TR-51
1973

Methodology for Assessment of Urban Water Planning Objectives

W.L. Meier
B.M. Thornton

Texas Water Resources Institute

Texas A&M University

RESEARCH PROJECT COMPLETION REPORT

Project Number A-020-TEX

(July 1, 1971 -- June 30, 1972)

Agreement Numbers
14-31-0001-3544
14-31-0001-3844

METHODOLOGY FOR ASSESSMENT OF URBAN WATER PLANNING OBJECTIVES

Principal Investigators

W. L. Meier and Billy M. Thornton

The work upon which this publication is based was supported in part by funds provided by the United States Department of the Interior, Office of Water Resources Research, as authorized under the Water Resources Research Act of 1964, P. L. 88-379

Technical Report No. 51
Texas Water Resources Institute
Texas A&M University

June, 1973

PREFACE

One of the most perplexing problems in the United States today is concerned with providing the public services required in rapidly-expanding urban areas. A substantial portion of the total public service problem in the urban area involves the development, use, and management of water resources.

Through planning, society attempts to define where it is going or should be going and focus its efforts toward achieving well-defined objectives through the efficient allocation of its resources. In urban water planning, the definition of well-defined, consistent objectives is complicated by the institutional structure.

It is characteristic of an urban area for many agencies to be concerned with water resource development, use, and management. These agencies may be federal, state, regional, and/or municipal in jurisdiction and usually have overlapping responsibilities and authority. This governmental "overbite" makes for complex and often inconsistent planning. Additionally, a more informed and concerned general public is currently seeking a greater role in the allocation of available resources.

In any planning problem, it is necessary to define the goals and objectives to be achieved by the plan, select alternatives to be considered, choose planning methodology and develop supporting data, develop and evaluate alternative plans, select an alternative, and implement the selected plan. Previous researchers have attempted to improve planning technology by utilizing operations research and systems analysis techniques in the investigation of alternatives to provide insight in selecting plans which best meet planning objectives. However, these improved planning techniques are effective only if a good definition of the problem and statement of the planning objectives are available. Most often the problem definition and statement of planning objectives are the most difficult tasks in the entire planning process. The definition of objectives is complicated by the fact that urban planning problems are most often attacked by interagency groups composed of local, state, and federal agencies.

In this report, procedures are developed whereby precise and consistent urban water planning objectives, reflecting the views of the involved agencies and the general public, may be developed in an equitable and unbiased manner. This is achieved by observing that objective setting procedures are composed of four basic components: 1) techniques for structuring the problem, 2) techniques for eliciting ideas and promoting consensus of opinion, 3) techniques for determining the public's attitude toward the objectives, and 4) techniques for providing an inventory of current resources and for estimating future requirements. Objective setting procedures can be generated by the judicious selection in combination of techniques from each of these components.

A specific objective setting procedure, developed for the San Antonio, Texas area, is presented in this report. The procedure

is illustrated using an example problem drawn from the study area. Additionally, opinions of five experts in water planning in the study area are utilized to compare the procedure developed with the objective setting procedures currently in use in the study area. The results of the evaluation unanimously ranked the procedure developed in this research above the currently-used procedures.

TABLE OF CONTENTS

		Page
PREFACE		ii
LIST OF TABLES		vii
LIST OF FIGURES		viii
CHAPTER		
1	INTRODUCTION	1
	Goals of the Research	9
	Outline of the Research	10
	Literature Review	11
	The General Urban Water Planning Problem	11
	Procedures for Generating Objectives	14
	Summary	20
2	THE PLANNING PROCESS	21
	The Planning Process Defined	22
	Relationships of the Objective Setting Phase	28
3	THE SAN ANTONIO WATER PLANNING ENVIRONMENT	32
	Geography, Demography and Water Resources	33
	Water-Related Organizations of the Area	43
	The Local Level Organizations	44
	The Regional Level Organizations	48
	The State Level Organizations	50
	The National Level Organizations	54
	The Current Planning Arrangement	61
4	APPLICABLE TECHNIQUES	69
	Strawman/Discussion Technique	72
	The Tree Structure	73
	Relevance Trees	76
	Brainstorming Technique	82
	The Delphi Technique	83
	Attitude Determination	87
	Summary	92

CHAPTER Page

5 OBJECTIVE SETTING PROCEDURES IN AN URBAN WATER PLANNING ENVIRONMENT 94

The Techniques in Granger's Framework 95
An Objective Setting Procedure 97
An Example Application of the Procedure in San Antonio 103
Discussion 119
Other Objective Setting Procedures 123
Summary 124

6 AN EVALUATION OF THE PROCEDURE 125

Evaluation Methodology 126
Experimental Conditions 129
Results and Analysis 133

7 CONCLUSIONS AND RECOMMENDATIONS 139

Conclusions 140
Recommendations 141

APPENDIX 144

BIBLIOGRAPHY 151

LIST OF TABLES

Table Page

3-1 Estimated water demands (acre-ft/year) from land utilization program in 1970 40

3-2 Estimated water usage (acre-ft/year) in 2000 41

3-3 Summary of costs; water resource management projects, 1970-2000 42

3-4 Most important management agencies in San Antonio 58

5-1 Inventory/forecast data 116

5-2 Quality standards 117

LIST OF FIGURES

Figure		Page
1-1	Some components of urban water investments and costs	2
2-1	The planning process	27
3-1	Water resources of the San Antonio area	35
3-2	The planning area	59
3-3	River Bend Area, San Antonio, Texas	60
4-1	Participation of the objective setter in the planning phases	71
4-2	Participation of the designer in the planning phases	71
4-3	A general tree structure	75
4-4	Matching matrix for level i+1	78
4-5	Example matching matrix	79
4-6	The completed relevance tree	81
4-7	The Delphi technique	84
5-1	The procedure	99
5-2	The deduced tree to level 1	105
5-3	First sample questionnaire	107
5-4	Second sample questionnaire	108
5-5	Third sample questionnaire	109
5-6	50% range and mean of response by criterion and questionnaire	110
5-7	Matching matrix for level 1	111
5-8	The relevance tree completed	113

