn Waterfall on the White Cart Water in Linn Park (GGS_9) and in the M8 Gartcraig Road section (GGS_15), although direct access to the latter site is restricted.

The palaeontological site of Fossil Grove has been recognised as an important geological site since its discovery in 1887 and has been designated as a SSSI. We highlight the importance of the overlying igneous sill in providing the context and setting for the Fossil Grove SSSI and include the quarry area, in which the sill is well exposed, as part of the locally important geodiversity site (GGS_6). A further paleontological site has been identified through this audit, comprising a petrified tree stump that has been placed as a feature in Househill Park (GGS_20). Although informal accounts highlight aspects of the local historical and cultural significance of the fossil tree, there has been no previous formal recognition of the geological significance of the feature. It is thought to be one of the largest examples of a fossil tree stump from Carboniferous strata in the Midland Valley. Consideration should be given whether the fossil tree might be safer rehoused in a museum.

5.2 SUPERFICIAL DEPOSITS AND GLACIAL LANDFORMS

A further two sites that provide examples of glacial landforms and terrains have been identified. The topography in much of the central Glasgow area is strongly controlled by landforms produced by glacial deposition and moulding of sediments. Examples of glacial drumlins can be seen in many of Glasgow's parks, and within some urban and residential areas. In the vicinity of the River Clyde and its estuary interdrumlin areas were inundated by the sea at times of higher sea level, resulting in deposition of raised marine and estuarine sediments forming flat terrain as can be seen in Bellahouston Park (GGS_18). Away from the Clyde, interdrumlin hollows commonly contain lakes or have been filled by lacustrine and peat deposits forming important wetland habitats. The Seven Lochs Master Plan Area (GGS_19) links together a range of these glacial features, forming an ecological 'corridor' in the north-east of Glasgow.

Although Glasgow is largely covered by superficial deposits few permanent sections through these sediments are found. Sections in glacial till and alluvial deposits can be seen overlying bedrock exposures in river-cut sections in Newlands Glen (GGS_16) and along the Levern Water in Househill Park (GGS_3), the latter also contains good exposures of artificial ground. However there are no sites which can be designated purely on the basis of superficial deposit exposures and knowledge of the deposits and their stratigraphy is largely based on borehole records and accounts of temporary sections documented in published literature and unpublished BGS reports.

5.3 ARTIFICIAL DEPOSITS, MINING AND QUARRYING

Many of the sites provide evidence of human interaction with and exploitation of the geological features and resources of the Glasgow area. Several of the bedrock sections and exposures identified are located in disused quarries as well as in road and railway cuttings, many of which are still in use (GGS_6, 7, 11, 12, 14, 15, 17). Evidence for historic mining is seen in the form of disused adits and shafts at some sites (GGS_5, 8 and 13). Sections through made ground consisting of spoil from ironstone and coal mining are well exposed in the banks of the Levern Water in Househill Park (GGS_3).

Site No.	Site name	Feature Type	Feature(s)	Overall Rating	
				Quality	Rarity
GGS_1	Cathkin Braes	Bedrock exposure	Clyde Plateau Volcanic Fm	Good CVDPA example	Local to regional (Glasgow/CVDPA)
GGS_2	Kittock Water	Bedrock exposure	Kirkwood Fm	Good CVDPA example	Local to regional (Glasgow/CVDPA)
GGS_3	Levern Water - Househill Park	Bedrock exposure	Lower Limestone Fm	Good CVDPA example	Local to regional (Glasgow/CVDPA)
GGS_4	River Kelvin - Belmont Bridge	Bedrock exposure	Limestone Coal Fm	Moderate CVDPA example	Local (Glasgow)
GGS_5	River Kelvin - Botanic Gardens	Bedrock exposure	Limestone Coal Fm	Good CVDPA example	Local to regional (Glasgow/CVDPA)
GGS_6	Fossil Grove SSSI and Quarry	Bedrock exposure	Limestone Coal Fm, igneous sill and palaeontology	Fossil Grove: World Class example Quarry: Good Midland Valley example	Fossil Grove: National (UK/Scottish) Quarry: Regional (Midland Valley)
GGS_7	Nitshill Station	Bedrock exposure	Limestone Coal Fm	Moderate to poor CVDPA example	Local (Glasgow)
GGS_8	Linn Park - Holmwood House	Bedrock exposure	Limestone Coal Fm	Good CVDPA example	Regional (Midland Valley)
GGS_9	Linn Park - Waterfall	Bedrock exposure	Limestone Coal Fm and igneous sill	Good Midland Valley example	Regional (Midland Valley)
GGS_10	River Kelvin - Dawsholm Park	Bedrock exposure	Upper Limestone Fm	Good Midland Valley example	Local to regional (Glasgow/CVDPA)
GGS_11	Possil Road Aqueduct	Bedrock exposure	Upper Limestone Fm	Good Midland Valley example	Regional (Midland Valley)
GGS_12	Merrylee Road	Bedrock exposure	Upper Limestone Fm	Moderate to poor CVDPA example	Local (Glasgow)
GGS_13	Waulkmill Glen SSSI	Bedrock exposure	Upper Limestone Fm	Good Midland Valley example	National (UK/Scottish)
GGS_14	Necropolis	Bedrock exposure	Passage Fm and igneous sill	Good CVDPA example	Local to regional (Glasgow/CVDPA)
GGS_15	M8 Gartcraig Road Bridge	Bedrock exposure	Scottish Middle Coal Measures Fm and igneous sill	Good CVDPA example	Local to regional (Glasgow/CVDPA)
GGS_16	Newlands Glen	Bedrock exposure	Scottish Middle Coal Measures Fm	Good Midland Valley example	Regional (Midland Valley)
GGS_17	Court Knowe	Bedrock exposure	Intrusive igneous sill	Good CVDPA example	Local (Glasgow)
GGS_18	Bellahouston Park	Quaternary landforms	Quaternary landforms	Moderate CVDPA example	Local (Glasgow)
GGS_19	Seven Lochs Master Plan Area	Quaternary landforms	Quaternary landforms	Good CVDPA example	Local (Glasgow)
GGS_20	Househill Park Fossil Tree	Fossil feature	Palaeontology	Good Midland Valley example	Regional (Midland Valley)

