



Underground Gas Storage in CSG Supply Chain

Alex Goie | Senior Reservoir Engineer | AGL Upstream Gas
QUPEX Event - Brisbane | 22 May 2012 | AGL External

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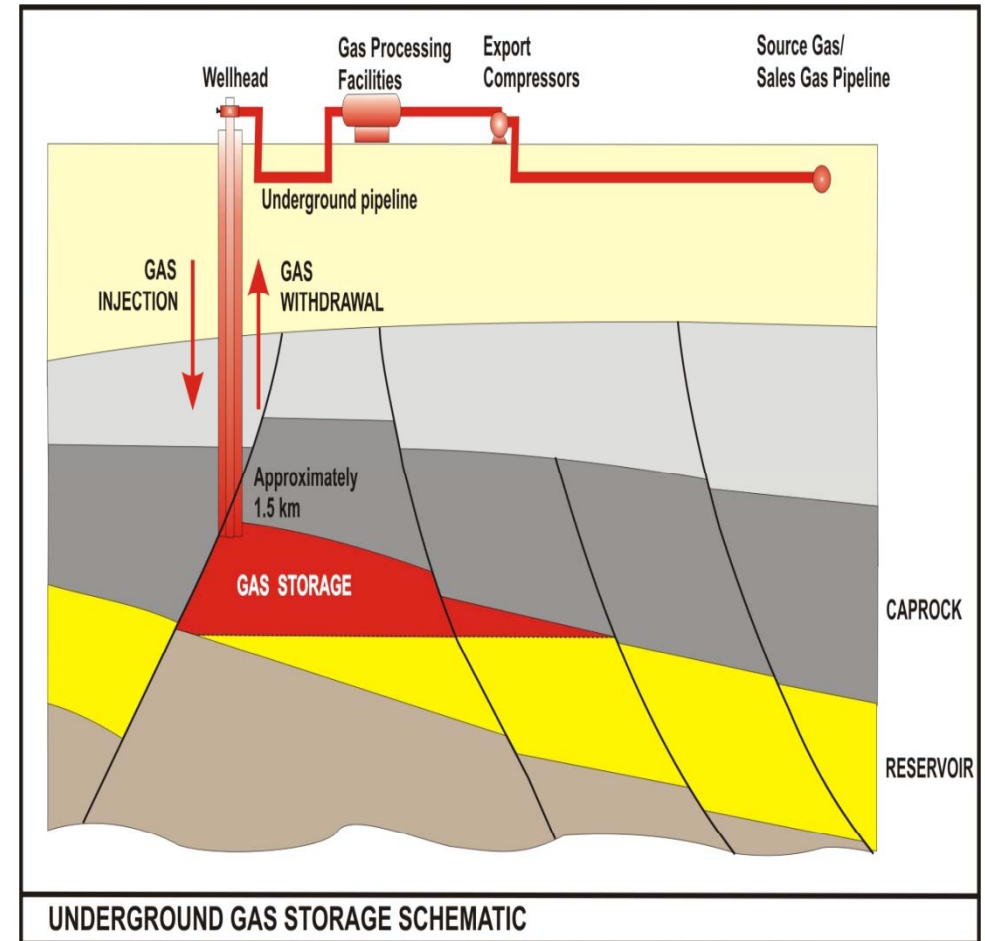
Technical aspects of
underground gas storage
(UGS)



UGS around the world

Various types:

- > 480+ depleted oil/gas fields
- > 88 aquifers
- > 66 salt caverns
- > 3 others.



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Criteria for UGS – depleted oil/gas field

Good reservoir quality is the key to developing UGS:

Reservoir Properties	Values
Porosity	>12%
Permeability	>100mD
Net to gross	>60%
Reservoir thickness	>5m
Residual Water Saturation (S _{wr})	<40%
Residual Gas Saturation (S _{gr})	<30%
Original Gas Water Contact (OGWC)	Well defined OGWC
Initial reservoir pressure	Known
Seal	Competent cap rock
Reservoir drive mechanism	Vary (water drive to depletion)

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Facilities for a typical depleted field

- › Pipelines/flowlines
- › Compressors
- › Gas metering (volume & quality)
- › Odourant dosing units
- › Gas hydration units
- › Condensate handling
- › MEG regenerations unit
- › Produced water handling
- › Injection/withdrawal wells
- › Monitoring wells
- › Produced water disposal
- › Separators.