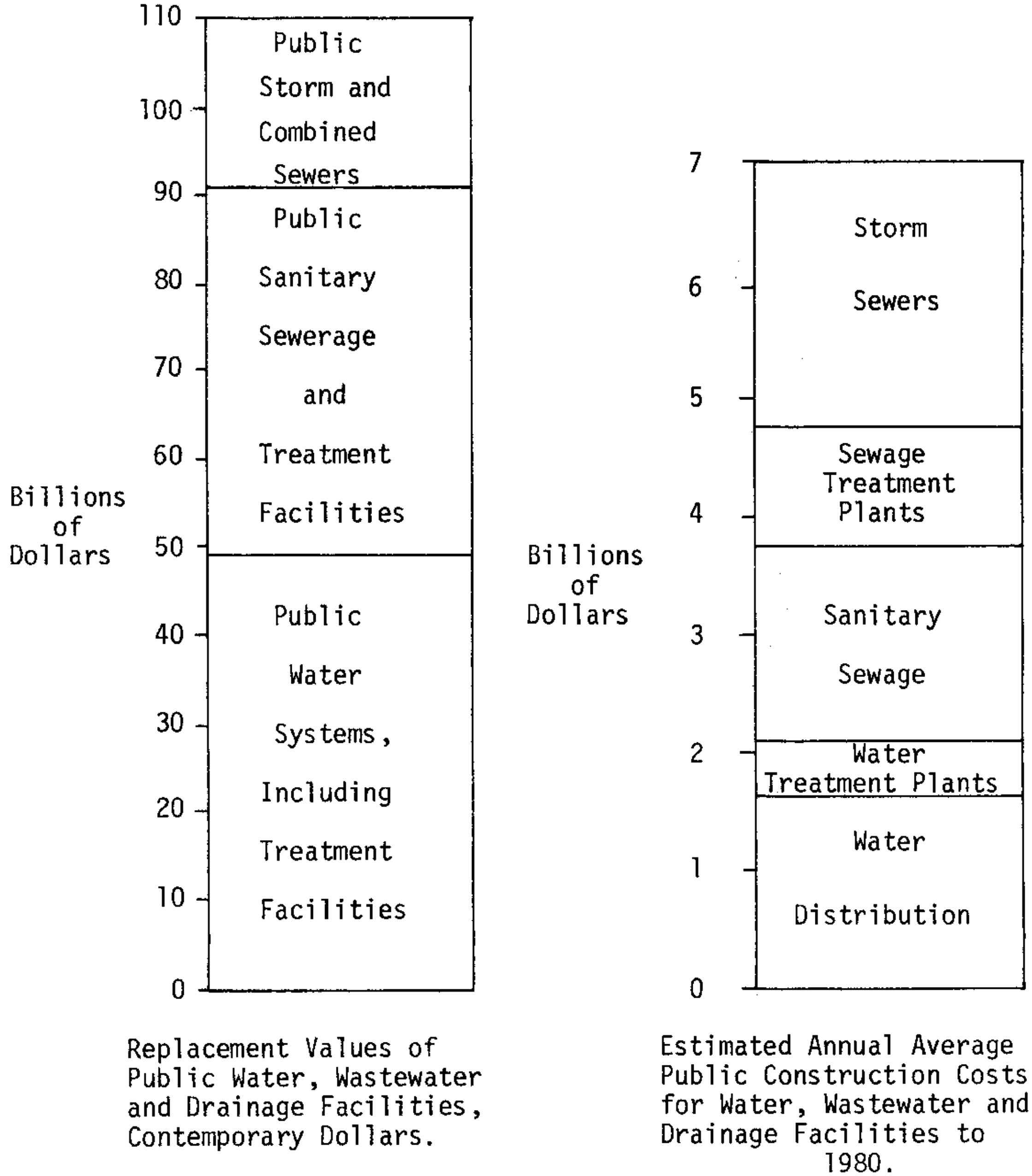
Figure		Page
5-9	Matching matrix for Medina River watershed family	114
5-10	Matching matrix for reclaimed wastewater family	115
6-1	The evaluation criteria	130
6-2	Introduction to the questionnaire	131
6-3	The questionnaire	132
6-4	Results of the evaluation	133
6-5	Summary of individual significance rankings	134
6-6	Results of equal weighting of criteria	135
6-7	Results of a pro-PROP weighting	136
6-8	Results of a pro-CURR weighting	136
A-1	Non-normalized matching matrix	148
A-2	Normalized matching matrix	148
A-3	A simple relevance tree	149

CHAPTER 1

INTRODUCTION

One of the most perplexing problems in the United States today is concerned with providing the public services required in rapidly-expanding metropolitan areas. In a National Academy of Sciences publication (70), it is estimated that over 90% of the nation's population is expected to be resident in urban areas by the end of this century. Indeed, a key description in most forecasts of the United States' demography is intensification--of people, of activity of all kinds and of competition and conflict. With the intensification of people in urban areas, the public service problem can only intensify, too. A substantial portion of the total public service problem in the urban area involves the development, use and management of water resources.

As an indication of the size of the urban water resources problem, consider Figure 1-1 which shows some components and costs of urban water investment in the U.S. through the year 1980. This figure, reproduced from an ASCE publication (6) and based on data obtained from the U.S. Department of Commerce and the American Public Works Association, shows estimated replacement values of public water, wastewater and drainage facilities to be $112.4 billion. The estimated, annual average public construction



Source: American Society of Civil Engineers (6).

Figure 1-1. Some components of urban water investments and costs.

costs for water, wastewater and drainage facilities are estimated at $7.2 billion/year. Expenditures on other urban water services, such as for storm drainage and recreation, were not available. However, the ASCE study did estimate that the average annual total expenditures by local governments on urban water resources would be on the order of $12 billion or more per year through 1980. The bulk of these costs will probably be carried at the local level through taxes, rentals and fees and as part of private property costs.

Fully aware of the severity of the public service water problem, the Texas Water Plan (88) notes:

> In the year 2020, more than 30,500,000 Texans are expected to use over 12 million acre-feet of water annually for municipal and industrial purposes as contrasted with the 1960 use of 2 1/2 million acre-feet of water by a population of 9,579,677. As Texas population grows, it is also shifting from a predominantly rural to a predominantly urban pattern. In 1960, it was estimated that 75% of all Texans live in urban areas, and by 2020, this percentage is expected to increase to about 84%.

With respect to water quality, the Texas Water Plan also indicates that the use of the full assimilation capacity of streams for the natural regeneration of water quality is not a practical long-term solution for the final treatment of municipal and industrial wastes. However, the capital costs for treatment of municipal wastes at a level adequate to combat pollution problems throughout the State of Texas are estimated as high as several hundreds of millions of dollars during the next decade alone. Because of the rapidly increasing demands for water, interaction between water-users and sharply increasing cost of water resources projects, great emphasis has been placed in recent years on water resources planning.

Planning has been defined as the process by which society directs its activities to achieve goals which it deems important. Through planning, the society attempts to define where it is going or should be going and focus its efforts toward achieving well-defined objectives through the efficient allocation of its resources (97). Planning studies normally include the following phases:

1. Forecasting of future needs and resources to identify and define problems.
2. Formulating objectives to meet the identified problems.
3. Establishing a set of feasible alternatives to satisfy these objectives.
4. Selecting courses of action from the available alternatives.
5. Delineating the sequence of activities necessary to implement the selected alternative.

In order to allocate the available physical and economic resources, water resource planners have concentrated on developing planning techniques to meet the allocation problem. Although there have been significant gains by the application of systems analysis (43) and operations research procedures (e.g., dynamic programming by Hall (43) and Meier (63)), these applications have been primarily concerned with phases 4 and 5 (and to a lesser extent, phase 3) of the planning process as outlined above. Little attention has been directed in past work toward the development of procedures for the formulation of objectives in water resources planning. This is particularly true in urban water resources planning.

The need for research in the development of procedures for the formulation of objectives is documented in the literature. For example, Hufschmidt (51) in 1965 called for research on establishing the objectives of design of water resource systems and on the translation of design objectives into design criteria. Branch (12) notes that "It has been rediscovered that planning implies and requires objectives," and, in a later article (15), flatly states, "Although the establishment of objectives is part of all planning and indeed its core consideration surprisingly little attention has been given to their analytical identification and formulation." Pollard and Moore (74), in an article on the state-of-the-art of planning, conclude that planners today have shown generally poor performance on the setting of objectives. Taft and Pollack (84) note that the urban "system, characterized by the diffusion of responsibility and authority, suffers ill-defined goals and objectives."

Thus, there is a significant need in water planning for procedures permitting the development of good, consistent objectives. The ultimate success and worth of a water plan is dependent to a large degree on the objectives defined in the early phases of the planning process. To paraphrase Hall (42), to choose the wrong system (alternative) is to select a non-optimum system, but to choose the wrong objectives is to run the risk of solving the wrong problem. In an urban area, the definition of good, consistent objectives is complicated by the institutional structure.

Only in fairly recent years has the national policy for water resources planning changed from single-purpose to multiple-purpose planning. Over the years, the river basin has evolved as the basic geographic entity for planning and development. However, urban areas within a river basin are usually looked upon as isolatable entities, with only modest attention paid to internal urban water problems and their solution. Each urban political subdivision generally evaluates and solves its own water problems within the constraints of local, regional and river basin constraints. Water planning responsibility in an urban area is usually partitioned into several functional areas, such as water supply, sewage, flood protection and sewage collection treatment. A separate agency is also usually associated with each function.

It is characteristic of an urban or metropolitan area for many agencies to be concerned with water resource development, use and management. These agencies may be federal, state, county and/or municipal in jurisdiction and usually have overlapping responsibilities dealing with waste treatment, water use, distribution, collection, quality, etc. This governmental "overbite" makes for complex and often inconsistent planning. Because of specialized missions or limitations, no one group has the overall interest, capability or authority for reviewing the total problem of supply, distribution, use, collection, reuse, etc. pertaining to urban water resources. As a consequence, conflicts between the agencies often arise in an attempt at coordinated planning for the urban area.

