COST Short Term Scientific Mission (STSM) TU1206- 24731

OSLO SUB SURFACE Project – Lessons and applications with particular reference to Urban Planning in Glasgow & Rotterdam

STSM Report to COST MC Chair

Review the work and lessons learnt in developing and implementing planning for the sub surface. Provide a comparison between Oslo, Rotterdam and Glasgow

STSM Author: Gillian Dick Glasgow City Council, UK
Host: Ingelöv Eriksson, Agency for Planning and Building Services, City of Oslo, Norway

STSM report submitted to:

COST MC Chair (DR S.D Campbell)

Chief Geologist of Scotland
British Geological Society
West Mains Road,
Edinburgh, EH9 3LA
UK

STSM reference details:

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STSM Applicant: Ms Gillian Dick, Glasgow City Council, UK

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Host: Host: Ingelöv Eriksson, Agency for Planning and Building Services, City of Oslo, Norway

Acknowledgements

A large number of individuals have contributed to this short – term scientific mission (STSM), and made the STSM a very valuable collaboration between the Cities of Oslo, Rotterdam and Glasgow. Particular thanks go to Ingelöv Eriksson at Agency for Planning and Building Services, Oslo Kommune, Norway for hosting the STSM, together with participants in the STSM from Agency of Planning and Building Services, Oslo Kommune and Petra van der Lugt, Gemeente Rotterdam for valuable discussions and work. Dr Diarmad Campbell - BGS, David Hay – GCC and Hans de Beer – NGU are also thanked for their advice and support to the STSM, and for previous work which laid the foundation for the STSM application. Finally the author thanks the COST action for offering the opportunity granted by the STSM programme and for the financial contribution to the collaboration.

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1. Rationale

Land Use Planning in Scotland deals with activities above ground and mineral extraction below ground, normally in the form of open cast mining. Underground mine working are covered by the separate legislation governed by the coal authority. Increasingly modern activities such as sustainable urban drainage; District Heating and ground source heating are resulting in proposals that have an impact both above and below ground. The UK Government have also let a number of exploratory licences in relation to Shale Gas, which could result in a series of drilling operations.
Glasgow's geology and historical spatial development means that the city has been built over old mine workings that may provide the opportunity for larger scale ground source heating linked into District Heating schemes, but also act as a development constraint.

The Metropolitan Glasgow Strategic Drainage Partnership (MGSDP) is a partnership formed by organisations involved with the operation of the sewerage and drainage network within the area - Scottish Water, Glasgow City Council, Scottish Canals, South Lanarkshire Council, Clyde Gateway URC, Scottish Enterprise and the Scottish Environment Protection Agency (SEPA). The MGSDP 50 year vision is to transform how the city region thinks about and manages rainfall to end uncontrolled flooding and improve watercourse water quality. One of its major initiatives is to *r*econnect our waterways - Watercourses in the past were often either incorporated into the sewer network or modified to flow through buried pipes. As the water was out of sight, it became increasingly out of mind for local communities.

In 2012, Glasgow City Council commissioned the British Geological Survey to undertake an audit to identify and assess a number of sites anticipated as having value for geology and geomorphology. This is the first audit of its kind for Glasgow. In addition, Glasgow is developing a comprehensive subsurface database. This includes the transfer of data to digital storage and exploring potential partnership with the British Geological Survey (with particular emphasis on viewing and manipulating data, using 3D geological modelling). Wider access to this database, comprising in excess of 100,000 borehole records, will be made available.

The Proposed Glasgow City Development Plan was published for consultation between 1 May and 27 June 2014. The plan is due to be presented to the Scottish Government for examination in spring 2015, with a view to being approved as a statutory plan in 2016. The plan contains new policies on Resource Management that covers Combined Heat and Power and Shale Gas exploration. This will lead to the development of Supplementary Guidance on Energy and the possibility of developing a Below Ground Masterplan for Glasgow.

The Scottish Government strengthened the Scottish Planning Policy as it relates to onshore unconventional oil and gas, when it was published in June 2014. The new Scottish Planning Policy, reinforced environmental and community protection, and community consultation guidance, in relation to planning applications for unconventional gas extraction. It also recognises the national benefit of indigenous coal, oil and gas production in maintaining a diverse energy mix and improving energy security. Amongst the changes to the policy it states that the planning system must "minimise the impacts of extraction on local communities, built and natural heritage, and the water environment."

In addition the new policy says that for areas covered by a Petroleum Exploration and Development Licence (PEDL), local development plans should also: identify licence areas; encourage operators to be as clear as possible about the minimum and maximum extent of operations (e.g. number of wells and duration) at the exploration phase whilst recognising that the factors to be addressed by applications should be relevant and proportionate to the appropriate exploration, appraisal and production phases of operations; confirm that applicants should engage with local communities, residents and other stakeholders at each stage of operations, beginning in advance of any application for planning permission and in advance of any operations; ensure that when developing proposals, applicants should consider, where possible, transport of the end product by pipeline, rail or water rather than road; and provide a consistent approach to extraction where licences extend across local authority boundaries.

Within Rotterdam the subsurface is not very well known amongst the general public. Plans for CO2 storage in the neighbourhood of Rotterdam caused, in 2008, fierce discussions between professionals, residents and environmental organisations. These discussions seemed more based on emotions than on facts. Similar occurred during the recent public debate on shale gas exploration elsewhere in the Netherlands and in other parts of Europe. The subsurface is equally unknown amongst city developers - and unknown equals unloved. The result is that the subsurface is too often brought in too late and/or in an unstructured way in the spatial development cycle. Thus relevant geotechnical, environmental, and physical obstacles are encountered too late in the process, leading to financial complications and delays. With the Underground scan methodology the Engineering Consultants from Rotterdam have found a way to introduce the subsurface (as well as themselves) to the first stages of city development projects. The Underground scan involves products and processes that manage to present both the obstacles in the subsurface as well as the opportunities that the subsurface offers in a clear, understandable manner to non-subsurface specialists.

The city of Oslo has faced similar major challenges, related to the use and the planning of the underground, to Glasgow and Rotterdam. Challenges that have been identified are increased use of the subsurface, conflicts of interest, tunnels vs. energy wells, alum shale, deep horizons of clay, increased building activity causing increased subsidence as well as sinking groundwater causing damages on, or loss of historical buildings.

In 2011 a pre project was carried out which resulted in the four year “Sub Surface Project” or; Prosjekt for økt kunnskap om undergrunn i Oslo” in Norwegian, that started up in February 2013. The project is owned and managed by the Agency for Planning and Building Services, the project group is put together with employees from five different municipal agencies, including:

Agency for Planning and Building Services

Cultural Heritage Management Office

Agency for Urban Environment

Agency for Real Estate and Urban Renewal

Agency for Water and Sewerage Works

The project group consists of 15 people, and is a truly interdisciplinary group; architects, counsellors, construction engineers, GIT engineers, geologists, 3D specialists, a geotechnician, hydrogeologist and a hydrologist are working closely together in order to improve the knowledge and management of the City's subsurface.

This STSM will allow benchmarking between OSLO, Rotterdam and Glasgow to be set up as each City adapts its nationally set urban planning legislation to allow it to plan for the subsurface. There is a clear immediate benefit of the STSM outputs to Working Group 2 subgroup reviewing and identifying best practice in Urban Planning and management across Europe. The evaluations and outputs of the STSM are highly relevant to the wider COST SUBURBAN Action as a whole.

Workplan

1*. STSM in PBE , Oslo, Norway in mid February 2015*
The STSM will involve a 5 day meeting in PBE, in which the main objectives outlined above, would be discussed and achieved, through a series of meetings and discussions between key personnel at the municipalities of Oslo, Rotterdam and Glasgow.

2. *Publication of STSM Reports, March 2015*
Outlining the main discussions and evaluations from the STSM

3. *Engagement of a wider group of COST participants 2015 - 2016*
Engagement with the Working Group 2 subgroup reviewing and identifying best practice in Urban Planning and management across Europe in relation to the Sub surface. Would enable the results of the STSM to be discussed and highlighted in wider European context. Discussion and presentation of this at COST workshop or meeting at Zagreb COST meeting (March 2015)

2. Work carried out within the STSM

The STSM involved a 5 day visit of the 2 STSM applicants (Gillian Dick ,GCC and Petra van der Lugt, Gemeente Rotterdam) to Oslo Kommune from 9th - 13th February 2015. Meeting discussions over the week were centred on:

The work on the Oslo Sub Surface Project provides an ideal case study for the COST SUB-URBAN Action to learn from. This STSM will allow benchmarking between OSLO, Rotterdam and Glasgow to be set up as each City adapts its nationally setting urban planning legislation to allow it to plan for the subsurface.

The work and outputs of this STSM will be of wide benefit to the COST Action and its participants, as well as to others outside of the Action, by:

• Facilitating knowledge exchange between key personnel in GCC, OK, GR to evaluate lessons learned from Oslo's Sub Surface project and its links to urban planning and law.
• Compare the issues in adapting national urban planning legislation to allow for local and strategic planning of the subsurface
• Review the key drivers – knowledge, economic, political & environmental
• Provide a detailed case study that can be benchmarked against the activities in Rotterdam and Glasgow
• Provide the basis for engagement of a wider group of COST participants.

This STSM would co-ordinate currently independent work between COST participants to allow a benchmarking process to be piloted between the three cities.

	Monday	Tuesday	Wednesday	Thursday	Friday
9:00 –				Geodata workshop:	
				«Data needed for sub –surface master plan» *Participants: Subgroup Geodata and city planners*	
12:00 -	**Lunch**	**Lunch**	**Lunch**	**Lunch**	**11:30 – 12:30 Lunch**, *with subsidence in Oslo, Rotterdam and Glasgow”*
13:00 – 15:00	Arrival of Petra ca 13:45 3D printed city model	City tour Bjørvika	*Geological mapping and use in municipalities* *Participants: Subgroup Groundwater*	Sub-surface city tour Participants: Johan B, city planner, Ingelöv Eriksson	Departure
15:00 – 16:30	Oslo Sub Surface project a short introduction	Oslo sub surface 3D model	Free time		
Evening	Welcome drink		Ski outing, or sledging at Frognerseteren	Group Dinner	

COST WG2: Sub project 1 Subsurface Urban planning and Management

It has been discussed that 'city needs' (for subsurface planning practices and information) should be the main drivers for the further development of (technical) 'practices and techniques'. It is expected that WG1 will provide (preliminary) conclusions regarding these 'city needs' and the status of current practices. On this basis WG2 will further identify relevant practices and techniques, focusing mainly on the (technical) content, exchange and use of subsurface information. This implies a more or less iterative approach, to cover the 'classical' demand/ supply aspect by which subsurface planning is characterised: experts (represented in WG2.2-2.6) possess analytic and scientific knowledge about the possible content, technical aspects and possibilities of the subsurface and connected information, while planners have the best view about socio-economic and political drivers behind certain planning and information needs. An iterative approach (alternately focus on technical vs. planning perspectives) will enable discussion towards more optimal solutions in the end. As a baseline for the work in WG2 there is a need for a summary of the city needs as a conclusion of WG1, covering the above-mentioned planning perspective. A table showing what city that describes what type of issues is also of great importance, e.g. regarding:

- Different problems in different areas
- Different solutions in different areas.

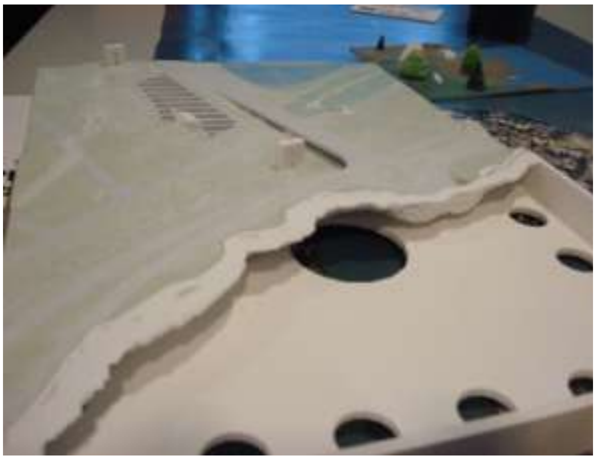
Starting with this summary presentation of WG1, WG2 focused primarily on the technical perspective, discussing the various systems, modelling and information base aspects of subsurface planning connected to geotechnical, geohydrological and geochemical domains. Once there is sufficient technical understanding, they can be evaluated against technical as well as planning needs. WG2.1 (practices for integration of subsurface information in urban planning and management) will play an important role to connect both perspectives.

There has been an enormous amount of baseline information gathered about 10 of the cities involved in the COST programme. Baseline reports on the current situation with regard to the A Coruna, Bergen, Glasgow, Hamburg, Helsinki, Ljubljana, Nantes, Odense, Oslo and Rotterdam have been produced. Attempting to compare and contrast this amount of information requires time and resources that are drawn from the existing partners. This STSM tried to focus on comparing Glasgow, Oslo and Rotterdam using the study visit to Oslo to act as a catalyst for discussion and hopefully a quick route through to drawing out the key similarities, differences and lessons that could be learned. This will hopefully allow a methodology to be devised that will allow the vast amount of information that has been gathered to be analysed and summarized so it can point towards the development of the right technical solutions and tools for all of the COST partners.

