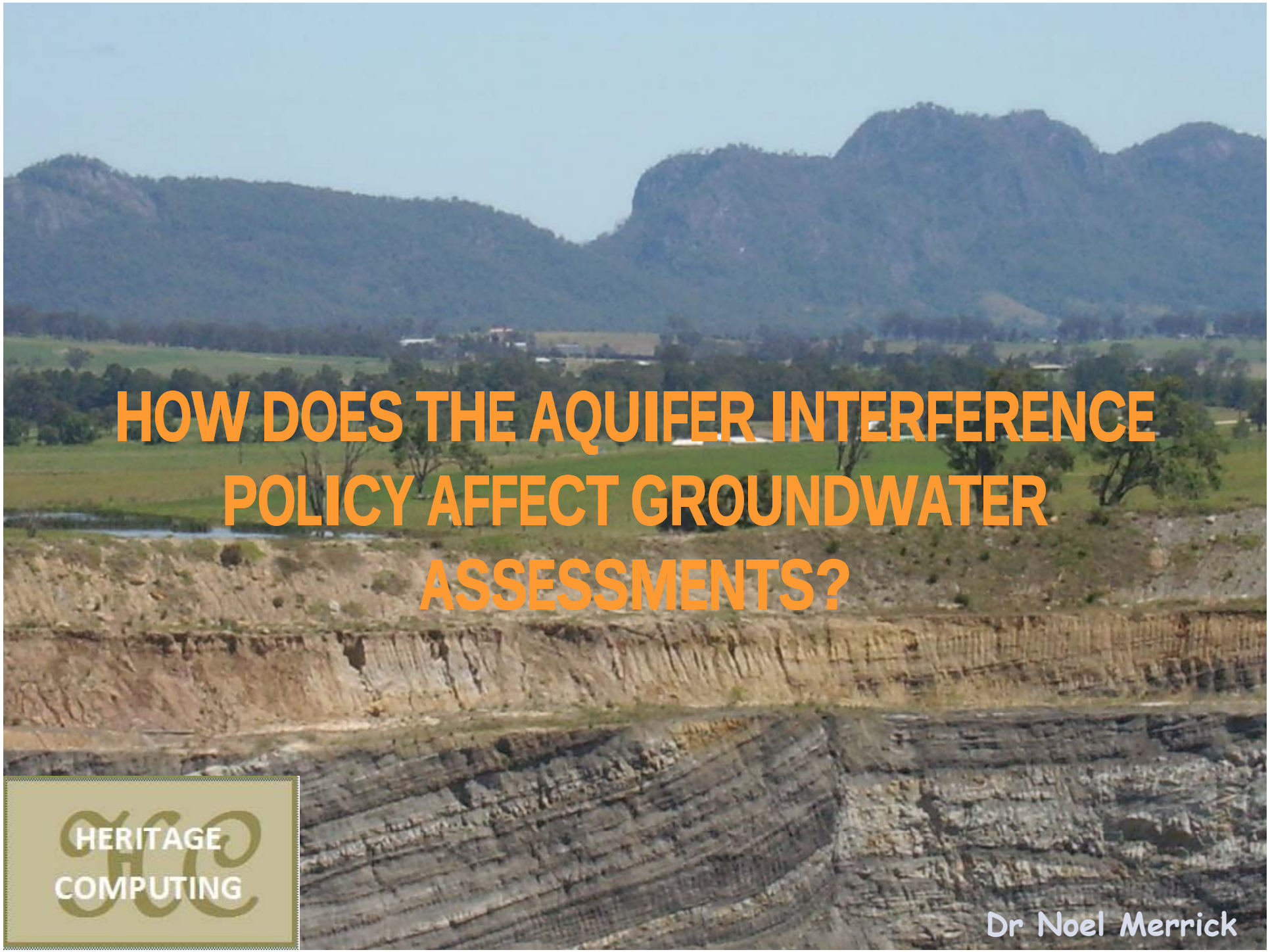

HOW DOES THE AQUIFER INTERFERENCE POLICY AFFECT GROUNDWATER ASSESSMENTS?
HERITAGE COMPUTING
Dr Noel Merrick

OUTLINE

- Chronology
- Problems with Stage 1 Draft (March 2012)
  - *Classifications*
  - *Modelling*
- Stage 2 Final (September 2012)
  - *Definitions*
  - *Minimal Impact Considerations*
  - *Examples*
- Licensing
  - *Partitioning between water sources*
- Gateway Process
  - *“Simple” Modelling Platform*

CHRONOLOGY

- Water Management Act 2000
  - Part 3, Division 6 (and Amendments to the Act)
- State Groundwater Policy Framework Document
  - Principle 14: *All activities or works that intersect an aquifer, and are not for the primary purpose of extracting groundwater, need an aquifer interference approval*.
- Aquifer Interference Regulation
  - 30 June 2011: licence required if >3 ML/a per activity
- Stage 1 draft Aquifer Interference policy
  - March 2012: linked to BSAL mapped areas
- Strategic Regional Land Use Policy [SRLUP]
- Stage 2 policy
  - "NSW Aquifer Interference Policy"
  - "NSW Government policy for the licensing and assessment of aquifer interference activities"
  - 10 September 2012: state-wide

WMA2000

Water Management Principles - Aquifer interference

1. "…aquifer interference activities must avoid or minimise land degradation, including soil erosion, compaction, geomorphic instability, contamination, acidity, waterlogging, decline of native vegetation or … salinity and … land must be rehabilitated …"

2. "the impacts of the carrying out of aquifer interference activities on other water users must be avoided or minimised"

AQUIFER INTERFERENCE POLICY (Stage 1 Draft March 2012)

AIP Stage 1 Draft March 2012

Six **water source features (WSFs)** identified in the Draft AI Policy,

- Highly productive groundwater (below BSAL);
- Non- highly productive groundwater (below BSAL);
- Groundwater works (bores) for major water supply (e.g. >1,000 people);
- Groundwater works (bores) for other water supply (e.g. <1,000 people);
- High priority groundwater dependent ecosystems (GDEs); and
- Groundwater dependent culturally significant sites (GDCSS).

For each WSF, there are up to four **risk management zones (RMZs):**

- Water Protection Zone (WPZ);
- Limited Intrusion Zone (LIZ);
- Inner Risk Management Zone (IRMZ); and
- Outer Risk Management Zone (ORMZ).

BSAL = Biophysical Strategic Agricultural Land

AIP Stage 1 Draft March 2012

For each WSF and each RMZ, minimal harm criteria were specified for:

- Water table drawdown
- Water pressure drawdown
- Aquifer compaction
- Water quality

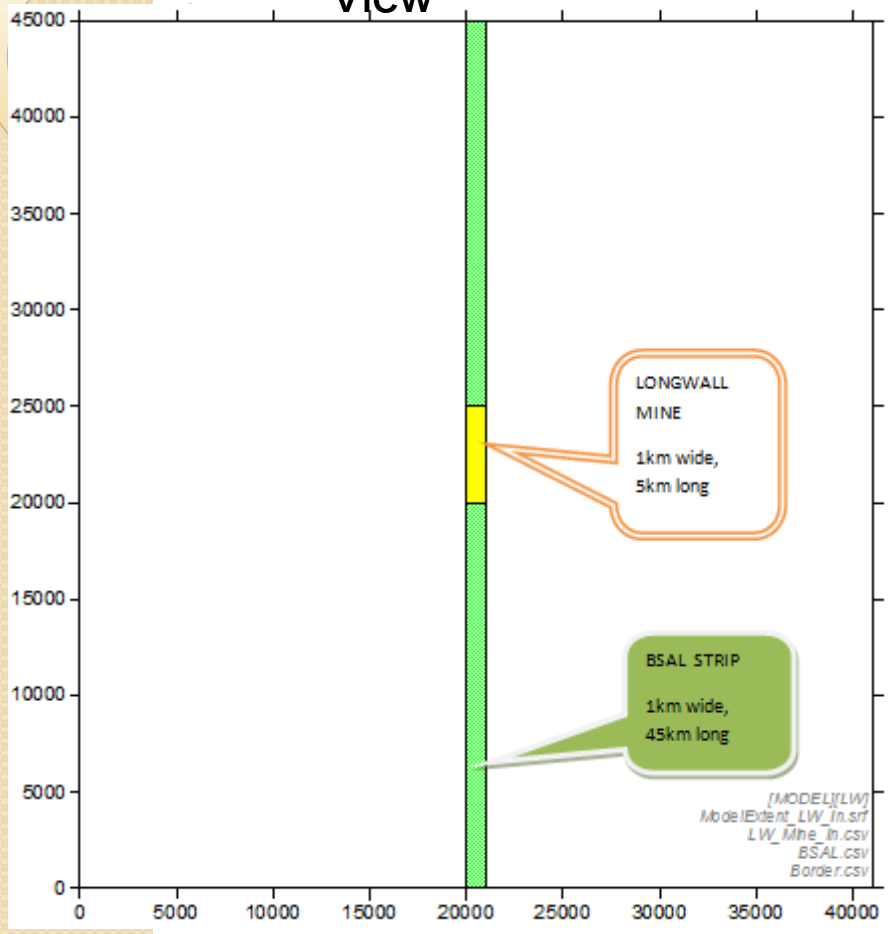
ANOMALIES

For open cut mining within BSAL, it is difficult to comprehend a circumstance where the minimal harm criteria could be met for any WSF (other than enclosure within a deep low-permeability barrier).

