GROUND INVESTIGATION IN THE SYDNEY CBD – A MORE SUSTAINABLE MODEL FOR THE FUTURE.

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ABSTRACT

Below Sydney's central business district (CBD) lies a complex network of transport and service tunnels competing for space with building basements and confined by changes in topography. Although the geological setting is well understood and documented, potentially millions of dollars are spent each year on new ground investigations. Why?

Over the last 50 years, NSW Government departments have spent millions of dollars on substantial engineering and geotechnical site investigations within the Sydney CBD and are estimated to have drilled thousands of boreholes.

The majority of existing geotechnical information was collected by government departments and geotechnical consultancies and stored in libraries or archived. Over time this data may become misplaced or in many cases disposed of. There are many government departments and consultancies that preserve data in systematic electronic GIS type databases. Indeed, if the basic information was attributed (e.g. grid coordinates, borehole No., Department, and Project No. etc.) the stored data could be assessed quickly to determine if any data is located within a project area by interrogating a central GIS database (or GIS web service) and therefore retrieved from the relevant storage achieve or geotechnical consultant at minimal cost. The NSW Government is planning on making it mandatory to apply for permits to drill, but also to record information from any borehole that encounters groundwater or potentially water bearing rocks. Permits and recording of boreholes is also the case within mining and mineral exploration in NSW. It is therefore envisaged that much of the geotechnical investigation data produced across the Sydney CBD could be centrally stored in a GIS database. A data model based on the British Geological Survey – National Geoscience Data Centre model is proposed to more efficiently store large amounts of geotechnical data. Access to this information could then be provided through a secure, GIS-based Internet web portal. In many cases, planning for new projects could rely heavily on accessing existing data through this single point-of-truth database and over time, new geotechnical models could be added to further develop an evolving 3-D geological model of the Sydney CBD and other key locations.

Keywords: Sydney CBD, Geodatabase Infrastructure, Hawkesbury Sandstone, Faults, GIS

1 INTRODUCTION

Below the Central Business District (CBD) of Sydney lies a complex network of transport and service tunnels competing for space with deep building basements and confined by sharp changes in topography. The geological setting is well understood, consisting predominantly of late Triassic Hawkesbury Sandstone, cut by numerous igneous dykes and characterised by a dominant NNE trending zonal fault/joint zones (Och *et al.*, 2009, and Pells *et al.*, 2004), overlain by thin layers of superficial and residual Ashfield Shale and Mittagong Formation (Herbert, 1983), Quaternary deposits and fill material (Roy, 1983, and Chestnut, 1983). On the other hand, geotechnical engineering requires parameters from the surrounding geology to assist planning and construction of tunnel, road and building projects, which requires intrusive investigation (i.e., boreholes). Yet despite the numerous boreholes, geophysical surveys and *in situ* stress tests that have been undertaken over a considerable period of time, and the wealth of knowledge accumulated, millions of dollars are still spent each year on new ground investigations. Why?

This paper discusses the effectiveness of a geotechnical database in providing a source of data, spatially located, which can be sourced from multiple originators (e.g. geotechnical consultants) when undertaking early planning of large infrastructure studies across the Sydney CBD. An early attempt was made to provide geotechnical structure in the form of a map that delineates mapped geological structure through the Sydney CBD (Pells *et al.*, 2004) (Figure 1a), which was well accepted and used, but as new information is encountered this map has never been updated. Therefore, early planning studies would benefit from an industry wide collaboration to compile essential, well-attributed geotechnical\geological data that can be accessed from a Geographic Information System (GIS) database. This would provide consultants with enough information to guide decision-making and determine whether to go ahead with a project and therefore plan for future site investigation based on an analysis of the data collected.

