Engineering Geology Map of Belfast and Surrounding District

1:25,000 scale

0 5 10km

Bedrock

	Rock Type	Rock Description
	UBF / LBF / IB	Antrim Lava Group	Basalt with subordinate lithomarge horizons Interbasaltic composed of weathered lateritic clays
	UWLF	Ulster White Limestone Formation	Chalk with flint
	HBG	Hibernian Greensand Formation	Glauconitic sandstone
	WAMU	Waterloo Mudstone Formation	Mudstone and limestone
	PNG	Penarth Group	Interbedded mudstone and limestone
	MMG	Mercia Mudstone Group	Mudstone with thin sandstone and evaporite horizons
	SSG	Sherwood Sandstone Group	Sandstone with thin mudstone
	CONN	Belfast Group	Siltstone, mudstone and evaporite, with Magnesian Limestone
	HARB	Belfast Harbour Evaporite Formation	Limestone, evaporites and breccia
ENLER GROUP	COOL	Coolbeg Breccia	Breccia
ENLER GROUP	ENLE	Enler Group	Sandstone and breccia
HOLYWOOD GROUP (HOLY)	BCF	Ballycultra Formation	Limestone and mudstone
HOLYWOOD GROUP (HOLY)	CVS	Craigavad Sandstone Formation	Sandstone with conglomerate intervals
	GALA	Gala Group	Greywacke sandstone and mudstone
	LHG	Leadhills Supergroup	Greywacke sandstone and mudstone

On the main map, bedrock colours will not be visible where they are overlain by superficial deposits. Where this is the case, the bedrock should be identified by the code shown in the key. For presentation, some superficial deposits have been grouped by colour. These units may be identified by the symbol shown.

Igneous Intrusive Rocks

	Feature / Rock Type	Rock Description
	UDG / DUSI	Dykes, sills and plugs	Dolerite, lamprophyre and microgabbro
	UDG	Volcanic agglomerate	Basaltic agglomerate

Superficial Deposits

	Sediment Type	Sediment Description
	River alluvium	Silt and sand deposited by over-bank flow and channel migration
	River terrace deposits	Silt and sand
	Estuarine deposits	Tidal flat and tidal channel deposits: clay, silt and sand deposited by sediment mobilised within an estuary
	Marine beach deposits	Sand with some gravel, deposited at a modern marine shoreline, or during previous high sea level
	Marine deposits	Clay, silt and sand deposited in a contemporary marine setting, or during a previous marine high-stand
	Peat	Accumulation of partially-decayed plant matter, mostly mosses and sedges, in a low-oxygen, water-logged environment
	Glaciofluvial deposits	Sand and gravel laid down by meltwater flowing from the front of a glacier, and laminated silts and clays settling into ice-marginal lakes
	Till	Well-consolidated sediment composed of a wide range of grain sizes, ranging from clay to boulder (aka 'boulder clay'), derived from underlying bedrock and superficial deposits beneath a glacier

Mass Movement

Landslide complex	Unstable rock mass on hill slopes

Linear Features

- Base of lava flow
- Fault inferred, downthrow on crossmark side
- Fault inferred, downthrow unspecified
- Fault observed, downthrow on crossmark side
- Fault observed, downthrow unspecified
- Fault undifferentiated, inferred
- Fold anticline
- Fold syncline

Estuarine Clay Contours (Sleech)

- Thickness of unit in metres

Line of Section

A — B

About this map

This Engineering Geology Map of Belfast and Surrounding District is a second edition of the Special Engineering Geology Sheet (GSNI, 1971).

Geological mapping
The bedrock and superficial deposits linework shown on this map is based upon the Geological Survey of Northern Ireland (GSNI) 1:10,000 digital geological map which was compiled from GSNI re-survey mapping.

Contours
Depth to rockhead, depth to top of till, and estuarine clay contours presented in this map are calculated from borehole data held by the GSNI. These were interpolated, with positional error, using a kriging algorithm in the python module of ESRI's ArcGIS Pro. Contours are estimates only, based on available data.

