RISK-BASED DESIGN FOR WATER SUPPLY INFRASTRUCTURE

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Deterministic engineering uses design values for input parameters to compute a single value for output. However, variability of input parameters to the design process result in variability in design output, rather than a single value. This is particularly crucial during bids or feasibility studies, when many of the design input parameters are uncertain, and hence output variability is increased. To make allowance for this uncertainty, contingency is often applied to designs, representing an added cost to the projects.

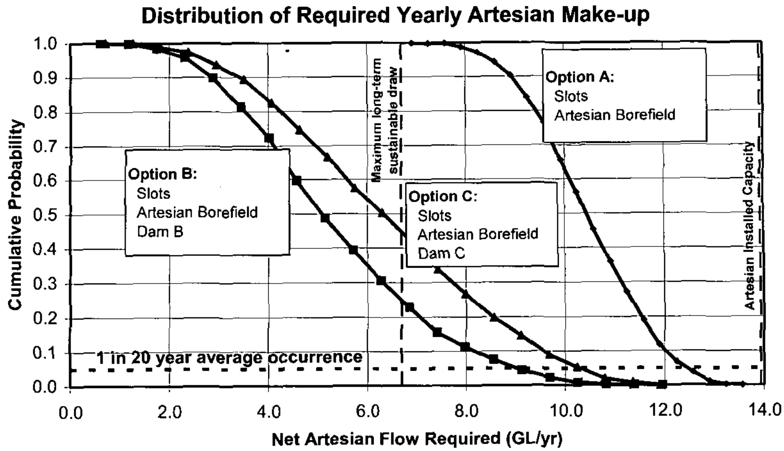
Design of water supply infrastructure is an example where variability of the yields from water sources affects the reliability of water delivery to end users. Detailed hydrological and statistical studies can be conducted to evaluate overall water supply reliability. However, data gathering and measurement required to derive the required statistical distributions can take significant time, which is often not available when conducting feasibility studies for industrial projects.

A simplified risk-based approach to design of water supply infrastructure is proposed to quantify reliability during early stages of design, when detailed hydrological and water use data are not yet available. In this risk-based approach, a triangular probability distribution captures existing knowledge and experience regarding variability in water supply parameters (such as catchment yield, water recycle efficiency, and demand forecasts). A stochastic water balance model incorporates parameter variability in a Monte Carlo simulation to compute the distribution of an output parameter representing water supply reliability.

Risk-based design was applied to a water supply system for a mineral processing plant. A number of sources for water were considered, including existing surface and sub-surface reservoirs, harvesting of rainfall runoff, recycling of water, and an artesian aquifer. The stochastic water balance model quantified, and assessed the reliance on, the annual make-up flow required from the artesian aquifer. Acceptable water supply reliability was based on criteria for long-term sustainability of the artesian aquifer and the installed capacity of water supply infrastructure.

Various water supply infrastructure options were compared to select the most cost effective option to meet acceptable levels of reliability. Experience from applying risk-based design has shown that the triangular probability distribution can capture existing knowledge and experience of water resources managers and operators into the analysis. In addition, selection of an appropriate output parameter to define water supply reliability was critical in communicating the results of the analysis.

The results of the Monte Carlo simulation are plotted in the figure below, showing the exceedence probability of the yearly artesian make-up required.



Risk-based design has proved to be a valuable tool in selecting of the most cost effective water supply infrastructure option to meet acceptable levels of reliability. The experience of applying the risk-based design approach and discussing its results with all stakeholders has shown that:

- Participation by operators and local water resources managers was critical to the success of the study. Use of the triangular probability distribution (based on expected maximum, minimum, and best estimate values for various parameters) incorporates existing knowledge and experience into the analysis.
- Correct selection of an appropriate output parameter to define water supply reliability helps to communicate the results of the stochastic modelling. In the case presented, the yearly required artesian flow was a quantifiable and identifiable value.
- The methodology presented here will not replace more extensive hydrological and statistical analyses. However, it serves as an important step during early stages of projects, when many parameters are uncertain and time available is short.

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