

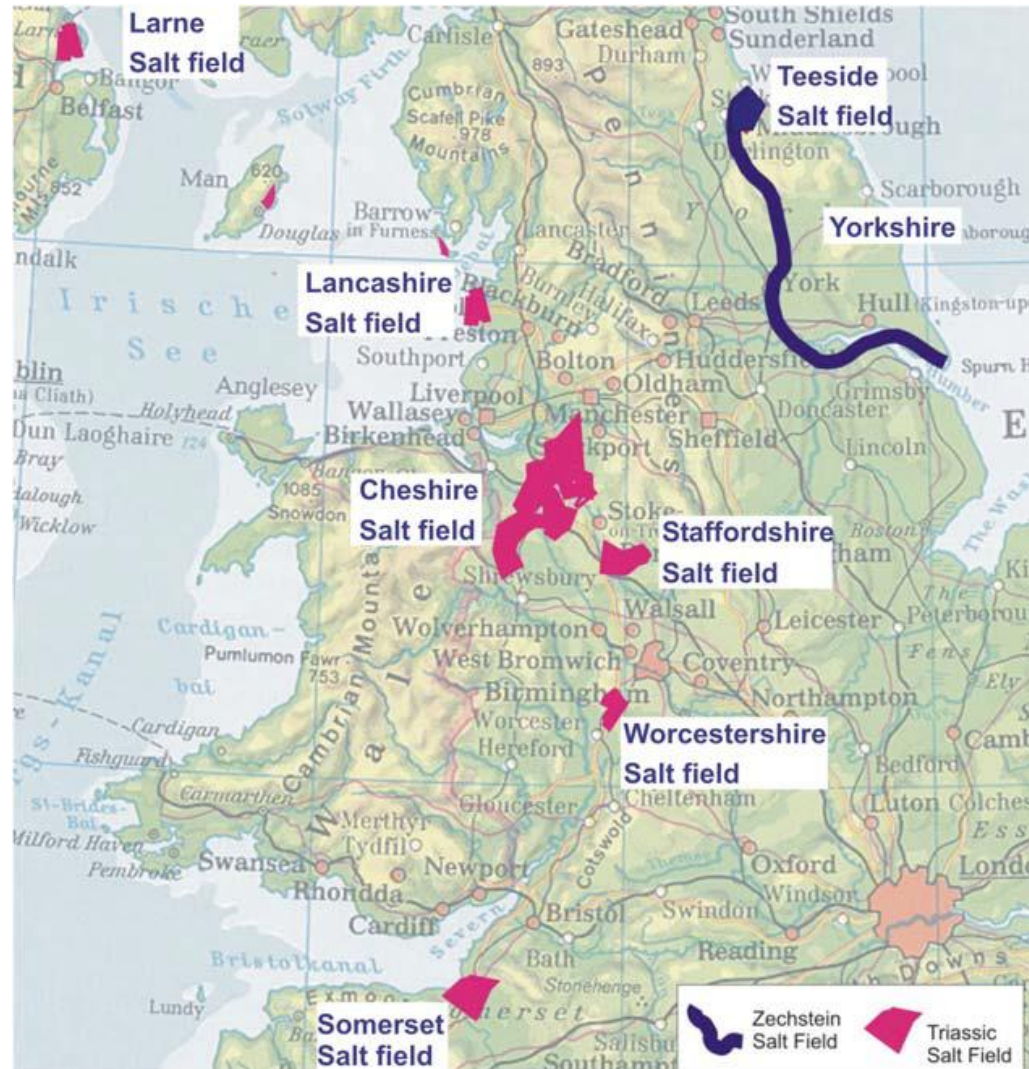


THE HOLFORD GAS STORAGE PROJECT

FROM SITE EXPLORATION TO GAS OPERATION: A CASE STUDY

THE HOLFORD GAS STORAGE PROJECT

Salt Field in the UK (*Beutel 2004*)