The information shown on this map does not replace the need for site specific ground investigation and should be used only as a guide. Site specific information can be accessed though the GSNI GeoIndex and Data Catalogue.

Topographic mapping
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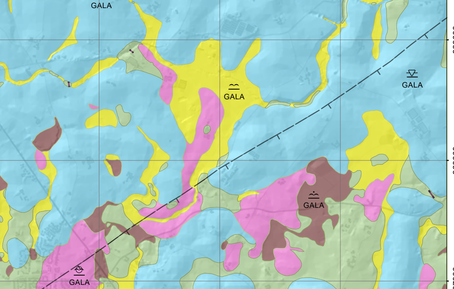

The extent of the main map is shown in red on the map of Northern Ireland.

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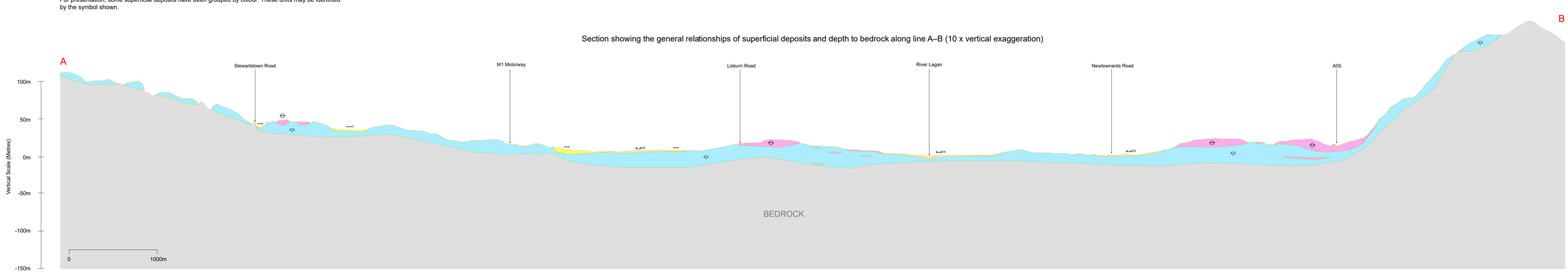
GSNI Geological Survey of Northern Ireland www.bgs.ac.uk/gsni

Section showing the general relationships of superficial deposits and depth to bedrock along line A–B (10 x vertical exaggeration)



