•*draft* meeting minutes of the last Community Consultative Committee Meeting, September 26

Water quality investigation report Camden Gas Project

Summary of Parsons Brinckerhoff report (2013)

Presented by Dr Wendy McLean, Principal Hydrogeochemist, EMM

EMM
EMGA Mitchell McLennan

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Dr Wendy McLean

- PhD, Hydrogeochemistry and hydrogeology (2003)
- 12 years experience – water quality, tracers & isotopes
- Member of International Association of Hydrogeologists
- Registered Professional Geoscientist (RPGeo 10,077)
- Australian Research Council Linkage Grant (2009-2012)
- Australian Research Council Fellow (2009)
- AWA Water Research Merit Award (2008)
- Appointed Panel Member, Thirlmere Lakes Inquiry (OEH 2011-2013)
- Coal seam gas experience (2004 – ongoing)
- Coal seam gas experience:
  - Site investigations including drilling, aquifer testing and sampling
  - Water quality studies
  - Isotope studies and age dating
  - Isotopic fingerprinting
  - Geochemical modelling
  - Produced water quality
  - Risk assessment

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Parsons Brinckerhoff's role

- Parsons Brinckerhoff was engaged by AGL to investigate the lower salinity of produced water coming from some gas wells and to provide reasons why this was happening

- Multiple tools used for study - hydrochemistry, age dating and isotopic fingerprinting

- This investigation was completed July 2013

- The investigation was based on an extensive literature review of:
  - local and regional geology
  - groundwater chemistry, and
  - local and international CSG and shale gas operations

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Methodology

1. Review literature
2. Develop hypotheses
3. Field sampling
4. Laboratory analyses
5. Data analysis and reporting

Hypotheses

Dilution	• Coal seam water that physically and chemically changed during its journey from the coal seam to the surface (up the well) due to pressure and temperature change
Groundwater or surface water	• A groundwater connection between the deep coal seams and shallow groundwater and/or surface water
Potable water (frac fluid)	• Leftover fracture stimulation (fracking) water or water from well maintenance

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Testing program

Sampling

- Atypical gas wells
- Typical gas wells
- Hawkesbury Sandstone bores
- Surface water
- Potable water

Laboratory analysis (water quality)

- ALS Environmental, Sydney – major ions, metals, nutrients

Laboratory analysis (isotopes)

- GNS Science, New Zealand – Stable isotopes (oxygen-18 and deuterium)
- ANSTO, Lucas Heights – tritium

