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Glasgow

TU1206 COST Sub-Urban WG1 Report

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The subsurface and urban planning in the **City of Glasgow**

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Cover image: the River Clyde in central Glasgow (Gillian Dick/Glasgow City Council)

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NATURAL ENVIRONMENT RESEARCH COUNCIL

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Table of Contents

1. Introduction

1.1. Overview

Glasgow, Scotland's largest city, lies along the River Clyde and its estuary in west central Scotland (Figure 1). The city grew rapidly in the 19th century, developing through industrialisation and trade to become the third largest city in Europe by the early 20th century. However, during the latter half of the 20th century a decline in heavy industries such as ship building and mining led to population decline, dereliction of land and social deprivation. Since the early 1980's, regeneration, restructuring and development have promoted an economic revival of the City. Regeneration of Glasgow's economy, environment and social fabric through the promotion of sustainable development, social renewal and improvements in health continue to underpin the planning strategies for the development of the City.

In Glasgow, the geographical and geological setting of the city, combined with the legacy of mining and heavy industry gives rise to a range of complex issues relating to the subsurface environment that affect development. Through collaboration between the British Geological Survey (BGS) and Glasgow City Council (GCC) there is increasing recognition that consideration of the subsurface environment within the development and planning processes in Glasgow is needed for the effective remediation and regeneration, hazard mitigation, the management of resources, and development of a sustainable economy.

In the absence of national legislation relating to the subsurface environment, developments in the application of subsurface data and spatial planning policy for Glasgow are arising through collaboration and partnership. Progress is being achieved through knowledge exchange initiatives, voluntary agreements and the use of contractual obligations to encourage private contractors to commit to share data in exchange for access to 3D subsurface information provided by BGS. The inclusion of geology and the subsurface in the new Development Plan for Glasgow (currently under consultation) reflects the growing awareness of policymakers of the importance of the subsurface environment and resources for the future development of the City.

1.2. City description[1]

Glasgow is located in the west of the Scotland, and forms part of an area known as the Central Belt, the most populated area of the country. It lies approximately 40 miles west of Edinburgh, the capital city of Scotland. The City of Glasgow covers an area of 176 square kilometres, and the Greater Glasgow Area, which includes surrounding metropolitan areas, is approximately 370 square kilometres (Figure 1, Figure 2).

1.2.1.Social

- Glasgow is the biggest city in Scotland with a recorded population within the City of Glasgow of 598,830 in 2011, and a population of nearly 1.2 million living in the Greater Glasgow Area. Almost 2.5 million people, half of Scotland's population, live within an hour of the City.
- Glasgow has the highest population density of any Scottish city, with 3395 people per square kilometre.

[1] Sources of information: Glasgow Economic Facts 2013, www.glasgoweconomicfacts.com; Glasgow for Business, www.glasgowforbusiness.com; General Register Scotland 2011 Census; Understanding Glasgow

- The number of households in Glasgow is predicted to rise by 28% in the next 25 years. It is predicted that single adult households will continue to rise and soon form the majority of households.
- Health in Glasgow has improved over a century or more and as a result, Glaswegians are living longer than ever before. However, the city has one of the poorest health profiles of any Scottish or UK city.
- The City has a relatively young population compared with the rest of Scotland, with a median age of 35 years and 68% of the population are of working age (between 16 and 65).

1.2.2.Environment, land use and infrastructure

- The total number of dwellings in the City of Glasgow is 301,513 (2012) with approximately 73% of these flats, reflecting the predominance of tenements in the City.
- Approximately 6 out of 10 Glasgow residents live within 500 m of derelict land, double the Scotland Average. Approximately 7.5 % (3.4 km^2) of Glasgow's land area is vacant or derelict and much has been this way for over 20 years. Contamination is one factor affecting the reuse of derelict land.
- Glasgow has the largest traffic volume of Scotland's local authorities. 41% of Glaswegians commute to work by car (as driver or passenger), 30% by public transport (by bus, train or underground) and 27% walk or cycle.
- The area of the city designated as greenspace is 3.3 km^2 (18.6%). There are over 1,800 listed buildings or structures and 23 Conservations areas and one proposed Conservation Area.
- Climate change predictions mean that there is a growing risk of flooding from various sources and major investment is needed in Glasgow's drainage networks over the next 50 years.

1.2.3.Economy

- Glasgow is the economic engine and main commercial hub, not only for the city region, but also for Scotland, generating £17 billion gross value added (GVA) to the Scottish economy each year.
- Glasgow has nearly 17,000 private registered enterprises which generate a turnover of £31,101 million, 5 universities and 7 further education colleges with 133,000 students from 135 countries.
- 60% of working age Glaswegians were employed in 2012/13, which was 11% lower than the Scottish average and lower than in other Scottish cities.
- Almost half of Glasgow's residents - 283,000 people - reside in the 20% of most deprived areas in Scotland.
- Glasgow has a large skilled and adaptable labour pool of over 400,000. A slightly higher proportion of working age adults in Glasgow had a degree or professional qualification (23%) than in Scotland as a whole, but the city also had a higher proportion of working age people without any qualifications (19%).
- 1.2 million people of working age live within a 45 minute commute of the City.