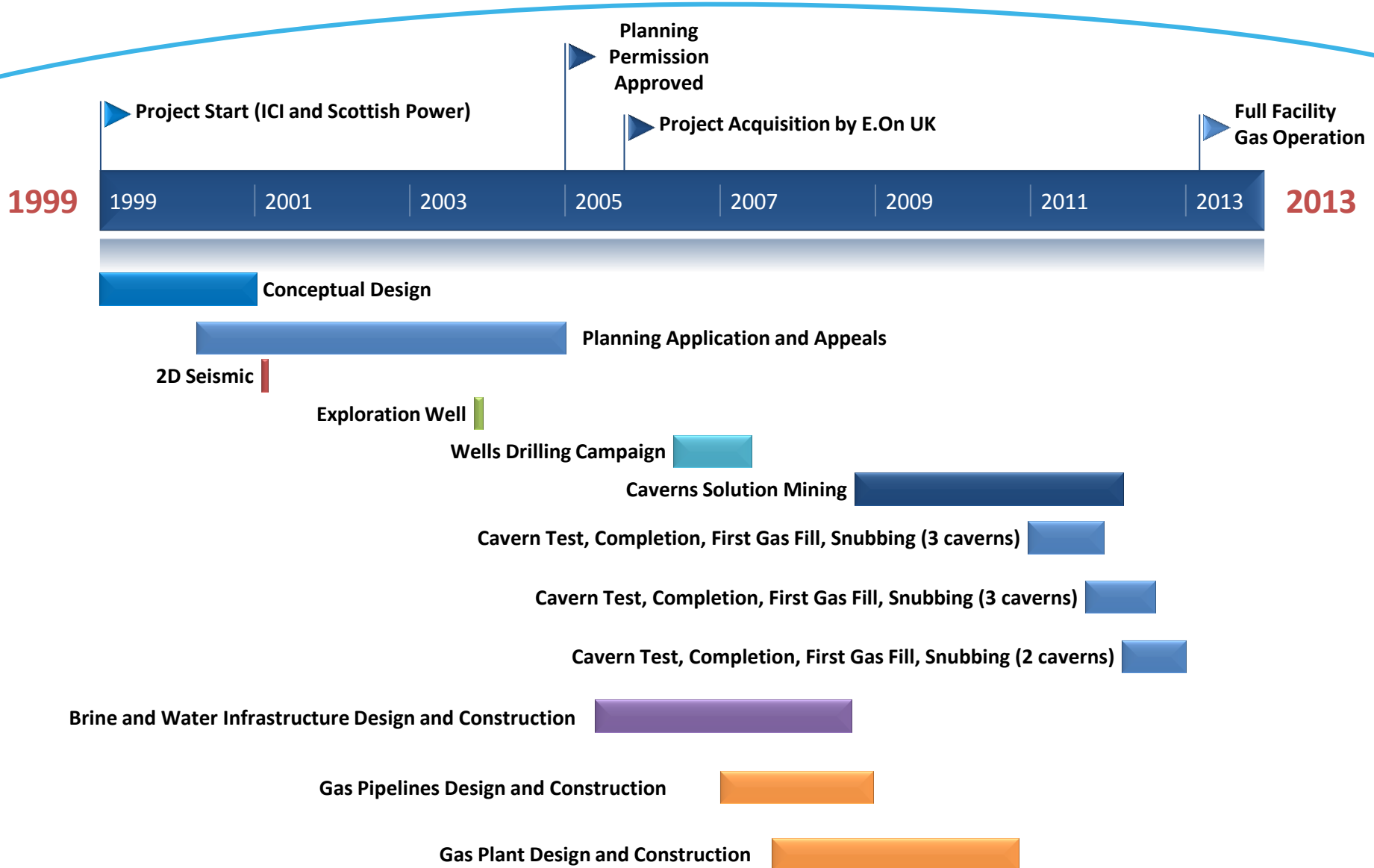
THE HOLFORD GAS STORAGE PROJECT

Project Summary

Site Location	Byley, Cheshire (near Northwich)
Construction	2006-2013
Number of Caverns:	8
Average volume:	370,000 m ³ (total 2,9 Mm ³)
Depth	570 – 700 m bGL
Operating Pressures	between 40 and 100 bar
Working Gas Volume	160 Mscm
Gas Operating Rate	22 Mscm/d
Compression Power	21 MW (3 compressors)
Water Injected	30 Mm ³ from Weaver river
Salt Mass Extracted	7,68 MT
Solution Mining Duration	2,5 to 3 years per cavern group
Leaching facilities	28,000 to 35,000 m ³ /day (to Soda Ash Plant)
Saturation of the brine	Holford Brinefield

THE HOLFORD GAS STORAGE PROJECT

Project Timeline



THE HOLFORD GAS STORAGE PROJECT

Subsurface investigations

Site Detection

Evaporite near surface, brine springs (Roman Times)
Salt extraction since 1680's (salt mine)
Wild brine pumping in the 19th century
Controlled Solution Mining since 1920's

Site Exploration and Qualification

Existing ICI surveys, Byley well (ICI 1950),
RM wells (Middlewich Mine)
2D Seismic 20km - 4 lines (SP 2001)
Drakelow 2A well (SP 2003)
225 m of cores,
Sonic, Neutron-Density, Spectral Gamma Ray,
Borehole Scanner, VSP, Formation permeability testing

Construction

Cavern Wells H401 – H408 (E.on 2006-2007)
Cores,
GR, Neutron-Density, Sonic, Spectral Gamma Ray
Nitrogen tightness tests (pre and post leaching)

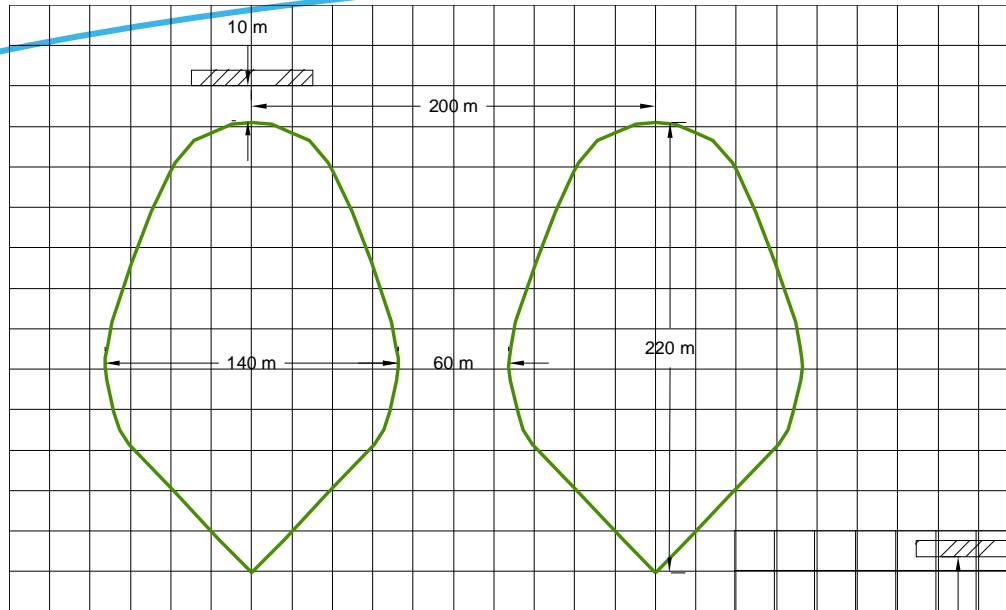
THE HOLFORD GAS STORAGE PROJECT

Comparison Salt Mining vs Gas Caverns

	SALT MINING	GAS STORAGE
Rock Mechanics	Long term stability of the cavern field under constant brine pressure	Long term stability of cavern field under fast pressure cycling Thermo-mechanical modelling
Gas Tightness	Enough for air blanket control during construction	Investigation of salt and marl tightness Gas tight casings, two cemented casings in the salt layer Downhole gas completion with safety valves
Brine Quality	Fully saturated, no impurities, no dissolved gas	No requirements
Schedule	Uninterruptible brine supply, flowrate depending on customers	Usually as fast as possible
Cavern shape	Limited controls	Regular shapes, strict control of roof and cavern neck
Process Controls	Long term, low frequency, low flow, numerous caverns online	Short term, high frequency monitoring, high flow
Corrosion	Long term acceptable, air blanket	Unacceptable on casings, nitrogen blanket
Costs	As low as possible	As low as possible

