



**British  
Geological Survey**

NATURAL ENVIRONMENT RESEARCH COUNCIL

Applied geoscience for our  
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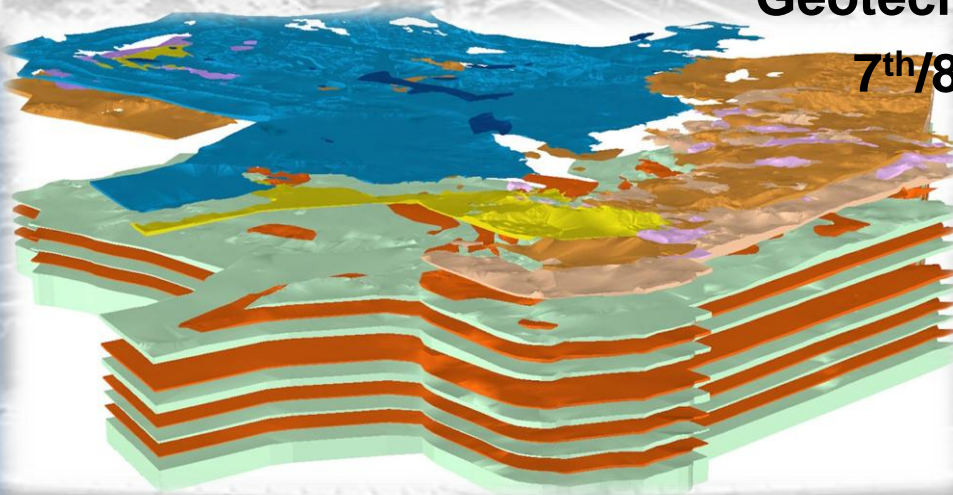


# 3D geological modelling use and application. Case study of the Abu Dhabi Urban area

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# Introduction

- 3D Geological Modelling at the BGS
- Applications of 3D Geological Modelling
- Case Study – Abu Dhabi
- Future of 3D geoscience modelling
  
- *Demonstration of Abu Dhabi 3D geological Model*

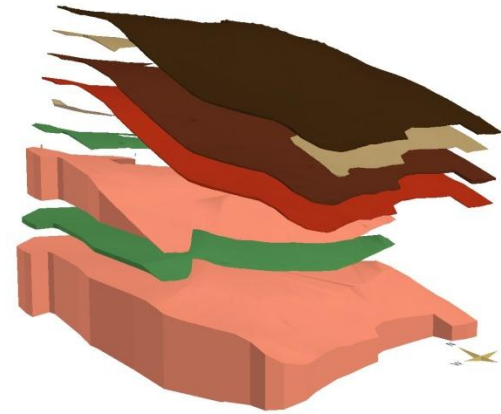
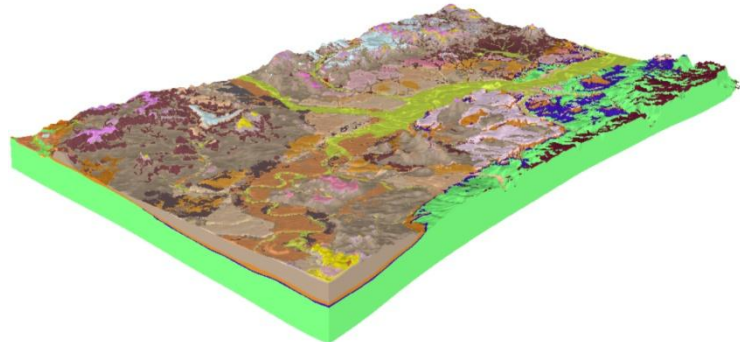
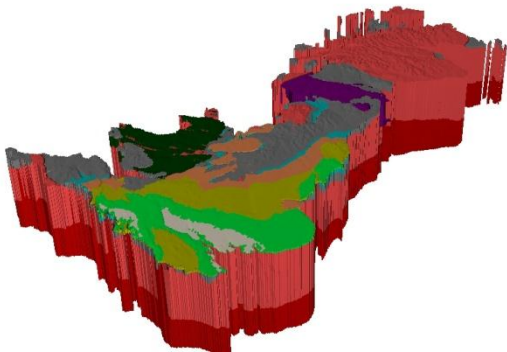


# 3D geological modelling – what is it

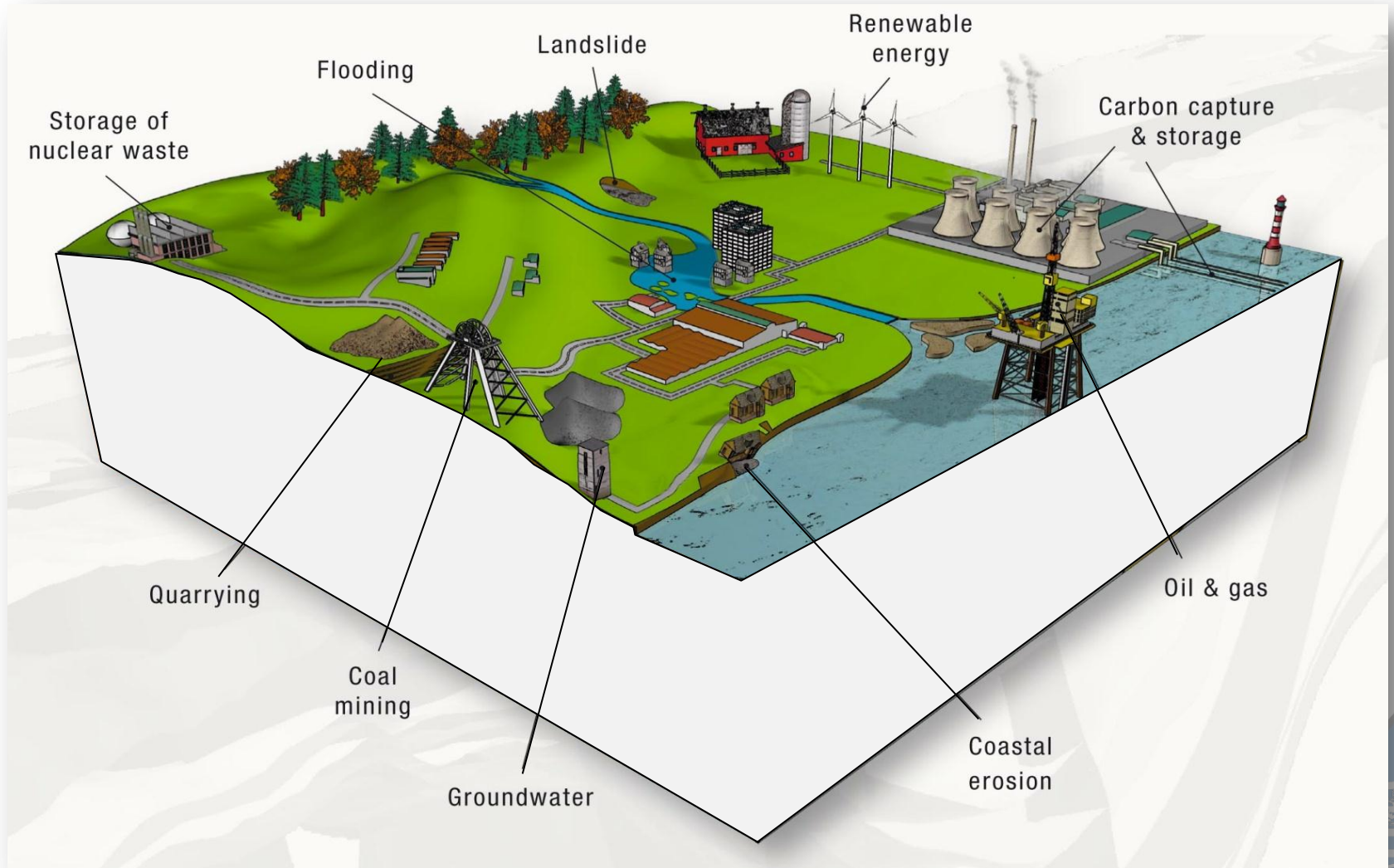
Geological modelling captures the Geologist's visions, concepts and understanding of underlying geological processes

A geological model synthesises all available data and knowledge for a given area in 3 dimensions to produce a consistent local and national geological lithostratigraphic framework

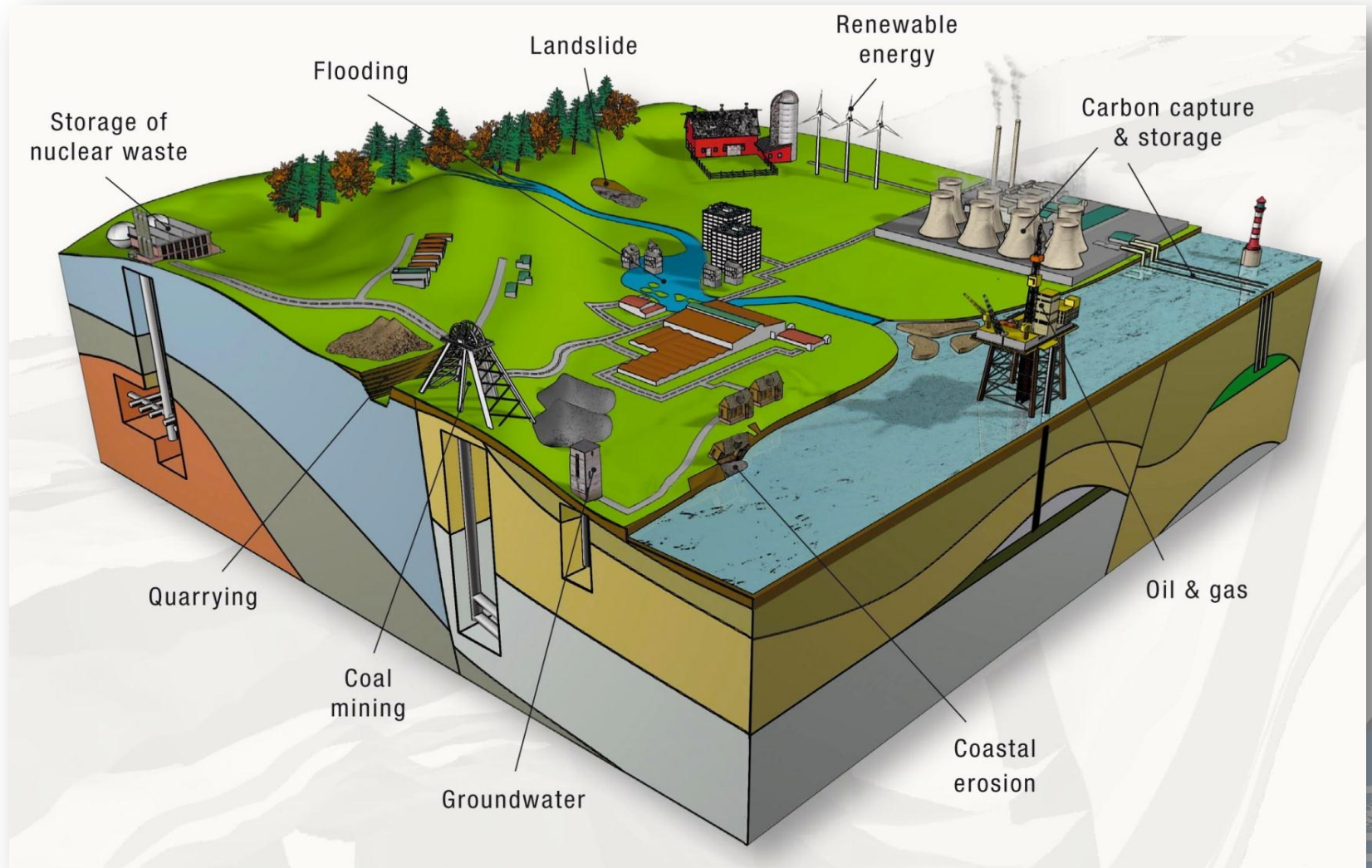
Just like its predecessor the 2D geological map, geological models need to be parameterised to make them useful and delivered in a suitable medium to make them usable.