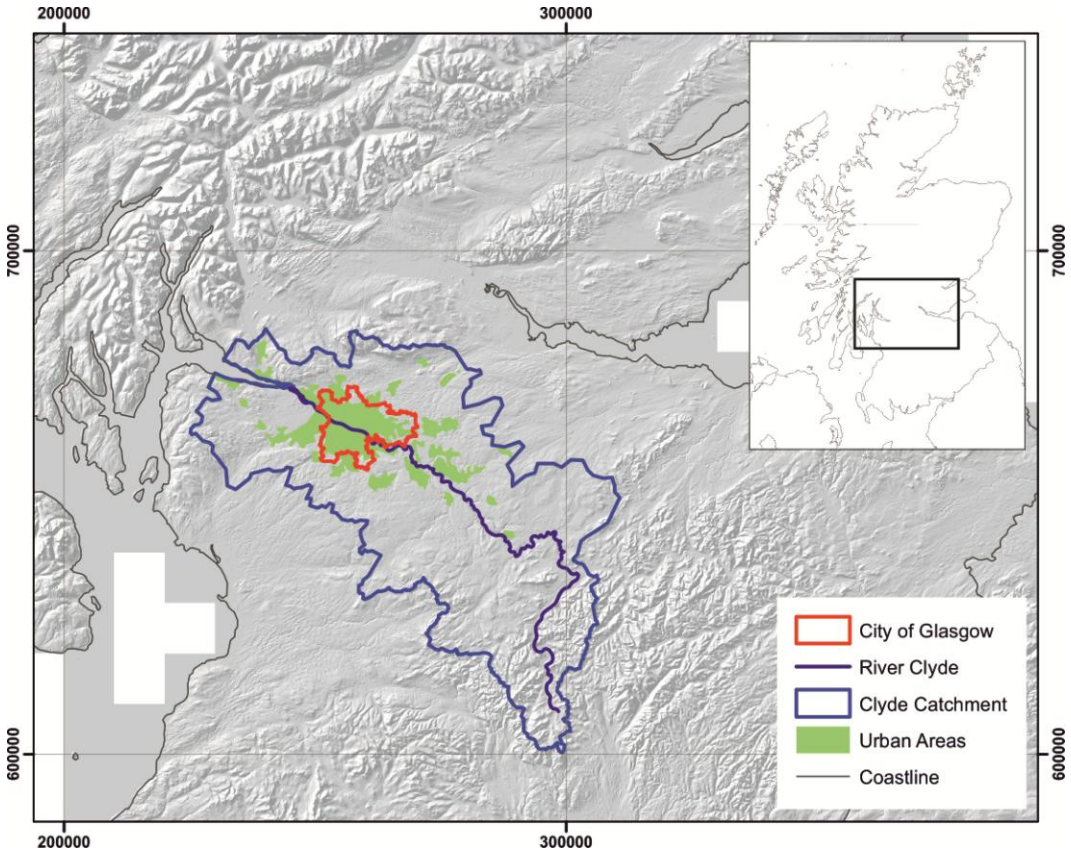

Figure 1 Map of central Scotland showing the location of Glasgow. The grid is British National Grid (scale in metres). The shaded terrain image is derived from the NEXTMap Digital Terrain Model at 50 m resolution (NEXTMap Britain elevation data from Intermap Technologies). The location of the main map in Scotland is shown in the inset map.

Figure 2 Map of Glasgow (Ordnance Survey Data © Crown Copyright and database rights 2014)

1.3. Geology and physical geography of Glasgow

1.3.1. Regional geological setting

The City of Glasgow lies in the west of the central lowlands, or Midland Valley, of Scotland. The Midland Valley is an area of generally low-relief terrain located between the mountainous Highlands to the north, and the hills of the Southern Uplands to the south (Figure 1). Geologically, the area of the Midland Valley corresponds to an extensional basin formed during Late Devonian and Carboniferous times. The ancient fault structures that constrain the northern and southern margins of this basin still control the large-scale form of the landscape of central Scotland (Figure 3), but the region is no longer tectonically active.

The Midland Valley formed an area of deposition during Carboniferous times (310 – 350 Million years ago) and the bedrock in the region is predominantly comprised of sedimentary strata with some extrusive and intrusive volcanic rocks (Figure 3). The 3 – 5 km thick stack of Carboniferous sedimentary rocks consists of varying sequences of sandstone, mudstone, siltstone and limestone with ironstone bands and coal seams. These rocks have provided valuable resources including coal, building stone and iron ore that supported the growth and development of Glasgow and the surrounding area.

The western part of the Midland valley is dominated by the catchment of the River Clyde, the third longest river in Scotland. The City of Glasgow straddles the lower part of the River Clyde and its estuary in the Inner Firth of Clyde, with the conurbation of the Greater Glasgow Urban Area covering much of the lower Clyde catchment (Figure 1). Several other rivers, tributaries to the River Clyde, traverse parts of the city, the most important being the River Kelvin in the north and the White Cart Water and Black Cart Water in the south.

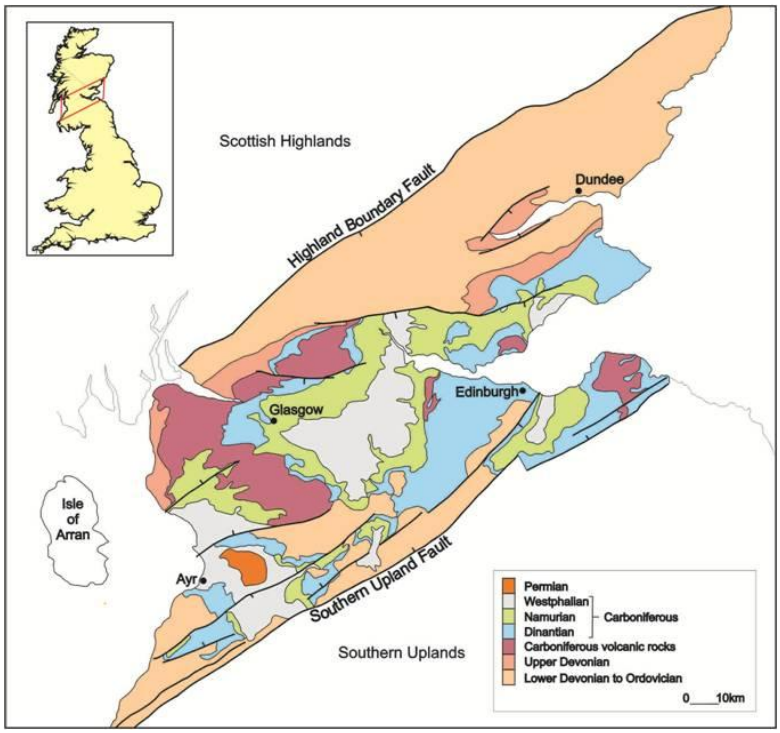

Figure 3 Simplified geological map of the Midland Valley of Scotland. Geological faults are shown by a thick black line with a tick on the downthrow side (Source: BGS DiGMapGB data).

1.3.2.Landscape history – processes and people

Glacial erosion over the past 2 Million years has resulted in preferential erosion of the softer sedimentary rocks in the Clyde basin. Resistant extrusive volcanic rocks form high ground to the north and south of the basin, and igneous dykes and sills form numerous smaller hills within the basin, many of which have been sculpted by glacial erosion. The latest glaciation to affect the Clyde valley occurred during the Late Devensian (c. 30 – 11.7 Ka). The glaciers deposited glacial till throughout the region, which was sculpted into rounded hills (drumlins) in many areas. These drumlins form distinct features within the City and have influenced the pattern of urban development.

Along the lower River Clyde and adjacent to the Clyde Estuary, glacial sediments have been overlain by raised marine deposits formed during periods of high relative sea-level soon after deglaciation. Fluvial and lacustrine sediments locally containing peat have also developed in many areas following deglaciation (since c. 11.7 ka).