Additionally, a more informed and concerned general public is currently seeking a greater role in the allocation of economic and physical resources. This desire of the general public matches a need in water planning (and planning, in general) for greater public participation in the planning process. The National Academy of Sciences (67) in its booklet, Alternatives in Water Management, calls for public contribution to all phases of the planning process. Young (98) calls for a means "to permit the rejection or acceptance of basic goals by the public or their representatives . . . . This must go beyond the public hearing where meaningful discussion on intangible goals is difficult or impossible." Moreover, to propose a plan which does not consider the desires of the affected public is to invite defeat of the plan at the polls. These setbacks, wasteful of manpower and money, are also costly in time, a resource which is often quite scarce in water planning.

The consequences of not achieving coordinated planning in an urban area are a waste or inefficient use of time, money and other resources. The lead-time for major resource projects is often quite long (10-15 years from inception to completion), with a significant portion often being associated with the planning for the project. Time spent in disagreements between agencies or in replanning after a defeat of the plan at the polls is at best an inefficient use of time and money. Moreover, the extra time used because of such disagreements or defeats can delay completion of the project to the point where it is completed too late to avoid shortages or the expenditure of other scarce resources as substitutes. As noted earlier, ill-defined objectives can lead to the solution of the wrong problem which again results in an inefficient use of time and money.

The lack of coordinated planning can also lead to duplication of effort. For example, one agency of the urban area may propose and build a rather shallow reservoir for the purpose of holding cooling water for power generators, and, another agency may propose and build another reservoir to support recreation for the area. In reality, it is quite possible that one reservoir of appropriate size could accomplish both objectives at a considerable savings in money and time. Although duplication of effort may sometimes have beneficial side effects (in the example, two water supply sources are created), it is usually not the most efficient way of obtaining the side objective.

Of perhaps more importance to urban water planning is the fact that the needs of the urban areas are growing quite rapidly in response to and in anticipation of the intensive urbanization of the country. Thus, the amount of time available for planning and implementing a project is shortening. To meet the needs in a timely fashion will require procedures which shorten the amount of time required for planning by reducing the conflict between agencies, insuring the right problem is being solved and considering the attitude of the public who ultimately accepts (and pays for) or rejects the project. Such procedures are the interest of this dissertation.

Goals of the Research

The purpose of this research is to develop procedures whereby precise and consistent planning objectives, reflecting the views of the involved agencies and the general public, may be developed and assessed in an equitable and objective manner. The specific objectives of the research are as follows:

1. Devise a procedure for the establishment of unified and consistent objectives, in a rational and objective manner, for an urban water resources problem involving more than one governmental agency and the general public.
2. Illustrate the applicability of the devised procedure to a realistic problem encountered by the San Antonio, Texas, metropolitan area.
3. Indicate how other such procedures can be generated, depending on the planning environment and the problem at hand.
4. Provide an assessment of the devised procedure.

Emphasis is placed on the development of procedures that also give indication of the public acceptance of the objectives determined. The specific intent of the research is to develop procedures which will be applicable in a wide variety of similar planning problems and is not to develop specific models which might tend to be highly detailed and applicable only to a specific problem. This emphasis on the development of an approach properly recognizes the wide variation of types of problems encountered in the urban water resources planning environment.

Outline of the Report

This chapter concludes with a general review of the literature on two broad topics: general urban water planning problems, and procedures for generating objectives. Succeeding chapters contain more specific references to the literature as they are required to properly introduce techniques used in the procedures. Chapter 2 presents briefly the planning process as assumed by this report. The third chapter contains a description of the San Antonio, Texas, planning environment--its physical characteristics, its organizations and its current planning arrangement. Chapter 4 reviews several techniques of use in generating objectives. In Chapter 5, these techniques are integrated into an objective setting procedure appropriate for the San Antonio area. The procedure is then illustrated by application to a realistic situation in the San Antonio area. Chapter 6 presents the methodology and results of an evaluation of the objective setting procedure. The report concludes with Chapter 7, a statement of conclusions and recommendations.

Literature Review

The review of the literature is divided into two main segments:

1. General references to water planning problems in an urban environment.
2. The generation of the objectives of the planning process.

At the outset, a distinction will be made between two terms often used synonomously in planning references: goal and objective. Throughout this document, a goal is defined as the end to which a design trends, i.e., an ideal or aim which is usually expressed in general and abstract terms. It is a value to be sought after, not an object to be achieved. An objective, on the other hand, is capable of attainment and measurement; it is an end point to be hit or reached. With these two definitions, the review of the literature can begin.

The General Urban Water Planning Problem

Because of the rapidly increasing demands for water and sharply increasing cost of water resource projects, great emphasis has recently been placed on water resources research. This research has resulted in significant advances in the evaluation of water plans through the use of simulation and operations research methods (43,63,87). Hall (43) and Meier (63) have applied dynamic programming to the evaluation of operating strategies for systems of interconnected reservoirs. The Texas Water Development Board (87) has constructed water quality simulation models for specific rivers of Texas for the analysis of water quality under varying environmental conditions. The need for further research in the evaluation of water plans was recently highlighted in the proceedings of a conference of the American Water Works Association (95). Because of the press of existing problems, emphasis has been placed on developing techniques for studying large regional, river basin or state-wide systems consisting of reservoirs, conveyance facilities and, sometimes, water quality control works. In these studies, simulation and operations research procedures were employed using economic (costs and benefits) measures of effectiveness and assuming that the purpose of the project (flood control, irrigation, municipal/industrial use) was clear. Furthermore, it was largely assumed that a single agency (state or federal, usually) would take charge of planning, implementing and operating the project. In an urban area, however, a variety of agencies exist which are local, county, regional, state-wide and federal in jurisdiction and which have interacting and/or overlapping responsibility. Thus, many of the techniques developed for large geographical areas are not immediately applicable and some are inapplicable.

Because of the increasing need for improved water planning in urban areas, various groups and agencies have attempted to assess the research needs in urban water planning and urban planning in general (6,62,68,69). Principally, these studies have recommended collecting additional data and conducting research to develop methods similar to those for river basin systems. Additionally, a recent research report of the American Society of Civil Engineers discussed the difficulty caused by the complex, intergovernmental structure found in urban areas (62). Although many possible institutional realignments were considered, it was ultimately concluded that the probability of obtaining these desirable realignments was quite low. Thus, if it is unlikely that the institutions will change, planning procedures must be developed to obtain unified planning objectives for the agencies as they currently exist.

Urban planning and water management have been the subject of a wide variety of studies (6,18,62,68,69). These investigations have lucidly discussed problems created by congestion, an increasing population, demand for increased services, etc. Most have recommended taking a "systems approach" to the solution of these problems. However, in a water resources context, the proposed solutions are largely described in the traditional compartments (waste treatment, water supply, storm drainage, etc.) which have been used to classify water problems in the past. Indeed, such compartmentalization is in some measure responsible for the emergence of the many agencies that characterize the urban institutional structure. Forward-looking, fully integrated plans are needed to bring these segmented urban water resources efforts together.

The institutional problems in urban water resource planning have been recognized at several governmental levels. At the national level, the Office of Water Resources Research (71) addressed the difficulty in defining the geographical region within which the description of the urban resources are complete. This same conference called for research "to develop a type of regional management organization, which can harmonize the conflicting and competing existing institutional arrangements, and at the same time equitably distribute the costs involved." At the state level, Casbeer and Trock (17) have noted several of the institutional factors influencing water development in Texas. At the local and regional level, the birth of the Area Council of Governments organization is testimony of the fact that current institutions are generally not well suited for urban planning. Organizational theory is not addressed in this study. However, the procedures contained herein were developed with the current institutional structure in mind.

Procedures for Generating Objectives

The difficulty in developing and assessing objectives in water planning (and planning in general) has been discussed at length in the literature (6,62,68,71,72,95). In a landmark study at Harvard University, Maass et al. (61) devoted attention to water planning objectives. This study noted that the objectives were seldom specific enough to be of use to the water resource analyst who generally expects the detailed objectives to be among the "given" data in a planning problem. Hufschmidt (51), Branch (13), Teitz (85), Ewing (30), Taft and Pollack (84) and Hill (48) have also noted the lack of specificity in the statement of objectives. Recently, many concerned with water planning practice have sought to improve evaluation procedures through establishing better planning objectives (94). Revised criteria for setting objectives have been tested in the field (93), but still represent only broad guidelines and refer principally to regional water development systems. Many difficulties in implementing these criteria remain, e.g., the very real problem of quantifying criteria involving environmental and aesthetic considerations.

