CLIMATE CHANGE AND MUNICIPAL WATER USE

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INTRODUCTION

Climate variability and climate change could affect water use and resource availability; demand management can play a significant role in reducing water use under potential future changes in climate. If water use and availability are affected, there is every likelihood that water resource management will change in an attempt to satisfy demand. The satisfaction of demands can be accomplished by resource expansion, changes in resource management, and/or demand management. This work describes the effects of a range of climate change scenarios on water use, and discusses the effectiveness of urban demand management measures, with specific results drawn from a recent study for the Washington, D.C. metropolitan area (Steiner *et al.*, 1997).

At five-year intervals, the Washington, D.C. area water supply agencies conduct a demand forecast for future water use and an analysis of resources needed to meet those demands. The results of this study of potential climate change impacts will be incorporated into that forecast and used in future planning activities with regard to water management and provision of new resources.

CLIMATE CHANGE AND WATER MANAGEMENT SETTING

Potential future climate change would likely affect temperature and precipitation. Changes from historical values of these parameters would have impacts on water availability and use. It is important for water managers to know now if responses to climate change need to be anticipated and implemented well in advance of actual impacts. Water use is often expressed by sector, e.g., urban (municipal and industrial/commercial), agricultural, and hydroelectric power generation. Water use may be managed by a number of measures which are applicable under conditions with and without climate change.

Urban demand management issues relate to residential and industrial/commercial sectors, and pertain to both indoor and outdoor water use. Measures available for managing demand under climate change would essentially be the same as those available with present climate. The likely exception to presently available measures would be an increase in public education effectiveness because of general awareness of climate change. Public education and information are a management measure which arches over all other measures. If significant climate change occurs, it will produce impacts in many areas, and thus will provide for demand management a “teachable moment,” “hot iron to be struck,” “sunshine in which to make hay,” and “a worm to be caught by the early bird”; in other words, a window of opportunity.

Other demand management measures may be considered as applying to residential and/or industrial/commercial; they may be passive and/or active. However they are classified, they include choices about the degree of water conservation in the purchase of major water using appliances (clothes- and dish-washers), repair or replacement of leaky high volume toilets and taps, selection of drought tolerant grasses and shrubs for lawns and ornamental plantings, habits and choices with regard to running full loads in washing appliances and not using the toilets as wastepaper baskets, flow limits placed on toilets, sink taps, and shower heads by provisions of the Energy Policy Act of 1992 (PL 102-486), and increased tariffs for water services. A study by Steiner (1990) concluded that flow limits placed on bathroom fixtures and fittings would have a greater total effect on water use as gradually introduced replacements in existing dwellings than in all new construction during the subsequent 50-year period in Maryland. Additional measures more specifically applicable to the industrial/commercial sector include reducing air conditioning based on water chilling (evaporation) and reuse/recycling for water-based processes.

The issue to be addressed here centers on quantifying the extent to which feasible demand management measures can mitigate the influence of potential climate change on increased water use.

ANALYTICAL APPROACH

The method of analysis was to develop a water use forecast from 1990 to the year 2030 assuming the perpetuation of historical climate and a range of climate change scenarios. The climate change scenarios were based on predictions of general circulation models (GCMs) for the Washington, D.C. region. The GCMs used to provide a range of sensitivity of potential future climates in the year 2030 were as follows:

Geophysical Fluid Dynamics Lab., new version	(GFDL)
Goddard Institute for Space Studies, version A	(GISS-A)
Goddard Institute for Space Studies, version B	(GISS-B)
U. K. Meteorological Office, Hadley Center	(UKMO)
Max Planck Institute, Germany	(MPI)

The weather characteristics which resulted from the climate change scenarios were used as input to the IWR MAIN water use forecasting system, version 5.1 (Davis *et al.*, 1988). IWR MAIN is a highly disaggregated model which has been widely applied in urban water use forecasting in the U.S. It is particularly well structured for examining the effects of conservation measures.

Three degrees of water conservation provided the basis on which to draw conclusions with respect to the effectiveness of demand management in the Washington, D.C. metropolitan area under a range of future climate conditions. They consist of a base case for year 1990 (Conservation Policy 1) and two policies which incorporate successively restrictive measures, as presented in Table 1.

Table 1: Water use conservation policies and associated conservation measures

Conservation Policy	Water Conservation Measures
1	Measures existing in 1990 within political jurisdictions Complete implementation of moderate plumbing code
2	Measures included in Policy 1 Public education Industrial reuse/recycle Commercial reuse/recycle Advanced plumbing code
3	Measures included in Policy 2 50% real increase in all water/ wastewater tariffs

RESULTS AND CONCLUSIONS

If a perpetuation of historical (existing) climate is assumed, water use with no change in conservation policies (demand management) is forecast to increase by 100.3 percent in the period 1990 to 2030. However, the relative effects of the three conservation policies on the selected range of climate change scenarios were modeled and are presented in Tables 2 and 3.

