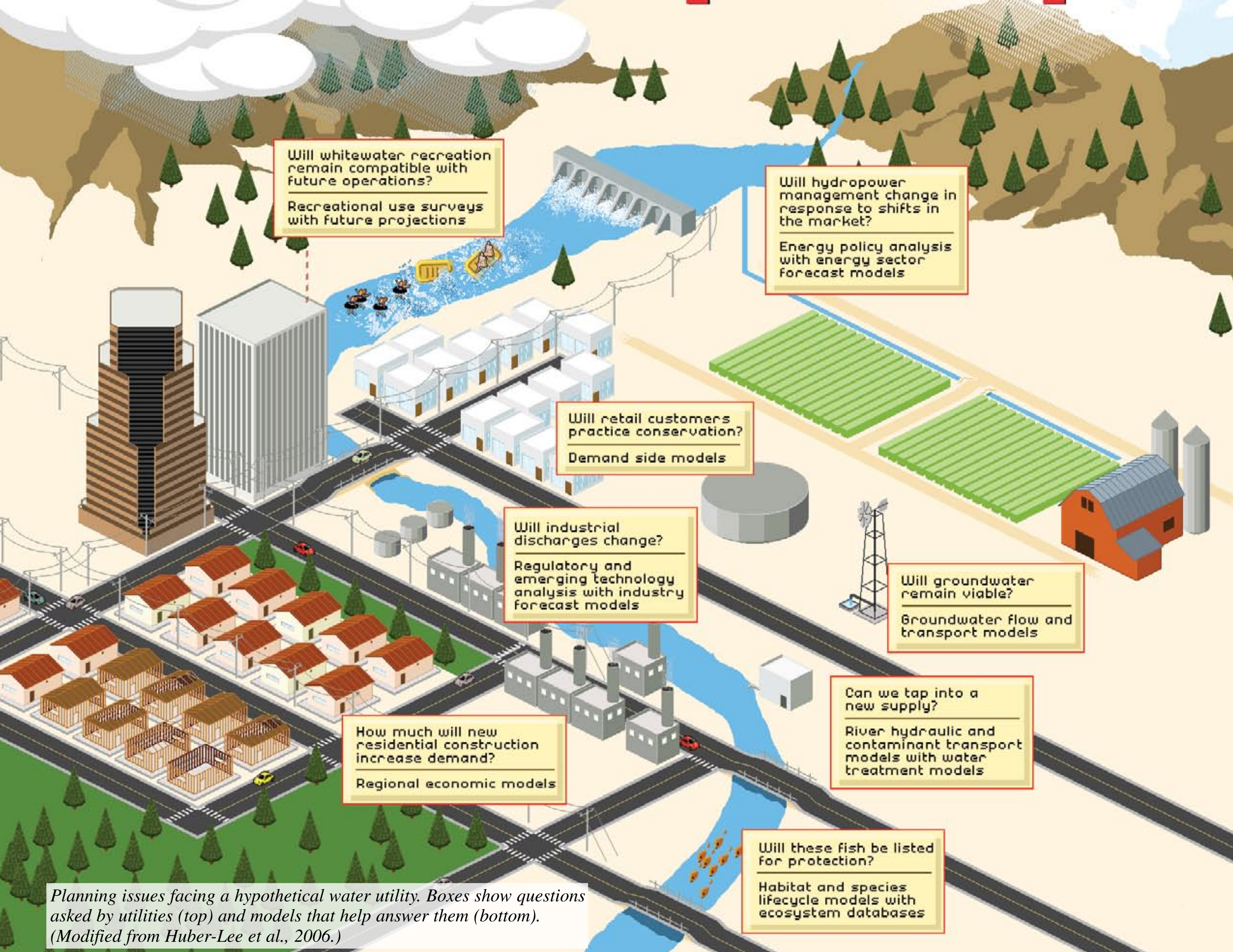
A DSS for Long-Term Water Utility Planning



Planning issues facing a hypothetical water utility. Boxes show questions asked by utilities (top) and models that help answer them (bottom). (Modified from Huber-Lee et al., 2006.)

