多湖區系統最佳地表地下聯合操作之研究

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摘要

人工湖水源調配方式為台灣近年來新水源開發的重要考量之一，而高屏大湖為臺灣第一個以大型平地人工湖為區域重要水源的案例，亦是至目前為止規劃較為完整的案例，其本身由 5 個湖區組成，且因此區之地下水位高，在操作時地表水與地下水會有明顯出/入滲交換機制，因此其操作營運方式較地表水庫，或是僅具有補注作用的人工湖較為複雜，若能對高屏大湖之操作營運方式做進一步的探討，不但可以增加其未來的效益，亦可做為其它地區人工湖開發的參考。

由於湖水與地下間之交換為高屏大湖系統重要的物理機制，且為非線性問題，因此，地下水反應不能以傳統的處理方式，如響應矩陣法(Response Matrix Method)加以簡化為線性反應，而必須以較複雜的地下水模式模擬之，惟若將此模式整合進以優選為導向的操作規劃模式，則又將使整體的計算量增加太大。為此，在兼顧地下水系統模擬的精確度與計算效率的考量下，乃先以地下水數值模式 MODFLOW 96 與湖泊模組(LAK2)模擬產生湖水與地下水交互作用之相關資料，並以其訓練並驗證類神經網路，則此類神經網路可兼具高計算效率與描述非線性反應的能力，接著再將此類神經網路嵌入高屏大湖地表地下最佳操作規劃模式中。模式中人工湖的操作乃引用一般地表水庫常用之規線操作原則，並利用遺傳演算法優選最佳操作規線。

本研究進一步以前述的最佳操作規劃模式，探討高屏大湖有無地下水系統的加入，與不同設計的操作規線，對系統供水效能之影響。

研究結果顯示，在未考量規線操作下，高屏大湖能與地下水交換之設計方案比高屏大湖為封底設計之方案，可增加 48%的供應量且還能補注地下水; 進一步運用規線操作後，則能降低尖峰缺水量，而使 SI 降低 21.77%;若增加規線彈性，SI 最多可再降低 44.6%。由本研究發現，地表地下交換之營運方式與規線操作皆對高屏大湖的供水能力皆有相當大的助益。

Optimizing the Conjunctive Surface and Subsurface Operations of a Multi-Lake System

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Abstract

Artificial lake is considered a new water resources alternative in Taiwan in recent years. Kao-ping Artificial Lake is an example and it is a lake system with five artificial ponds. The groundwater level surrounding the lake is higher than those in the surrounding areas. Therefore, the determination of available water from the system is more complex than those for reservoir operations. This research considers the effects of the water supplied by the lake, the water stored in the lake, and the exchange between the lake and groundwater system in the operations of the Kao-ping Artificial Lake.

The research attempts to develop an optimal conjunctive model for the Kao-ping Artificial Lake. However, if a numerical model is used to simulate the behavior of Kao-ping Artificial Lake operations, it will increase the computational burden. In order to solve the problem, a Back Propagation Neural Network (BPN) trained by simulation results for MODFLOW 96 and LAK2 is applied to represent the nonlinear dynamic relationship between the lake and the unconfined aquifer. Secondly, the water to be provided by the system at each time step is determined by an optimal rule curve found by a Genetic Algorithm (GA).

Results of this study indicate that the conjunctive use model can significantly increase the water supply reliability. In addition, the model also provides an optimal groundwater recharge strategy. The model is shown to be able to reduce the magnitude of the water shortage and increase the resilience of the operating rule curve and is therefore believed to be a promising tool in Kao-ping Artificial Lake’s future operations.