Table 6 Summary of ratings for Glasgow Geodiversity sites (Note 'Fm' is an abbreviation of Formation).

Appendix 1 Extended site list

As described in sections 1.2 and 3.1 the Geodiversity Audit Sites selected for this study were identified following an initial assessment of previously recognised geological/geomorphological sites within the city of Glasgow, and a number of additional potential sites identified by a variety of people and sources. These were entered into a spreadsheet, duplicated sites were removed and a desk study, focussing on bedrock exposures and Quaternary landforms, allowed us to prioritise 26 sites for field assessment and auditing. These sites were selected to provide as full a representation of the geological and geomorphological sequence of the area as practical, and to give a good geographical spread. Following field inspection, six of these sites were removed due to poor or no exposure - these are listed under "Sites visited (not included in audit)" in the table below.

The resulting list of 20 Geodiversity Audit Sites represent the best geodiversity sites identified within the limited timeframe and resources available for the project. The list is not exhaustive, and it is possible that additional or better exposures may exist or be created (for example as a result of future development). In order to capture all proposed localities, a number of additional sites are presented below, this includes sites which were brought to our attention retrospectively or where there was insufficient time to visit them – listed under "Sites not visited".

Key boreholes which give a stratigraphic framework for the sites audited, a selection of key buildings which represent the diversity of local building stone used in the city and museum collections where local and exotic specimens are housed are also listed. These latter categories are discussed further in Appendices 2 to 5.

GCC Geodiversity Audit Sites				
Site No.	**Site name**	**Easting**	**Northing**	**Main geological unit and/or features**
GGS_1	Cathkin Braes	261814	658558	Clyde Plateau Volcanic Formation
GGS_2	Kittock Water	258653	657150	Kirkwood Formation
GGS_3	Levern Water- Househill Park	252234	661206	Lower Limestone Formation
GGS_4	River Kelvin - Belmont Bridge	257539	667238	Limestone Coal Formation
GGS_5	River Kelvin - Botanic Gardens	256903	667861	Limestone Coal Formation
GGS_6	Fossil Grove SSSI and Quarry	253781	667334	Limestone Coal Formation, sill and palaeontology
GGS_7	Nitshill Station	252322	660141	Limestone Coal Formation
GGS_8	Linn Park - Holmwood House	258662	659605	Limestone Coal Formation
GGS_9	Linn Park - Waterfall	258170	659298	Limestone Coal Formation and sill
GGS_10	River Kelvin - Dawsholm Park	255917	669709	Upper Limestone Formation
GGS_11	Possil Road aqueduct	258690	667058	Upper Limestone Formation
GGS_12	Merrylee Road	257220	660235	Upper Limestone Formation
GGS_13	Waulkmill Glen SSSI	252181	658401	Upper Limestone Formation (Calmy Limestone
GGS_14	Necropolis	260445	665471	Passage Formation and sill
GGS_15	M8 at Gartcraig Road	264080	666093	Scottish Middle Coal Measures Formation and sill
GGS_16	Newlands Glen	269529	663294	Scottish Middle Coal Measures Formation
GGS_17	Court Knowe	258814	660016	Intrusive igneous sill
GGS_18	Bellahouston Park	254935	663803	Quaternary landforms (drumlin and raised marine deposits)
GGS_19	Seven Lochs Master Plan	263874	667214	Quaternary landforms (drumlins and peat filled