# Out of sight.....

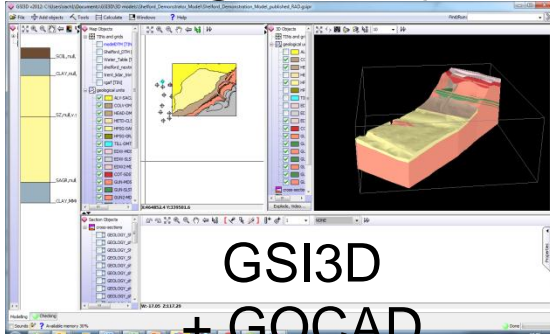


# ...should not be 'out of mind'



# The geological modelling workflow

## Geological objects



GSI3D

+ GOCAD

+ GIS

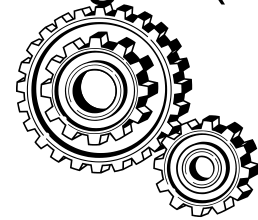
+ GeoVisionary

In future access to  
external parties

**Check in/check out/approval**

Central  
geological  
object store

Engine(s)



**STATIC**

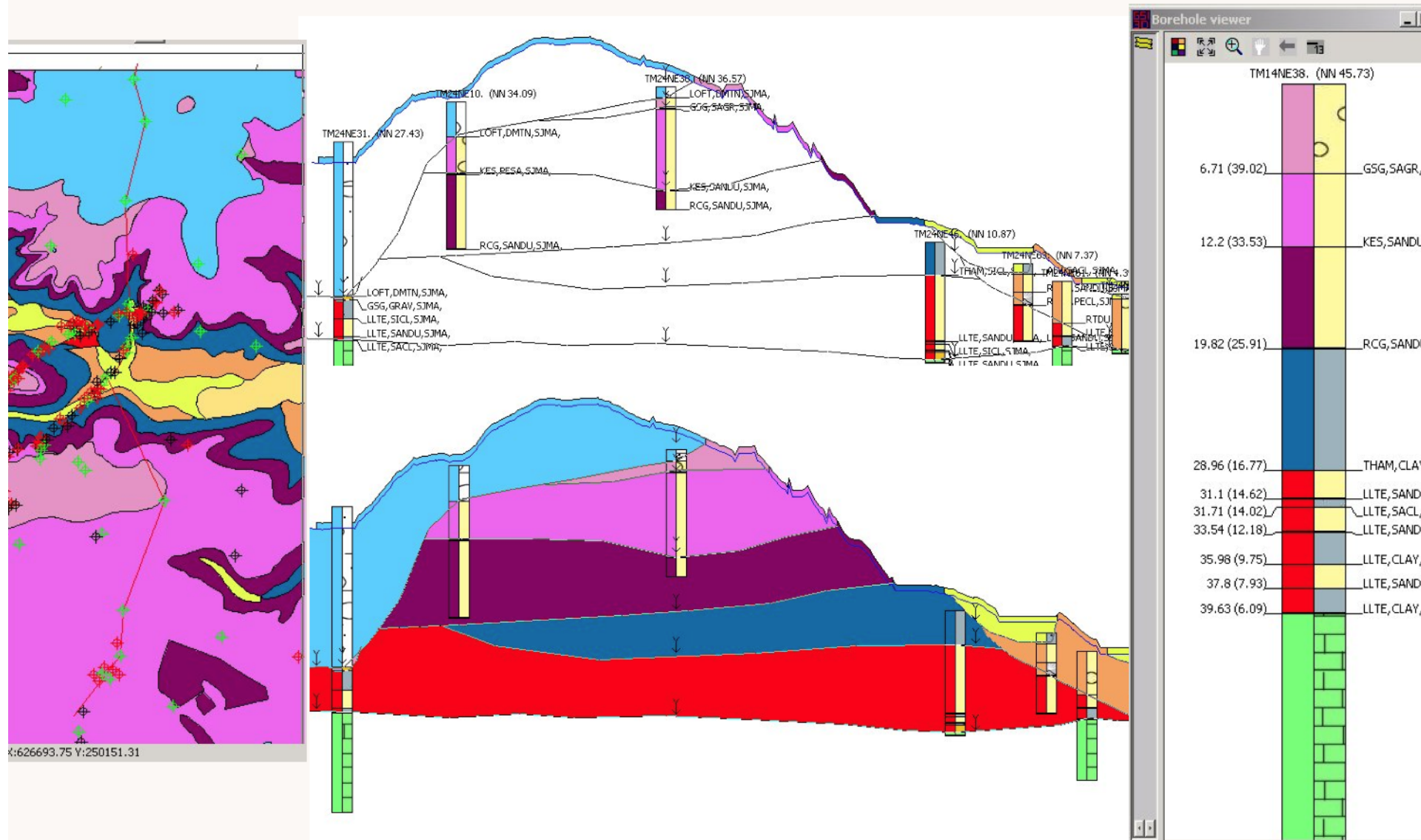
3D Models  
Surfaces  
Thicknesses  
MODFLOW,  
ZOOM  
specific

**DYNAMIC**

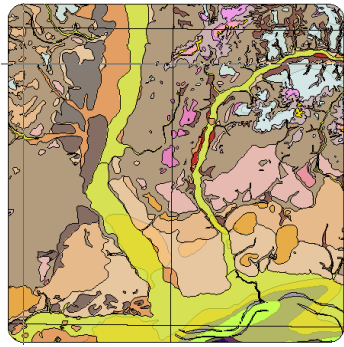
DiGMap  
Derived products  
Web-based products



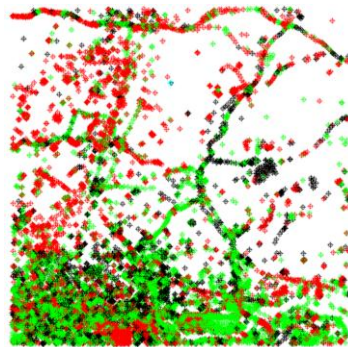
# Interactive section drawing in GSI3D – the expert decides...



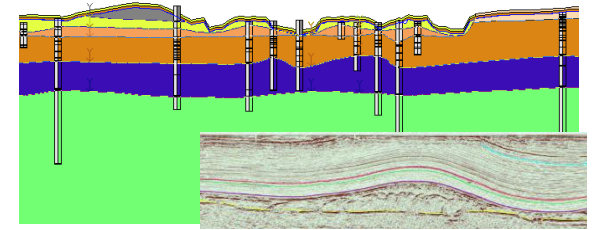
# Geological Modelling in 2012



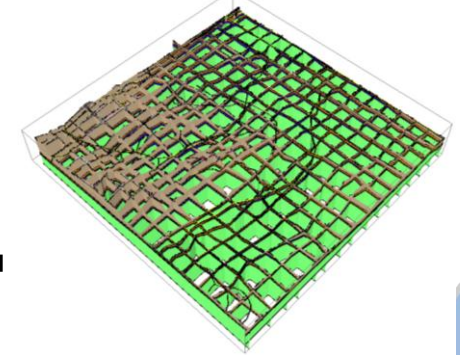
Map and DTM



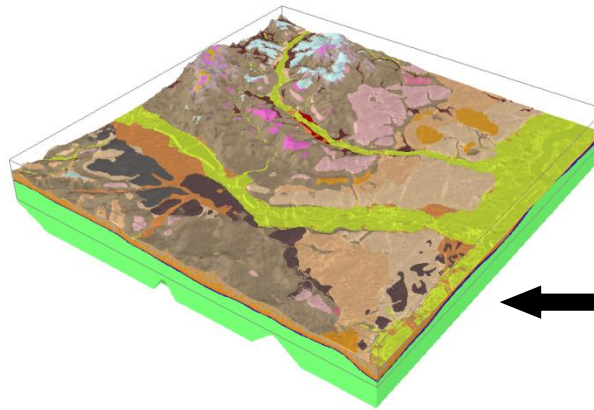
Boreholes



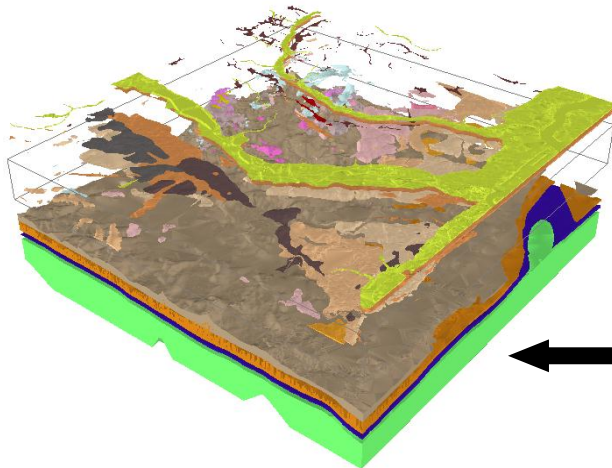
Cross-sections



Fence diagram



Geological Block model

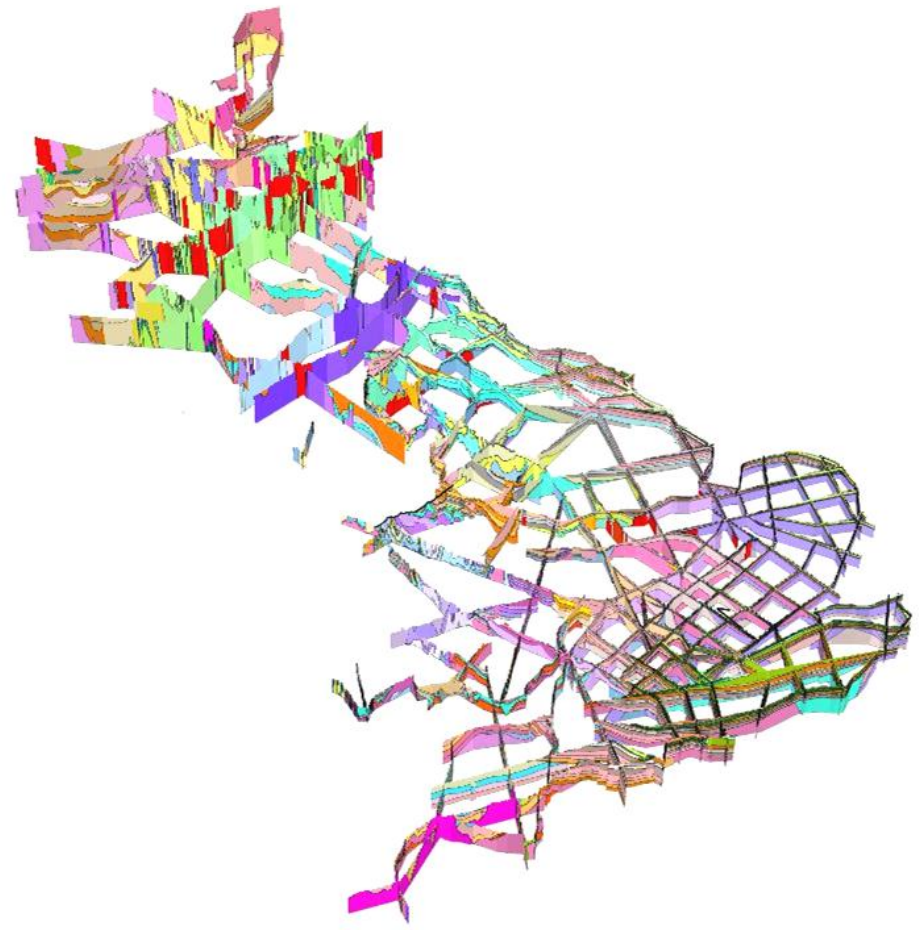


Exploded model,  
synthetic sections, etc.