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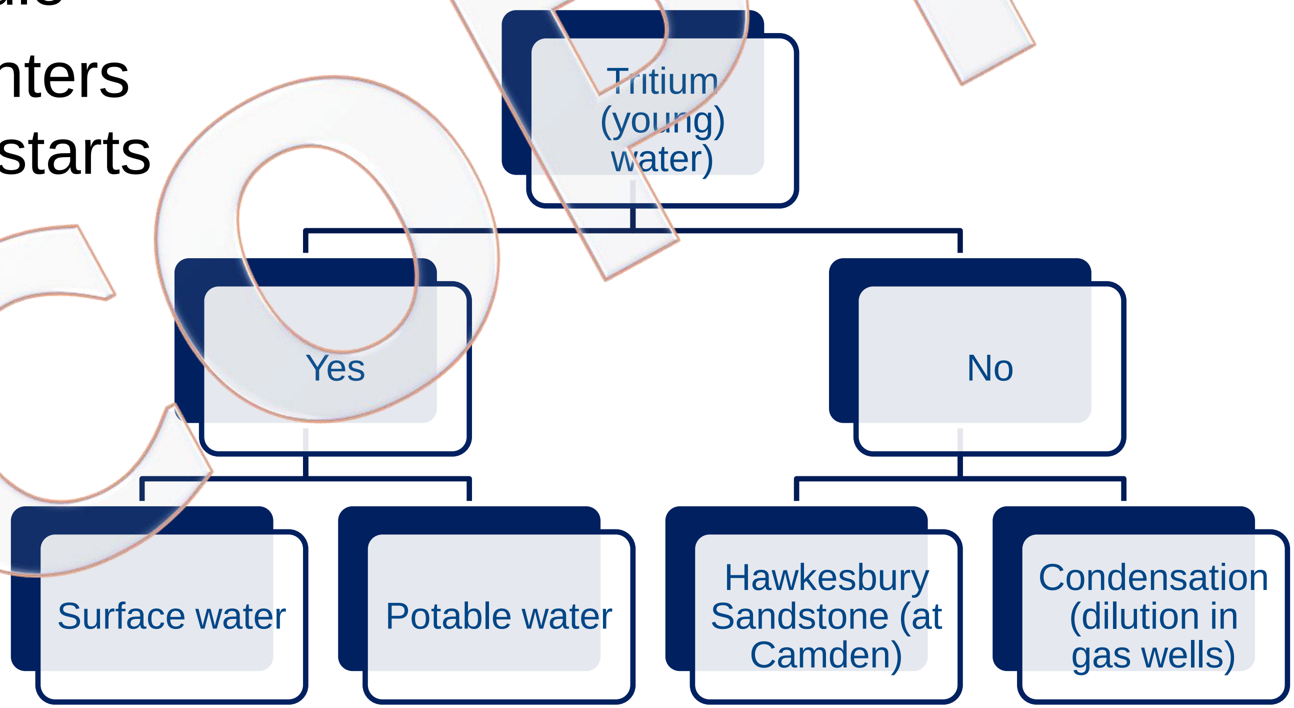
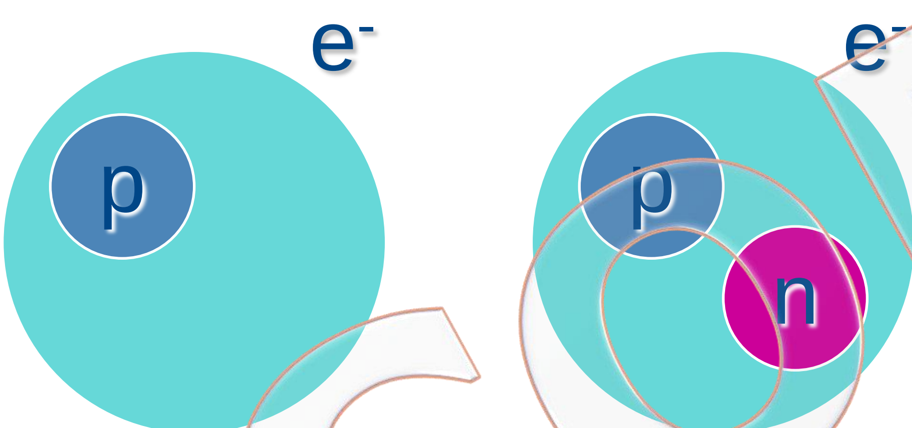
Background on tritium

- Age dating young water (decades)
- Naturally occurring isotope in water molecule
- As soon as it enters aquifers, clock starts ticking...



Background on stable isotopes of water

Atoms of same element with differing masses; # of protons same, # neutrons different



Hydrogen, ^{1}H

Deuterium, ^{2}H, D

Lighter → Heavier

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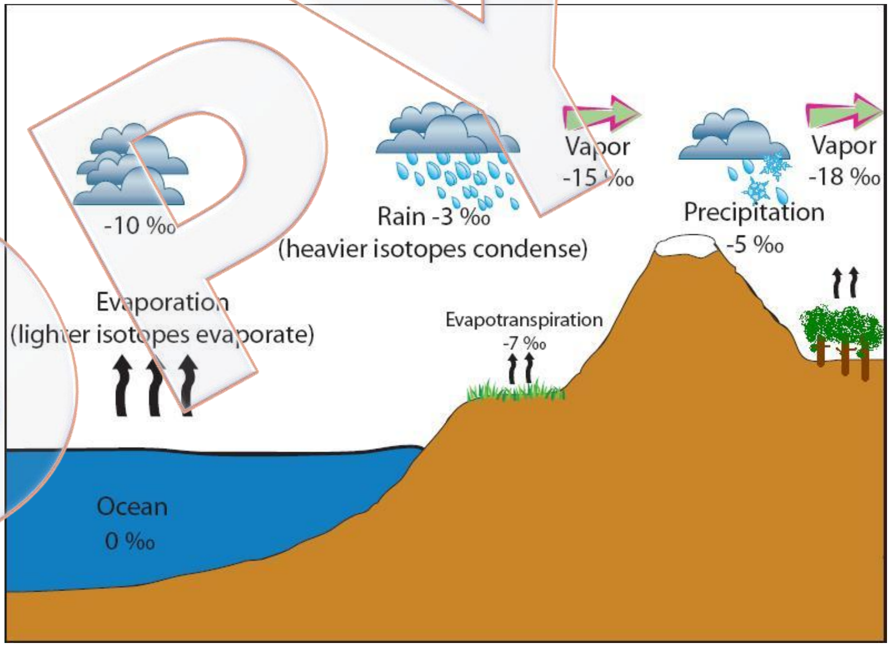
Background on stable isotopes of water