	Area			hollows)
GGS_20	Household Park Fossil Tree	252561	661256	Paleontology
Sites visited (not included in audit)				
	Drumry Wood, Bearsden	250864	671690	Quaternary deposits (no exposure)
	Provanmill recreation ground	263396	667163	Igneous sill (poor exposure)
	Cowlairs railway cutting	260420	667720	Upper Limestone Formation (no accessible exposure)
	Anniesland playing fields	254200	668570	Quaternary landforms (poorly exposed)
	River Levern (Pinmore Street)	251689	660583	Lower Limestone Formation (limited exposure, poor access)
	White Cart Water, Millbrae Road	257580	661050	Upper Limestone Formation (limited exposure)
Sites not visited				
	Queen Street Station cutting	259222	665636	Upper Limestone Formation
	Pollock Park	255330	662350	Quaternary landforms (drumlin and raised marine deposits)
	Mine Workings: Glasgow University Chemistry Department	256600	666710	Limestone Coal Formation
	River Kelvin (Garscube to Partick)			Quaternary landform (gorge)
	Crow Hill, Millichen	256865	672615	Quaternary landforms and Antonine Wall
Boreholes				
	Bridgeton	26121	66367	Quaternary deposits
	Broomhill No. 2 (Pinkston Drive)	25989	66652	Quaternary deposits
	Bellahouston Park			
	Alexandra Parade	26176	66566	Scottish Lower Coal Measures, sill, Passage Fm
	Hurlet	25111	66123	Lawmuir Fm; Hurlet Limestone
	Maryhill	25718	66856	Limestone Coal Fm, Lower Limestone Fm
	Corkerhill	25411	66237	Limestone Coal Fm
	Shettleston	26307	66414	Scottish Upper & Scottish Middle Coal Measures Fms
	Prospecthill	25999	66184	Scottish Upper Coal Measures Fm
	Lawmuir	25183	67310	Lower Limestone, Lawmuir, Kirkwood Fms
	Wellpark	26082	66516	Scottish Lower Coal Measures Fm, Passage Fm, sill
Building stones				
	Western Infirmary buildings			Auchinlea Sandstone
	Glasgow University			Gilmorehill and Giffnock Sandstones
	Former Post Office (George Square)			Giffnock Sandstone
	Kelvingrove Museum interior			Giffnock Sandstone
	Former Stock Exchange, Buchanan Street			Overwood Sandstone
	Hutcheson's Hall			Possil and Woodside Sandstones
Museum collections				
	Hunterian Museum			
	Kelvingrove Museum			

Appendix 2 Boreholes and subsurface data

The bedrock exposures identified within Glasgow generally display one to two rock units and thus individual sites give limited information regarding the rock sequence. In addition, the exposed rocks generally consist of the more resistant rock types (sandstones and igneous intrusions) and weaker rocks such as siltstones and mudstones, which make up most of the rock sequence, are consequently under-represented in the audit

Similarly, exposures of Quaternary and Anthropocene (man-made) deposits are rare, despite their extensive nature and great thickness in some areas. Their extent can be mapped principally by landforms, but their thickness and internal character can remain largely unknown, any sections exposing these deposits are generally small and/or temporary due to their unconsolidated nature.

However, the vast amount of re-development across Glasgow over recent years, despite physically concealing the underlying geology, has provided an invaluable resource in the form of an extensive borehole dataset, which, together with mine plan information from historic mineral extraction, gives us a detailed picture of what lies beneath the surface. This information not only allows us to place the 'snapshot' exposures visible at the surface into context, in the full geological sequence, but allows us to visualise the geology in 3D. A selection of the 'best' (deepest and/or most detailed) boreholes across the city, can be brought together to illustrate the full superficial and bedrock sequence beneath the surface of Glasgow and additionally show the lateral variations in this sequence across the city.

In addition to the table in Appendix 1 which includes some key boreholes, the table below lists all the BGS 'Golden Spike' boreholes within Glasgow City Council area, which extend more than 10 metres below the ground surface (borehole names in **bold** text are more than 300m deep). Some of these boreholes record the 'type section' for a particular part of the stratigraphy (bedrock or superficial), and as such have regional or national significance. For example, 'Cardowan No 2 Bore' records the type section for the upper part of the Limestone Coal Formation.