In discussion between Oslo, Rotterdam and Glasgow representatives during the STSMs week, it was agreed that we would try to produce a table that produced a quick read comparison for the three cities that could be expanded to include the information for the other 7 cities that had reported. This table could be added to and adapted as reports are produced for Cities by other COST partners, or by cities wishing to compare their activities with COST partners. The table is included as Appendix 1. In addition this report will provide an in depth analysis that can better inform the decisions about which techniques and tools to develop.

3. Lessons learned from the STSM – From programme activities

3D printed City Model




[Building the Oslo 3d model - You Tube video]

Oslo originally had an old wooden 3d model on display in its entrance area. There was an understanding that it required to be up dated. The original model was produced from 3d data provided by Oslo Kommune, but the company employed to produce the wooden model, and possibly an updated version, stated that once they used the data to convert to a model, they owned the output. Therefore, each time Oslo wished to update a part of the model they were being charged for the output and were effectively being held to ransom by the modelling company. The Council therefore decided to produce the next iteration of the model in house and looked around for possible solutions. 3d digital modelling was coming into the public sector across Europe. Oslo Kommune visited Barcelona. There they had moved from a wooden model to a modern iteration which they could project information onto.

It's worth noting that in 2008 there was a big discussion in Norway about how to construct a 3d plan. It was decided that every Norwegian Kommune would came together to create a national 3d plan. The Kommunes agreed to scan from the air on a yearly basis. Each Kommune pays a proportionate share of the cost dependant on how much data they use. Road departments are currently they main users of data. GEOVEKST, a government service, covers small municipalities. Oslo is part of a large municipalities grouping and, within the City Planning & Building Service in Oslo Kommune, creates original maps and sells them to other parts of the Kommune particularly roads, telecommunications and infrastructure providers. Therefore Oslo Kommune owns a lot of the source data that was used for 3d model.

Following discussion and study visits Oslo put the case for purchasing second hand 3d printers. In order to justify this purchase they first had to work out how to turn 3d digital data into useable information to print from. The following tasks were agreed:

- Yearly orthophoto (aerial photography) used as baseline data.
- Decided that the city model would be created from 360 blocks - A3 size. Size determined by printer.
- Base is heavy ply.
- Used GIS to work out the difference in height between the front and the rear of a block. This meant that the ply base could deal with the geographical rise or fall in ground height and the blocks could be printed on a flat base.

- Used Lego to experiment how to get the land heights right. From this created a grid system.
- Model is set at an angle so that the whole city can be seen from the main reception area. Printing machines and storage at the rear of the model.
- Reception would house 3d printed model, digital information and touch screen.
- Improvised printing accessories - Ikea trays to hold drying models; old deep fat fryers as dipping baths for wax; old food heaters to heat wax etc.
- Identified a student who had skills in studiomax software. Used their skills to teach GIS / techs how to build houses in 3d that could then be printed.
- Learnt how to deal with bridges and voids in model.
- Idea originated in 2010, funding identified in 2012.
- 1 year for testing and 9 months in production. Just being completed spring 2015.
- Founding came from main budgets.
- Started with 2nd hand printers. Started out being able to produce 16 prints a month, now up to 78 prints per month. Average printing time is between 3 to 7 hours.
- Software used includes FME, ArcGIS, Xfactor, GISline, Zprint, ZeditPro,3d studiomax
- Each new print started from scratch, using building information from Kommune.
- Begin each model with the building information data that the Kommune holds -Terrain data from aerial laser scan, aerial photography, and raster dataset. TRN remade point cloud to allow 3d printer to use data.
- Chose to colour terrain but leave structures as white block model.
- 6 projectors set up in roof, projection aligned by using fibre optic points on printed model.

Proposed way forward

The initial goals with the 3d model were to update the existing urban model; identify the redevelopment areas clearly and use in the waiting area as an interactive tool for masterplanning. 2nd stage iteration has the aim of developing a mobile system so that parts of the model can be taken out to the public and linked with video and projection. They also propose to video project onto the main model. The idea has sparked imagination with neighbouring municipalities, some of which want Oslo to print models for them; this could generate income for the city and create employment opportunities.

The Planners, Architects and Civil engineers working for the City see the potential to be able to attend meetings with printed basic models, hand out clay and get the community to interact with it to look at planning scenarios. The Kommune are also starting to work with the police for scanning various areas. Going forward they have funding to print 40 blocks a year at a cost of approx. 3000NKR (£300) a block. The Kommune is seeking to ensure that they are upskilling all members of the team, by ensuring that the subsurface team of GIS specialists; graphics specialists; geologists; and engineers understand how to produce the models. They also want to ensure that the planners have access to GIS so that they can break down the barriers between the Planners, GIS specialists and producers of maps.

They'd like map making to get back to an iterative process where new data created by Planners can be captured and fed into 3d models. They therefore want to create the Oslo development plan as a 3d model. They view the model as a positive way to tell a story and demonstrate visually the impact of change on neighbourhoods within the city.

Comparison with Glasgow

Glasgow's urban 3d model was also designed to replace a block model. However, the technology was designed by Glasgow School of Art and the end product aims for photorealism and is squarely targeted at Architects. Its main use is currently in the urban design review panel. As either a Planner or a member of the public accessing the existing model is difficult, as a large memory capacity and a high spec graphics card are required to run the model. As a result uptake of the use of the model has been slow and it is not generally used by planners in their daily working processes. Architects 3d modelling under the BIM system is emerging. This covers both above and below ground in relation to individual buildings. There may be an opportunity to capture the block model from both the BIM process or the existing 3d urban model to allow Glasgow to look at how the City could follow the Oslo methodology. It may be worthwhile identifying a live project, such as Sighthill or Sauchiehall Street and piloting to the use of 3d modelling. Glasgow should discuss if it may be possible to get colleagues in Oslo to 3d print the model blocks for a pilot project.

As an alternative to 3d modelling for masterplanning areas, the Scottish Sustainable communities Initiative (SSCI), is a Scottish Government led initiative to encourage the creation of places designed and built to last, where high quality of life can be achieved. The government developed an interactive, public design workshop or Charrette. The Scottish charrettes are unique in their approach to community engagement and participation. Generally taking place over several days, a Charrette is an interactive design process, in which the public and stakeholders work directly with a specialised design team to generate a specific community vision, usually based around a Masterplan.

Typically, a temporary design studio is set up within the neighbourhood which the Charrette is focusing on. The public and other stakeholders then work with the design team over several days to develop ideas in to plans and designs. So far there have been over 10 charrettes within Scotland and Glasgow has been lucky enough to host a couple of charrettes focusing on areas around the forth and Clyde canal – notably Port Dundas Charrette. Each Charrette follows a common format, typically including:

- Visits to the site and surrounding area
- A series of meetings with the public and specialised groups including planning, environment and transport specialists
- On-going production of drawings and illustrations; and
- Public presentations intended for audiences representing the relevant communities.

Throughout the course of the Charrette, the design team develops and revises proposals incorporating the emerging ideas and concepts generated during meetings and public design sessions. The iterative process allows a high degree of active public engagement. It also develops and tests a wide range of ideas in order to identify approaches that are well-informed and specific to the particular situation in a masterplanning area. Whilst the main aim of the Charrette is the design of the physical environment, it will also consider socio economic and health issues that relate to the resilience of a community to deal with change.

Comparison with Rotterdam

The engineering department of Gemeente Rotterdam has worked with Strategis and RO2 to develop the serious Game Underground. Commissioned by SKB (sustainable development underground functions) and SBNS (foundation soil remediation Dutch railways), the municipalities of Rotterdam, Utrecht and the provinces of Groningen, Drenthe and Noord-Brabant. www.strategisgroep.nl/en/products/serious-game-underground/ - a demonstration game is available here.

The underground game is a multiplayer serious game about the important role of the underground in spatial development. Within the game, participants experience real world issue in a safe, virtual environment. Whilst playing the game they get a real sense of the issues, terminology, prevailing themes and possible measures that require to be understood by different sets of professionals working above and below ground. Participants take on specific roles, namely Planner, Water service, Energy Company, Housing Authority, Politicians and Media and will therefore be able to, from within the role they are playing, take actions which will impact on satisfaction levels for citizens; the environment; politicians, water, housing or energy companies or the media. The game allows players to develop both the sub surface and above ground areas in their control. It is played in a staged way starting by teams working in isolation; then have to negotiate or collaborate to reach shared goals. The game allows for scenarios to be tried to test the impact above and below ground; identify who needs to collaborate with whom to reach a positive outcome for a community. It allows different collaborators to reach an understanding of the each other's roles and responsibilities. The output from the game is a greater knowledge and understanding of the different roles, missions, interests, responsibilities and points of view of all the different stakeholders. The game also provides a platform to exchange knowledge and information between often very diverse parties in spatial development. Rotterdam has teamed this with a monthly sub surface tour of the city centre where the can explain issues to colleagues and members of the public.

The Serious game is used as an awareness tool / visualisation rather than a model. The Engineering Department at Gemeente Rotterdam are currently developing the Rotterdam-model, which will be a genuine model.

Lessons Learned

1. Remember that 3d model is just a tool.
2. In order to validate the 3d geometry found that architects 3d drawings were too detailed.
3. Had to work around to find software solutions that were successful – finding a software savvy student helped to short cut some research and upskilling.
4. Can look at model from different angles and capability to print individual bits to take to meetings.
5. Only reprinting the sections that are subject to change.
6. Can print a section and use modelling clay on it to change what buildings look like.
7. Produce a YouTube video to explain and make interactive

8. Use technology that people can access.
9. Everybody in team knows how to print a model.
10. Keep it simple and agree who target audience are. Block model is enough to explain and discuss concepts.
11. Block models can take projections
12. Oslo should create and share its step by step guide to how to digitally print an urban block model.
13. The Scottish Charrettes use a mix of low and high tech technologies to stimulate discussions between specialists and the public.
14. The serious game – underground is a methodology for testing scenarios and learning about the different perspectives of stakeholders whilst undertaking an activity. A good way of bring different professions together and provides a quick route to understanding. Can a Scottish version of the game be produced for use in the UK?

Oslo Sub Surface project a short introduction

The Oslo Sub Surface project is based at the Agency for Planning and Building Services within Oslo Kommune. In 2011 pre project discussions and research were carried out which resulted in the four year "Sub Surface Project" or; Prosjekt for økt kunnskap om undergrunn i Oslo" being set up. The project started up in February 2013 and will run until February 2017. It's managed by Ingelöv Eriksson.

Whilst the project is owned and managed by the Agency for Planning and Building Services, the project group brings together employees from five different municipal agencies, including: Agency for Planning and Building Services; Cultural Heritage Management Office; Agency for Urban Environment; Agency for Real Estate and Urban Renewal; Agency for Water and Sewerage works

The project group consists of 15 persons, and is a truly interdisciplinary group; architects, counsellors, construction engineers, GIT engineers, geologists, 3D specialists, a geotechnician, hydrogeologist and a hydrologist are working closely together in order to improve the knowledge and management of the City's subsurface. Whilst the Subsurface team does not have any Spatial Planners or Building Control specialists within it, they do work in close collaboration with these teams as they can call on existing resources within their own Agency (the Agency for Planning and Building services) and from the other 4 key partners agencies or services within the project.

Comparison with Glasgow

The responsibility for the management of Glasgow's subsurface currently sits between two services and several teams within the Council and a number of external Organisations. The responsibilities and teams relating to these services are stated below:

Glasgow City Council

Development & Regeneration Service (DRS)	**Responsible for:**
Project Management & Design Service, Engineering Group –	Civil & Structural Engineering; Flood Risk Management; Geotechnical & Land Remediation.
Planning & Building Control Service, Development Plan Group –	Development Plan; Place Strategy & Environmental Infrastructure; West of Scotland Archaeological Service;
Neighbourhoods Group –	City design, 3d Urban Model / historic environment, Neighbourhood forward planning

Land & Environmental Service (LES)	
City Parks and Open Space Group	Management of Parks and Open Spaces; Landscape Design, Nursery and Plant Production; Natural Environment; Allotments ; Trees and Woodlands
Environmental & Sustainability Group	Public Health; City Energy; Carbon Management; Environment & Strategy; Sustainable Glasgow; Future Cities; Resilience
External Organisations	
British Geological Survey	3d Geological subsurface maps; Ask Network; GSpec
SEPA	Soil contamination; Ground water; flood risk
Utilities	Cables and Pipes – national networks maintenance & development
SNH	Ecosystem Management
Historic Scotland / Rchms	Archaeology; Historic buildings ; World heritage

The lead for pulling together planning input and policy sits with the team leader of the Place Strategy & Environmental Infrastructure Team. Through the development of spatial planning guidance DRS is aiming to provide a co-ordinated way forward for Glasgow on the sub surface. Glasgow also has a number of projects running that will deliver on or will require to use the subsurface – Rockefeller 100 Resilient Cities; Climate Ready Clyde; Metropolitan Glasgow Strategic Drainage Partnership and Sustainable Glasgow.