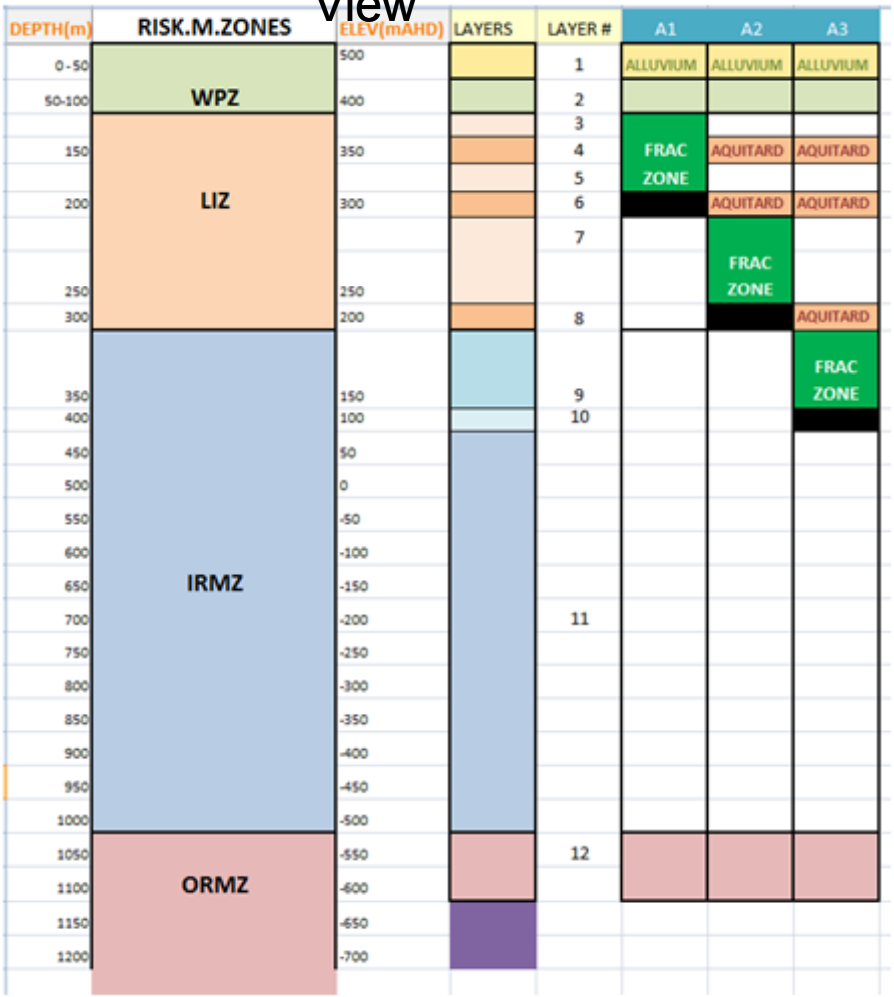
The water table drawdown criteria for LIZ, IRMZ and ORMZ are nonsensical, as water tables do not occur naturally at the depths defined for these zones.

The most severe criterion is the water pressure drawdown in the LIZ. At economic mining depths, it is physically impossible to comply with such low water pressure drawdown criteria.

Plan View



Section View



Results

RMZ	LAYER	DRAWDOWN CRITERION	CRITERION	CASE A1 DRAWDOWN	CASE A2 DRAWDOWN	CASE A3 DRAWDOWN
WPZ	1	Water Table	0.1 m	50 m	<1 m	<1 m
WPZ	2	Water Pressure	2 m	70 m	<1 m	<1 m
LIZ	3	Water Pressure	4 m	70 m	<1 m	<1 m
LIZ	6	Water Pressure	4 m	>100 m	>100 m	>100 m
LIZ	8	Water Pressure	4 m	>100 m	>200 m	>200 m
IRMZ	10	Water Pressure	NA	100 m	200 m	>300 m
WPZ	1	Saturated Thickness	10 %	100 %	<1 %	<1 %
WPZ	2	Saturated Thickness	10 %	75 %	<1 %	<1 %

AQUIFER INTERFERENCE POLICY (Final September 2012)

DEFINITIONS

Aquifer

- "...*a geological structure or formation, or an artificial landfill, that is permeated with water or is capable of being permeated with water*."
- Includes low-yield groundwater systems
- Includes saline groundwater systems
- Excludes unsaturated zone and perched groundwater systems

DEFINITIONS

- Highly Productive Groundwater Sources
  - Officially declared; and
  - TDS < 1,500 mg/L; **and**
  - Existing works with yield > 5 L/sec
- Less Productive Groundwater Sources
  - TDS >= 1,500 mg/L; **or**
  - Existing works with yield <= 5 L/sec

DEFINITIONS

Aquifer Interference Activity

- Penetration of an aquifer
- Interference with water in an aquifer
- Obstruction of groundwater flow
- Taking of water from an aquifer
- Disposal of taken groundwater

DEFINITIONS

High Risk Aquifer Interference Activities

- Open cut mining
- Underground mining
- Coal seam gas (CSG) extraction and produced water disposal
- Exploration drilling
- Dewatering activities for civil works
- Sand and gravel extraction
- Injection of water into an aquifer
- Activities that contaminate groundwater, cause loss of storage or structural damage to an aquifer

DEFINITIONS

- Aquifer Types – Highly Productive Groundwater Source
  - Alluvial
  - Coastal sands
  - Porous rock
    - GAB – Eastern Recharge, Southern Recharge
    - GAB – Surat, Warrego, Central
    - other
  - Fractured rock

DEFINITIONS

- Aquifer Types – Less Productive Groundwater Source
  - Alluvial
  - Porous rock
  - Fractured rock

WATER LICENSING

- Regulation
  - Water licence required:
    - Removal of water (of any quality for consumptive use or incidentally)
    - Movement of water *between* different groundwater sources (adjacent, overlying or underlying)
    - Movement of water between connected surface water sources and an aquifer (and *vice versa*)
      - Incidental take from a river must be returned to river when river water users must cease to pump
    - Movement of water *within* the one groundwater source
  - *Water Management Act 2000*
    - Where Water Sharing Plans exist
  - *Water Act 1912* Part 5
    - Groundwater elsewhere in NSW
  - *Water Act 1912* Part 2
    - Surface water elsewhere in NSW (due to aquifer interference)

WATER LICENSING

- Quantity of licensed water:
  - Predicted annually prior to project approval
    - During operation and post-closure
    - NOW will recommend a licence condition for *maximum* annual take from the start
  - At a fixed rate or varying in time
    - River loss – high security water if constant/unavoidable; general security if controllable
  - Using “complex groundwater modelling” where potentially significant impacts might occur
    - Compliant with Australian Groundwater Modelling Guidelines
  - Using less complex techniques where potentially significant impacts will not occur
  - Measured, and reported annually
  - Proportional assignment to affected water sources
  - Availability of water entitlements and water allocations
  - Mechanism for obtaining a licence
    - On hand
    - Trading rules
    - Market depth

MINIMAL HARM

- "*Aquifer interference approvals are not to be granted unless the Minister is satisfied that adequate arrangements are in force to ensure that* ***no more than minimal harm*** *will be done to any water source, or its dependent ecosystems*..."