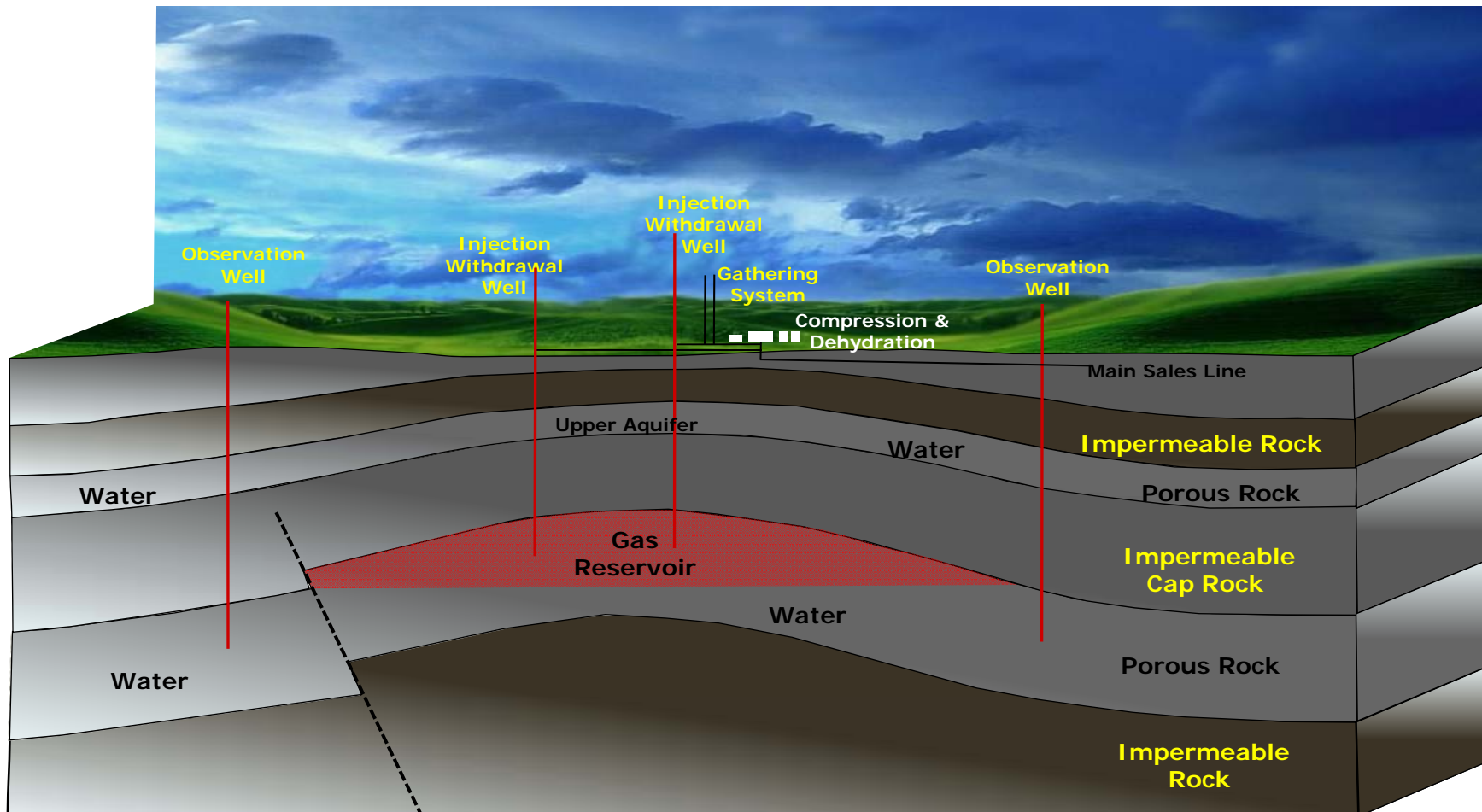
^Compression facility Silver Springs UGS