Extensive industrial development and urbanisation has resulted in substantial modification of the ground surface in the City. The modifications include excavations associated with quarries and road and rail cuttings, and made and landscaped ground associated with former developments, waste from mine and quarry workings and embankments. Successive periods of development have resulted in several generations of modifications to surface deposits within areas of the City.

2. The urban subsurface environment

2.1. Landscape and terrain

Although generally low lying, the terrain of the Glasgow area is marked by the presence of steep hills formed by both resistant bedrock outcrops and rounded drumlins of glacial till. The drumlins have influenced the pattern of urban development; place names such as Yorkhill, Garnethill and Dowanhill reflect the influence of large drumlins in the western parts of the city. Hills formed on resistant volcanic microgabbro (dolerite) dykes and sills are commonly used as recreational grounds, and many were formerly worked for road stone. The most prominent of these hills is the site of the Necropolis, an important historic and cultural site, historically known as ‘the grey rock’ which is argued to be the source of the City’s name.

The undulating terrain means that many large industrial sites and infrastructure (road and rail) developments have required substantial landscaping work including the excavation of cuttings, tunnels and the construction of embankments and levelled platforms. Several motorways, including the M8, M77 and the recently extended M74, and many other major road routes traverse the centre of the City. The rail network in Glasgow comprises several active lines and many abandoned railway routes with derelict cuttings, embankments and tunnels.

Through the influence on shipbuilding and trade, the River Clyde has been central to the growth of Glasgow; however the river also forms a natural barrier between the northern and southern parts of the city. There are many road and rail crossings linking the two halves of the City, as well as road, metro tunnels.

2.2. The near-surface environment

2.2.1.Soils, artificial ground and superficial deposits

Glasgow is predominantly underlain by superficial deposits formed by deposition from glaciers and rivers, within lakes, and along the margins of the Clyde estuary under varying sea-levels. The highly variable nature of these sediments gives rise to a range of potential hazards which can lead to "unforeseen ground conditions" for construction and development projects. Running sand, compressible ground and shrink-swell clay hazards affect various parts of the City and are particularly associated with regions of alluvial and glaciofluvial deposits that flank the River Clyde and its estuary. This area, known as the 'Clyde Corridor', is designated as a target area for development and regeneration.

Industrial and infrastructure developments are commonly associated with areas of artificial ground. Made ground deposits are very variable in composition and may locally exceed ten metres in thickness. Made ground deposits commonly contain reworked superficial deposits, gravel, tarmac, wood, brick, ash and broken rock waste from mining activities. In places made ground and soil has been contaminated with heavy metals including lead and chromium as a result of historic industrial activity. Contaminated ground affects groundwater and is a major cause of long term dereliction of land in parts of the city (Figure 4 c and d).

Substantial areas of made ground occur along the margins of the lower River Clyde and its estuary where many docks for former ship yards were excavated into the banks of the river and have since been infilled and redeveloped. Other large areas of made ground are associated with industrial sites in the east of the city that are currently targeted for regeneration (Figure 4 d).

Figure 4 Photographs from Glasgow showing (a) groundwater flooding, (b) catastrophic collapse of a mine shaft resulting in loss of a drilling rig, (c and d) contaminated and derelict ground.

The thickness of superficial deposits in Glasgow is highly variable. The greatest thickness of sediment occurs in the north of the City, associated with a buried channel beneath the Kelvin River valley. The channel is defined by an irregular depression in the rockhead surface, probably a result of erosion by sub-glacial meltwater streams, in which the sediment thickness locally exceeds 80 m. Sediments 20 – 40 m thick also occur along the line of the River Clyde and occupy a broad valley likely to be related to pre-glacial drainage along the Clyde valley. Elsewhere local variations in sediment thickness over 1 – 10 m scales result from the presence of drumlins along with the irregular nature of the rockhead surface. Due to the significant change in properties from poorly consolidated deposits to resistant bedrock, knowledge of the level of rockhead is important for many construction and infrastructure projects.

2.2.2.Groundwater

Within the superficial deposits sequence, glaciofluvial sand and gravel deposits along the Clyde corridor through the centre of the City form the main shallow aquifer. The groundwater level is typically shallow, at approximately 3 m depth, meaning that the shallow aquifers are vulnerable to contamination from soils and surface water sources. Groundwater flooding is also a hazard in some areas of the city (Figure 4 a). Heavy metal contamination of soils as a result of historic industry, buried chromium waste and chromium contamination of the River Clyde are major potential sources of contamination of shallow ground water aquifers.

Sandstone units within the cyclic sequence of Carboniferous sedimentary strata form distinct aquifers in the bedrock underlying the City. Where unaffected by mineworkings these deep aquifers contain good quality groundwater; however where groundwater enters mineworkings it becomes contaminated. Seeps of contaminated groundwater from adits affect soils and surface water supplies in parts of the City.

In recent changes to the planning process, planning applications now require implementation of Sustainable Drainage Systems (SuDS) in new developments. These systems locally increase groundwater recharge to shallow aquifers, but little is known about the potential impact of this increased recharge on groundwater quality and flow. Recent modelling of groundwater by BGS is providing some insight into the potential impact of SuDS on groundwater flow in Glasgow.

2.2.3.Quarrying legacy

Quarrying of sandstone for building stone and microgabbro (dolerite) for road stone formerly took place throughout the City. Quarries were typically small and many have been infilled with waste material since they were abandoned and subsequently built over. The sandstone was used in many buildings within the Glasgow area. Sand and gravel, and clay (for brick making) were also formerly extracted from small pits in areas of the city.

2.3. Mining and the deep-earth environment

Coal, limestone and ironstone were formerly mined within the City. Glasgow lies within an area known as the Lanarkshire Coal Field, and coal mining began in the area over 300 years ago, with intensive mining taking place between the mid 1800’s and early 1900’s. The final coal mine in the city closed in 1966.

Shallow mine workings (within 30 m of rockhead) underlie many parts of the city. These workings are the result of the earliest mining activity in Glasgow, when coal and ironstone were extracted by the pillar and stall method (locally known as “stoop and room”) in which open galleries (stalls/ rooms) were worked and pillars (stoops) left to support the roof. In some mines, the pillars were removed at the cessation of mining, resulting in collapse of the workings, but in many mines the pillars and stalls were left intact when the mine was abandoned. The failure of pillars and the resulting mine collapse is a major cause of subsidence in areas of abandoned shallow mine workings within the City (Figure 4 b).

