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Operational technologies and practices of water resources systems

Hydrolink

OPERATIONAL TECHNOLOGIES AND PRACTICES OF WATER RESOURCES SYSTEMS

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The operation of water resources systems is characterized by multi-objectives, multi-levels and high uncertainties, and thus these systems should be considered as a whole from multiple perspectives and levels. The basic principles and theories of hydrology, hydraulics, economics, operations research and mathematics, as well as new theories and techniques such as cybernetics and heuristic algorithms, need to be taken into account in the simulation and optimization of hydrological, water supply, water use and consumption and water drainage processes. Here, we proposed a technical framework for the operation of water resources systems, which was then illustrated using the Middle Route of the South-to-North Water Transfer Project.

What is a water resources system?

A water resources system can be considered as a unit consisting of various water bodies such as rivers, lakes, reservoirs and groundwater in a given region that are connected hydrologically and hydraulically and can be potentially exploited for the benefit of mankind, as well as of related engineering projects for different purposes. It is evident that the individual water bodies in a water resources system are highly interdependent and mutually influential, thus forming a unit with an integrated function and a unique hierarchical structure.

The middle route of the South-to-North Water Transfer Project (STNWTP) in China is mainly composed of four sectors: the water source project, the compensation project in the middle and lower reaches of the Hanjiang River, the water conveyance project in the middle route and the matching project in the water receiving area. It consists of 27 reservoirs, 88 separate gates and 165 water units. Water in the middle route of the STNWTP is extracted from the Danjiangkou reservoir located in the Hanjiang River of Yangtze River tributary, then through Henan and Hebei Provinces, and finally arrived into Tianjin and Beijing. It consequently provides industrial and domestic water for the towns and also meets agricultural and ecological water demand in some areas.

