Mine Water Management

Heaven or Hell for Hydrologic Modellers?

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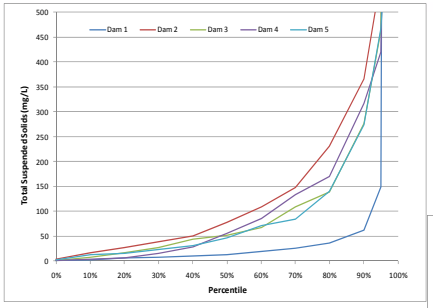
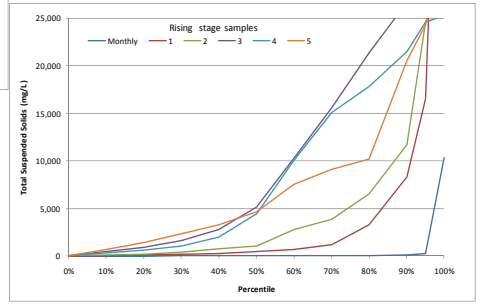
Water Quality
Numerous sources – Different pollutants

- Runoff into pit — Coal dust, sediment;
- Groundwater inflow — Salinity, pH, iron;
- Coal stockpiles — Coal dust;
- Haul roads — Sediment, coal dust;
- Vehicle maintenance — Hydrocarbons;
- Fuel storage — Hydrocarbons;
- Overburden runoff — Sediment;
- Overburden leachate — Salinity, acid leachate;
- Washery tailings disposal — Sediment, salinity, pH?

Comparison of sediment dam and drainage line water quality





Mine Water Quantity & Quality

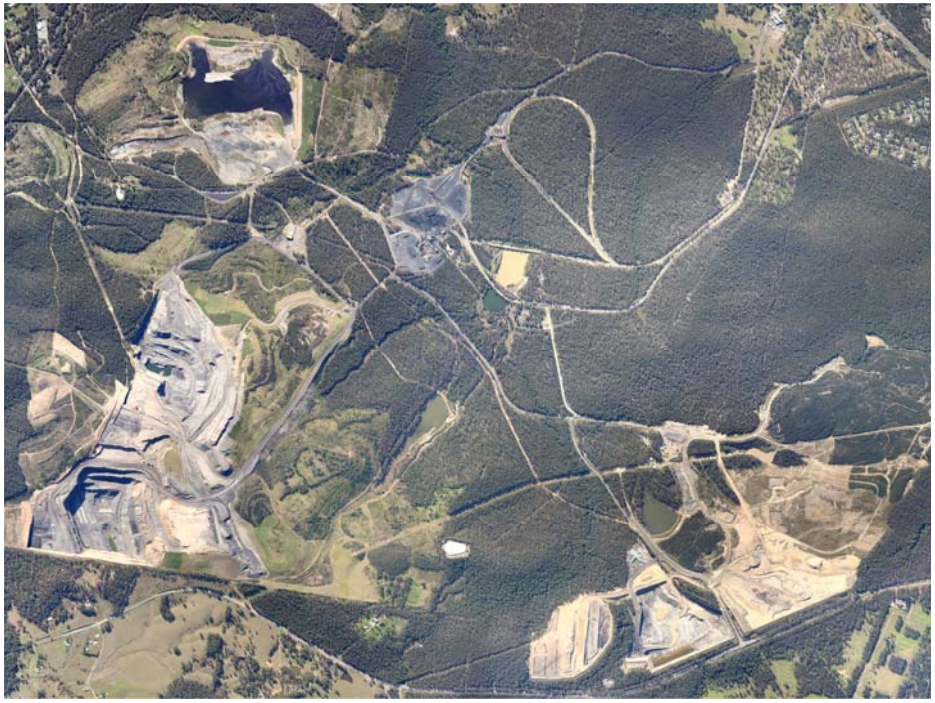
- Highly variable over time;
- Pit & overburden area variable throughout mine life;
- Groundwater inflow to pit variable – generally related to depth of pit;
- Groundwater inflow to U/G workings variable depending of mine layout;
- Runoff highly variable depending on climate (typical annual variation: 20% - 300% of average)
- Consequences of changes to mine plan