THE HOLFORD GAS STORAGE PROJECT

Comparison design Salt Mining vs Gas Caverns

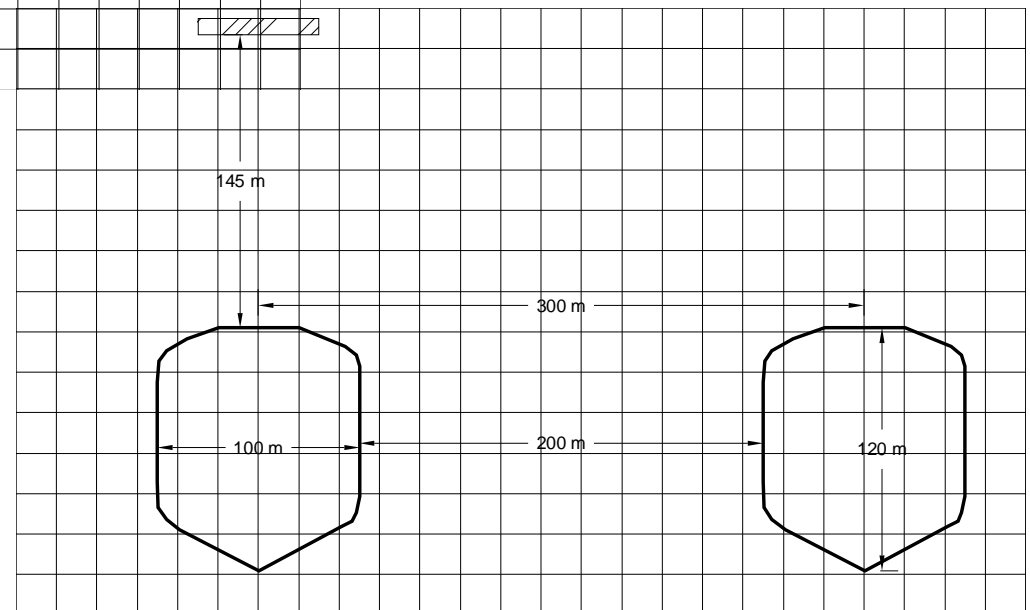


Typical Salt Mining:

- Distance between caverns: 200 m
- Cavern Diameter: 140 m
- Pillar to Diameter ratio: 0.4
- Cavern Volume: 600 000 m³+
- Distance to rock head: 15 m
- Cavern creation: 20 years+

Gas Storage Caverns:

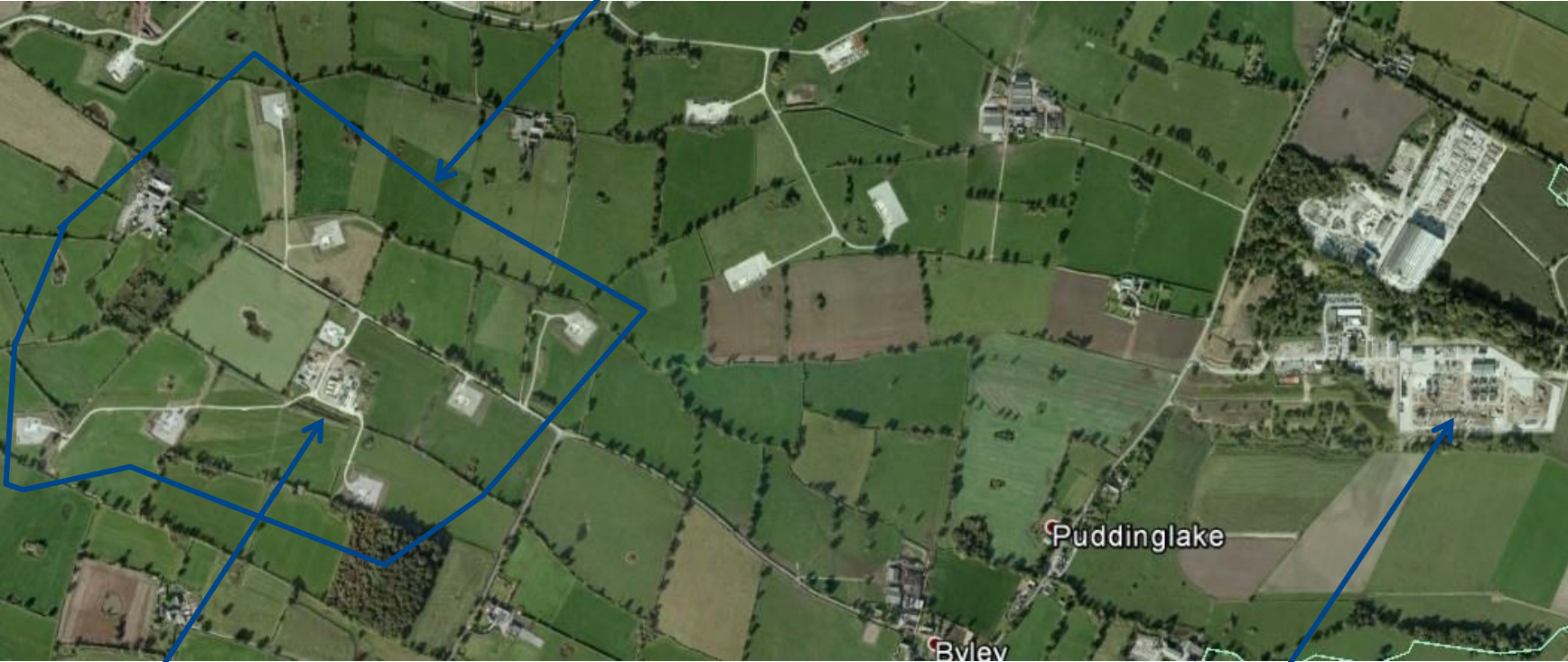
- Distance between caverns: 300 m
- Cavern Diameter: 100 m
- Pillar to Diameter ratio: 2
- Cavern Volume: 350 000 m³+
- Distance to rock head: 145 m
- Cavern creation: 2.5 years+