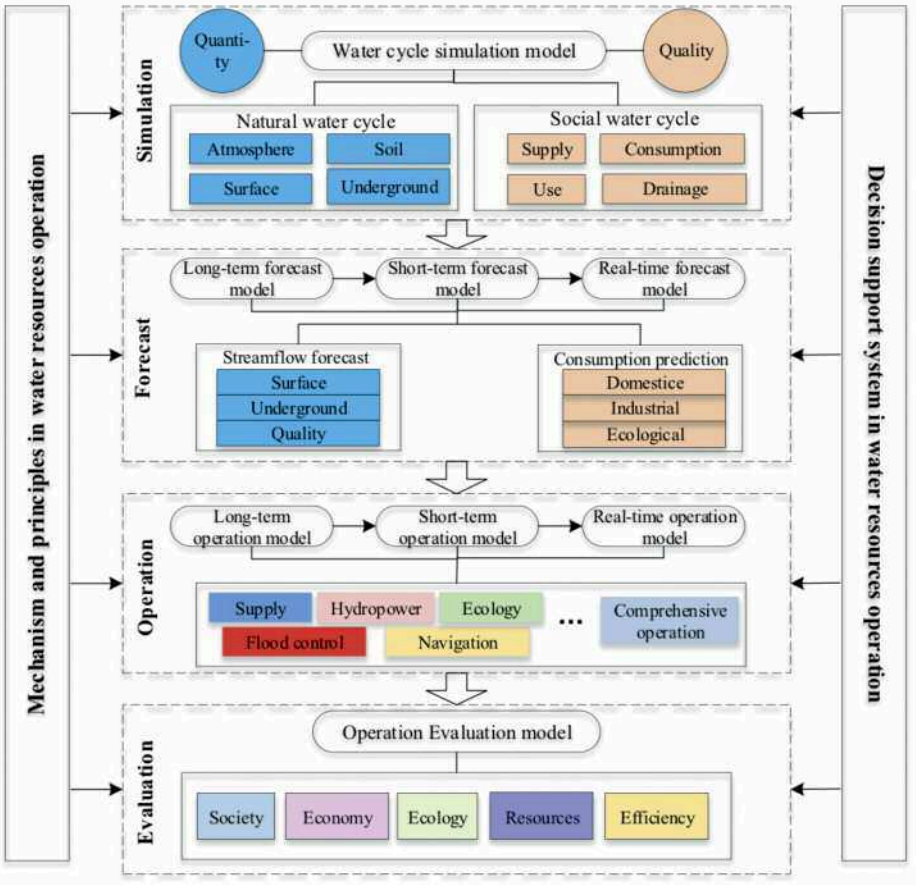

Figure 1. An integrated technical framework for water resources operation

Basic concepts in water resources operations

Water resources operations should abide by the principles of fairness, high efficiency and sustainable development One of its primary objectives is to balance the interests of different regions and parties (e.g., flood control, water supply, irrigation, electricity generation, ecological environment, navigation and tourism) on the premise of ensuring flood control safety. Consideration should also be given to historical and current domestic, industrial and ecological water uses and demands. Accordingly, there is a need for unified management of water resources

in the basin or region according to the current availability of water resources and the forecast of future water inflows and demands. Efforts should be made to obtain an optimal spatiotemporal allocation of water resources by engineering projects and by the implementation of other measures, so that the water demand of various uses in the basin and region can be better satisfied. An important consideration in water resources operations is the competitive, sometimes even conflicting, water demands from different sectors (e.g., flood control, water supply, irrigation, electricity generation, ecological environment, shipping and tourism), making water resources operations a complex multi-objective group decision-making problem. However, the major objective of water resources operations is largely determined by the actual demands in the basin and region. From a spatial perspective, water resources operations can involve a single water storage project or multiple projects in the region, or the whole basin and inter-basin transfers; from a temporal perspective, water resources operations can be long term, short term or real time; From the perspective of operational targets, water resources operations can involve a single water source, or the combination of several or all water sources in the basin and region; From the application perspective, water resources operations can be applied to water transfer projects, urban water supply and drainage systems, rural irrigation and water supply and drainage systems, etc.; From the perspective of operational measures, water resources operations are made possible by the use of engineering projects and other measures, such as the control of total water intake, water quota, water quality, water conservation, and water pricing.

Figure 2. A schematic of the middle route of the STNWTP

An integrated technical framework for water resources operations

As China was working on the middle route of the South-to-North Water Transfer Project (STNWTP), we proposed an integrated technical framework for water resources operations in the basin, which consisted of four closely interrelated hierarchical levels, including simulation, forecast, operation and evaluation. The simulation of water cycles in the basin can have a direct effect on subsequent forecast, operation and evaluation, and thus it is the basis for the proposed hierarchical technical framework for water resources operations. The forecast model should have the capacity of long-, medium- and short-term forecast, real-time updating and self-correction, so that the parameters or structures required in forecast models can be appropriately adjusted and the existing runoff forecast can be corrected promptly. The operation model plays a key role in the adaptive operation of water resources systems, which includes the determination of operational criteria and objectives, development of models of different time scales, solution methods, and conversion of models of different time scales. It is closely related to the actual problems in the utilization of water resources and their management. The purpose of evaluation is to qualitatively and quantitatively evaluate possible impacts and the efficacy of different operational strategies, which can contribute significantly to preventing the ineffectiveness and irrationality of water resources operations resulting from subjective preferences and incomplete information.

The application of the proposed water resources operations approach to the middle route of the STNWTP

At the technical level, we investigated some key techniques involved in the operation of the middle route of the STNWTP, such as the simulation of distributed nature-social water cycle system, forecast of medium and long term runoff, inter-basin water resources operation, reservoir operation, multi-objective optimization, evaluation of water resources operation, decision support system for inter-basin water resources operation. At the application level, we developed various dynamic water resources operation models for the simulation and optimization of the middle route of the STNWTP, including the simulation of distributed nature-social water cycle system, water resources operation models for water source regions, water receiving regions and the main routine, the combined water resources operation models, and decision support system for water resources operation. We also integrated inter-basin simulation for nature-social water cycle system, forecast, operation and evaluation using system integration techniques, and developed a decision-making support system for water resources operations in both water source and water receiving regions, which can assist annual, monthly, ten-day and weekly water resources operations and provide technical support and a management tool for operation negotiation to maximize the profits of the middle route of the STNWTP. ■

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