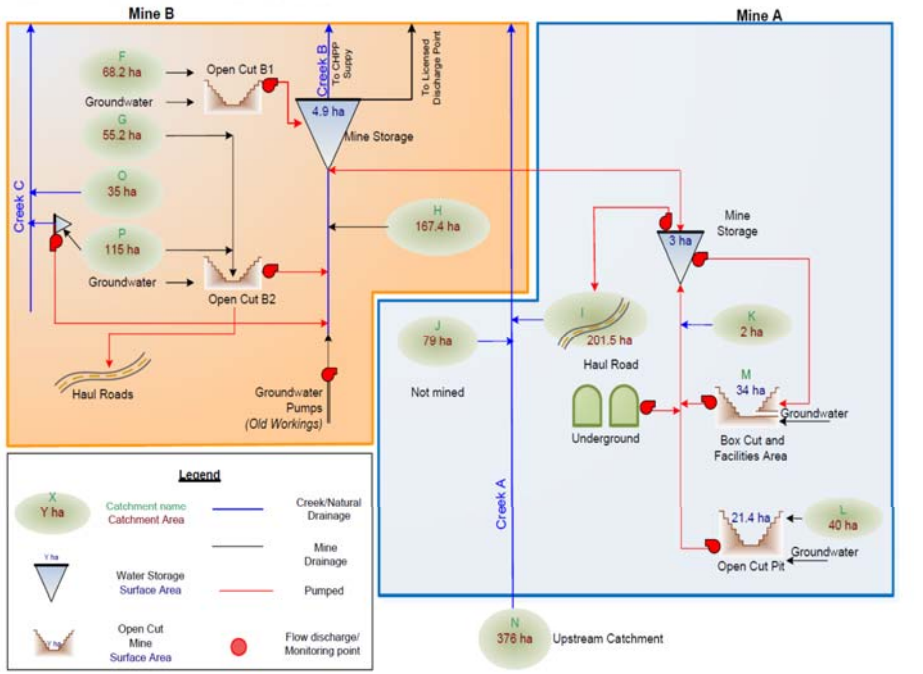
Management Issues

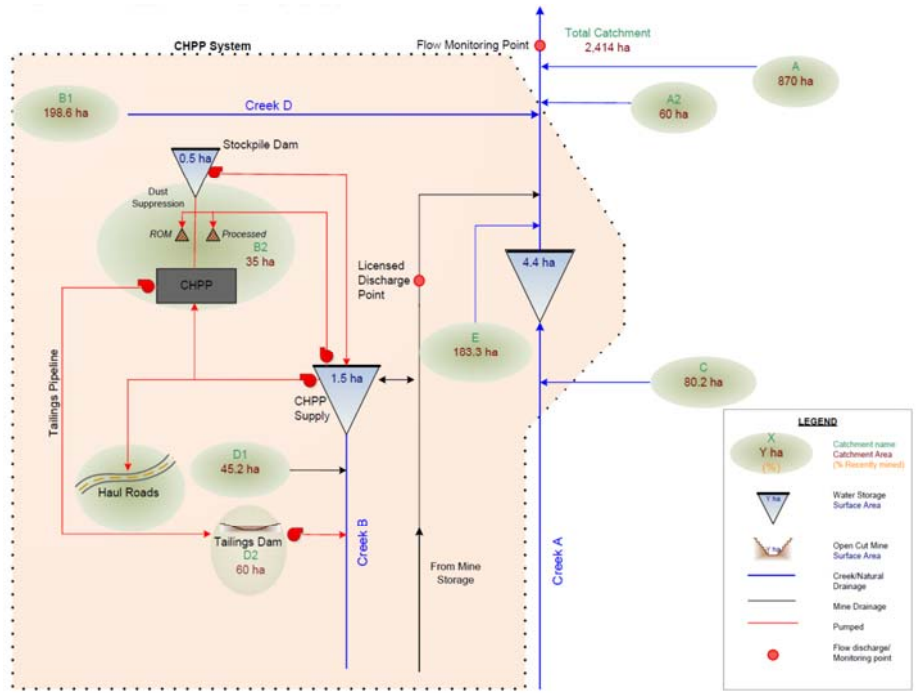
- **Sufficient supply** for mine operations:
  - Dust suppression
  - Longwall operation
  - Coal washing
- **Sufficient storage** to meet operational requirements
  - Reliability of supply
  - Storage of excess – without compromising production
  - Treatment and discharge in the event of excess?
- **Minimise discharge** (zero discharge preferred)
  - Divert external catchments
  - Enhanced use/loss (irrigation, evaporation)
  - Water quality (sediment, salinity)
  - Treatment
  - HRSTS.