- In water, heavy isotope (^{2}H) compared to light isotope (^{1}H) (^{18}O/^{16}O)
- As water changes phase (i.e. evaporation and rainfall), the ratios change between heavy and light (i.e. ^{18}O/^{16}O)
- Can provide unique fingerprint



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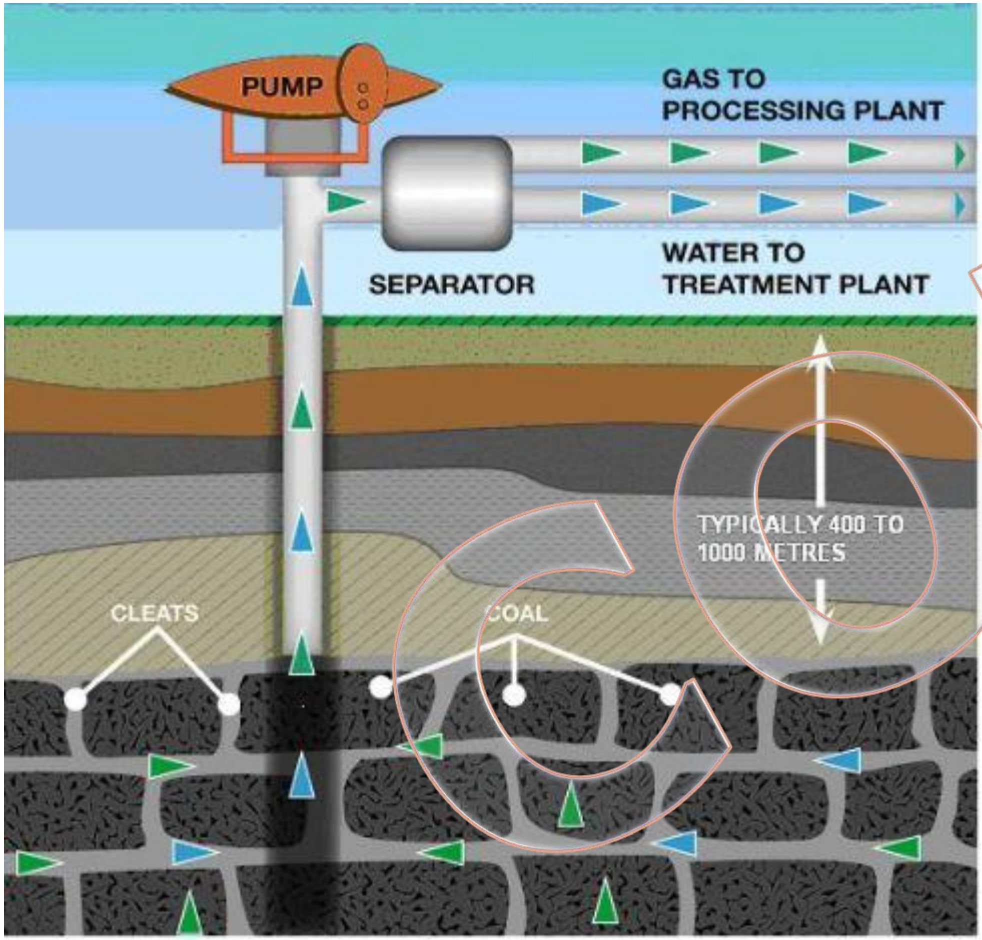
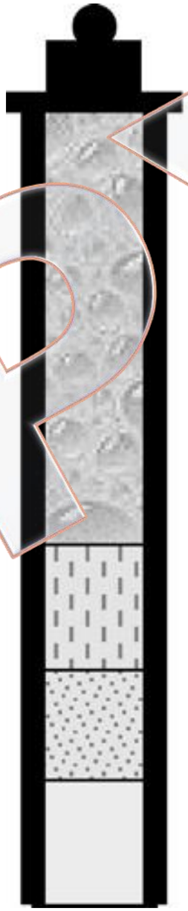
Results