THE HOLFORD GAS STORAGE PROJECT

Project Map

Gas Cavern Field



Leaching Station and Gas Manifold

Gas Plant

THE HOLFORD GAS STORAGE PROJECT

Core Analysis and Testing



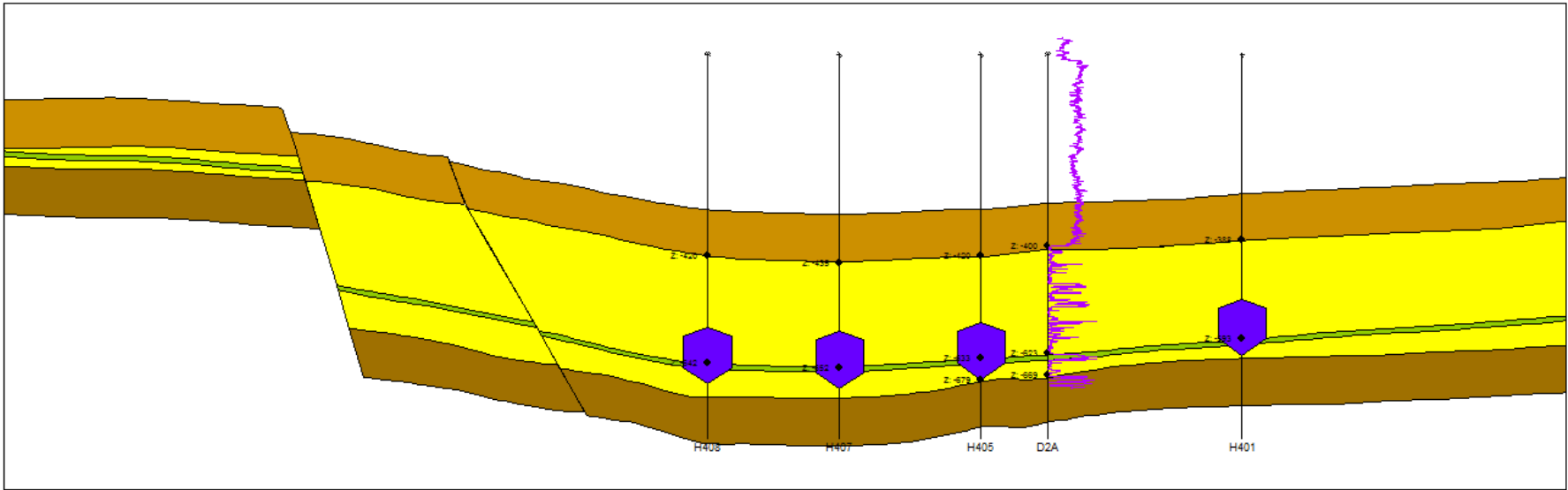
