

# Coal seam gas development and groundwater

Gunnedah Basin NSW

What water information can tell us

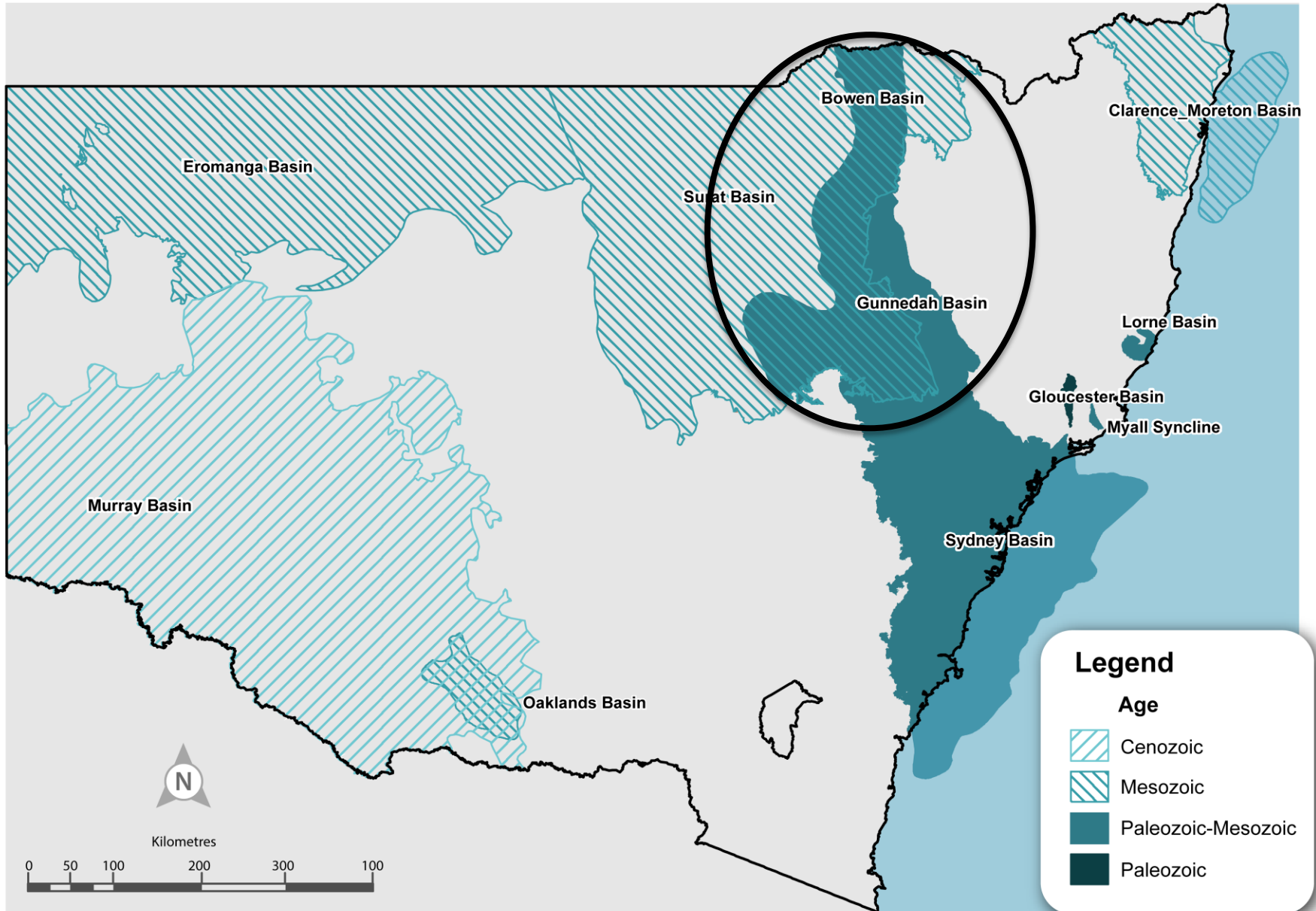


# Presentation overview

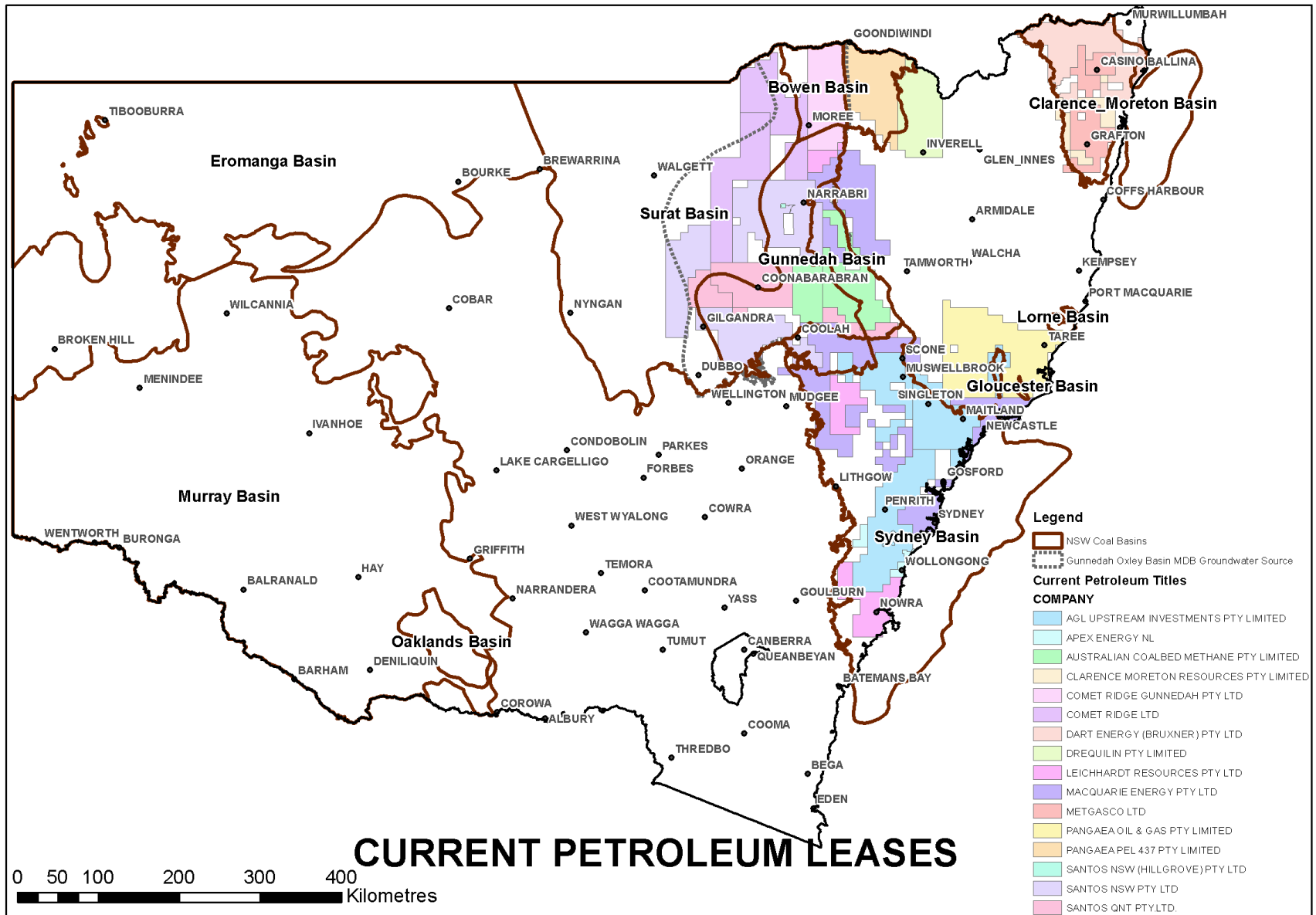
- Coal deposits in NSW and rights
- Water quantity
  - Rights and use
  - Groundwater levels
- Water Quality
  - Baseline data
  - Potential risks to groundwater quality
  - Well integrity
  - Produced water
- Gaps and summary



# Sedimentary basins in NSW that contain coal



# Who has exploration rights for CSG in NSW?





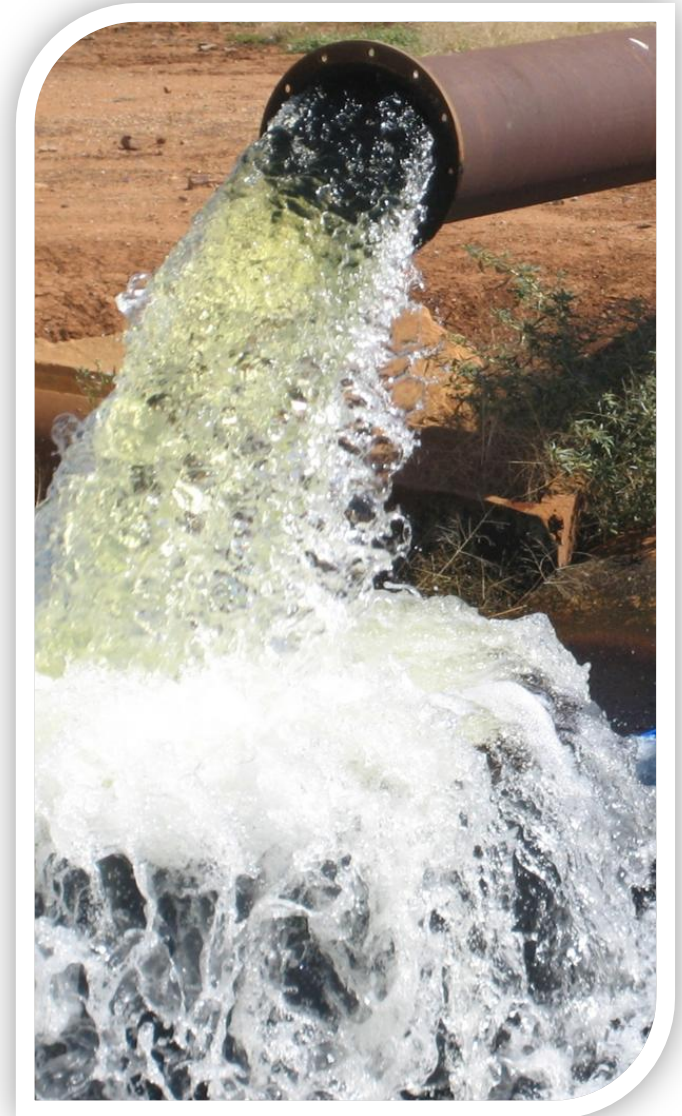
# Groundwater concerns

## Quantity:

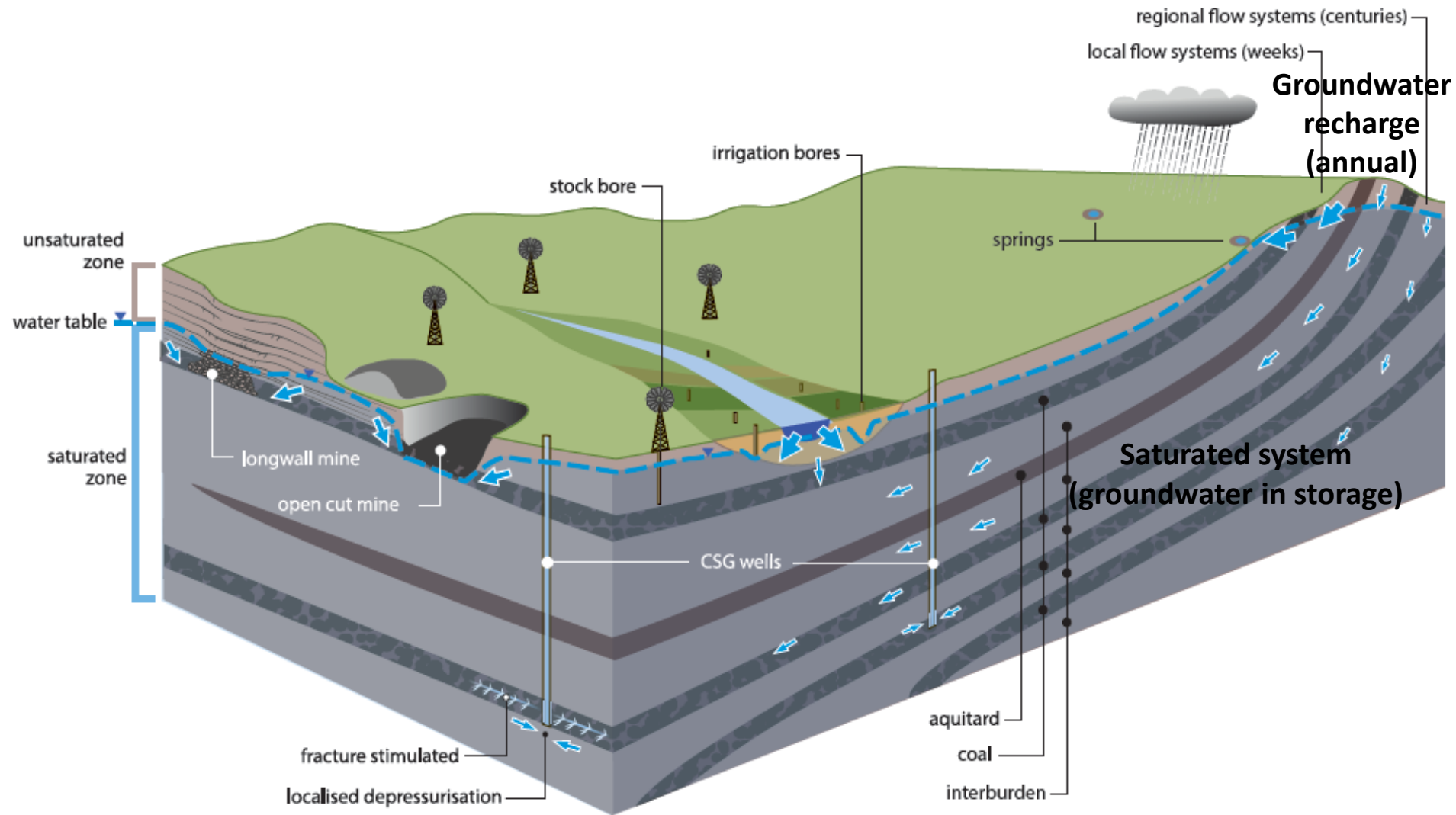
- Reduced groundwater levels/pressures (potential reduced access or increased pumping costs)

## Quality:

- Potential risks to groundwater quality

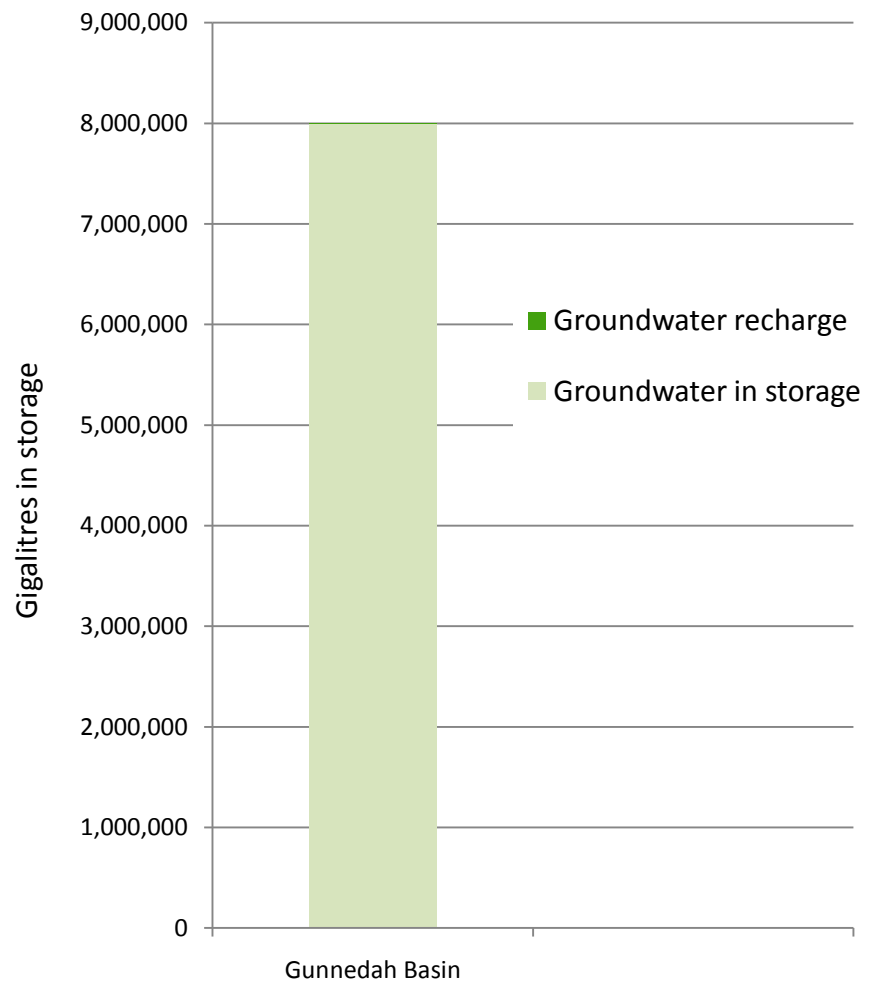
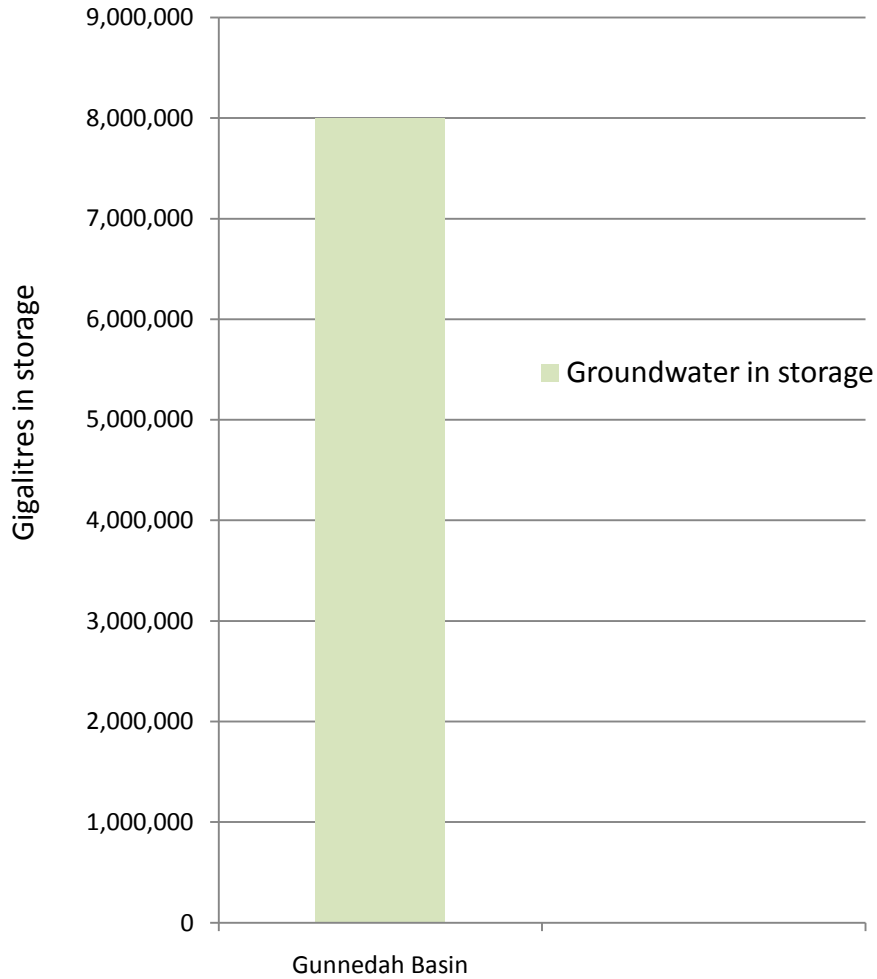