Regulatory Issues

- **Water access licenses for incidental take**
  - Unavoidable groundwater make
  - Problem when linked to ‘cease to pump’ rules in the WSP
  - Aquifer interference policy
  - Return flows not counted
- **Water access licenses for supply;**
  - Availability of surface and groundwater licenses
  - Supply reliability
- **Discharge licenses/permits**







Issues

- **Complex interactions between**
  - Evolving mine landform
  - Rehabilitated and ‘natural’ catchments
  - Water management system
  - Storage requirements
- **Water balance highly dependent on climate**
- **Increasing salinity:**
  - Deeper pits
  - Underground mining

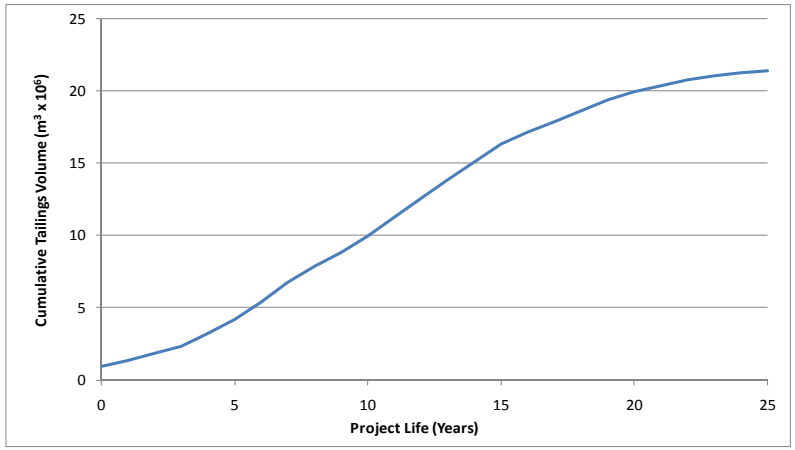
Issues

- Alterations to mine plan and production
- Short term variation in CHPP throughput
- Operating rules for exchange of water between mines
- Opportunities for discharge from sites

Predicted Annual ROM Supply and CHPP Water Requirement

(Assumes slurry disposal)

Projected Tailings Storage Requirements



Mine Water Balance

- Water sources (internal and external)
- Water demands
  - Dust suppression,
  - Coal processing,
  - Underground operations
- Losses / discharge
- Storage

Water Demands

- **Dust suppression,**
  - Mainly achieved by water spray (chemicals in special situations)
  - Differentiate between stockpiles and haul roads
- **Consistency of approaches** by air quality modellers and hydrologists?
- **Underground operations**
  - Typical longwall – 1 ML/day
  - Dust suppression

Dust Suppression

- **Dust suppression – haul roads**
  - Mainly achieved by water spray (chemicals in special situations)
  - Dependent on haul area and weather (rainfall and wind)
  - Little benchmarked data in Australia
  - South African research – water required to maintain wet surface (effects of road albedo and wheel movement)
- **Dust suppression – coal stockpiles**
  - Dependent on dump height and reclaim process
- **Consistency of approaches** by air quality modellers and hydrologists?