BOREHOLE NAME	EASTING	NORTHING	LENGTH (m)	BGS ID
NEWLANDS BORE, POLLOK ESTATE	256675	660590	292	1068183
BOGLESHOLE DYKE, SOUTH SIDE	264130	661565	296	1080107
BOGLESHOLE PIT 4	264370	661680	215	1080138
PROSPECTHILL NO1 BOREHOLE	259990	661845	160	1068691
NO2 PIT+BORE TITWOOD COLLIERY	256940	662640	390	1068211
POLLOKSHAWS ROAD 1	257885	662698	33	1068932
DALMARNOCK	261180	662710	295	1079959
GOVANHILL 3	258790	662810	48	1068813
POLLOKSHAWS RD 1 GLASGOW	258050	662950	26	1068930
POLLOK	256805	662960	182	1067892
ALBERT DRIVE 8 (AREA 3)	257980	663240	43	1069089
GLASGOW GREEN 1 GLASGOW	260062	663480	76	1081387
BORE AT GOVAN IRONWORKS,GLASGOW	259105	663545	265	1068130
LANCEFIELD FORGE	257870	664060	205	1067874
SHETTLESTON NO.2 BORE (IGS)	263065	664145	116	1080930
CAMLACHIE STUDY AREA, GLASGOW R15	261770	664280	44	12841339
BROWNS STARCH WORKS	257170	664730	226	1067869
CROWN BREWERY	261310	664770	112	1079584
THREESTONEHILL	264500	664800	181	1079883

QUEENSLIE NO3 BORE	267560	664900	716	1020966
PRINCES DOCK GLASGOW (VOLUME 2) 3	257030	665020	28	1089663
CUILHILL BORE	270127	665052	757	953200
BEATTIES BAKERY, DENNISTOUN	261855	665125	240	1073841
MARYVILLE LINK 51	269744	665190	19	1011138
DRYGATE BORE AT 134	260340	665230	121	1073898
WELLPARK BREWERY	260570	665230	319	1073837
ALEXANDRA PARADE 1GS	261765	665660	235	1074340
QUEENSLIE NO4 BORE	264640	665975	732	1073964
QUEENSLIE BRIDGE BORE (NO 1)	266300	666030	682	1010187
COMEDIE BORE	264970	666675	109	1073756
KEPPOCHILL ROAD B	259340	667030	25	1089290
KEPPOCHILL ROAD A	259360	667030	22	1089289
CARDOWAN NO 2 BORE	267060	667520	551	1010168
BALGRAY 1	261300	667600	198	1073410
POSSIL PARK NO.2	259450	667850	31	1089310
LANDS OF MILTON NO3 BORE	263550	667880	491	1073417
GARRIOCH RD 3 GLASGOW	257010	667886	25	1089205
POSSIL PARK NO.1	259410	667910	28	1089309
SARACEN ST 12 GLASGOW	259000	668000	17	1089092
BEACONSFIELD ROAD 1	255970	668240	48	1089294
STRATFORD ST 1 MARYHILL	257102	668262	13	1089094
MARYHILL BOREHOLE	257178	668558	306	1088944
BALMORE PLACE 15 GLASGOW	258848	668608	22	1089189
BALORNOCK DIAMOND	262340	668750	357	1073414
CUMLODDEN DR 3	256459	669251	30	1089218
BLACKHILL 16	257880	671520	41	925751

Public online access to a selection of BGS datasets is possible using the map-based Onshore GeoIndex on the BGS website (http://www.bgs.ac.uk/geoindex/). This includes the geographical location, metadata and downhole information for approximately 850 000 (>35 000 of which are within the GCC boundary) borehole records held by BGS. A search can also be made to find out if there are any associated samples or drill core material held in the BGS archives. Access to borehole records and any associated samples can be arranged by contacting the BGS Enquiries Service.

Appendix 3 Buildings and building stones

Most of Glasgow's traditional buildings are constructed from stone. Much of the stone was obtained from local quarries, in particular the blonde and buff sandstones that give character to much of the city. This means that many of Glasgow's buildings directly reflect the geology underlying the city, much of which is no longer visible. A number of major quarries (and mines), for example at Giffnock and Bishopbriggs, produced exceptionally high quality stone that was used for prestigious buildings and was also exported to cities such as Belfast. Early and less important buildings typically used stone from very local sources, for example the highly distinctive 'wispy' bedded sandstone that characterises buildings in the Blythswood area. Different parts of the city reflect the different local quarries that were active at a particular time

(Hyslop et al., 2006). All of the quarries are now closed and infilled with no visible outcrop, although many are documented. Records also exist for the sources of stone used in many of Glasgow's best-known buildings. Other stone types, in particular basaltic igneous rocks, were extracted from within the city, for example at the Necropolis, and used extensively for street paving (setts and kerbstones). Although these rocks are not strictly 'in situ', they provide an accessible and valuable resource to illustrate some of the geological diversity lying directly beneath the surface. More information on Glasgow's building stones is given in the booklet Building Stones of Glasgow (Lawson, 1981).

Appendix 4 Museums and collections

The Hunterian and Kelvingrove museums both contain large collections of general geological interest as well as much local material, including the 'Bearsden shark' collected by S.P. Wood. An overview of the geological specimens held at the museums is given in Lawson and Weedon, (1992). These collections are considered a useful tool to stimulate the public to learn more about their local rocks and landscape, and enhance their understanding of the importance of geology.