Summary of the characteristics of the bedrock and superfical deposits

System	Rock Groups	Thickness	Rock and Deposit Types	Distribution and Structure	Geotechnical Properties	Groundwater (Wilson et al., 2023)
Holocene (Post–Glacial)	Estuarine Clay (Sleech)	0.5–15m	Grey sandy silt–clay with shelly layers and thin peat.	Weakly stratified deposits. Present in low lying areas of the Lagan Valley and Belfast Lough.	Typically soft or very soft. Highly compressible with very low bearing strength. Easy digging. Water sulphate content may be high, requiring sulphate–resistant cement.	Non aquifer.
	River Alluvium and River Terraces	0.5–6m	Silty fine sand with gravel to cobble channel bases.	Stratified to unstratified deposits, associated with the River Lagan and its tributaries.	Typically soft and compressible. Easy digging.	Superficial aquifer with intragranular flow. Limited potential due to thin deposits.
	Peat	0.5–7m	Organic.	Some localised thick deposits found in the depressions of glaciofluvial sands and gravels (kettle holes). Also in an impersistent layer about 0.3m thick at the base of the Estuarine Clay.	Highly compressible.	Non aquifer.
Pleistocene (Glacial)	Glacial Till (upper)	0.5–8m	Brown to reddish–brown plastic clay with a low stone content. Some laminated clay (glaciolacustrine) with partings and lenses of silt and fine sand.	Present in the Lower Lagan Valley, composed of reworked ice–contact and glaciofluvial deposits.	Typically firm to stiff with medium to low compressibility. Slightly over–consolidated. Easy to hard digging.	Non aquifer.
	Malone Sands	0.5–20m	Typically a stratified reddish–brown fine to medium grained, silty sand with subordinate gravel and occasionally laminated clay (glaciolacustrine).	Poorly to moderately stratified deposits, mostly confined to the Lagan Valley and extending into the Enler Valley.	Medium to low compressibility. Loose to dense, generally medium dense. May blow or run in excavations under hydrostatic pressure. Easy digging.	Moderate productivity, intragranular flow, relatively small volume aquifer.
	Glacial Till (basal)	Up to 51m	Silty reddish–brown clay, usually with a high stone and boulder content. Some sand lenses and laminated clays.	Present across much of the Lagan Valley and extending onto the higher ground of the Belfast and Castlereagh Hills. Matrix and clast supported basal till, poorly stratified. Drumlinised on Castlereagh Hills and Craigantlet. Thicker in valley bottoms, thinning onto higher ground.	Typically stiff to very stiff. Low compressibility. Easy to hard digging.	Non aquifer.
Palaeogene	Upper Basalt Formation, Lower Basalt Formation and Interbasaltic Formation	0.5–>300m	Dark grey to brown massive to vesicular olivine basalts. Interbasaltic composed of weathered lateritic clays.	Sequence of well–jointed lava flows confined to the Antrim Plateau escarpment north of the Lagan Valley.	Extremely weak to strong (0.6–100 MPa). Unweathered to destructured at rockhead. Excavatability ranges from hard digging to drill and blast depending on state of weathering.	Moderate productivity, fracture dominated, but highly variable.
	Intrusive Dykes and Sills	1–8m wide	Dark grey to green, basalts and dolerites.	Present across the region. Usually NW–SE to NNW–SSE orientated, well jointed, steeply dipping and associated with faults.	Extremely weak to very strong (0.6–250 MPa). Excavatability ranges from hard digging to drill and blast depending on state of weathering.	Limited aquifer potential, though associated faults may yield significant groundwater locally.
Cretaceous	Ulster White Limestone Formation	10–30m	White limestone and flint.	Confined to the Antrim Plateau escarpment, bedded, gently dipping white limestone with <10% flint content.	Weak to very strong (5–250 MPa). Unweathered and distinctly weathered where exposed. Rippable to drill and blast required for excavation.	High productivity fracture flow, with a karstic element.
	Hibernian Greensands Formation	0.5–22m	Glauconitic calcareous sandstones and siltstones.	Confined to the Antrim Plateau escarpment, bedded and gently dipping.	Extremely weak to medium strong (0.6–50 MPa). Unweathered to destructured at rockhead. Hard digging to ripping required.	Moderate productivity, intragranular flow, relatively small volume aquifer.
Jurassic	Waterloo Mudstone Formation	0.5–12m	Grey mudstones and shelly limestones.	Confined to the Antrim Plateau escarpment, bedded and gently dipping.	Extremely weak to strong (0.6–100 MPa). Unweathered to destructured at rockhead. Hard digging to ripping required.	Non aquifer.
Triassic	Penarth Group	0.5–14m	Mudstones and limestones.	Confined to the Antrim Plateau escarpment, bedded and gently dipping.	Extremely weak to strong (0.6–100 MPa). Unweathered to destructured at rockhead. Hard digging to ripping required.	Non aquifer.
	Mercia Mudstone Group	0.5–300m	Mudstones with thin sandstones and evaporite horizons.	Present in much of the Antrim Plateau Escarpment, extending into the northern slopes of the Lagan Valley. Bedded and gently dipping.	Extremely weak to weak (0.6–25 MPa). Unweathered to destructured at rockhead. Hard digging to ripping required.	Non aquifer.
	Sherwood Sandstone	0.5–300m	Red to yellow sandstones with thin siltstones and mudstones.	Forms the base of much of the Lagan and Enler valleys. Bedded and gently dipping.	Extremely weak to medium strong (0.6–50 MPa). Unweathered to destructured at rockhead. Hard digging to ripping required.	High productivity, intergranular and fracture flow. High to moderate yields.
Permian	Belfast Group	0.5–90m	Siltstones, mudstones and evaporites (Belfast Harbour Evaporite Formation) with Magnesian Limestone.	Present along the southern limits of the Lagan Valley, extending into the Enler Valley, and exposed at Cultra. Bedded and gently dipping.	Extremely weak to strong (0.6–100 MPa). Unweathered to destructured at rockhead. Hard digging to ripping required.	Non aquifer.
	Enler Group	0.5–9m	Pink to yellow sandstones and red to brown Coolbeg breccias.	Present along the southern limits of the Lagan Valley, extending into the Enler Valley, and exposed at Cultra. Bedded and gently dipping.	Extremely weak to medium strong (0.6–50 MPa). Unweathered to destructured at rockhead. Hard digging to ripping required.	High productivity, intergranular and fracture flow. Moderate to low yields.
Carboniferous	Ballycultra Formation	140m	Dark grey limestones and mudstones.	Exposed only near Cultra. Bedded and gently dipping.	Very weak to medium strong (1–50 MPa). Unweathered to distinctly weathered. Ripping to drilling and blasting required.	Poor productivity, fracture flow. Low yields.
	Craigavad Sandstone Formation	140m	Red to yellow sandstones with conglomeritic intervals.	Exposed only near Cultra. Bedded and gently dipping.	Very weak to to strong (1–100 MPa). Unweathered to slightly weathered. Ripping to drilling and blasting required.	Limited productivity, fracture flow.
Silurian and Ordovician	Gala Group and Leadhills Supergroup	>1000m	Grey micaceous grits, greywackes, slatey siltstones and mudstones. Minor intrusive dykes (Lamprophyres).	Forms the Castlereagh Hills and Craigantlet, steeply dipping, bedded and well jointed.	Weak to very strong (5–250 MPa). Unweathered to partially weathered. Ripping to drilling and blasting required for excavation.	Limited productivity, fracture flow.