For a complete description of water use forecasts and enumeration of results, see Boland (1997). The results presented in Tables 2 and 3 show that under Conservation Policy 1, all selected climate change scenarios except GISS-B produce higher water use in year 2030 for both the summer and full year periods than would be the case under a continuation of historical climate conditions. The GISS-B scenario with volcano activity would produce reductions of 13.1 percent (summer) and 7.6 percent (full year). The other climate change scenarios would produce increased water usage of 7.9 percent to 19.0 percent and 4.5 percent to 10.8 percent, respectively, for the summer and full year periods, compared with a continuation of historical climate under Conservation Policy 1.

Conservation Policy 2 would reduce year 2030 water use of all climate change scenarios to below levels expected with a continuation of historical climate and Conservation Policy 1. The reductions would be expected to range from 4.2 percent to 30.1 percent and 10.6 percent to 25.9 percent for the summer and full year, respectively. The reductions in year 2030 water use under Conservation Policy 3 compared with Policy 1 range from 13.3 percent to 36.9 percent and 19.3 percent to 32.9 percent for the summer and full year, respectively.

In summary, the water use that is forecast to occur in the year 2030 under a range of climate change scenarios can be reduced to (or below) that which is forecast to occur with a continuation of historical climate and conservation measures in place in the year 1990. In addition to the potential mitigating impact of feasible demand management measures, the fact that climate change impacts on water use are relatively small in the period 1990 to 2030 compared with the expected percent of growth due to population alone, may also reduce the need for water managers to plan now for impacts of future climate change. This result is consistent with the conclusions of a White Paper (Department of the Interior *et al.*, 1997) in which seven recent studies of potential climate change impacts for regions across the United States were summarized.

It is useful to have raised and addressed the issue of the potential impact of a range of climate futures on the demand for water and resource availability in the Washington, D.C. region. These results will be considered by senior water managers as they estimate future demand for water and plan for adequate resources to meet those expected demands. It appears that no current or foreseeable plans need to be modified to explicitly take account of the effects of climate change affecting water supplies for the region. The effects appear to be limited in extent and within the ability of the concerned water supply agencies to adapt existing and future management measures to a wide range of potential future climate changes.

Table 2: Summer (April to September) year 2030 deviation (percent) from historical climate forecast under Conservation Policy 1

Climate Change Scenario	Conservation Policy 1	Conservation Policy 2	Conservation Policy 3
Historical	n/a	-19.5	-27.4
GFDL	15.3	-7.3	-16.2
GISS-A	7.9	-18.4	-21.5
GISS-B	-13.1	-30.1	-36.9
UKMO	19.0	-4.2	-13.3
MPI	16.5	-6.4	-15.3

Table 3: Twelve-month (January to December) year 2030 deviation (percent) from historical climate forecast under Conservation Policy 1

Climate Change Scenario	Conservation Policy 1	Conservation Policy 2	Conservation Policy 3
Historical	n/a	-19.5	-27.4
GFDL	8.7	-12.5	-20.6
GISS-A	4.5	-16.1	-24.0
GISS-B	-7.6	-25.9	-32.9
UKMO	10.8	-10.6	-19.3
MPI	9.6	-11.9	-20.4

REFERENCES

Boland, J.J.: 1997, “Assessing Urban Water Use and the Role of Water Conservation Measures under Climate Uncertainty,” in *Climate Change*, Kluwer Academic Publishers, 37: pp 157-176.

Davis, W.Y., D.M. Rodrigo, E.M. Opitz, B. Dziegielewski, D.D. Baumann, and J. J. Boland: 1988, *IWR-MAIN Water Use forecasting System--Version 5.1: User’s Manual and System Description*, US Army Corps of Engineers, Institute for Water Resources, Fort Belvoir, VA.

Department of the Interior, Geological Survey; Department of the Interior, Bureau of Reclamation; and Department of the Army, Corps of Engineers: 1997, *Effects of Climate Change on Water Resources and Their Management in the United States: A State-of-Knowledge Assessment: A White Paper Prepared at the Request of the Vice President of the United States.*

Steiner, R.C.: 1990, *The Potential Impact of Conservation Oriented Plumbing Codes in Maryland*, Interstate Commission on the Potomac River Basin, Rockville, Maryland, Report No. 86-9a.

Steiner, R.C., N.N. Ehrlich, J.J. Boland, G. S. Choudhury, W. Teitz, S. McCusker, and A. Yamamoto: 1997, *Water Resources Management in the Potomac River Basin under Climate Uncertainty*, Interstate Commission on the Potomac River Basin, Rockville, Maryland, Report No. 94-3.