# 3D geological model applications

- Assessment of ground conditions
- Groundwater management
- Urban and infrastructure planning
- Utility Management
- Geohazard assessment
- Waste disposal
- Environmental regulation
- Soil science
- Education and public dissemination
- Geological research

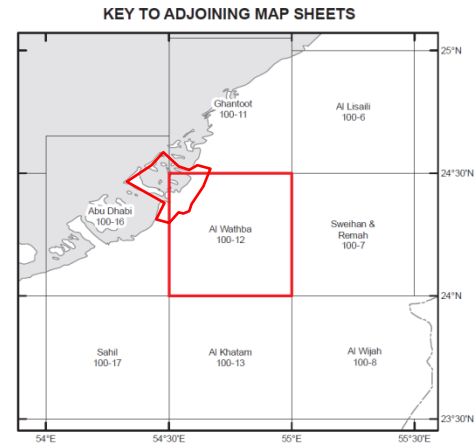
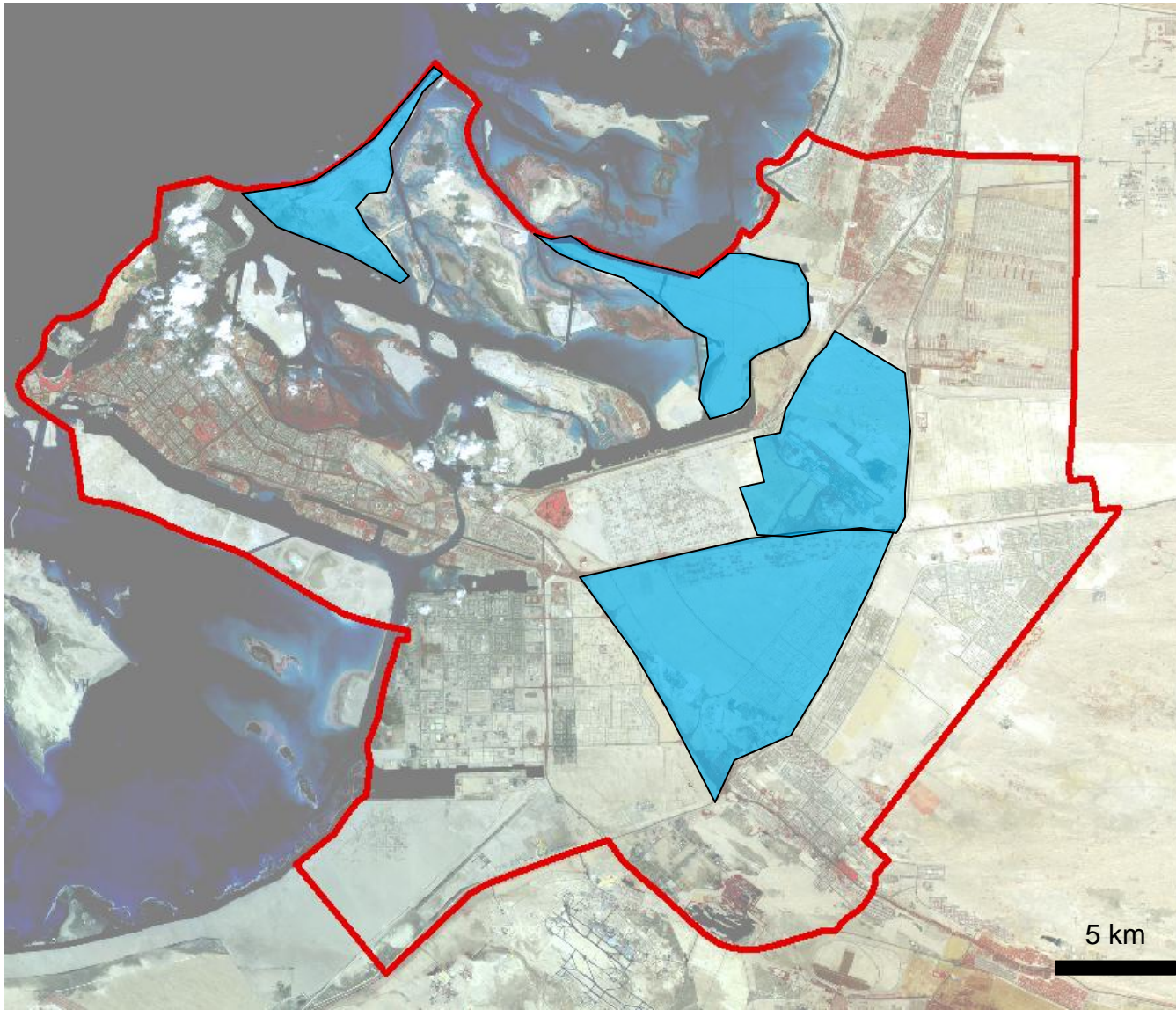


# The Abu Dhabi Model

The help and collaboration involving many partners including:

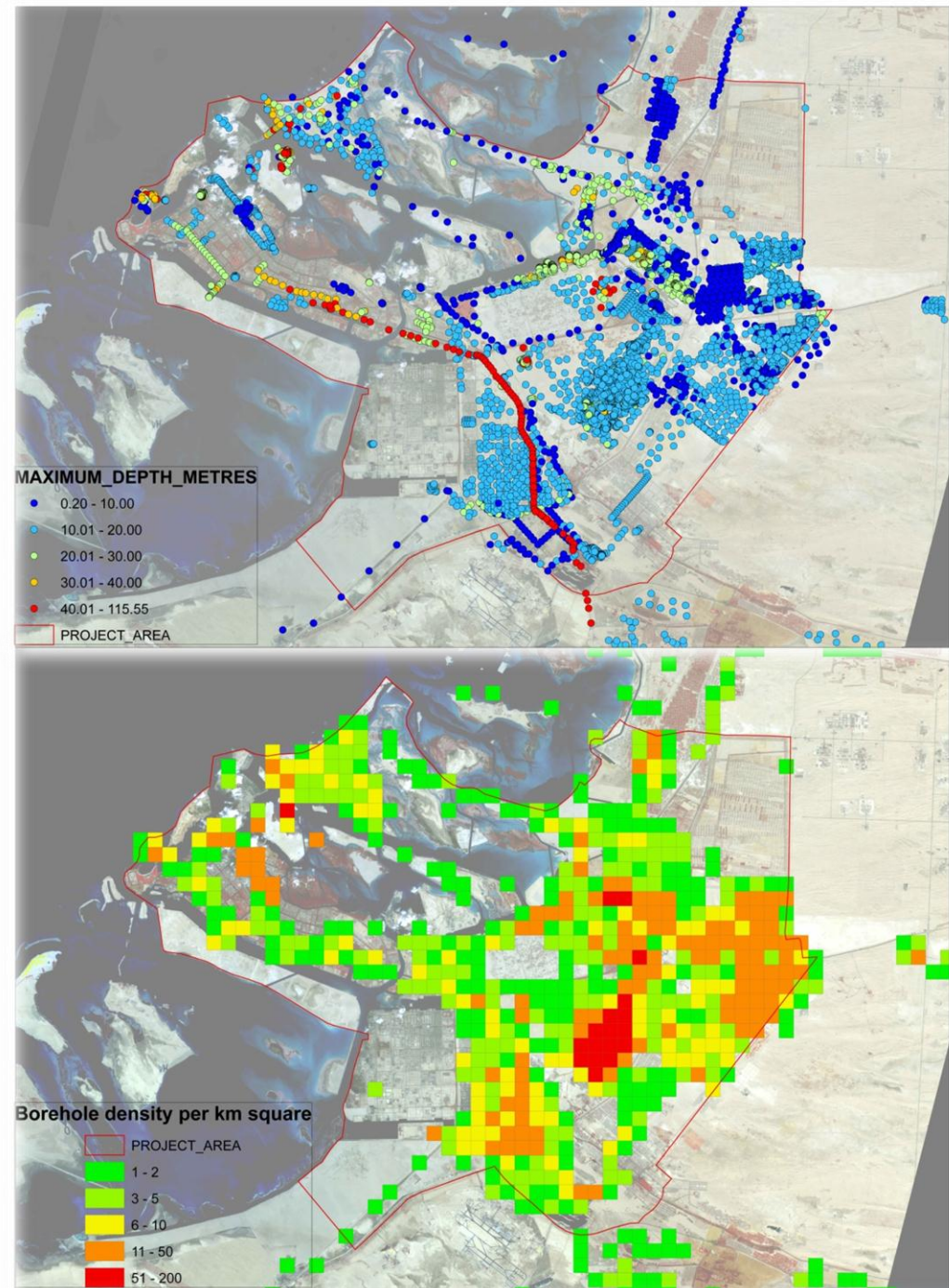
- Federal Ministry of Energy, Department of Geology and Mineral Resources
- Abu Dhabi Municipality
- Abu Dhabi Sewerage Services Company (ADSSC)
- Abu Dhabi Airports Company (ADAC)
- ALDAR, TDIC, ADTA
- Consultants and contractors including CH2MHILL, Atkins Global, Fugro, ACES, Mott Macdonald and Halcrow