Summary of the bedrock geology

The **bedrock geology** of the Belfast region is remarkably diverse and includes rocks that range in age from the Ordovician to the Palaeogene (450–60 million years old). South of Belfast, forming the Castlereagh and Craigantlet hills, the Ordovician and Silurian Leadhills Supergroup and Gala Group are composed of indurated, bedded, greywacke sandstones and slatey mudstones that are steeply inclined and complexly folded. In north Co. Down at Cultra, lower Carboniferous, generally indurated, bedded sandstones, limestones and mudstones of the Craigavad Sandstone and Ballycultra formations dip gently northwards into Belfast Lough. Also exposed at Cultra are the Permian Enler and Belfast groups are comprised of breccias, porous sandstones, limestones and evaporites. These dip gently northwards into Belfast Lough, extending southwest into the Lagan Valley and southeast into the Enler Valley and Strangford Lough. Forming the floor of the Lagan and Enler valleys, the Triassic Sherwood Sandstone Group is composed mostly of porous and permeable sandstones. These are excellent aquifers that provide opportunities for groundwater use and geothermal energy. Above the Sherwood Sandstone, forming the southern escarpment of the Antrim Plateau, the Mercia Mustone and Penarth groups are mostly non-aquifer mudstones with some evaporites and thin sandstone units.

Landslips are a common geohazard feature of the Antrim Plateau escarpment that are associated with the presence and outcrop of the incompetent Jurassic Waterloo Mudstone Formation. Failure and rotational slumping of overlying competent Ulster White Limestone Formation and Lower Basalt Formation blocks into the Waterloo Mudstone Formation is the main landslip driver. The Cretaceous Ulster White Limestone Formation is present towards the top of the escarpment north of Belfast and can be karstic. Naturally formed groundwater conduit systems within and springs towards the base of this rock unit are a common feature. The youngest Palaeogene Lower Basalt Formation is the capping rock formation of the Antrim Plateau and is composed of stacked basalt lava flows that are separated by palaeosoil horizons. Also formed during the Palaeogene, are numerous dykes and occasional sills, mainly of dolerite, that cut across pre-existing rocks. Dykes in this area trend mostly NW-SE to NNW-SSE, and are steeply dipping sheets (1–8m wide) that are often associated with faults. The dykes and faults can act as baffles and groundwater flow pathways.