Analyte/ parameter	**Atypical water – the water in question**	Surface water	Shallow groundwater	Potable water (frac fluid)	Dilution by condensate
Salinity	**Fresh (<250 µS/cm)**	Fresh (~150 µS/cm)	Fresh (~650 µS/cm)	Fresh (~230 µS/cm)	Fresh (<250 µS/cm)
Water type	**Na-HCO_3**	Na-Cl-HCO_3	Ca-Na-Mg-HCO_3	Ca-Na-Cl-HCO_3	Na-HCO_3
pH	**Acidic**	Neutral	Neutral	Alkaline	Acidic
Barium and strontium	**Low**	Low	Elevated	Low	Low
Manganese and iron	**High**	Low	Low	Low	High
Fluoride	**Low**	Low	Low	High	Low
Ammonia	**Low to high**	Low	Low	Low	Low to high
Tritium	**No**	Yes	No	Yes	No
Stable isotopes	**Left of GMWL**	On GMWL	On GMWL	On GMWL	Left of GMWL

Explanation of low salinity water





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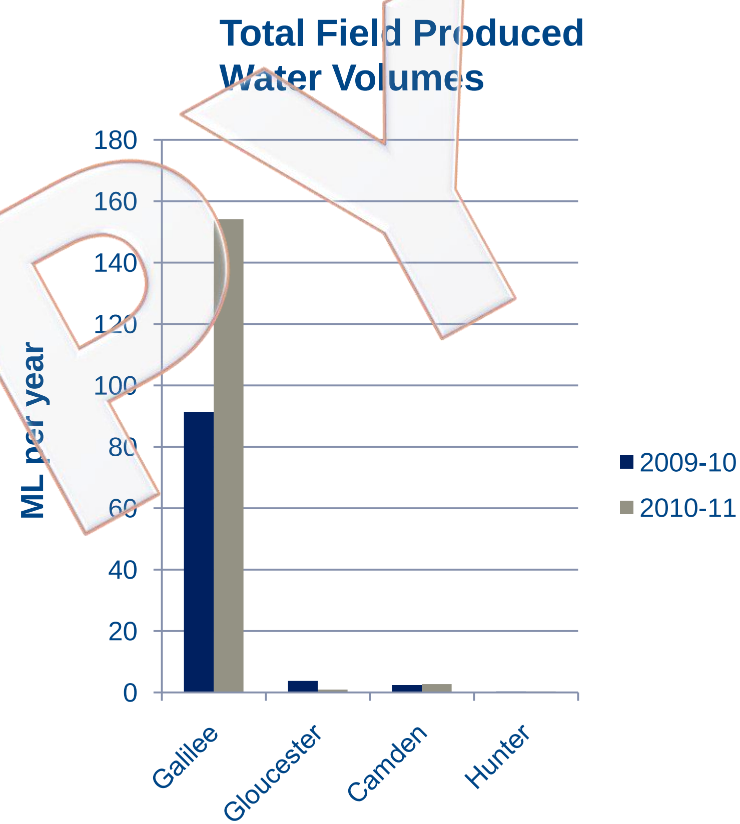
Why is low salinity water unique to Camden?

- High volume wells – physical processes (e.g. evaporation and condensation) do not occur so water chemistry does not change (remains the same as in coal seams)

- Low volumes – physical processes occur and water chemistry changes (forms low salinity water)

- Produced water volumes are a function of:
  - Geology (rock type and permeability)
  - Proximity to shallow aquifers and recharge areas
  - Degree of confinement/isolation

- Produced water volumes are small at Camden (<4.7 ML per year) (<2 Olympic swimming pools)



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Summary

Dilution

- **The chemical composition and isotope data support the conclusion that the water is coal seam water that has been physically and chemically changed during its journey from the coal seam to the surface due to pressure and temperature changes.**

Groundwater or surface water

- The chemical composition and isotope results rule out the possibility of groundwater connection between deep coal seams and shallow groundwater and/or surface water as a source of low salinity water.

Potable water (frac fluid)

- The chemical composition and isotope results rule out the possibility of leftover fracture stimulation (fracking) water or water from well maintenance programs as a source of low salinity water.

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