# Abu Dhabi Urban Project area

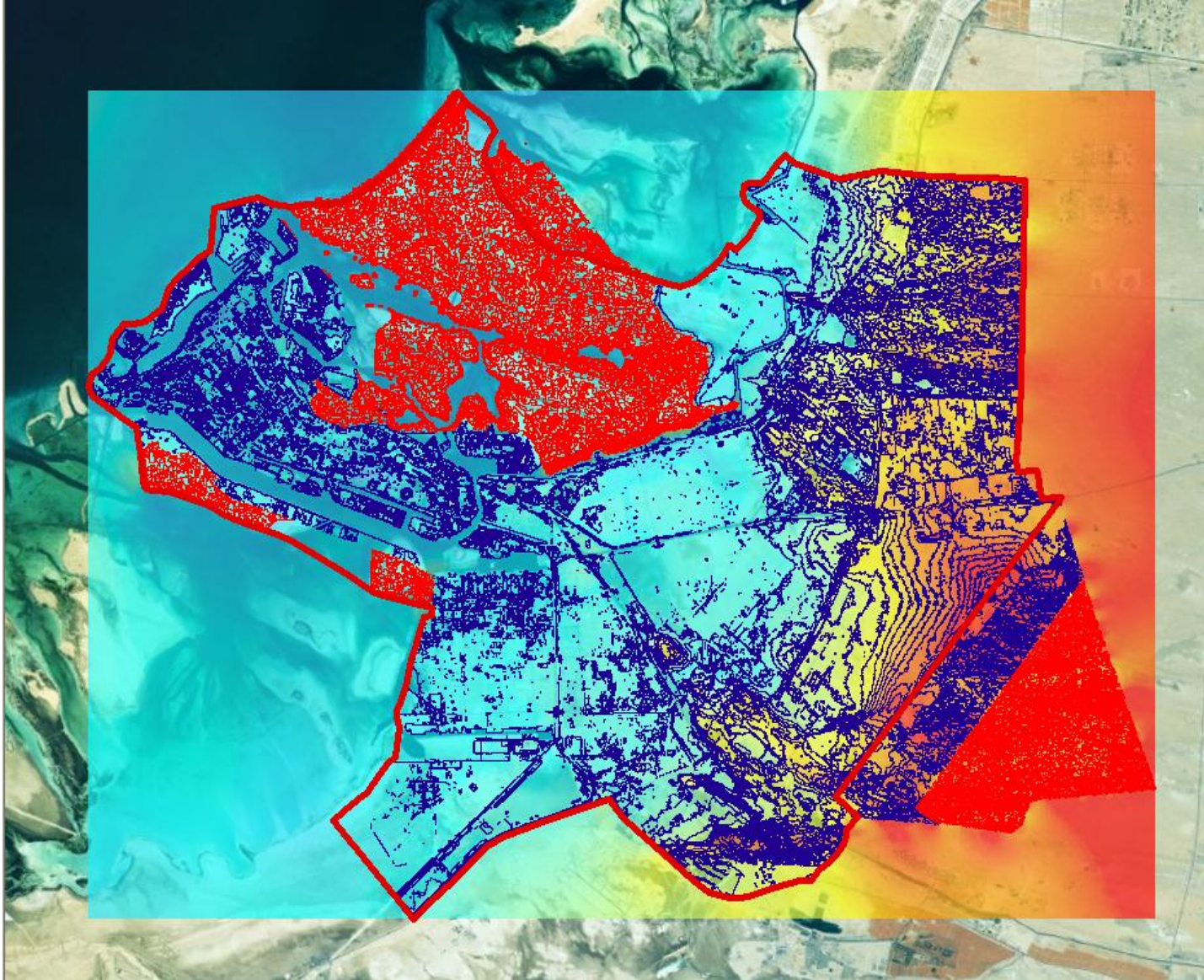


# Borehole data

- 9673 unique borehole records collected and processed
- 6453 contained downhole geological and/or geotechnical information
- ~ 1000 boreholes interpreted and coded manually
- ~ 2400 boreholes used to create the 3D geological model



# Digital Elevation Model (DEM)

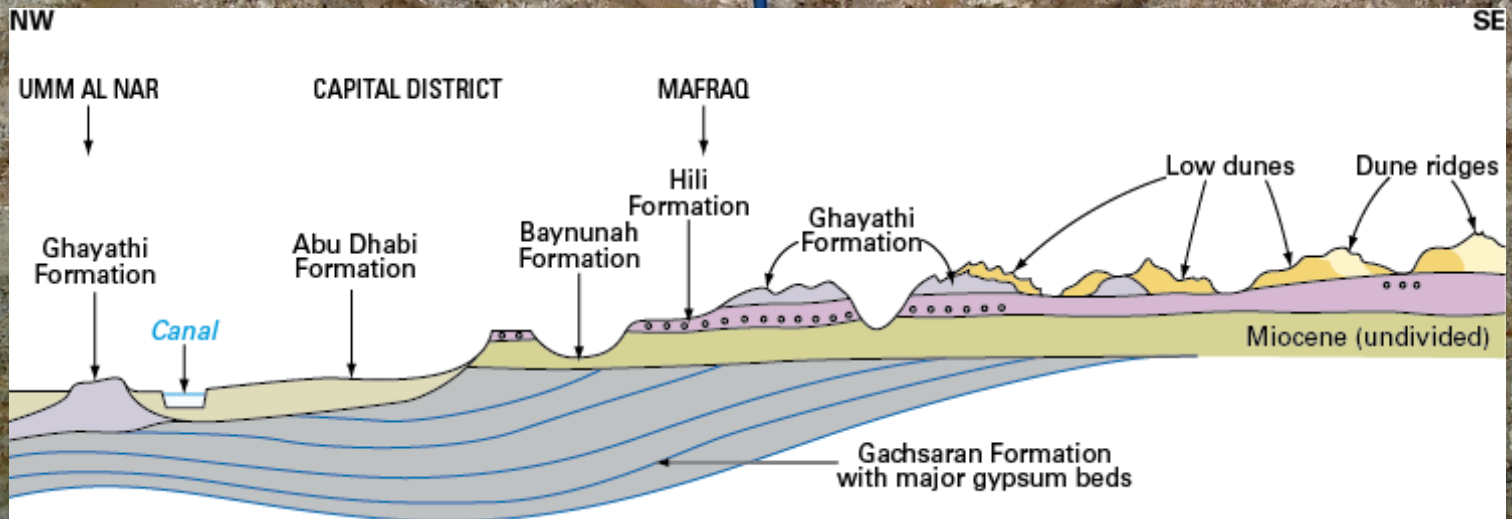




253437.86 2678276.09  
73.89N -6.74E  
20045.76 19970.76  
359.70 -48.30 0.00



# Geology



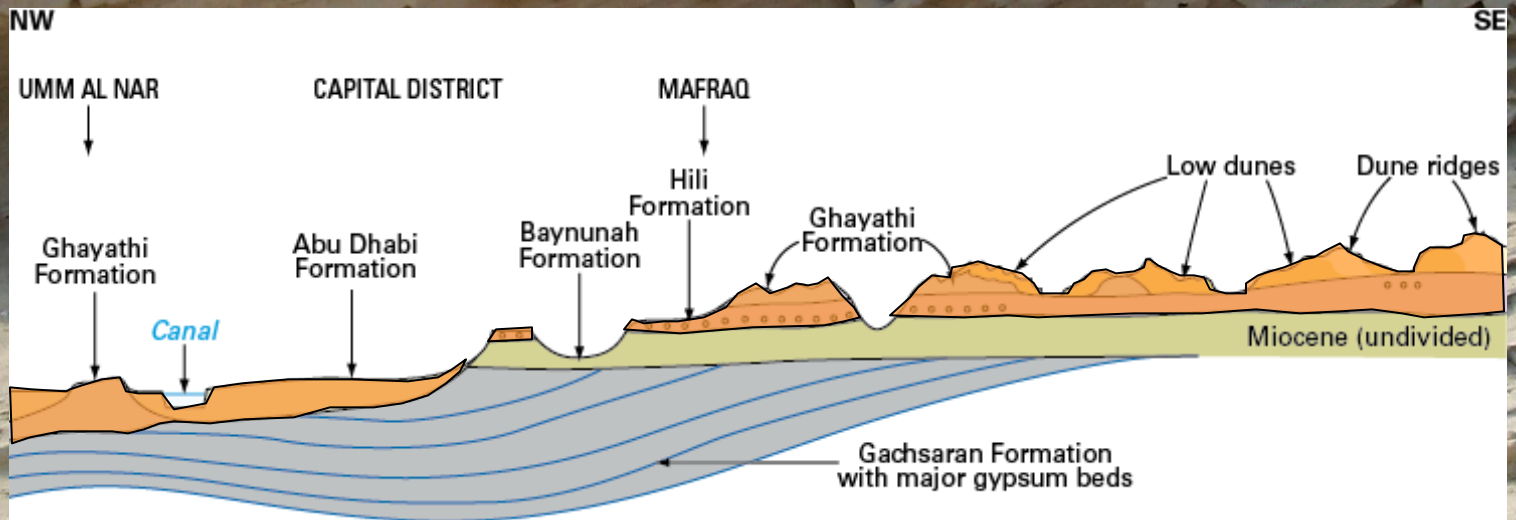
Geology	Model Unit Code	Lithostratigraphy	Lithology
Superficial (Quaternary) deposits	build	Not applicable	Buildings typically >100 m elevation
	mgr	Made Ground	Sand with common gravel
	mat	Abu Dhabi Formation (algal mat)	Organic clay and silt
	mat_t	Abu Dhabi Formation (algal mat lens)	Organic clay and silt
	ad	Abu Dhabi Formation (undifferentiated)	Bioclastic sand
	aes	Aeolian Sand	Sand
	mar	'Saadiyat' Formation	Bioclastic limestone
	ghay	Ghayathi Formation	Sandstone
	hili	Hili Formation	Sandstone and conglomerate



Geology	Model Unit Code	Lithostratigraphy	Description
Bedrock	bay	Baynunah Formation	Silty sandstone and siltstone
	mdst_1	Gachsaran Formation	Variably calcareous mudstone and siltstone
	gyps_1	Gachsaran Formation	Mainly crystalline gypsum
	mdst_2	Gachsaran Formation	Variably calcareous mudstone and siltstone
	gyps_2	Gachsaran Formation	Mainly crystalline gypsum
	mdst_3	Gachsaran Formation	Variably calcareous mudstone and siltstone
	gyps_3_t	Gachsaran Formation	Mainly crystalline gypsum
	gyps_4	Gachsaran Formation	Mainly crystalline gypsum
	mdst_4	Gachsaran Formation	Variably calcareous mudstone and siltstone
	gyps_5	Gachsaran Formation	Mainly crystalline gypsum
	mdst_5	Gachsaran Formation	Variably calcareous mudstone and siltstone
	gyps_6	Gachsaran Formation	Mainly crystalline gypsum
	mdst_6	Gachsaran Formation	Variably calcareous mudstone and siltstone
	daml	Dam Formation? facies	Bioclastic sandstone or limestone
Void 1 to 5	Cavities	Void 1 to 5	
Voids	Void 1 to 5	Cavities	Voids proved in boreholes

