Review of the assessment of reliabilities for licences in the Tindall Limestone and Oolloo Dolostone Aquifers based on potential impacts on Daly River streamflows

Dr Michele Akeroyd | Director | The Goyder Institute for Water Research

The Goyder Institute for Water Research

- Commenced operation in 2010
- A collaborative approach to develop and deliver science-based policy solutions to water management in South Australia
- Government and research organisations partners
- Foster pro-active responses to water resource issues
- Independent, credible and quality science
- Broker to deliver independent and applied R&D targeted to the policy needs of Government

The Goyder Institute – a collaborative model

The Goyder Institute – A proven model

- Harnessing the **best minds**
- **Facilitate and coordinate** multi-disciplinary research teams
- **One-stop shop** to access SA's water expertise
- **Credible** and trusted science
- **Independent** and high quality science
- **Low-cost** in administration and procurement
- **Demand driven** focusing on **Government priorities**
- Knowledge **Exchange** and **Building** capability

Science Supporting Decision Making

- South Australian Murray-Darling Basin Plan negotiations – science support to provide expert advice regarding the environmental outcomes of proposed environmental water scenarios
- Establishment of a Water Sensitive Design policy for new urban development
- Regional Impact Assessment of Marine Park Sanctuary Zones
- Establishment of SA Climate Ready (future climate scenarios at weather station scale) and application in State government transport and water infrastructure assessments

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The Review Team

DHI – (as a member of the NCGRT, a partner of the Institute)

- Led by Craig Mackay

SA Research and Development Institute

- Professor Jim Cox

Goyder Institute

- Dr Michele Akeroyd

Structure of the Independent Review

Terms of Reference :

1. **Overview of the licence evaluation process including:**
   - relationship to defined environmental flow thresholds, available datasets, the current licence entitlements, and the simulation models, verify and confirm the reliability calculations
2. **Scope Item 1: Assessing the suitability of the current FEFLOW and MIKE11 model**
3. **Scope Item 2: Assessing the suitability of model input, model output and streamflow data**
4. **Scope Item 3: Assessing the validity of the determinations for licence reliabilities**

Review Process

- Application of the National Modelling Guidelines (National Water Commission, 2012)
- Modellers review of application of modelling package
- Review of calculation process

Overall Conclusions

1. The modelling package, including the input and output data used in this process meet Australian modelling guidelines and industry practice and are suitable for the purpose of assessing water extraction licences.
2. No process errors were identified in the reliability calculations for the new licence applications, which are the focus of this review.
3. The water resources team have excellent knowledge of the hydrogeology and hydrological processes of the system and strong modelling capability.
4. Additional model runs were sought by the reviewers to test the robustness of the assumptions made in the modelling process and to document this understanding.
5. In response to the request of the Independent Reviewers, DLRM undertook additional modelling to investigate the sensitivity of licence reliabilities to changing these assumptions for the Daly water resource assessment model.
6. This additional modelling work demonstrated that the licence reliability was not sensitive to changing these key assumptions. On this basis, the reviewers confirmed the reliability assessment methodology and calculation.

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Craig Mackay | Engineer | DHI Water and Environment

Scope Item 1 – Model suitability

Scope Item 1: Assess the suitability of the current Feflow and Mike11 connected modelling package used by DLRM to describe the potential impacts on Daly River stream flows associated with granting applications for water extraction licences

Assess the suitability of the modelling package

- The Daly River catchment has a highly connected surface water – groundwater system
- This means it needs a model that can represent many processes:
  - Catchment rainfall runoff
  - Rainfall infiltrating into the soil and down into groundwater
  - Flow in the creeks and rivers
  - River losses into the aquifer
  - Aquifer discharge into the river
  - Extractions from the river and from the aquifer

Scope Item 1 – Model suitability

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Assess the suitability of the modelling package

- The processes a modelling package can represent depends on what it's intended for e.g. flood modelling packages only simulate river hydraulics
- MIKE11 – river hydraulics (flow in creeks and rivers, river pumping)
- FEFLOW – groundwater flow (rainfall recharge and soil infiltration, groundwater movement, groundwater pumping)
- This project uses them linked together to model surface water / groundwater exchange
- There are few packages that do this in physical detail, and MIKE11-FEFLOW is a suitable choice from available options in this situation

Scope Item 2 – Inputs and outputs

Scope Item 2: Assess the suitability of the input data provided for the connected modelling package; the output data delivered by the modelling package; and the streamflow monitoring data used for the most recent licence applications being processed by DLRM

Suitability of input data – rainfall and evapotranspiration

- Rainfall and evapotranspiration are the major inputs to the model
- The modelling uses SILO datasets to estimate historical rainfall and evaporation on the catchments (SILO uses station observations to form grids covering all of Australia)
- Use of SILO is a common approach for long-term water resource modelling, especially where rainfall records aren't continuous or there are few rainfall stations
- It may not accurately represent every storm event, but it will be more accurate in estimating the total wet season rainfall that fell
- SILO datasets change from time to time as the technical process used to calculate them improves, and DLRM need to consider how to deal with any changes in the future