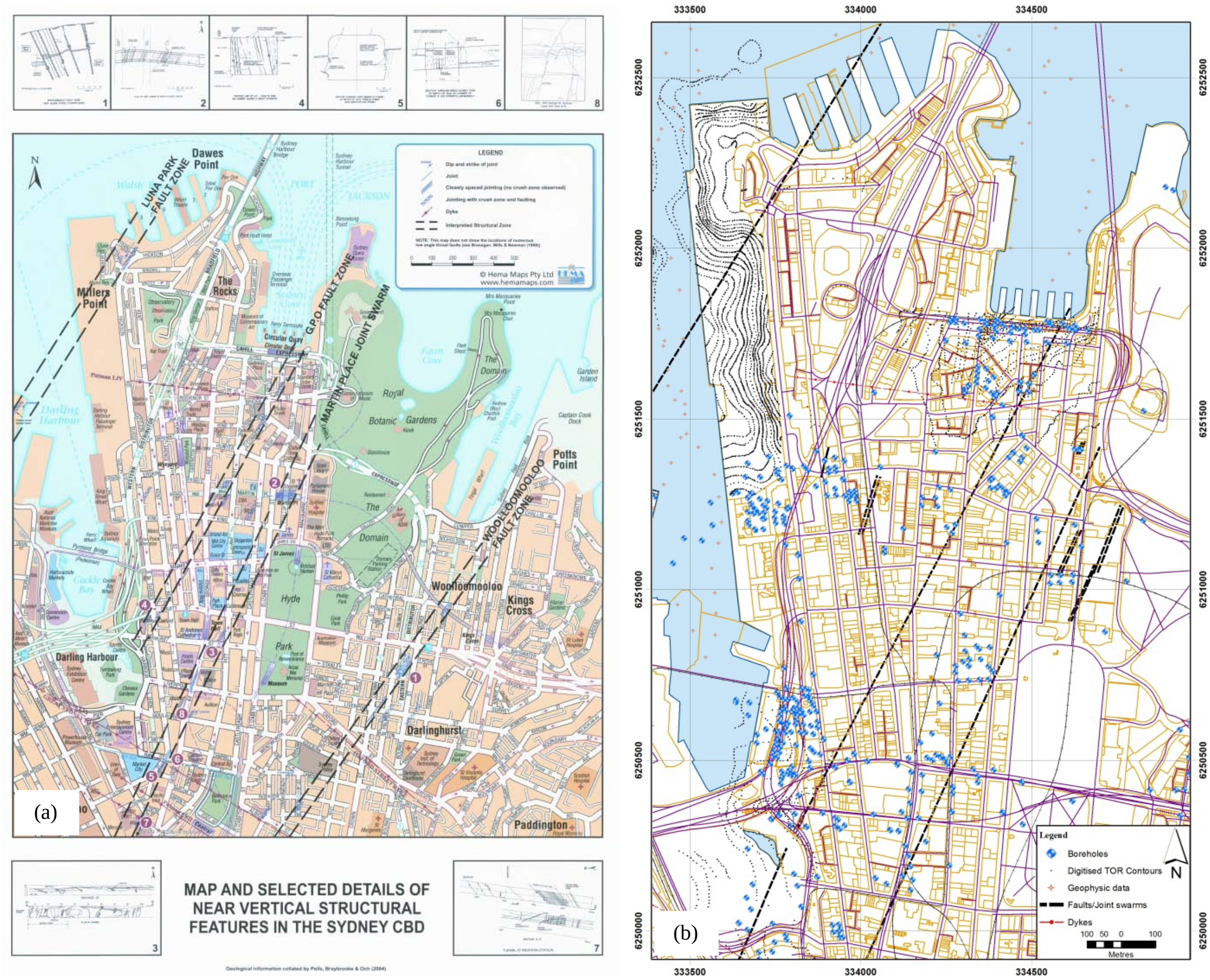

Figure 1 (a) A geotechnical map produced by Pells *et al*. (2004) on near vertical geological structures through the Sydney CBD. (b) Different types of data that could be stored in a GIS based framework that would allow for easy interrogation of attributed data for any future projects in the Sydney CBD.