Appendix 5 Local interest groups and webpages

Strathclyde Geoconservation: http://www.geologyglasgow.org.uk/geoconservation/strathclyde/

Glasgow Necropolis (GCC): http://www.glasgow.gov.uk/index.aspx?articleid=6581

Friends of the Necropolis: http://www.glasgownecropolis.org/

Dams to Darnley Country Park: http://www.damstodarnley.org/

Friends of Linn Park: http://friendsoflinnpark.btck.co.uk/

Friends of the River Kelvin: http://www.fork.org.uk/

Friends of Victoria Park: http://www.fovp-glasgow.co.uk/

An account of the Nitshill mining disaster: http://scottishmining.co.uk/27.html

Scottish Geodiversity and Local Nature Conservation Site Systems (SNH guidance document):

http://www.snh.org.uk/publications/on-line/heritagemanagement/LNCS/default.asp

Appendix 6 GCC Assessment Criteria and Guidance

Map, Location and Boundary Suggestions

1. The location of the important geodiversity site or feature should be clearly marked on a map.

2. A suggested boundary for each site should be supplied which shows the **minimum** anticipated to **protect the site**. This should be clearly labelled on the map.

However, having been on site it would appear that a wider boundary might also be useful (to either protect the sites visual or other setting or to provide a buffer from potential impacts) then please clearly mark and distinguish this on the map as well. The reason why this might be useful should be outlined in an accompanying explanatory note.

3. If part of the site is included within the boundary solely to provide the setting for another feature or site then please mark this seperately and explain this in a note.

4. Where there are two sites/ features close together (or within a similar setting) then please supply separate individual boundaries for **each** of them on the map (even if there is overlap between any of their suggested boundaries).

If there is any geological relationship or connection between them then please explain this in the site descriptions.

If it appears that there might be some merit in combining sites into a single site in future please explain this in the site descriptions and give a reason why. This also applies to combining it with any cross boundary sites that the audit has identified.

5. If the site is large or elongated, then clearly mark the boundary of the larger area on the map but also describe how it could be potentially be subdivided into distinct areas of geological importance. The boundary for these subdivisions should also be marked on the map and accompanied by an explanatory note.

Again, for all of these boundaries they should in the first instance be the minimum needed to protect the important geology of each area. Any other boundaries suggested for a different reason should be treated seperately.

If you are not sure if a site is large enough to be subdivided then please favour sudividing it if possible. Separate maps are welcome.

For the larger or more elongated sites please mark on the map if there are places where its distinctive features or values are easier to see or get access to.

6. Where other sites that have value for geodiversity (particularly if they are described in this audit) are present within 500m of the margin of the OS Map Extract being used for a particular site then their presence is to be noted. Please also indicate where they are, which direction they lie in and include the site identifier and an OS grid reference given (if known). Please feel free to include another map if it is helpful.

7. Where a site is part of a wider Network of sites or it lies within a particular terrain type, then also show on the map:

- This network (and any obvious physical links between them); and
- The extent of the terrain on a map. This may require the inclusion of an additional OS Map Extract at a larger scale; with explanatory notes. Where it information about the terrains is available then this should be reasonably accurate. However, in some cases this might have to be just a guide. Please state clearly on the map which it is and cross reference it to the source of information.

Site Photos

Please include photos, and briefly describe here what they indicate- with cross referencing to the rest of the form. Photos should also be used to indicate the condition of features if appropriate.

GGS1: GeoScientific Merit and Value

Scales/ context for describing Rarity and Quality

- **World** Class.
- **UK/Scottish** significance or value.
- **Regional** significance or value*.
- **Significance of value within the Glasgow and Clyde Valley Strategic Development Plan Area.**
- **Glasgow** citywide significance or value (i.e. within the Glasgow City Council Boundary).
- **Local Community/** area significance or value (identify which area you used) within Glasgow.
- **X-Boundary** significance or value where connected with sites in other local authorities or in relation to sites in their other Local Geodiversity Action Plans.
- **Not identified**

*Regional refers to the Midland Valley of Scotland (between the Southern uplands and the Highland Boundary Fault).

Literature and Collections:

Please indicate on the form if these are:

- Detailed studies;
- Interpretative material;
- Collected material;
- References in scientific literature; of
- If no information found/known.

Assessment of the Overall Relative GeoScientific Importance

1. The overall relative value of the site (or literature/collection) using the same scales/ context as above and provide a description of what it is that gives it this value.

2. When providing the assessment please consider:

- **all** of the scales above (including reference to its Glasgow context);
- how unique or outstanding it is;
- how representative it is;
- its contribution to the setting for other sites; and
- how well preserved it is and its role within networks or terrains etc.

3. Sites are to be formally assessed under this heading for importance **solely on the basis** of their Geoscientific merit and value. Please don't try to combine this with values talked about in other parts of

the form. Provision is made elsewhere on the form for comment on the other values (i.e. as described below) which may also make contribute significantly to enhancing a site's relative importance.