Although numerous authors (Collier (20), LeBreton (58), Branch (13), Dyckman (26), Ewing (30), Altshuler (5), Gidez (38), Miller (64), Hughes (52), Hall (42), Goodman (39)) have written of the importance of objectives to the success of the venture, only a few have attempted to indicate how the objectives are determined and/or detailed. These exceptions are treated in the following paragraphs.

Branch (13) and Branch and Robinson (15) offer a general procedure which can be paraphrased as the following steps:

1. Representation of the current state: An expression which depicts the recent development of the entity and its current state in all essential respects. It embodies past objectives, both explicit and implicit.
2. Projection of the current state: Showing probable development of the entity at successive stages in the future, assuming the entity and its current policies and objectives and external environment remain unchanged.

3. Modification of projected current state: Incorporates known circumstances both internal and external which will affect the entity's future significantly.
4. Optimistic formulation: Representation of the entity under exceptionally favorable and unlikely conditions. This encourages a greater range of imaginative consideration and identifies unusual paths of opportunity to be followed should the situation permit.
5. Comprehensive plan: An adjustment between steps 3 and 4 which incorporates a combination of established, necessary, desirable and possible objectives at successive stages of future time. It is the formal statement of accepted or prescribed activity, direction and intention of the organizational entity.

No procedures or techniques for accomplishing the steps are suggested. This method is seen to be more of a philosophy of setting objectives rather than an analytic procedure for setting and detailing objectives.

Ewing (30) also notes two other philosophies for setting objectives. One is termed the inside-out approach, which is much like Branch's philosophy. In the inside-out approach, a thorough analysis of the strengths and weaknesses (the current state of Branch) of the entity is made. Management then looks outside of the entity at the field of need and then "decides" what its objectives are. The other philosophy is the outside-in approach and is even more business oriented than the first approach. In this second approach, management first looks for significant needs, then concerns itself with an analysis of the entity so that an ultimate decision as to the objectives can be made. It is apparent that Ewing's approaches are even more philosophical in nature than Branch's.

Granger (41) begins with a hierarchy of what he terms objectives. Actually, at the broadest level, these are goals which become progressively what is known as creeds, grand designs, objectives, targets, etc., as more detail is specified, as the duration of these aims decreases and as the aims deal with more concrete notions. He formulates a seven step process which is used repetitively at each level of the hierarchy. The seven steps are:

1. State the broader objective.
2. Establish tentative criteria in the form of "key result areas" and standards for measuring the success of the broader objective, recognizing other objectives and changing internal and external conditions.
3. Create alternative sub-missions or sub-objectives to attain the broader objective.
4. Analyze the effectiveness and the resources consumption or costs of these alternative sub-programs.
5. Select and state the preferred sub-objectives.
6. Repeat the foregoing process to minimize inconsistencies

and conflicts of the sub-objectives with each other and with the broader objectives.

7. State the final sub-objectives.

Granger's process is certainly less philosophical than Ewing's since it provides a definite series of steps to follow although Granger mentions no techniques to accomplish these steps. Like Branch's process, it contains an iterative step designed to reduce inconsistency with "real world" facts. Step 4 of Granger's process seems to be drawn from a later phase of the planning process in which system design takes place. In summary, Granger's process appears to represent a logical method of detailing objectives, but it lacks specific techniques for accomplishing the steps.

Hall (42) lists several suggestions to keep in mind while setting objectives. Some of his suggestions are: admit any idea, commit the objectives or ideas to paper, check for completeness, identify means and ends, apply the wisdom of semantics, check for realizability, check for consistency, etc. Techniques for following many of these suggestions are not given.

Hughes (52) cites eight steps that form the goal-setting process, his definition of a goal encompassing that defined as an objective in this study. The steps are:

1. Establish specific goals to support the stated purpose.
2. Determine the importance of these goals.
3. Make plans for action.

4. Arrive at performance standards and measurement criteria.
5. State anticipated problems.
6. Weigh the resources required to carry out the planned action.
7. Provide for the interaction of organizational and individual goals.
8. Follow up with actual performance measurement and evaluation.

Hughes states no specific techniques to use in achieving these steps, especially step 1. Indeed, step 1 appears to make the stated procedure circuitous by declaring the first step of goal setting is the setting of goals. Hughes probably intended that sub-goals be set to attain the overall goal.

Thus, few detailed procedures for objective setting are available from the literature and, indeed, most of the literature on objectives is concerned with the importance of objectives and some of their more important characteristics. It is interesting to note some of these characteristics which are found in several references. For example, stating the importance of objectives is advocated by Hughes (52), Hall (42) and Miller (64). Delineating the relationships between ends and means (goals and sub-goals) is again noted as important by Hughes (52) and Hall (42) and seconded by Granger (41). Miller (64), Granger (41), Hufschmidt (51) and several other authors advocate detailed objectives for improved planning. Finally, Young (98) and Hall (42) note there should be agreement on the objectives by all relevant participants. For many water resource projects, this will include the general public. Because these characteristics are frequent in the literature, they must be deemed important. Objective setting procedures should be devised with these characteristics in mind.

Summary

In summary, there have been several investigations discussing the peculiarities/complexities of the urban planning environment and the need for detailed, consistent planning objectives. However, it does not appear that the investigators have treated the development of objectives in urban water planning in a satisfactory manner because:

1. they have generally spoken only of the importance of objectives, and
2. they have not postulated detailed procedures (including specific techniques) for generating objectives.

Despite the recognized importance of objectives in the planning process, few procedures have actually been formulated to generate objectives. There thus exists a real need for procedures to develop unified water resource objectives for the urban area. These objectives can then serve as a basis for coordinated action to solve urban water problems.

CHAPTER 2

THE PLANNING PROCESS

Planning is today a very popular word. With the many social, physical and economic problems under investigation today, the literature virtually teams with the word planning. It is not surprising, therefore, to find many different uses and definitions of planning. Altshuler (4) has called planning "simply the effort to infuse activity with consistency and conscious purpose." Friedman (35) terms it "primarily a way of thinking about social and economic problems." "Planning," say Bollens and Schmandt (10), "results in blueprints for future development; it recommends courses of actions for the achievement of desired goals." Now, there are many ways, not all mutually exclusive, of categorizing planning.

One such classification is by the field of application. Thus, the literature contains references to urban, social, developmental, land use, transportation and water planning, to name just a few. Another categorization is by who sponsors the planning. Thus, departmental, agency and advocate planning are discussed in the literature. Another classification often found is by for whom the planning is done, giving rise to public, business and government planning. Another common classification is by time frame of the planning, yielding short-range, mid-range and long-range planning. Yet another classification is afforded by what planners try to achieve through the planning effort. This gives rise to normative planning (the activity of establishing rational or reasonable ends), policies planning (a process of establishing ends and determining the means by which ends will be obtained) and technical planning (the activity of delineating the steps to achieve an end). With the multitude of uses and definitions associated with the word planning, it is no wonder that the literature on planning is often confusing.

Because this study is to address procedures for setting objectives, it is necessary to fix where objective setting occurs in the planning process. This, in turn, necessitates an assumption on the form of the planning process. Thus, it is necessary to categorize planning in yet another way. This is done in the following section. The purpose of this chapter, then, is to set forth a general planning process and to indicate the importance of the objective setting phase of this process.

The Planning Process Defined

As to be expected, the literature contains many definitions of the planning process, e.g., Davidoff and Riener (24), Collier (20), Branch (14), Rothblatt (77), Lindblom (60) and Goodman (39), to cite only a few. Indeed, there are almost as many definitions of the planning process as there are authors of articles on the planning process. Basically, however, there are two divisions within the many definitions and commonality within each division. The two basic divisions are between the rational comprehensive approach and the approach of successive limited comparisons, hereinafter termed the rational and incremental approaches, respectively.