2 DISCUSSION

Over the last 50 years, substantial engineering and geotechnical site investigation work has been undertaken within and close to the Sydney CBD by many NSW Government departments. It is estimated that during this period many thousands of boreholes have been drilled in the Sydney CBD and its surrounding area by the NSW Government at great cost i.e., the Sydney Harbour Tunnel, Western Distributor, Eastern Suburbs Rail, Cross City Tunnel, New Southern Railway (Airport Link), CBD Metro, and the many electric cable tunnels (Figure 1b). There are also many major building developments that have undertaken site investigations by the private sector both on the land and in the surrounding harbour. While many of the boreholes from older site investigations unfortunately lack location specific coordinates (and may be of poor quality), they usually have detailed plans which include road or cadastre lines that provide enough information to georectify the plans/maps into a GIS platform. This secondary process is used to position these boreholes with enough spatial accuracy to construct models in early concept design studies. This data would provide a basis for assessing the existing data to produce a “gap analysis” to guide additional site investigations and minimise costs by ensuring that previous investigations are not duplicated except during more detailed phases of design.

The majority of geotechnical datasets from large infrastructure projects are stored by the relevant government departments in hard-file libraries or are archived away in storage, with only a few of these departments now preserving the data in spatial retrieval systems (GIS database systems). The bulk of geotechnical data from investigations is also collected by geotechnical consultants, and again, there are only several of these firms that have spatial retrieval systems that store and provide easy access to data if they are approached during any large project. At present there are several publically available geodatabases:

1. DIGS - serves as a repository for geological information such as geological reports and maps, mining exploration reports, and papers, with only a few historic geotechnical reports (Och, 2007). *http://www.resources.nsw.gov.au/geological/online-services/digs*
2. MinView - allows on-line interactive display and query of exploration tenement information and geoscience data across New South Wales. *http://www.resources.nsw.gov.au/geological/online-services/minview*

All Maintained by Geological Survey of New South Wales (NSW Trade & Investment – Resources & Energy) with links to geological maps and publications with a link to:

3. GADDS - a Geophysical Archive Data Delivery System that provides magnetic, radiometric, gravity and digital elevation data from Australian National, State and Territory Government geophysical data archives and *http://www.geoscience.gov.au/bin/mapserv36?map=/public/http/www/geoportal/gadds/gadds.map&mode=browse*
4. there is also the NSW Groundwater Works database where attributed data are presented along with a printable report. *http://nratlas.nsw.gov.au/wmc/custom/homepage/home.html*

The main issue of the authors driving the preservation of this data for future use is the fact that many of these government departments with internal geotechnical groups are subject to government budgetary constraints. If these groups undergo change or redundancies, then key people are potentially lost, or in some cases, whole groups may be disbanded and data repositories and libraries built up over decades may in fact be lost. As a result many geotechnical consultancies have established secure electronic systems to accommodate their intellectual property as the information is essential to the sustainability of their practice. Critical information residing in databases maintained by individuals or consulting companies is not best-for-business or best-for-industry.

It is desirable that these disparate geotechnical databases are collated to a centrally located GIS administered by a large government department such as the Geological Survey of NSW, and at a minimum, attributed data could be made available to all government departments and possibly in time, to industry (e.g. British Geological Survey - National Geotechnical Database). Indeed, it could be argued that should such a large amount of attributed information be made available, then many concept studies could utilise this definitive compilation of existing data rather than work through the costly and lengthy process of SI procurement, approvals, mobilisation, drilling and subsequent analysis and report writing that should be left for future detailed designs.

This envisaged geotechnical database could be modelled on the British Geological Survey (BGS) – National Geotechnical Database *(http://www.bgs.ac.uk/science/landUseAndDevelopment/engineering_geology/geotechnical_database.html)* where the database holds geotechnical information extracted from site investigation records (63,000 boreholes, 280,000 lab tests, and 3,400 site investigation reports) provided by external sources and testing carried out by the BGS. The database maintains data to current industry standard digital format, all spatially located to regional coordinates. An example of the data structure is detailed in the Figure 2 where the data is processed into well attributed data for dissemination or interpretation.

