DROUGHT AND WATER SUPPLY

DROUGHT AND WATER SUPPLY
Implications of the Massachusetts Experience for Municipal Planning

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This book is one of RFF's studies on water resources, which are directed by Charles W. Howe. Research was conducted under an RFF grant to Clark University. Clifford S. Russell is research associate with Resources for the Future; David G. Arey is assistant professor of geography at the University of Pittsburgh; Robert W. Kates is professor of geography at Clark University. The manuscript was edited by Roma K. McNickle. Charts were drawn by Clare and Frank Ford. The index was prepared by Adele Garrett.

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FOREWORD

The unexpected enlivens human affairs. It often elicits behavior different from that which responds to likely and predictable events. The latter tend to be routinized by established institutions or management systems and their measurement results in clusters of only marginally differentiated observations. A dominant tradition in social science has been to seek an understanding of society by analyzing stimulus-response patterns within a system. Far less attention has been devoted to assessing the consequences of outside shocks which shake up that system. Yet such disturbances leave a legacy of effects on individuals and institutions which influences the future behavior of a community.

This book is about an unusual natural event and how communities and individuals respond to it. Following a period of well-watered years, New England experienced in the mid-1960's five years of very low rainfall. Clifford Russell, David Arey, Robert Kates, and their associates have used data covering the dry 1962–66 period to explore what happened when unexpected drought was encountered and what types of defensive response were taken by three New England communities. The authors use this unusual and rather extreme climatic event to explore the adequacy of community water supply systems in terms of both physical structure and operation, and to analyze the capacity of communities to adapt to drought conditions. The data developed were in turn used in a model depicting the efficient expansion of an existing water supply system.

This study is part of a small but growing literature which explores society's ability to cope with natural hazards. Much of the early work in this field, centering on flood problems, was undertaken at the University of Chicago under the direction of Professor Gilbert White. His analysis of land use activities on the flood plain suggested that insurance programs and land use zoning might provide more efficient alternatives for communities seeking protection from flood damage than the physical structures upon which they traditionally have relied. The present study substantially broadens our understanding of community water supply management, and suggests that expanding the physical system is not necessarily the most efficient response to anticipated shortage.

To exploit the research opportunities offered by a reasonably well documented extreme event, the authors found it necessary to elaborate a com-

prehensive framework of concepts and definitions as well as a methodology which could be made operational in their case studies. Their definition of adequacy of a water supply system is a welcome contribution to an area of substantial public expenditure for which no very firm investment criteria exist. The rules of thumb which the authors have developed for efficient water supply system planning help fill this void.

In making explicit the service capacity of a system under drought conditions, by considering the curtailment of water use as an investment, and by expressing "losses" in dollar terms, important options for future water system planning are developed. One may expect that similar types of studies will be undertaken in different areas of the country, and that the insights and specific information developed from them will lead to the improved management of community water supply systems.

Michael F. Brewer
Vice President, Resources for the Future

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For basic financial support we thank Resources for the Future, Inc., which also made it possible for the senior author to put the final touches on the manuscript as part of his duties as a research associate at RFF. At one stage, the Harvard Water Program provided secretarial, computational, and other support for the entire study.

A special debt is owed Duane Bauman who provided challenging ideas and hard work at every stage of the study and who prepared Chapter 8 on municipal response to drought. Donald Volk undertook a study of the Metropolitan District Commission from which we have taken much useful material. Charles W. Howe, director of the Water Resources Program at RFF, gave help ranging from advice and guidance at the beginning of the study through critical review of successive drafts. Blair T. Bower, also at RFF, generously took the time to review the study and to share with us his broad background in water resource problems. Early in the study, Myron Fiering of Harvard University provided us with simulation studies indicating the impact of the drought on the estimation of streamflow variability in Massachusetts.

In the area of data gathering, our largest debt is to the forty-eight water system managers and twenty-three private firm executives we interviewed at great length. These men cheerfully put up with our questioning and gave us the raw material for the study. This phase of the study would certainly have been far harder (and probably far less successful) had we not had the cooperation in Braintree, Fitchburg, and Pittsfield of the executives of the local Chambers of Commerce. In addition, we are grateful to Wayne Palmer of the U.S. Weather Bureau for providing us with data on climatic variation over long periods in Massachusetts. Hyman Steinhurst of the Massachusetts Department of Public Health assisted us greatly in obtaining, copying, and interpreting documents in that organization's custody.

In the initial stages of the formulation of the research report Roger Kasperson, then at Clark University with Arey and Kates, contributed many valuable insights into the political processes surrounding water supply decisions.

At Harvard, where Russell worked on the study as the basis of his thesis, Professors Robert Dorfman, Harold Thomas, and Henry Jacoby gave freely of their time in helping us over some of the rough spots. In particular, Professor Dorfman suggested the present form of the capacity expansion planning model and provided an exacting critique of the economic and econometric work. Professor Thomas assisted us whenever engineering problems arose. Professor Jacoby also served as a valuable critic but even more important, perhaps, as the keeper of the Water Program funds he smoothed our path by providing support during a critical period.

When it came time to try to solve the nonlinear programming problem defined by our planning model, we were fortunate to be able to turn to Douglas Shier. As part of the research for his B.A. Honors thesis in Applied Mathematics at Harvard, he undertook all the programming required in the solution of the model. His version of the method of feasible directions proved to be very efficient and quite robust in the face of the nonconvexity of our problem.

The testing and manipulation of our data on rainfall have been greatly improved thanks to the detailed comments on an earlier draft provided by Nicholas Matalas of the U.S. Geological Survey.

In final preparation of the manuscript we are grateful to Roma McNickle, our editor, and to Henry Jarrett of RFF, both of whom suggested important improvements in organization and presentation.

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