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UGS setup for depleted oil/gas field

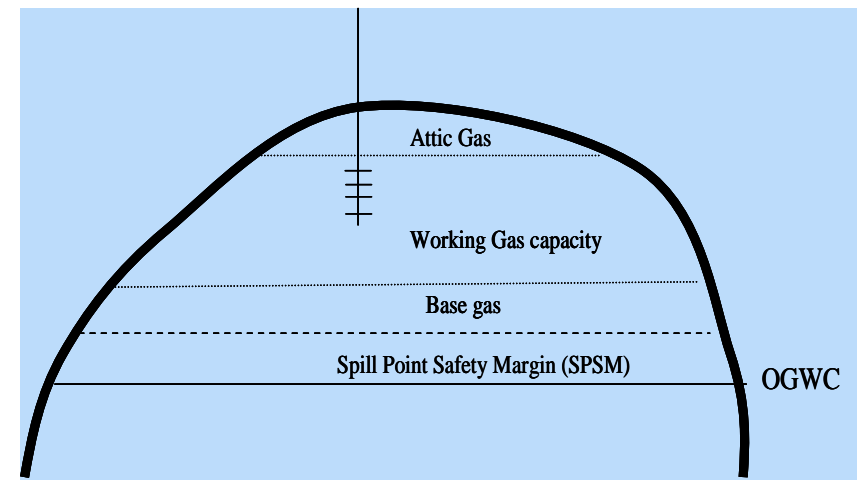


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UGS setup for depleted oil/gas field (cont)

Definition of gas volumes in UGS reservoir.

- > Attic Gas:
 - » Structurally high gas
 - » Inaccessible gas after gas-water contact reaches highest perforations.
- > Working Gas Capacity:
 - » Reservoir volume available to market.
- > Base Gas (Cushion Gas):
 - » Permanent gas inventory reservoir
 - » Maintain adequate reservoir pressure
 - » Support deliverability requirements
 - » Minimise water encroachment .
- > Spill Point Safety Margin (SPSM):
 - » Volume filled by water above OGWC
 - » Prevent gas spills below the OGWC.



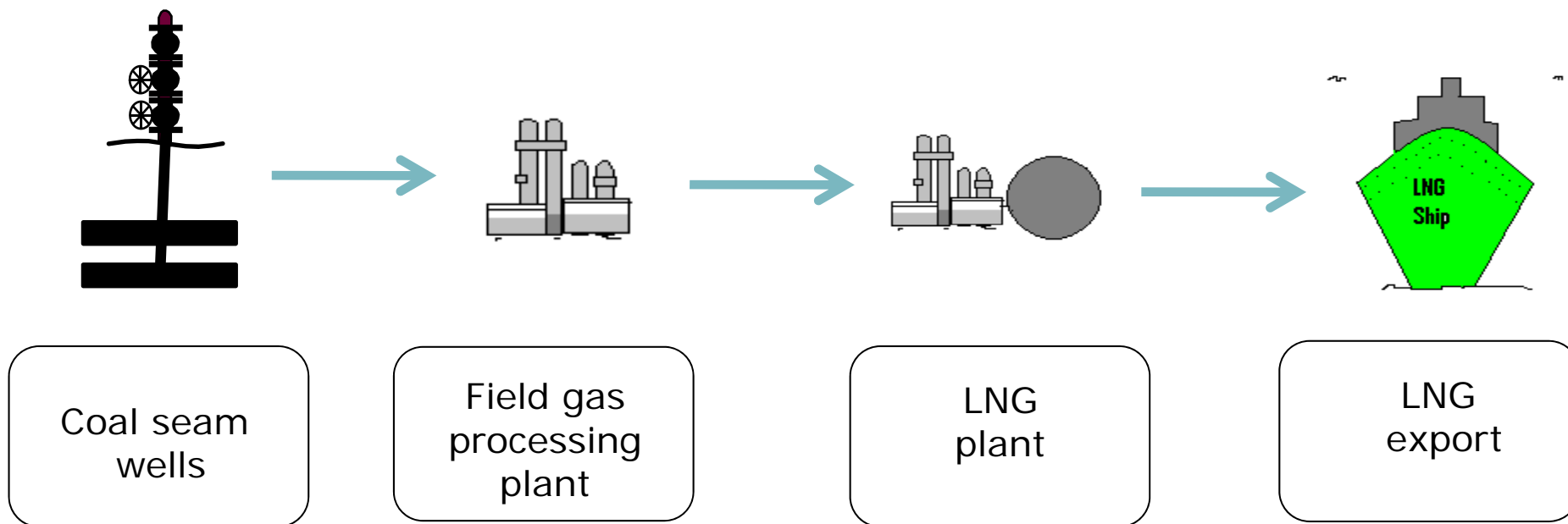
^ Source: Goiye, Alex; 'Gas Storage Presentation – Otway Basin, Victoria, Truenergy, SPE/PESA, April 2009.