- Criteria developed for water-dependent assets:
  - Groundwater sources
  - Connected water sources
  - Dependent ecosystems
  - Culturally significant sites
  - Water users

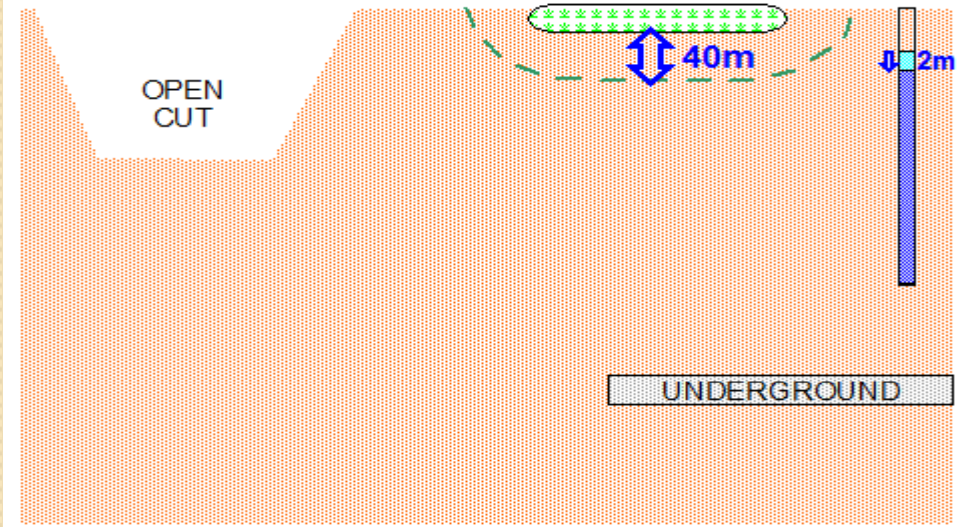
MINIMAL HARM

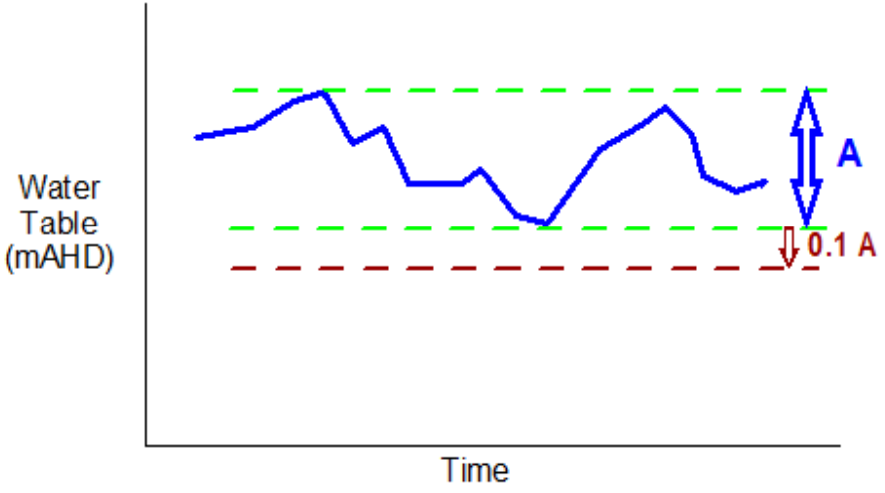
- Three attributes:
  - Water Table
  - Water Pressure
  - Water Quality
- Two Groundwater Source Categories:
  - Highly Productive
  - Less Productive

MINIMAL IMPACT CONSIDERATIONS

[Typical Rules for Highly Productive Groundwater]

- Water Table:
  - <10% of seasonal variation at 40m from
    - High priority GDE
    - High priority culturally significant site
  - <2m at water supply work (“bore”)





e.g. A=2m; drawdown <

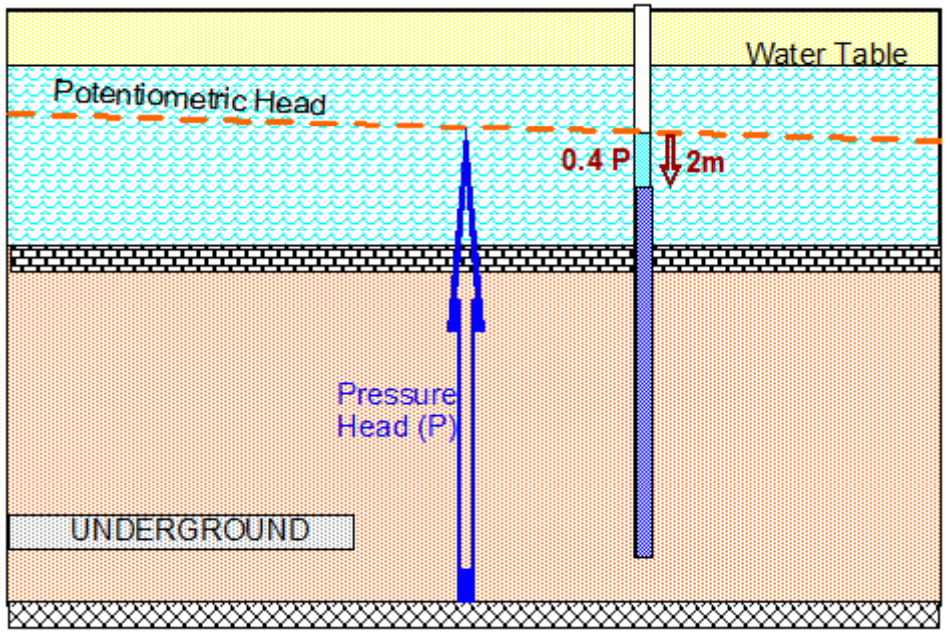
MINIMAL IMPACT CONSIDERATIONS
[Typical Rules for Highly Productive Groundwater]

- Water Table:
  - The drawdown allowances are cumulative for all AI activities
  - Seasonal variation is to be assessed *after* the WSP started
    - oldest 2004; this means irrigation impacts are acknowledged
  - The GDE must be listed in the WSP
  - If >10% drawdown, "appropriate studies" are required to prove no effect on long-term GDE viability
  - If >10% drawdown, modelling accuracy will be taken into account
  - If >2m at water supply work, "make good" provisions are required
  - The rules are the same for all 4 aquifer types (not applicable for GAB)
  - The rules are the same for *Less Productive* Groundwater

MINIMAL IMPACT CONSIDERATIONS

[Typical Rules for Highly Productive Groundwater]

- Water Pressure:
  - <40% of post-WSP pressure head above the base of the water source; and
  - <2m at water supply work ("bore")



2m rule holds unless P < 5m

MINIMAL IMPACT CONSIDERATIONS
[Typical Rules for Highly Productive Groundwater]

- Water Pressure:
  - The drawdown allowances are cumulative for all AI activities
  - The pressure head is to be assessed *after* the WSP started
  - The 40% rule is unlikely to ever apply
  - If >2m pressure head drawdown, "appropriate studies" are required to prove no effect on long-term bore viability
  - If >2m pressure head drawdown, modelling accuracy will be taken into account
  - If >2m at water supply work, "make good" provisions are required
  - The rules are almost the same for all 4 aquifer types:
    - No 40% rule for coastal sands, porous rock, fractured rock
    - 3m rule for Lower Murrumbidgee
    - More stringent national rules for GAB
      - 20cm drawdown at 40m from GDE/cultural site
      - 15m or 30m cumulative pressure head decline
      - 10% of 2008 artesian head
  - The rules are the same for *Less Productive* Groundwater

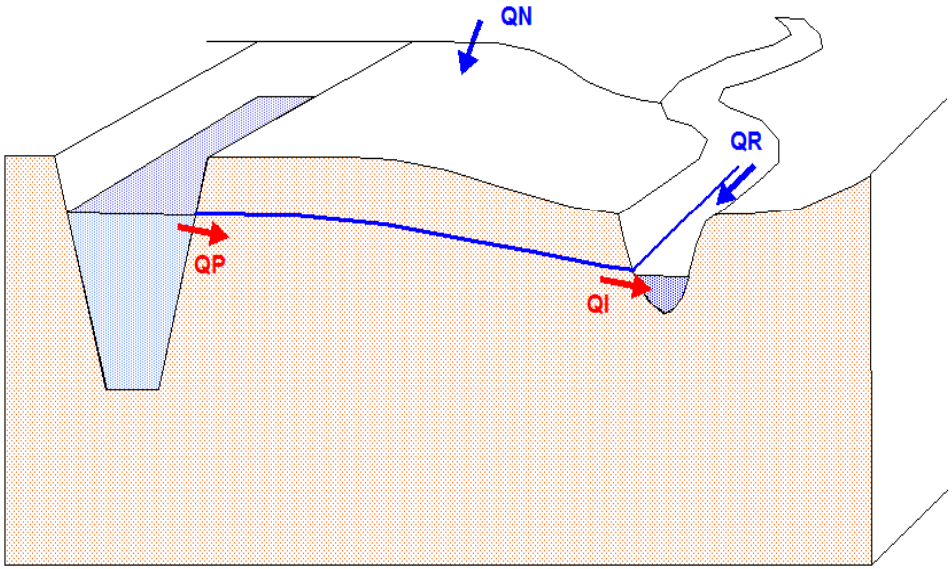
MINIMAL IMPACT CONSIDERATIONS
[Typical Rules for Highly Productive Groundwater]

