Computer simulation models have value beyond their use as purely predictive tools. They commonly are used as learning tools to identify additional data that are required to better define and understand ground-water systems. Furthermore, computer simulation models have the capability to test and quantify the consequences of various errors and uncertainties in the information necessary to determine cause and effect relationships and related model-based forecasts. This capability, particularly as it relates to forecasts, may be the most important aspect of computer models in that information about the uncertainty of model forecasts can be defined, which in turn enables water managers to evaluate the significance, and possibly unexpected consequences, of their decisions.

If a model is used to address questions about the future responses of a ground-water system that are of continuing significance to society, then field monitoring of the ground-water system should continue and the model should be reevaluated periodically to incorporate new information or new insights.

Strategies for Sustainability

When broadly considered, alternative management strategies are composed of a small number of general approaches, as outlined below.

Use sources of water other than local ground water. The main possibilities are (1) shift the source of water, either completely or in part, from ground water to surface water, or (2) import water (usually, but not necessarily, surface water) from outside river-basin or ground-water system boundaries. In two previous examples given in the "Storage Changes" section—the Chicago metropolitan area and Kings County, Long Island—the ground-water systems were stressed sufficiently to cause undesirable effects, and surface-water sources were substituted for ground-water sources as a result. On the other hand, ground water currently is used or is being considered for use in many localities as a supplement for surface-water sources that are no longer adequate.

Change rates or spatial patterns of ground-water pumpage. Possibilities include (1) an increase in pumpage that results in a new equilibrium of the ground-water system, (2) a decrease in pumpage that results in a new equilibrium of the ground-water system, or (3) a change in the spatial distribution of pumpage to minimize its existing or potential unwanted effects. Management strategies might include varying combinations of these approaches.

Increase recharge to the ground-water system. Usual options include (1) pumpage designed to induce inflow from surface-water bodies, or (2) recharge of surface water or reused water (ground water or surface water) of good quality by surface spreading or injection through wells. Examples of several of these options are presented in Box G.

Decrease discharge from the ground-water system. Possibilities include pumpage that is designed to decrease discharge (1) to streams, lakes, or springs, or (2) from ground-water evapotranspiration. Both of these possibilities can have undesirable effects on surface-water bodies or on existing biological resources.

Change the volume of ground water in storage at different time scales. Possibilities include (1) managed short-term (time scale of months and years) increases and decreases in storage in the ground-water reservoir, which suggests that the ground-water reservoir might be managed at a time scale that is comparable to the management of surface-water reservoirs, or (2) a continuing long-term (possible time scales of decades and centuries) decrease in ground-water storage. Of course, complete or almost complete depletion of aquifer storage is *not* a strategy for sustainability, but an extreme approach that may be considered in some situations.

Consideration of these general approaches indicates that they are not mutually exclusive; that is, the various approaches overlap, or the implementation of one approach will inevitably involve or cause the implementation of another. For example, changing rates or patterns of ground-water pumpage will lead to changes in the spatial patterns of recharge to or discharge from ground-water systems.

The short list of general approaches may suggest that proposing and evaluating alternative management strategies is deceptively simple. On the contrary, ground water is withdrawn from complex, three-dimensional systems, and many possible combinations of these approaches typically should be considered in developing management strategies for a particular ground-water system.

Innovative approaches that have been undertaken to enhance the sustainability of ground-water resources typically involve some combination of use of aquifers as storage reservoirs, conjunctive use of surface water and ground water, artificial recharge of water through wells or surface spreading, and the use of recycled or reclaimed water.