Importance of gas storage
in CSG to LNG supply
chain



The CSG to LNG chain

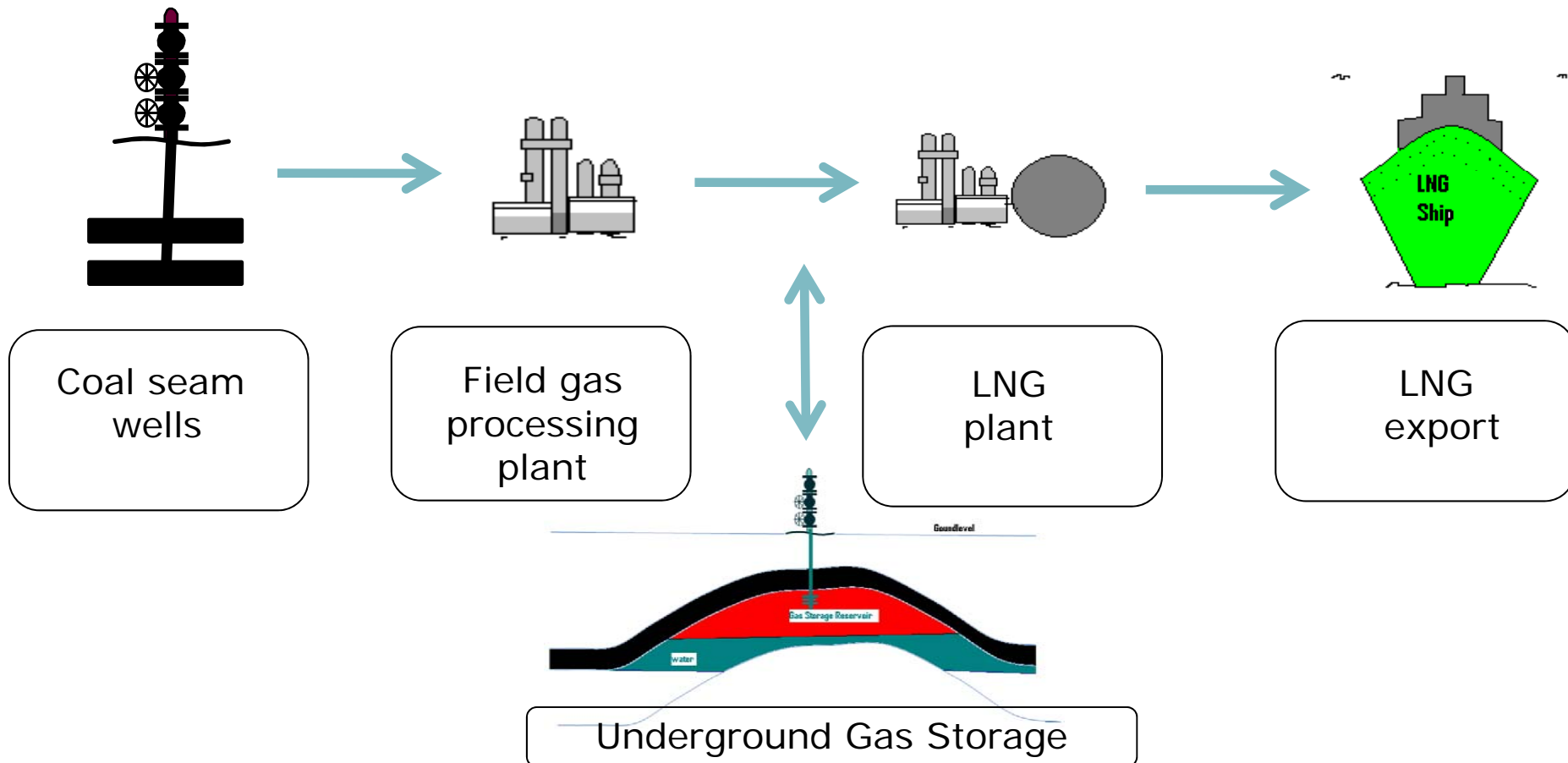
Where is gas storage needed in the CSG to LNG supply chain?