- Water Quality:
  - No lowering of beneficial use category beyond 40m from the AI activity
  - <1% change in average salinity of nearest stream
    - Highly connected surface water source
    - For <u>each</u> AI activity
    - "Reliable water supply":
      - Stream order 5, 6, 7...
      - Any unregulated stream flowing >95% of the time

MINIMAL IMPACT CONSIDERATIONS

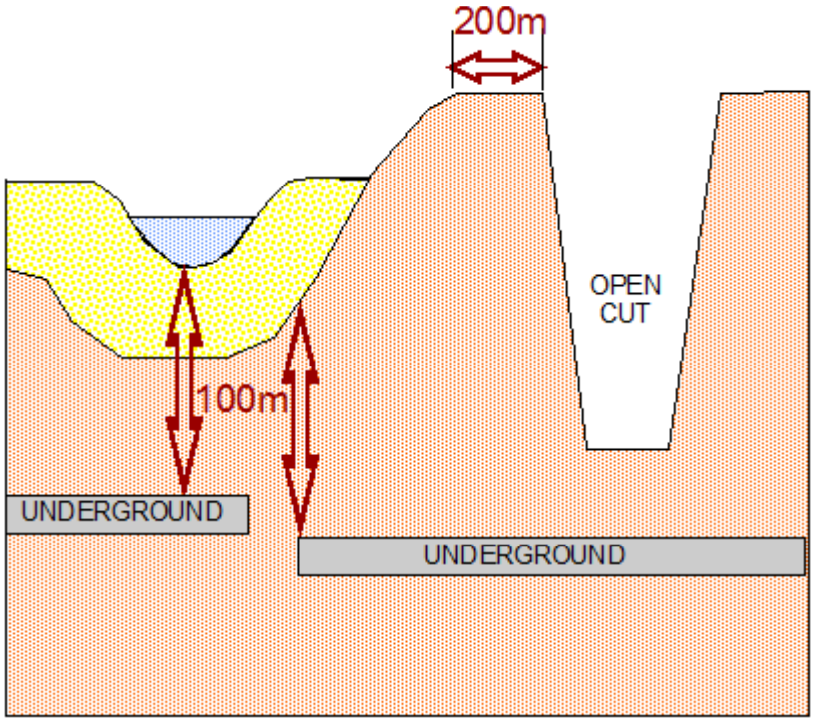
[River Salinity Increase]

- **Salt Loads**
  - Pit: $SL_P = Q_P C_P$
  - River (pre-mining): $SL_{R1} = Q_R C_{R1}$
  - River (post-mining): $SL_{R2} = SL_{R1} + SL_P = (Q_R + Q_P)$ C_{R2}
- **Example**
  - C_{R1} = 250 mg/L = 0.25 kg/m^3
  - Q_R = 1000 ML/day = 10^6 m^3/day
  - Q_P = 0.5 ML/day = 500 m^3/day
  - C_P = 5000 mg/L = 5 kg/m^3
  - SL_{R1} = (10^6)(0.25) = 250 t/day
  - SL_P = (500)(5) = 2.5 t/day
  - SL_{R2} = 250 + 2.5 = 252.5 t/day
  - C_{R2} = 252.5 / 10^6 = 252.5 mg/L
  - Salinity Ratio: f = (252.5 – 250) / 250 = 2.5 / 250 = 1.0%
- **Concentration**
  - River (post-mining):
  - $C_{R2} \approx SL_{R2} / Q_R$
  - ...for $Q_R >> Q_P$
- **Salinity Ratio**
  - $f \approx (C_{R2} - C_{R1}) / C_{R1}$
  - ...for $Q_R >> Q_P$



MINIMAL IMPACT CONSIDERATIONS
[Typical Rules for Highly Productive Groundwater]

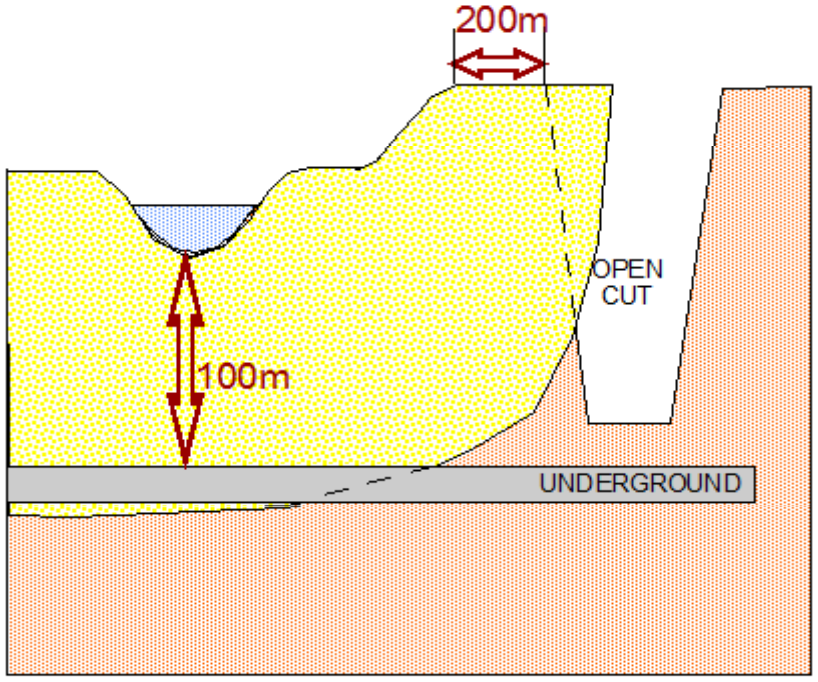
- Water Quality:
  - No mining activity within 200m laterally from the top of high bank or 100m vertically beneath (or the three dimensional extent of the alluvial water source - whichever is the lesser distance) a highly connected surface water source that is defined as a “reliable water supply”.



MINIMAL IMPACT CONSIDERATIONS

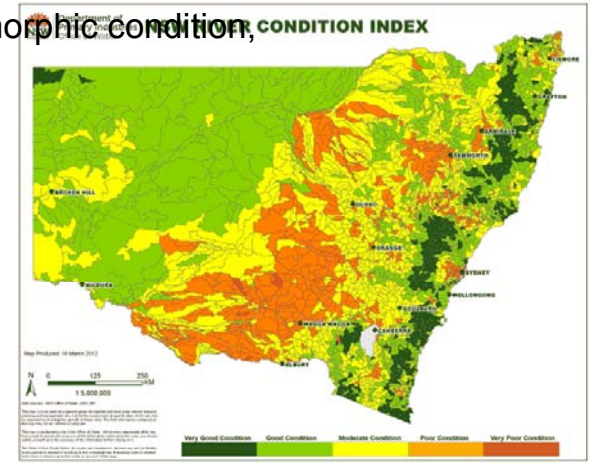
[Typical Rules for Highly Productive Groundwater]

- Water Quality:
  - Not more than 10% cumulatively of the three dimensional extent of the alluvial material in this water source to be excavated by mining activities beyond 200m laterally from the top of high bank and 100m vertically beneath a highly connected surface water source that is defined as a "reliable



MINIMAL IMPACT CONSIDERATIONS
[Typical Rules for Highly Productive Groundwater]