Water Demands

- **Coal processing – dependent on**
  - Mining process and source characteristics (Open-cut ± 12% fines; Underground ± 8% fines)
  - Dewatering process

Treatment	Relative Water Requirements
Slurry disposal	100%
Secondary flocculation	90%
Paste thickener	60%
Belt press	40%
Pressure filter	30%
Solid bowl centrifuge	30%

- **Underground operations**
  - Typical longwall – 1 ML/day
  - Dust suppression

Why do we use models?

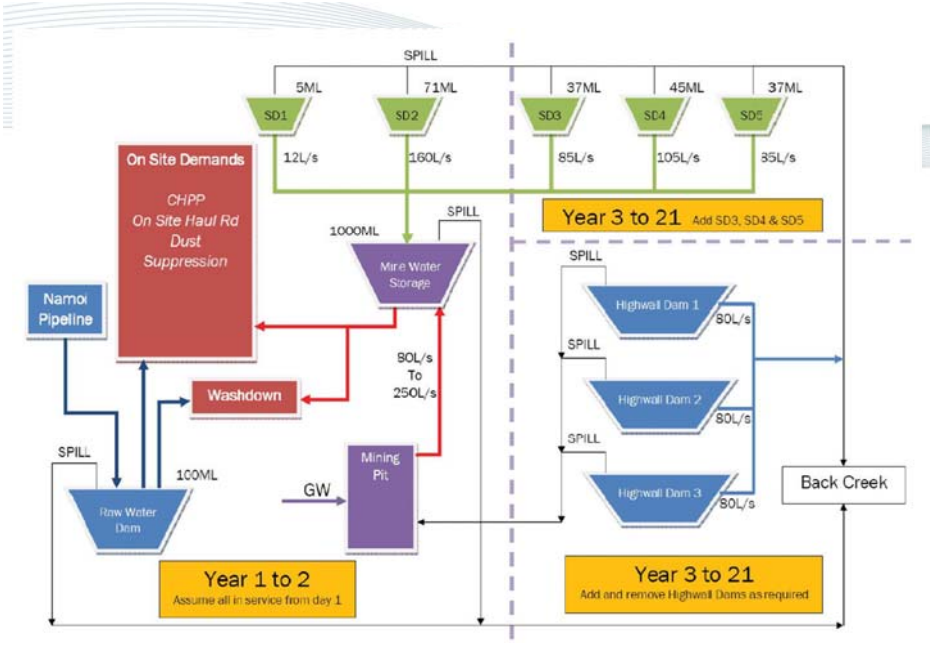
- **Prediction** of interaction between the mine, climate and the surrounding environment
- **Assessment (design)** of the location and size of facilities necessary to manage water
- **Understanding the risks**
- **Ongoing management** of water at an operating site:
  - Are predictions valid/correct?
  - Does management need to change?
  - Are new/additional facilities necessary?