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The CSG to LNG chain

Why is gas storage needed in this CSG to LNG supply chain?



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Gas storage in the CSG to LNG chain

Manages production assurance risks associated with CSG reservoirs:

- › Stores gas during:
 - » Dewatering stages and early start-ups
 - » Maintenance or other emergency shut downs of LNG plant
 - » Maintenance or shut-down of facilities along pipeline route.
- › Supplies gas during:
 - » Ramp-up period for LNG plant before full field production to LNG
 - » Plant shut-downs or emergencies causing field production shortfalls
 - » Unexpected reduction in production from wells during the CSG field's mid-lifecycle.

CSG reservoir production issues

- › CSG reservoir more complex than conventional
- › Detailed reservoir characterisation needed
- › Gas contents and isotherm data used for resources/reserves estimates
- › CSG companies have booked reserves but dynamic data is lacking (*Poro-perm-stress, rock mechanics, fluid/rock, SCAL*)
 - » Full field reservoir simulation models need field specific dynamic data
- › Production pilots modelled and history-matched with unmeasured/unguided variables may give rise to large uncertainty ranges in production forecasts

CSG reservoir production issues (cont)

- › Well interventions may reduce/increase production for extended periods.
- › Well production management strategy.
- › Water production/handling issues.



^Not forgetting Natural disasters in the region.

Therefore gas storage is essential in smoothing out the deliverability requirements of the CSG-LNG supply chain.

CSG to LNG in QLD



CSG-LNG projects in QLD

- > QCLNG (BG Group/CNOOC/Tokyo Gas) – 8.5 Mtpa (FID)
- > GLNG (Santos/Petronas/Total/Kogas) – 8.0 Mtpa (FID)
- > APLNG (Origin/ConocoPhillips/Sinopec) – 9 Mtpa (FID/Planned)
- > Arrow LNG (Shell/PetroChina)
- > 4 other smaller merchant plants.

Will all proposed CSG-LNG projects above have some supply levelling mechanism such as gas storage?