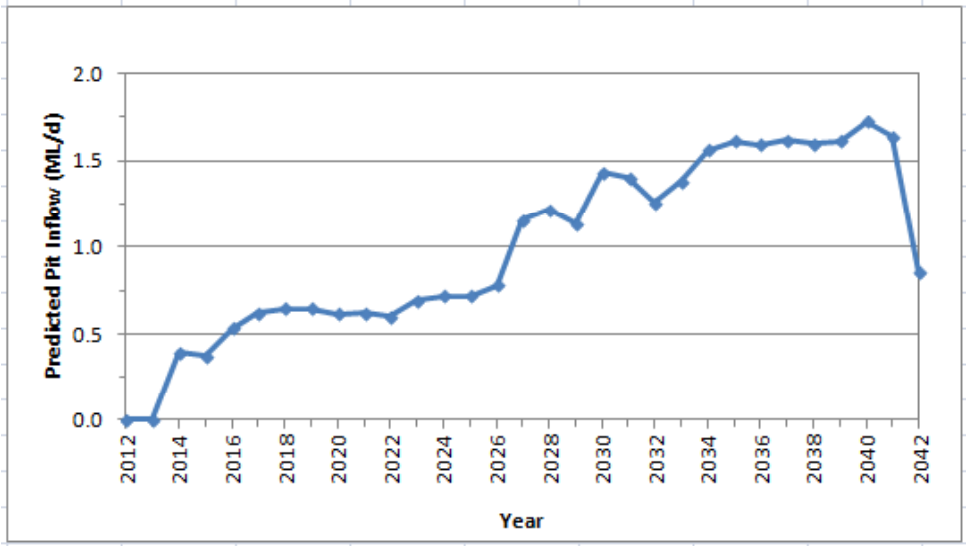
- Water Quality:
  - The beneficial use rule applies to all aquifer types and less productive groundwater
  - The 1% salinity rule applies only to Alluvial Water Sources - highly productive and less productive
  - The 200m offset rule applies only to Alluvial Water Sources - highly productive and less productive
  - The 10% volume rule applies only to Alluvial Water Sources - highly productive and less productive
  - If beneficial use rule is breached, "appropriate studies" are required to prove no effect on long-term GDE viability, cultural site or production bore
  - If 1% salinity or 10% volume rule is breached, "appropriate studies" are required to prove no effect on River Condition Index category
    - very poor, poor, moderate, good and very good
    - riparian vegetation, hydrologic stress, river biodiversity, geomorphic condition, catchment disturbance
  - If 200m offset or 10% volume rule is breached, "appropriate studies" are required to demonstrate:
    - negligible bank instability
    - prevention of maximum flood entering the mine
    - effective low-permeability barrier

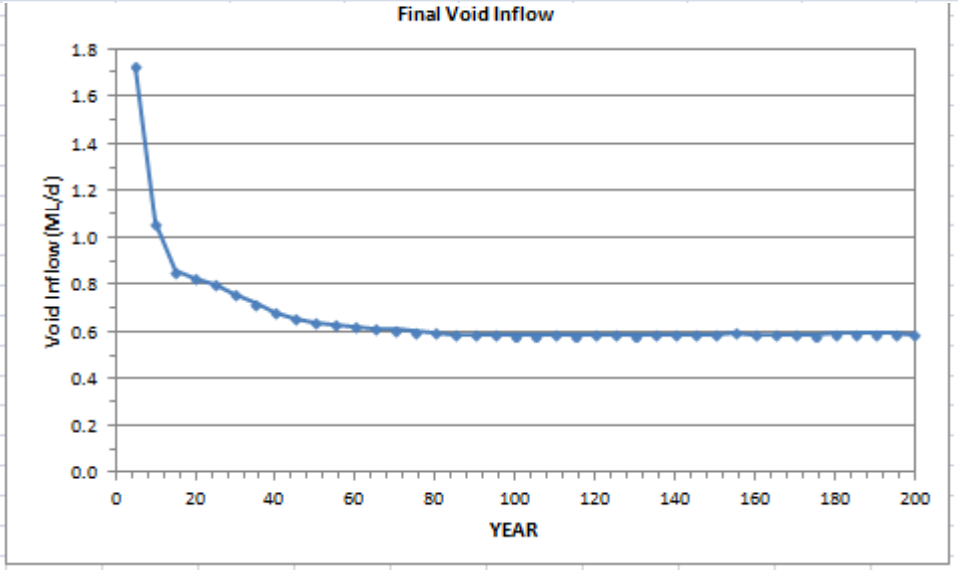


EXAMPLES

DEWATERING

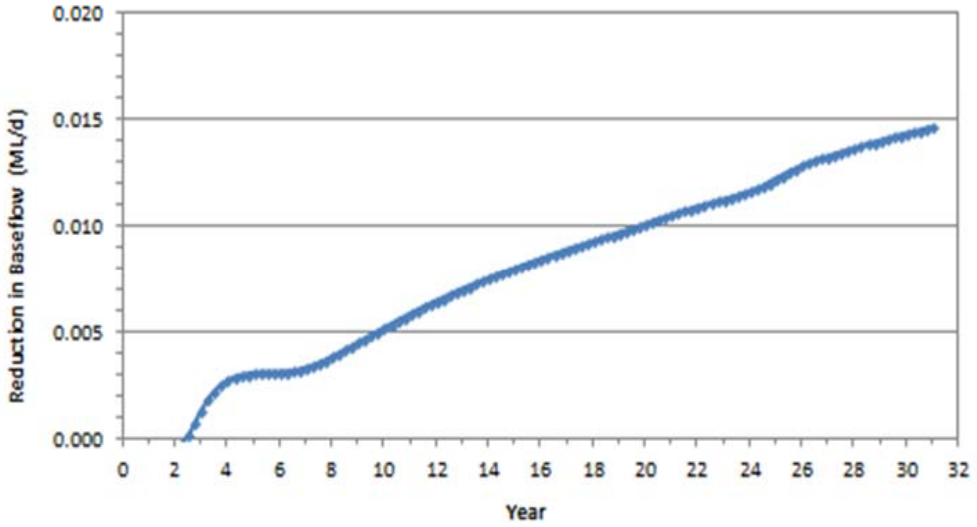
- Pit inflow during mining
  - 30 years
- Final void inflow post-mining
  - 200 years