# Groundwater flow systems within a catchment



# Groundwater volumes

(difference between storage and recharge)



**Recharge to storage to ratio for Gunnedah Basin is approximately 1:24,000**



# Groundwater quantity

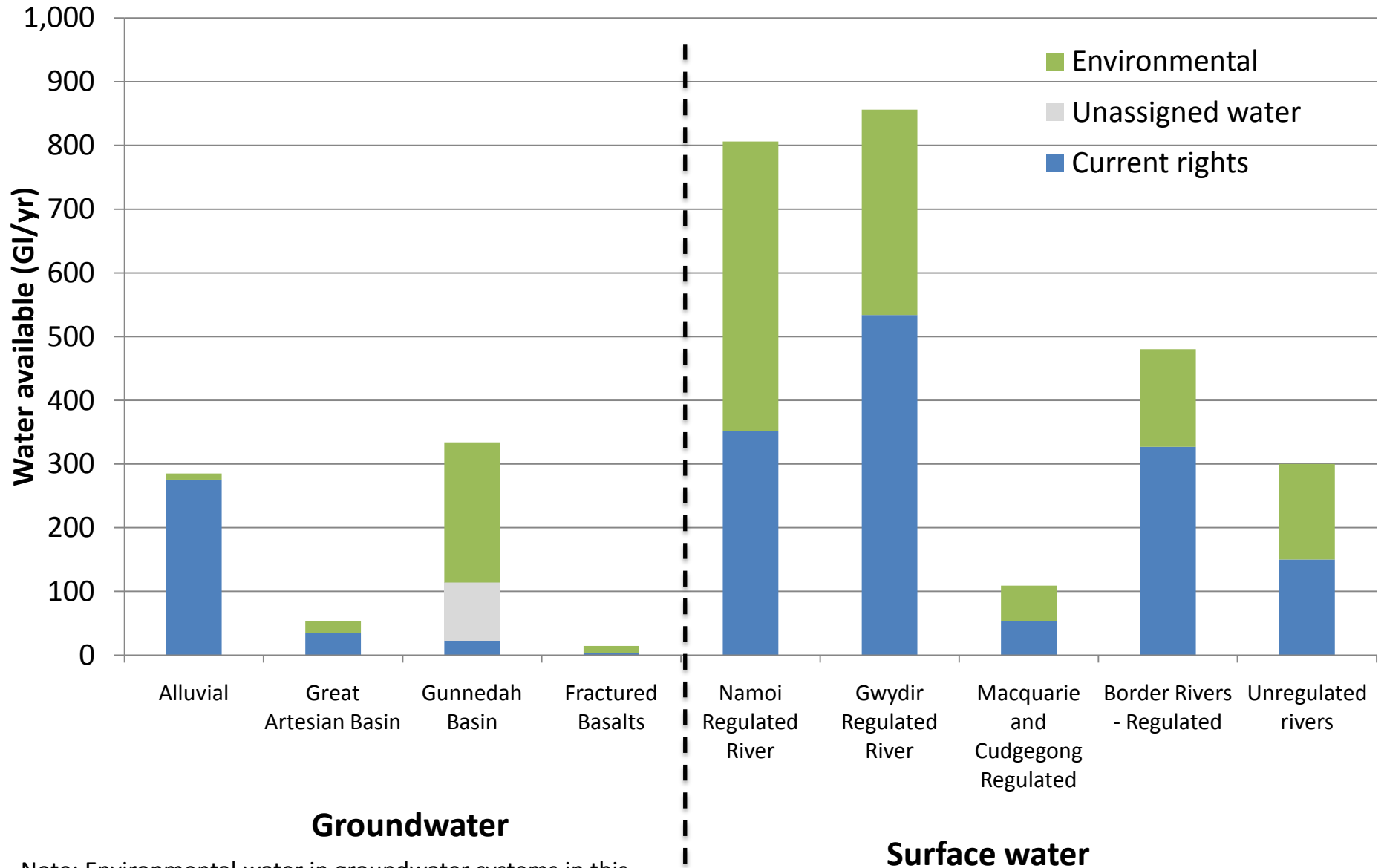
**Concern: Reduced groundwater levels/pressures**

## **Information**

- Groundwater systems and rights
- Groundwater levels



# Available water in and overlying the Gunnedah Basin

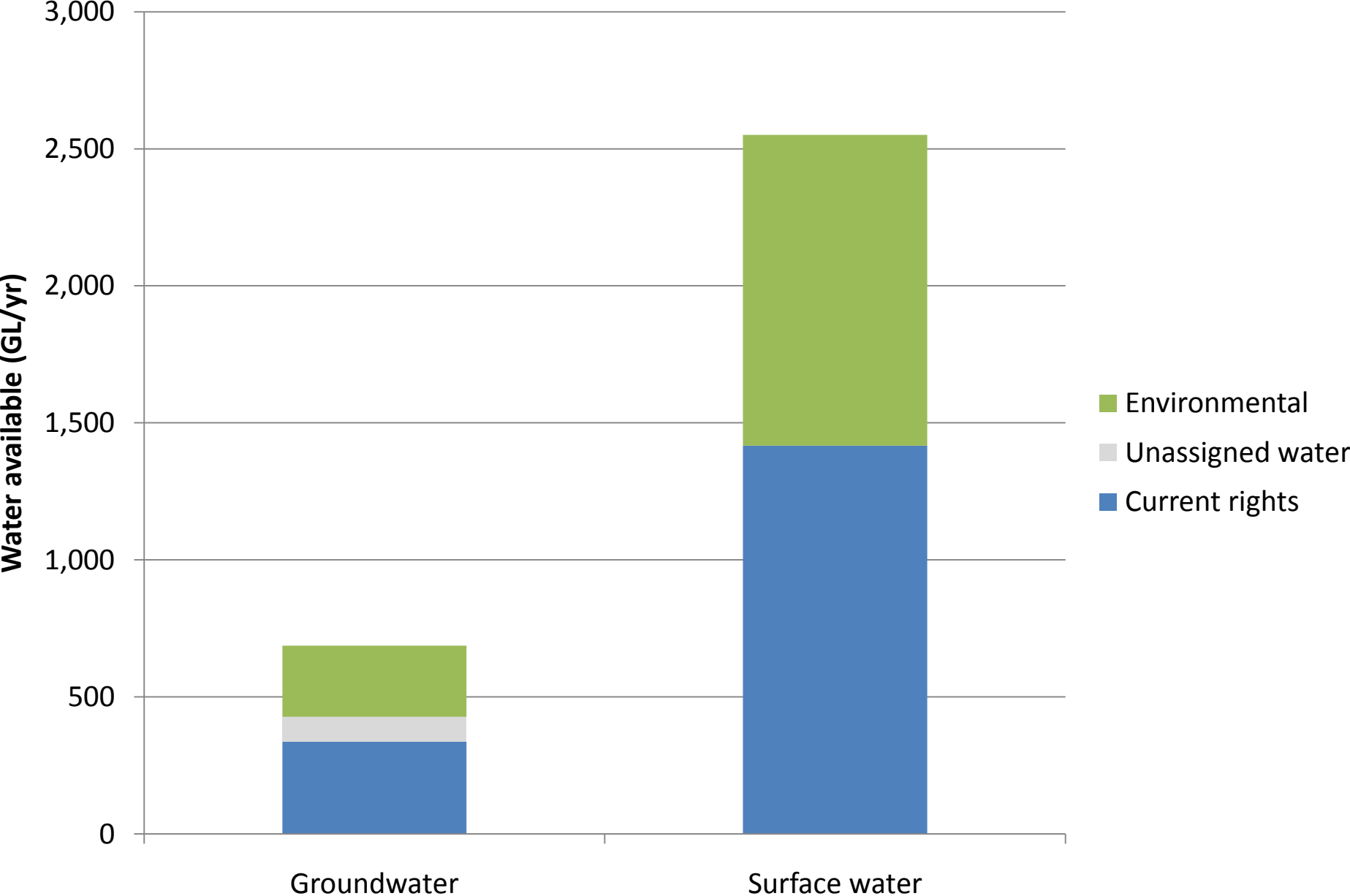


## Groundwater

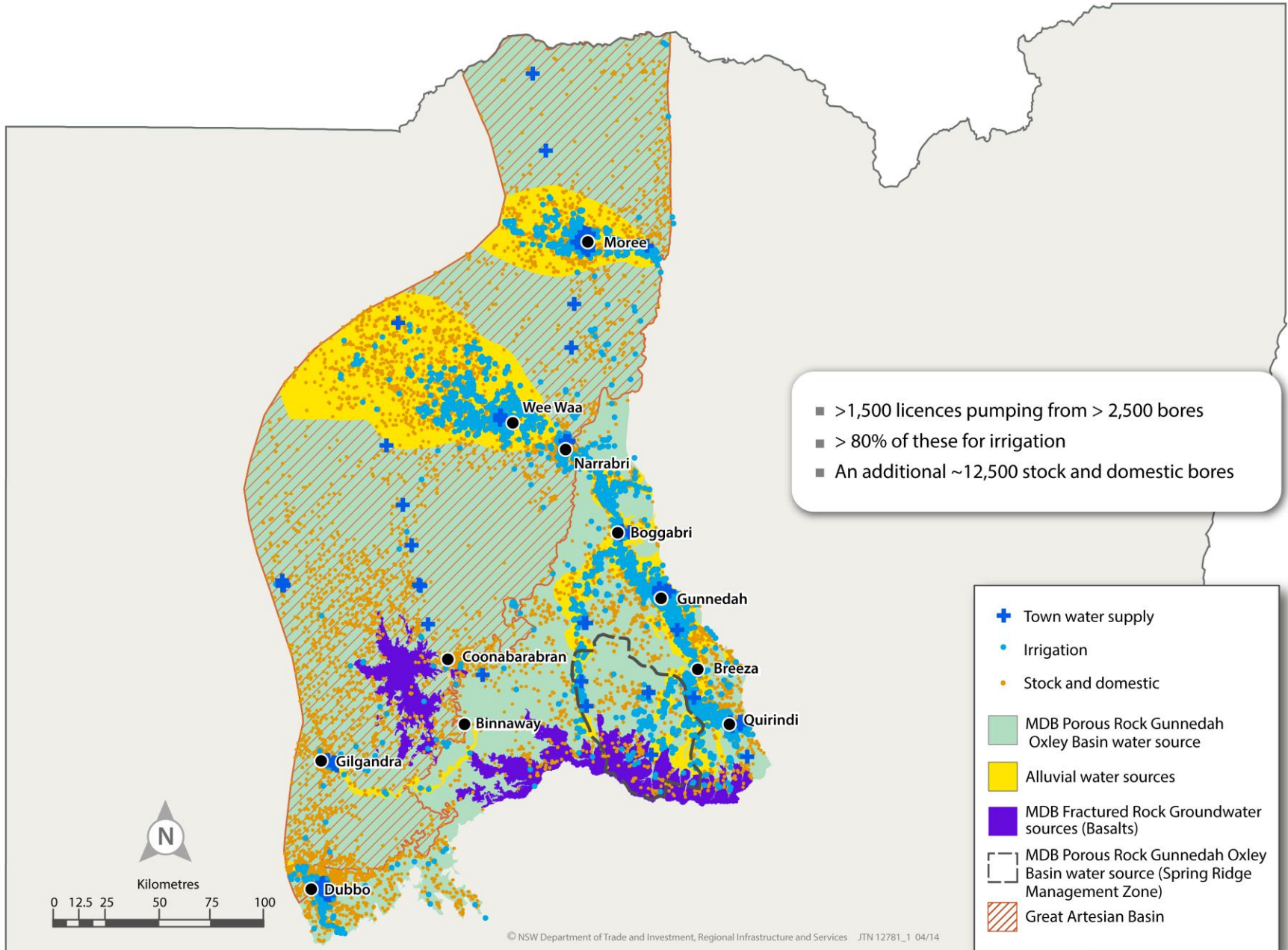
## Surface water

Note: Environmental water in groundwater systems in this chart does not include storage, which in the Gunnedah Basin is approximately 8,000,000 GL