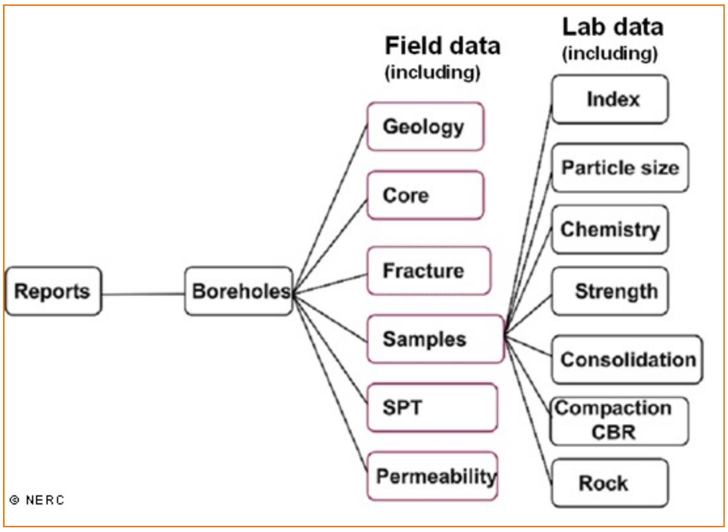

Figure 2: A simplified process of data collection of the BGS National Geotechnical Database (cf. BGS website).

Many of the previous and current transport and building infrastructure projects located in the Sydney CBD and outlying suburbs have relied on spatial information compiled from earlier site investigation works. This information has enabled the construction of 2-D and in some cases 3-D models to inform project teams on subsurface geotechnical and geological configuration and helped to plan options and reduce rework. These local models can be integrated to produce larger models with wider coverage. These are particularly useful for long linear projects spanning several contiguous areas. The importance of these generated datasets is demonstrated by the 3-D computer models built for complex, high-density areas such as the Sydney CBD (Figure 3a & b) and Parramatta. By combining additional information from tunnels, building basements and existing and planned services, these models make a powerful tool to guide infrastructure planning, improve efficiency and most importantly, reduce cost. The Geological Survey of New South Wales realises the value of this technology and has invested in constructing 3-D models for several regional mapping programs *(http://www.resources.nsw.gov.au/geological/about/geophysical-surveys/3d-geology)*. The BGS and many local engineering consultancies have also embraced this approach and rely heavily on well-engineered spatial databases as source data for clean, efficient, model input.

