Water Resource Planning and Development

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Preface

This book was originally prepared as a teaching aid in an experimental graduate-level course in river basin and project planning in the Department of Civil Engineering and Engineering Mechanics at the University of Arizona. My purpose was to give an overall perspective of principles, procedures, and practical problems involved in water resource planning by presenting material that was widely scattered in the literature as well as in lesser-known or less readily available manuals and guidance of government agencies, primarily the U.S. Army Corps of Engineers and the United Nations. The book also provides a historical overview of water resource planning in the United States and compares the U.S. experience to problems in third-world countries, since many of our graduate students are foreign.

I am grateful to my students who have enriched my life and who, by their questions, were responsible for clarification of the text.

I also want to express my thanks and acknowledge my indebtedness to colleagues too numerous to name in various offices of the Corps of Engineers over the years for their encouragement, cooperation, and support. Special thanks are due to James B. Smith and Charles S. Mifkovic, Sacramento District, who generously provided encouragement and information that was invaluable in my transition from practicing engineering to teaching, to John J. Cassidy who reviewed the manuscript, and to Steven Skelly whose assistance has made teaching possible.

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Margaret S. Petersen

List of Abbreviations

ac-ft	Acre-feet
ASA (CW)	Assistant Secretary of the Army for Civil Works
ASCE	American Society of Civil Engineers
BEB	Beach Erosion Board (now Coastal Engineering Research Center)
BERH	Board of Engineers for Rivers and Harbors
BUREC	United States Bureau of Reclamation
c	Coefficient
CE	U.S. Army, Corps of Engineers
CEQ	Council on Environmental Quality
CERC	Coastal Engineering Research Center, CE
CFR	Code of Federal Regulations
CP	Critical path
CRF	Capital recovery factor
DP	Dynamic programming
E & D	Engineering and design
EIR	Environmental impact report (prepared by other than a federal agency)
EIS	Environmental impact statement (prepared by a federal agency)
EM	Engineer memorandum (CE)
EP	Engineer pamphlet (CE)
EQ	Environmental quality
ER	Engineer regulation (CE)
ETL	Engineer technical letter (CE)

FPC	Federal Power Commission (now Federal Energy Regulatory Commission)
ft	Feet
H	Head in feet
ha	Hectare
IBRD	International Bank for Reconstruction and Development (World Bank)
IWC	Inland Waterways Commission
km	Kilometer
kw	Kilowatt
kwh	Kilowatt-hour
ln	Logarithm
LP	Linear programming
m	Meter
mi	Mile
MR & T	Mississippi River and Tributaries
MRC	Mississippi River Commission (CE)
msl	Mean sea level
MWP	Egyptian Master Water Plan
NED	National economic development
NEPA	National Environmental Policy Act of 1969
NWC	National Waterways Commission (temporary, established 1909); National Water Commission (temporary, established 1968)
OCE	Office of the Chief of Engineers (CE)
OMB	Office of Management and Budget
O & M	Operation and maintenance
OM & R	Operation, maintenance, and replacement
CORBDA	Ogun-Oshan River Basin Development Authority, Nigeria
OSE	Other social effects
OSWC	Oyo State Water Corporation, Nigeria
P	Power (kilowatts)
P.L.	Public Law
PMF	Probable maximum flood
p.w.	Present worth
Q	Discharge in cubic feet per second
RED	Regional economic development
SA	Secretary of the Army
S & A	Supervision and administration
SDF	Spillway design flood
SOGREAH	Société Grenoblaise d'Etudes Applique Hidrologic
SPF	Standard project flood
sq	Square

Stat.	Statute
TVA	Tennessee Valley Authority
U.N.	United Nations
UNDP	United Nations Development Program
UNDPSF	United Nations Development Program Special Fund
U.S.	United States
USAID	United States Agency for International Development
USC	United States Code
WMO	World Meteorological Organization
WRC	United States Water Resources Council
yr	Year

Contents

APPENDIXES

Chapter 1

Introduction

The discussion of water resource planning procedures in this book is based on practice in the United States, and in particular on that of the U.S. Army Corps of Engineers in their civil works program because that is the author's background. Also, most U.S. examples of planning and development described are by the Corps of Engineers. However, the fundamentals of planning are generally universal. Planning everywhere and by anyone is essentially the same, modified only by local conditions and locally imposed constraints. Accordingly, the reader must recognize that the methodology presented probably will require some modification for any specific investigation. Planning guidance of the Corps of Engineers in Engineer Manuals, Regulations, and Technical Letters was the primary source of much of the material presented. While some of the referenced guidance has been rescinded owing to the evolving philosophy of water resource planning and development and because some of the requirements set forth are no longer mandatory, the considerations identified and the procedures discussed afford valid guidance for water resource planning and development in general.