THE HOLFORD GAS STORAGE PROJECT

Core Analysis and Testing



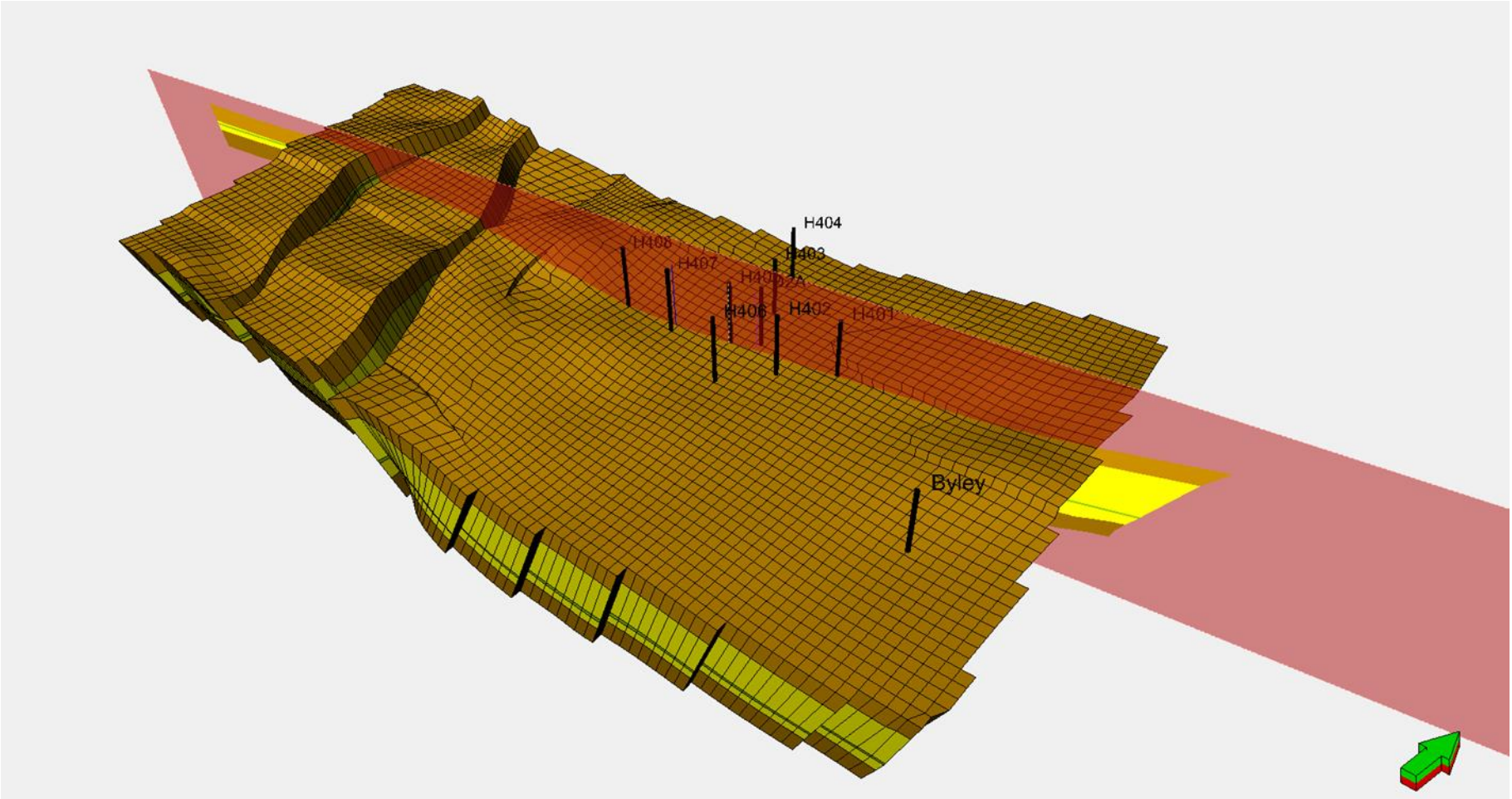
THE HOLFORD GAS STORAGE PROJECT

Site E-W Cross section