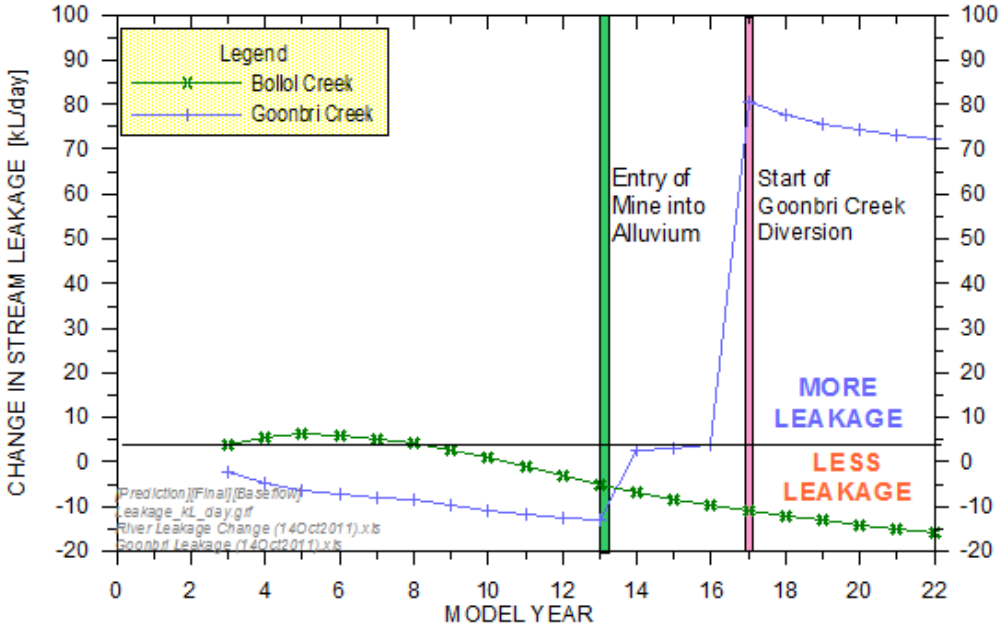


IMPACTS

- Reduction in baseflow during mining
  - 30 years

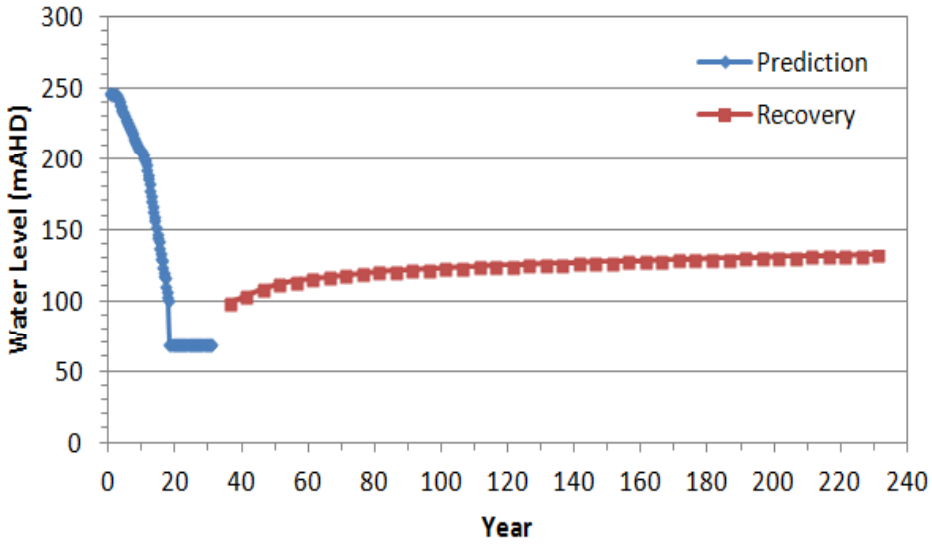


- Changes in stream leakage
  - 20 years
  - excavated alluvium
  - creek diversion
  - low-permeability barrier