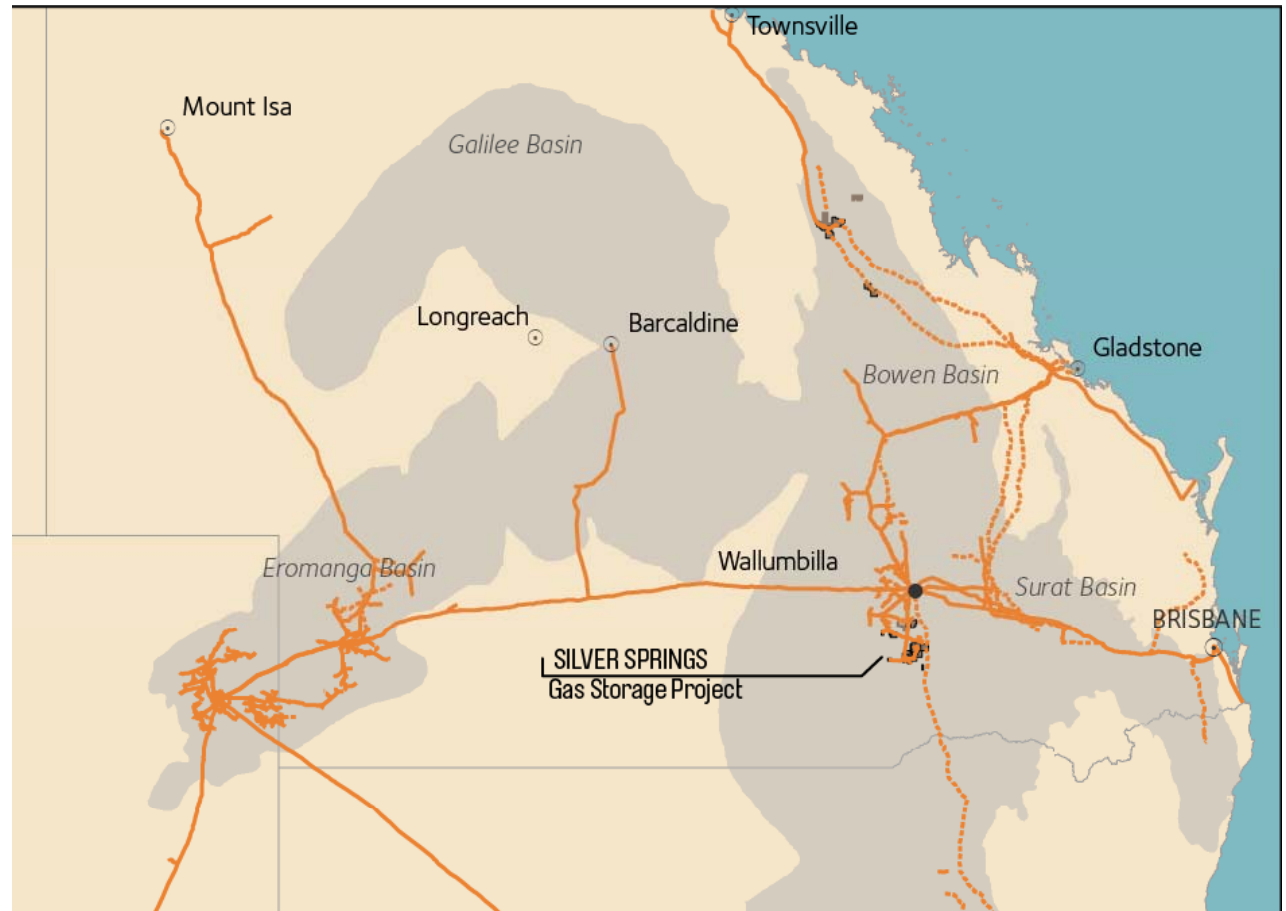
^CSG fields supplying gas to LNG Plants in Gladstone.

Source: *Blueprint for Queensland's LNG Industry*, Queensland Govt.