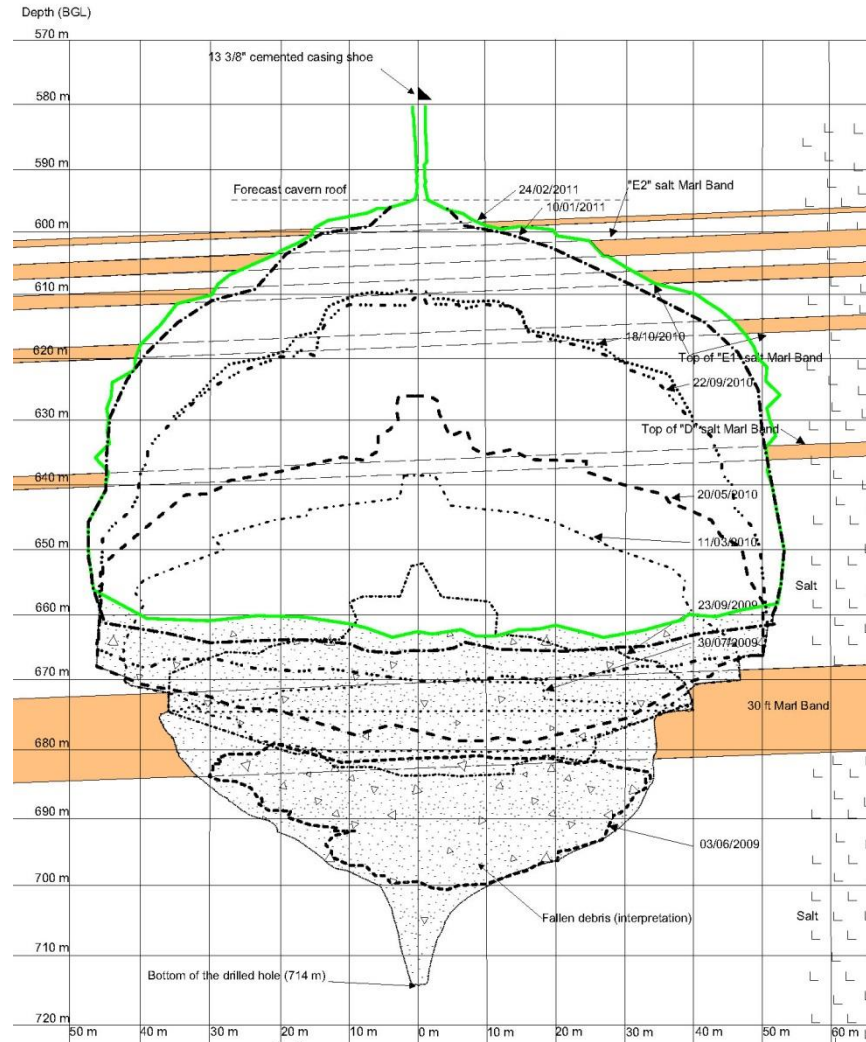
THE HOLFORD GAS STORAGE PROJECT

Salt Mass Model



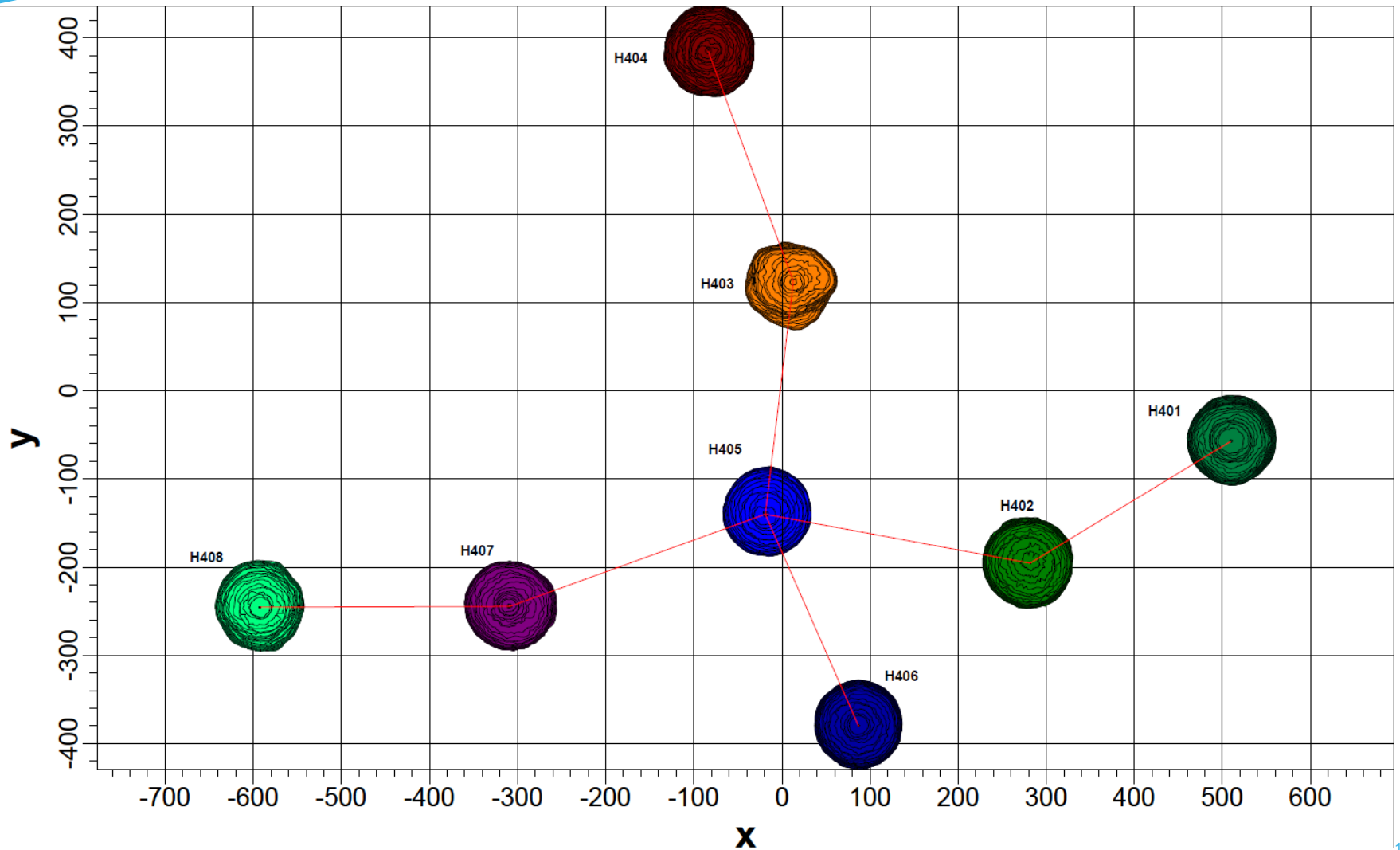
THE HOLFORD GAS STORAGE PROJECT

Cavern Development