4. Although the assessment methodology is somewhat subjective, this guidance is provided to ensure that the assessment process is clear, consistent and will result in a robust and defensible justification for any future measures put in place to protect the sites.

Therefore, enough information should be provided to understand the relative importance of each individual site (at the various scales), its relative importance compared to other sites in the audit and for the larger sites the relative importance of each of its components. The latter will be particularly important for dealing with future planning applications which might potentially only affect part of the site.

Safety of Access/ Site Condition/ Fragility/ Threats/ Sensitivities	
Current condition and how clearly the values can be seen at the moment (close and at a distance)	If there is something which has been degraded but could potentially be improved to add value to the site or increase its importance then please include this.
Site fragility and sensitivities	This might include for example: • geohazards; • weathering/erosion; • natural overgrowth; • sample/fossil collecting; • dumping; • sensitivity; or • direct or cumulative impacts from development or other activities.
Other Current Site Values, Associations or Significance	
Scientific study and education	When describing education please differentiate between the different levels e.g. primary, secondary etc.
Associations with biodiversity or ecosystem and ecosystem services	This is about the role of the site in supporting these things which can be explored in more depth later. However, it would be useful if the audit is able to identify any connections at this stage.
Aesthetic, landscapes, Archaeology, History and cultural associations	This might also include the proximity or relationship to important sites such as scheduled ancient monuments where they are part of it setting.

Local Communities/ visitors and promoting public awareness	Please describe how it is currently used/ not used (if know) and to what extent how often e.g. daily use

Potential Opportunities for Using or Enhancing the Site

Once you have seen the site you may have some ideas about how the site could be enhance, the issues dealt with or value added to it. These are welcome and they might include:

- Improving site management and access;
- Potential ways to address any of the ways for the site fragility etc;
- Research or scientific study;
- Training or adult/Higher/ further/ primary or secondary school education (please distinguish between these);
- Promoting public awareness of geology and earth sciences in general or improving understanding of the site e.g. interpretation, trails;
- Cultural activities or enhancing understanding of the links with archaeology, historic sites, biodiversity or landscapes;
- Promoting health and well being;
- Environmental or other projects;
- Economic geology; or
- Multifunctional uses.

Glossary

Agglomerate	A coarse-grained rock made up of material ejected during a volcanic eruption.
Alluvial	Environments, actions and products of rivers or streams.
Basalt	A fine-grained, dark-coloured igneous rock composed of iron and magnesium rich minerals.
Bedding	A feature of sedimentary rocks, in which planar or near-planar surfaces known as bedding planes indicate successive depositional surfaces formed as the sediments were laid down.
Bedrock	A term used to describe unweathered rock below soil or superficial deposits. Can also be exposed at the surface.
Biological weathering	Biological processes and changes that contribute to the breakdown of rocks, for example tree roots or animal burrows.
Bioturbation	The disruption of depositional sedimentary structures by organisms e.g. activities such as burrowing.
Bivalve	Class of molluscs with paired oval or elongated shell valves joined by a hinge (e.g. mussels).
Brachiopods	A phylum of solitary marine shelled invertebrates, the shell is made up of two unequal valves.
Bryozoa	Tiny colonial animals superficially similar to coral. They date back to the Ordovician, 480 million years ago, to present day. Mainly living in a marine environment, they cover rocky surfaces like moss.
Calcareous	Containing calcium carbonate.
Carboniferous	A geological period [359–299 Ma] of the Palaeozoic Era preceded by the Devonian and followed by the Permian.
Chronostratigraphy	The branch of stratigraphy linked to the concept of time. Chronostratigraphical units are defined as bodies of rock that formed during a specific interval of geologic time. Chronostratigraphical units are thus special rock bodies that are conceptual, as well as being material.
Clast	Particle of broken down rock, eroded and deposited in a new setting.
Cyclothem	Repetitive sequence of marine and non-marine sedimentary strata indicating cyclic deposition regimes.
Columnar jointing	A type of jointing which looks like columns. Found in igneous rocks and results from the internal contraction during cooling of lava, as seen in the vertical columns of the Giant's Causeway, N. Ireland.
Conglomerate	A coarse-grained clastic sedimentary rock, a significant proportion of which is composed of rounded or subrounded pebbles and boulders.
Country rock	A general term used to describe any rock which has been penetrated by an igneous intrusion.
Crinoid	A sea dwelling creature (class Crinodea) which has survived since Ordovician times. They are known as sea-lilies and have three sections, the stem, the calyx and feather-like arms by which they collect food. There abundance in the Palaeozoic era has meant that their remains have formed large thicknesses of limestone due to their calcareous skeletons.
Cross-bedding	Sets of strata which are inclined to the general stratification of the beds. They dip in the direction of fluid flow at the time when the beds were laid down.