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QLD UGS facilities in the CSG to LNG chain

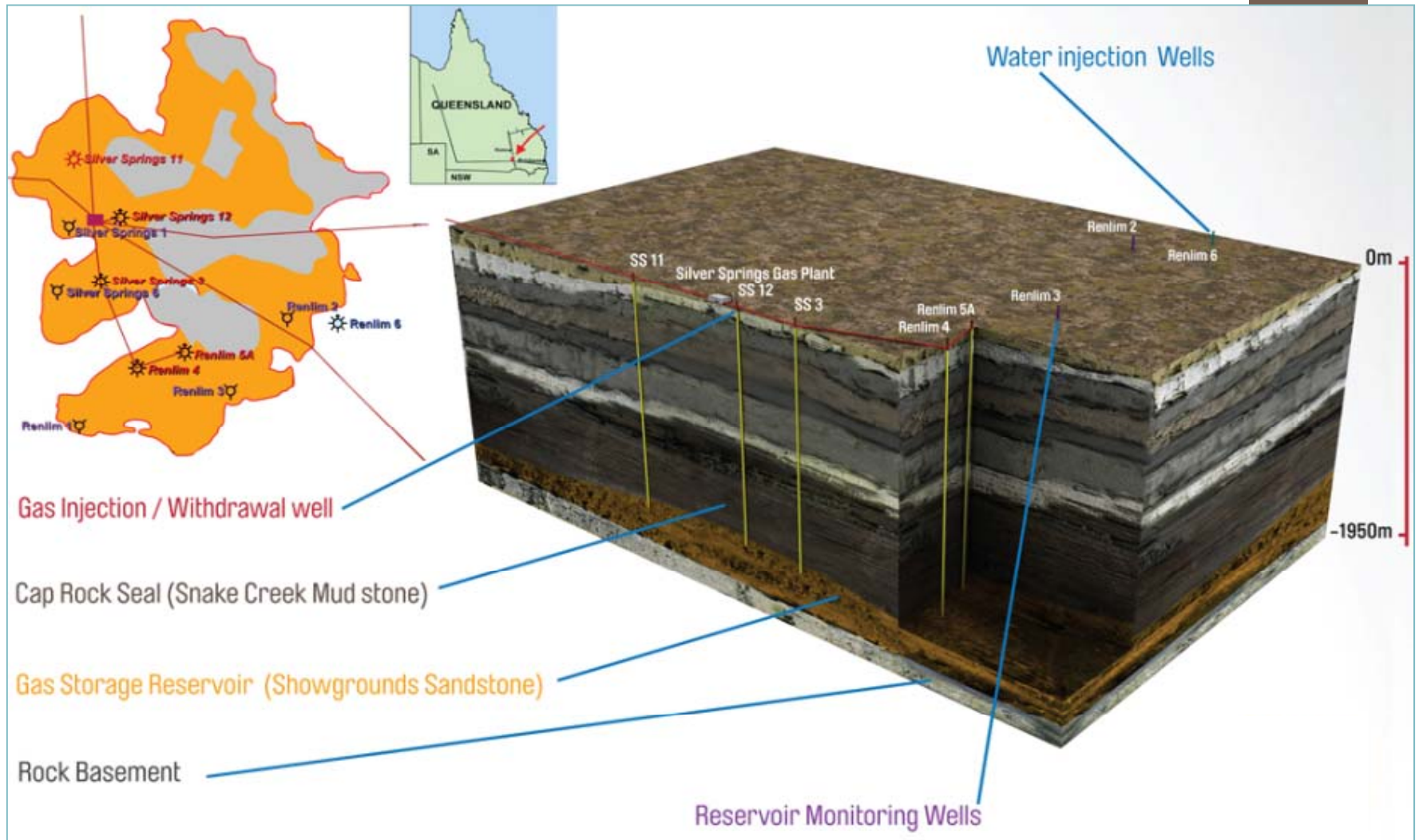
- › Silver Springs/Renlim UGS:
 - » AGL for QCLNG (Curtis Island-Commercial Storage - Third Party Access)
- › Roma UGS:
 - » Santos for GLNG
- › Other UGS:
 - » For private use and no third party access



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Silver Springs/Renlim Gas Storage Reservoir

- > 90 BCF removed from SSR
- > Started production in 1977
- > Depleted 2010
- > Gas storage Sept 2011



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Value of gas storage in
changing market