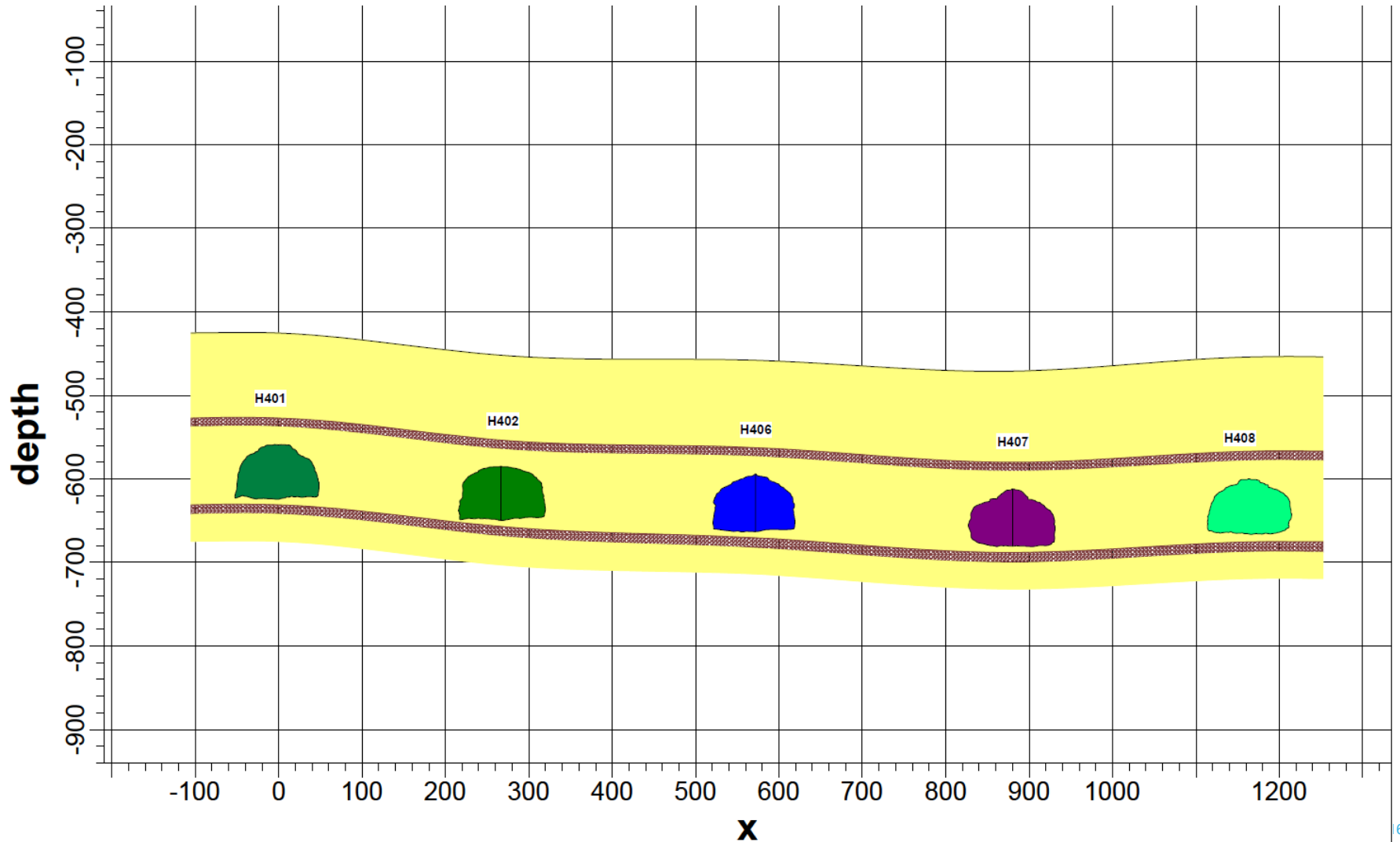
THE HOLFORD GAS STORAGE PROJECT

Cavern field horizontal view



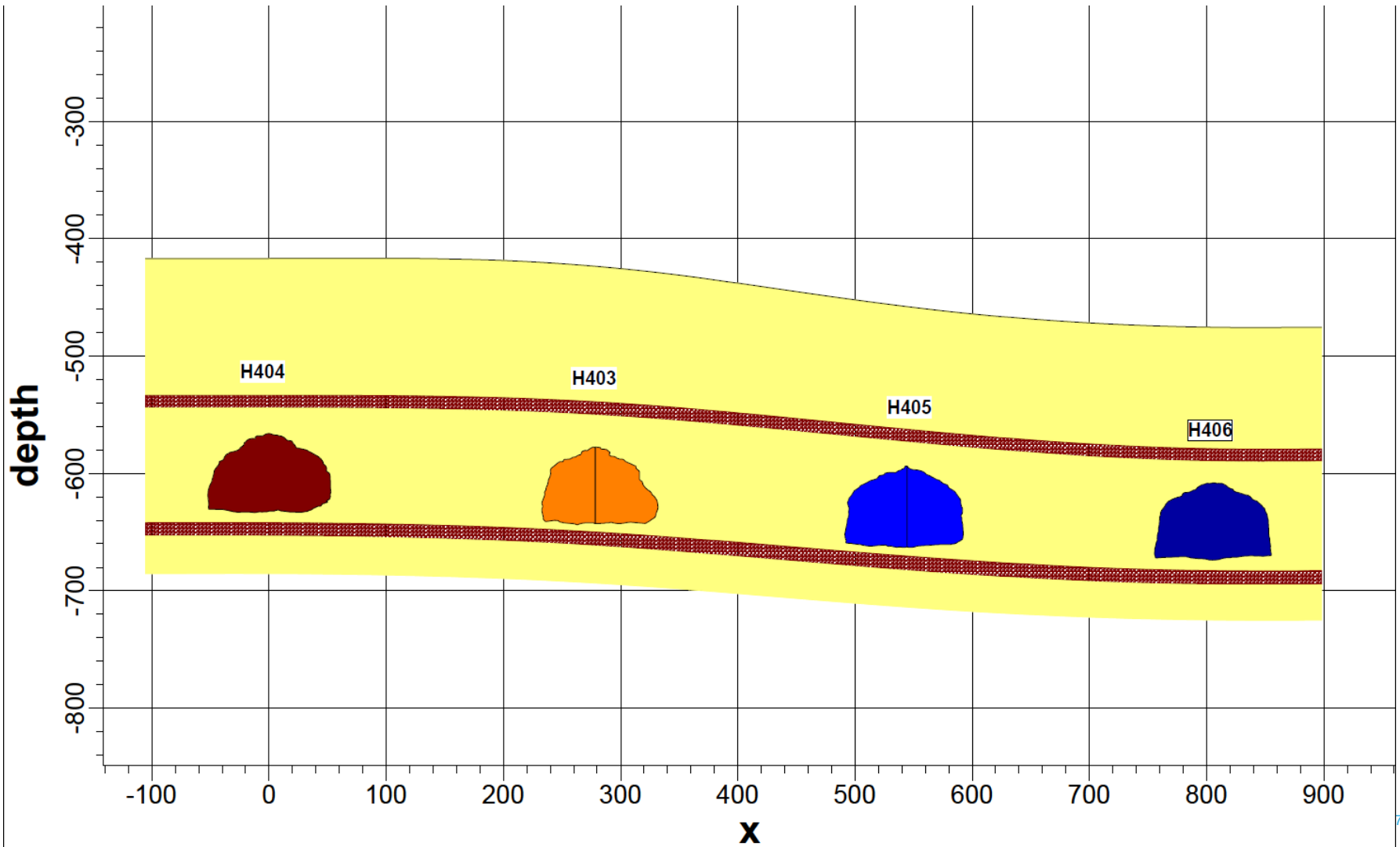
THE HOLFORD GAS STORAGE PROJECT

Cavern field vertical view (E-W)