In discussion between Rotterdam, Oslo and Glasgow about what management arrangements are in place with regard to the subsurface it became very clear that one of the major issues is ensuring that there is awareness about what information and data is available; where to find it quickly and how to bring specialists together. Glasgow sited an example where they had brought in external facilitators (Greenspace Scotland) to run a work shop under the heading Integrated Green Infrastructure (IGI). From 10 invites sent out to key people, over 40 people turned up at the workshop from DRS and LES. Facilitated discussions looked to identify who had responsibilities in relation to IGI; what they thought others did; where there was duplication; synergies and gaps. The workshop identified that lack of awareness and communication were major barriers to moving forward.

All 3 Cities agreed that there was merit in having a shared information resource via the web – some form of wiki or web site where best practice; guidance; information and key contact could be stored and accessed easily. This would appear to be a key proposed output from Work Package 3 of the main project but could be piloted by the three cities.

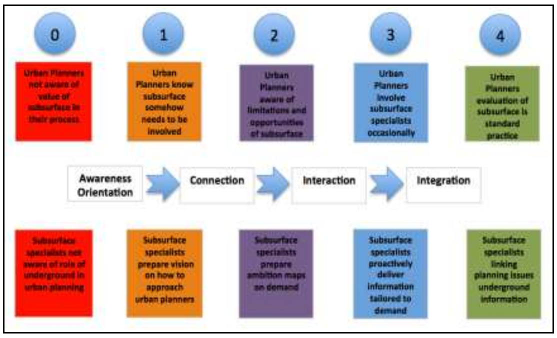
Comparison with Rotterdam

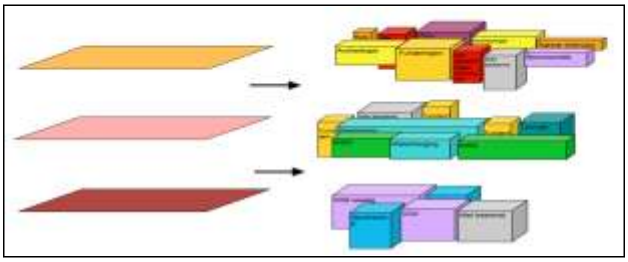
The responsibility for the management of Rotterdam's subsurface lies with specialists in Gemeente Rotterdam who are organized in teams along disciplinary lines. These different disciplines - archaeologists, geo-hydrologists, environmental, cables & pipelines specialists, geotechnicians, ecologists, etc work alongside the City's Planners.

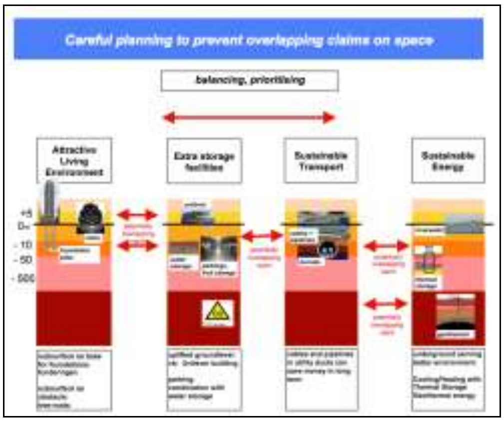
The Gemeente Rotterdam has a wealth of information and knowledge about the subsurface of Rotterdam. It is the responsibility of its subsurface specialists to make this information and this knowledge available to decision makers, urban planners, and city developers as well as to the public.

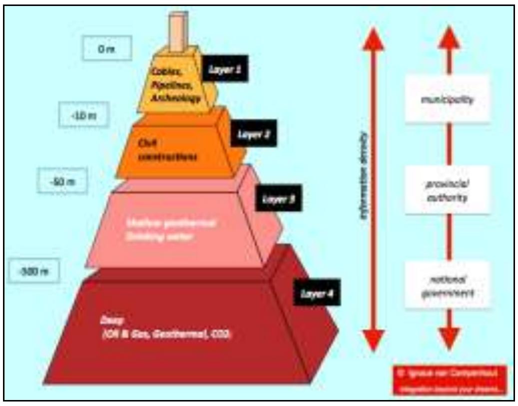
The subsurface specialists have acknowledged that they should provide insight into the underground with attractive visualisations of the right information, presented at the right time, geared to demonstrate what is possible within the subsurface; what information is available and what the subsurface cannot do, in order to encourage decision makers to sustainably exploit the underground. They acknowledged that there a number of different stakeholders who have an interest in the subsurface for a number of different and possible divergent roles.

Rotterdam participated, together with 3 other Dutch cities (Utrecht, Arnhem, Enschede), in the national programme on spatial planning of the subsurface (Ruimtelijke Ordening Ondergrond) that was initiated in 2008 by the Ministry of VROM. This was the first time that a holistic view was applied to the subsurface usage. Since then Rotterdam has continued to invest in answering questions like “what are the possibilities of the subsurface, what is their desirability (influences on the subsurface, environmental effects, urgency, contribution to climate objectives) and on how to prioritise one possibility versus another”. In order to get a debate going the City has prepared a number of different visualizations to explain who has a stake in the subsurface and how do they use it. Examples of these are shown below.









Lessons Learned

1. Even with a co-ordinated project it can be difficult to get all the experts / specialists on the "same page"
2. Be aware that different stakeholders are interested in different parts of the subsurface and that this could be at the same or different times.
3. Development of a wiki / shared web page could provide a home for visualisations; useful links; presentations; papers and contacts. The information gathered for this STSM about Oslo, Glasgow and Rotterdam such as STSM presentations and papers could be used as the building blocks – Note Rotterdam has already purchased a web domain.
4. Each Council should develop its own webpage about the subsurface. This should link into the COST Sub urban home page and partner cities
5. Raise awareness within each Council about the subsurface and who has responsibility for each layer; what infrastructure is found in each layer and who has a co-ordination role
6. The team responsibilities within Glasgow and Oslo are very similar (and there is an awareness that Rotterdam may also have synergies) and therefore there are strong possibilities of benchmarking; co-production of guidance and working in cooperation together.

Subsurface planning: challenges and lessons learnt in Oslo, Rotterdam and Glasgow

Oslo is the fastest growing city in Europe, growing at 2% per annum. The city will have increased population by 150,000 by 2030. It sits at the hub of the national transport network and the political aim is to get more people using public transport, walking and cycling. Main investment has been in the new metro system. Currently 100 metro stations have been opened across the city. However Oslo notes that they are not good at creating non-motorised transport options. A new statutory system has been introduced for transport planning. The hope is that this will lead to better co-ordination.

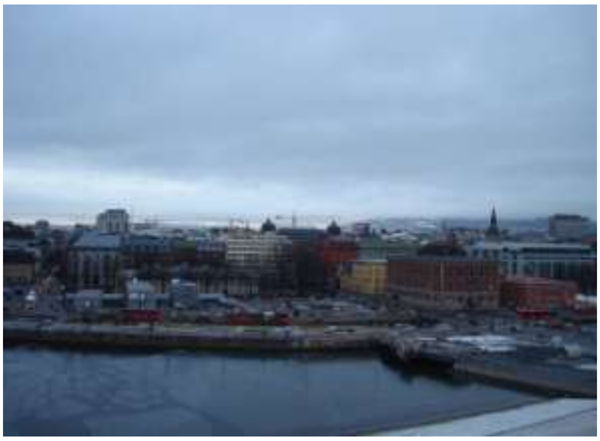
The new transport proposals, including a new double track railway heading south towards Ski / As and then onwards to Gothenburg and a new double track metro through downtown Oslo will be built partly or mainly underground. There is an existing tunnel taking the high speed airport train out to the north of the city. This is all backed up by a good network of buses and trams.

The city of Oslo is situated in north end of the Oslo fjord, in a sedimentary basin formed during the last glaciation period. These glacial structures have subsequently been covered with marine sediments, mostly clays. Moraine from the glacier dammed up lakes, from which the eight main waterways in Oslo stem from. The City is surrounded by a forestry based green belt. This constrains City growth and means that it is currently growing within defined growth corridors. The Kommune is currently considering the expansion of the metro system along these growth corridors and is also looking at the possibility of introducing light rail. The planned and proposed expansions off the rail network will result in an additional 20km of tunnels beneath Oslo.

The development of these new tunnels throws up problems relating to the archaeology in the oldest part of the city which surrounds the southern parts of the central railway station and the first hill through which the southern railway needs to pass; issues of avoiding existing cables and pipes; buffer zones around new technologies like thermal wells; old infrastructure such as basements and 2nd world war installations; impact on existing ground conditions and groundwater levels.

In addition the redevelopment of the old airport site at Fornebu, the realignment of the existing metroline and proposed renewal of the waste water system also pose a number of below and above ground infrastructure issues. Align this with the fact that major developments all make a demand on the subsurface for the provision of infrastructure relating to foundations, ground conditions, groundwater management, water, sewage, heat, electric and provision of basement or tunnels. They also impact on and have to negotiate around existing archaeology, cables / pipes, transport tunnels, plant roots, thermal wells and historic voids and ground conditions. It becomes very clear that the current Norwegian planning system is not geared up to deal with this effectively. Thus each application is currently dealt with on a case by case basis.

The current development planning system within Norway, which originated in 2008, is very similar to the Scottish system. Municipalities produce a Municipal master plan every 4 years which is endorsed by the politicians. This can be supplemented by a municipal sub plan for specific communities, a detailed plan for smaller development areas and a building project submission for individual sites. Whilst the plans are legally binding they do not cover all themes and Oslo has identified issues with the cumulative impact of individual energy wells within its neighbourhoods. Currently permission is not required to drill energy well. If a utility or transport company subsequently wants to lay cables and pipes or create tunnels, the energy well effectively becomes a ransom strip if it is within the "underground" space that is required for the infrastructure development. Thus Oslo is starting to look at identifying sub surface zones where you can't drill for energy, however if you do and an infrastructure development results in the removal of your well no compensation will be paid. In the long term they would wish to have more control over energy wells and see them brought within the building application system.



Comparison with Glasgow

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

Glasgow is the biggest City in Scotland. It is the economic engine and main commercial hub not only for the city region, but also for Scotland. Almost 2.5 million people, half of Scotland's population, live within an hour of the City. Since the 1980's the City has been undergoing an economic revival through regeneration, restructuring and reinvention of some of its communities.

Glasgow, although low lying, is characterised by its drumlin landscape. 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.

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.

Regional planning for the wider Glasgow area is the responsibility of a joint committee covering the City of Glasgow and seven surrounding administrative areas, the Glasgow and Clyde Valley Strategic Development Planning Authority (GCVSDPA). 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.

The Plan sets out a strategy that aims to deliver on the following four strategic outcomes: **A vibrant place with a growing economy** - by providing the right environment for businesses to develop; **A thriving and sustainable place to live and work** - by providing opportunities to build new housing, and creating vibrant places and town centres to provide a good quality of life in the long term for the City's growing population; **A connected place to move around and do business in** - by improving accessibility for all citizens to employment, shopping and leisure destinations, and providing more sustainable travel options; **A green place** - by helping to care for Glasgow's historic and green environments, increasing the City's resilience to climate change, and reducing energy use.

In May 2014, a new City Development Plan, 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), updated government guidance on the format for development plans (published in 2013) and updates to the National Planning Framework and Scottish Planning Policy (2014). When finalised, the new plan ('the proposed City Development Plan') will supersede the current Local Plan (City Plan 2).

The development phases of the proposed City Development Plan

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

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 reflects the growing awareness of policymakers of the importance of the subsurface environment and resources for the future development of the City.

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 (TU 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.

Comparison with Rotterdam

In The Netherlands spatial planning sits with a number of different governmental bodies: National government; Provinces or Regions in Urban; Cities / Municipalities and Waterboards (Waterschappen/ Hoogheemraadschappen).

The National Government produces an overarching plan; this could be comparable to the National Planning Framework and Planning Guidance in Scotland. Rotterdam, like Glasgow, sits within a regional planning area called Stadsregio Rotterdam. This covers Rotterdam and its surrounding municipalities. The Region, which is an independent administration body, works on a regional scale and has a focus on infrastructure and environmental policies.

The 12 provinces in the Netherlands make their own ‘structure vision’, based on the national governmental plans. Municipalities create their own vision and detailed ‘zoning plans’, both should fit in the national vision. Spatial Planning within The Netherlands is therefore organised in three levels/scales. Together with surrounding municipalities, Rotterdam is part of the Stadsregio Rotterdam. This is an official independent administrative body working on a regional scale with emphasis on issues relating to infrastructure and environmental policies. In 2015, the Stadsregio Rotterdam will be merged with a Haaglanden, a similar administrative body for the greater The Hague area. Together they will form the “”Metropole Rotterdam The Hague””.

Below Regional scale, Gemeente Rotterdam has responsibility for the formulation of the **spatial development strategy 2030** which focuses on the following elements:

<u>Strong economy</u>: Creating a strong economy concentrates on the transition from an industrial economy to knowledge and services economy, based on the further development of the medical and creative sectors. In the port area besides the recently concluded construction of Maasvlakte 2, a large new port area, the emphasis will be on innovation in the fields of energy consumption and energy production as well as on the reduction of the emission of carbon dioxide.