The rational approach, in one form or another, is espoused by a good many writers, Collier (20), Branch (14), and Rothblatt (77), to name just a few. This approach generally consists of the following phases:

1. Comprehensive overview and definition of the problem (policy area) involved.
2. Goal formulation based on the comprehensive overview.
3. Translation of goals into detailed objectives.
4. Examination, evaluation and choice of alternative courses of action with respect to objectives sought.
5. Implementation of the alternatives chosen.
6. Feedback to adjust the preceding steps.

The preceding process is then applied to all planning problems, private or public in nature.

In recent decades, some writers (Lindblom (60), Banfield (8), Simon (82)) have suggested that public programs are neither comprehensive nor rational and suggest that the actual process involved in public planning is the incremental process. This process is characterized by the following steps:

1. Set a relatively simple goal which is compromised or complicated by only a few other goals, disregarding other goals as beyond the present interest.
2. Outline the policy alternatives that immediately occur

to the planner.

3. Compare these alternatives, relying heavily on past experience with small policy changes to predict the consequences of similar changes extended into the future.
4. Final selection of an alternative, combining into this alternative the choice among values and alternatives for reaching these values.
5. Implement the alternative.

Because practitioners of the second approach expect to achieve their goals only partially, they would expect to endlessly repeat the above process as conditions and aspirations change and as accuracy of prediction improves. Thus, planning and achievement of goals is achieved through a series of small, incremental steps.

Critics of the rational process (primarily the advocates of the incremental process) have criticized that:

1. the policy area or problem may be too complicated to view comprehensively;
2. goals may not be clearly defined or agreed upon;
3. goals may not be easily translated into operational objectives;
4. because of time and financial constraints, few alternatives (instead of all) are examined, resulting in a "satisficing" of goal attainment rather than a maximization of goal attainment;
5. planning agencies may not have the political power to

implement their plans; and

6. effects of feedback are only small incremental shifts.

However, in a recent article entitled "Rational Planning Reexamined," Rothblatt (77) demonstrates that a sizeable program, The Appalachian Regional Development Act, 1965, did indeed use a process which closely approximated the rational planning process. Moreover, the incremental approach is not without its own faults.

For example, in step 1 of the incremental process, it is not clear that difficult problems would ever be approached because the most difficult problems generally deal with the conflict between two goals, e.g., pollution control and productivity increase. By not attempting to make an exhaustive search for alternatives as in step 2, many "not-so-obvious" but "good" alternatives may be completely overlooked. Relying heavily on past experience in the comparison of alternatives as in step 3 virtually ignores the bodies of theory that have been developed for comparing alternatives. Moreover, considering the effects of only small changes extended into the future is essentially making a straight line or linear extrapolation which usually fails to take into account cumulative effects of previous policy changes. For example, one or two small policy changes in favor of alternatives favoring increased production over pollution control may have little individual effect but collectively may seriously deteriorate the environment of concern. Finally, Lindblom (60) claims that many public agencies actually employ the incremental approach. With the past record of duplication of effort, lack of efficiency in solving the total problem involved and crisis-motivated planning found in many public agencies throughout the U.S., this is not a very good recommendation for incremental planning.

It is realized that the "pure" rational process is an ideal, i.e., a goal, towards which planning agencies should strive. Without these attempts at "pure" rational planning, the complex problems confronting planners today will not be solved and planners will be constantly faced with crisis situations within which planning will have to be accomplished. For this reason, the realization that each attempt at "pure" rational planning improves the next effort and the fact that research into procedures to effect the "pure" rational process is continually in process, this dissertation will employ a rational process similar to the method outlined above.

The process utilized by this study, hereinafter termed "the planning process," is depicted in Figure 2-1. This process assumes that the basic goals of the agency employing the process are given or known. Forecasted needs or opportunities for the appropriate time frame with respect to these goals are then obtained and the problem of interest is fully defined (problem definition phase). From this problem definition, detailed objectives are formulated to meet the forecasted needs (objective setting phase). A wide variety of feasible alternatives are then devised by the system designers (the design phase) and, ultimately, an optimum alternative is selected (evaluation/selection phase). Finally, those activities required to implement the selected alternative are selected and

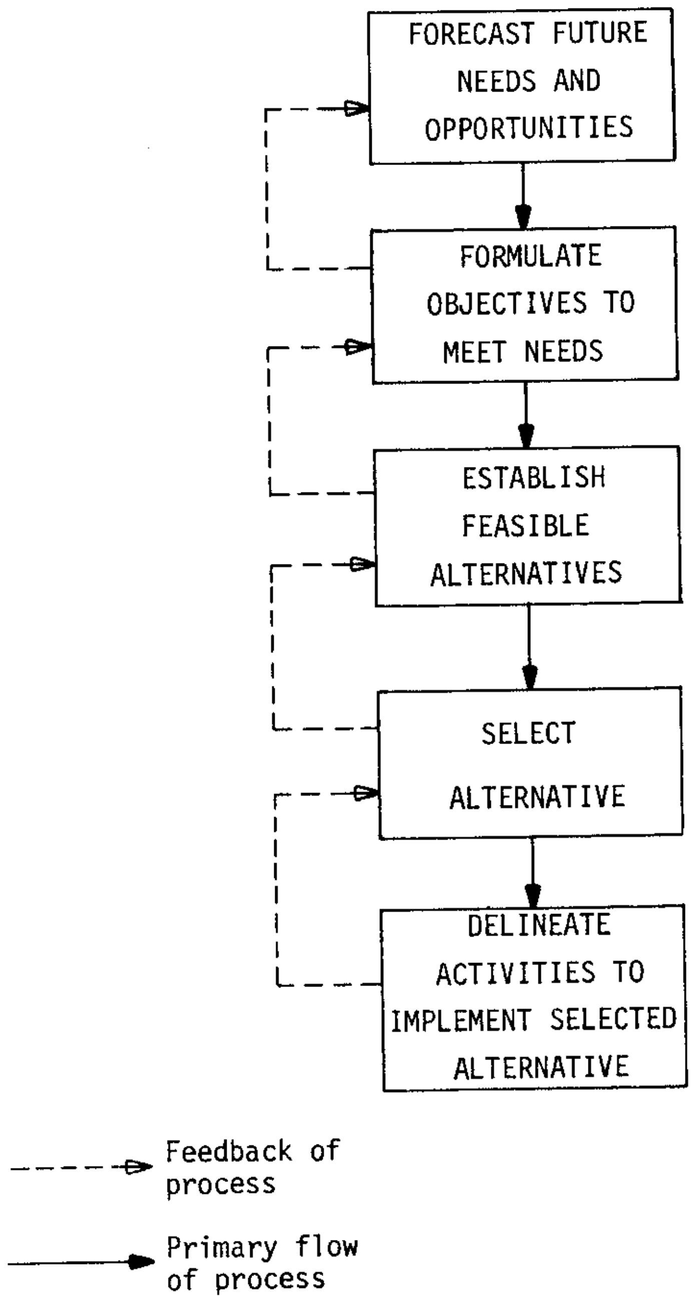


Figure 2-1. The planning process.

scheduled (activity delineation phase), using, say, the Program Evaluation and Review Technique (PERT) or the Critical Path Method (CPM). The actual implementation of the selected alternative would follow (although not shown as a step of the planning process). Feedback among the several phases is shown by the dashed arrows. Such feedback can be over more than one phase although the majority of the feedback will follow the indicated paths.

As noted above, this planning process is an ideal toward which planners strive; it is only rarely found in its "pure" form in the real world, as will be illustrated in Chapter 3 on the San Antonio, Texas, planning environment.