Devensian	The last glacial stage in Britain, lasting from around 70 000 BP (Before Present) to about 11,800 BP.
Devonian	A geological period [416–359 Ma] of the Palaeozoic Era preceded by the Silurian and followed by the Carboniferous.
Drumlin	A low, rounded, elongate hill of glacial till, which was moulded by glaciers passing over it. Drumlins are elongate in the direction of ice flow.
Dyke	A sheet-like body of intrusive igneous rock emplaced along a vertical or near vertical fracture, normally discordant to the structure in the country rocks..
Earth heritage	The geological and landscape heritage of an area. Used mostly in the context of geoconservation.
Earth science	Science related to planet Earth. Also known as geoscience. Includes disciplines such as economic geology, geochemistry, geomagnetism, geomorphology, geophysics, glaciology, hydrogeology, mineralogy, palaeontology, petroleum geology, petrology, stratigraphy, structural geology, engineering geology, sedimentology, seismology.
Extrusive	Describes igneous rocks that have been extruded onto the Earth's surface, rather than being intruded beneath the surface (intrusive).
Fault	A fracture in the Earth's crust across which the rocks have been displaced relative to each other.
Fault plane	A vertical or dipping surface of a fault.
Felsite	A general term used to denote pale-coloured, fine-grained igneous rocks.
Fireclay	A fine-grained sedimentary rock. It often contains fossil plant roots, commonly occurring beneath a coal seam. A fossil soil.
Fluvial	Referring to a river environment.
Fold	A bend in planar structures such as rock strata or bedding planes.
Fold axis	A line which lies parallel to the hinge line and marks the intersection of the axial plane with the hinge zone
Formation	The fundamental unit used in lithostratigraphy. Specific features distinguish one formation from another. Formations may be subdivided into members and several formations may constitute a group.
Freestone	Any fine-grained sandstone or limestone that can be sawn easily.
Geomorphology	The study of landforms and the processes that forms them
Glaciofluvial	Refers to sediments deposited by flowing glacial meltwater.
Glaciolacustrine	Refers to deposits and landforms derived from materials brought by glacial meltwaters into lake environments.
Holocene	The youngest epoch of the Quaternary Sub-Era. Covers the last 11 800 years. The concept of the Holocene ending at the end of the 18th Century is gaining ground, with the following Epoch termed the Anthropocene.
Igneous rocks	A rock that has formed from the cooling of magma (molten rock).
Intrusion	A body of igneous rock which has been injected as magma into existing hard rocks (country-rock). On cooling the magma is called an igneous intrustion.
Joints	A fracture, or potential fracture, in a rock adjacent to which there has been no displacement.
Lacustrine	Refers to a lake environment.
Limestone	Sedimentary rock composed mainly of calcium carbonate.
Lithology	The character of a rock expressed in terms of its mineral composition, structure,

	grain size and arrangement of its constituents.
Lithostratigraphy	The branch of stratigraphy concerned with the description of rock units in terms of their lithological features and spatial relationships
Ma	Abbreviation for megannum (or more correctly, megannus) meaning million years
Magma	Molten rock.
Massive	A term used to describe a thick rock unit without any stratification, jointing or fracturing.
Mass-movement	The down slope movement of earth material due to the force of gravity.
Meltwater	Water produced by melting of snow or ice.
Midland Valley	The Midland Valley of Scotland is the name given to the relatively low lying central part of Scotland, lying between the Grampian Highlands and Southern Uplands. Geologically it is bounded by the Highland Boundary Fault to the north and the Southern Upland fault to the south.
Moraine	Accumulations of material which have been transported and deposited by ice.
Permian	A geological period [299–251 Ma] of the Palaeozoic Era preceded by the Carboniferous and followed by the Triassic.
Phenocryst	Large crystals, usually of near perfect shape, which occur in a finer-grained groundmass in igneous rocks.
Pleistocene	A geological epoch [1.8Ma–11.5 ka] preceded by the Pliocene and followed by the Holocene. Part of the Cenozoic Era and Quaternary Sub-Era.
Point bar	An accumulation of material (usually sand and/or gravel formed on the inside of a river meander.
Porphyritic	The term applied to igneous rocks which contain isolated crystals, or phenocrysts, larger than those forming the main body of the rock.
Pyroclastic	Describes rocks that form directly by explosive ejection from a volcano.
Quartz	The mineral form of silicon dioxide (SiO_2). The most abundant and widespread of all minerals, it generally appears transparent or white and is hard enough to scratch glass.
Quaternary	A geological sub-era [1.8 Ma to present day] of the Cenozoic Era, following the Neogene
Reach	A stretch of river
River-cliff	A steep face in rock or unconsolidated deposits, located on the outside bend of a meander. Formed by continual undercutting of the face.
Ripple marks	Small scale ridges and troughs formed by the flow of water or wind over unconsolidated sandy or silty sediment. The fossilised equivalent of ripples found today on beaches and river sands.
Seatearth	A sedimentary rock underlying a coal seam representing an old soil that supported the vegetation from which the coal has formed.
Sedimentary rock	A rock formed in one of three main ways: by the deposition of the weathered remains of other rocks (clastic sedimentary rock); by the deposition of the results of biogenic activity; and by precipitation from solution. Four basic processes are involved in the formation of a clastic sedimentary rock: weathering (erosion), transportation, deposition and compaction.
Sill	A tabular igneous intrusion with concordant contacts with the surrounding country rocks
Spheroidal	A type of chemical weathering where jointed blocks of rock are slowly rounded