<u>Attractive residential city with a balanced composition of the population</u>: Good housing alone is not enough for an attractive residential city. High-standard public space is an important condition for creating attractive and popular residential environments,

For the last 2-3 decades urban planners have not considered the subsurface as a very important factor that has to be taken in account whilst planning. The most relevant issues that were considered were: archaeology and soil pollution. These issues have/had to be considered because of national and international laws. Other themes like groundwater (levels and flow patterns), geotechnical capacities and subsurface space were only taken in account on a project scale. During the last five years attention for all themes in the subsurface is increasing. The fact that the subsurface has to be considered in city planning is more and more acknowledged.

Lessons Learned

1. Have an awareness of the impact on the sub surface of major proposals
2. Identify who owns the sub surface infrastructure that currently exists
3. Identify buffer zones between various sub surface uses
4. Understand the multitude of government legislation that controls the sub surface
5. Understand the opportunities and constraints that exist around energy wells – both closed and open systems
6. Remember to plan outside the 3d red line of the site
7. Understand the sub surface layers and who regulates them
8. Understand who the key players are who have a stake in the different parts of the spatial planning of the sub surface
9. Ask the right questions about the impact of development on the sub surface at the right time.
10. Note that not all stakeholders are interested in all the layers of the sub surface. They all have different priorities and deliverables that impact on what they can and cannot do within the subsurface.
11. Subsurface data layers require to be available to a wide audience of professionals within a GIS environment (both private & public data). They require to have a clear description; identified data owner and parameters. There should be an indication about which layer of the subsurface they relate to.
12. The responsibility for keeping subsurface data up to date lies with the data owner. They should also determine what can be placed on a public facing web service and what is for internal system use only.
13. Information on the sub surface spatial planning needs to be gathered in one place; in one format and needs to be an identified responsibility for a team or individual. Data management system may be required.

City Tour Bjørvika

Bjørvika is a community that sits at the heart of the original settlement of Oslo. The city developed from the 11th century onwards due to a strategic location both with regard to transport, trade and military. By the 1300's Akershus Fortress, several churches; monasteries and manor houses for the King and Bishop had been established. The community consisted mainly of wooden buildings. In the 16th and 17th century's the community was repeatedly blighted by fire and in 1624 King Christian IV ordered a new city plan and changed the name from Oslo to Christiania. A square city grid was introduced to the west of the original Bjørvika settlement, and the first brick buildings were built. The city grew as an important centre for the timber industry and port facilities developed at the old Bjørvika settlement.

From 1814, Christiania became the capital of Norway, which had regained partial independence from Denmark and entered a union with Sweden. Industrialization started in 1840, initially along the Aker River. The population grew rapidly, and new infrastructure was built. Commercial activities increased, and in 1854 the railway station was opened. Between 1835 and 1890 the population grew from 18,000 to 151,000 and the City became an important shipping port.

By the sixties, sales of cars exploded following the deregulation. A new road system through Bjørvika was opened in 1970. Ten years later, the Oslo Tunnel connected the city's two railway networks together. Starting in the 1960s, containerisation and automation became leading trends in the development of the port technology. The steady construction of new roads and port facilities created a physical and visual barrier that hindered Oslo from having access to the waterfront. For instance the European route E18 took up 1.8 kilometres (1.1 mi) of waterfront before passing into a tunnel under the city centre, before the Bjørvika Tunnel (*Bjørvikatunnelen*) was opened in 2010. The tunnel has two bores, with three lanes in each. In the west, it connects to the Festnig Tunnel (opened 1990) at Akerhus Fortress and runs under the Bjørvika arm of the Oslofjord before ending in an intersection on the east shore, where it splits into Mosseveien (E18) and the Ekeberg Tunnel. The tunnel is 1,100 metres (3,600 ft) long, 675 meters of which run below sea level. The Bjørvika Tunnel is part of the Opera Tunnel complex which is the name of the interconnected system of tunnels between Ryen and Flipstad. The Bjørvika Tunnel is the first immersed tunnel in Norway.

From the turn of the millennium, Bjørvika has been undergoing major redevelopment. The building of tunnels to remove the barrier created by the E18 has allowed a new neighbourhood to be developed between the railway and the fjord. A new avenue, Dronning Eufemias gate, has been constructed along the current route of Bispegata. It will serve as a main route for public transport, and the Ekeberg Line of the tram system is planned to be rerouted along the avenue in 2014 /15

Between Dronning Eufemias gate and the Central Station, twelve medium-rise buildings, up to 22 stories tall, are being constructed. These have officially been christened the Barcode Buildings. Whilst the aim is to create a connection between the old and new parts of Oslo via the use of public realm, the existing railway still acts as a barrier between the City and the new community. A large part of Bjørvika is built on quick clay which is relatively stable unless groundwater moves. Modern foundations for the Barcode Buildings and infill development within Bjørvika have moved the groundwater and made the quick clay unstable. As a result older buildings, which were already sinking due to changes in ground conditions, are now sinking faster. Tunnelling work has hit problems due to unmapped energy wells for which compensation has to be paid if they are to be removed to make way for the new infrastructure.

Major archaeology has also been an issue, as Bjørvika has multiple layers dating back to the 1100 and the early settlement of Oslo. Existing foundations have been reused over the centuries and demolished or burnt buildings have been used to provide foundations for new build over the centuries. Due to the area also being an early centre for the timber industry a lot of the made up ground consists of wood chip and sawdust.

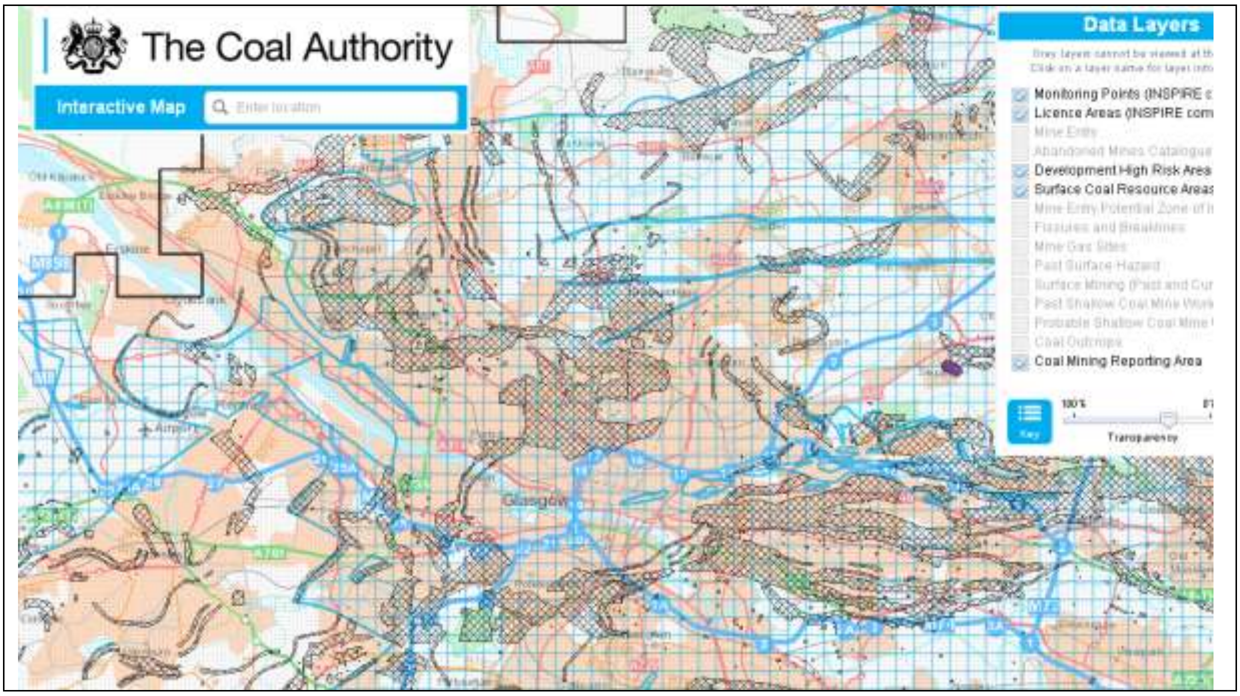
Comparison with Glasgow

Glasgow, Scotland’s largest city, lies along the River Clyde and its estuary in west central Scotland. 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.

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.

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.

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

Watercourses in the past were often either incorporated into the sewer network or modified to flow through buried pipes. As the water was out of sight, it became increasingly out of mind for local communities. Increasingly residents of the city have become aware of the buried water due to the changes in the weather. The west of Scotland is becoming milder and wetter. This is leading to increased flood events when the water can’t be dissipated below ground or when in extreme periods of heavy rainfall the buried pipes overflow above ground. Over 63km of water courses are currently culverted and built over within the City boundaries.

The City is also moving away from hard engineering solutions with regard to sustainable urban drainage. In the past engineered sub surface solutions were preferred. The City now aims to discouraged sub surface drainage solutions in favour of projects which keep water on the surface. This will help raise the public's awareness of their responsibility for flood risk management as they will be able to see how storm water is managed. A full range of novel and innovative methods will be introduced but will require significant support and backing from developers, planners, design professionals and statutory bodies. It will also require, through re-education, an attitudinal change to land use and the perception of risk from surface water.

Comparison with Rotterdam

Rotterdam is located geographically within the Rhine – Meuse – Scheldt river delta where it flows into the North Sea. Its history goes back to 1270 when a dam was constructed in the Rotte River and people settled around it for safety. In 1340 Rotterdam was granted city rights and slowly grew into a major logistic and economic centre.

During World War II, the German army invaded the Netherlands on 10 May 1940. The advancing German army met unexpectedly fierce resistance. The Dutch army was finally forced to capitulate on 15 May 1940; following Hitler's bombing of Rotterdam on 14 May and threatening to bomb other

Dutch cities. The heart of Rotterdam was almost completely destroyed by the Luftwaffe. Some 80,000 civilians were made homeless and 900 were killed; a relatively low number given that many had fled the city because of the warfare and bombing going on in Rotterdam since the start of the invasion three days earlier.

Rotterdam was gradually rebuilt from the 1950s through to the 1970s. It remained quite windy and open until the city council from the 1980s on began developing an active architectural policy. Daring and new styles of apartments, office buildings and recreation facilities resulted in a more liveable city centre with a new skyline. In the 1990s, the Kop van Zuid was built on the south bank of the river as a new business centre.

Nowadays it is home to the Europe's largest port and has a population of 624,799 (2014, city proper), ranking second in the Netherlands. The Greater Rotterdam area is home to over a million people. Rotterdam is part of the yet larger Randstad conurbation with a total population of 7,100,000.

Within building projects, with underground sections, it is usually necessary to lower the groundwater level by temporary groundwater extraction. Groundwater extraction is regulated by rules and permits of the water boards.
In the (deeper) polder areas seepage of deep groundwater is an issue. Seepage occurs when the head of the deep groundwater is higher than the shallow groundwater level. In most parts of Rotterdam there is a separating layer of clay and peat (thickness: usually 10 tot 15 meters) between the deep and shallow groundwater, which limits vertical groundwater flow. In the deep polder areas the ground level is often lower than the head of the deep groundwater, combined with a relatively thin separating layer because of peat mining in the past. Seepage can lead to increased shallow groundwater levels. Because seepage water is usually brackish, with a relatively high content of iron and nutrients, it can also lead to a decrease in surface water quality.

Problems associated with (shallow) groundwater include:
-High groundwater levels, resulting in damage of road constructions, water in basements, squashy gardens etc.
-Low groundwater levels can lead to putrefaction of wooded pile foundations of older buildings when the wood is (periodically) above groundwater level (oxide conditions). This degradation can eventually lead to damage of buildings.
-Settlement of buildings without a pile foundation. This will reduce the distance between ground and groundwater level, which can therefore lead to groundwater problems.
-Groundwater contamination by industrial/commercial activities in the past

Lessons Learned

1. Understand the impact of modern foundations on ground water and soil conditions
2. Gain a good understanding of the geology and how it reacts – ie quick clay is stable until you add water (reacts very like Corn flour paste – fluctuates between a solid and a liquid)
3. Remember that you can have layers of transportation tunnels – both Oslo and Glasgow have heavy rail and light rail tunnels layered on top of each other.
4. A high density modern city built, with an historic core requires to understand its history and archaeology.
5. There needs to be an understanding of how foundations for buildings were constructed in the past and how new modern building techniques will impact on them.
6. Infrastructure doesn't need to be ugly. Oslo could learn from Glasgow's integrated green infrastructure experience to improve the sense of place.
7. Use the geology as a positive to create great environments – work with it.