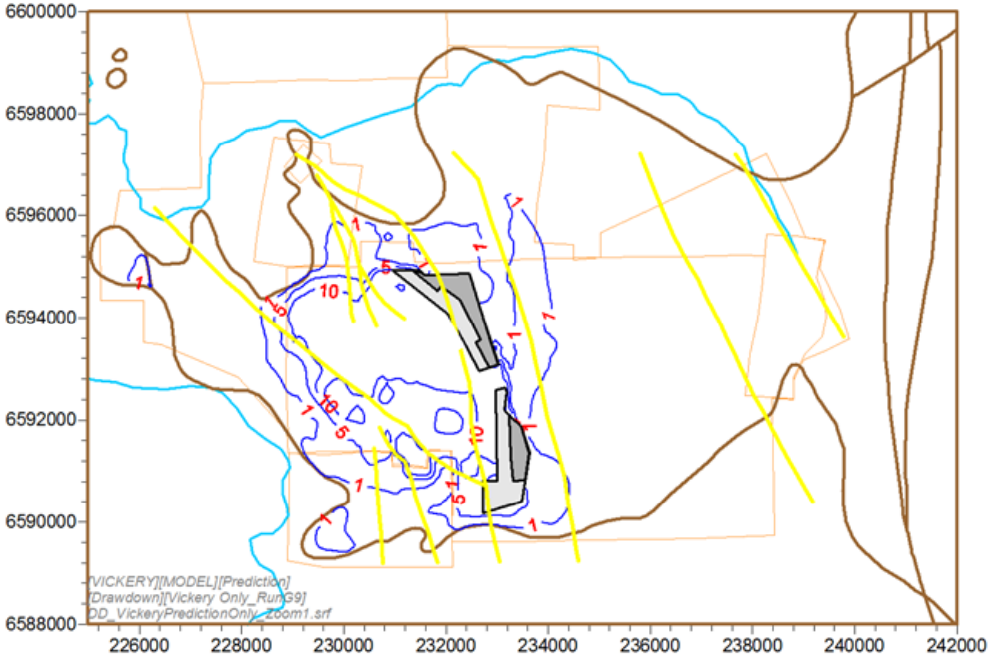


IMPACTS

- Drawdown during mining and recovery post-mining
  - 230 years

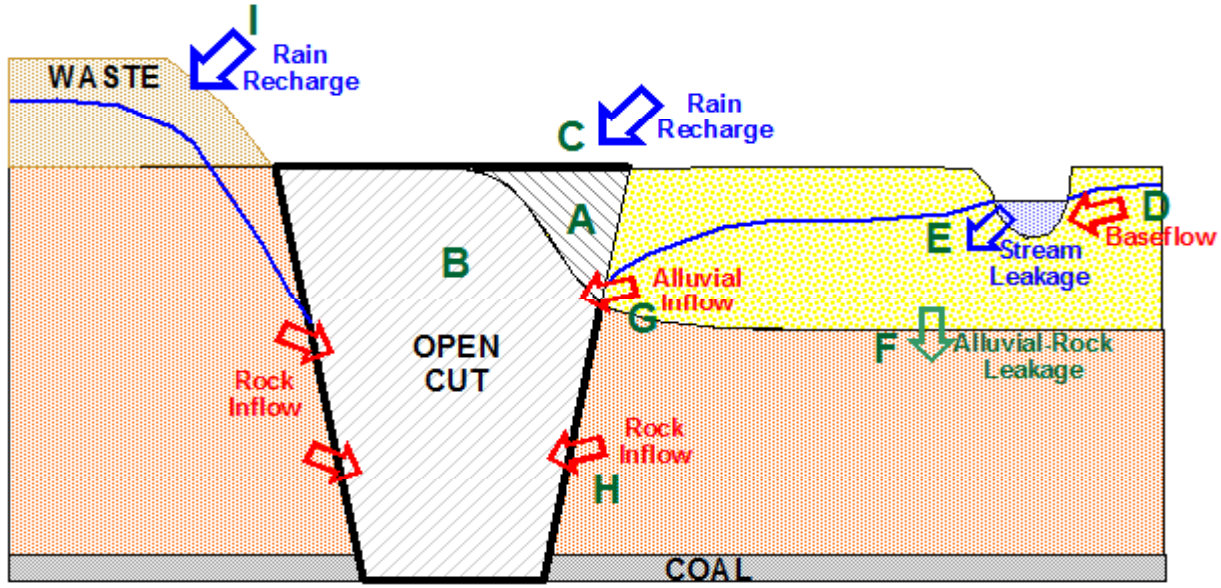


- Spatial drawdown
  - end of mining
  - alluvium / regolith



LICENSING

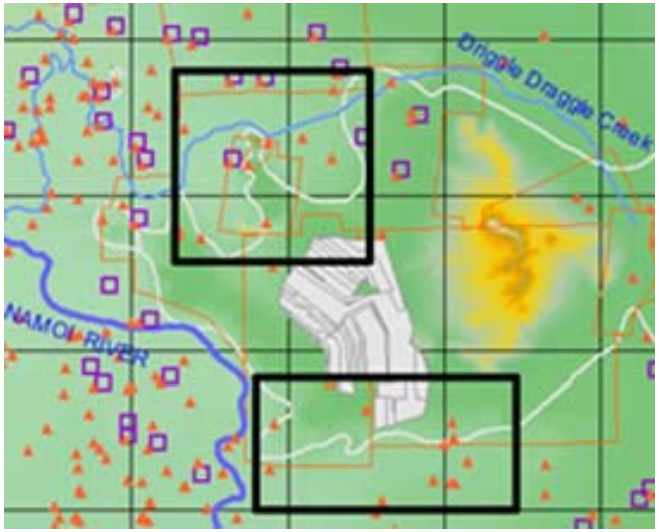
PARTITIONING

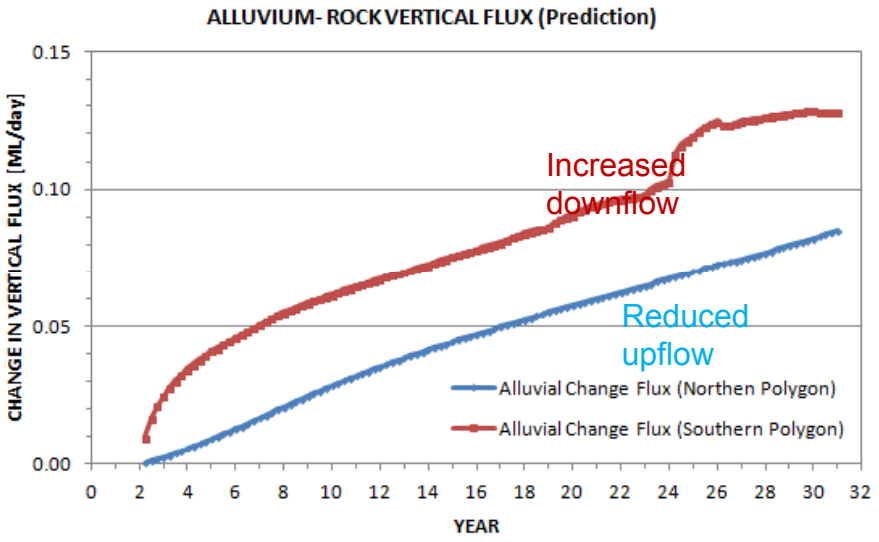


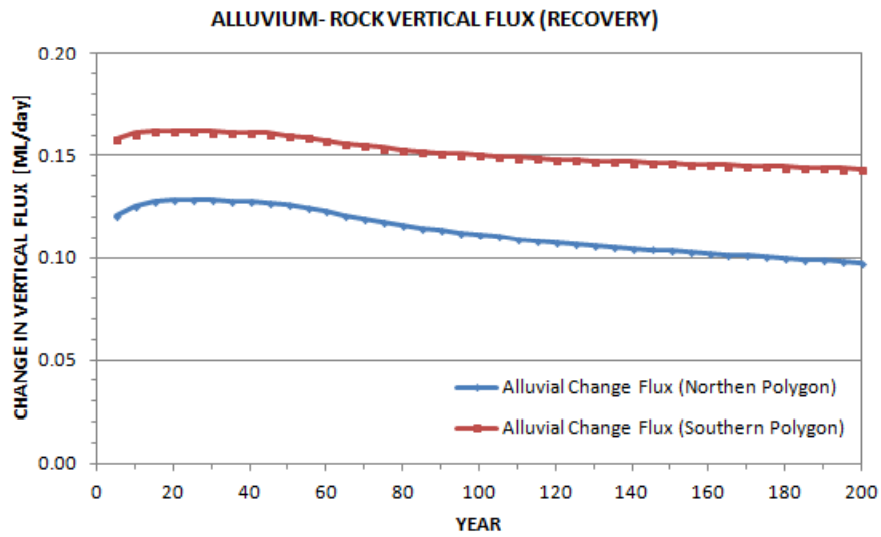
A. Water stored in excavated alluvium – *recycled in rehab soil*
B. Water stored in excavated rock – *recycled in waste*
C. Loss of rain recharge to excavated alluvium – *rain is not State's water rights*
D. Reduced baseflow – *take from stream*
E. Increased stream leakage – *take from stream*
F. Enhanced alluvial-rock leakage – *take from alluvial water source*
G. Mine inflow from alluvium – *take from alluvial water source*
H. Mine inflow from porous rock– *take from porous rock water source*
I. Enhanced rain recharge through waste emplacements and pit infill – *rain is not State's water rights*

LICENSING

- Changes in vertical leakage from alluvium to rock
  - *during mining*
  - *post-mining*







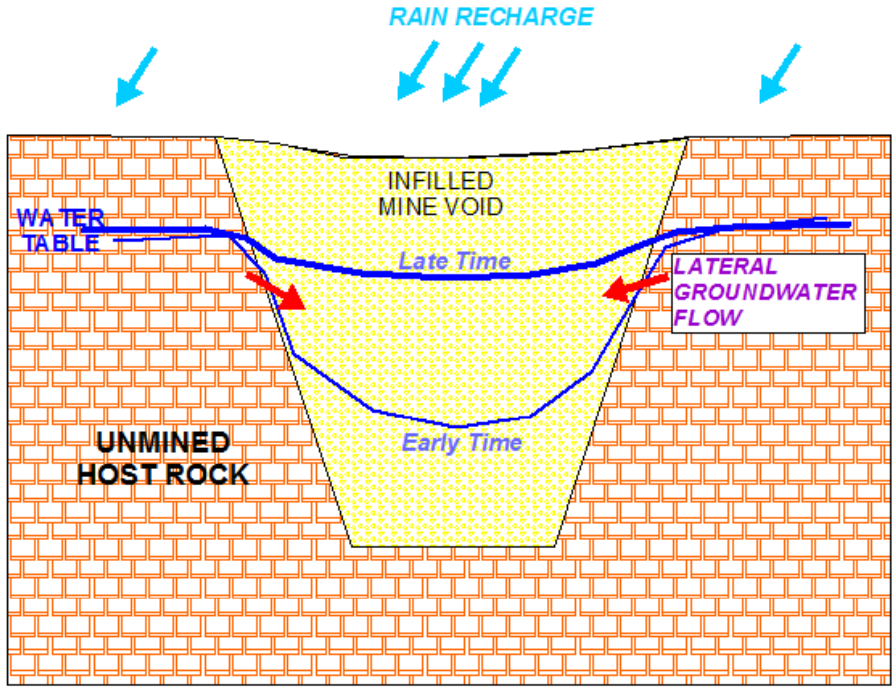
PARTITIONING

Water Sharing Plan	Management Area/ Management Zone/ Water Source	Predicted Average Annual Inflow Volumes requiring Licensing (ML/annum)			
		Years 1 to 11	Year 12	Years 13 to 17	Post-Mining
Upper Namoi and Lower Namoi Regulated River Water Sources 2003 *(commenced July 2004)*	Namoi River within Namoi Water Management Area	Nil*			
Upper and Lower Namoi Groundwater Sources 2003 *(commenced November 2006)*	Upper Namoi Zone 4 - Namoi Valley (Keepit Dam to Gin's Leap)	Negligible	198~	142~ (Average) 169~ (Maximum)	Negligible^
NSW Murray Darling Basin Porous Rock Groundwater Sources 2011 *(commenced January 2012)*	Gunnedah-Oxley Basin – Namoi	209 (Average) 252 (Maximum)	209	209 (Average)	167+ (Maximum)
Draft Namoi Unregulated and Alluvial Water Sources Order *(October 2011)*	Maules Creek Tributaries Management Zone in the Maules Creek Water Source within Namoi Unregulated Rivers Extraction Management Unit	Nil[1] - Negligible[2,3]			

- Extra vertical leakage from alluvium to rock: 5 ML/a
- Loss of natural recharge to excavated alluvium: 6 ML/a
- Loss of water stored in excavated alluvium in backfill - retained
- Goonbri Creek: 5 ML/a
- Bollol Creek: 5 ML/a
- Nagero Creek: 0.001 ML/a

LICENSING

- Post-mining flow to an infilled void:
  - *"Movement" of water must be licensed until groundwater level equilibrates*



THE GATEWAY PROCESS

The gateway process

The Gateway is an independent, scientific and upfront assessment of how a State significant mining or CSG proposal on strategic agricultural land will impact the agricultural values of the land on which it is proposed to be located. It will consider proposals at a very early stage before a development application is lodged.

To pass the Gateway unconditionally, a proposal must demonstrate that it meets the Gateway criteria relating to agricultural and water impacts.

If a proposal can't demonstrate that it meets these criteria, it will be subject to stringent requirements – included as conditions of a Gateway certificate – that must be addressed at the development application stage.

The Gateway assessment will be undertaken by an independent panel of experts in fields such as agricultural science, water, and mining against explicit, objective criteria.

The Gateway will be given statutory force through an amendment to State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007.

- Home
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- Strategic Planning
  - Regional strategies
  - Sydney over the next 20 years
  - Strategic Regional Land Use
    - Former Coal & Gas Strategy
    - Archive - Draft SRLUP and consultation
  - Employment lands
  - Transport
  - Catchments and Waterways
  - Coastal protection
  - Major hazards
  - Funding Programs
  - iPlan Services
- Housing Delivery
- Local Planning
- Development