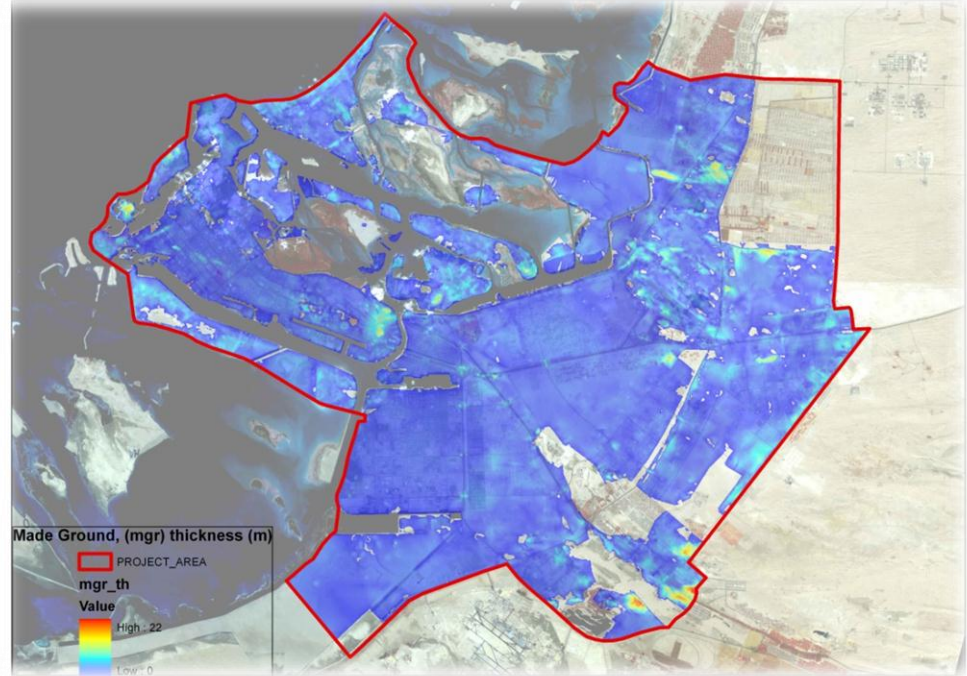
	Grain size	Strength/density	Lithostratigraphy	Engineering class
Soil	COARSE and OTHER MATERIAL (mainly sand)	Loose to very dense	Made Ground (mgr)	ENG1
	COARSE	Loose to dense	Abu Dhabi Formation (ad), Aeolian Sand	ENG2
	FINE	Generally stiff to very stiff	Abu Dhabi Formation algal mat (mat and mat_t)	ENG3
Soil & Rock	COARSE, calcareous	Moderately dense to very dense, extremely weak to weak	Ghayathi Formation (ghay), Hili Formation (hili)	ENG4a and ENG 4b
	COARSE and FINE	Moderately dense to very dense, extremely weak to weak	Baynunah Formation (bay)	ENG5
Rock	COARSE or LIMESTONE	Extremely weak to weak	Saadiyat Formation (mar), Dam Formation? Facies (dam)	ENG6
	MIXED FINE and MINERAL	Very weak to strong	Gachsaran Formation (mdst 1 to 6)	ENG7
	MINERAL	Weak to strong	Gachsaran Formation (gyps 1 to 6)	ENG8
Void	Void		Void	ENG9

# Quaternary geology



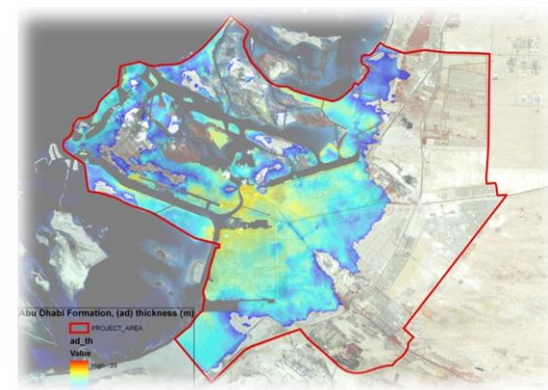
# Artificial Ground

- Made Ground (including engineered fill)
- Associated with land reclamation and site development
- Grey sand with common gravel or rock fragments and shells
- Very common and widespread



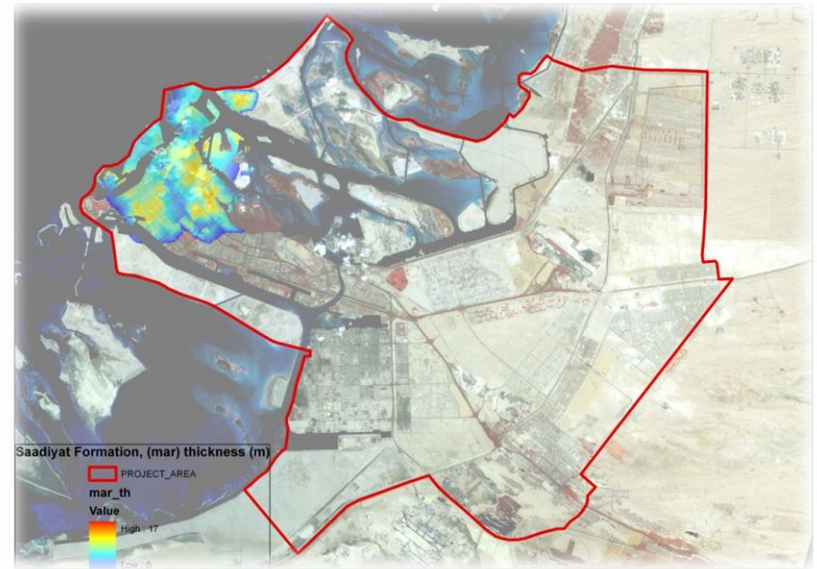
# Abu Dhabi Formation

- Bioclastic sand, silty sand, organic clay and silt
- Complex sequence of subtidal, intertidal and supratidal marine sediments forming a transgressive-regressive cycle
- It includes, lagoonal, beach-barrier, oolite shoal, tidal delta, channel, wash-overs and algal mat
- It is undivided in the 3D model except for organic clay and silt (algal mat deposits)



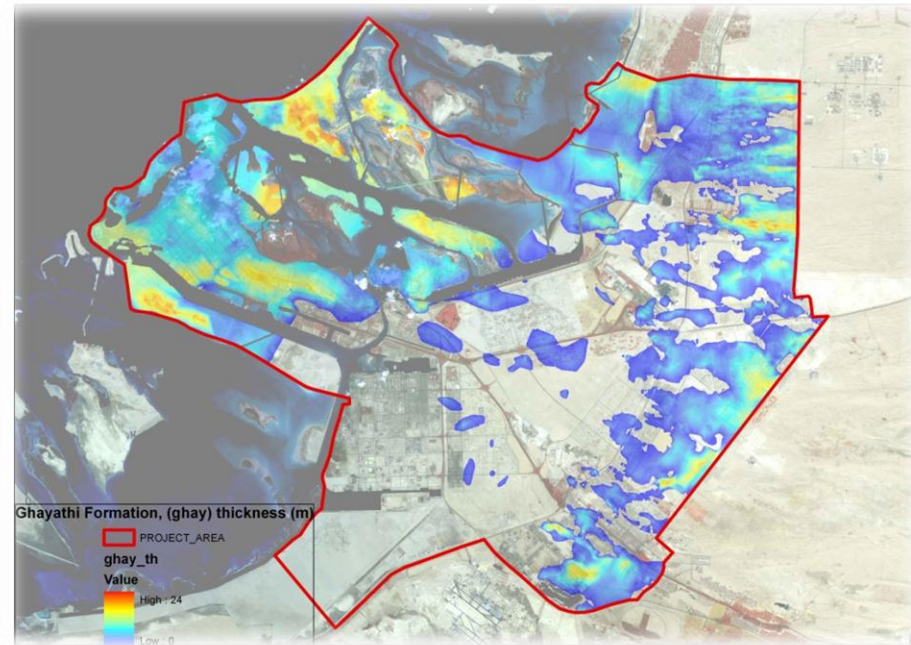
# 'Saadiyat' Formation

- Light grey, bioclastic limestone (packstone) with common gastropods and bivalves generally <0.6m thick
- Commonly described in borehole logs as calcarenite



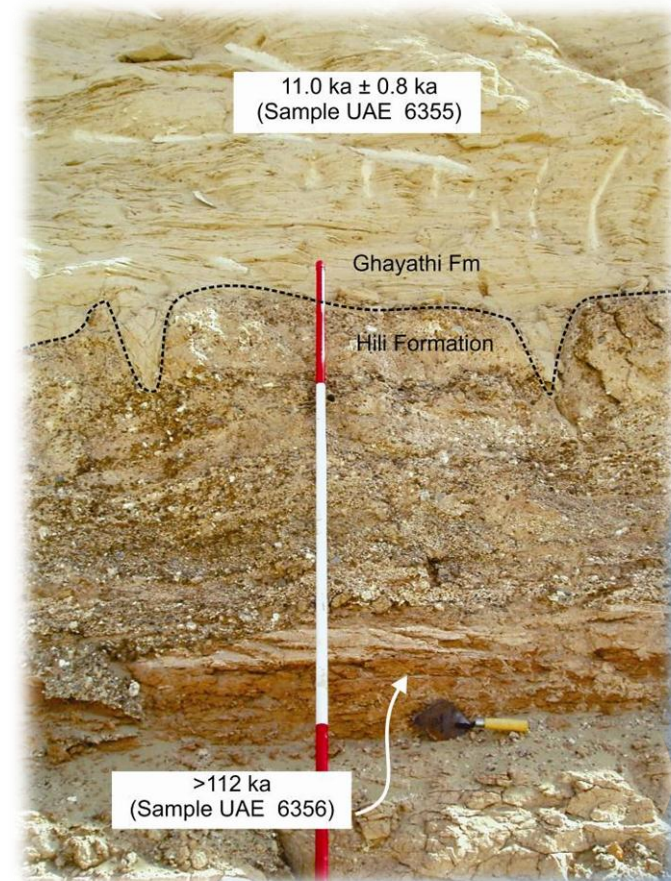
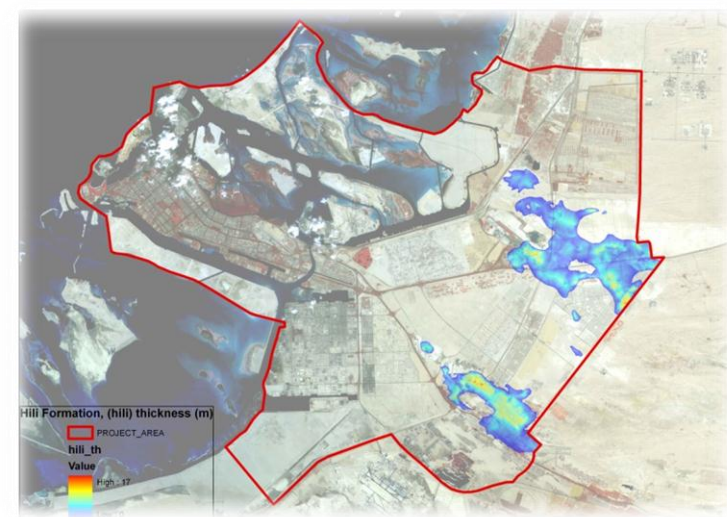
# Ghayathi Formation