weathering	by the removal of their outer shells. Often known as onion-skin weathering and typically seen in igneous rocks.
Strata	Rocks that form layers or beds.
Stratigraphy	The definition and description of the stratified rocks of the Earth's crust.
Terrane	A fault-bounded body of rock of regional extent, characterized by a geological history different from that of contiguous terranes. A terrane is generally considered to be a discrete allochthonous fragment of oceanic or continental material added to a craton at an active margin by accretion.
Terrigenous	Derived from the erosion of rocks on land.
Throw	The amount of displacement on a fault.
Tuff	A rock formed of consolidated volcanic ash and fine-grained material ejected during a volcanic eruption. Finer grained than agglomerate.
Type section	The sequence of strata has been identified as the designated sequence for a given area, and serves as a standard of reference against which other sections are compared. This may be a sequence of strata referred to in establishing a stratigraphic unit and used to define the character or boundaries of the stratigraphic unit.
Unconformable	A term generally applied to younger strata that do not conform in position or that do not have the same dip and strike as those of the immediately underlying rocks. Also applies to the contact between unconformable rocks.
Unconformity	A surface of contact between two groups of unconformable strata. Represents a break in the geological record where a combination of erosion and lack of deposition was taking place.
Vein	A fracture in the rock infilled with secondary minerals, often quartz or calcite.
Vesicles	Small spherical or elliptical cavities in an igneous rock which represent bubbles of gas which existed in the hot magma. Before the gas could escape, the magma cooled and hardened, ‘trapping’ the gas bubbles in the rock.

References

British Geological Survey holds most of the references listed below, and copies may be obtained via the library service subject to copyright legislation (contact libuser@bgs.ac.uk for details). The library catalogue is available at: http://geolib.bgs.ac.uk.

BROWNE, MAE, DEAN, MT, HALL IHS, MCADAM, AD, MONRO, SK and CHISHOLM, JI. 1999. A lithostratigraphical framework for the Carboniferous rocks of the Midland Valley of Scotland.. *British Geological Survey Research Report*. RR/99/07.

BROWNE, MAE and MCMILLAN, AA. 1989. Quaternary geology of the Clyde valley. *British Geological Survey Research Report*. SA/89/1.

CLEAL, CJ and THOMAS, BA. 1995. Palaeozonic Palaeobotany of Great Britain. *Geological Conservation Review Series Vol. 9, Joint Nature Conservation Committee.Cambridge, Chapman &Hall.*

FORSYTH, IH, HALL, IHS, MCMILLAN, AA. 1996. Geology of the Airdrie District. *Memoir of the British Geological Survey*, Sheet 31W (Scotland). ISBN 0 11 884508 X

HALL, IHS, BROWNE, MAE, and FORSYTH, IH. 1998. Geology of the Glasgow District. *Memoir of the British Geological Survey*, Sheet 30E (Scotland). ISBN 0 11 884534 9

HYSLOP, EK, ALBORNOZ-PARRA, L, FISHER, LC and HAMILTON, SL. 2006. Safeguarding Glasgow’s stone built heritage skills and materials requirements: façade surveys and building stone analysis. *British Geological Survey Commissioned Report* CR/06/077

LAWSON, JA 1981. Building Stones of Glasgow. *Geological Society of Glasgow*. ISBN 0 902892 061

LAWSON, JD and WEEDON, DS. 1992. Geological Excursions around Glasgow and Girvan. *Geological Society of Glasgow*. ISBN 0 902892 09 6

SNH, 2006. Guidance on Establishing and Managing Local Nature Conservation Site Systems in Scotland. Local Nature Conservation Site Working Group Report.

SNH. 2009. Waulkmill Glen SSSI Site Management Statement.

WHYTE,MA. 2004. Midland Valley Basin. In British Lower Carboniferous Stratigraphy (P.J. Cossey, AE Adams, MA Purnell, MJ Whiteley, MA Whyte and VP Wright), *Geological Conservation Review Series No. 29, Joint Nature Conservation Committee.Peterborough. pp 13-102*

WILSON, RB. 1967. A study of some Namurian marine faunas of central Scotland. *Transactions of the Royal Society of Edinburgh*, Vol. 66 p445-490.