Mining in the late 1800’s to early 1900’s typically exploited coal seams at greater depths (100’s of meters) and was limited in extent compared to the early shallow mining. The deep mining utilised newer short/longwall extraction methods, in which the whole seam was extracted and controlled collapse of the roof of the mine was orchestrated as the mining progressed. In Glasgow, there are fewer subsidence issues related to this form of mining due to the controlled collapse of the mine roof, the greater depths and limited extent of the workings.

Although there are many mine plan records held by the British Geological Survey and the Coal Authority for large mines in the City, many smaller workings, shafts and levels remain unrecorded and are only generally known from intersections with boreholes. Even when plan records are held for shallow mines, the removal of pillars from the workings at abandonment may not have been recorded and the current state of the mine workings may be poorly known. Subsidence associated with the collapse of underground workings occurs in many areas of the City, and there are occasional incidents of catastrophic collapse of workings, shafts and levels (Figure 4 b). Glasgow City Council has undertaken grouting to stabilise some near-surface mine workings in order to halt or prevent subsidence and mine collapse in many areas of the City.

3. Subsurface information for Glasgow

The BGS has a long history of data collection in the Glasgow and Clyde areas through historic survey activity since the mid 1800’s. The superficial deposits and bedrock geology have been mapped through numerous field surveys, the most recent culminating in the publication of solid and superficial deposits maps of Glasgow at 1:50,000 scale in 1993 (Hall et al., 1998).

The BGS borehole database holds over 40,000 records of boreholes drilled within the City of Glasgow. The borehole information is derived largely from site investigations and wells drilled by private companies and deposited voluntarily within the BGS archive. Records from a limited number of boreholes drilled by BGS as part of resource surveys or to facilitate the characterisation of key deposits are also archived.

In 2009 the Clyde Urban Super Project (CUSP) was initiated to bring together a range of different BGS projects focussed in Glasgow, the wider Glasgow conurbation, and the Clyde catchment. The multidisciplinary project incorporated the development of 3D subsurface models, geochemical analysis of soils and monitoring and modelling of groundwater. The CUSP also fostered collaborative research within BGS and between the BGS and other research partners, to address a range of issues related to the urban subsurface environment.

3.1. 3D Geological models

The BGS initiated a programme of subsurface modelling for Glasgow in 2002 – 2003. Pilot 3D models of the superficial deposits and bedrock were developed using borehole and geological map data held in the BGS archives, combined with additional information from seismic data and mine records.

3D superficial deposits models for Glasgow and the wider Clyde catchment have been progressively developed at a range of spatial scales, culminating in those developed as part of CUSP in 2012 -2014 which include a regional catchment model (>3000 km^2; Figure 5) and 8 urban 'block models' (each 50 - 100 km^2; Figure 6). These models have been developed using the modelling software GSI3D^{TM}. The modelling process for superficial deposits follows a 'deterministic' methodology in which the geologist correlates cross-sections based on borehole data and other records, and networks of cross-sections are interpolated to form surfaces using a deterministic algorithm. Sediment units were defined using a lithostratigraphic approach that combines elements of lithology, depositional environment and stratigraphic order. The superficial deposits models (Figure 7 a) can be attributed with a range of geotechnical properties to predict ground conditions or model groundwater flow. A further process of stochastic modelling has been developed to predict lithological variability between and within lithostratigraphic units directly from the borehole data (Kearsey et al., in review).

Bedrock surfaces including stratigraphic unit bases, faults and areas of worked coal seams have been modelled from borehole records, mine plans and seismic data using GOCAD® to produce a Clyde 'catchment' model (900 km^2 centred on the lower Clyde area), a higher resolution Central Glasgow model (100 km^2; Figure 6, Figure 7 b), and detailed models of some areas of disused coal workings (Figure 8).

In addition to the catchment and block models, BGS has developed several bespoke site-specific models of superficial deposits, rockhead surfaces, bedrock and mine workings for a range of private contractors. These small-scale, high resolution models have been developed by incorporating new borehole and site investigation information into target areas of the existing block models.

3.2. Geochemistry and soils

As part of the BGS's national strategic geochemical survey of the UK (G-BASE), systematic geochemical sampling of rural stream sediments in the Clyde catchment was initiated in the 1980's. In 2001 – 2004 sampling of urban and peri-urban soils and urban stream sediments in Glasgow was undertaken. Rural stream water and urban and rural soils were sampled between 2010 and 2011.

The geochemical surveys indicate that urban soils in many areas of Glasgow have elevated levels of heavy metals including Calcium, Copper, Lead, Tin, Antimony and Chromium. This contamination is largely related to historic mining and industrial activity. The geochemical data along with groundwater information has been used to develop a GIS tool to assess the threat of contamination of shallow ground water by leaching of soil contaminants (GRASP: Groundwater and Soil Pollutants; Fordyce et al., in prep).