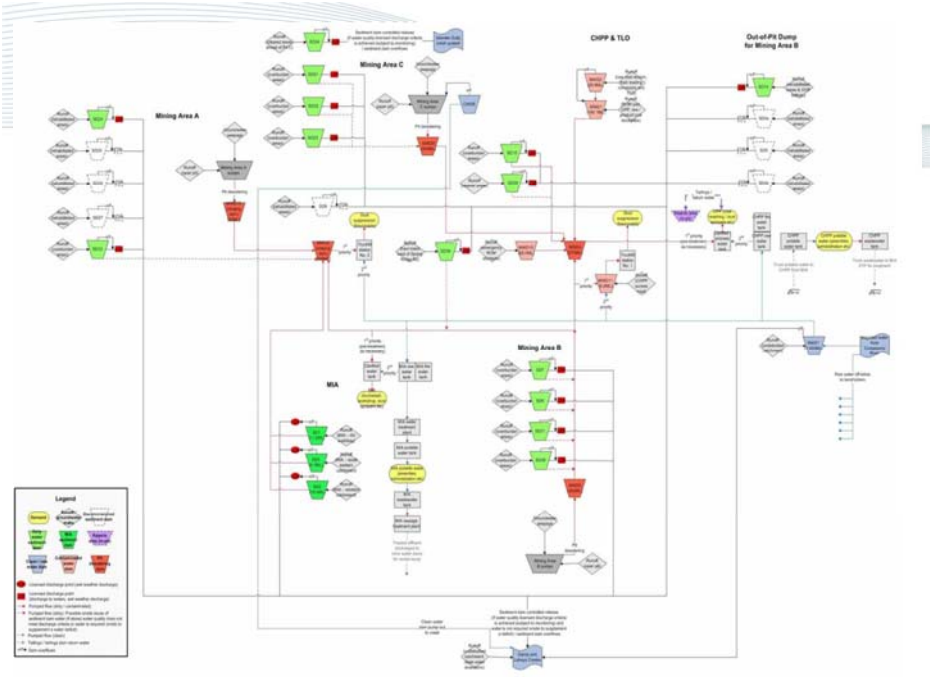
Modelling Considerations

- **Adequacy of supply - enough water?**
- **Adequate storage –**
  - Seasonal variation of rainfall and evaporation
  - Probability of extreme sequences of rainfall
  - Variation of groundwater make
  - Year-to-year carry-over of water
- **Discharge frequency, volume and quality**
- **Relevant timescale** to characterise runoff and mine operations
- **Data requirements and availability**

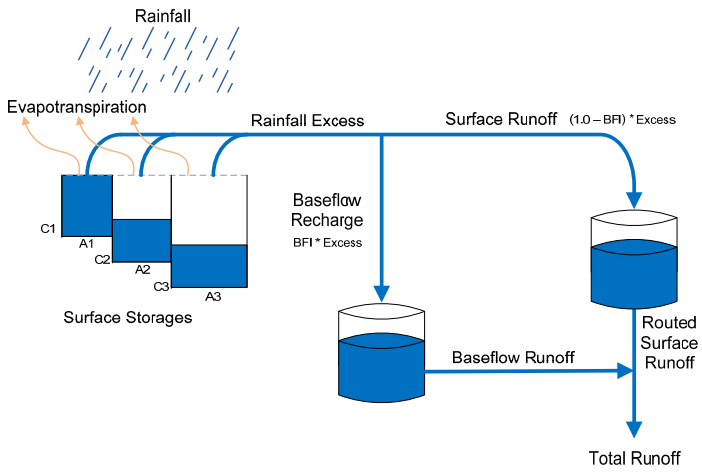
Mine Site Models

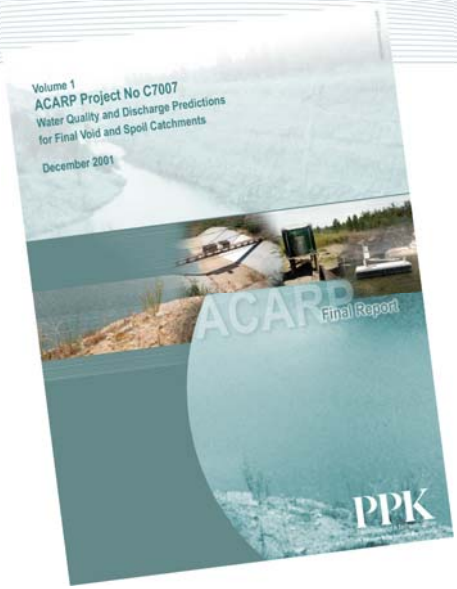
- **System models:**
  - Water gains and losses
  - Storages
  - Water conveyance (channels, pumps, pipelines)
  - Operating rules/triggers
- **Process models:**
  - Groundwater make
  - Runoff from different surfaces
  - Water uses (dust suppression, coal washing, etc)
  - Losses (evaporation, seepage)