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Suitability of input data – pumping rates

- Water is extracted from the groundwater model (borehole pumping) and surface water model (river pumping)
- Pumping is continually at full allocation for the entire modelled period
- It isn't reduced if the year would otherwise have been restricted

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Suitability of input data – recharge

- Recharge of the aquifer by rainfall infiltration through the soil column into groundwater
- More refined processes have been progressively used since 2006:
  - Estimated water balance of total volume into aquifer
  - Soil moisture deficit model
  - Physics-based unsaturated zone / saturated zone model
- This wasn't part of the scope of the review, however the sensitivity of the model to this was considered

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Suitability of data – streamflow

- The methodology relies on flow measurements at the Mt Nancar and Dorisvale Crossing gauging stations (water level and flow measurement points)
- Typically every gauging station has some error - the Mt Nancar and Dorisvale Crossing gauging stations have good levels of accuracy
- The accuracy at very low flows hasn't been tested recently due to the relatively wet conditions since the mid-2000's, although this doesn't affect the current process outcomes

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Suitability of output data – the role of model calibration

- Models are constructed from available data, e.g.:
  - Hydrogeology
  - River cross-sections
  - Catchment topography
  - Vegetation types
  - Rainfall and evaporation
- However there is still some uncertainty about whether our data covers everything, and whether the model processes exactly match real life

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Suitability of output data – calibration and output accuracy

- To deal with this models are calibrated by adjusting some parameters (e.g. hydraulic conductivity, river channel friction losses) so that they better recreate historical records, usually measured streamflow and groundwater levels
- This is very relevant to output data quality, as a model that is poorly calibrated is unlikely to make accurate predictions
- DLRM and others have calibrated the Daly River model extensively and repeatedly and achieved what would widely be considered good calibration
- This has produced one set of model input parameters thought to be best represent the historical catchment and aquifer
- This has then used for the reliability assessment

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Suitability of output data – uncertainty

- Other model parameter sets may also give similar calibration performance reproducing historical streamflows and groundwater levels
- It's possible these alternative parameter sets might give different reliabilities when we use the model to test extraction impacts
- DLRM had done work in 2008 looking at how much this affected the *model outputs* (i.e. river flow and groundwater levels)
- However this review recommended DLRM should also look at how much these alternative sets affect *licence reliabilities*

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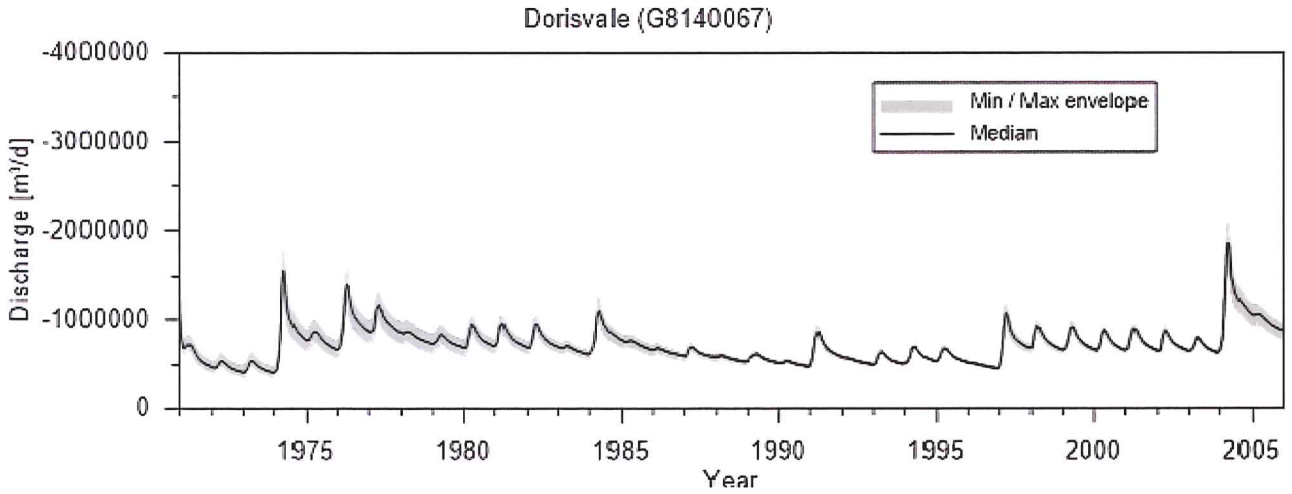
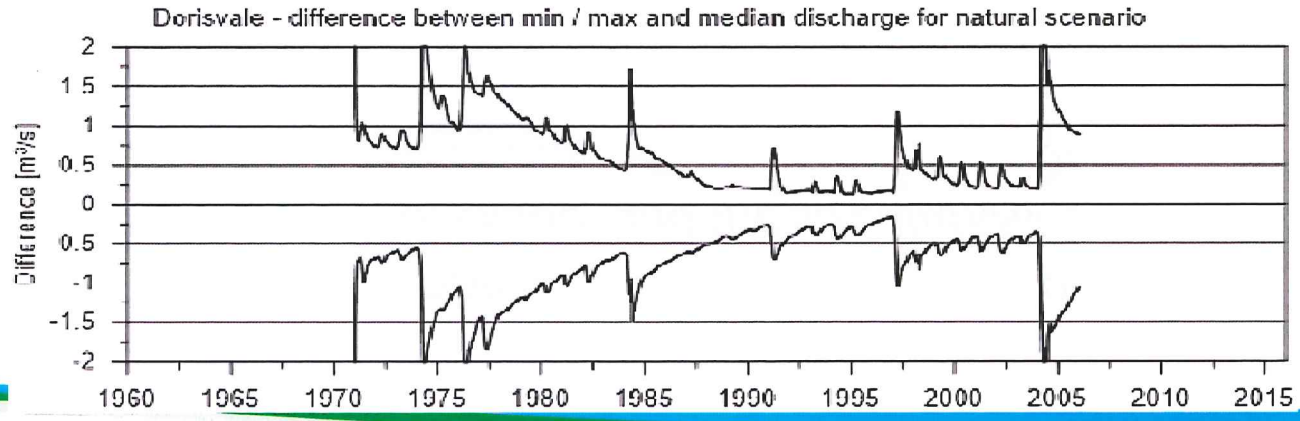
Suitability of output data – uncertainty from model parameters