Oslo Sub Surface 3D model

Oslo is developing a 3d sub surface model utilising the geodata that is readily available either from the Kommune or from infrastructure providers or other governmental departments. The aim is to develop three test models based on the communities of Majorstuen, Bryn and Ekeberg. The start point has been identifying the data that the planning service already holds, the majority of which is in a 2d format. This includes traditional spatial mapping; aerial photography and Building Information modelling (BIM). The 3d digitally printed model of the city and the data behind it has been used as a “foundation” for developing the 3d sub surface model. The service set up a matrix to identify for each set of data – what data actually exists, the data owner, how data collected (type, frequency etc), 2d or 3d and security issues around access to the data. The discussion around identifying who holds the data has allowed the sub surface team to raise awareness about the information that is available and where it is held within the city.

Not all the data was held by the city. Bedrock data came from NGU; borehole data from the water and sewerage companies; tunnels information from transport bodies and cables and pipes locations from energy suppliers. Building information data did not tend to go below ground, thus the service took information that they held for the Majorstuen area about the location of buildings with basements. They estimated that the average basement level was 3m per floor. Using data they had available about number of levels of basements within each building in the area they were able to start to create a 3d model of the subsurface of a building attached to the known above ground building.

In order to get foundation depths they pulled information from the City archives and the archives of Byantikvaren (Cultural heritage management) which provided information about type and depth of foundations. This was then digitised and dropped into the 3d model and a visualisation was created using ArcGIS.

Data available about fill mass, depth and type; water and sewerage pipes; energy wells – location and depth; electrical cables, traffic control cables and location and depth of manholes was all then taken from a 2d data source and converted to 3d. Where the depth of cables and pipes weren’t known, a best estimate was agreed on and this was used for modelling. Finally, disposal wells, transport tunnels, bedrock typography and geology were added to the model in a 3d format.

Some of the major challenges encountered included access to the datasets; security around who should have access to the data and what it was going to be used for; agreeing protocols for data exchange; uncertainty about data quality and the need to create own data to plug the gaps. For instance the sub surface team had to create their own data set for the basements; guess the depth of pipes and decide on what would be appropriate buffer zones between different sub surface uses in order to allow a 3d model to be created.

In order to test reaction and to make the model accessible, 3d pdf’s have been produced which allow the recipient to manipulate the view of the model. The next stage is to attempt to simplify the data collection and reduce the need for file conversion. Each year the City pays for a laser scan of the city from the air and aerial photography. These supply points for the terrain model of the city. The City spends a lot of money to obtain this data but is now questioning whether it is being supplied in a useable format. Ultimately they want to simplify the data collection process and collect data once but use it for multiple outputs.

Comparison with Glasgow

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.

The Project Management and Development group within Development and Regeneration Services have been investigating how to use Building Information Modelling (BIM). This is created on "as needed" basis for individual sites and includes some information about basements and foundations.

West of Scotland Archaeology Service manages the West of Scotland Sites and Monuments Record. An interactive 2 d map is available. http://www.wosas.net/search.php

Glasgow also operates a 3d urban model. http://www.glasgow.gov.uk/urbanmodel This is a 3D digital representation of the City Centre and River Clyde corridor. The model can be viewed online in two versions: Photorealistic detail (+/- 20 cm accuracy) and Block detail (+/- 0,50m accuracy)

The Energy team within Land & Environmental services have worked with Scottish Power to produce heat mapping for Glasgow and have developed a 3d block model.

The utility / transport companies hold 2d mapping in relation to cables and pipes; culverted waterways and tunnels.

To date no attempt has been made to merge the data from these various models to create a true 3d model for the subsurface in relation to the surface.

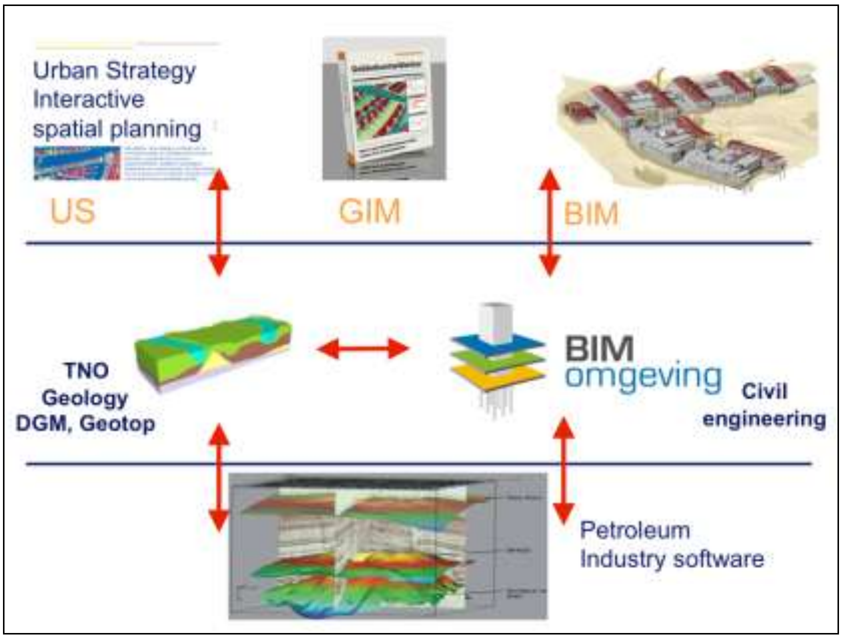
Comparison with Rotterdam

There is a vast amount of data, information and knowledge available on the subsurface of Rotterdam. This data is gathered by numerous specialists from various disciplines, working on different locations and for different organizations. Urban development projects require an integrated approach, in which all the information from these different disciplines can be evaluated in an integral way. Collaboration between different disciplines and organisations is the key word. The basis of a good cooperation is willingness and the ability to share and evaluate information with each other.

Therefore data requires to be:
- up-to-date and reliable
- be presented in conjunction
- is transparent; and
- instantly accessible

150 years ago Gemeentewerken, the public works organisation of the City of Rotterdam and predecessor of the present Stadsontwikkeling Rotterdam had its own engineering department that collected and archived data and information on the subsurface in a well organised way. These days all geographical data of the whole city that is collected by Stadsontwikkeling and by the other city departments is well maintained and stored and archived in central databases. As over 90% of this data has a geographical component the data is available for viewing in GISWEB, a GIS viewer developed by Stadsontwikkeling. At present Stadsontwikkeling has made over 500 layers (maps) available to its employees. Maps from other departments and from other organisations can also be integrated in GISWEB as long as they are presented via WEB services.

INSPIRE is an EU initiative to establish an infrastructure for spatial information in Europe, that is geared to help to make spatial or geographical information more accessible and interoperable for a wide range of purposes supporting sustainable development. Based on these European directives, the Dutch governmental initiative GIDEON has developed national directives that force governmental organisations and Dutch universities to harmonise their basic data handling. Stadsontwikkeling has adapted GIDEON's organisational principle of "Single storage, multiple use" of data.



Lessons Learned

1. Identify areas to test out the 3d subsurface modelling within.
2. Identify what useful data exists – but start with the data that the planning service owns
3. A lot of data exists in 2d, but not 3d
4. Build a relationship with the partner organisations that own useful sub surface data.
5. Useful data includes – Bedrock topography (above and below ground); Borehole location and depth; number, depth and location of basements; building foundation depth and type; fill mass and depth; cables & pipes – depth, type, size, manhole locations; energy wells type & location, transport tunnels
6. Challenges - access to data, data security, routines for data exchange, data quality; buffers and constraints
7. Producing output as a 3d PDF is really effective and user friendly

Presentation of Subsurface and planning challenges in Rotterdam and Glasgow

Copies of the presentations given by the representatives from Glasgow and Rotterdam or summarised versions will be made available on the COST Sub Urban website. The issues in relation to the sub surface have been drawn out in relation to the various sections of this report, but key lessons learned following the discussion on the presentation are drawn out below.

Lessons Learned

1. Norwegian, Dutch and Scottish Planning systems are fairly similar
2. Both Oslo and Glasgow want to produce subsurface guidance
3. Rotterdam wants to produce guidance that doesn't see the ground level as a barrier – information above and below ground should be in same document.
4. Key drivers for understanding the sub surface for all 3 Cities are: Sense of place; flood risk / water management; Resilience / Climate mitigation / Geology; 3 d urban modelling / BIM; open source data
5. Lots of different terminology used to describe the same output – Specialists need to speak the same "language"
6. New drivers include: Geothermal; resource management; ground conditions / contamination; high density developments
7. Keep solutions simple and think about the target audience

Geological mapping and use in municipalities

Oslo currently has a 2d bedrock depth map (which is, in the current state, easily transferred to a 3D map. It has already partly been done in the City's test area of Majorstuen). The map was created using data from 186 thousand boreholes. Data about boreholes started to be captured in 1914 and the Geotechnical office within the City was set up in 1955. The 2d visualisation has been created by taking all the borehole information, creating 20 to 50 metre buffer zones around the boreholes and interpolating the information. There are, however, areas of the City where there is no borehole information, particularly around central station. It should be noted that this 2d visualisation does not show what type of bedrock is where and there is no information about the geology above the bedrock. What is known is that there is a lot of debris from sawmills and metal works around the Aker River that has been used as infill. In addition as the Aker reaches the historical centre of Oslo it enters a tunnel under the station near Bjørvika, and remains culverted under the Barcode Buildings, emerging into the harbour via a pipe.

Over the years the City gradually reduced its geological service, relying on the NGU and data supplied by private companies as part of applications or commissions. There were a number of years when the City did not have a geological service of its own. The sub surface project brought geologists already in the City's employ together in 2013, enabling them to work to a defined agenda. This was the result of recognition that the City and its surrounding municipalities required access to better geological visualisations and data.

The City has encountered a real issue with the private sector data managers who seek to make a profit from the sale of data. The value of the data requires to be repositioned to sit with the manipulation and analysis of the data rather than with the raw data. Due to the value being in the baseline difficulties are encountered with access to the data. For instance the department responsible for electrical cables granted the subsurface team access to its data, but the department dealing with district heating did not. This means that incomplete data is available. There have also been issues with the baseline data being incomplete as it has been collected for one purpose, but is attempting to be used for another. The biggest issue in relation to this is depth information.

The best existing sedimentary geological map of Oslo is Bogörlykke from 1898. In order to create a 3d geological map the City has started with the 2d bedrock map and converted it to 3d. The city then created a 3d model of the existing geological map and placed it below the bedrock visualisation. It should be noted that the map that is created has accuracy issues and the colours chosen to represent various layers are not great. However, the visualisation does allow the City to start to visualise where toxic sedimentary soils, such as black shale, may exist within the City.

Black shales are found frequently in Norway, especially in the Oslo area. Black shales swell when disturbed from their natural deposition setting, resulting in damage to buildings, deterioration of steel and concrete, sulphur and heavy metal contamination of the groundwater, emission of carcinogenic radon gas. In addition, there is the uncertainty about the best solution for sound disposal of masses containing black shales. Within Oslo there are areas where the Black Shale has eaten through the fresh water and sewerage pipes. Research is ongoing jointly with Norwegian Geotechnical Institute (NGI) http://www.ngi.no/en/About-NGI/VP09/RnD-activity/OK---Black-shale-A-construction-and-environmental-problem/ to identify workable solutions to this problem. NGU currently has geological maps that show where to find Black Shale but no information about the depth or volume of the shale. It should be noted that in some parts of the city Black Shale can be found above the surface. There is also now a problem with the radon gas the Black Shale produces, to the extent that legislation has been passed that forces landlords to provide information about radon gas in their property before they can legally rent it out. In new buildings the black shale requires to be capped to prevent radon gas coming into the buildings.

Resources are being allocated to create a 3d visualisation using available terrain, sedimentary and depth to bedrock data. The 3d map that is created is only accurate for the first 0.5km as there is only a thin layer below the surface where the data is accurate. Below 0.5kn extrapolation is used to create the visualisation. There is an awareness that more detailed data about the sedimentary geology is contained with achieves, and this needs to be brought into the model. In addition the sub surface project team are attempting to capture the data that is being gathered by other services with regard to soil pollution; archaeological digs and ground condition reports.

Due to the types of soil, water infiltration is a problem in Oslo. Currently 27 litres of drinking water is leaking into the ground per minute as the pipes can be “eaten” by surrounding geology. Every building project therefore requires a geotechnical report before it can progress. A temporary one year water surface project has been set up in Oslo to look at how to manage Sustainable Urban Drainage (SUDS), water squares and water infiltration. The NGU has also applied for funding to carry out research into how SUDS schemes impact on groundwater, cultural heritage with regard to retrofitting, relationship to new water and sewerage pipes and the development of non permeable surfaces.

Comparison with Glasgow

The regeneration within Glasgow, which is a national planning priority, is intended to stimulate economic growth, drive smaller community regeneration projects, and tackle concentrated deprivation resulting from industrial decline.

To underpin this regeneration BGS are developing integrated and attributed dynamic shallow-earth 3D models in partnership with Glasgow City Council and other organisations. This transdisciplinary project aims to make geoscience information more accessible, relevant and understandable to the wide range of users involved in the sustainable regeneration and development of Glasgow and in particular the Clyde gateway area of the city.