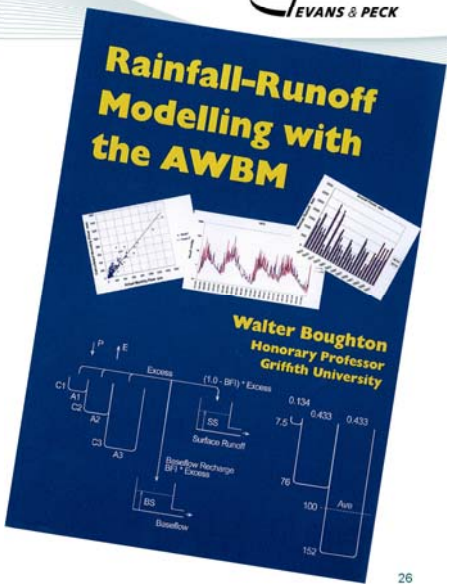




AWBM



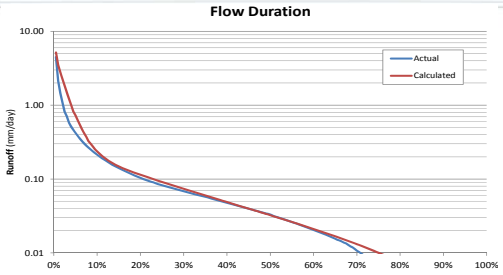


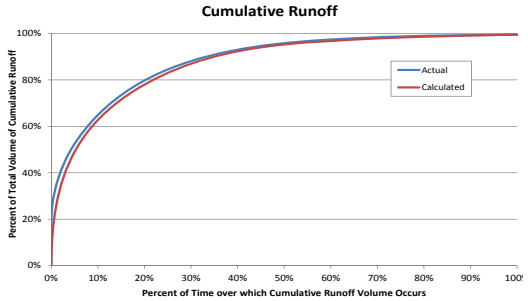


Model Parameter Estimation
Leave One Out Cross Validation

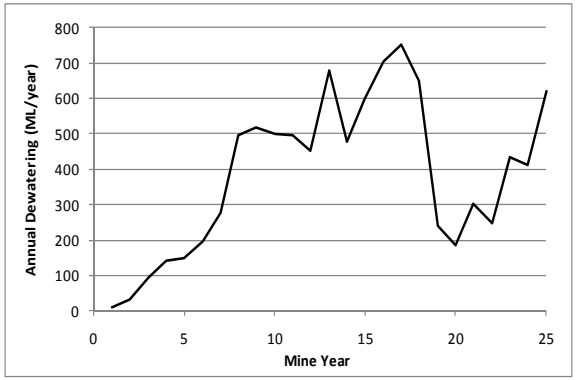
- Automatic AWBM calibration for full data set with one year omitted
- Use estimated parameters to model runoff for missing year
- Assess adequacy of fit between modelled and observed (Total volume, R^2, Nash-Sutcliffe coefficient of efficiency, flow duration, etc)
- Repeat process taking out successive years of data
- Assess statistics of parameters and goodness of fit to select parameters for adoption