# Available water in and overlying the Gunnedah Basin



# Distribution of groundwater extraction

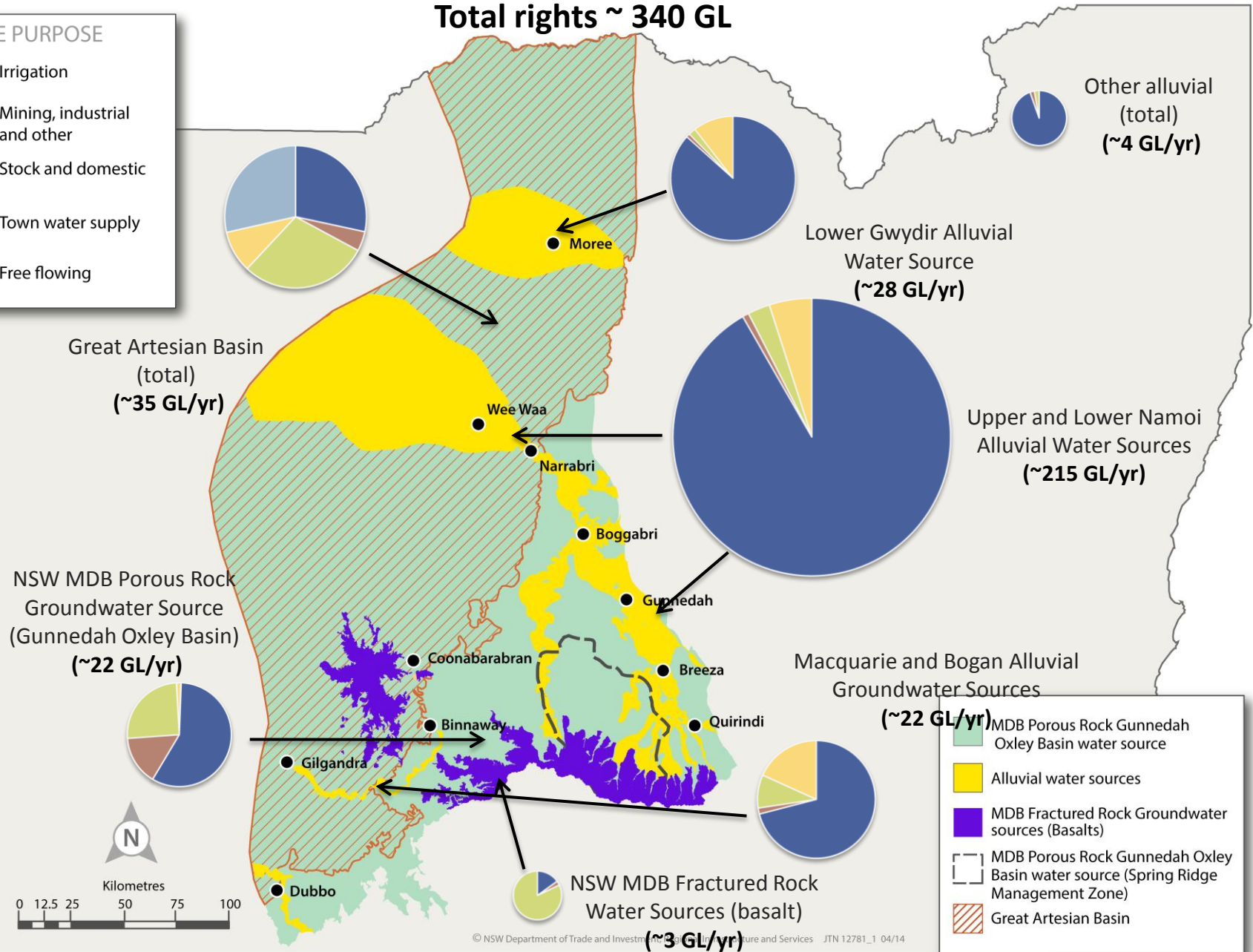


# Gunnedah Basin: Distribution and purpose of groundwater rights

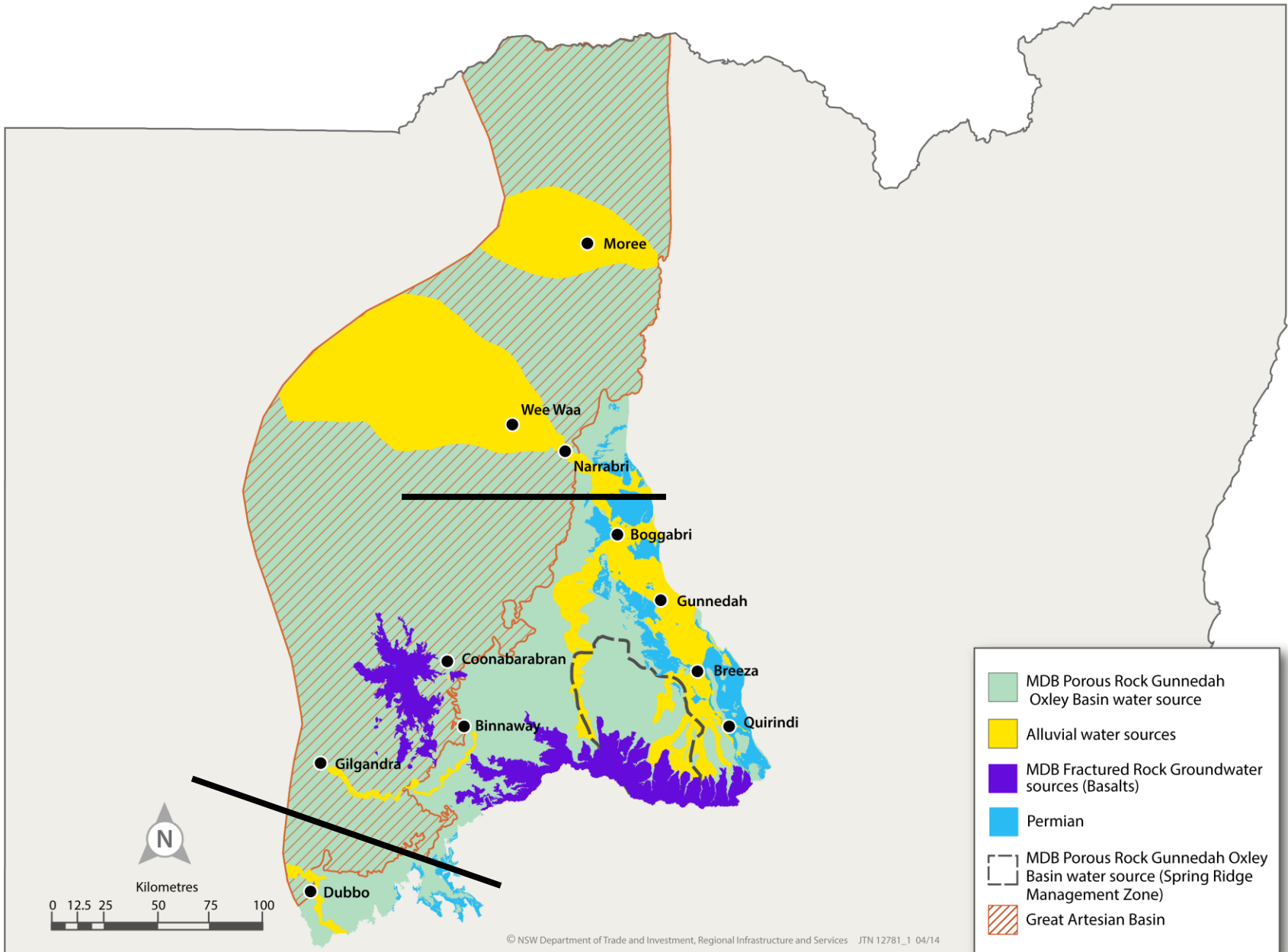
Total rights ~ 340 GL

## BORE PURPOSE

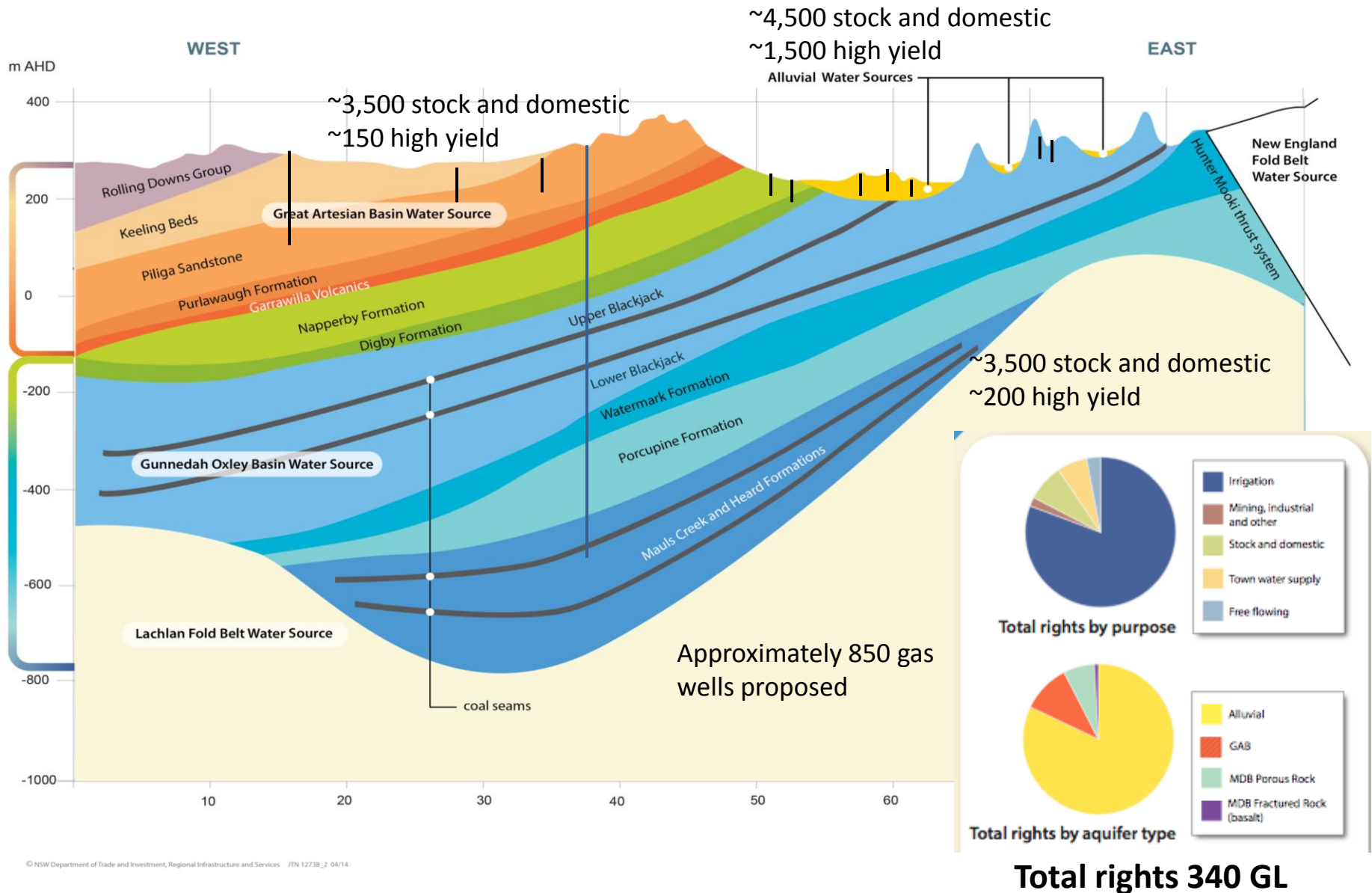
- Irrigation
- Mining, industrial and other
- Stock and domestic
- Town water supply
- Free flowing



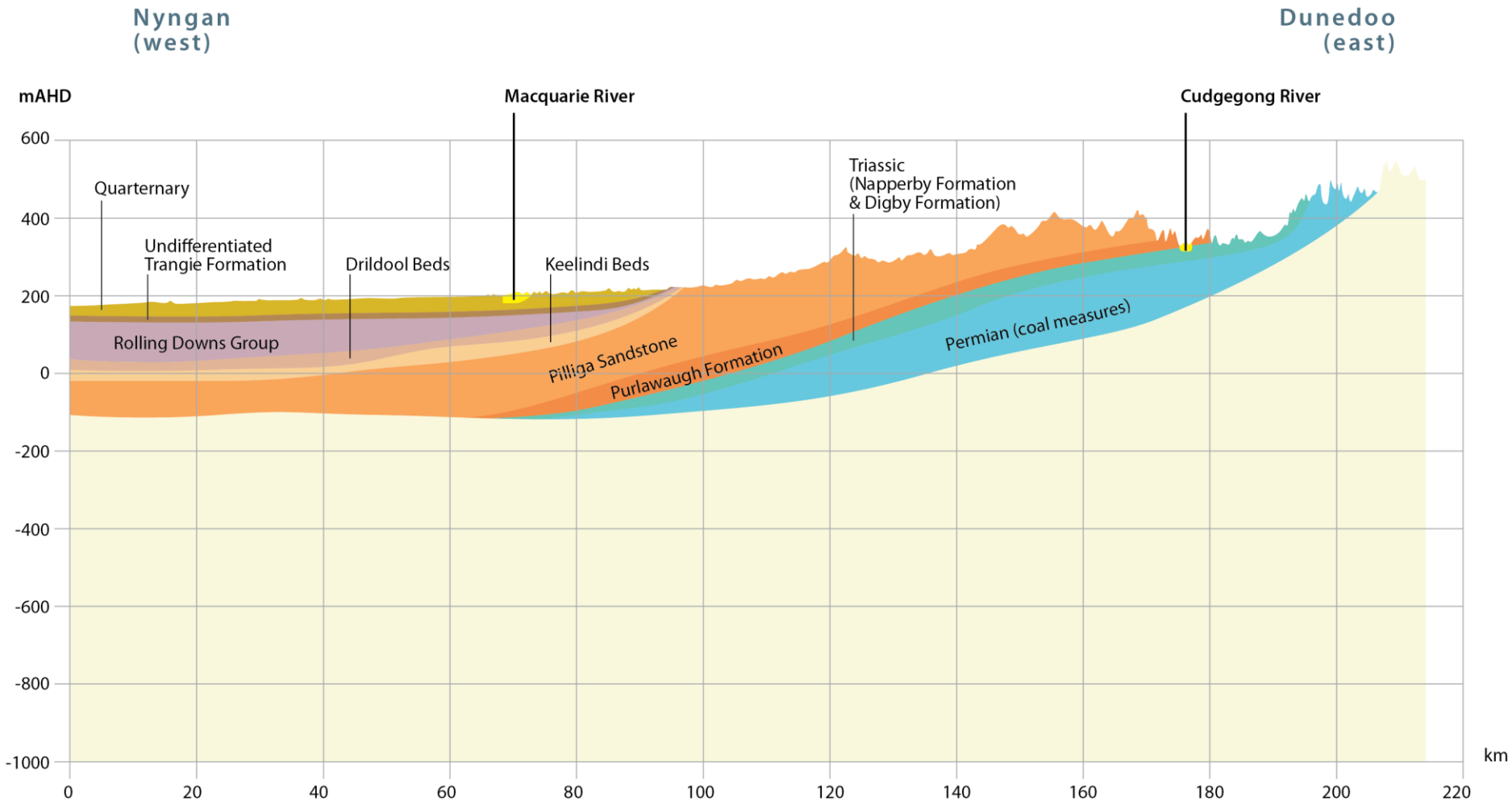
# Gunnedah Basin: Areas of Permian outcrop



# Gunnedah Basin: vertical distribution of groundwater rights

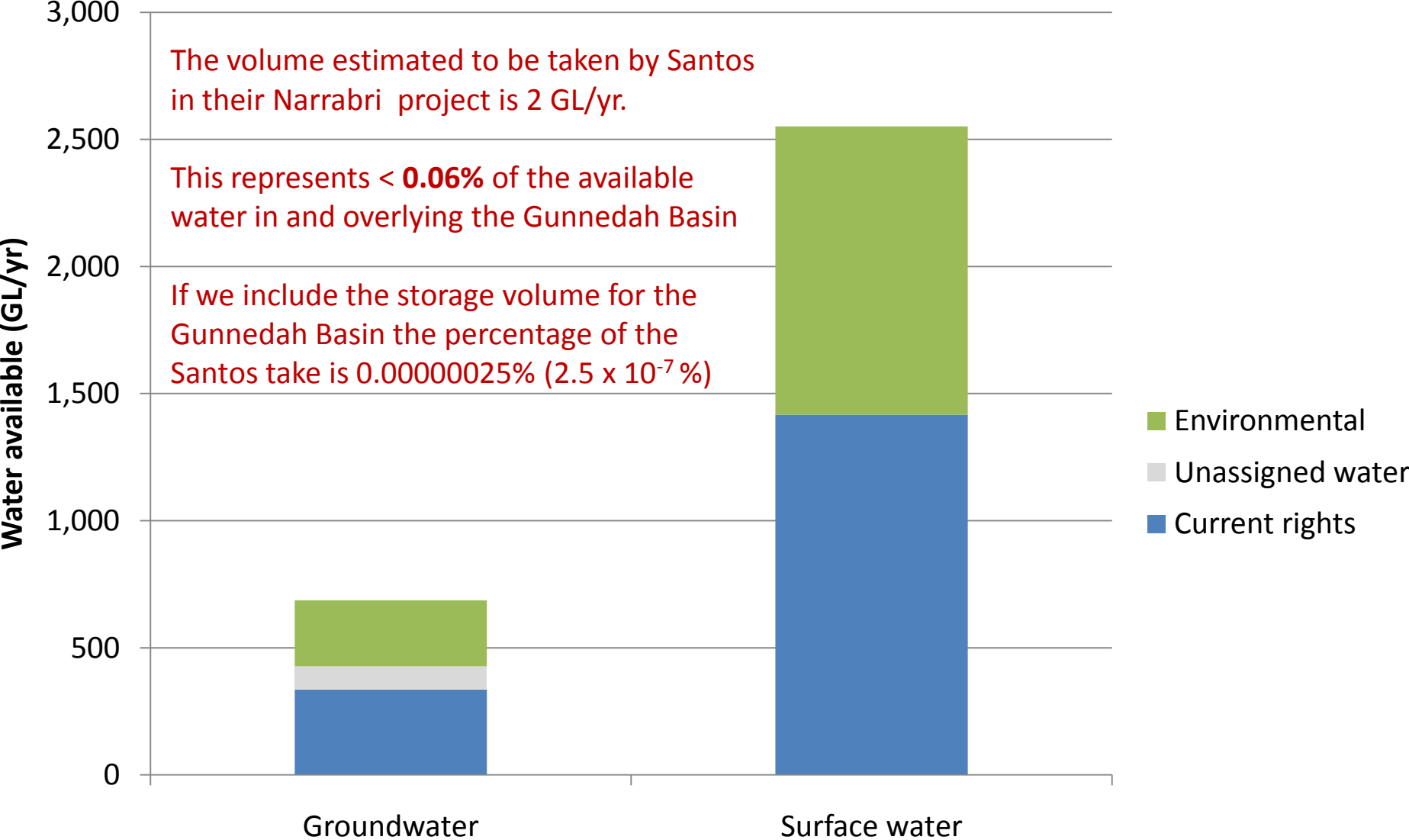


# Gunnedah Basin: Cross section (south western basin)





# Available water in and overlying the Gunnedah Basin



The volume estimated to be taken by Santos in their Narrabri project is 2 GL/yr.

This represents < **0.06%** of the available water in and overlying the Gunnedah Basin

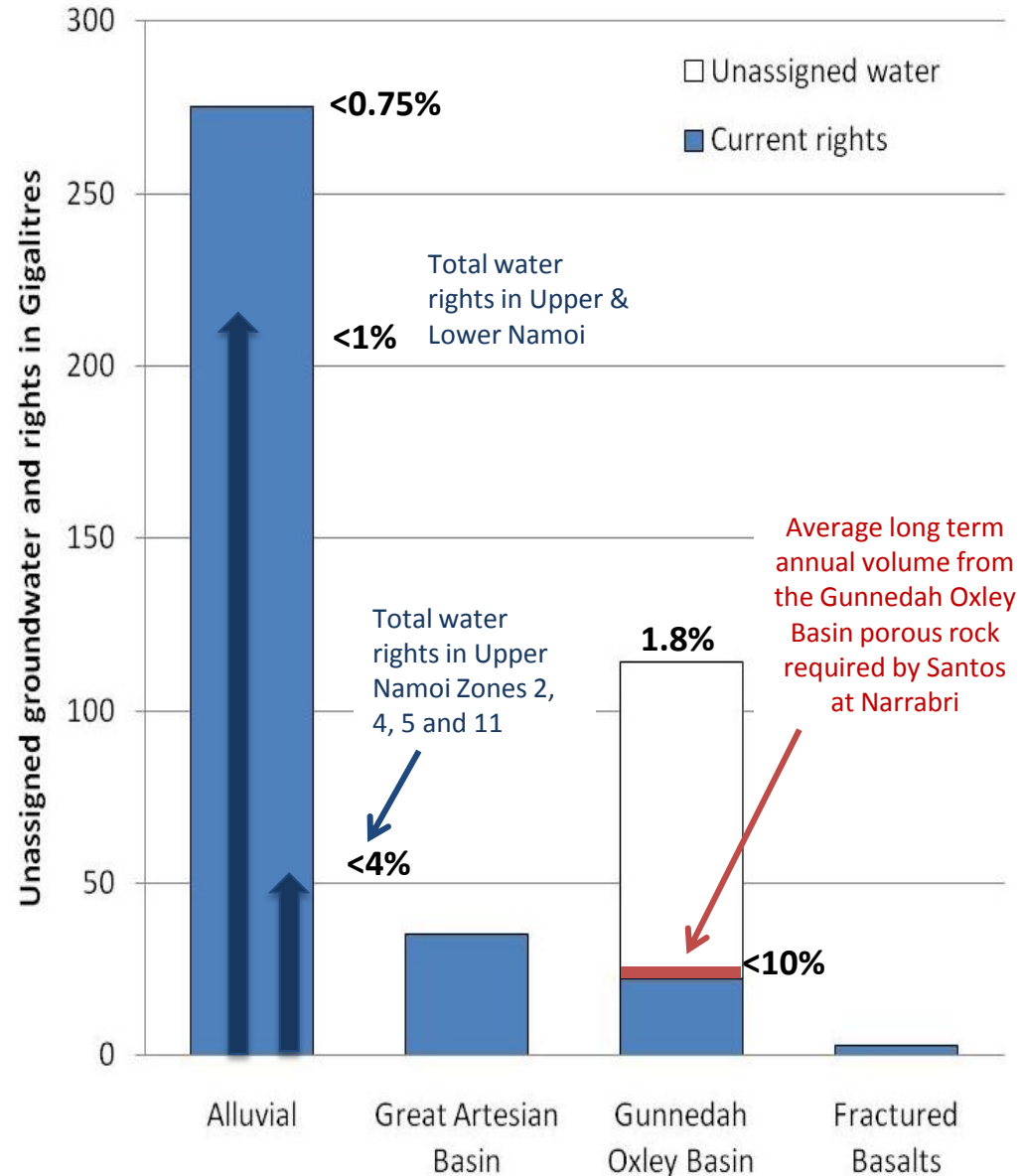
If we include the storage volume for the Gunnedah Basin the percentage of the Santos take is 0.00000025% ( $2.5 \times 10^{-7}$  %)