Strategic Regional Land Use

Overview

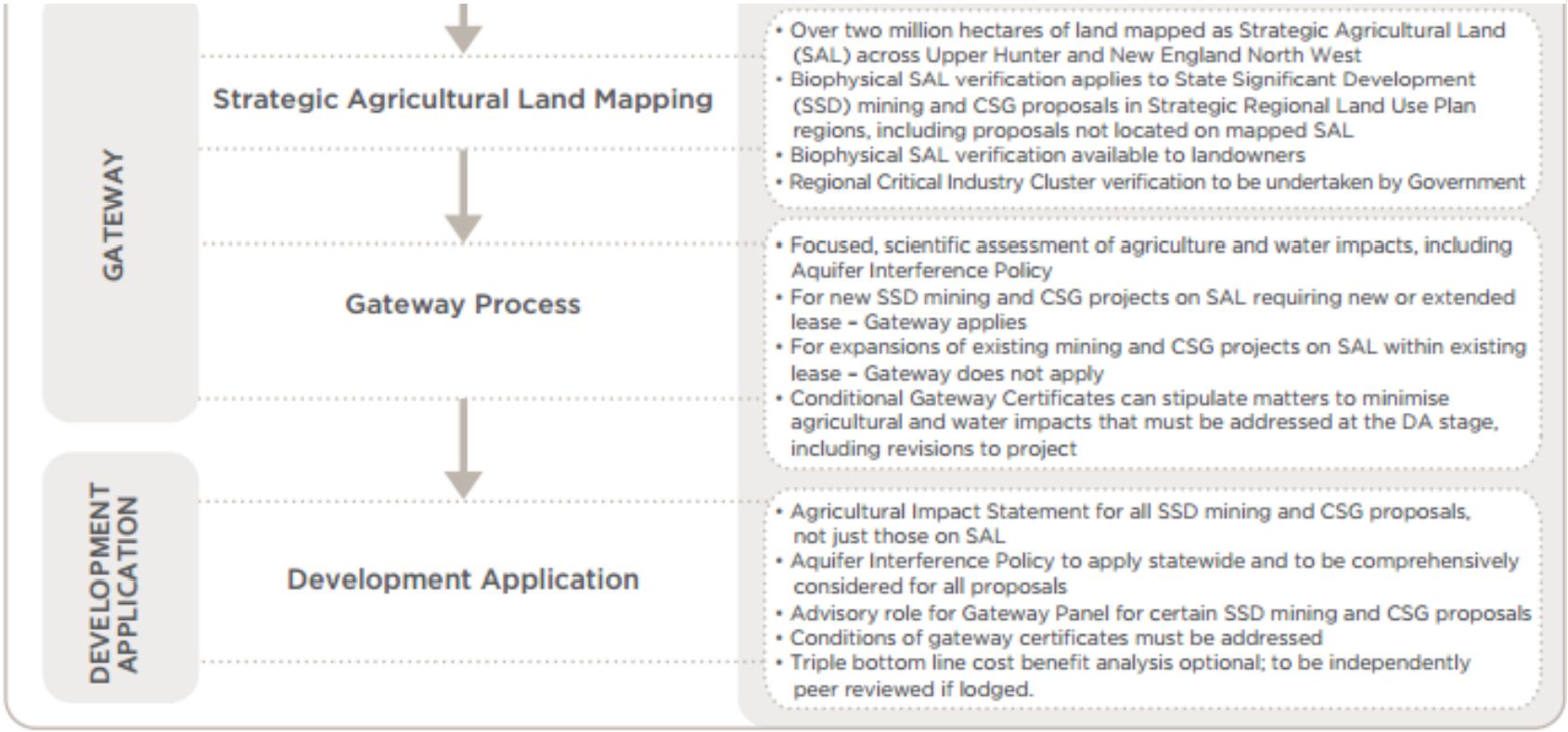
The Strategic Regional Land Use Policy identifies and protects more than 2 million hectares of strategic agricultural land, protects valuable water resources and provides greater certainty for companies wanting to invest in mining and coal seam gas projects in regional NSW.

Key elements of the package include:

- Strengthening the regulation of exploration activity and creation of a Land and Water Commissioner
- Strategic Regional Land Use Plans (SRLUPs) covering the Upper Hunter and New England North West regions
- A statewide Aquifer Interference Policy
- The requirement for an Agricultural Impact Statement at the exploration and development application stages
- Two new Codes of Practice for the CSG industry

As a result of this policy, all State significant mining and coal seam gas proposals that extend beyond an existing lease area on strategic agricultural land must go through an independent, scientific and upfront assessment of their agricultural land and water impacts before a development application can be lodged.

Status of Strategic Agricultural Land Mapping	
Strategic Regional Land Use Plans	
Complete:	Upper Hunter New England North West
Commenced:	Central West Southern Highlands
To be commenced in 2013:	Western Murrumbidgee Alpine
Other Regions	
Regional Strategies – to be reviewed and updated over the next two years:	Far North Coast Mid North Coast Lower Hunter Central Coast Illawarra South Coast Sydney-Canberra Corridor Murray



EFFORT REQUIRED

- Provide estimates of all quantities of water that are likely to be taken from any water source ... *(during and afterwards)* ... and all predicted impacts ... based on
  - a simple modelling platform (for the Gateway process)
    - deemed "fit-for-purpose"
    - available baseline data (apt frequency & scale)
  - a complex modelling platform (for other State significant developments)
    - calibrated over period with temporal variations
    - 2 years baseline *if* more than minimal harm likely
  - desk-top analysis (for all other processes)
    - deemed "fit-for-purpose"

HOW SIMPLE IS “Simple”?

HINT

- NOW expects a risk management approach ...
  - Level of detail is to be proportional to
    - Likelihood of impacts; and
    - Potential consequences of impacts

PERSONAL VIEW

- This suggests “horses for courses” rather than “one size fits all”:
  - Each project should undergo a *mini risk assessment*, in terms of the minimal harm criteria being breached, before settling on the modelling methodology

HOW SIMPLE IS “Simple”?

CAUTION

- The assessment time for Gateway is likely to be compressed by proponents
- Limited to groundwater and agriculture assessments (no cost-benefit argument)
- Out of “sync” with traditionally parallel assessments (*surface water hydrology, subsidence, geochemistry, ecology*) that will happen later
- 70-90 day assessment window for Gateway Panel, which includes time for advice from
  - IESC (Commonwealth Independent Expert Scientific Committee)
  - NOW (Office of Water *for* Minister for Primary Industries)
  - *(No public consultation or exhibition)*
- Outputs:
  - Level 1 Certificate: within harm criteria
  - Level 2 Certificate: likely to breach harm criteria; conditions on reduced project size or extra studies or more data or better modelling, etc.
  - Gateway conditions must be considered by PAC in its determination of the subsequent development application
  - Gateway conditions must be addressed by proponent

HOW SIMPLE IS “Simple”?

OPTIONS

- DESK-TOP:
  - Little chance of estimating reliable water takes and impacts
- Analytical Models:
  - Some chance of estimating reliable impacts and some water takes (not baseflow/leakage)
  - Limited number of layers
- 2D or Analytic Element Models:
  - Limited number of layers
  - Some chance of estimating indicative impacts and water takes

HOW SIMPLE IS “Simple”?

OPTIONS

- 3D Steady-State Regional Area:
  - Good chance of estimating *conservative* water takes and impacts
  - Substantial work building model geometry up-front
  - Faster development time than a transient model
- 3D Transient Local Area:
  - Good chance of estimating *reliable* water takes and impacts
  - Some work building model local geometry
- 3D Transient Regional Area:
  - Best chance of estimating *reliable* water takes and impacts
  - Substantial work building model geometry up-front
  - Perhaps coarsen the stratigraphy
  - Perhaps coarsen the model grid away from the impact areas

HOW SIMPLE IS “Simple”?

What do you think?

Extracted Slides from “Water in Coal Mines” 2012 Course (Noel Merrick): Groundwater Impact Assessment

UNCERTAINTY ANALYSIS

UNCERTAINTY

- Uncertainty in quantity of licensed water:
  - *If significant impact on the environment or other authorised water users might occur*...
  - Report on a number of issues rather than allowing for them through more conservative licensing
    - Quantify the risk for “take” estimates due to enhanced hydraulic connection
    - Quantify other uncertainties due to groundwater impact modelling
    - Quantify other uncertainties due to surface water impact modelling
    - Strategies for monitoring actual take
    - Strategies for reassessing predicted take
      - How will changes be accounted for?
      - Analysis of water market depth
      - *In situ* mitigation
      - *In situ* remediation

UNCERTAINTY

- Uncertainty in quantity of licensed water:
  - ***2012 Modelling guidelines...***
    - More emphasis than 2001 guidelines
    - No prescribed method
    - **Guiding Principle 7.4: "**Analysis of uncertainty should recognise that there is more uncertainty when reporting confidence intervals around an absolute model output, and less uncertainty when a prediction can be formulated as a subtraction of two model results."
    - **Guiding Principle 7.6: "**Uncertainty should be presented to decision-makers with visual depictions that closely conform to the decision of interest."
    - "When possible, the visual depiction should highlight the fact that the model prediction is more than a single result or set of results, thus underscoring the inherent non-unique nature of groundwater modelling."

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