AWBM



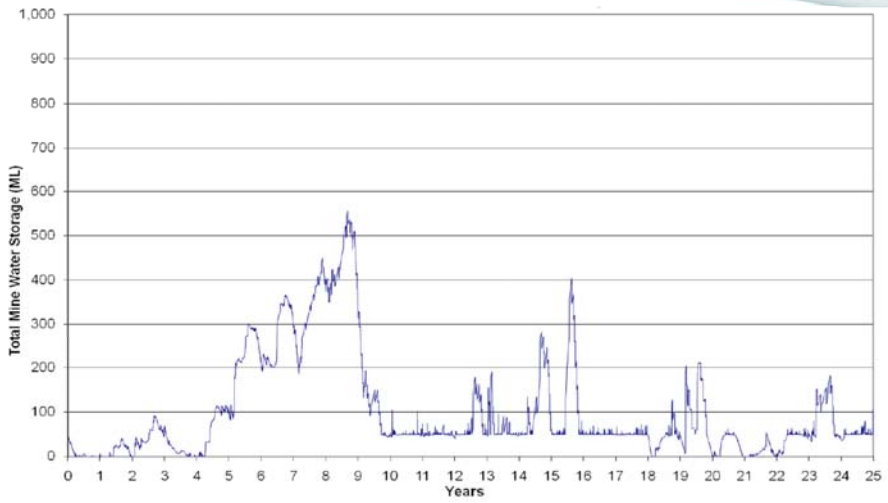


Groundwater Inflows to Pit and Underground Workings

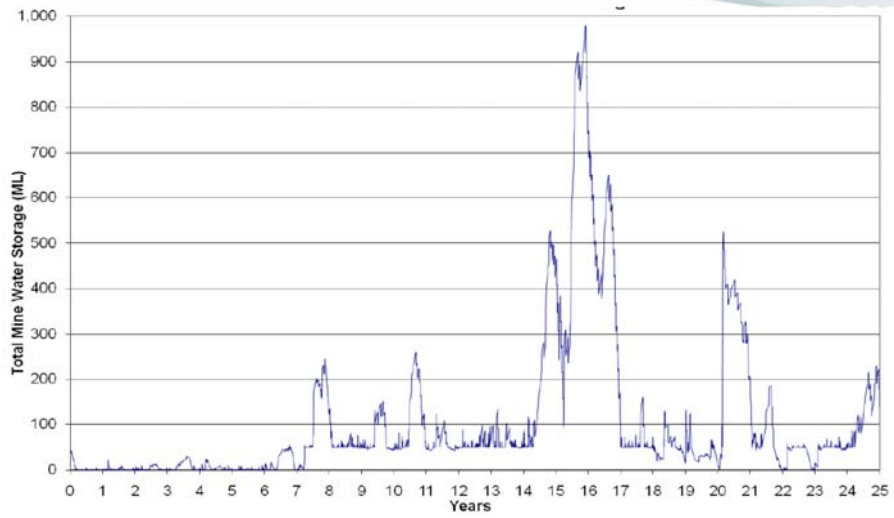


- Derived from groundwater modelling
- Relatively steady day to day
- Significant variation over mine life – depends on mine plan

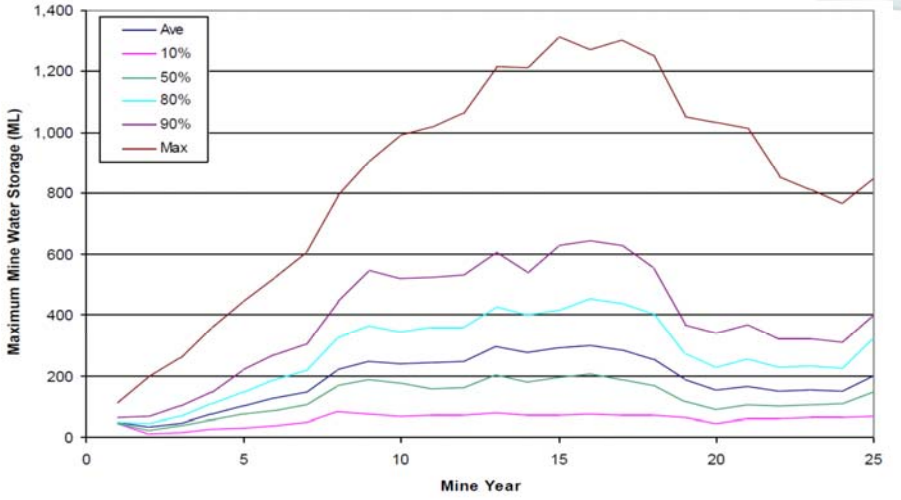
Storage Requirements – median rainfall *Sequence: A*