Summary of the superficial geology

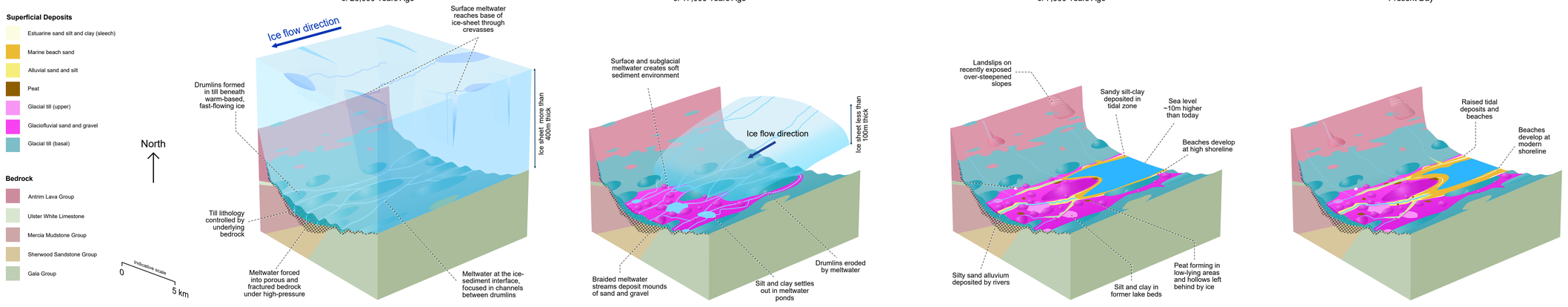
The **superficial geology** of the Belfast region is dominated by Pleistocene glacial deposits from the last glacial cycle, the Devensian (or Weichselian), forming sediments up to 45m thick in the Lagan Valley, and generally less than 1–2m thick on adjacent high ground. Till (formerly 'boulder clay') is primarily derived from rock strata immediately beneath an ice sheet (Dempster et al., 2013), although more resistant components (e.g. flint from the Ulster White Limestone) may be transported far from their point of origin. In the Lagan Valley, tills near the surface are often associated with the tectonism of glaciofluvial deposits. These were re-incorporated into the base of the ice sheet as the ice margin oscillated back and forth during a period of overall ice sheet retreat at the end of the last glacial cycle. Glaciofluvial sands and gravels are mainly restricted to the Lagan and Enler valleys, formed by braided meltwater rivers issuing from front of the ice sheet. This unit also includes laminated silts and clays settling out in small proglacial lakes. These clays and silts have been used in the past to make bricks.

The major landslips in Belfast occur on the eastern edge of the Antrim Plateau, and probably developed in the millennia immediately following the departure of the last ice sheet. During this time, a combination of the freshly exposed till deposits, over-steepened slopes, crustal rebound, and increase in ground temperature resulted in a high level of slope instability.