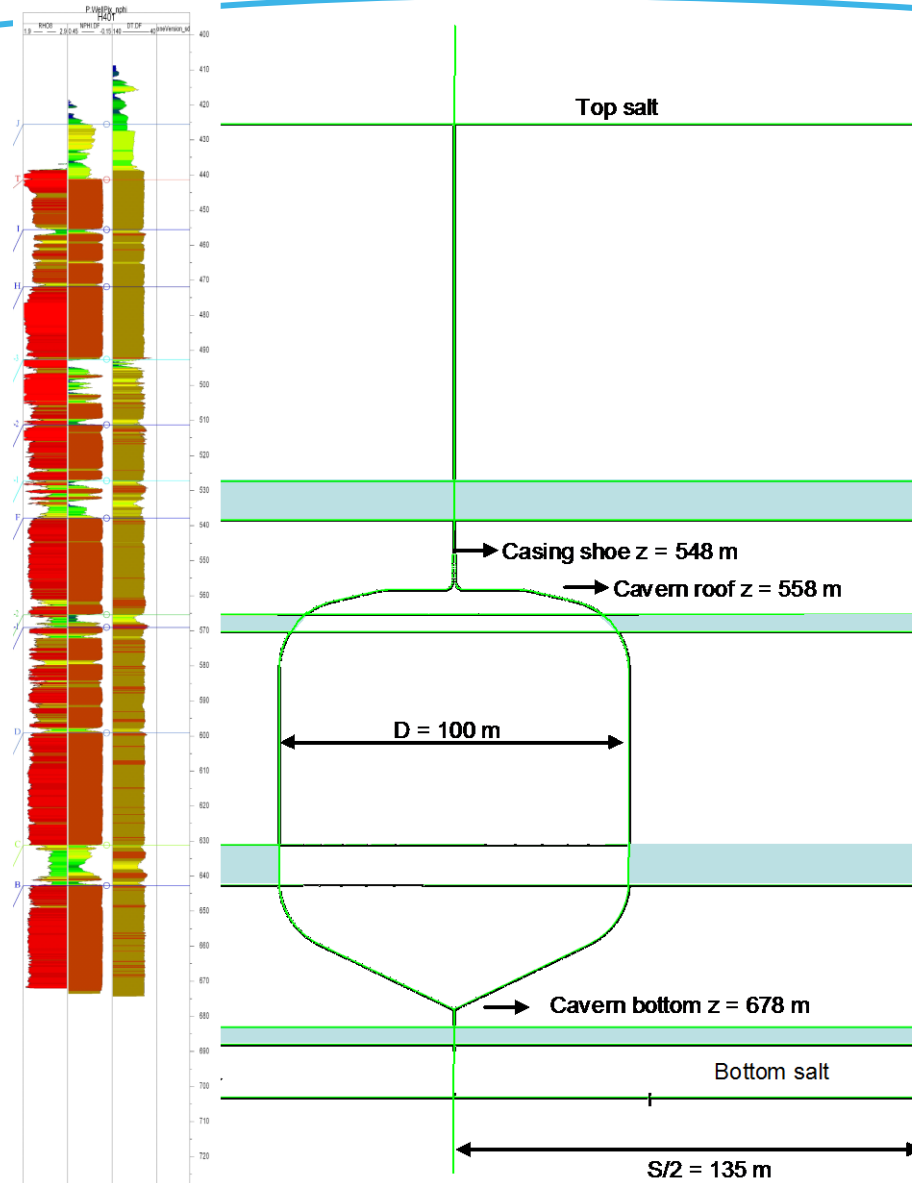
THE HOLFORD GAS STORAGE PROJECT

Cavern field vertical view (N-S)



THE HOLFORD GAS STORAGE PROJECT

Cavern geomechanical model



THE HOLFORD GAS STORAGE PROJECT

2D Seismic survey and drilling rig



THE HOLFORD GAS STORAGE PROJECT

Weak brine pumps and leaching wellhead



THE HOLFORD GAS STORAGE PROJECT

Brine Tanks and Nitrogen Facility



THE HOLFORD GAS STORAGE PROJECT

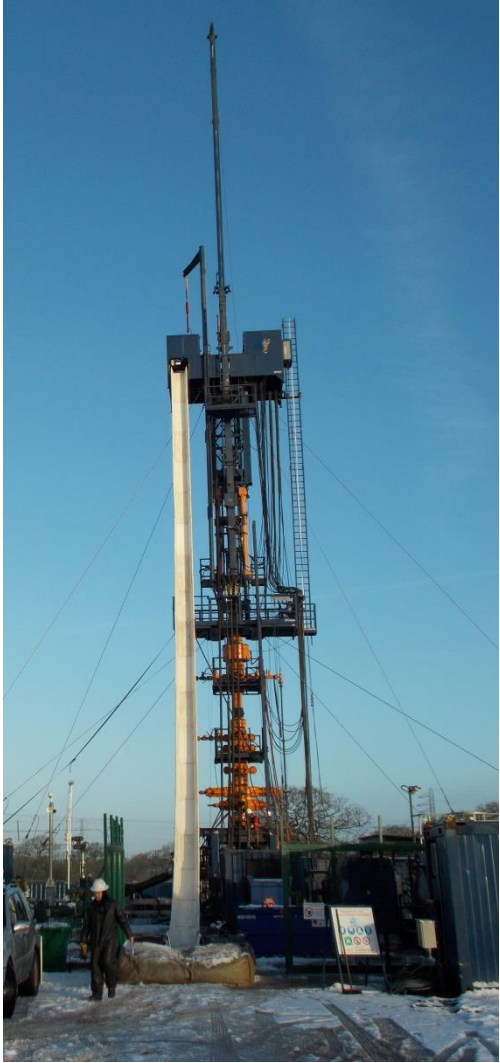
Gas Wellhead and Completion Packer latch



42 R/H Anchor Seal

THE HOLFORD GAS STORAGE PROJECT

Debrining Wellhead and Snubbing



THE HOLFORD GAS STORAGE PROJECT

Gas Plant and Temporary Construction Offices