Development and management of water resources involves modification of the hydrologic cycle to regulate the natural water supply to better meet human needs. Planning for water resources development and management is based on recognition of the close interrelationship of the hydrologic cycle with other systems such as:

- Land use, soil conservation, and watershed management.
- Groundwater supply and use.

- Drainage and aquatic weed control.
- Demographics (population characteristics and distribution).
- Economics.
- Social well-being.
- Flora and fauna.
- Public health and control of disease vectors.

In the real world all things are related, but time and financial resources for planning are finite. Therefore, early in the planning process interrelationships must be identified as primary or secondary so that the scope of planning studies can be limited to manageable dimensions while assuring that all relevant factors are considered.

Water resources planning is a systematic study of:

- Long-range goals for water and related land resources.
- Present and projected future water-related problems and needs.
- Alternative solutions, including costs, impacts, and benefits.
- The optimum plan.

The need for long-range planning of water resources has become more evident in recent years with population growth and increased development and utilization of the world's resources. There is no substitute for water, and the objectives of planning center on wise use of water resources to avoid future shortages that might otherwise limit a nation's economy or the social well-being of its people.

Because manpower and funding are limited, priorities for resource development and utilization must be established through systematic planning. Wise planning and integrated development of water resources in a river basin serve to assure that no isolated irreversible plan for a part of the basin is implemented that might limit future freedom of choice and also that costs of water resources control measures are minimized.

In the last twenty years our definition of river basin "development" has changed. It was formerly narrowly defined as "economic" development, which entailed improvement of general health and well-being through provision of job opportunities; environmental and social impacts were not directly addressed. Today river basin "development" is defined as encompassing economic, environmental, and social factors. The emphasis has shifted from development programs to water resources management programs.

In the United States prior to 1970, the optimum plan generally considered was that which economic analysis indicated would result in the greatest economic return, such as the highest ratio of benefits to costs, the greatest excess of benefits over costs, or the least-cost plan. When dealing with benefits and costs in economic terms, such analyses (while sometimes complex) are straightforward and relatively free of subjective judgments.

Following passage by the U.S. Congress of the National Environmental Policy Act in 1969, analysis of social and environmental impacts became an integral part of project formulation and evaluation, and these impacts became a major consideration in determining the optimum plan. Initially it was not possible to assess the benefits and losses of such impacts in monetary terms. The general consensus was that they are subjective and lie "in the eye of the beholder," varying with the concerns, interests, and biases of individuals, groups, and political entities.

Subsequently procedures have been developed to forecast and evaluate perceived environmental and social impacts fairly well in the planning process. Many primary environmental and direct economic effects can be measured relatively easily and expressed in monetary terms. Secondary effects are more difficult to assess. Some impacts that cannot be assessed monetarily can be equated with the difference in cost of a project with and without those features resulting in the specific impacts.

What is generally lacking as an integral part of the water resources planning process is a program of systematic monitoring to assess the real impacts of programs over a period of years of operation following completion of construction in order to verify the planning evaluations. Future economic and social conditions that evolve following construction of a project often are affected by external factors that could not be foreseen at the time of planning, and real project impacts often are obscured.

DEFINITION OF TERMS

Some terms commonly used in water resources planning are defined as follows by the Corps of Engineers:

a. "Alternative plans" are different ways for managing water and related land resources employing structural and/or nonstructural measures.

b. "Base conditions" are the existing economic, social, and environmental characteristics of the area under study.

c. "Benefit/cost (B/C) ratio" is the ratio of estimated average annual benefits (for project outputs which can be expressed in monetary terms) to average annual costs (including interest and amortization of construction costs and annual operation, maintenance, and replacement costs).

d. "Cost allocation" for a multiple-purpose project is the process by which total project costs are apportioned to the various project purposes.

e. "Detailed plans" are water resources plans for which sufficient feasibility investigations have been conducted for the evaluation and selection of a plan for implementation.

f. "Economic life" is the projected useful life of a project (assuming adequate maintenance and replacement), or the time in years (usually 100 years) beyond which additional benefits and costs would not influence project economics.