An overarching project known as CUSP (Clyde Urban super Project) has been created with the following research themes:

- Ask Network
- 3D attributed geological modelling
- 3D geotechnical modelling
- 3D hydrogeological modelling
- 3D modelling visualisation
- Geothermal potential
- Groundwater in the Clyde Valley
- knowledge transfer systems for developers, policy makers and planners
- natural and contaminant geochemistry
- Sustainable Urban drainage (SUDS)

Growing partnership between the BGS and GCC led to the development of the ASK Network (Accessing Subsurface Knowledge), 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.

As stated previously work has started to look at data management and 3d modelling within the City that will hopefully lead to a sharing of data and the creation of a unified 3d model for above and below ground within Glasgow.

Comparison with Rotterdam

In Rotterdam the geological information that is held by TNU relates to the deeper sub surface. So the TNU model starts from a depth of 200 – 300 metres. The City holds data about the immediate sub surface but is now moving towards trying to create a 3d visualisation to connect the surface to the 3d depth model. The City currently has a Masters student working on profiles using existing borehole data to allow sedimentary layers to be identified, however they require more information about the quality of the soils.

Within Rotterdam, 2d visualisations of the building foundations have been created. 1500 measuring points have been used to develop the visualisation which is being used to look at how buildings and tunnels are impacted on by groundwater. Due to the type of clay that is in the subsurface below Rotterdam, groundwater is drawn towards man made structures. This can create variations in water pressure; leakage within tunnels and flooding of basements via an underground capillary action. In some locations manmade barriers have been constructed within the subsurface to try to prevent the movement of groundwater.

The engineering department, of Gemeente Rotterdam, have created hot and cold maps for the subsurface. The department are trying to identify hot and cold zones so that there is a minimum separation of 20m between2 cold and 2 hot wells and 120m between a hot and a cold well. Realised that without knowledge of where wells existed, the installation of a new hot cold system could "destroy" an existing system nearby and render it unworkable, as a difference of only a few degrees in water temperature can affect the core water pressure. Currently developers require permission before they can construct new wells within Rotterdam and the City employs 4 hydrologists.

Lessons Learned

1. Identify gaps in data ie; - certain buildings and soil above bedrock
2. Combining 2d data with 3d data can sometimes produce inaccuracies
3. Some of the best geological maps of Oslo were created in 1898.
4. 3d mapping of the sedimentary geography is useful – especially when dealing with toxic soils. There are locations in Oslo where the fresh water and sewage pipes have been eaten by the black shale.
5. NGU has information about where to find Black shale, but no information about the depth.
6. New legislation (2013) in Norway requires land lords to provide information about radon gas emissions relating to their property.
7. Use terrain, sedimentary and depth to bedrock to create 3d model. Map is only accurate to 0.5m depth thus only have a thin layer where data is accurate, have to extrapolate the rest.
8. The most detailed information about sedimentary layers is in the archives.
9. Oslo is trying to capture technical information in standard format ("SOSI (Systematic Organisation of Spatial Information) is the largest national standard for geographic information. SOSI is also a widely used file format for Norwegian mapping. *http://kartverket.no/standarder/sosi/* In relation to European standards, (InSpire and so on), SOSI is quite far ahead. There is a standard for geotechnical drillings and one for pipes and cables that is under development
10. There is an opportunity to share ASK network and GSpec methodology and benchmark against the Norwegian system.
11. In Rotterdam TNO model starts at 200 - 300 metres below surface, City Council trying to create the surface to depth model.
12. Rotterdam using geothermal wells hot / cold system to allow them to decontaminate ground water.
13. In Rotterdam need permission to build geothermal well – no similar permission required in Glasgow or Oslo
14. There is an issue with ownership of data and making it a money earner. Need to make the output of the combined data more valuable than the baseline data.
15. Rotterdam has started to asset manage the sub surface infrastructure. Risk manages the data / infrastructure – criteria for risk include political, safety, health. Put founding where risks are highest
16. If you can monitor and manage the use of the subsurface you may create better data sets.

Geodata workshop

Oslo Kommune is divided into several agencies, each of which gathers its own data and creates its own maps. The key agencies creating mapping and data in relation to the subsurface are:

Agency for Planning and Building service, within which the Subsurface project team sits, is responsible for Spatial Planning, Building Control and Planning permissions. As explained above, the subsurface team are creating a range of maps based on data collected from primary sources within the Kommune and its partners. They work closely with the Planning and Thematical Mapping Unit also based within the agency for Planning and Building who provide the main mapping service for the Agency. The main mapping system used by the Planners is based on Open mapping running from ArchGis. Within this system they can create and export shape files; layer different base maps and create new projects which can be exported to others. Planners also tend to create maps by hand drawing them and then expect geodata specialists to digitize them.

Agency for Urban Environment has responsibility for all the space between buildings including parks, forestry, traffic lights / lighting, roads and street. They currently have a geodata staff of 6 who create maps for their main functions. These can include both public facing maps and maps for specialists use. They manage common areas such as streets, squares, parks, recreation areas, sports facilities, forest and the inner Oslofjord . Responsibility for air , noise, water, soil also sits with the Urban Environment Agency.

Vann –og avløpsetaten - Oslo Water and Sewerage Works (VAV) is a self-financing company within the municipality of Oslo and supplies water and collects / treats sewage for the city's 624,000 inhabitants. They create their own base mapping but it tends not to have depth data attached.

The Agency for Cultural and Heritage deals with archaeology and historic buildings and communities. Their mapping tends to be in a 2d format and relates to location of cultural and heritage objects and buildings.

The Agency for Real Estate and Urban Renewal is the municipality landowner and leads on the redevelopment of the city. This includes development of land for projects; development agreements and decontamination and environmental improvement of sites

The Subsurface team are attempting, through their subsurface 3d maps to bring all this data together. However the challenge is how you present that data back to Urban Planners in a useable and understandable format. Oslo has had some success with 3d pdf's which allows them to present complex information in a way that it can be viewed from different perspective without the need for powerful pcs.

Comparison with Glasgow

The two main services within Glasgow that create geodata are Development and Regeneration Service and Land & Environmental Service. Both have specialist GIS teams and also have specialists utilising GIS within their everyday jobs. However, the introduction of GIS into the Council led to a disconnect between Planners and GIS specialists. GIS was seen as a technical tool and it was assumed that Planners would not require access to it. It was also felt that due to the technical nature of the tool, that an inexperienced operator, such as a Planner, ran more of a risk of corrupting the data. As a result Planners in Glasgow hand draw maps; utilise Google maps or use the internal mapping tool called ATOM. Thus the power of GIS as an analytical tool is not being utilised by the Planners as they are unaware of the layers of data that are available for analysis. Other specialists such as Geologists, engineers and architects do have access to GIS and use its analytical power on a daily basis.

Glasgow has started to look at Open mapping in line with direction form the Scottish Government. Work has been undertaken in conjunction with the University of Strathclyde using open source GIS to see whether GIS layers could be exported and analysised in this way. Thus overcoming the fear of data loss as the original source data is not altered or manipulated in anyway in the corporate GIS system. The pilot resulted in an interactive map being created in relation to opportunities for photo voltaics on vacant & derelict land. Environmental and spatial planning layers were exported and layers were created in relation to technical criteria.

Glasgow has started to investigate and identifying the data that is available that may relate to the subsurface and whether it is stored in a visual or a written format. Initial meetings have identified that the subsurface can be used for water storage, infrastructure routing, roads, basements, archaeology, foundations, ground source heat, mineral extraction, fracking etc. The type of data that the council may hold includes:

The type of 3d modelling that is available

- BIM (Building information modelling),
- 3d Geological sub surface models (BGS),
- the urban model (GCC),
- time series modelling
- Heat mapping

How these models can be used

- case studies,
- Visualisations
- monitoring

Subsurface / above ground linkages

- BIM,
- buried infrastructure,
- archaeological & cultural assets

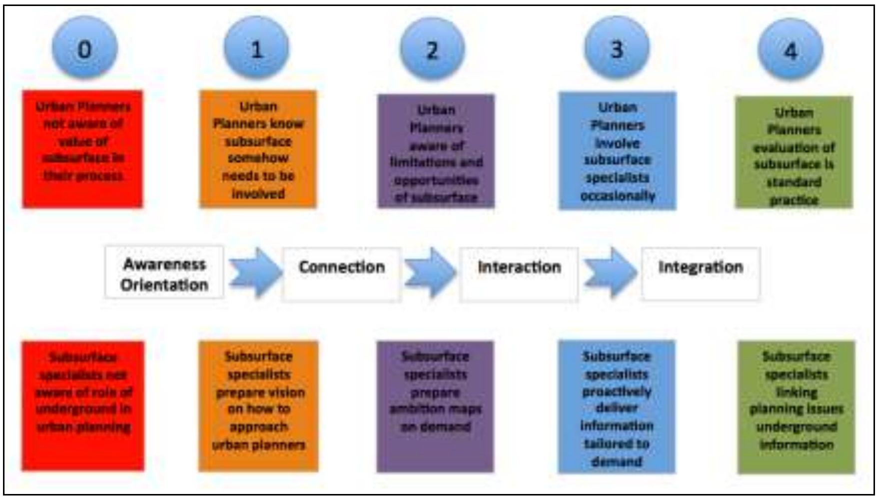
How models and data are used in decision making tools for the following subsurface uses: -

- volumetric planning,
- ecosystem services stewardship,
- aquifer vulnerability / groundwater protection,
- thermal & mineral resource extraction / storage,
- ground stability and foundations conditions,
- risk management in development / construction,
- protection of cultural heritage,
- hazard identification,
- Burial of services and development of subsurface infrastructure including transport, storage & waste disposal.

Discussions are ongoing about the creation of a baseline on data management and 3d modelling within the council; identifying what data is required in connection with placemaking; city deal; masterplanning and other key infrastructure projects. Areas require to be identified where 3d modelling of the sub surface can be tested and the added value measured.

Comparison with Rotterdam

Together with TU Delft and Deltares, Rotterdam has developed the “U-scan” methodology, This Underground scan bridges the gap between stages 2 and 3 in the figure below.



Subsurface professionals, such as engineers and geologists, appeared to be working in parallel but rarely interacting with urban planners. In effect, operating two separate development processes that need to interact with each other to deliver on the same project. Within Rotterdam it was identified that Subsurface Specialists and Urban Planners, working for the same organisation, were probably not all at the same level of understanding, and were working on different parts of a development process at the same time. In effect, they were travelling in the same direction, but at different stages or levels from each other. Thus neither profession was very sure about how they could influence the decision making process of the other, and even how or when and by whom the interaction process should be initiated. So the task facing Subsurface professionals and Urban Planners within Rotterdam is twofold: developing your own sector as well as trying to involve the other sector and get them to develop along the same trajectory. Each stage requires different products and processes.

Together with TU Delft and Deltares, Rotterdam has developed the "U-scan" methodology. The Underground scan (UScan) bridges the gap between stages 2 and 3 in the figure above. The first U-scan has been carried out for the project Kop van Feijenoord in 2009. Since then it has been applied to several urban development projects in Rotterdam (Stadshavens, Binnenrotte, Agniessebuurt, and Lupine) as well as The Hague (Binckhorst in 2012). Recently Rotterdam and TU Delft jointly organise "U-scan" workshops for Urban Planning students at TU Delft. Currently Rotterdam, Deltares and TUDelft are working on further development of the methodology in the EU Snowman project "Balance 4P' (balancing decisions for brownfield regeneration).

Traditionally, the underground was mainly seen as an obstacle. Cables and pipelines, soil-pollution, archaeological remains and debris were all things that were viewed as slowing down development and also dealing with this subsurface infrastructure in order to make a site "shovel ready" was seen as making area development more expensive.

Within Rotterdam there is a lot of knowledge about the subsurface available. However, it is fragmented across different subsurface sectors. The sectorial maps made by underground specialists are designed to be used by other specialists belonging to the same sector. These maps are not designed to communicate their information to specialists from other sectors (nor to the public). However these specialist maps were presented to the urban planners who were expected to be able to understand the information that they contained about basic subsurface information (e.g. drilling holes). To compound the communication difficulties, these maps were presented on different scales with legends that could not be understood. Urban planners need to receive relevant, clear material that informs them unambiguously about costs, opportunities and risks. Instead they received information they could not understand.

Potential obstacles, which could have serious impact on the development of a project, as well as on the timing, were not communicated well. This resulted in frictions and delays, and/or in higher costs. Furthermore because this information was incomprehensible, urban planners preferred to leave the subsurface issues till the end of their process, when it was too late for them to incorporate the potential opportunities the subsurface offers in their plans. Thus opportunities for Shallow geothermal energy, telling the archeological story of an area or adapting a project to allow for multi – functional space and smart combinations of uses to be implemented were lost.

During the projects where the U scan is applied the different subsurface sectors need to cooperate to better inform the urban planners. Basic information is aggregated, analysed and combined with GIS in quality- and economical maps. Opportunities within the subsurface were marked on opportunity maps, which answered questions such as “what areas in the plan area are less or more suitable for developments?” and “which area is less costly than the other?” Clever combinations could be made between different themes, which gave rise to the development of an improvement to the proposals that the urban planners were considering.

Maps were presented in a uniform scale and layout and visualized in a clear manner and with readable “traffic light” legend. These maps could be directly overlaid with the spatial planning maps that the urban planners were working on. Thus the urban planners and the subsurface specialists gained understanding of each others perspective and found common ground to facilitate discussions.