Plus 8 Million GL in storage in the Gunnedah Basin alone

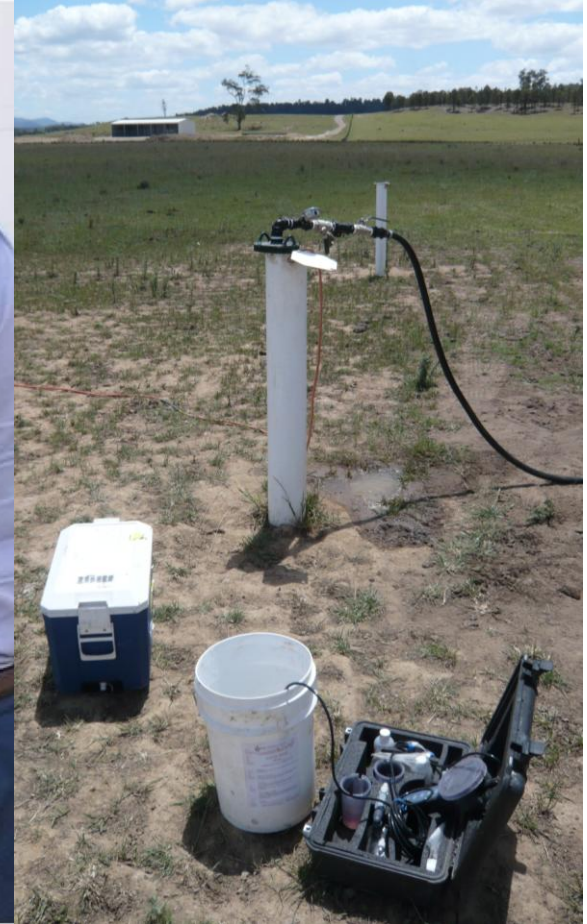
# Gunnedah Basin Groundwater

## Regional volumetric risk quantified

- CSG Narrabri Project average take estimated at 2 GL/yr. This represents:
  - 1.8% of the porous rock extraction limit
  - <10% of porous rock rights
  - <0.75% of all alluvial rights
  - <1% of Namoi alluvial rights
  - <4% of alluvial rights in nearby alluvial water sources (Upper Namoi Zones 2, 4, 5 and 11)
- Licences have to be obtained



# Groundwater levels



# Water level monitoring

## Purpose:

- Establish baseline groundwater conditions
- Establish long term trends
- Determine natural seasonal fluctuation
- Develop conceptual model
- Model calibration
- Monitor impacts (ie water level decline)

## Who:

- CSG companies
- Mining companies
- NSW Office of Water

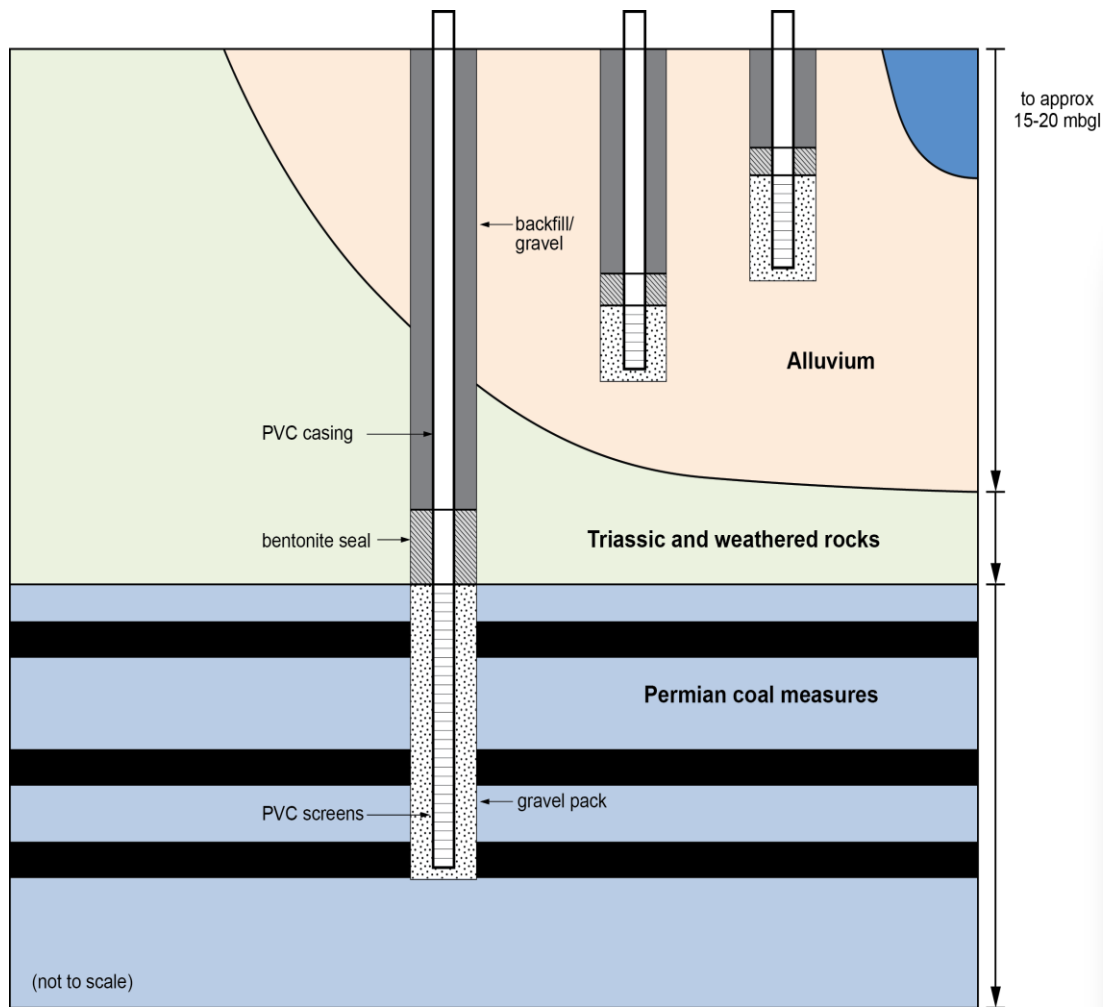


# Groundwater monitoring networks

- Government undertakes regional monitoring of key water resources (ie mostly alluvium and GAB)
- Companies undertake high density local monitoring for localised baseline information and prediction of impacts

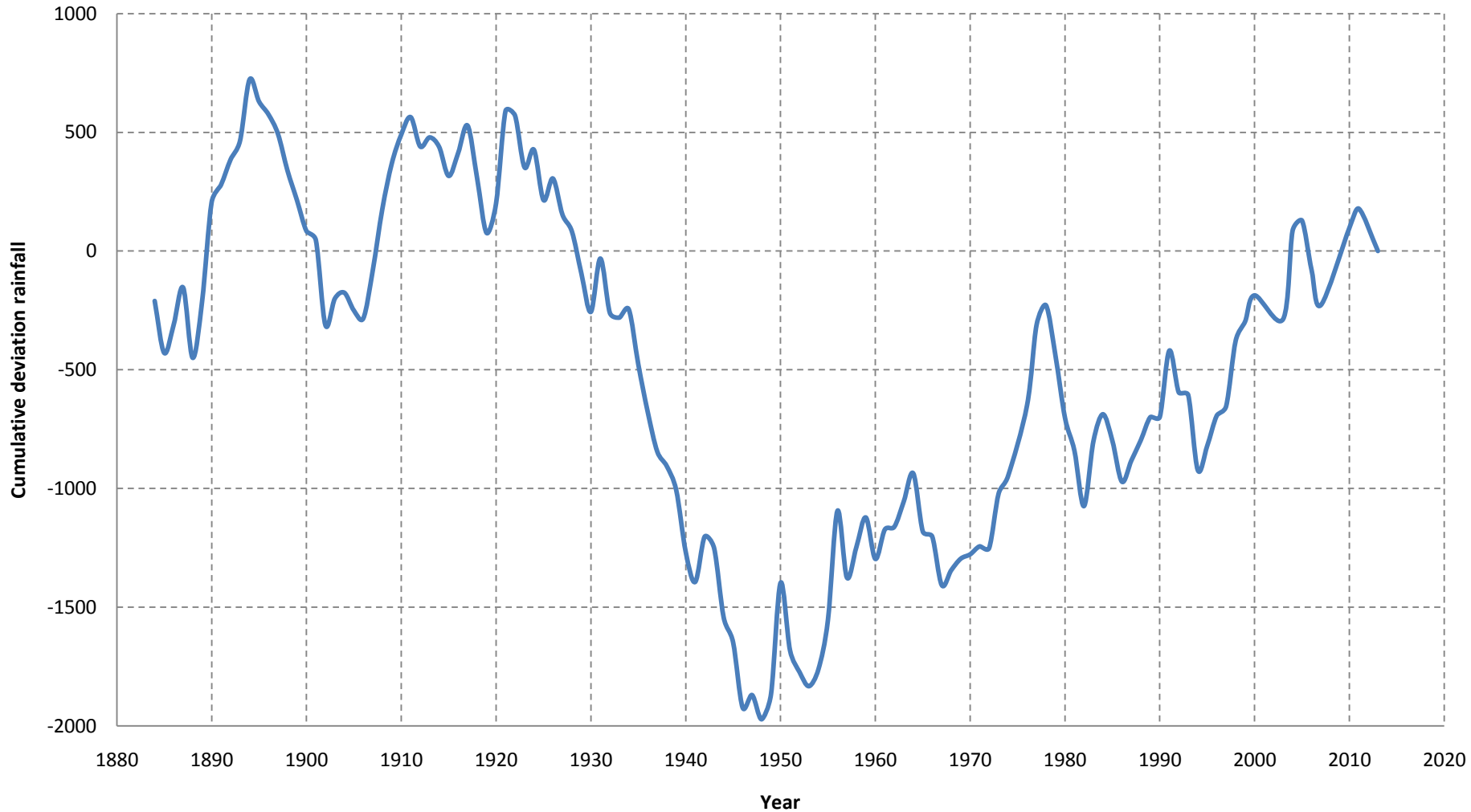


# Typical construction of a nested monitoring site

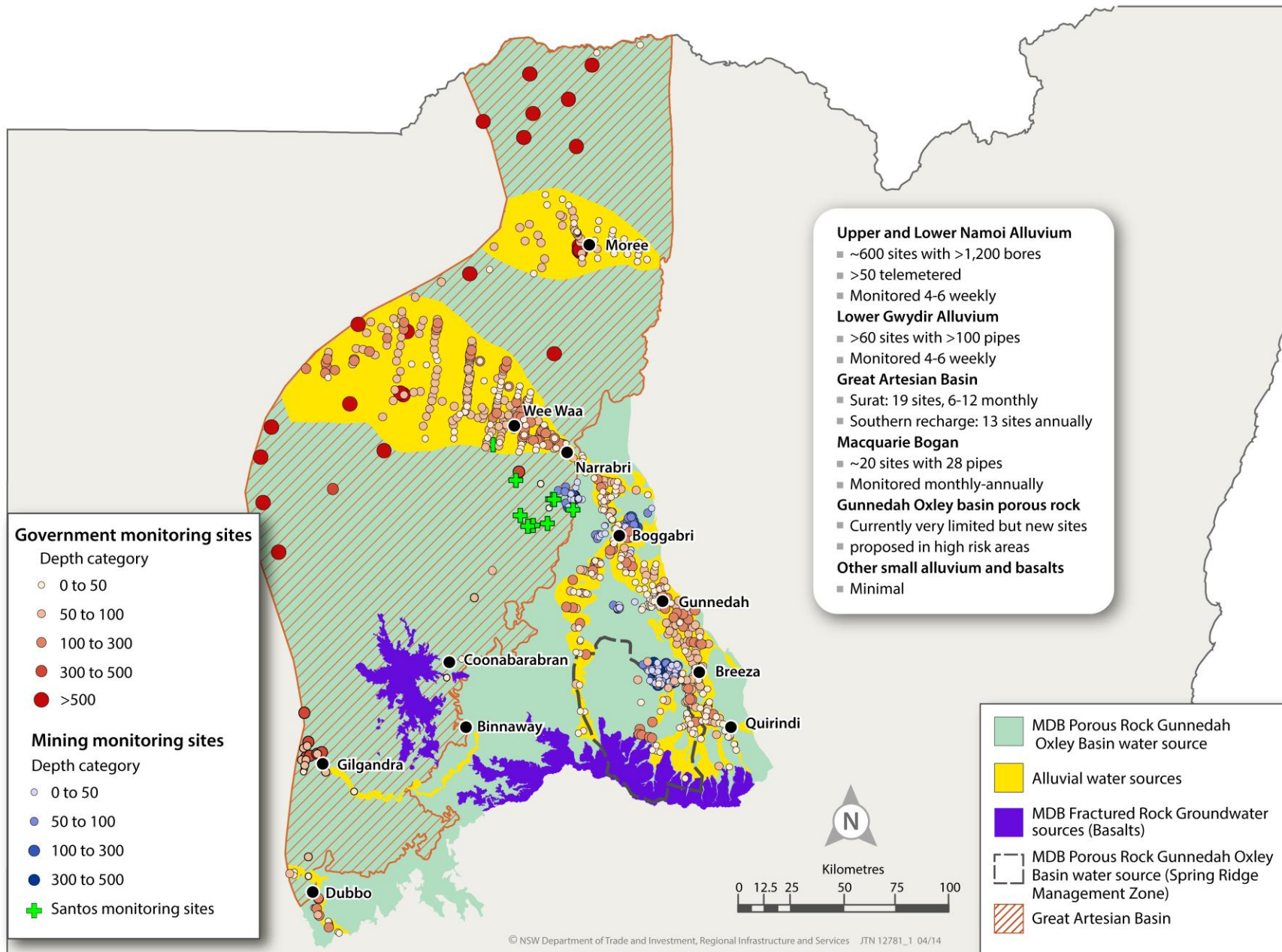


# Long term rainfall trends

**Rainfall at Wee Waa - Station 53044**  
(cumulative deviation from the mean)



# Gunnedah Basin: Groundwater monitoring sites



## Government monitoring sites

Depth category

- 0 to 50
- 50 to 100
- 100 to 300
- 300 to 500
- >500

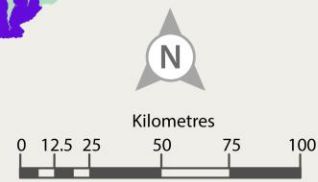
## Mining monitoring sites

Depth category

- 0 to 50
  - 50 to 100
  - 100 to 300
  - 300 to 500
  - +
- Santos monitoring sites

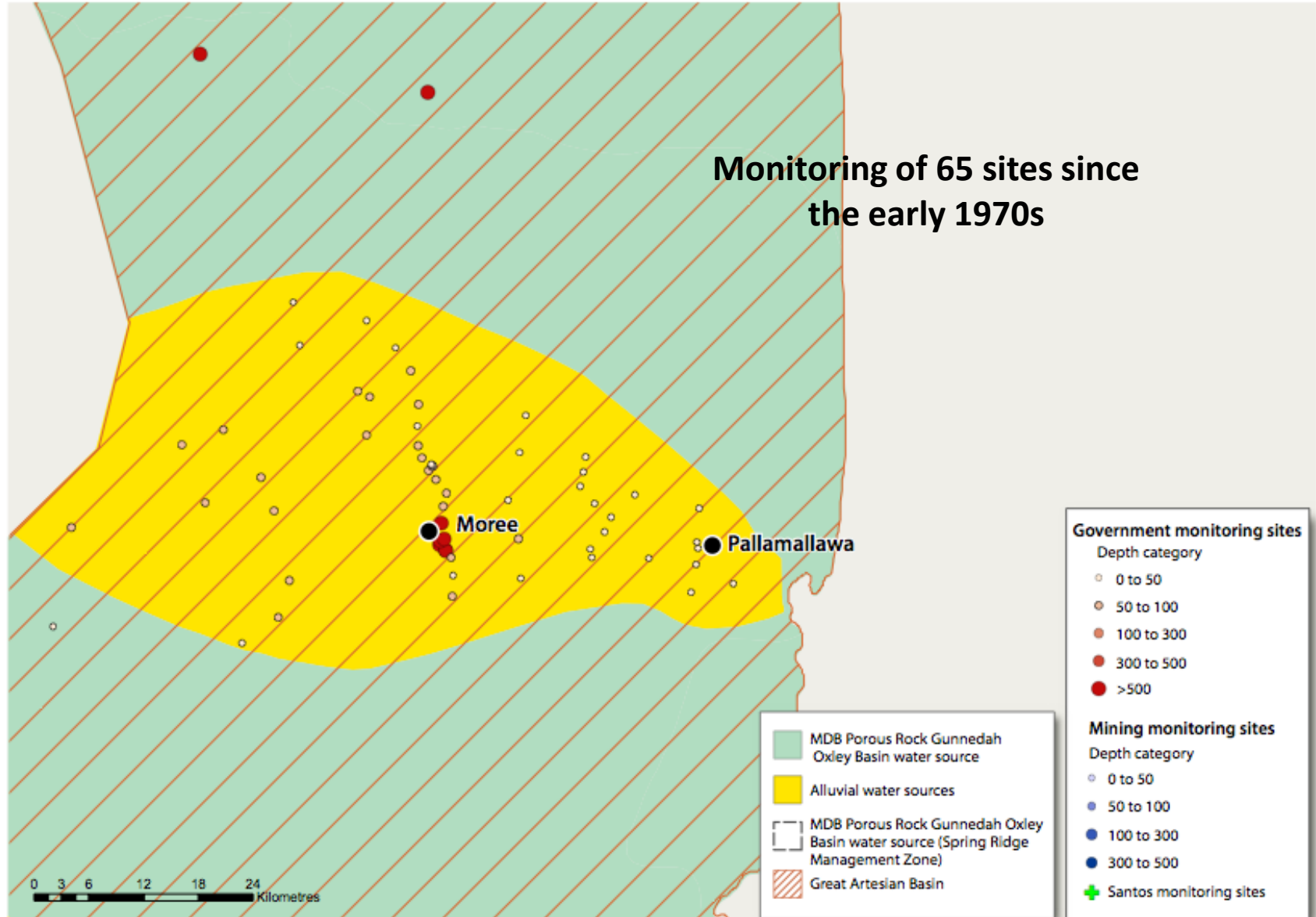
- Upper and Lower Namoi Alluvium**
- ~600 sites with >1,200 bores
  - >50 telemetered
  - Monitored 4-6 weekly
- Lower Gwydir Alluvium**
- >60 sites with >100 pipes
  - Monitored 4-6 weekly
- Great Artesian Basin**
- Surat: 19 sites, 6-12 monthly
  - Southern recharge: 13 sites annually
- Macquarie Bogan**
- ~20 sites with 28 pipes
  - Monitored monthly-annually
- Gunnedah Oxley basin porous rock**
- Currently very limited but new sites
  - proposed in high risk areas
- Other small alluvium and basalts**
- Minimal