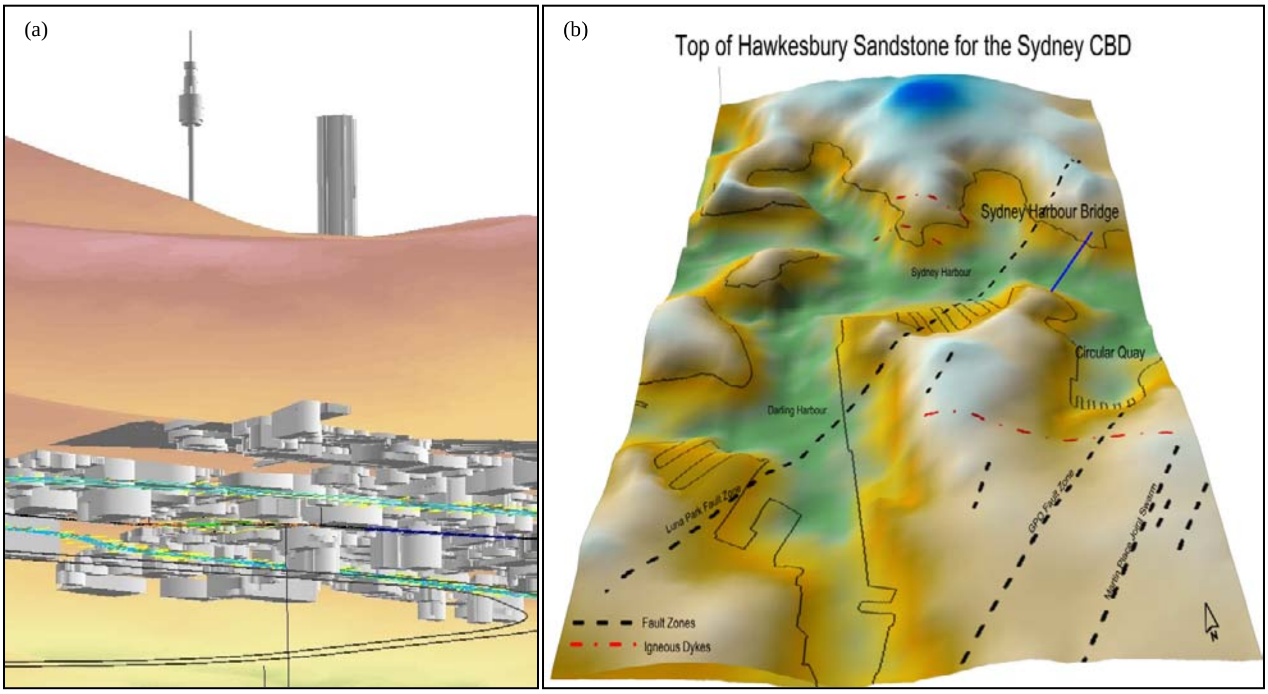

Figure 3: (a) 3-D snap shot of building footprints, infrastructure options and the spatial association with the top of Hawkesbury Sandstone in the Sydney CBD. (b) An example where combined data sources can be used to build 3-D models, in this case the top of Hawkesbury Sandstone overlain by geological structure across the Sydney CBD.

A framework for industry collaboration needs to be established to develop an integrated GIS database to service planning and infrastructure projects and provide efficiencies for rapid development of 3-D geotechnical/geological models. This aligns with the Draft Industry Action Plan - NSW Digital Economy (2012) (*http://www.business.nsw.gov.au/doing-business-in-nsw/industry-action-plans/digital-economy*). This framework could potentially be established through the Australian Geomechanics Society, Academia (e.g. Melbourne School of Engineering – 3-D computer simulation of the engineering geology of Melbourne*(http://apps.eng.unimelb.edu.au/research-projects/index.php?r=site/webView&id=158)*), and the New South Wales Committee for the Coordination of Government Geological Programs (NSW-CCGGP) of geotechnical data sources. While it is appreciated that engineering consultancies use their knowledge and data sources for commercial advantage, there needs to be some guidelines and direction provided to the industry during these large government funded projects so the data is captured, preserved and made available to other government departments and consultants for future infrastructure planning. This centralised geotechnical database should store, at a minimum, well attributed data points (i.e. shapefiles for ArcGIS or Excel spreadsheet) that could be used by planners in a similar way we use Dial-Before-You-Dig. This approach would address stakeholder concerns around releasing information in spatial format given that many of these earlier corridors are confidential and at times highly sensitive. Therefore, having access to basic information, planners could then approach relevant stakeholders and data custodians to discuss data sharing arrangements or purchase for information to carry out studies with appropriate confidentiality.

3 CONCLUSION

Given the vast wealth of geotechnical and geological data captured over many decades from major projects and concept studies in NSW, and the advances in digital capabilities for storing, retrieving and processing information, it is time to develop a centralised GIS database designed around industry best-practice data models similar to that developed by the

BGS in the United Kingdom. The database would accommodate all critical information from all available sources and be made available to government departments and partners through a secure internet web portal to guide future planning and decision-making and minimise rework during major infrastructure projects. The database could also be used to improve efficiency and accuracy during the creation of innovative 3-D geological models to communicate the complexities of subsurface configurations in CBD areas. It is envisaged the database would integrate datasets from the CBD area initially, and allow for future expansion to cover the Sydney metropolitan region. As a minimum, critical information should include all boreholes and related geotechnical, groundwater and mining investigations, geology (lithology and structures), secured easements, building basements tunnels and utility services. This information will provide planners with improved knowledge of what's-where in the subsurface to more effectively design and position new infrastructure within the existing physical constraints of the urban environment. As a community the geotechnical and planning profession has yet to fully embrace the opportunities offered by recent advances in GIS technology. Centralised geodatabases will need to develop in alignment with tight data standards and legislation to ensure consistency and compliance with industry best-practice, in line with the Draft Industry Action Plan - NSW Digital Economy (2012). To achieve these objectives, the establishment of a joint government-industry-academic committee is suggested to provide direction and framework to the reform process. Centralising information and leveraging the disparate datasets residing in various pockets across the industry will result in multiple efficiencies and substantial cost savings to both the NSW Government and professional services companies alike.

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