Lessons Learned

1. Urban Planners and Subsurface specialists travelling in the same direction, but at different stages or levels from each other.
2. Specialists and Urban Planners not very sure about how they could influence the decision making process of the other, and even how or when and by whom the interaction process should be initiated.
3. Combining 2d data with 3d data can sometimes produce inaccuracies
4. Specialists and Urban Planners are not speaking the same language
5. If communication is not fluid then potential opportunities in relation to efficiencies and co-operation are lost.
6. Rotterdam’s UScan process creates “traffic light maps” – similar to the photo voltaic pilot mapping in Glasgow – that are easy to understand and work with.
7. Need to identify who holds data and in what format.
8. Open source data that allows non GIS specialists to unlock the analytical power of GIS are valuable tools.

Data needed for sub surface master plan

The Kommune has visited Helsinki to look at how they used and created their subsurface masterplan. Whilst the Helsinki plan was innovative, the planners in the city have admitted that they have not updated it since it was produced. Planners within Oslo have been tasked with producing a subsurface masterplan as it is seen as having a positive efficiency return. Started by asking the following questions:

- Who is the audience – internal agencies, external utilities, transport?
- could this information be delivered elsewhere – is it in existing plans / masterplans
- what would be the parameters – political, legislation, timescale,
- who would be involved - Public, private, officers
- what are the conflicts - barriers to plan operating, ownership, buffer zones, legal context, and short falls in legislation

- what are the resources required – funding, people, knowledge, competence
- How important is it – do you need a stand alone plan and can you afford to divert resources
- what are the critical factors to success – risks, showstoppers, use as a planning tool, achievable, maintainable, data management, communication

Finally they have thought about which approach is best. Do they need a standalone plan or should it just be incorporated into the Development plan. Alternatively, can another existing plan be altered to incorporate the guidance? There is also a debate ongoing about how you education and explain to politicians about the importance of the subsurface. Oslo is starting to focus on how you can explain the risks and there relationship to resources and budgets.

Comparison with Glasgow

Within the draft action plan, for the emerging Local Development Plan for Glasgow, the City aims to continue to work in partnership with British Geological Society to contribute towards and participate in E-COST SUB-URBAN and to develop an integrated approach to the planning and development of sub-surface infrastructure. The Council supports an integrated approach to the planning and development of the infrastructure which can often be necessary to facilitate new development. This includes sub-surface infrastructure such as utility services, district heating, energy and broadband infrastructure and transport, SUDS and water management infrastructure. The Council intends to bring forward a strategy to support such an approach. Updated Supplementary Guidance may be necessary to address any land use planning implications arising from such a strategy.

Initial project planning has been undertaken to explore how subsurface planning guidance would be created. The following subjects and questions have been identified:

Geothermal

- where is the potential geothermal?
- What type of geothermal - closed loop or open?
- If an open system can we use it to decontaminate the groundwater when it is above ground?
- How do we define the hot and cold zones and their buffers so that open loop systems will work?
- What depth do the geothermal wells require to go to
- What infrastructure is required above ground
- What is the impact on the ground conditions; ground water levels and existing foundations of implementing geothermal systems? – Ground water levels rising or falling; ground temp rising or falling
- How will existing sub surface infrastructure impact on where geothermal wells can be drilled?

Cables and Pipes

- Where are the existing subsurface cables and pipes? Depth, direction of travel and size
- Where the manholes are and what depth do they go to?
- What type of buffer zone do you require around cables and pipes
- Cables and pipes includes electric, sewerage, water, gas, telecommunications – private and public
- Which hard surfaces have cables and pipes buried under them?
- What above ground infrastructure relates to the below ground infrastructure and is it moveable or permanent?

Tunnels, basements and storage

- Depth and type - road, rail etc
- Which ones are operational and which ones are abandoned
- Where are the existing and surviving basement structures – depth and scale
- Where have we instances of tunnels over tunnels
- Where are the existing mine workings? - Depth, voids or filled (soil or water), structurally sound or otherwise
- What existing water storage systems are in the subsurface – culverts, attenuation tanks – depth, length, construction type
- Who owns and what mapping do they have?
- Buffer zones - how close can voids, tunnels, sub surface storage be with out impacting on safety?

3d Mapping

- What types of 3d mapping do we currently have available?
- Who is currently 3d mapping? DRS – Urban model, BIM. LES – City model (heat energy) BGS – Geological
- What do we have in 2d? Utilities – cables and pipes, Network rail – tunnels, Coal authority – mine workings
- Can we produce 3d pdf's and 3d digital printed models (Oslo City Council will be able to help us with the methodology behind this)
- What level of accuracy is the mapping at?
- What type of aerial photography do we have available?
- Can we create a 3d visualisation of the buildings and their foundations – existing and or proposed as an area not individual buildings in isolation

Soil Conditions / Foundations / Archaeology

- How much V&DL and what are the contamination issues
- What type of geology are we working with – type and depth
- What level is the ground water at across the site
- How are existing foundations constructed on buildings that are going to survive on site and what is the impact of modern building foundations around them going to be?
- What is the archaeology story of the site
- If tree planting is surviving anywhere – depth and spread of routes
- Descriptor of types of foundations – floating or pile. Depth of piles and amount of backfill
- Impact of new foundations compressing soil and what that does to groundwater
- Timescale for the monitoring of groundwater - maybe 6 months before development starts and for 4 years after to ensure we know the impact of new development on the existing soil and ground water conditions
- Terrain modelling – do we know the type, depth of the bedrock and what is above and below it

Risk

- Asset and risk management of what is in the ground at the moment
- Need to set up a system to monitor the usage of the subsurface.
- Require to establish a baseline
- What are the flood risk management issues on site

During the planning exercise there has been an acknowledgement that there is a need to raise awareness about the proposal to plan the sub surface and that it might be worthwhile identifying pilot projects to provide a focus for data collection and 3d mapping. There are therefore a number of opportunities emerging. Major infrastructure funding is becoming available through a UK Government initiative called City Deal and discussions have been on going about using one of the City Deal areas, namely Sighthill, as a pilot area for guidance. Secondly, BGS have recognised the recent steps taken by Council – the UKs second largest unified local authority – to explicitly acknowledge subsurface planning within its City Development Plan as a first in the UK, and to commence work to develop the UK's first subsurface guidance to planning. This presents a key opportunity for BGS to begin to marry the need of future cities planning, to NERC subsurface data and knowledge and modelling, developing and trialling a volumetric planning approach within the UK. This could also enable more efficient delivery of user relevant 3D models.

BGS have put a bid to NERC for funding to enable a BGS geologist to work to harness the opportunity presented in Glasgow and Scotland, and to act as a national co-ordinator of the activities in Scotland across a large range of stakeholders. The development of a new mechanism of subsurface data capture into NERC (BGS) which would be developed as part of the activities, is fundamental for NERC (BGS) to be able to capitalise on existing modelling capabilities to be able to deliver new, more user-relevant 3D subsurface models efficiently, integrating groundwater, energy, and subsurface infrastructure and geology in 3D models.

Glasgow forms a key pilot, with potential for wider roll-out to a national scale, using Scotland as a proving ground for the UK. Focused pilots in the Super Cities of Cardiff, Bristol and Newport in England and Wales could begin to transfer the Scottish trial to the UK. The key stakeholders and partners required to achieve this work within the KE fellowship are already in place.

Comparison with Rotterdam

Within Rotterdam the view is that there should be no perceived barrier or difference between the guidance tools used for the sub surface and surface spatial planning. Rotterdam would like to see the guidance provided within the one plan or 3d visualisation. Therefore they are pursing the use of UScan as describ3d above and are seeking to raise awareness about the subsurface by getting the different specialists to speak the same language to each other.

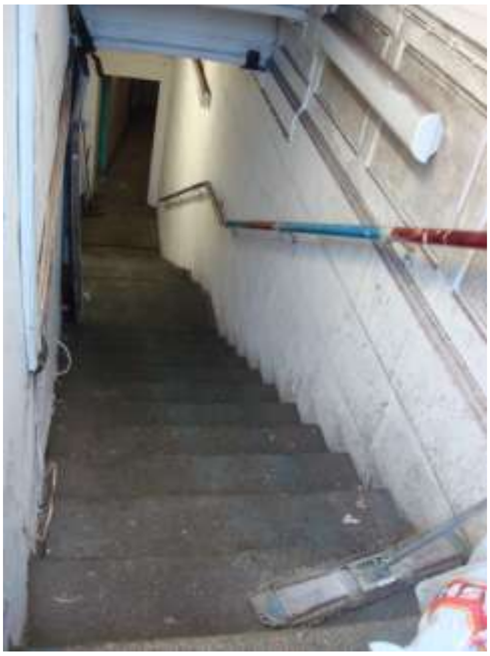
Lessons Learned

1. Identify a preferred route forward – standalone or incorporated into an existing plan
2. Scope the parameters and produce a project plan – this could be a standardised scoping as the questions asked in Oslo and Glasgow are similar and complimentary
3. Key buy in from both Planners and key subsurface specialists is vital
4. Upskilling an Urban Planner in the subsurface can help with communication and identification of City needs
5. Upskilling sub surface specialists in urban planning can help with communication and identification of City needs
6. Identify a pilot area to test out the parameters and proposed guidance
7. Can guidance produced in Glasgow be adapted for use in Oslo and Rotterdam as the planning systems are similar
8. Can UScan be adapted for use in Glasgow and Oslo

Sub surface city tour

Majorstuen is an affluent neighbourhood in Oslo. It is a vibrant residential and commercial area and acts as a main transport hub with major road networks intersecting with the subway, bus and tram systems. Majorstuen station at the centre of the community is shared by all the subway lines and is located just after the tunnel entrance. It is the only inner city station not located underground. Majorstuen was originally the end station for Holmenkollbanen developed in 1898, and remained so until the tunnel to National Theatre Station was completed in 1928. On average a subway train arrives at the station every ½ minute. After Majorstuen the subway lines split up to head in three different directions. Sognsvannsbanen runs northwards, Holmenkollbanen runs to the northwest while Røabanen and Kolsåbanen are on a shared track to the west.

Valkyrie plass is a former subway station in the Majorstuen suburban .The station was opened when the Holmenkollen Line was extended from Majorstuen to National Theatre in 1928. Though not originally planned, when 800 m² of the street collapsed during the construction of the first parts of Fellestunnelen, a station was built anyway. It was closed in 1985 due its proximity to Majorstuen, and as it was both difficult and dangerous to expand the station to accommodate trains with more than two cars (which was needed for the conversion of the western lines to metro). The former station building is now used as an independent fast food café, but the staircase to the platform is maintained to provide access to emergency and maintenance personnel and act as an emergency exit.



Majorstuen developed rapidly after the arrival of the subway and the development of the major transport interchange. The core of the community consists of elegant townhouses built between 1880 and 1890. Ground conditions were variable even at the beginning of the expansion of Oslo, as shown by the ground collapse that led to the development of Valkyrie plas station. Late 20th and 21st century infill development with its modern foundations; barriers to movement of ground water and disruption of the quick clay are impacting on the 19th century buildings foundations. Older buildings are sinking, cracking and in some cases collapsing.

The Kommune would like to understand the cumulative impact of the layers of development at Majorstuen and therefore has chosen the area as one of its pilots for the creation of a 3d subsurface map. The process of developing the 3d visualisation has been described elsewhere within this report.

Comparison with Glasgow

Throughout the 19th century Glasgow underwent a rapid urbanisation and growth. The coming of the railways, subway and subsequently the corporation tram system led to the development of garden suburbs in the more affluent west end and south west of the city as it expanded away from the industrial cores of the City centre, east end and the shipbuilding industry along the banks of the Clyde. The expansion of the railways meant that Glasgow now has the biggest urban rail network in the UK, outwith London.

Both the subway and the urban rail network rely on tunnels within the city centre and the inner suburbs and there is a fairly extensive network, some of which are still in operation and some that have been abandoned. There are at least ten abandoned tunnels under the west end of Glasgow and six in the east end.

Glasgow Central Station, which opened in 1879, has extensive catacombs below it which were originally developed on the site of the old Grahamston village which was removed to make way for the station. There are also four sub surface platforms, two of which are currently in use. The catacombs were created to store goods and mail that arrived at the station either via train or from the nearby harbour on the Clyde.

Over the Christmas festive period of 1994, on 11 December, torrential rain caused the River Kelvin to burst its banks at the closed Kelvinbridge station. The water made its way through the disused tunnels to Exhibition Centre and the Low-Level station at Glasgow Central, which was completely submerged by the resultant flash flood. It was closed for many months while repairs were made.

In August 2002, torrential rain flooded out the low-level stations from Dalmarnock in the east end through to Exhibition Centre for a number of weeks. Most services were routed to the high-level platforms, or to Queen Street station. The 2002 Glasgow floods had a number of other effects, including causing a cryptosporidium outbreak in Glasgow's water supply.

The Glasgow Subway opened on 14 December 1896; it is the third-oldest underground metro system in the world after the London Underground and the Budapest metro. It is the only heavy rail underground metro system in the UK outside London, and also the only one outside London which operates completely underground.