- Silty, calcareous, cross-bedded and cross-laminated fine- to medium-grained sandstone
- Comprise cemented palaeodunes 'aeolianite'
- Often form elongate east-west trending ridges or isolated zeugen



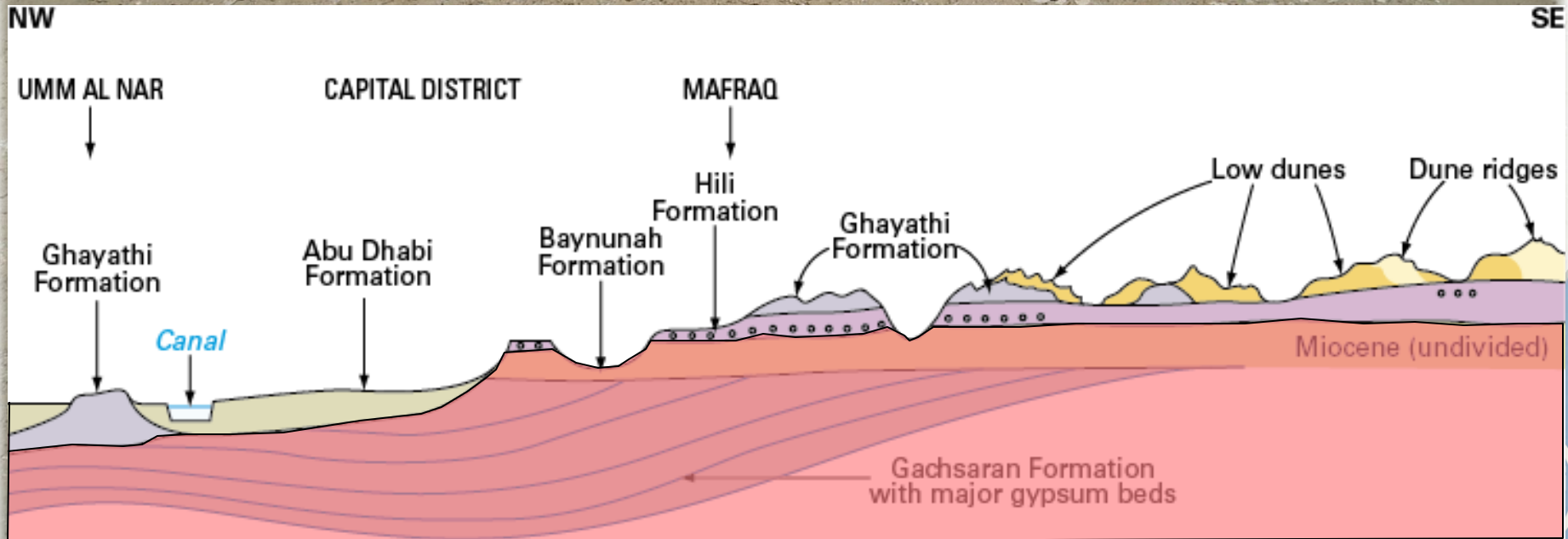
# Hili Formation

- Mainly red and reddish brown sandstone and conglomerate
- Fluvio-aeolian sandstone, quartz-rich with common beds and lenses of well-sorted and trough cross-bedded conglomerate



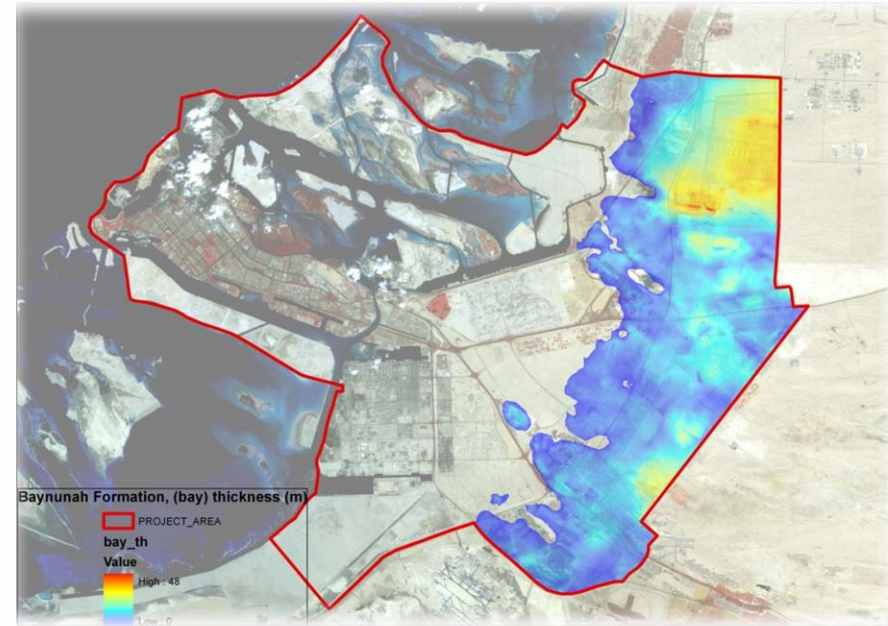


# Bedrock geology



# Baynunah Formation

- Mottled, red, grey and greenish-grey, interbedded siltstone, sandstone and sand
- Comprise cemented palaeodunes 'aeolianite'
- Common rhizoconcretions



# Gachsaran Formation

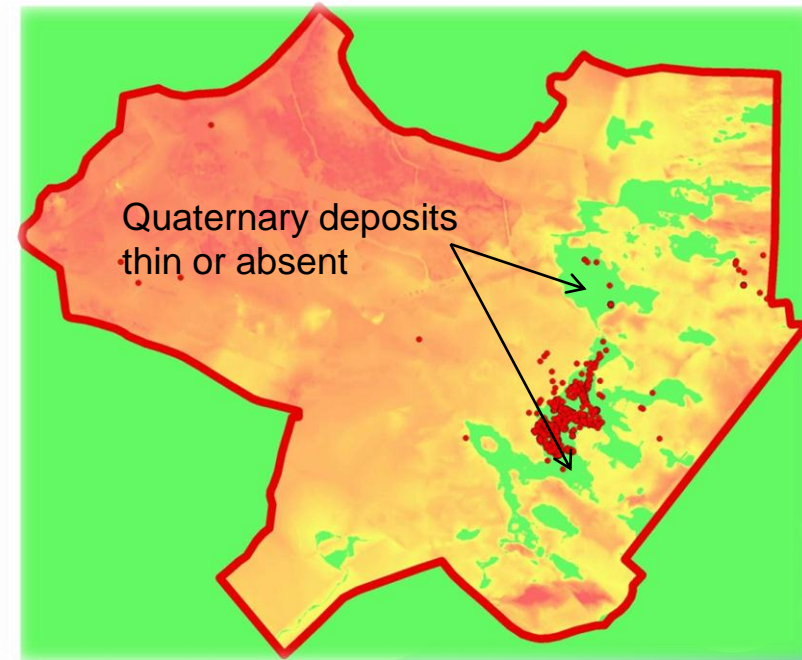
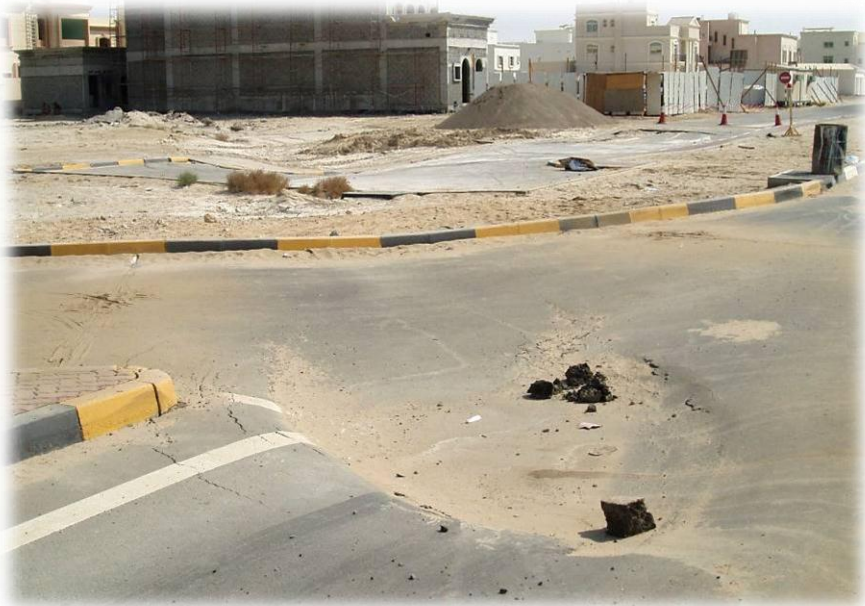
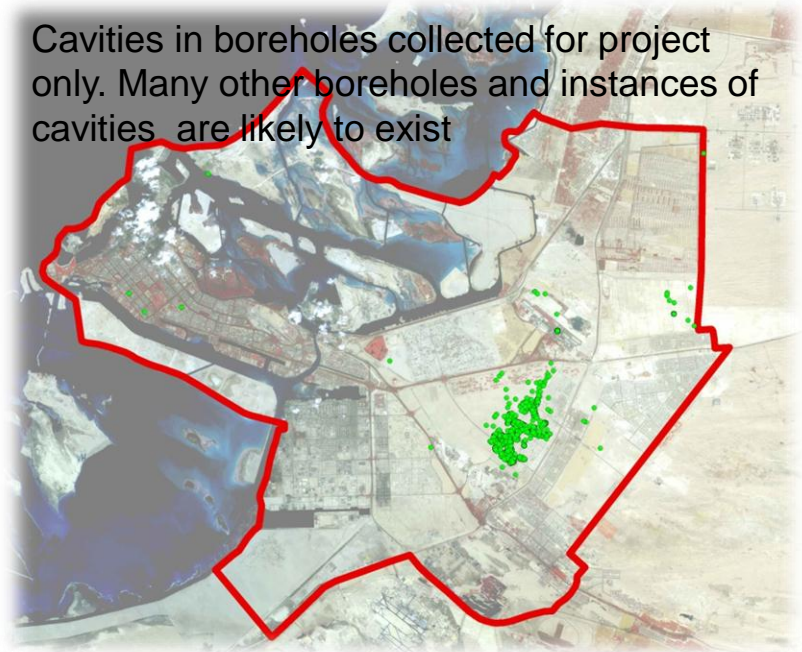
- Interbedded sequence of variably calcareous mudstone and siltstone with gypsum
- Gypsum present as nodules, beds and lenses
- Up to 6 major gypsum beds identified in the Abu Dhabi Urban area