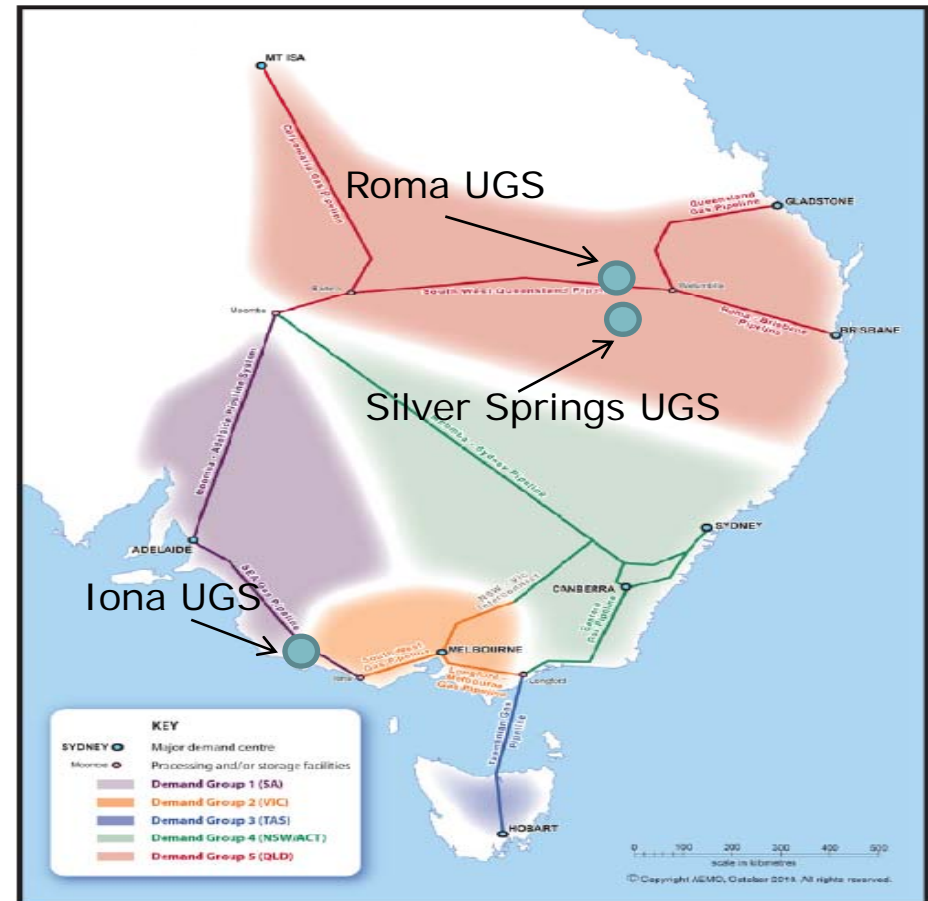
Value of UGS

UGS service providers can capture additional value opportunities apart from CSG to LNG, depending on their UGS physical limitations and contractual agreements:

- › Stores gas during low demand period by injecting into UGS
- › Supplies gas to the market to meet peak demands
- › Mitigates short-term supply risks
- › Allows arbitrage between high and low demand thus levelling production capacity to customers
- › Customers use gas storage to manage MHQ or MDQ
- › Backup energy security
- › When CSG dominates supply of gas to East Australian markets – UGS will play a critical role.

Existing commercial UGS Eastern Australia

- › Iona UGS – in operation since 2001
- › Silver Springs UGS – Construction started in August 2010 and completed in August 2011. Commence operation in September 2011.
- › Roma UGS
- › Other proposed UGS sites – yet to be developed.



Source: AEMO.

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Conclusion

UGS:

- › Is a well established tool to manage peak domestic gas market demands
- › Will be critical to the CSG to LNG chain (e.g. for ramp gas)
- › Mitigates production fluctuations from CSG production
- › Will provide additional long term value as eastern Australian gas market mature
- › UGS will play important role, when CSG dominates Australian energy market.

References

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