- MDB Porous Rock Gunnedah Oxley Basin water source
- Alluvial water sources
- MDB Fractured Rock Groundwater sources (Basalts)
- MDB Porous Rock Gunnedah Oxley Basin water source (Spring Ridge Management Zone)
- Great Artesian Basin

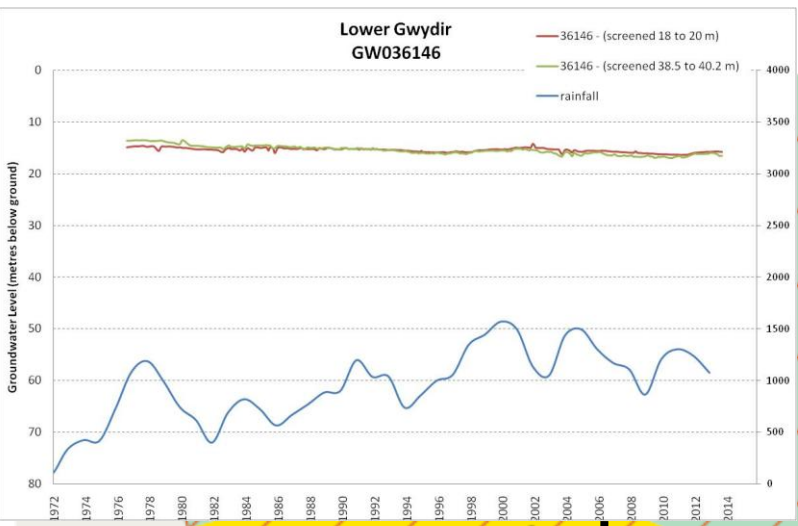




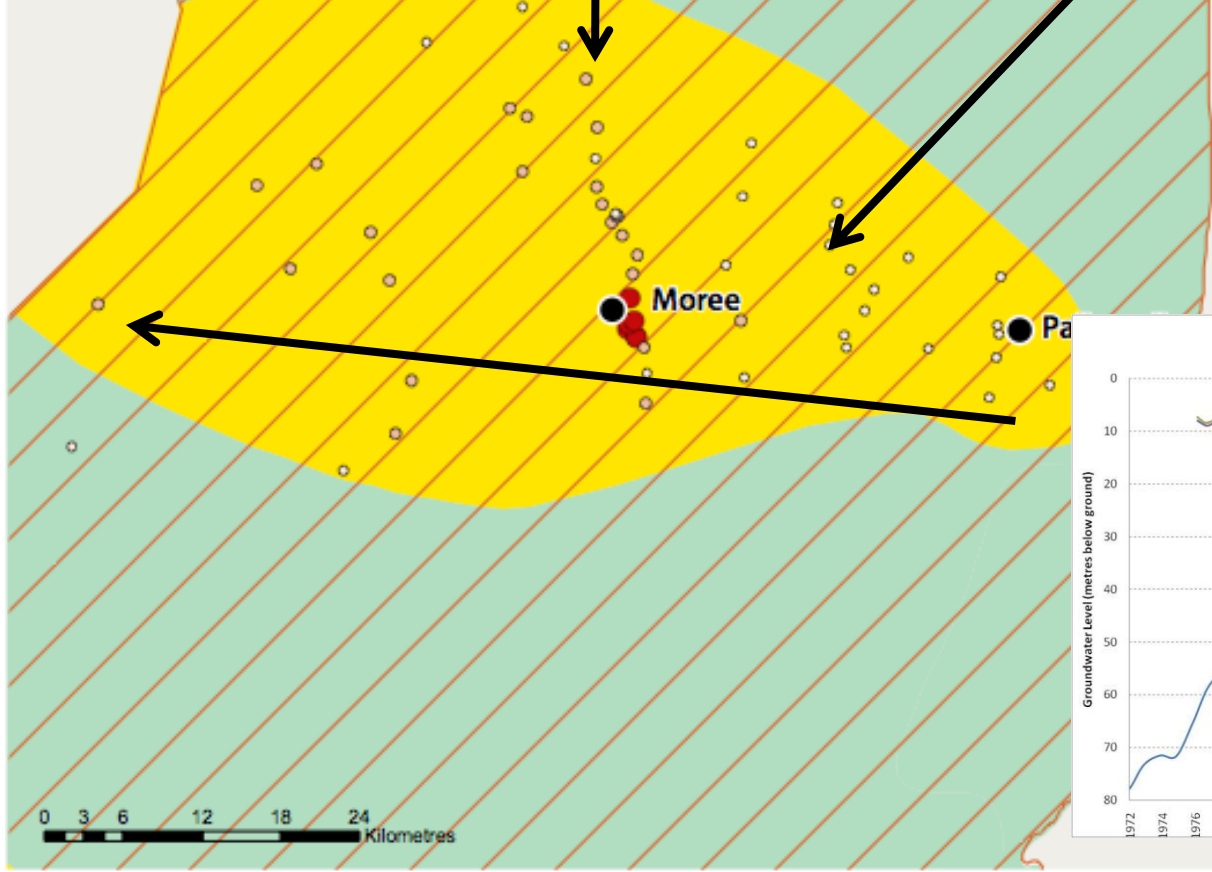
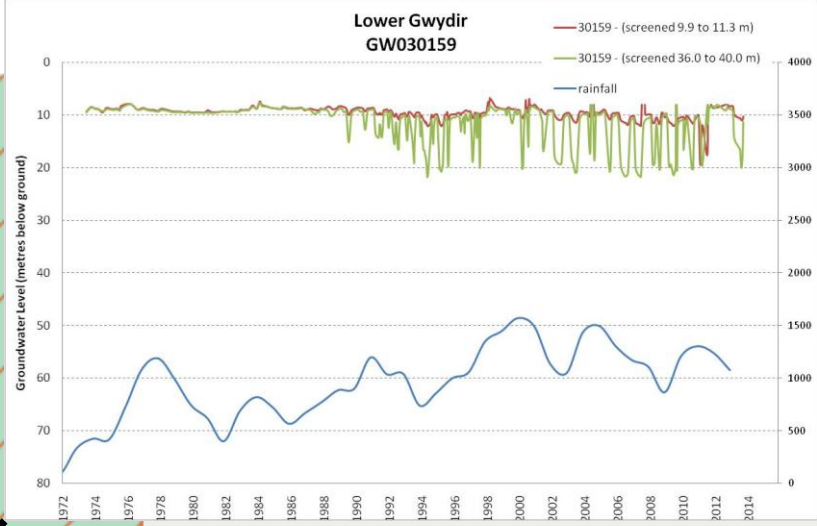
# Baseline water level data - Lower Gwydir



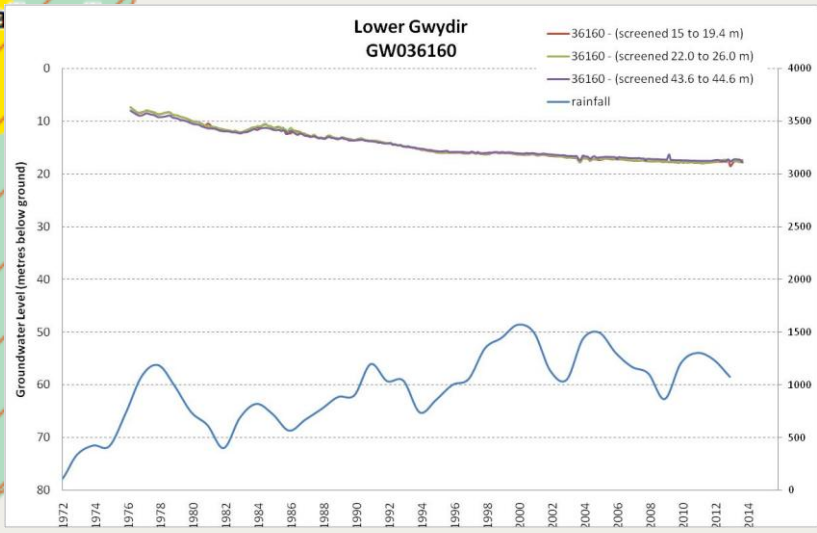
Lower Gwydir  
GW036146

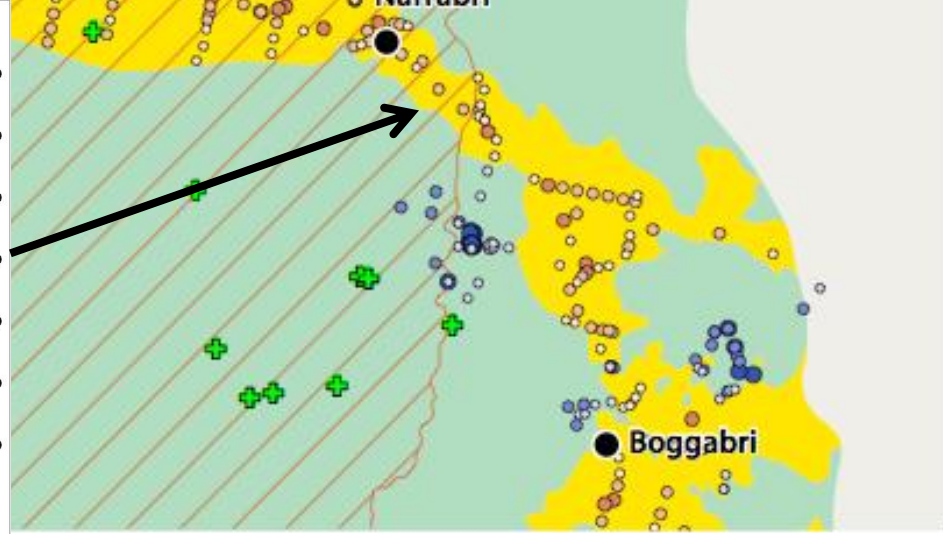
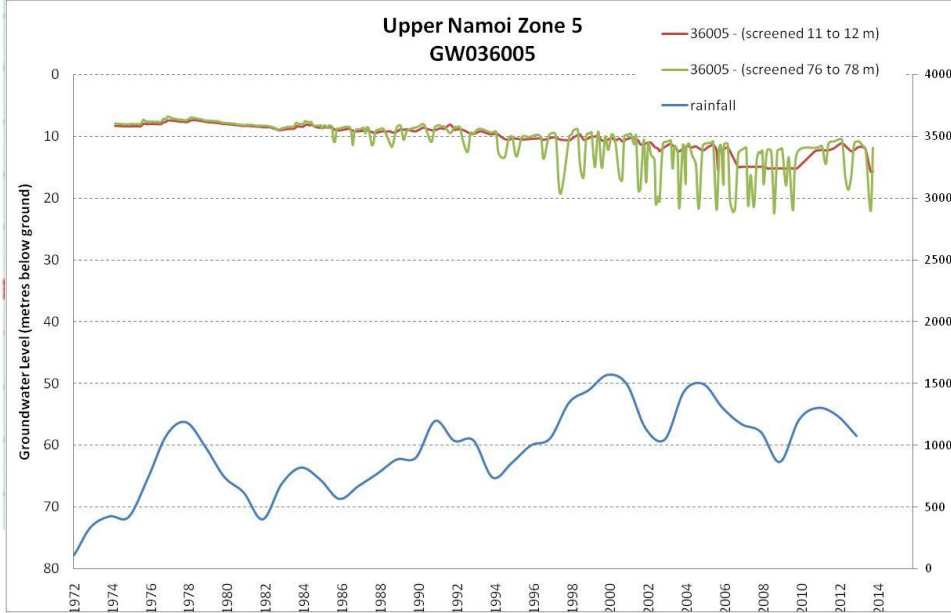
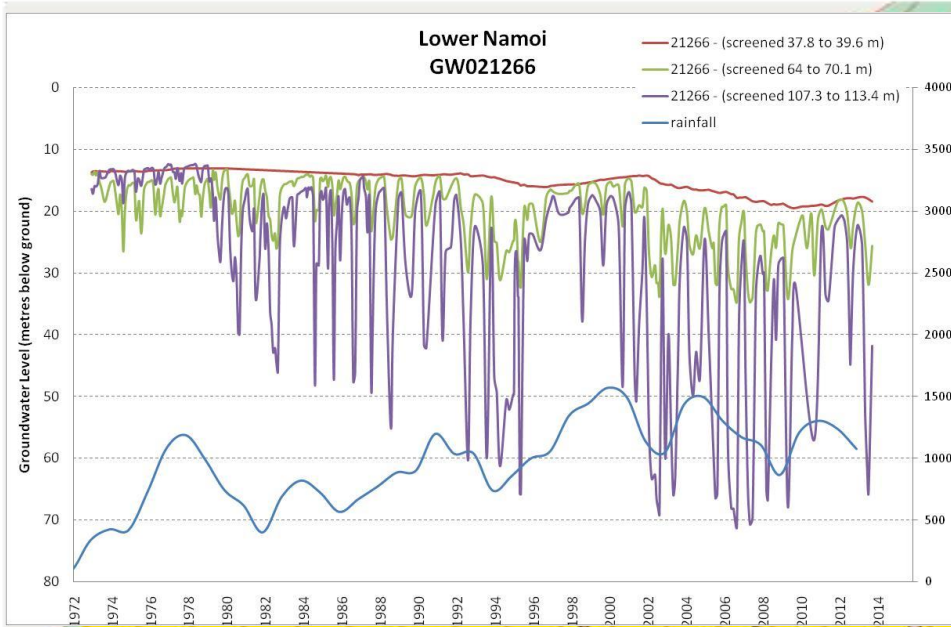