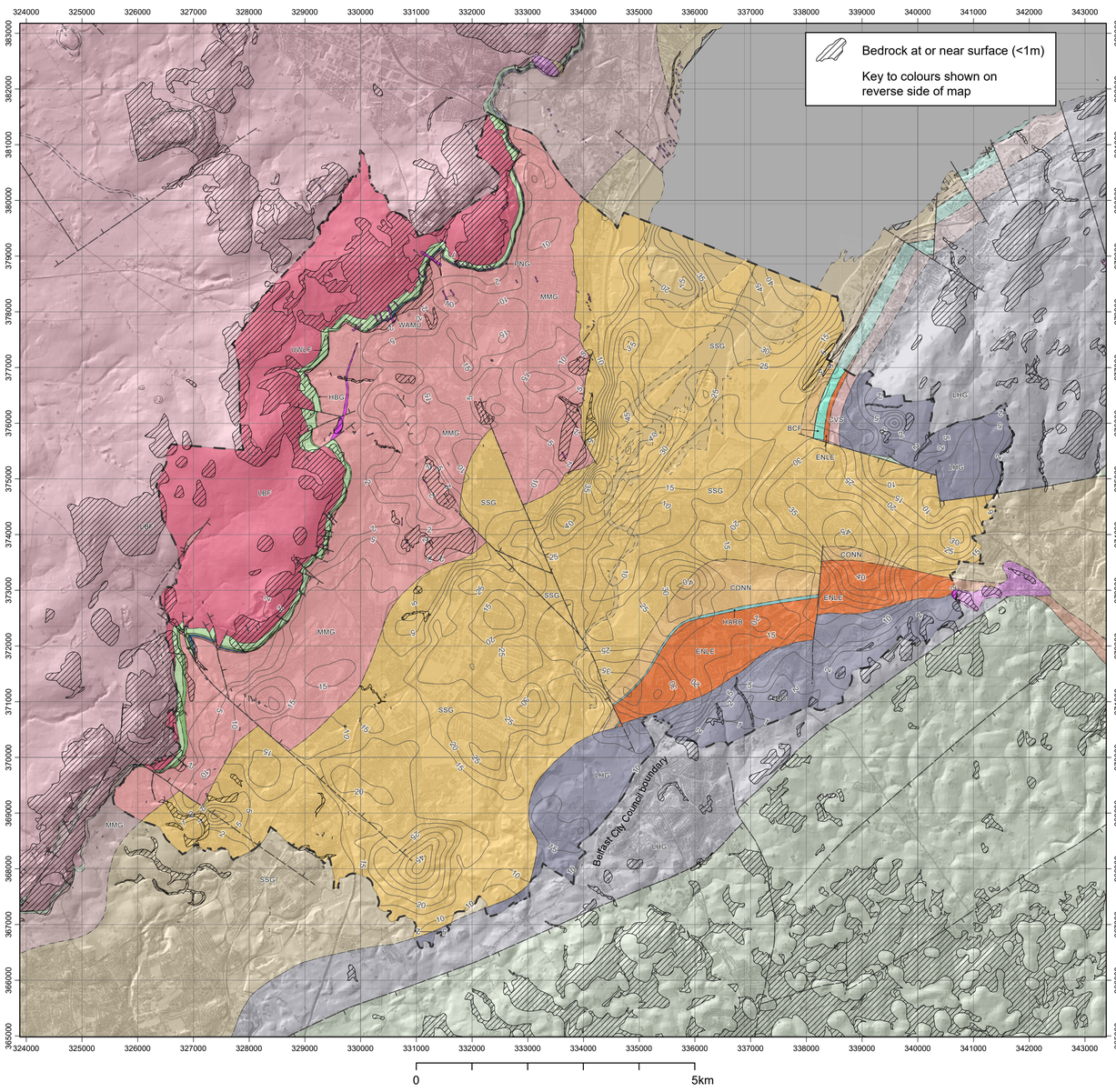
During the Early Holocene, Belfast experienced a relatively high sea level, peaking c. 7,000 years ago (Bradley et al., 2011), during which time estuarine clays and silts ('sleech') were deposited in the lower parts of the Lagan and Enler valleys. Around this time peat started to form in low lying areas within these valleys, within kettle holes left behind by the ice sheet, and in upland areas like the Antrim Plateau and Castlereagh Hills. River alluvium, composed of thin layers of sand and silt, is restricted to flood plains adjacent to modern river channels, as well as isolated terraces.