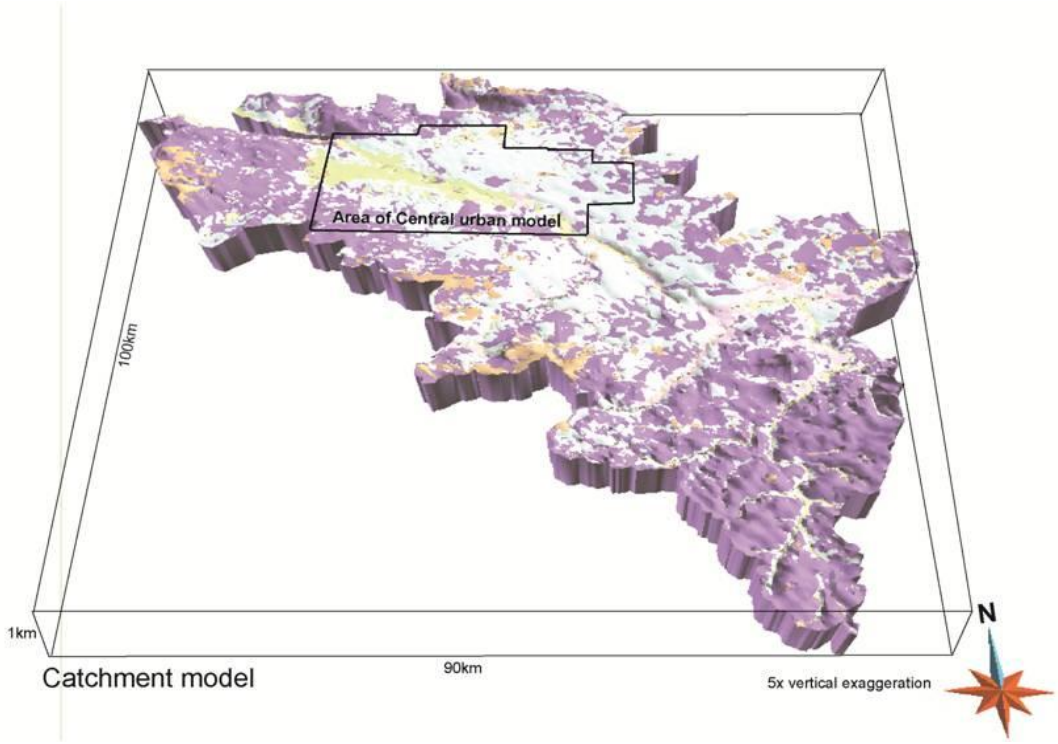

Figure 5 The regional subsurface model of the superficial deposits in the Clyde Catchment showing the location of the local model (block models) of the Greater Glasgow Area.

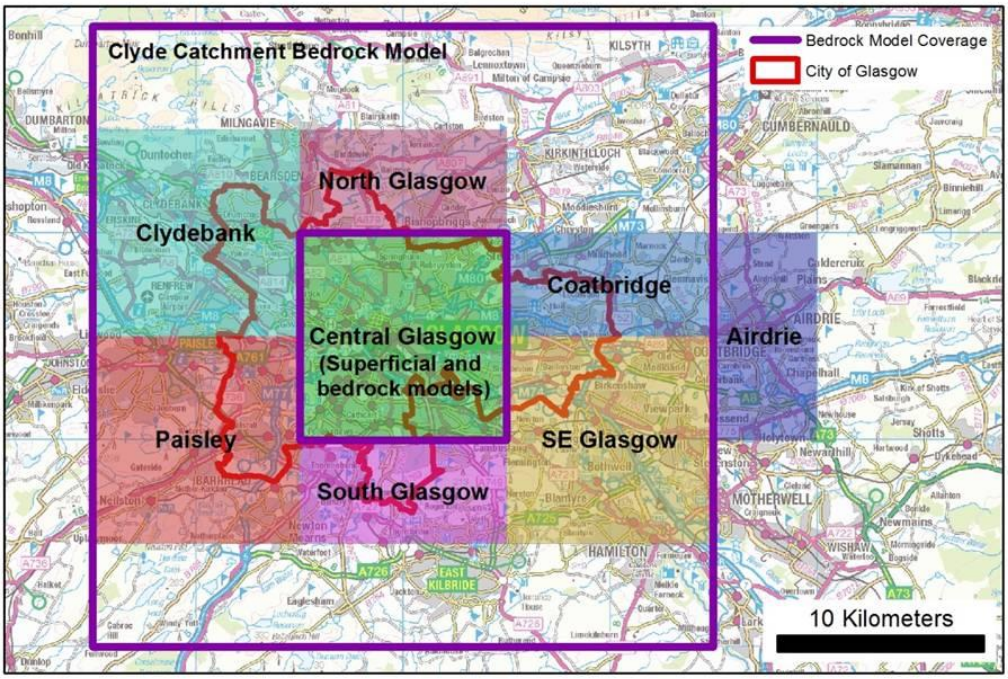

Figure 6 The coverage of eight superficial deposits models (coloured areas) and two bedrock models in the Greater Glasgow Area.

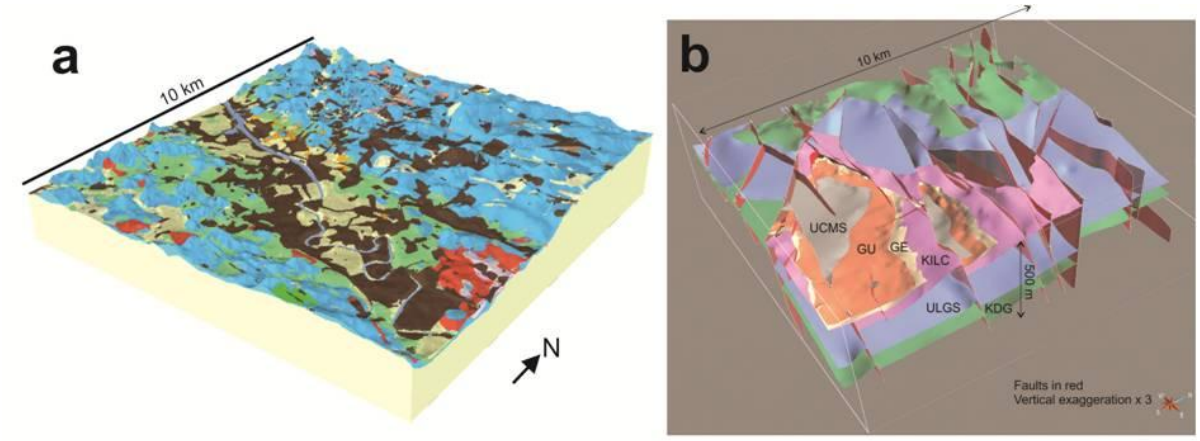

Figure 7 Example images of the superficial deposits model (a) and bedrock model (b) for the Central Glasgow area (cf. Figure 6).

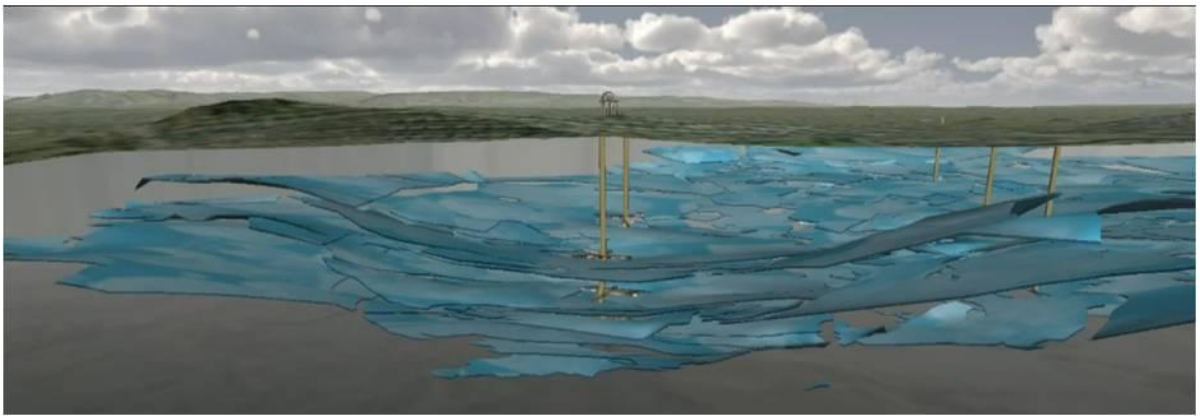

Figure 8 Modelled extent of abandoned mine workings under a site in eastern Glasgow displayed using the 3D visualisation software Geovisionary®.