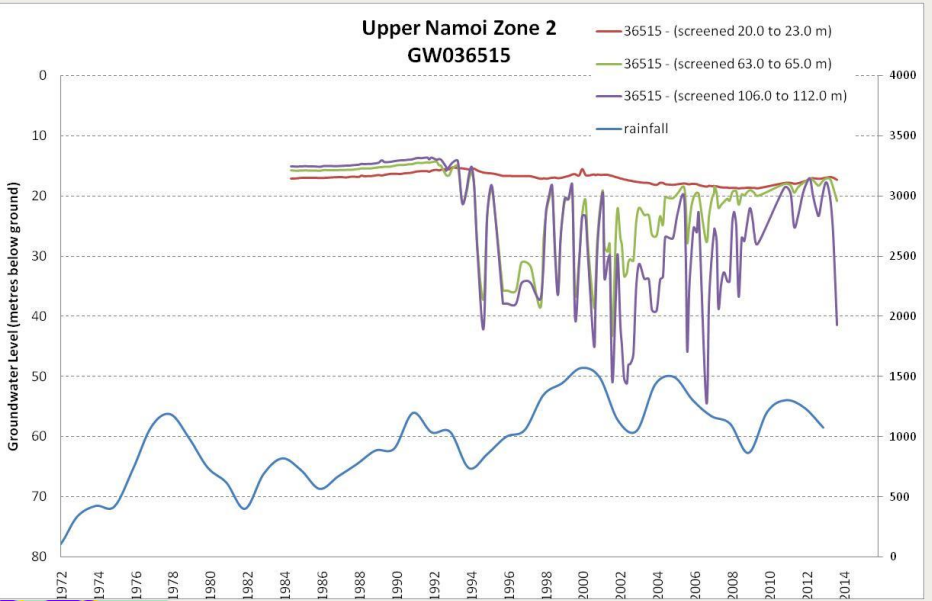
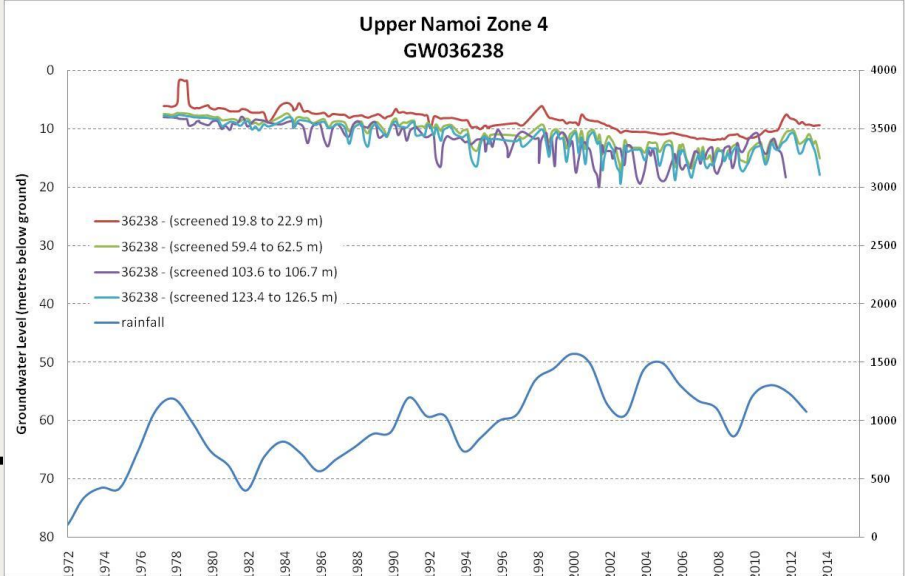
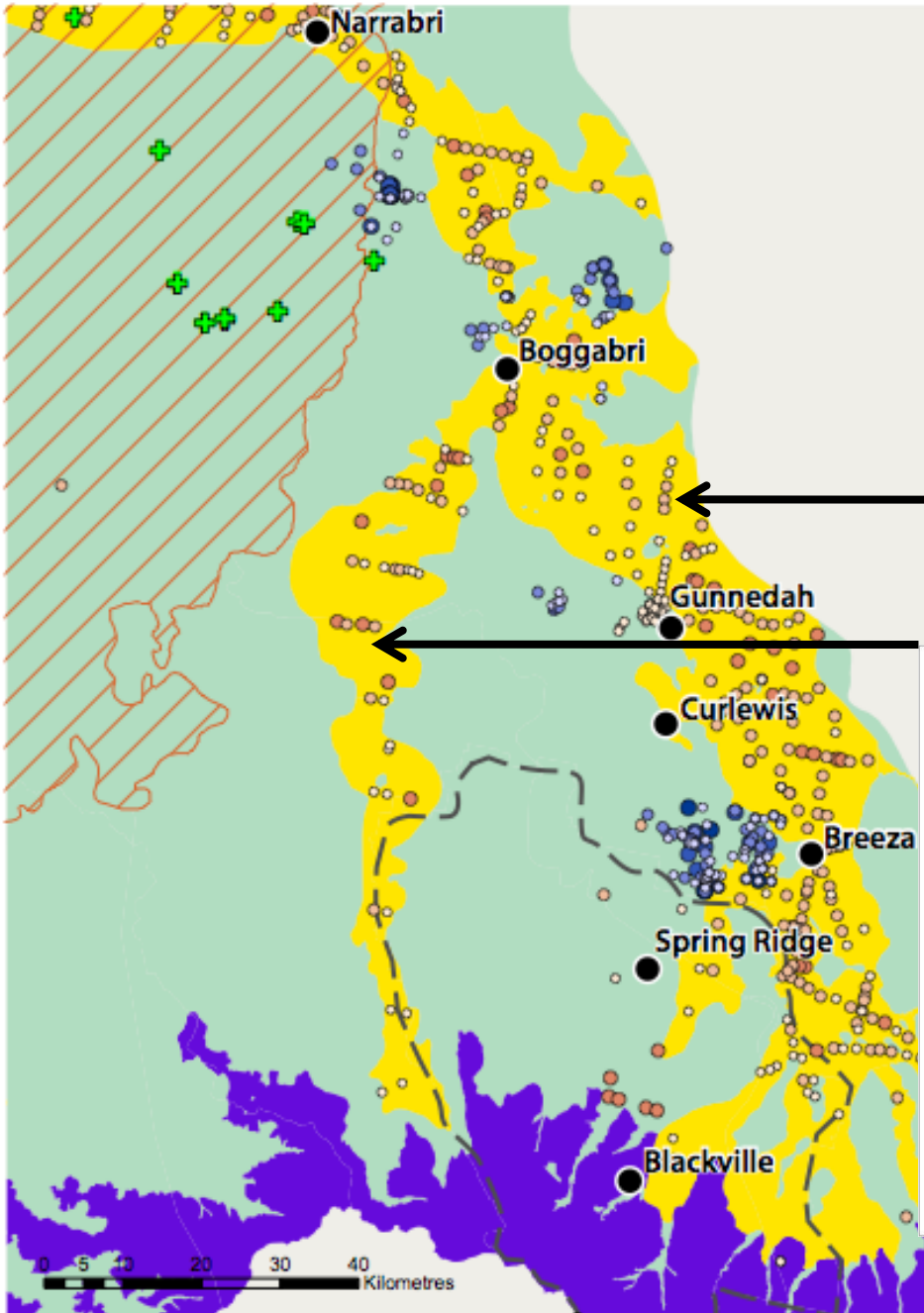
Lower Gwydir  
GW030159



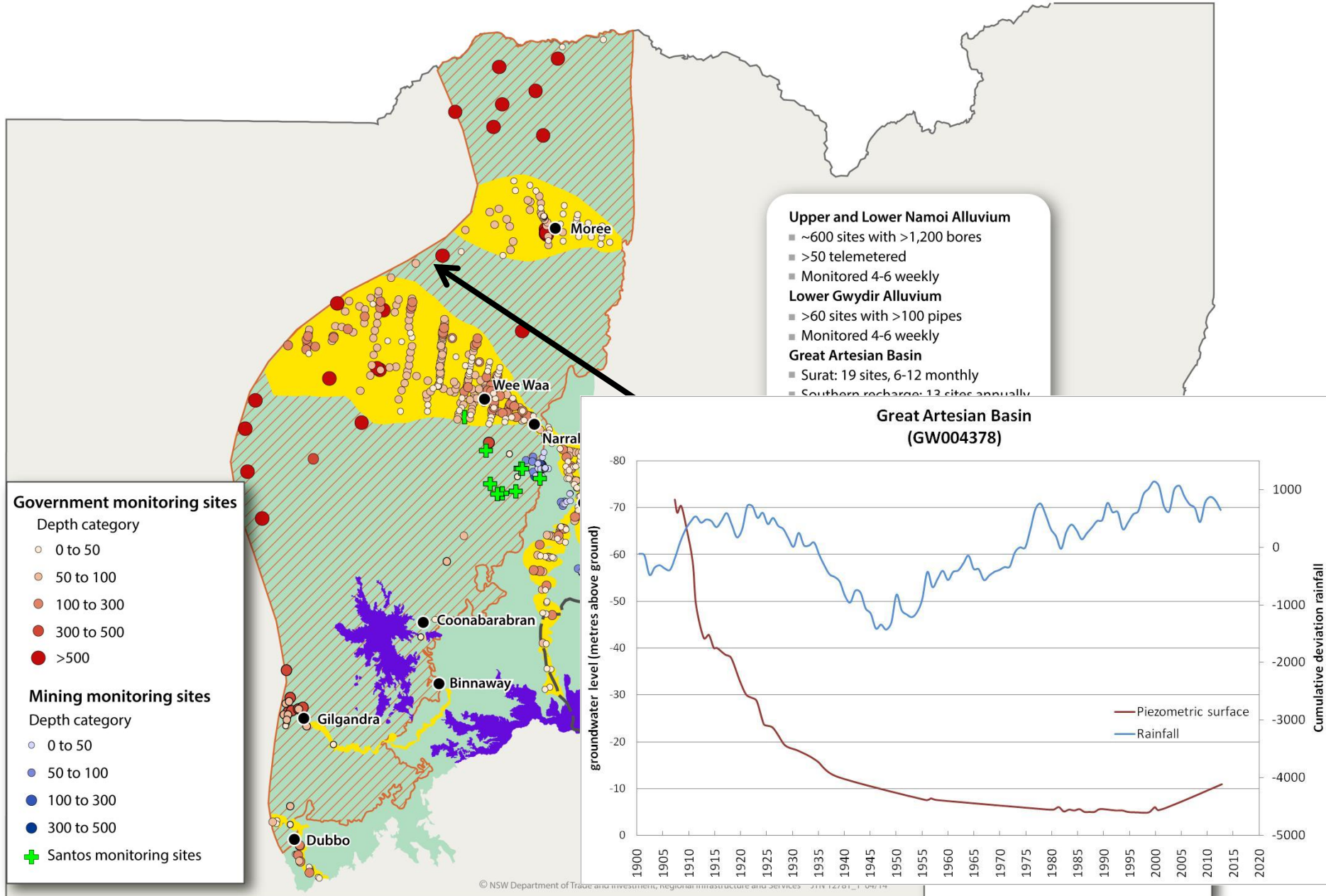
Lower Gwydir  
GW036160





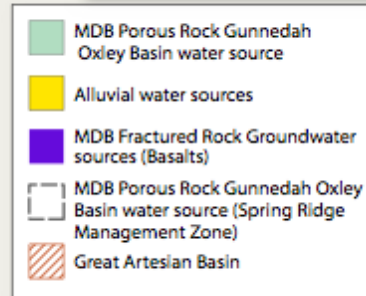
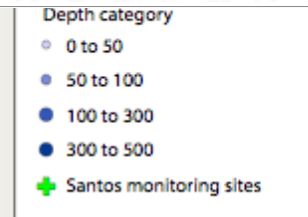
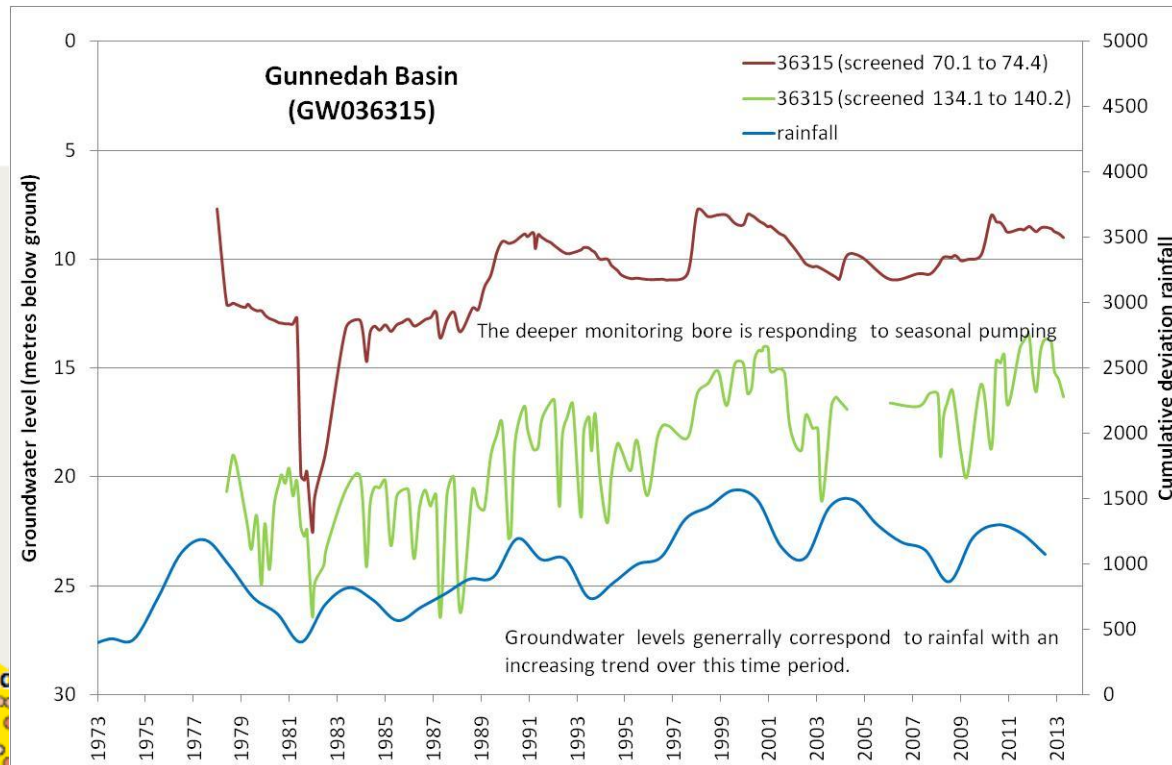
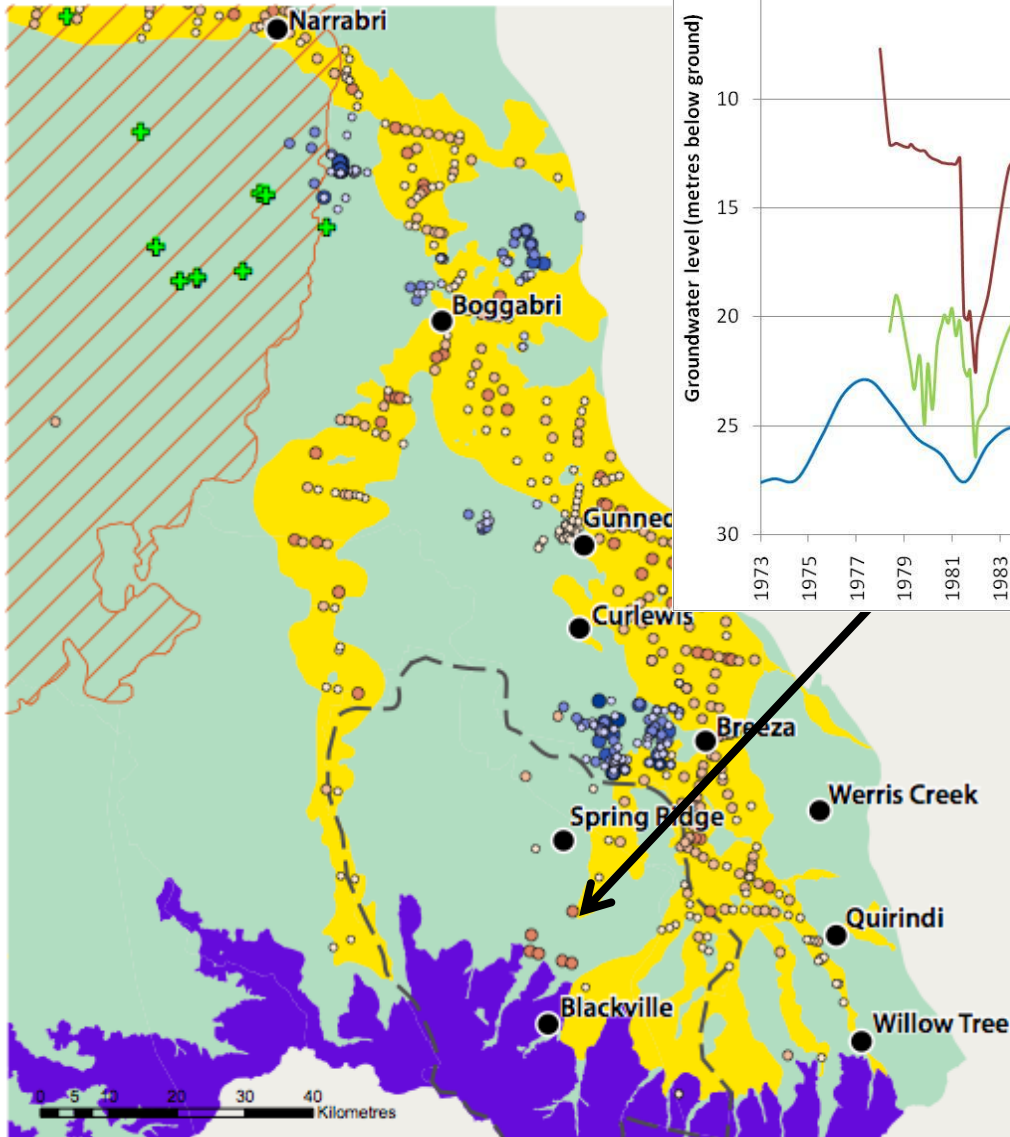


# Groundwater level monitoring - GAB



# Baseline water level data - Gunnedah Basin

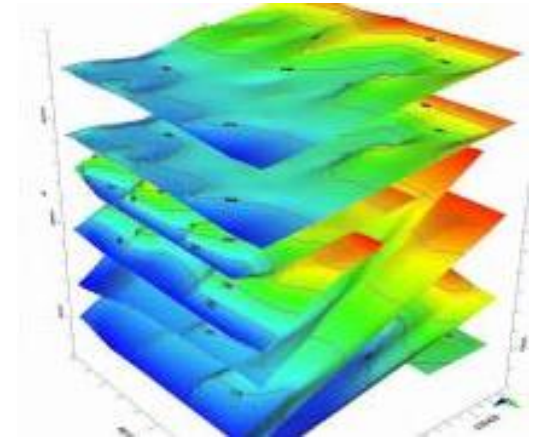
Monitoring ~ 10 bores in the Gunnedah Basin – Spring Ridge area since late 1970s



# Groundwater modelling

## Major inputs:

- Geology/stratigraphy
- Groundwater levels (time series)
- Groundwater extraction
- Robust conceptual model
- Rainfall and river stage height
- Aquifer parameters from field testing (pumping tests, core tests)



## Who:

- CSG and mining companies – required as part of development application (and gateway) processes
- NSW Office of water undertake regional modelling and assessment for ‘sustainable yields’ / to determine resource availability

