

Hydrological and Water Quality Models and Basin Management Strategies for the Nakdong River Basin

Argonne, together with several universities in Korea, participated in a study to develop management strategies for the Nakdong River Basin, the second largest river basin in the Republic of Korea. The study was initiated in 1997 by the Research Institute of Industrial Science and Technology (RIST) in Pohang, Korea. Argonne's role was to develop and apply a modeling framework to evaluate management strategies. Argonne reviewed data provided by RIST and developed a model to evaluate three scenarios for future basin management for the years 2001, 2006, and 2011.

PROBLEM/OPPORTUNITY

The Nakdong River Basin has a drainage area of about 23,800 square kilometers and a population of about 7.2 million people. Moreover, its water resources also support an additional 6.1 million people living outside the basin. Rapid industrialization, land development, and population increases in the last few decades have caused a dramatic increase in demand for water from the river and have affected the water's quality. Although, its quality has, in general, been improving during the past decade, future development demands might reverse this trend. Appropriate management strategies are needed to ensure that water supplies are adequate and that water quality is appropriate for the intended use. To evaluate potential management strategies for the basin, a robust computer model capable of simulating a wide variety of complex physical, chemical, and biological processes is needed. Argonne was asked to develop such a model.

APPROACH

After evaluating several computer codes, Argonne selected the HSPF (Hydrological Simulation Program-FORTRAN) model for the study. HSPF was developed to evaluate basin-scale flow and water quality issues. Argonne used digital terrain elevation data to derive topographic aspects of the basin. The model was driven by time-series inputs for precipitation, climate variables, reservoir operations, consumptive water use, and pollution loadings for the period 1994 - 1995. The model was

calibrated with flow data and with monthly measured data for concentrations of dissolved oxygen (DO), biochemical oxygen demand (BOD), nitrogen (N), and phosphorus (P) in Nakdong River water.

The calibrated HSPF model was used by RIST, with Argonne's assistance, to evaluate future scenarios affecting water quality. The future scenarios, evaluated for the years 2001, 2006, and 2011, included a "no action" scenario that assumes no additional domestic wastewater treatment facilities (Scenario 1), and two other scenarios that assume additions of domestic wastewater treatment facilities: one according to the 1996 Korean Ministry of Environment (MOE) Plan (Scenario 2) and the other according to the 1998 Revised MOE Plan (Scenario 3).

RESULTS

The initial application of the model indicated the following results:

- The HSPF model developed for the Nakdong River Basin provided a useful tool for examining basinwide effects of various future scenarios.
- Model results for Scenarios 2 and 3 indicated that the mainstem water's quality improves primarily in the vicinity of the Kumho River, one of the major Nakdong tributaries where pollution loadings are highest and significant increases in domestic wastewater treatment capacity are planned.

- Additional water quality improvements in the Kumho River probably require flow augmentation as well as increased wastewater treatment.
- High levels of BOD, N, and P appear driven by non-point sources of pollution.
- BOD levels in the mainstem are heavily influenced by nutrient (N and P) levels. Both controls of non-point sources and tertiary treatment facilities for point sources of pollution are required to control BOD levels.
- Strategies are required to identify, manage, and reduce these pollution sources.
- Historical data indicate high coliform counts. This problem can be addressed only with strategies for improved domestic and animal waste management practices.
- Accurate flow data are needed for reliable evaluation of management strategies.
- Water quality data acquisition activities in the Nakdong River Basin should be planned in an integrated, basinwide manner related to specific management issues.

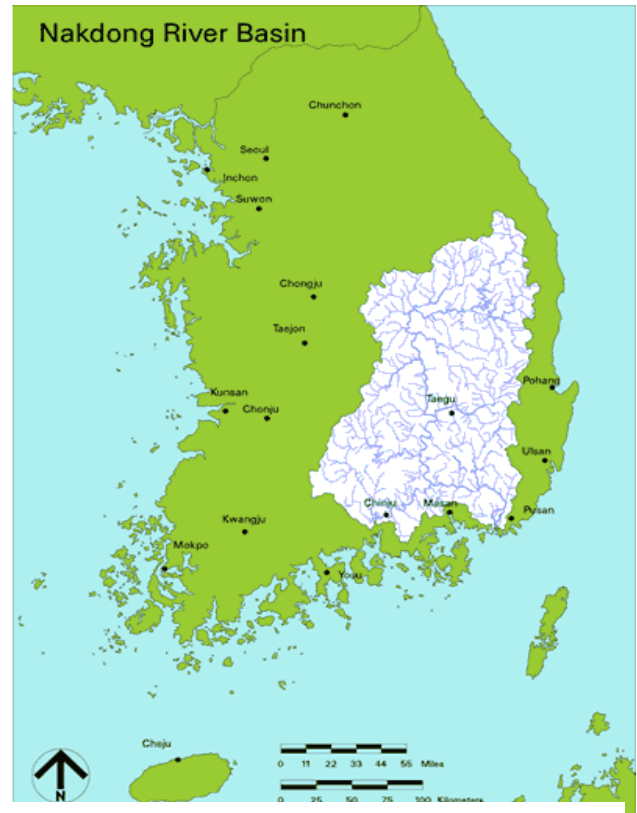
FUTURE

The HSPF model developed in this project is the first “watershed” type model applied to the Nakdong River Basin. The model was initially run by RIST staff with Argonne’s assistance, but it is currently being run independently in Korea to evaluate potential effects of other future scenarios, including the effects of the non-point sources of pollution identified in the initial application.

This project is a good example of a national laboratory developing a tool with an international partner and transferring the tool for implementation. This modeling tool will help Korean authorities solve water supply and water quality problems and reduce conflicts among different regions (in this case, upstream and downstream regions).

COMMUNICATION OF RESULTS

EVS prepared a report on the evaluation of water quality and supply issues in the Nakdong River Basin for the years 2001, 2006, and 2011 for the Research Institute of Industrial Science and Technology in 1999. Results of the modeling study were published in *Environmental Engineering and Policy*, 2:131-143 (2001).



Nakdong River Basin, Korea