3.3. Groundwater

Groundwater is not widely utilised as a resource for industry or private supply in Glasgow, and there has been no previous systematic monitoring of groundwater systems within the City. Thick sand and gravel deposits in the Clyde Valley and Kelvin buried valley form the largest regional near-surface aquifers and are likely to be the main conduits for groundwater flow. Groundwater sources for these aquifers include both surface recharge and inputs from deeper bedrock aquifers. The 3D geological models of the superficial deposits in Glasgow have been used to analyse groundwater interactions and groundwater flow in the Clyde and Kelvin valley aquifers.

A pilot groundwater monitoring network to assess temporal variations in groundwater level and associated controls was set up by BGS in eastern Glasgow, utilising six site investigation boreholes drilled by private contractors. Monthly borehole monitoring for groundwater level, temperature and conductivity has been ongoing since 2012. The long term monitoring of these boreholes is to be taken over by the Scottish Environmental Protection Agency following the completion of the pilot study.

In the bedrock, aquifers are confined to relatively thin sandstone units within cyclic sequences of mudstone, siltstone and sandstone with thin limestone and coal seams in parts of the sequence. Disused coal mines form conduits for groundwater flow. Research is currently underway at Glasgow Caledonian University to assess the potential for development of ground source heat installations designed to extract heat from groundwater circulating within the system of deep mine workings under Glasgow.

3.4. Delivering subsurface information – CUSP and the ASK Network

Throughout the development of the CUSP, BGS has engaged with Glasgow City Council and private contractors to raise awareness of the new subsurface data produced through CUSP and to inform the BGS development of accessible environmental and engineering geoscience data suitable for a range of practical applications.

Growing partnership between the BGS and GCC led to the development of the ASK Network (Accessing Subsurface Knowledge)[2], a partnership of public and private sector organisations focused around the exchange and reuse of subsurface data and knowledge. The ASK Network was formally launched in 2013, and the 3D subsurface models for the Greater Glasgow Area developed by BGS are now freely available for network members under the terms and conditions of a BGS/National Environment Research Council Innovation Agreement. The data exchange has prompted collaboration between BGS and private sector consultants and contractors through bespoke model developments for particular sites, and provided a mechanism for feedback to BGS from model users to support ongoing model development. The 3D geological models are increasingly being used to inform planning and development processes, reduce risks resulting from unforeseen ground conditions in construction work, to analyse groundwater flow and assess contaminant pathways, and to address issues related to sustainable drainage.

Through the collaboration initiated within the ASK Network, BGS has been working with GCC to encourage borehole data exchange to aid groundwater assessments and continued 3D subsurface model development. In 2013, GCC introduced a requirement that contractors working on commissioned developments for GCC supply key site investigation data to BGS in a defined format (GSPEC). The GSPEC initiative is also extended to private contractors and developers as a voluntary agreement incorporated into the planning process.

4. Urban planning and management

4.1. Glasgow – the planning process

In the UK, infrastructure, housing and other developments may be commissioned by Local Authorities or by private contractors. Private contractors are required to submit planning applications to the local authority for approval prior to development. Planning applications are considered with respect to regional and local development plans. Through the planning process, potential developments are assessed in respect of impacts on the environment, in particular protected or designated ecological cultural or historical sites. Site assessments that consider issues

[2] ASK Network webpage: http://www.bgs.ac.uk/research/engineeringGeology/urbanGeoscience/Clyde/askNetwork/home.html

relating to ground conditions and groundwater are also required. The planning process allows Glasgow City Council to effectively control urban development, regeneration and infrastructure in the City of Glasgow.

4.2. Glasgow land use and spatial planning framework

Regional planning for the wider Glasgow area is the responsibility of a joint committee covering the City of Glasgow and seven surrounding administrative areas (Figure 9), the Glasgow and Clyde Valley Strategic Development Planning Authority (GCVSDPA). The City of Glasgow is administered by Glasgow City Council. The spatial development plan for the City of Glasgow, the 'City Development Plan', is the statutory Local Development Plan prepared by Glasgow City Council. The purpose of the City Development Plan is to ensure efficient use of land and provision of good infrastructure to improve the social, cultural, economic, and environmental health of the city.

In May 2014, a new City Development Plan[3], setting out a 10 year planning framework for Glasgow, was released for consultation. The new plan accounts for recent revisions of National planning legislation (2006)[4], updated government guidance on the format for development plans (published in 2013)[5] and updates to the National Planning Framework and Scottish Planning Policy (2014)[6]. When finalised, the new plan ('the proposed City Development Plan') will supersede the current Local Plan[7] (City Plan 2).

Figure 9 The City of Glasgow (darker green) and the 7 other local authority areas that comprise the Glasgow and Clyde Valley Strategic Development Plan Area (light green).

[3] Proposed City Development Plan webpage: http://www.glasgow.gov.uk/index.aspx?articleid=11752
[4] The Town & Country Planning(Scotland)Act 1997, as amended by the Planning etc (Scotland)Act 2006 http://www.scotland.gov.uk/Topics/Built-Environment/planning/Development-Planning/Legislation
[5] 6/2013 – Development Planning http://www.scotland.gov.uk/Resource/0044/00441577.pdf
[6] Scotland's third National Planning Framework (NPF3) and Scottish Planning Policy (SPP): http://www.scotland.gov.uk/Topics/Built-Environment/planning
[7] City Plan 2 webpage: http://www.glasgow.gov.uk/index.aspx?articleid=2910

The development phases of the proposed City Development Plan are shown in Figure 10. The Executive Committee of Glasgow City Council approved the proposed City Development Plan for public consultation between 1 May and 27 June 2014. Following the consultation phase, the proposed City Development Plan is now proceeding towards examination by independent reporters appointed by the Scottish Government, which should occur at the beginning of 2015.

The proposed City Development Plan is consistent with the strategy of the approved Glasgow and the Clyde Valley Strategic Development Plan (SDP, May 2012). When the proposed City Development Plan is adopted, the two documents covering the City of Glasgow and the wider region will become 'The Development Plan for Glasgow'. The relationship between the City Development Plan and other related documents is shown in Figure 11.