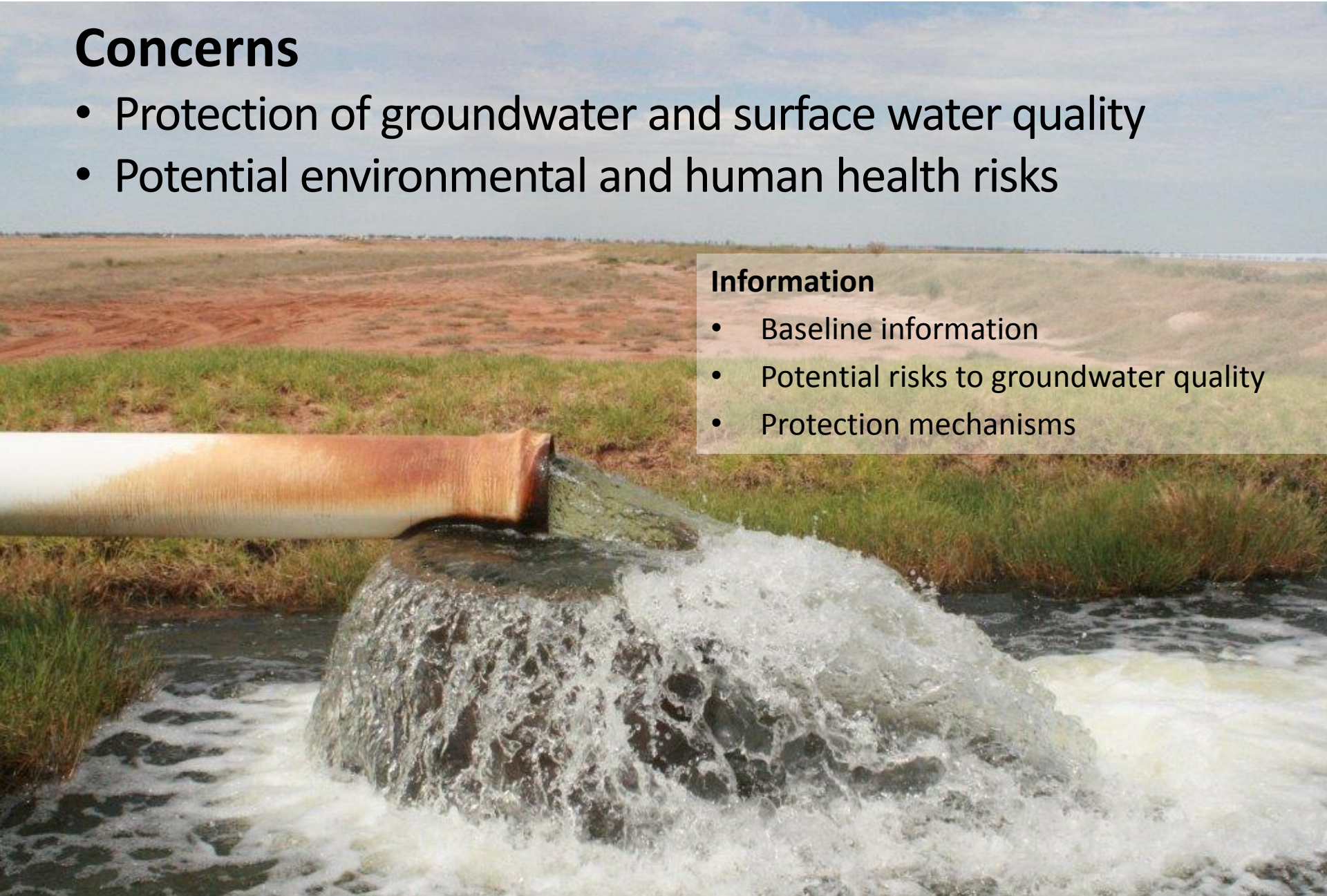
# Groundwater quality

## Concerns

- Protection of groundwater and surface water quality
- Potential environmental and human health risks

### Information

- Baseline information
- Potential risks to groundwater quality
- Protection mechanisms





# Baseline groundwater quality



# Water quality monitoring

Purpose – to inform:

- Suitability of water for various purposes
- Establish baseline groundwater quality conditions
- Optimal management of produced water
- Monitor for potential water quality impacts of CSG activities

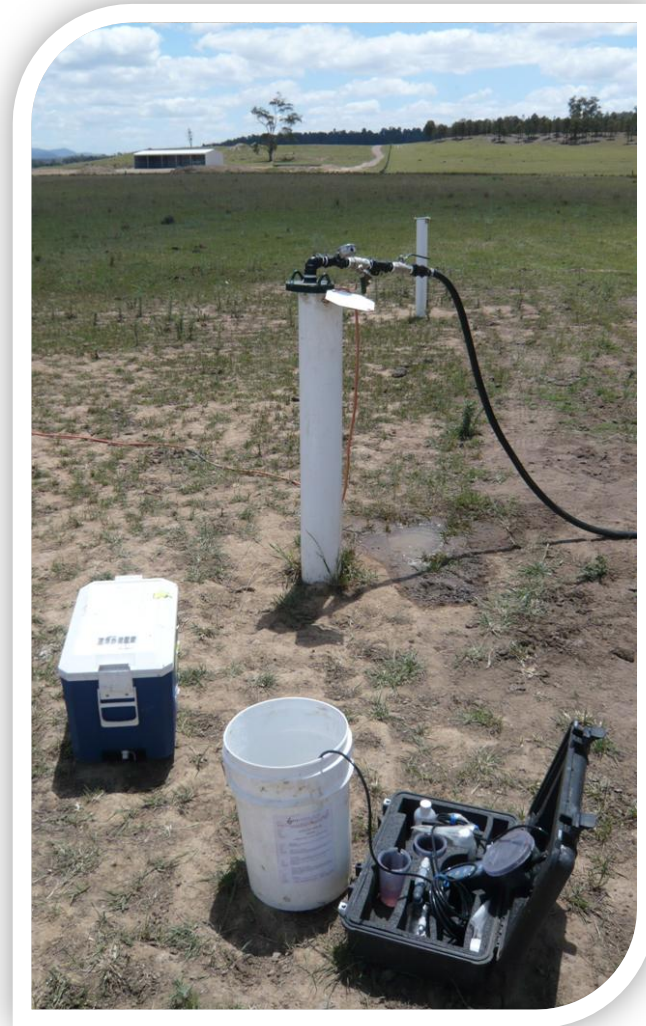
Who:

- CSG companies
- Mining companies
- NSW Office of Water



# Government water quality information

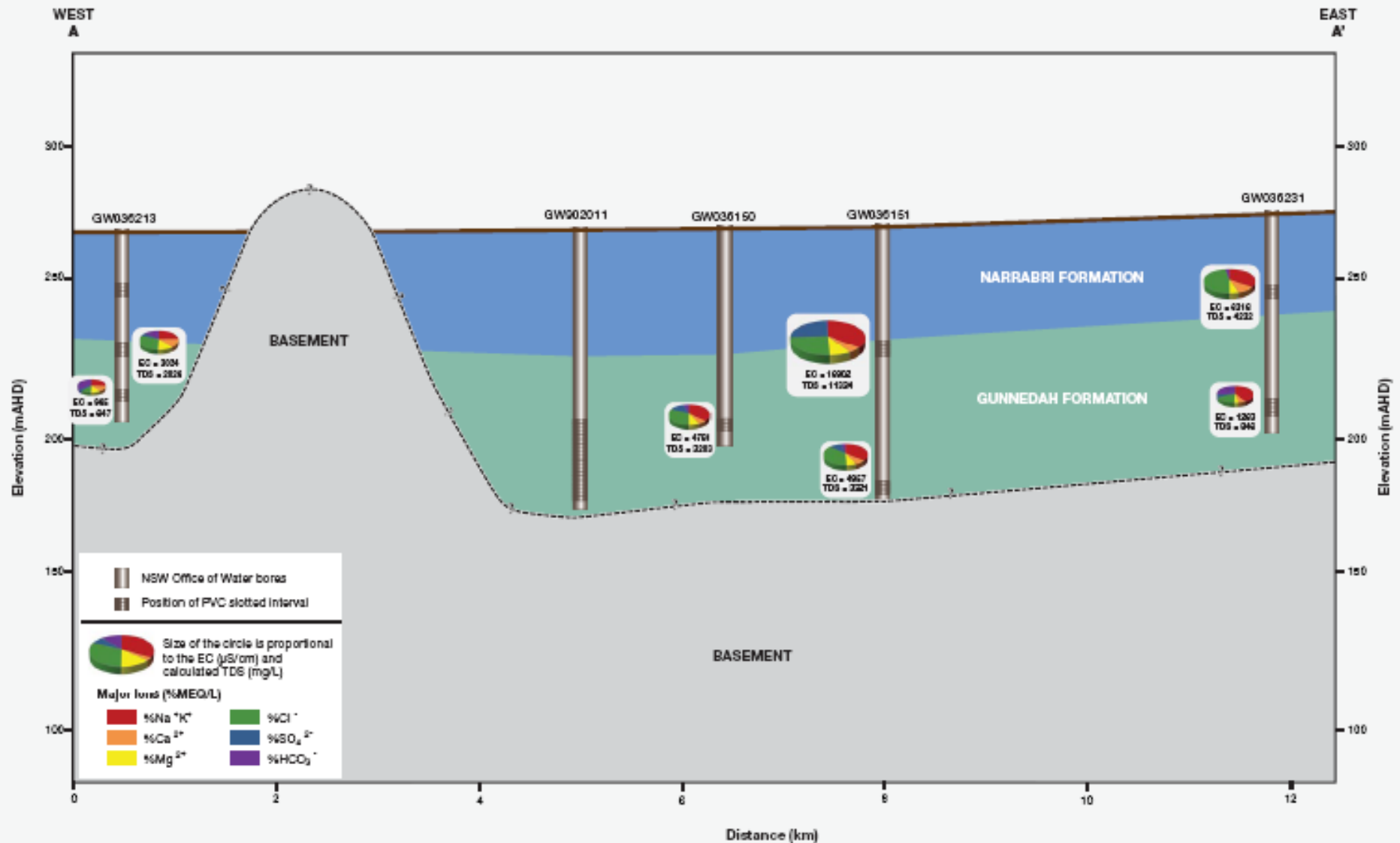
- Limited groundwater quality data
- No long term trends
- Salinity is the priority
- Some 'project based' water chemistry
- Water quality monitoring is expensive



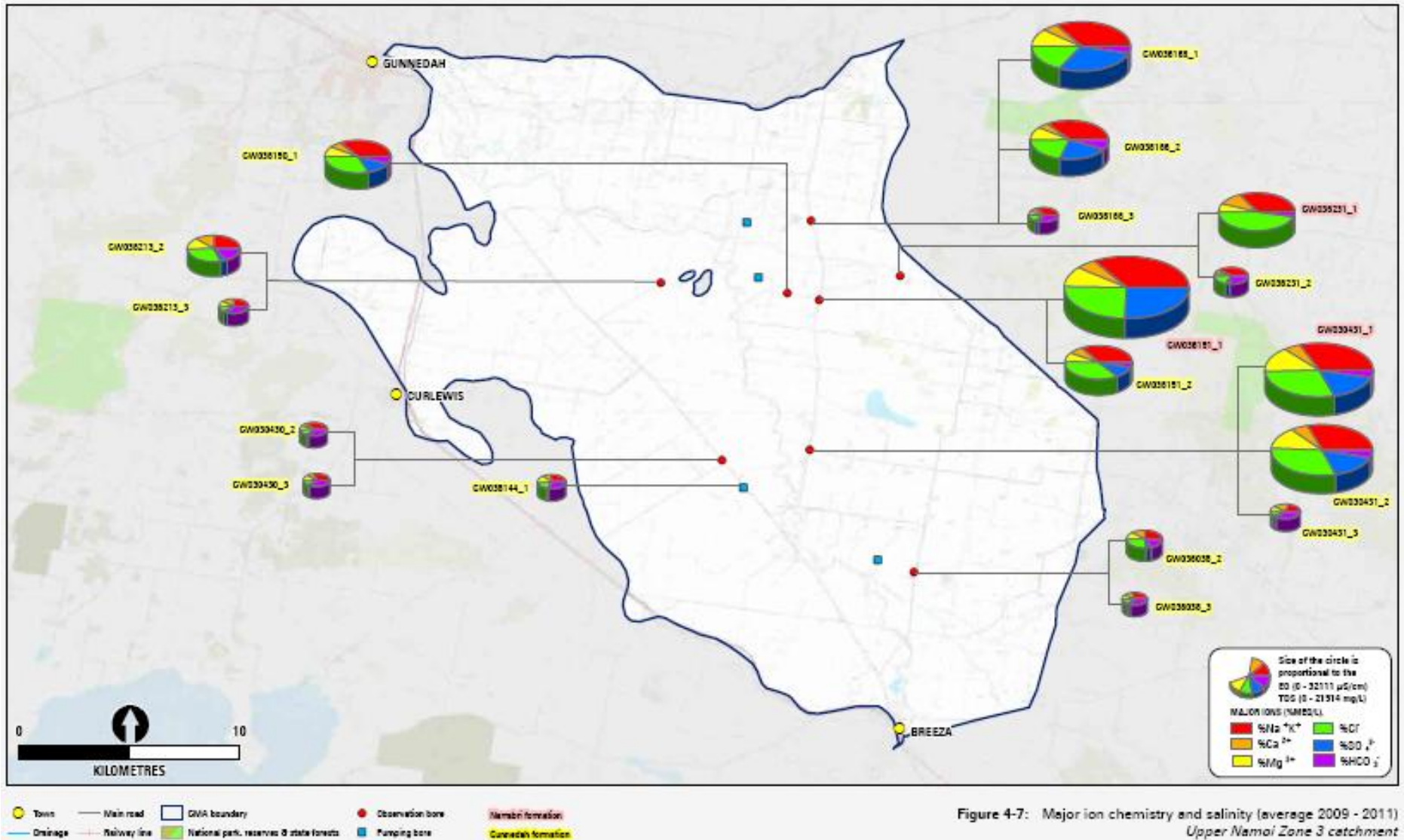
# Government water quality information

- Highly variable between and within systems
- Freshest in deep alluvial systems
- Shallow alluvium and can be very saline
- GAB water fresh in recharge areas, but declines to stock to the north west
- Gunnedah porous rocks mainly suitable for stock, (limited irrigation use in recharge areas eg Spring Ridge area)
- Coal measures of Gunnedah Oxley Basin are generally saline

# Example of government groundwater chemistry data (Project based – Upper Namoi Zone 3)



# Example of government groundwater chemistry data (Project based – Upper Namoi Zone 3)



# Example CSG water quality analysis suite

Field parameters	Major ions	Dissolved metals/trace elements	Other analytes	Total suspended solids	Nutrients	Dissolved gases	Hydrocarbons	Isotopes
EC TDS pH Dissolved Oxygen Redox	Calcium Magnesium Sodium Potassium Chloride Carbonate Bicarbonate Sulphate	Aluminium Antimony Arsenic Barium Beryllium Boron Bromide Cadmium Chromium Cobalt Copper Iron Lead Manganese Mercury Molybdenum Nickel Selenium Strontium Uranium Vanadium Zinc	Fluoride Total organic carbon Cyanide Silica	TSS	Nitrate Nitrite Ammonia Reactive phosphorus Total phosphorus	Methane	Phenol compounds Polycyclic aromatic hydrocarbons (PAH) Total petroleum hydrocarbons (TPH)/ benzene, toluene, ethyl benzene and xylenes (BTEX)	<b>Stable isotopes</b> (ie Oxygen / Deterium)  <b>Radio isotopes</b> (ie carbon 14, chlorine 36, tritium)
<b>Basic Analysis</b>								
<b>Intermediate analysis</b>								
<b>Comprehensive analysis</b>								
								<b>Occasional</b>

# Potential risks to groundwater quality

## Underground activities and works

- Exploration (drilling exploration holes)
- Fracture stimulation
- Production (drilling and construction of gas bores, operation of gas bores)
- Long term integrity of gas wells (during operation and following decommissioning)



## Surface activities and works

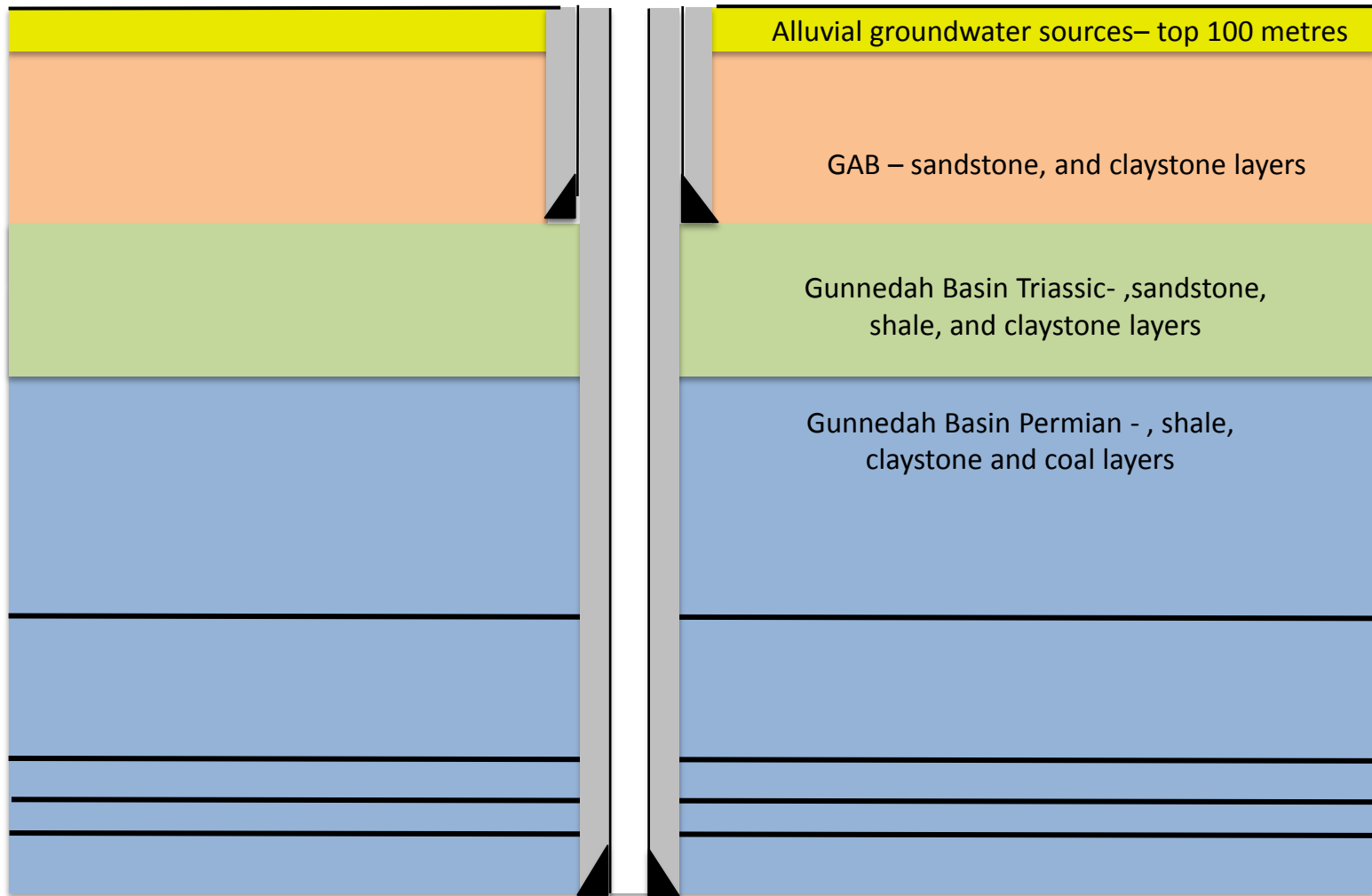
- Co-produced water (storage, treatment and disposal)