Relationships of the Objective Setting Phase

The importance of the objective setting phase can be appreciated through an analysis of the relationships of the objective setting phase to the other phases of the planning process. The first relationship to be discussed is that between the problem definition phase and the objective setting phase. It is clear that without a detailed definition of the problem, detailed objectives representing the values of the planners cannot be set. And without detailed objectives, the problems, as seen by the planners, cannot be solved. A detailed definition of the problem should contain a statement of the need involved, both in quantitative and qualitative characteristics. As shall be set forth in Chapter 4, detailed objectives require quantification and an explicit statement of the values associated with the problem or needs. There is thus a trade-off between the amount of work performed in these two phases. If a skimpy problem definition is made, then considerably more work must be done in the objective setting phase, and the procedures for generating objectives must reflect this added work. On the other hand, a thorough definition of the problem greatly reduces the amount of work required in the objective setting phase. In this case, the only tasks required in the objective setting phase are those of classification and arranging the quantitative and qualitative characteristics into the appropriate format. In reality, what normally occurs is that problem definition is insufficient for generating detailed objectives and this feedback causes a greater definition of the problem to be performed. In this dissertation, the procedures for generating objectives recognize this condition and contain the elements for additional problem definition.

As noted above, detailed objectives are a necessary prerequisite for the system design phase. If the desired purpose and the quantitative and qualitative values associated with the purpose are not specified, then the system designer must specify such data himself. If the objective setter and system designer are the same individual, there is little cause for concern. Normally, however, these two roles are assumed by different individuals. In such cases, there is then the real danger that the system designer will assign different values to the purposes and solve the wrong problem. Thus, there is a strong relationship between the objective setting phase and the system design phase.

Similar comments apply to the relationship with the evaluation/ selection phase. The detailed objectives act as yardsticks that measure a proposed system's (alternative's) fulfillment of requirements. In example, if an objective calls for a system to deliver 20,000 acre-ft of reclaimed wastewater per year and is designed such that it is capable of delivering only 10,000 acre-ft per year (this conclusion might have been determined through simulation of the design), the designed system has not met the objective; the objective has served to measure the system with respect to the requirements.

The objective setting phase has no direct relationship with the activity delineation phase. Indirectly, feedback from this latter phase up through the preceeding phases can ultimately affect the objective setting phase. In this case, changes will be made to the objectives and the impact of these changes will ultimately be felt in the activity delineation phase.

The importance of the objective setting phase of the planning process is indicated by the fact that it is directly related to all but one of the remaining phases of planning process. Because of this importance, the literature should contain several references to studies on objective setting and to procedures for setting objectives. However, as noted in the literature review of the preceding chapter, there are few such references and most references that are made are to ill-defined procedures which are usually philosophical in nature.

Thus, there is a real need for procedures to aid in the setting of objectives.

CHAPTER 3

THE SAN ANTONIO WATER PLANNING ENVIRONMENT

In order to illustrate the techniques and procedures to be introduced in subsequent chapters, it is necessary to choose and describe a study area wherein these methods could be used. The area selected for this study is the urban area surrounding and including the city of San Antonio, Texas. As shall be illustrated in the following, San Antonio possesses several of the characteristics of an urban area wherein coordinated and comprehensive water planning is desirable and desired. The purpose of this chapter, then, is to describe the San Antonio water planning environment. This description is initiated by a discussion of the geography, demography and water resources of the area. Next, the important water related agencies of the area are investigated as to mission, authority and past or current water problems encountered. Lastly, a brief section describing the water planning process as currently found in the study area is presented. Much of the following data have been summarized from two reports, Garner and Shih (36) and an unpublished report by a seminar at the Lyndon B. Johnson School of Public Affairs (92). These reports form the basis of the description of the area water planning environment although further reference to the reports will not be made.

Geography, Demography, and Water Resources

San Antonio, the fifteenth largest city in population in the United States, is located in Bexar County in South Central Texas. The area is not naturally endowed with an abundance of surface water and is largely dependent on ground water resources for its supply. The area is not facing an immediate water shortage but its major water problem is that of insuring an adequate future water supply.

San Antonio is an old city that lies in a populated area of approximately one million persons. It is unique in that it is the largest city in the world primarily dependent on ground water resources. The city is presently 182.73 square miles in size. Within the city of San Antonio, there are five separately incorporated cities; seven military reservations lie within or adjacent to the city. San Antonio is an active business community and the region is well developed with both agricultural and commercial enterprises. There is relatively little basic industrial activity within the region and thus the economy heavily relies upon the military complexes of the area and upon tourism.

The San Antonio River Valley is classified as a modified subtropical climate, predominantly mild during the winter months and warm-to-hot during the summer months. The San Antonio River divides a semiarid area to the west and the coastal area of heavy precipitation to the southeast. Average annual rainfall varies across the river valley from 25 inches to 36 inches per year. The rainfall is relatively well-distributed throughout the year with heaviest amounts during the months of May and September. Precipitation from April through September is primarily from thunderstorms whereas most of the winter rain occurs as drizzle. Hail of damaging intensity seldom occurs although light hail is frequently observed with spring thunderstorms. Measurable snow falls only once in three or more years.

Soils in the upper valley generally overlay cretaceous limestone and are characterized by steep slopes, shallow depths and limestone fragments in the surface soil. These soils are generally least suitable for agriculture and urban development due to the high cost of pre-use preparation. The soils in the lower parts of the valley have a medium to course texture with great depth, rendering them very suitable for intensive urban development. Juniper, oak and mesquite surrounded by dense undergrowth dominate the area and support a wide variety of wildlife and birdlife. Freshwater fish are in abundance in the reservoirs and streams of the area.

As illustrated by Figure 3-1, the San Antonio River Basin comprises an area of more than 4,100 square miles and includes parts of two physiographic sections, the West Gulf Coastal Plain of the Coastal Plain province and the Edwards Plateau of the Great Plains province. These two sections are separated by the Balcones Escarpment. The principal stream that drains the Edwards Plateau section is the Medina River, which rises in the northwestern part