# Cavities

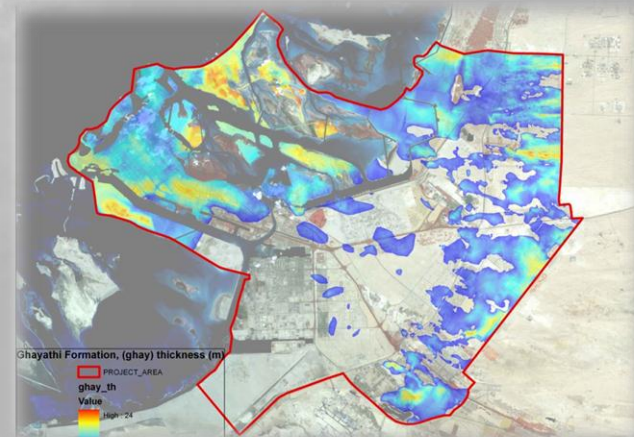
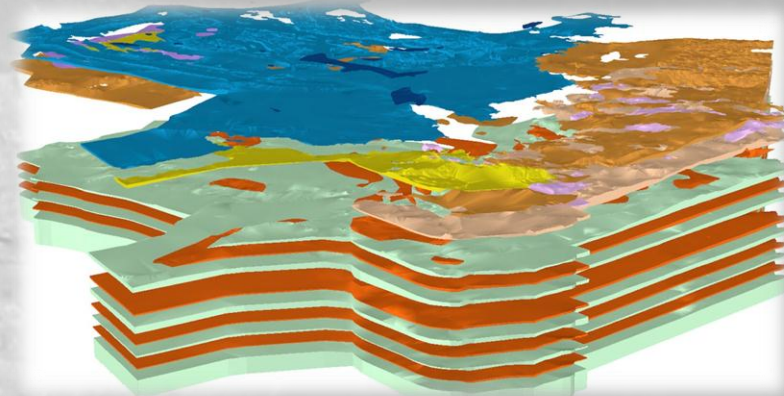
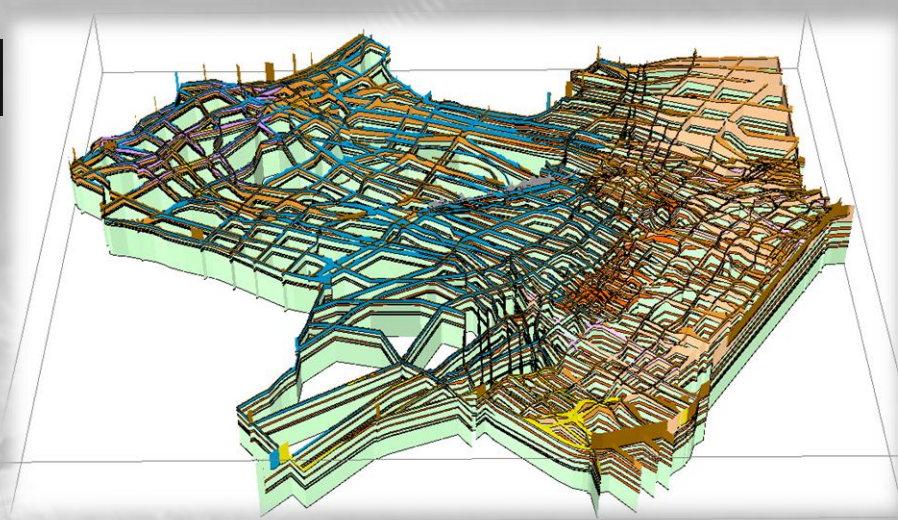
- The location of cavities (voids) recorded in 539 borehole records shown in the Abu Dhabi 3D
- Many records have multiple, downhole instances of cavities
- This does not represent all instances of cavities in the Abu Dhabi urban area

Cavities in boreholes collected for project only. Many other boreholes and instances of cavities are likely to exist



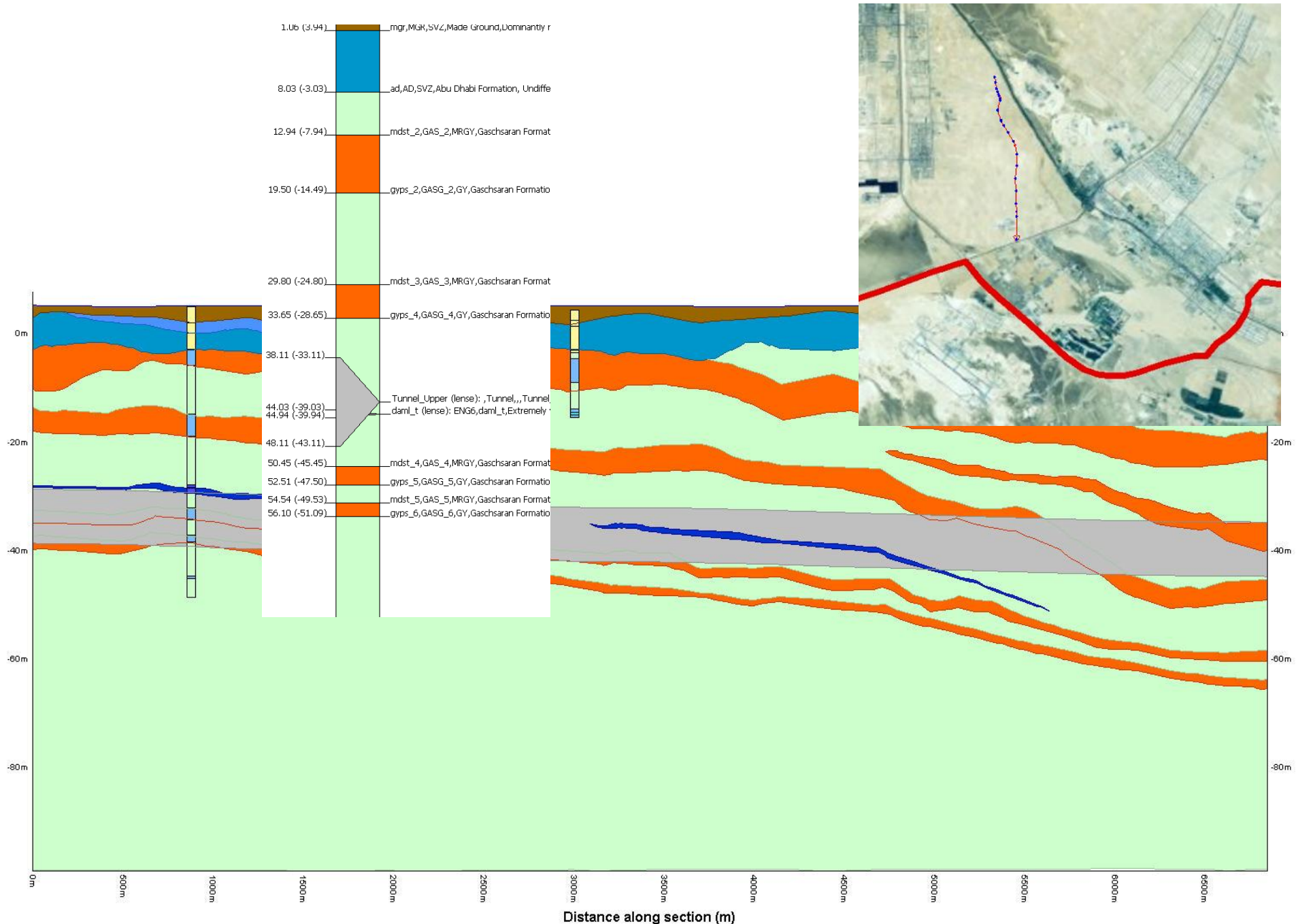
# 3D Geological Model

- Constructed using GSI3D™
- ~2400 boreholes correlated to produce 76 cross-sections
- 22 geological units were correlated and calculated
- 3D geological model delivered in the LithoFrame Viewer for visualisation
- GIS data exported from model includes shapefiles and raster grids



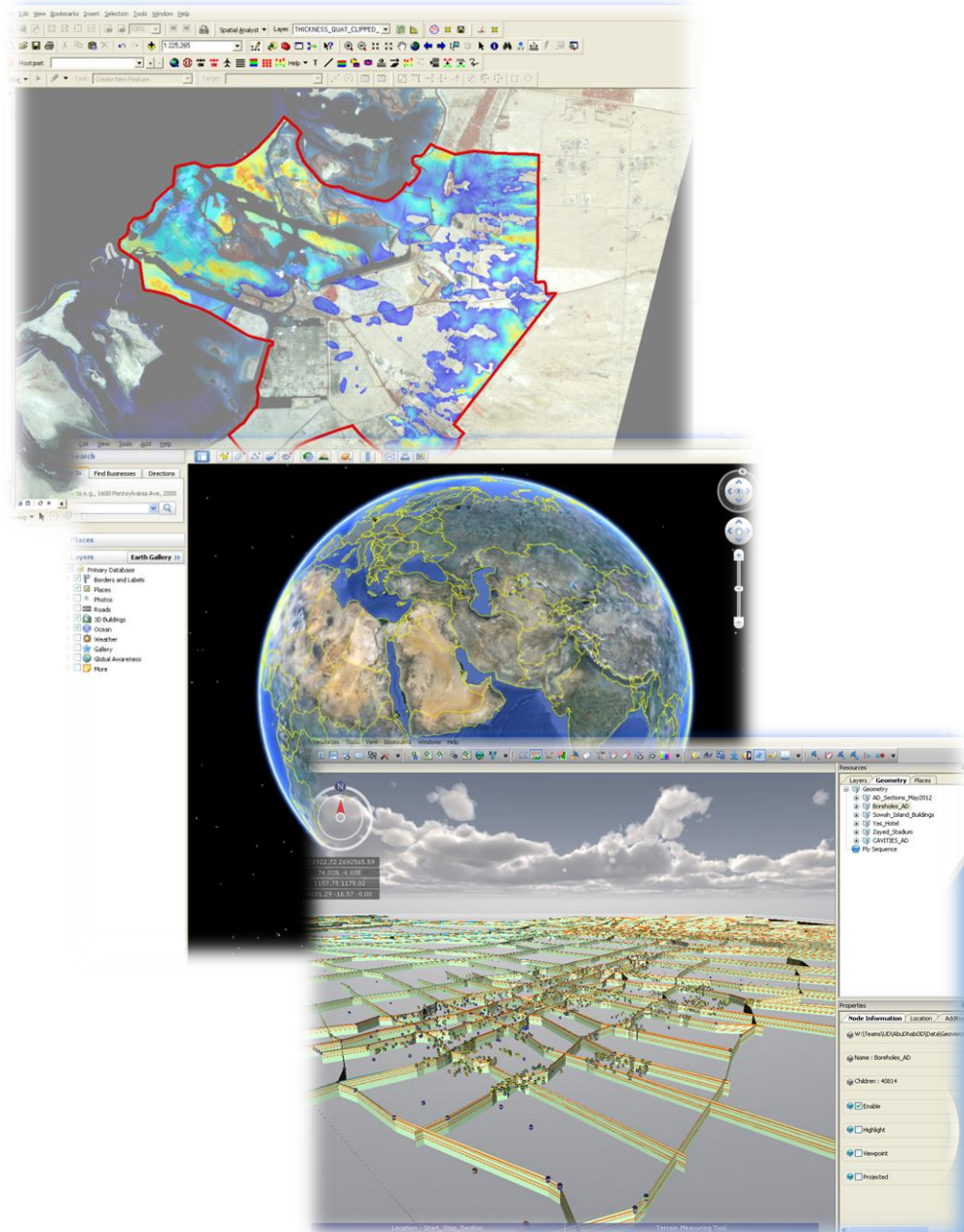
# Live Demonstration of The Abu Dhabi Model