The Glasgow District Subway is a circle railway, about six and a half miles in length, constructed at an average depth of 29 ft. beneath the surface. The line passes under the River Clyde on both its eastern and western sections, and it has no fewer than fifteen stations. The depth of the line varies considerably, ranging - from the surface to the top of the tunnel heading - from 115 ft. to only 7 ft, while the greatest depth on the under-river section is 56 ft. below high-water mark, also reckoned to the top of the tunnel. Because of the variety of soil encountered by the engineers, no uniform method of construction was adopted, but the sections nearer the surface were generally built on the cut and cover system. On account of these differences in geological conditions the tunnels are partly cylindrical and partly of the more conventional horse-shoe shape.

Comparison with Rotterdam

Public space is scarce in Rotterdam. Increasingly the City has to deal with the opportunities and the constraints that the subsurface offers to spatial development in a sustainable way. The city has ambitions with the public space: housing, working, transport, recreational activities, green, water. City planners translate these aspirations to a model in which public space is designed with features: buildings, parks, roads, pipelines, lakes etc.

At present the subsurface is already used for foundations and for infrastructure. But the subsurface also could strengthen the identity of an area with archaeology, re-usage of quay walls as storage space, and for smart combinations that can improve the exploitation of plans and lead to cost savings like combining thermal storage with groundwater remediation. Sustainable energy like thermal storage (KWO) and geothermal energy could offer cost savings and these themes fit seamlessly within the objectives of the Rotterdam Climate Initiative. Contributions are delivered in terms of both mitigation and adaptation. And the subsurface in the Rotterdam region also offers possibilities for CO2 storage and for water retention.

In order to create a high quality living environment and to facilitate sustainable development of the city it is necessary to adapt a holistic view on the city in which subsurface plays an important role. The scale, the composition and the behaviour of the surface as well as the presence of groundwater (clean and contaminated) make it necessary that all subsurface relate themes are evaluated in relation to each other.

Lessons Learned

1. There are areas within Oslo and Glasgow, in particular, where transport tunnels are layered on top of each other.
2. New build in older historic areas can have a detrimental impact on existing foundations of older buildings.
3. Older buildings tend to have basements, but there is limited knowledge about their location and depth.
4. Existing voids in the subsurface can present opportunities as well as risks.
5. Unstable ground can create valuable open space in high density communities.
6. Existing transport tunnels can be at risk of flooding in extreme weather conditions.
7. Smart combinations of subsurface usage can create opportunities and efficiency savings.

Byantikvaren - Oslo’s Cultural Heritage Agency

The Cultural heritage Agency is aware that the subsurface can have a high impact on the heritage of the City. It is where the archaeology is buried; watercourses are culverted and old building foundations are located. Byantikvaren is Oslo's academic advisor in all issues relating to the conservation of architectural and historical valuable buildings, facilities and environments and archaeological heritage. Working for the city, protected cultural heritage and ensuring that the cultural heritage is taken cognisance of as a natural part of all land use planning, construction and management of the physical environment. Byantikvaren also engaged in extensive dissemination of information and guidance to a wide range of audiences.

Although there is a listing system in Oslo, where buildings can be graded for their architectural and historic importance, there is no legal protection given to the buildings. Central Oslo is predominantly a brick city, built on wooden float foundations. Little remains of the early wooden houses that formed the medieval city. Many of the older brick buildings were built on the existing foundations from earlier buildings.

Over the years new build has encroached into the historic core of Oslo. Modern building methods mean that foundations and basements are built within a shutter system designed to keep the groundwater out. New buildings can also compress soils, drawing water away from the foundations of older buildings. This will dry out the wooden float foundations and destabilise the older buildings. Over time this leads to cracks appearing, subsidence and movement outwards of walls. Several old buildings have collapsed or have had to be demolished, within areas such as Majorstuen, as a result. Whilst there was an acknowledgement that older buildings, in certain parts of the City, were sinking due to movement of groundwater there is now a growing concern that they are sinking at a faster speed than previously predicted. This is being linked to the increased new build in redevelopment areas. The problem is particularly visible around the Central Station area, where the development of the Barcode Buildings and new transport links and tunnels has speeded up the sinking of Central Station itself.

There are currently no laws or regulations within Norway to protect heritage buildings over a long period of time. Thus there are no methods to make new build developers responsible for the impact of their development, over time, on the older buildings in the neighbourhood of their site. Currently reliant on the engineer for the new development undertaking the right calculations and the building permit team within the Kommune asking the right questions at the right time.

There has also been, until the subsurface team started to investigate, no research into the cumulative impact of new build on the subsurface below the existing heritage buildings. The pilot project in Majorstuen is the first time the City has looked at what is going on in the subsurface and how it is impacting on a neighbourhood. Oslo is currently looking at how they could develop a groundwater monitoring project, as the want to oblige the developer to control and monitor groundwater levels before, during and after construction.

Comparison with Glasgow

Glasgow's distinctive character has been shaped over many years. Previous generations have left their mark in the form of buildings, scheduled monuments, battlefields, townscapes, gardens and designed landscapes, and in the pattern of the City's streets and parks. This rich historic tapestry of buildings, spaces and places is the historic environment and is covered by designations including a World Heritage Site, Listed Buildings, Conservation Areas and Designed Landscapes. The historic environment is part of our everyday lives and gives us a sense of place, well-being and cultural identity. It also:

- projects a high quality image of the City, reflects historic achievement and enhances regional and local distinctiveness;
- helps to connect people and places, and makes Glasgow a great place to live, work and visit;
- provides a sense of identity, place and continuity for local communities;
- contributes to economic growth, development and regeneration;
- supports the growth of tourism and leisure and helps to foster craft and construction skills; and
- contributes to sustainability through the conservation of resources.

The policies for the protection and management of the built heritage are underpinned by the Historic Environment (Amendment) (Scotland) act 2011.

Glasgow's Historic Environment can be experienced throughout the city in both traditional form and historic function. Its vibrant historical past has created a rich fabric of listed buildings, conservation areas, scheduled monuments and archaeological sites which are embedded within the makeup of Scotland's largest city. However, the demands of a contemporary city result in extreme pressure on the preservation of the historical environment. It is therefore crucial that the City Council, in its role as a Local Authority, take appropriate action in both policy and practice to protect and enhance these key attributes to maintain their historical significance for future generations while befitting Glasgow's aspirations as a world class city.

Within the Scottish Government's Scottish Planning Policy (SPP) the historic environment is identified as a key part of Scotland's cultural heritage and it enhances national, regional and local distinctiveness, contributing to sustainable economic growth and regeneration.

Thus any development that has a negative impact on a listed building or a conservation area can be refused or the applicant can be asked to mitigate the impact. In practice this means that where there is an awareness of layers of development, archaeological investigations may be requested and design statements may be requested. If there are known geotechnical issues on or near the site a geotechnical investigation may be requested. However, there is limited knowledge of the value of the geology from which the buildings are constructed and on which they sit.

Glasgow has lost several historic buildings through neglect and fire (usually occurring in abandoned buildings). Several of these buildings currently appear on the Buildings at Risk Register. The Buildings at Risk Register has been in operation in Scotland since 1990 in response to a concern at the growing number of listed buildings and buildings in conservation areas that were vacant and had fallen into a state of disrepair. The register is maintained by the Royal Commission on the Ancient and Historical Monuments of Scotland (RCAHMS) on behalf of Historic Scotland (HS), and provides information on properties of architectural or historic merit throughout the country that are considered to be at risk. Later this year RCAHMS will merge with HS to form Historic Environment Scotland.

In addition West of Scotland Archaeological Service, which covers the City and neighbouring authorities, has responsibility for maintaining and updating the Historic Environment Record (HER). This is a complete record of all known archaeological sites, finds, fieldwork and research for the west of Scotland.

Comparison with Rotterdam

Archaeology is one of the four fields of the Cultural Heritage Agency of the Netherlands. The other fields are: Monuments, Landscape and Art. Rotterdam does not have a lot of monuments and protected landscapes. Since 1960 the city of Rotterdam has its own archaeological department - BOOR. The BOOR team does archaeological research in Rotterdam and also acts as an archaeological advisor for a number of neighboring cities in the Rotterdam Region. There is already a lot known about the archaeological history of the city and its surroundings.

In 2007 the law on preservation of archaeology came into force. From then, each municipality became responsible for its own archaeology policy. In 2008 Gemeente Rotterdam prepared a policy document on the Archaeology of Rotterdam. This policy implies an obligation to carry out an archaeological investigation prior to construction works being carried out. The intensity of the required investigation is dependent on the expected archaeological value of the site involved. This means that different areas have a different value or risk of finding archaeological artefacts. BOOR assesses construction plans of building sites and advises how to conduct works in the subsurface in accordance to this archaeological policy. To preserve the archaeology in the subsurface and to avoid costly delays, it is important that archaeologists are involved from the start of city development projects.

Lessons Learned

1. Strong legislative support for historic buildings and the historic subsurface is important.
2. There need s to be a better understanding of the impact of new build on the foundations of older buildings.
3. There is limited understanding of the impact of subsurface development on the historic buildings situated above.

4. Summary

- Continue to benchmark between Oslo, Glasgow and Rotterdam
- Create a shared wiki / Pinterest / webpage to capture the information shared during the STSMs in Oslo and the comparison information that exists in Glasgow and Rotterdam .
- Parallel run the development of sub surface urban models
- Parallel run the development of sub surface guidance for planners, geologists, engineers etc
- Ensure that an understanding of the subsurface is part of the training of spatial planners; an understanding of above ground spatial planning is part of the training of engineers, architects and geotechnical professionals
- Look at removing the perceived barrier created by visualising of ground level that is created in models (whether 2d or 3d)
- Ensure that all the professions dealing with the subsurface understand each others key drivers and language
- Use the contents of this report to inform Work Package 3
- Encourage similar study visits between other cities with similar agendas.

Confirmation by the host institution

Report noted with approval,

Ingelöv Eriksson

Names and Divisions of the participants from Oslo Kommune who participated in discussion

Monday morning

Stein Moen — leader of the Planning and thematical mapping unit — Agency for planning and building services

Tuesday morning

Johan Borchgrevink — urban planner — Agency for planning and building services
Marianne Haahjem, — lawyer — Agency for Urban Environment
Kirsti Rusten Antonssen — lawyer — Agency for planning and building services
Odd Johnsen — engineer/urban planner — Agency for planning and building services
Atle Røiom — Lawyer — Agency for Real Estate and Urban Renewal

Tuesday afternoon

Cecìlia Cerdeira — GIS engineer/Geomatician — Agency for planning and building services

Wednesday morning

Sub surface project group + Planning and thematical mapping unit

Wednesday afternoon

Hans Kristian Daviknes — Geologist — Agency for Urban Environment
Ulf Fredrikssen — Geotechnician — Agency for Water and Sewerage Works

Thrursday morning

Cecìlia Cerdeira — GIS engineer/Geomatician — Agency for planning and building services
Mats Hallen — GIS engineer — Agency for Urban Environment
Leif Rune Ulle — GIS engineer — Agency for Urban Environment
Johan Borchgrevink
Odd Johanssen

Friday lunch

Marte Muan Sæther — Archeitect — Cultural Heritage Management Office
Andre Korskaksel — Construction Engineer — Cultural Heritage Management Office
Morten Stige — Division manager — Cultural Heritage Management Office

Appendix 1 - Management and organisation

City	Competence of local groundwater table	Competence of local Geology	Early stage communication between subsurface specialists and urban planners.	Subsurface organisation	Municipal subsurface space management	Subsurface maps available for internal use Geology, geotechnical info	Subsurface maps available for internal use	Subsurface maps available for external use	Subsurface ownership, laws
Glasgow	Scottish water, SEPA are responsible for groundwater. (Drinking water from a Loch)	Geology team with 4 geologists.	Charrettes, (Scotish government supported standard) http://www.slideshare.net/wmud/port-dundas-charrette-final-evening-session	BGS, Coal Authority	Geology team and flooding engineers	BGS data, coal maps, plus geological maps from the geology team	pipes and cables by Scottish Gas and Scottish Power, British telcom. Data needs to be asked for for each project. Energy team collects and provides this data for the urban planners. Tunnels, road and railauthorites, local tunnels in the geological maps, not with great detail.	Coal maps, BGS data	
Oslo	Consultants. Groundwater responsibility is unclear. Drinking water from neighbouring Maridalsvannet (Water Agency is responisble)	Geologists scattered over different departments	Workshops(?)	Project based 2013-2016	Initiation	Geological maps from NGU, 1:50 000. Depth to bedrock from the municipality, Polluted ground from the municipality	Pipes and cables for planning purposes are to be collected from each organization. For digging coordination and planning existing system K-Grav. https://gravemelding.no/forside		
Rotterdam	Municipality is responsible for groundwater, 4-5 hydrogeologists works at Roterdam municiplaity. Drinking water from	Soil specilists	U-Scan, (non standardised)	Undrgrond…		Contamination.	Pipes and cables available through GIS Web, municipal plans,		