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To respond to the challenges that member utilities of the American Water Works Association Research Foundation (AwwaRF) often confront in developing long-range plans, in 2002 AwwaRF solicited proposals to "develop a computerized decision support system (DSS) tool that will aid utility strategic planners to effectively evaluate options for managing and developing reliable, adequate, and sustainable supplies of water for their customers for the next 50 to 100 years." The objective was to produce a software package that utilities could customize to build their own DSS to evaluate multiple future water management scenarios and to support the integrated social, financial, and economic analyses needed for this planning.

The resulting software package is now available for free to AwwaRF subscribers. It is based on the Water Evaluation and Planning (WEAP) system developed by the Stockholm Environment Institute. Functionally, WEAP is a water-modeling package (similar in many ways to Stella or Extend, which are generic modeling packages) that includes a number of built-in water objects (such as rivers, reservoirs, aquifers, diversions, points of demand) that can be assembled to represent the essential elements of any water utility system. Default settings are available

Illustration: Mike Buffington

for each object, or users can introduce more site-specific details using WEAP's scripting environment. This functionality allows WEAP to represent general characteristics of a water system or delve into the fine details of a particular utility. The AwwaRF grant required the DSS package to be developed in collaboration with test site utilities, and WEAP applications were developed with the water utilities in Portland, Oregon; Austin, Texas; and Philadelphia.

The Hypothetical Utility

The motivation for developing and applying a DSS in the context of water utility planning is illustrated at left for a hypothetical water utility. This utility taps two sources to provide water to municipal and industrial customers: a local aquifer in an overdraft condition and surface water from a distant mountain watershed that is shared with long-standing agricultural water users. The mountain source is regulated by a dam equipped with hydropower production capacity, the operation of which influences conditions in a downstream river segment prized by whitewater enthusiasts. The utility is dealing with new growth and contemplating bringing online a new surface water supply that may require treatment that the water from the mountain source does not. Viable treatment options will depend on unknown future regulations pertaining to drinking water quality and wastewater discharge. Complicating matters are the possibilities that climate change will alter precipitation amounts, that changing land use could alter the hydrologic response of the watershed above the original surface water supply impoundment, and that a local fish species may be listed for protection. Even this highly stylized system presents a startling range of issues confronting utility strategic planners.

Understanding these issues is the task of specially trained analysts asking very specific questions. For example, hydrogeologists develop strategies to deal with aquifer overdraft. Climatologists assess long-term impacts of climate change. Hydrologists may study future land use changes in the primary supply watershed and the associated watershed response. Economists might evaluate growth potential in the utility service area or develop an economic-growth forecast. Engineers produce preliminary designs for supply and treatment options. Recreation specialists might quantify whitewater use and plan for future increases in the number of users. Policy analysts track legislative initiatives on drinking water quality and wastewater discharge. Lawyers might study the water rights situation in the basin and explore options for water trading. Ecologists study the condition of the potentially listed species. And strategic managers try to make sense of it all.

Each discipline working within a utility maintains an independent set of analytical tools; attempts to integrate these tools often founder on resistance to make the simplifications needed to achieve integration.

Scenarios: Strength of the DSS

The DSS can cover this breadth of issues by allowing planners to craft and evaluate scenarios that can guide the planning narrative in a number of directions. What if the fish species is listed and a flow regime is imposed below the utility's surface water storage facilities? What if water quality standards are strengthened such that previously acceptable diversions and discharges are no longer permissible? And what if the growth in water demand exceeds expectations after significant investments have been made to meet these expectations? Importantly, what are the financial implications of these uncertainties for the utility and its ratepayers? The WEAP platform creates a framework comprising the full range of planning components that can anticipate the potential changes and surprises that are inherent in water supply planning.