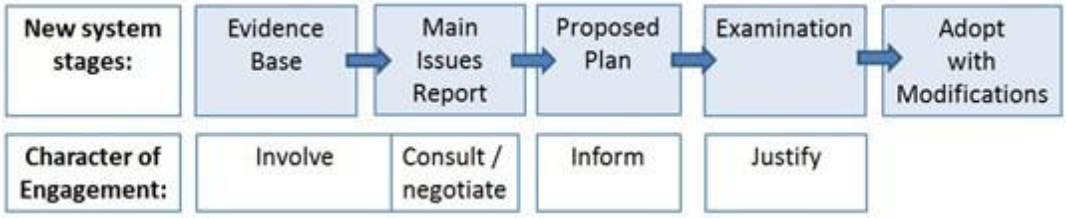

Figure 10 The development process for the City Development Plan for Glasgow.

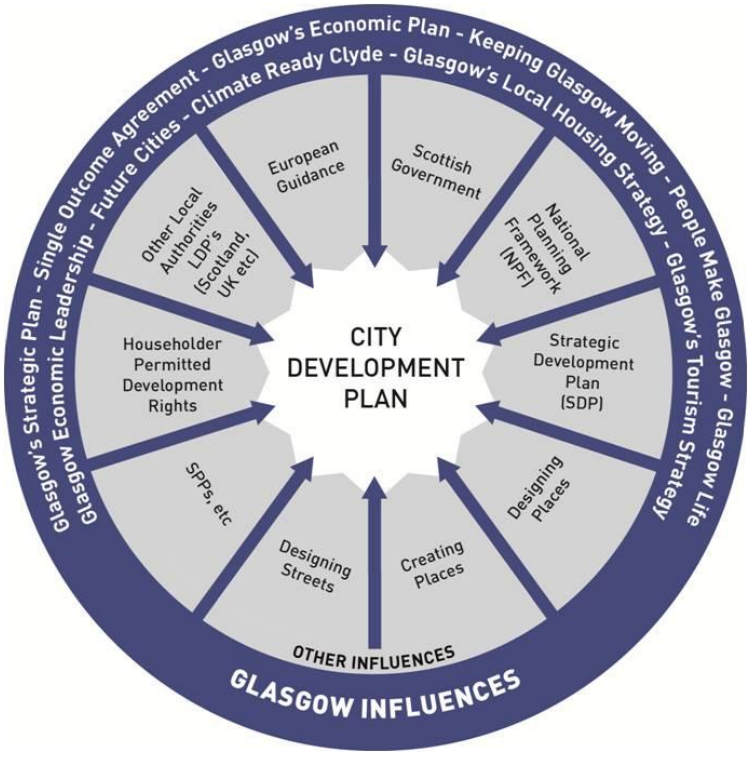

Figure 11 The relationship between the City Development Plan for Glasgow and other policy, plans and strategies.

4.3. Structure of the new City Development Plan

The proposed City Development Plan follows a different format to previous plans, incorporating an accessible overview document that outlines the broad-scope of the development plan, with detailed outlines of how the broad-aims of the plan can be achieved, presented as supplementary guidance documents.

The supplementary guidance documents form an important component of the new plan. Rather than incorporating all detailed planning guidance within the main plan document as in previous plans, this guidance is now incorporated into supplementary guidance documents focussed on key areas of the planning framework. This development is intended to make the planning system more adaptable to reflect potential political, socio-cultural, scientific and technological changes that influence how the city environment may be managed. The supplementary guidance documents are also approved by committee but are subject to a less stringent review process than the main plan document and may be updated or revised following the adoption of the City Development Plan.

Another important addition in the new City Development Plan is the inclusion of an 'Action Programme' which outlines key activities to be undertaken by Glasgow City Council and partner organisations to support the application of the (proposed) City Development Plan.

4.4. Subsurface information in planning and development – the present

4.4.1. Glasgow City Council – commissioned developments

In development projects commissioned by GCC, site assessments are conducted by Development and Regeneration Services (within GCC). In these assessments, a range of subsurface information is considered, typically 2D geological maps and borehole records. Since access to 3D subsurface models was provided via ASK Network, these are now also used on an *ad hoc* basis during site assessments. Particular issues include the location and depth of shallow mine workings and the occurrence and extent of contamination. The GCC team liaises with contractors over remediation and site development. Consultation with other government bodies such as the Scottish Environmental Protection Agency or Scottish Natural Heritage may be required to address environmental, archaeological and cultural issues arising from site assessments. These bodies will also consult a range of subsurface information sources, primarily 2D geological maps and borehole records but also 3D groundwater models.

Private contractors generally undertake or commission their own site assessments as part of the planning process. Typically 2D geological information (maps) and borehole records made available by BGS are used. BGS may provide bespoke site assessments through sales of GeoReports (small scale sites) or commissioned site assessments (large sites). Through the ASK Network, BGS has provided free access, under license conditions, to 3D subsurface models for Glasgow to developers and private consultants and contractors. These models have been used by some consultants and contractors to assist in the design and planning of development projects and associated ground investigations.

4.4.2. Geodiversity and the protection of geological sites

The Scottish Geodiversity Charter, prepared by the Scottish Geodiversity Forum, and supported by Scottish Natural Heritage, the BGS and the Scottish Government, was launched in 2012. Signatories

of the Charter, which is non-statutory, commit to the recognition, protection and preservation of Geodiversity. Glasgow City Council is a voluntary signatory of the Charter. In 2012 GCC commissioned BGS to undertake a Geodiversity Audit for the City of Glasgow. This audit identified and described 20 key geological sites in the City and forms the basis for future recognition of geological sites within the planning framework as designated Local Nature Conservation sites.

4.5. Subsurface information in planning and development – the future

Geology and the subsurface environment are not explicitly recognised in City Plan 2, the current local development plan for Glasgow. Following the sustained collaboration between BGS and GCC, alongside the efforts of the Scottish Geodiversity Forum, the proposed City Development Plan now incorporates consideration of the subsurface environment and resources in the planning policy framework. This development reflects an increasing awareness of the role of the subsurface in supporting a sustainable economy and vibrant, healthy society and environment. The proposed City Development Plan:

- Recognises the inclusion of geodiversity sites as protected Local Nature Conservation sites, selected for their values for scientific study and education, historical significance and cultural or aesthetic value;
- Includes an action that formalises the commitment of GCC to continue to work in partnership with BGS and engage with other European partners through the COST (Cooperation in Science and Technology) SubUrban Action (TUI 1206), which falls under the Transport and Urban Development domain of COST;
- Commits GCC to the development of supplementary guidance in relation to the subsurface environment – incorporating utility services, district heating, energy and communication services, transport, SuDS and water services in addition to ground properties and other geological conditions;
- Commits GCC to the development of further guidance and planning requirements in relation to heat generating technologies including options such as groundsource heat and other subsurface energy resources.