# Data integration and visualisation

- GIS output of shapefiles and raster grids
- Integration with below ground and above ground information systems
- Integration with environmental spatial information
- Export to 3D PDF, Google Earth
- Export to customised visualisation systems -



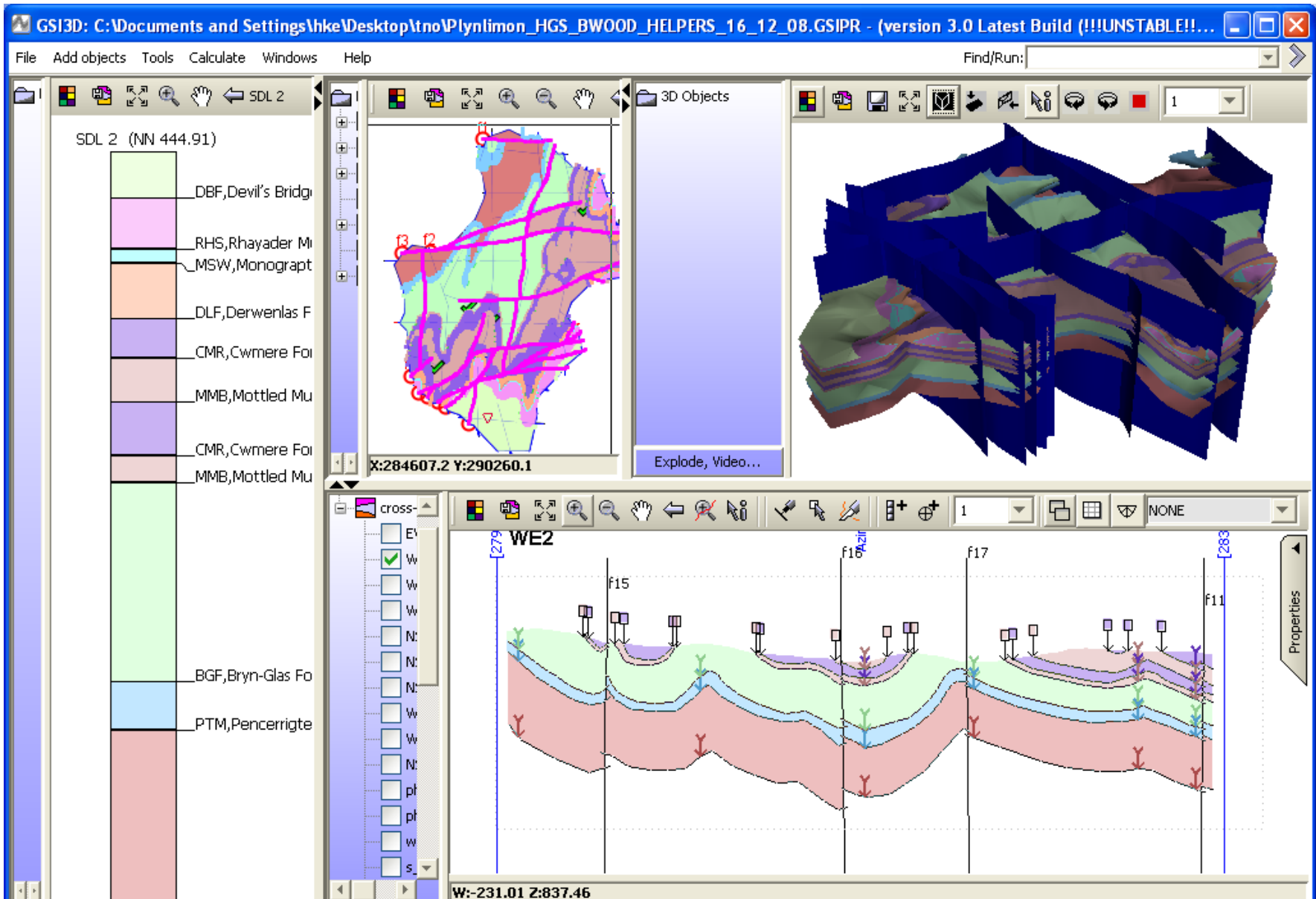
GeoVisionary



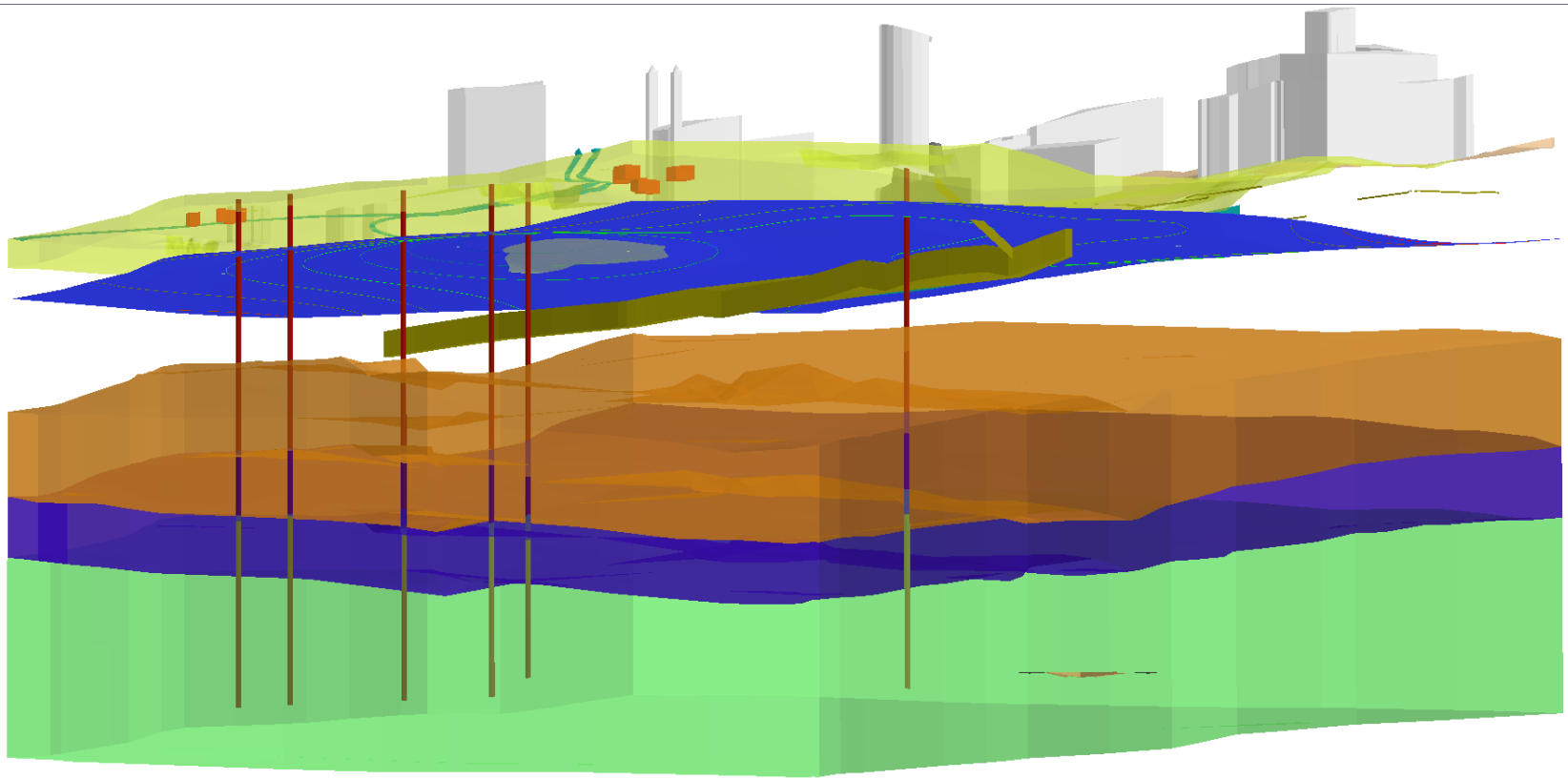
# A Look Into The Future



# Development of Bedrock Modelling

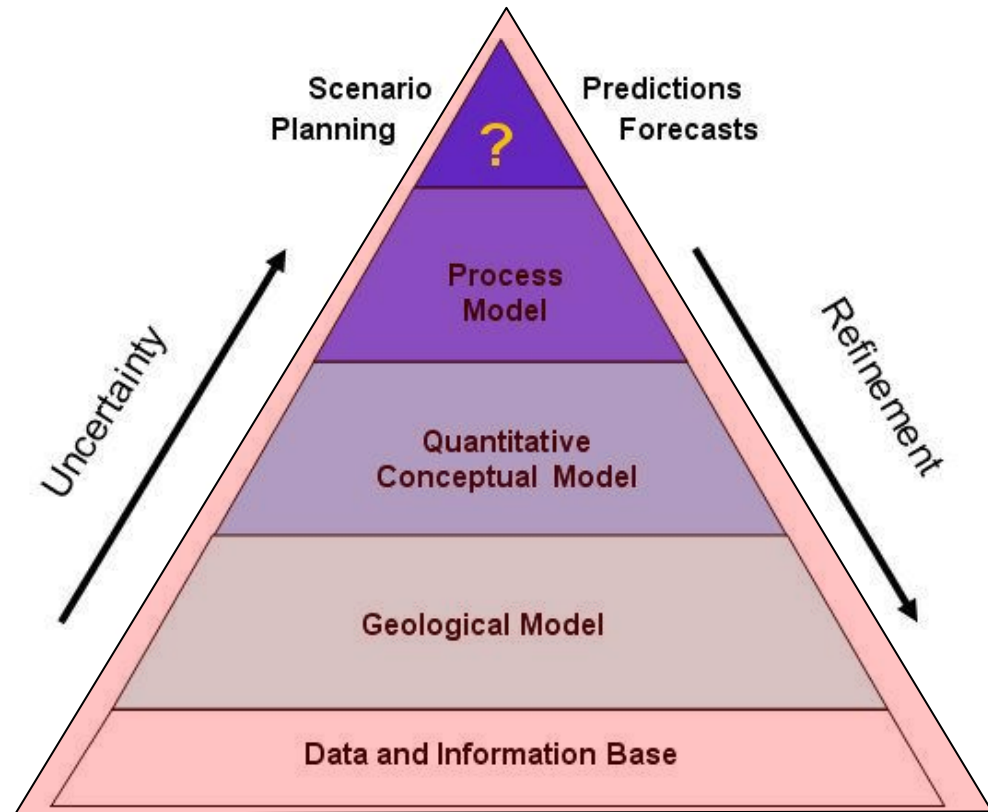


# An integrated surface and subsurface management system



Will the subsurface under major cities become regulated?

# Linking models and predictive scenarios



Examples of recent progress towards the use of the Environmental Modelling Platform for **scenario planning**

[http://www.bgs.ac.uk/services/3Dgeology/  
home.html](http://www.bgs.ac.uk/services/3Dgeology/home.html)

[www.geovisionary.com](http://www.geovisionary.com)

[www.gsi3d.org](http://www.gsi3d.org)

[GSI3D - Wikipedia](#)