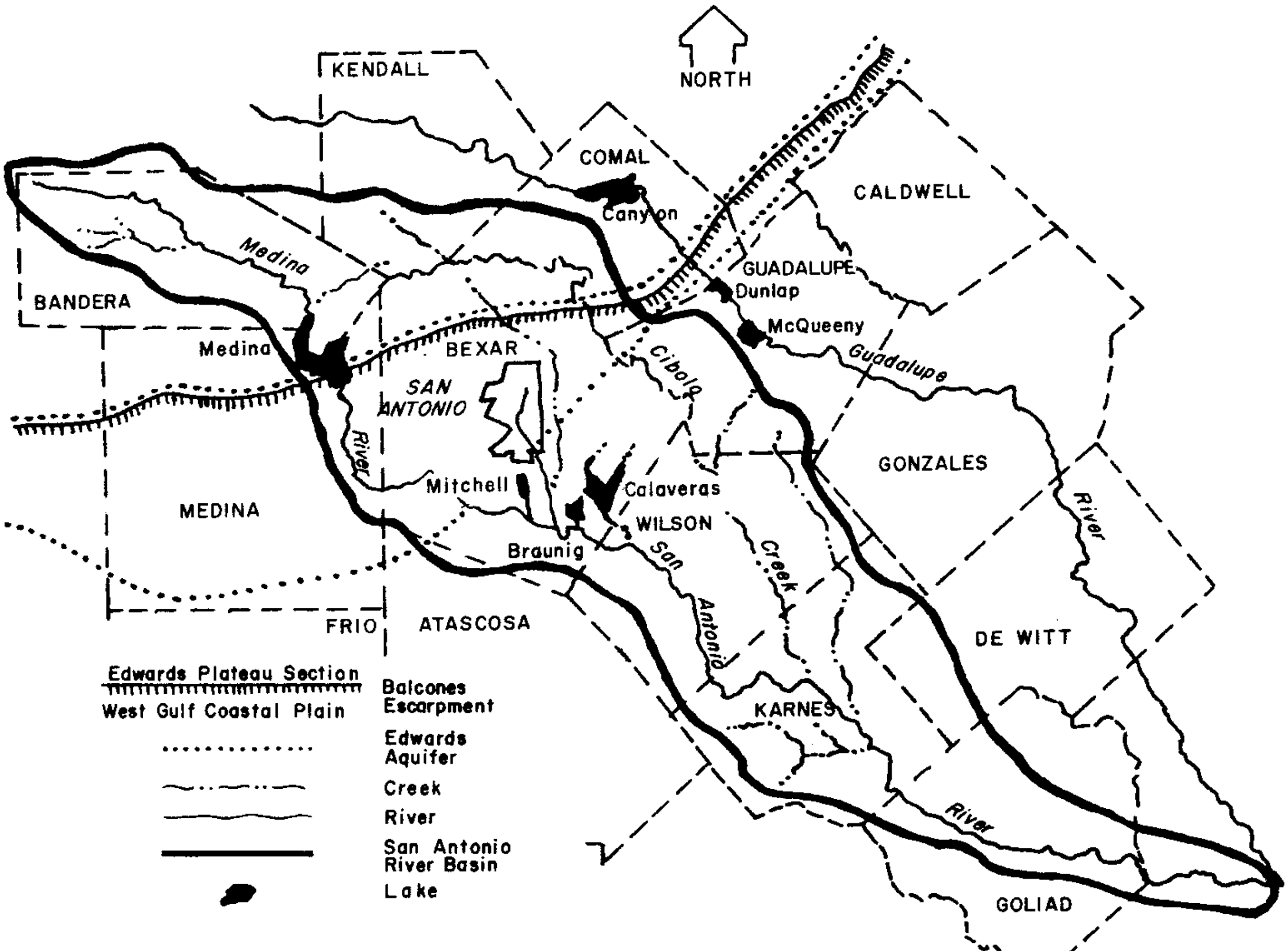


Figure 3-1. Water resources of the San Antonio area.

of Bandera County, flows eastward across the Edwards Plateau, and joins the San Antonio River about 15 miles south of San Antonio. The mainstream of the San Antonio River rises in the city of San Antonio near the center of Bexar County, flows southeastward across the West Gulf Coastal Plain and joins the Guadalupe River about 11 miles upstream from San Antonio Bay. Cibolo Creek, the principal tributary to the San Antonio River, rises in Kendall County in the Edwards Plateau section, flows southeastward across the Balcones Escarpment and West Gulf Coast Plain section and joins the San Antonio River in Karnes County.

There are four major aquifers in the region. However, the Edwards and its associated limestones is the region's most important aquifer. The Edwards provides the water supply to the major population areas of the region including the city of San Antonio. The volume of water in storage within the Edwards varies rapidly in response to precipitation and water demands placed upon the aquifer.

Springflow from the Edwards and associated limestones in the Edwards Plateau contributes to the base flow of the Medina River and Cibolo Creek. In turn, most of the base flow and part of the flood flow infiltrates into the Balcones Fault zone on the outcrop of the Edwards and associated limestones. The Balcones Fault zone is the principal recharge zone of the Edwards aquifer.

Although the area depends solely upon ground water to meet the population's water needs, there is a limited amount of surface water in the region. Canyon, Medina, McQueeny, Dunlap, Braunig, Calaveras and Mitchell are the major lakes and reservoirs of the area. All are man-made and are used primarily for flood control, waste treatment, power generation or recreation purposes. Mitchell Lake is part of the San Antonio waste treatment process and as such has limited recreational usage. It does, however, supply water for irrigation purposes.

Portions of the area were declared a Standard Metropolitan Statistical Area (SMSA) by the Bureau of the Census. This is a designation applied to an area whose city boundaries and subdivisions are interconnected in such a manner that compilation of data for any one sector is meaningless. For this reason, it is better to speak of the economy of the area in terms of the SMSA rather than the various governmental units.

Total population of the San Antonio SMSA in 1970 was 864,014. Of this total, 794,737 were white, 59,887 were black and 9,390 were of some other race. The 1967 Census of Business reports that there were 6,301 retail establishments within the SMSA with total sales of $1,075,774,000.00 and a payroll of $132,542,000.00 annually. The Central Business District of San Antonio accounted for 18.6 percent of sales within the SMSA, indicating a viable business district within downtown San Antonio.

In 1967, there were over 1300 financial institutions in the region including banking, insurance and real estate. Additionally, there is a local Federal Reserve Branch Bank located in San Antonio. It appears likely, therefore, that future economic growth demands of the area will be met.

Educational institutions of the area account for more than 8 percent of non-agricultural employment. There are forty-one independent school districts, two junior colleges and five senior colleges. Additionally, several private organizations provide specialized training which is not provided in other educational institutions.

Agriculture in the area consists of private farms whose production is common to the southwest region; there is a heavy use of irrigation in the area. Cattle and beef production account for a portion while the rest are farm products. Over the past several years, farm production has remained constant while the number of farms has decreased.

Because some of the data are classified, exact data on the number of military personnel in the area are not available. The percentage of military and associated civil service personnel in the area is adequately termed high. Exact data on the importance of tourism to the region's economy are also not available. However, because of the Alamo (a historic Texas monument) being located in downtown San Antonio and the existence of other historic sites associated with Texas' bid for independence, the area is said to have a healthy tourist trade.

It is interesting to note the pattern and magnitude of use of the water resources in the area described above. As noted earlier, the principal supply source for the nearly one million people of the area is the Edwards aquifer. It supplies most of the water for municipal, industrial, irrigation and domestic purposes and is the only source of water for San Antonio and several small cities and communities of the area. The aquifer yields approximately 260,000 acre-ft of water annually in the San Antonio River basin, principally through wells and springs with approximately 80 percent of the discharge coming from wells.

During the period 1955-1970, one-half of the annual discharge from wells was used for municipal and military purposes. Out of this amount, approximately 90 percent was required for municipal and military uses in Bexar County. Of the 90 percent, over 70 percent was used by the City of San Antonio.

As an indication of the magnitude of the water demands of the area, consider Tables 3-1 and 3-2, taken from the AACOG Water Resource Management Plan (3). These data are estimates based on land utilization and population forecasts and include a thirteen county area. They show a total water use of 505,400 acre-ft per year in 1970 and a projected use of 786,200 acre-ft per year in the year 2000. A portion of the supply to meet these demands will be obtained from other basins of the thirteen county area, i.e., the Edwards aquifer is not the sole supply source for the thirteen county area. The anticipated expenditures over this thirty year period are on the order of $315,300,000, as indicated by Table 3-3, also taken from the AACOG Water Resource Management Plan (3).

Thus, the demands and potential expenditures in the study are

Table 3-1: Estimated water demands (acre-ft/year) from land utilization program in 1970

County	Urban Use	Irrigation Use	Cooling (Consumptive)	Total Water Use	Urban Waste Water	Net Consumption
Total Region	269,500	226,900	10,000	505,400	134,850	371,550
Atascosa	3,300	34,000	0	37,300	1,600	35,700
Bandera	300	400	0	700	150	550
Bexar	240,000	40,000	10,000	290,000	120,000	170,000
Comal	4,700	300	0	5,000	2,600	2,400
Frio	2,100	69,000	0	70,100	1,000	70,100
Gillespie	1,400	1,400	0	2,800	700	2,100
Goliad	500	1,300	0	1,800	250	1,550
Guadalupe	5,300	2,400	0	7,700	2,600	5,100
Karnes	2,800	1,000	0	3,800	1,400	2,400
Kendall	1,000	600	0	1,600	500	1,100
Kerr	3,200	1,500	0	4,700	1,600	3,100
Medina	3,400	58,000	0	61,400	1,700	59,700
Wilson	1,500	17,000	0	18,500	750	17,750

Source: Alamo Area Council of Governments (3).

Table 3-2: Estimated water usage (acre-ft/year) in 2000

County	Urban Use	Irrigation Use	Cooling (Consumptive)	Total Water Use	Urban Waste Water	Net Consumption
Total Region	382,600	313,600	90,000	786,200	216,150	570,050
Atascosa	4,800	50,000	0	54,800	2,400	52,400
Bandera	800	1,000	0	1,800	400	1,400
Bexar	326,000	30,000	90,000	446,000	188,000	258,000
Comal	9,500	200	0	9,700	4,700	5,000
Frio	3,000	100,000	0	103,000	1,500	101,500
Gillespie	2,000	1,500	0	3,500	1,000	2,500
Goliad	1,000	3,000	0	4,000	500	3,500
Guadalupe	16,000	2,400	0	18,400	8,000	10,400
Karnes	3,200	1,500	0	4,700	1,600	3,100
Kendall	1,500	1,000	0	2,500	750	1,750
Kerr	7,500	3,000	0	10,500	3,750	6,800
Medina	4,600	100,000	0	104,600	2,300	102,300
Wilson	2,700	20,000	0	22,700	1,300	21,400

Source: Alamo Area Council of Governments (3).