The proposed City Development Plan is the first planning policy for Glasgow to explicitly recognise the environmental and economic value of the subsurface. Following the consultation, review and approval procedure, the proposed measures will ensure that the planning policy for Glasgow reflects the importance of the subsurface environment to the health, wealth and growth of the city.

The initiation of streamlined procedures for development and revision of supplementary guidance provides a flexible platform for the evolution of the City Development Plan to reflect growing knowledge of the subsurface and developments in technology that facilitate the use of high-resolution 3D digital subsurface data in spatial planning and urban development.

5. Conclusion

The subsurface environment and its resources have fundamentally influenced the geography, and industrial and social development of the City of Glasgow. Exploitation of geological resources including coal and building stones led to the development of Glasgow as a key economic powerhouse of the UK following the industrial revolution (c. 1850 – 1930). Despite a progressive

decline in heavy industry since ~1950 Glasgow remains the economic hub of Scotland, but there are numerous challenges to future growth and development due to the legacy of mining and heavy industry and the complex superficial deposits and bedrock geology of the region.

Subsurface information, generally from 2D maps and borehole records has long been used on an *ad hoc* basis by private contractors engaged in development work and resource extraction. 3D subsurface information is now increasingly being used to develop more strategic approaches to managing the subsurface environment in Glasgow. Key areas where subsurface information is being used are in the development of spatial planning policy, regeneration and infrastructure development projects, management of contaminated land and groundwater resources, and the identification and characterisation of potential future energy resources.

The partnership between the BGS and GCC, developed through sustained communication, has been responsible for growing awareness of the value of the subsurface environment and its resources to the City. The development of this key relationship between the national survey and local council can be traced through several key stages.

> *In 2009:* Building on previous survey mapping and soil sampling programmes, the BGS initiated the multidisciplinary Clyde Urban Super Project to develop 3D geological models for Glasgow and the Clyde catchment, and to improve our understanding of groundwater systems, and soil/sediment/water geochemistry in the city.
>
> *In 2009 – 2014:* Through the CUSP a dialogue between BGS and GCC was established, forming a basis for feedback relationships in which potential users are informed about the research developments and user needs were discussed to facilitate the development of geological information suitable for applied uses.
>
> *In 2012 – 2014:* Dialogue between BGS and GCC developed into partnership with the inception of pioneering collaborative projects such as the ASK Network and the GSPEC data exchange initiative to provide platforms for data and knowledge exchange.
>
> *2014 onwards:* The inclusion of aspects of geology and the subsurface in new spatial planning policy for Glasgow reflects the growing awareness of policy makers of the value of the subsurface environment and resources. Recent revision of national planning legislation in Scotland has made planning documents more accessible and adaptable, paving the way for ongoing development of policies relating to the subsurface that can evolve as knowledge and technology develop, and adapt to changes in economic, political and social contexts.

Within the UK context, Glasgow City Council is taking a leading role in the development of a strategic local planning framework that accounts for the subsurface environment, reflecting the growing need for proactive approaches to management of the subsurface. In the case of Glasgow, it is now recognised that 3D subsurface information can; help address issues related to the legacy of industry and mining, form a basis for management of the subsurface environment, and provide opportunities to identify and develop future energy resources. In partnership, Glasgow City Council and the British Geological Survey are working to ensure that effective management of the subsurface environment underpins the future health and prosperity of the City of Glasgow.

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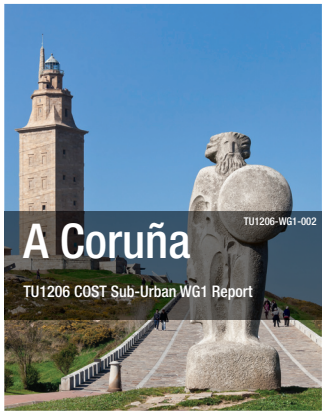

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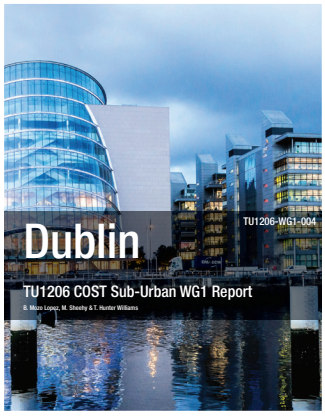

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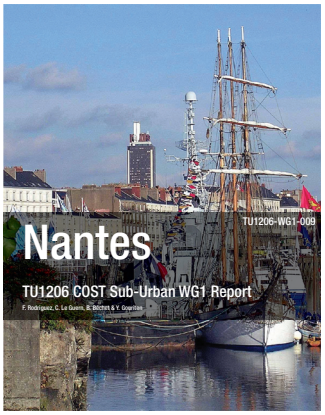

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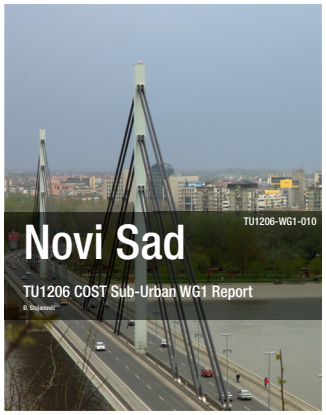

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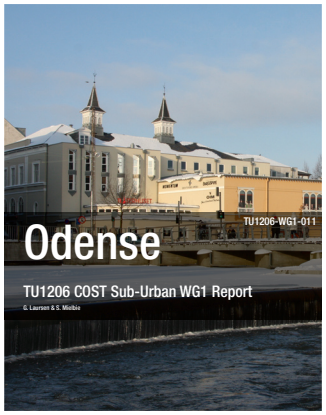

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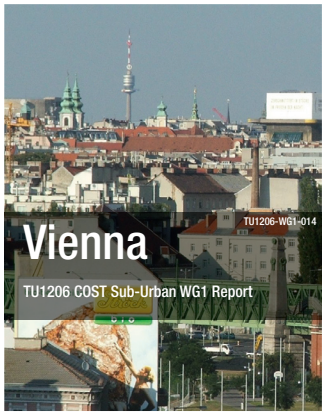

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