Storage Requirements – median rainfall *Sequence: B*



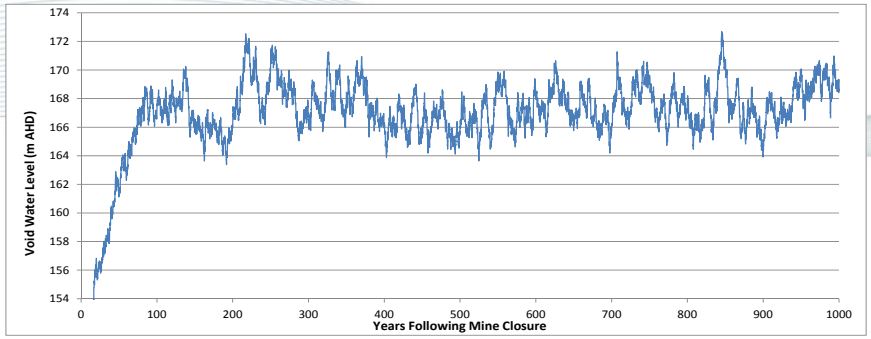
Storage requirements – risk profile (± 125 years rainfall data)

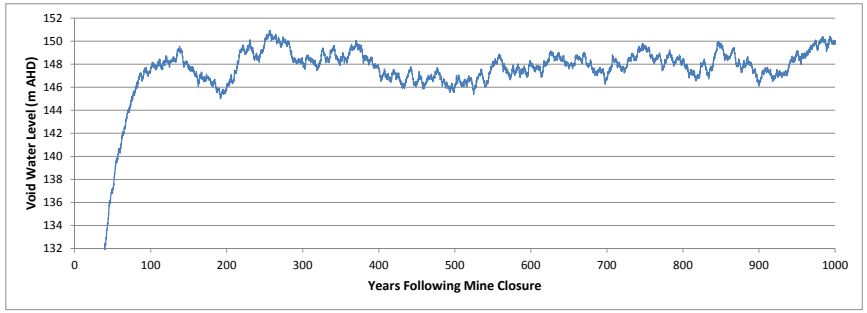


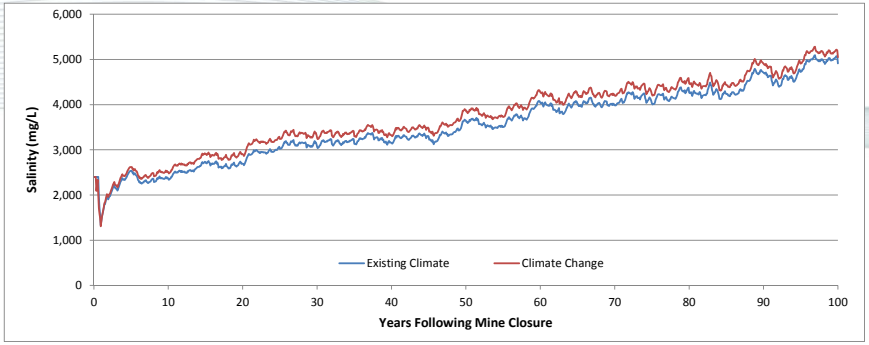
Water quality modelling

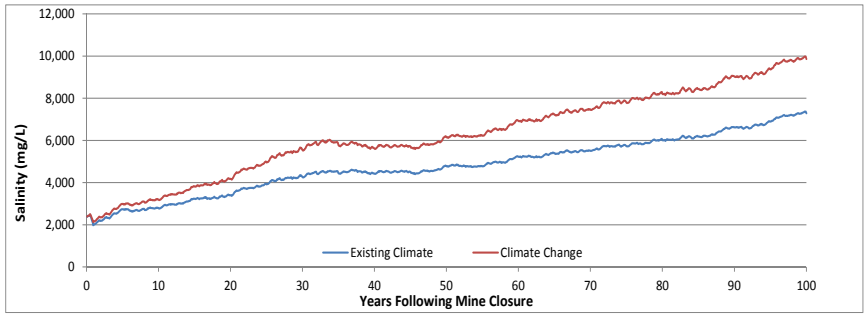
- **Salt balance –** conservation of mass
- **Final void salinity –** water and salt balance:
  - Groundwater leaching through in-pit spoil
  - Surface runoff from void
  - Groundwater loss from 'lake' (or make)
  - Evaporation loss (accounting for depth of void)

Need for strong linkage between surface and groundwater models









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