- In response DLRM chose five models with very different parameters sets from the calibration model (these are from the 100 alternative calibration models DLRM produced and reviewed in 2008)
- DLRM recalculated the licence reliabilities using the five models

Scope Item 2 – Inputs and outputs

- The modelled discharge at the gauging stations used in the licence reliability calculation is shown by the black line
- The difference in discharge for all the alternative models is shown by the grey shading
- The most difference is in the wet season, less in the dry season





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Suitability of output data – uncertainty from model parameters

When the licence reliability was recalculated with the five alternative models:

- There was no difference in licence reliability at the Mt Nancar gauging station
- The Dorisvale Crossing gauging station results were within 3% of the calibration model results
- This means the calibration model reliabilities are very similar to other alternative model reliabilities, and ***it doesn't affect the licence reliability assessment if we don't get the model parameters exactly right***

Objective 1 – Confirming the approach

Objective 1: Confirm the approach taken and model data outputs used to derive reliability for the most recent ground water extraction licence applications in the Tindall Limestone – Flora Aquifer and the Oolloo Dolostone Aquifer based on potential impacts on Daly River stream flows

This review found that the model and model outputs produced are consistent with Australian modelling guidelines and industry practice, and suited for the purpose of licence reliability evaluation.

The current licence reliability process uses the model to estimate:

streamflow impact = *extraction model streamflow – natural model streamflow*

- The licence reliability is then calculated by comparing the impact against the *observed* natural streamflow record
- The superseded process compared the impact against the *modelled* natural flow
- The current licence reliability process has less error than the superseded approach, as it only uses the relative difference of two model results, instead of using the absolute value from the models

Objective 1 – Confirming the approach

Objective 1: Confirm the approach taken and model data outputs used to derive reliability for the most recent ground water extraction licence applications in the Tindall Limestone – Flora Aquifer and the Oolloo Dolostone Aquifer based on potential impacts on Daly River stream flows

Other important findings were that:

- **Documentation**: The licence reliability assessment approach needs to be clearly documented, including:
  - the principles behind the approach,
  - how it relates to Water Allocation Plans and environmental water requirements,
  - how licence security is determined
  - What the key assumptions are
- **Natural streamflow series**: The process assumes the observed streamflows are the same as natural streamflows; due to wet years since the mid 2000's this is unlikely to have affected the licence reliability assessment, however it will need to be considered in future

Objective 2 – Verify the calculations

Objective 2: Verify and confirm the reliability calculations for those licence applications

- The spreadsheet used by DLRM to translate model outputs into a licence reliability has been reviewed and confirmed to be consistent with the intended licence reliability assessment process, and no calculation errors were found.

Scope Item 3 – Determination validity

Scope Item 3: Assess the validity of the determinations made by DLRM for expected licence reliabilities for the most recent licence applications being processed by DLRM.

- Following additional work by DLRM looking into how model uncertainty affects calculated streamflow impacts and licence reliabilities, the reviewers confirm the reliability assessment

Thank you

Further questions?