Conceptual Models

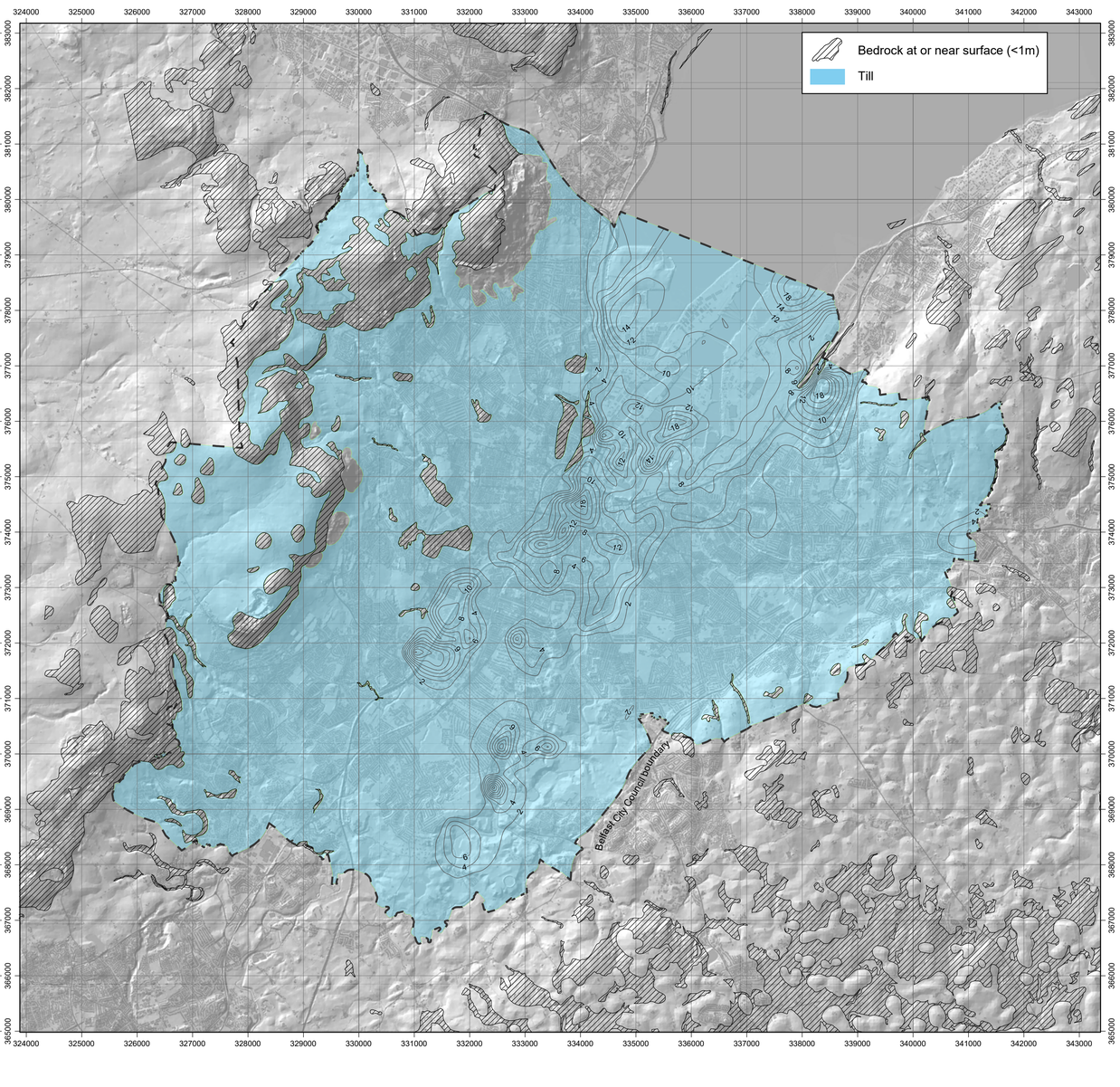
Illustrations of the hypothesised development of superficial deposits during the last glacial cycle ('Weichselian') and Holocene in Belfast at key time slices. Time slices are approximate, based on regional ice sheet advance and retreat patterns presented by Clark et al. (2021) and Hughes et al. (2016), and modelled sea level curves from Bradley et al. (2011).



Depth to rockhead (metres below ground level)



Depth to top of till (metres below ground level)



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