Decision-Support Modelling
Model-Design Self-Questionnaire

Modelling context

- Will the model be used to set policy, to assist in operational decision-making, or for some other purpose?

- How can it be tuned to this purpose?

- Do multiple decisions require the construction of multiple models?

Management failure criteria

- What is management seeking to avoid or mitigate?

- What specific model predictions will establish management failure?

- Do any model design features artificially preclude or inhibit predictions of management failure?

Management-Salient Predictions

- Are some management-salient predictions more immune from the deleterious effects of model deficiencies than others (for example predictive differences and/or direct predictive comparisons)?

- Should simulation and history-matching be focussed on raising the integrity of these predictions (i.e. reducing possible predictive bias), and reducing the uncertainties of these predictions, as much as possible?

Pre-modelling assessments

- What calculations can be done prior to modelling to assess the likely magnitude of management-salient predictive uncertainty?
- What parameters/processes are likely to contribute most to the uncertainties of management-salient model predictions?

- Does modelling-based data assimilation have the capacity to reduce these uncertainties?

Potential impact pathways

- What groundwater pathways link stressors to high-value assets?

- How should the model represent and parameterise potential impact pathways so that history-matching can illuminate the existence (or otherwise) of these pathways, and so that failure-pertinent predictive uncertainties can adequately reflect insufficiency of information with respect to these pathways?

Information harvesting

- Is prediction-pertinent information plentiful (so that management-salient model predictions are likely to be data-driven), is it sparse (so that management-salient model predictions are likely to be null space dominated), or is it somewhere in between?

- If the uncertainties of management salient model predictions are null-space dominated, can information harvesting and uncertainty quantification be implemented using data space inversion? Is there any need to undertake parameter-based history-matching?

- If information is harvested through parameter adjustment, how can model design facilitate parameter-based history-matching and uncertainty quantification?

- Should model calibration (i.e. regularised inversion) precede posterior uncertainty analysis, or should history-matching be entirely ensemble-based and probabilistic?

- If implementing calibration, should this be based on individual parameters, or can it be expedited by working in a reduced parameter subspace defined by ensembles that sample the prior parameter probability distribution (i.e. ENSI)?

- If undertaking calibration as a precursor to posterior predictive uncertainty analysis, can post-calibration linear analysis assist in illuminating flow of information from data to parameters and/or predictions?

Prior parameter uncertainty

- How is prior parameter uncertainty best expressed?

- Is spatial correlation between parameters best described by stationary or non-stationary geostatistics?

- Are any parts of the model domain likely to exhibit anisotropy of spatial correlation?

- Are hydraulic properties of different types likely to be statistically correlated?

- Can modelling be used to expose the possibility of prior-data conflict?

- Can incorrectly assigned prior parameter probability distributions induce bias and/or compromise evaluation of predictive uncertainty?

- Should the upscaled nature of model parameters, or their propensity to adopt compensatory roles during history-matching, be taken into account when ascribing prior probability distributions to them?
- Should uncertain historical stresses be denoted as such, and hence be represented stochastically instead of simply being "assumed"?

Objective function formulation and observation weighting

- What aspects of historical system behaviour are likely to be most informative of management-salient aspects of future system behaviour?

- Should functions of observations (such as temporal/spatial head differences) be included in the objective function that is minimized through history-matching?

- How should observations be grouped?

- How should different observation groups be weighted for visibility in the overall objective function?

- If using PESTPP-IES, should observation weighting be distinguished from observation noise?

Model design trade-offs

- Are model run times too high, or is the model too numerically unstable, to support parameter-based history matching and uncertainty quantification?

- If so, should history-matching (and information harvesting) therefore employ a DSI surrogate model?

- Alternatively, can the numerical model be simplified without compromising its decision-support utility?

Data worth assessment

- If model-based uncertainty analysis reveals the possibility of management failure, can it also suggest data-collection strategies that can reduce the uncertainties of failure-pertinent model predictions?

- Can formal data worth analysis be implemented using linear methods or DSI?

- Can modelling support design of an optimal monitoring network?