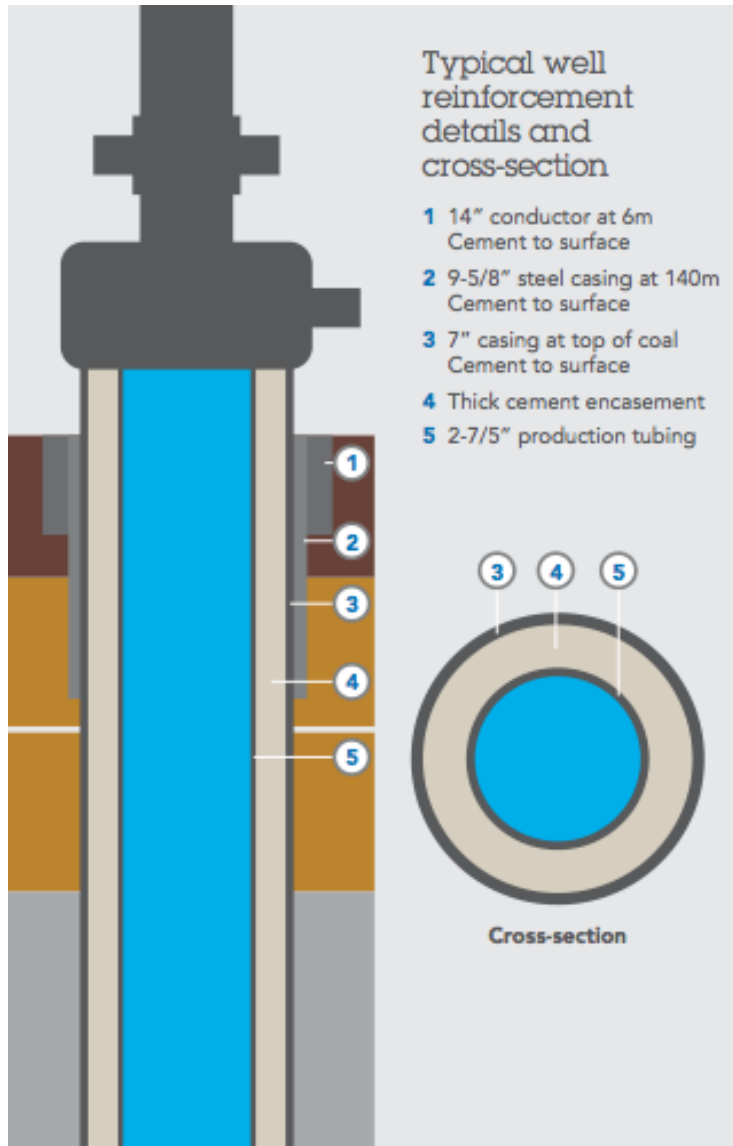
# Well integrity



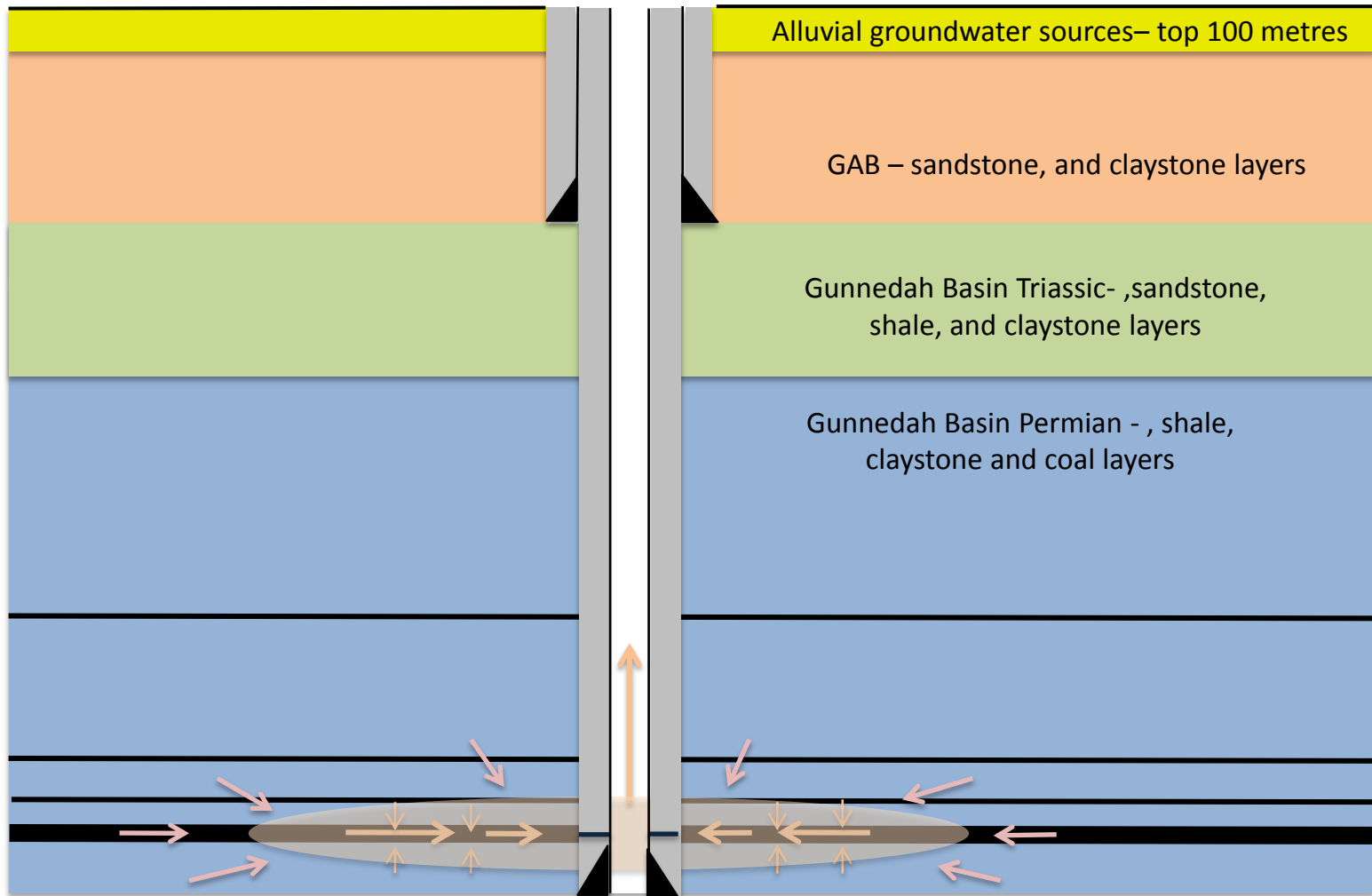
# Well integrity: Bore construction



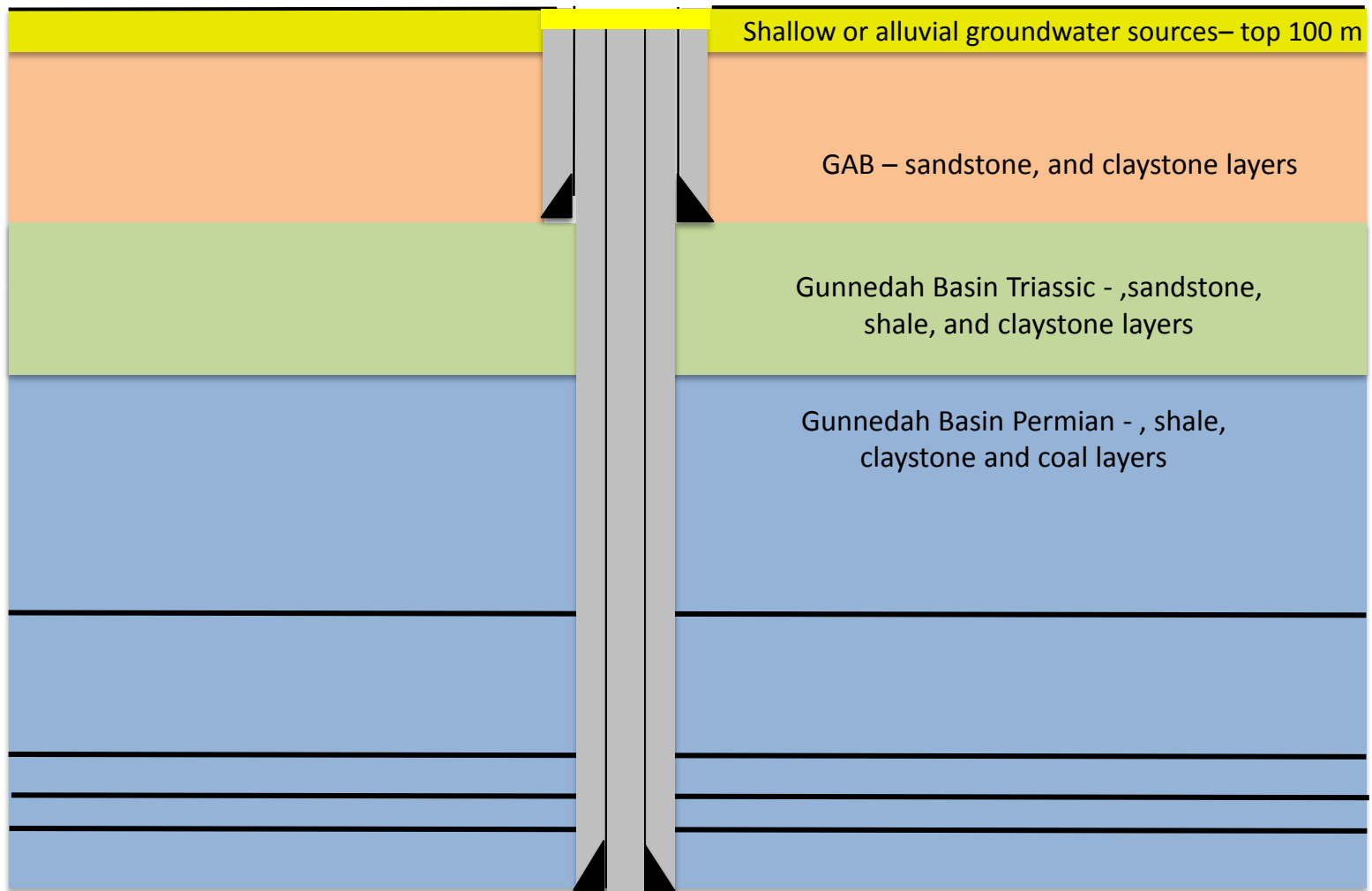
# Well integrity: Bore construction



# Water quality and flow dynamics



# Decommissioning and long term integrity



# Management of underground works and activities

## Planning and design

- Designs and plans submitted to OCSG for approval
- Risk assessment
- Safety management plan
- Environmental management plan
- Incident and emergency response procedures



## Construction

- Notification to drill
- Well integrity
- Construction standards
- Pressure testing
- Down hole logs
- Well completion report
- Cementing report
- Fracture stimulation management plan



## Operation

- Well condition monitored on an ongoing basis to ensure integrity of the well and well equipment
- Maintenance as required
- Mandatory annual reporting
- Mandatory incident reporting



## Decommissioning

- Pre approval from OCSG
- Standards for abandonment
- Mandatory reporting

# Produced water – groundwater from within coal seams

- Generally high in dissolved salts and metals
- Naturally occurring hydrocarbons and dissolved gases



# Management of produced water

It is critical to understand the quality and quantity of the produced water to determine the optimal strategy for management

## Planning

- Regulated through the EPA EPLs and development consent conditions
- Environmental management plans
- Water monitoring and management plans
- Incident and emergency response procedures



## Operation

- Maintenance as required
- Mandatory monitoring of produced water, brines etc
- Mandatory monitoring of streams and groundwater quality
- Mandatory periodic reporting
- Mandatory incident reporting



## Post operation

- Implementation of rehabilitation plans
- Ongoing monitoring



# CSG and groundwater summary



# Summary.....

## Local impact analysis must include:

- Volume of water extracted by CSG
- Proximity of users (both extractive and environmental) to CSG activities
- Depth of CSG activity (compared to depth of beneficial groundwater system)
- Geological model (ie geological conceptual model)
- Hydraulic connection (both vertically and horizontally)
- Well integrity management
- Management of produced water



# Summary.....

Regulation of the CSG industry is stringent (compared to other industries and states)

- EIA and project approval conditions
- Licences (EPL, WMA etc AI Policy)
- Groundwater monitoring and modelling ‘musts’
- Mandatory periodic and incident reporting
- Well integrity and compliance
- Produced water management (use, disposal, monitoring)

# Information gaps



# Information gaps: What's been said...

## **Office of Chief Scientist and Engineer and the Commonwealth Independent Expert Scientific Committee**

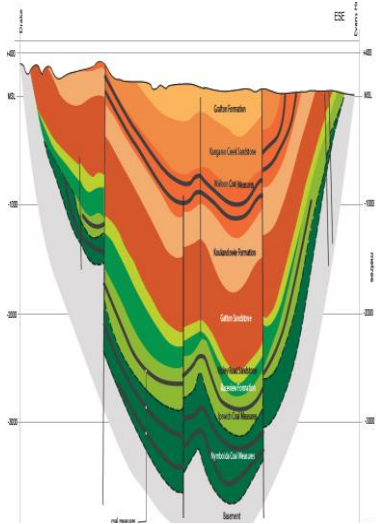
- Cumulative impacts
- Hydraulic connectivity between systems
- Fine scale geological understanding (ie understanding faults)
- Bore integrity
- Hydraulic fracturing and chemical migration and toxicity
- Reinjection
- Timeframe for recovery/remediation
- Managing produced water

# Information gaps: What's being done...

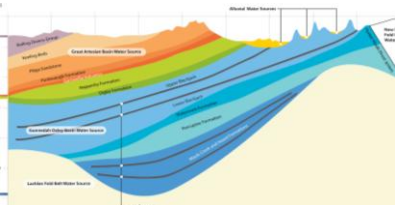
- **Additional regional groundwater monitoring targeting coal basins (by Government)**
- **The bioregional assessment process (Commonwealth Government)**
- **NSW Water Sharing Plans (cumulative volumetric impacts)**
- IESC research projects
- Other projects (CSIRO, CRC for Mining, Aust Coal Research Ltd, etc)
- Regulation of the industry (ie reporting requirements, focus on addressing gaps)



# Relative comparison of basin size



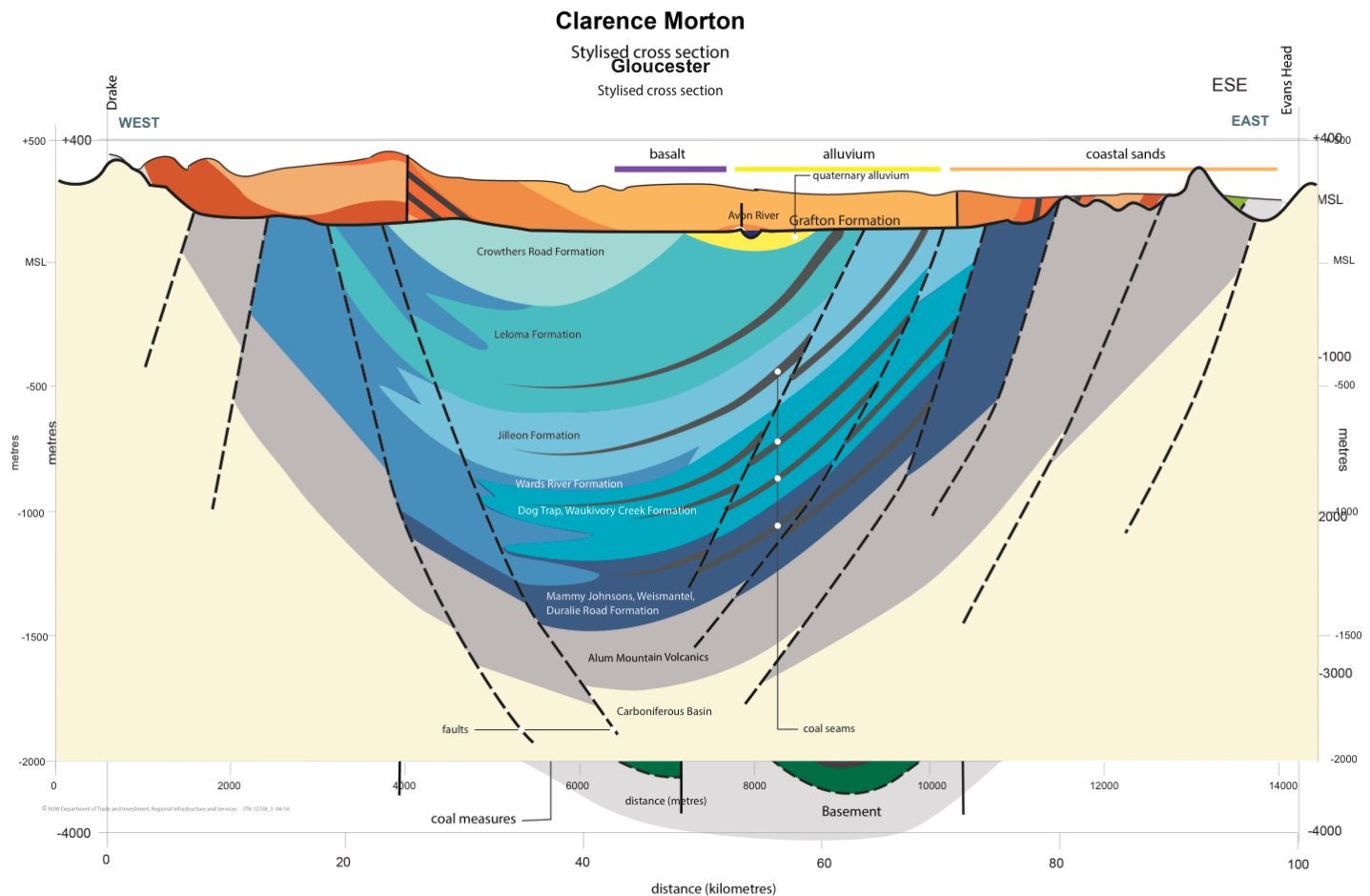
Clarence Moreton Basin



Gunnedah Basin



Gloucester Basin



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Murray Basin