In Portland, particular emphasis was placed on logic related to the coordinated management of surface water and groundwater supplies under various assumptions about environmental flow requirements, future demand, and distribution system configuration. In Austin, the analysis focused on using WEAP's financial module to sort out

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future costs of various mixes of supply enhancement, water reuse, and demand management actions. For Philadelphia, the DSS assessed how various water-use and wastewater-return scenarios interacted with natural hydrology patterns in a watershed of high aesthetic value. By collaborating with the test site utilities, the research team was able to demonstrate the utility of the WEAP DSS for long-term, sustainable water-supply planning. Planning issues addressed that are commonly faced by utilities include:

- the timing of investments in future facility expansions;
- investments in demand management and water reuse and recycling;
- coordinated operation of multiple supply sources;
- changing environmental regulations;
- service-area expansion and regional coordination; and
- water supply and wastewater treatment management to improve the status of receiving water bodies.

While this list does not cover every planning issue that utilities face, the research demonstrated that an integrated DSS framework could address and analyze future scenarios comprised of multiple elements.

Getting the Most From a DSS

As with any new software tool, there is a learning curve before the application can be completely mastered. This goes beyond manipulating the interface and extends to issues of gathering the correct data, formulating the proper questions, and interpreting the output. These are ubiquitous challenges for applying any DSS; our experience at the test sites showed that the integrated, flexible, and transparent nature of a WEAP DSS allows analysts to address these challenges more directly. The biggest challenge is not figuring out how to make a WEAP DSS represent particular scenarios, but defining which scenarios are most appropriate, useful, and compelling.

Developing WEAP DSS in the three cities provided important insights about the way that analysis supports decision-making by water utilities. Often, each discipline working within a utility maintains an independent set of analytical tools; attempts to integrate these tools often founder on resistance to make the simplifications needed to achieve integration. Typically each analyst, an expert in his or her own discipline, feels that simplifying their analysis in the interest of developing an integrated DSS should be avoided so as not to lose important insights. From the perspective of utility strategic planners, however, integrating the various factors that can influence long-term water planning into scenarios developed in a graphical environment is essential for the evaluation of various tradeoffs.

One potentially fruitful area of research for a utility is to assess whether simplifications pursued in favor of integrated analysis would change the decision that would be made based on the output of a DSS. This research assumes, however, that a software package is available that can be configured to represent both stylized schematics and detailed representations of a water utility. WEAP is such a system. Through continued use of WEAP DSS, we can iteratively learn to derive the maximum benefit from it.

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Reference

Huber-Lee, A., C. Swartz, J. Sieber, J. Goldstein, D. Purkey, C. Young, E. Soderstrom, J. Henderson, and R. Raucher, 2006. Decision support systems for sustainable water supply planning. Awwa Research Foundation. Denver, CO.

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- 100-liter-per-second withdrawal from the tailings facility to a polishing pond, where the water commingles with runoff and eventually is released to the river;
- maintaining minimum river flow requirements by releasing fresh water from the polishing pond versus from the main reservoir.

Other inputs in the simulations include the rate that ore is processed in the mill, the types of ore being processed, and the schedule for increasing the dam crest. The simulations track whether the ore processing rate can be maintained under different climate conditions and operational assumptions. Under the extreme-wet climate condition assumption, the likelihood of production being impacted due to unacceptable water elevations behind the dam can be assessed. Alternatively, the extreme-dry scenario evaluates whether the concentrator throughput would have to be periodically reduced or suspended because of insufficient water availability in the tailings facility. The ability of the mine to maintain minimum flow requirements in the river by releasing water from the fresh water reservoirs can also be assessed.

The DSM has provided insights into the appropriateness of some operational rules and a diagnostic understanding of the water management system. It highlights, for example, the need to regularly evaluate existing conditions at the mine to assess possible water deficits during the dry season and whether emergency measures should be instituted. The model is also being used for planning the dam-raising schedule to reduce the likelihood that the freeboard criteria will be violated.

The greatest challenge in developing the model was creating an accurate conceptual model of the water management system and decision rules and assembling and verifying the requisite input data. Considerable time was also required to communicate information about the capabilities of the simulation model and engage clients at the mine who were not directly involved in its development. Because mine conditions are constantly changing, periodic updates to the conceptual model are required to ensure consistency with actual conditions.

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