Table 3-3: Summary of costs;
water resource management projects, 1970-2000

Type of Project		Capital Cost
Reservoirs & Conveyance Systems		$184,500,000
San Antonio River Basin	$93,600,000	
Guadalupe River Basin	90,900,000	
Nueces River Basin	0	
Colorado River Basin	0	
Urban Water Pumps and Treatment		81,500,000
San Antonio River Basin	18,900,000	
Guadalupe River Basin	36,650,000	
Nueces River Basin	0	
Colorado River Basin	0	
Edwards Groundwater	24,550,000	
Carrizo-Wilcox Groundwater	400,000	
Minor Water Resource Areas	1,000,000	
Urban Waste Water Disposal Plants		49,300,000
San Antonio River Basin	44,100,000	
Guadalupe River Basin	4,300,000	
Nueces River Basin	900,000	
Colorado River Basin	0	
Total Water Resource Management Projects		$315,300,000

Source: Alamo Area Council of Governments (3).

sizeable and important. The planning to meet these demands and manage the large expenditures must be carried out within a planning environment consisting of several agencies with overlapping areas of responsibility and authority.

Water-Related Organizations of the Area

Within the region there exists an intricate network of governmental units which have the responsibility for water resource planning. This network has been developed over time in response to the growth of the area. Additionally, there exist numerous private organizations, both commercial and non-profit, that act in their own interest and normally do not consider planning for future water resources as part of their current activities. These private organizations can be encouraged to act in the interests of the general public through rules and regulations and through tax and/or other incentives. The result is a decentralized planning process in which the patterns of decision-making and administration are amorphous and political in nature.

The purpose of the following sections is to briefly outline the important water-related organizations of the area. There are four levels of government involved in water planning in the study area: local, regional, state and national. As is evident in the following descriptions of the agencies, considerable overlap of authority and responsibility exist. However, the San Antonio area is fortunate in that the many organizations at all levels are attempting to cooperate and coordinate their planning activities to the common goal of coordinated water planning for the San Antonio area. The major agencies of the area are discussed in the following sections.

The Local Level Organizations

At the local level, the San Antonio Water Board, the several water districts of the area and the City Public Service Board are the major organizations involved with water planning and development. A host of other local agencies are also involved, but at lesser levels of importance.

The San Antonio Water Board was established in 1925 and is governed by a Board of Trustees which is appointed by the San Antonio City Council. The Board appoints a general manager who acts as the Chief Administrator of the Board and the agency. Although the Board is empowered by the city and must act in accordance within the terms of the ordinance under which the system's bonds are issued, the Board is quite autonomous in conducting its business. It is to be considered as a powerful political organization.

Since the Board is the largest supplier and distributor of water in Bexar County, it is intensely concerned with the development of future water resources and conservation of the existing supply. The Board therefore has participated in various programs aimed at means of recharging the Edwards aquifer and developed supplemental water supplies from surrounding areas.

The Texas Legislature authorized the definition of Water Control and Improvement Districts (WCID) for irrigation control, flood control, drainage, reclamation, forest preservation, conservation, creation of hydro-electric power, navigation, sewage, garbage collection and waste disposal within the boundaries of the district. The Legislature also empowered such districts to finance their operation through the issue of bonds and the levy of taxes. A WCID may be created by the commissioner's court, the Legislature or the governing body of a city when the district is to be located within its bounds. All such districts, however, must be formed and operated within state law, and, approved by the Texas Water Rights Commission.

There exist eleven WCID within the study area. Seven of the districts actively furnish water to the area; five deal in sewage disposal and two also engage in garbage collection and disposal. Three are inactive at this time. All of the active districts have issued bonds for the construction of water systems. These bonds are honored through water charges and taxes. Three of the districts have created funds through property taxes. In order to prevent heavily indebted or inadequate systems in districts situated in newly annexed territory, the City Water Board requires the new districts to maintain adequate systems in accordance with a set of criteria relating to purity of water, system design and pressures, etc. The City Water Board also requires a WCID to have a refunding clause in its bond indentures which allows the City of San Antonio to refund the bonds and substitute bonds bearing a much lower interest rate. (This is a good indication of the power of the City Water Board.)

An important water district of the area is Bexar-Medina-Atascosa Water Improvement District One. The district has approximately 34,000 acres under its jurisdiction of which about 60 percent of the district lies within Medina County, about 10 percent in Atascosa County, and 30 percent in Bexar County. The district is authorized by the State Constitution to obtain and distribute water for irrigation, domestic, power, and commercial purposes. Persons using water for domestic purposes must install their own purification facilities. The district also levies a 20 percent ad valorem tax and a "maintenance charge" on all persons residing within the boundaries of the district. Additionally, a "crop water charge" is paid by all persons who actually use water from Medina Lake.

Another important water district is the Bexar Metropolitan Water District. This district is a multi-purpose district with jurisdiction over much of metropolitan San Antonio. It is authorized to control, distribute, conserve, protect and utilize storm and flood water of rivers, streams and underground water located within the district and to control and regulate the accumulation and disposal of sewage, wastes and refuse. It also has the power to make rules and regulations governing the operation of the district and to provide penalties for violation of the rules.

Additionally, it is empowered to regulate waters of the San Antonio River watershed and to cooperate with state and federal agencies in such undertakings. The functions and jurisdictional area of this district overlap considerably with those of the City Water Board and the San Antonio River Authority. Historically, the district has limited itself to water supply and restricted its area of operation to the Southwest San Antonio area.

The City Public Service Board is a private organization with the goal of providing electrical power to the city of San Antonio and other areas. It is employed by the city for this purpose. As such, the city can exert some control over the agency in terms of rates and charges for electrical power. Otherwise, the City Public Service Board is quite autonomous in its business activities. The agency has a tremendous need for water in the generation of power and for cooling-water for its operations, on the order of 90,000 acre-ft/yr by the year 2000. The agency has developed water on its own initiative for these purposes in the past and can be expected to do so again in the future if sufficient water is not available through the city's supply channels.

Among the remaining local organizations involved in water planning for the area is the River Walk Commission. The River Walk is an area of the San Antonio River which winds through the Central Business District. The Commission is a seven member advisory commission appointed by the City Council with the purpose of preserving and promoting the natural beauty of the area. The River Walk is a successful tourist attraction of the area. Other local agencies involved with water planning for the area are the Department of Public Works, the City Planning Department, the San Antonio Parks and Recreation Department and the San Antonio City Council.

The Regional Level Organizations

At the regional level, there are four major organizations: the San Antonio River Authority, the Edwards Underground Water District, Bexar County, and the Alamo Area Council of Governments. These agencies are discussed in the following paragraphs.

The San Antonio River Authority, a conservation and reclamation district, includes the portions of the state within the boundaries of the counties of Bexar, Wilson, Karnes and Goliad. Empowered by the Texas Constitution, the Authority is authorized to construct, maintain and operate navigable waterways and canals; to effect flood control, conservation and use for all beneficial purposes of ground, storm flood and unappropriated water in its jurisdiction; and to effect irrigation, soil conservation, sewage treatment and pollution control. Additionally, the Authority has responsibility and interest in development of parks and recreational facilities, in the encouragement of forestation and reforestation and in maintaining the ecosystem balance. The Authority also has the responsibility of preparing a master plan for the maximum development of the soil and water resources of the jurisdictional area. This responsibility includes plans for the complete utilization, for all economically beneficial purposes, of the water resources of the jurisdictional area. In accordance with this master plan, the Authority may act as the coordinating agency for problems of water supply and distribution on a basin-wide basis. It may also negotiate with other river authorities of the state and with federal agencies. The Authority can issue negotiable bonds and levy taxes. A large portion of the Authority's revenue derives from a fifteen cent flood control tax which is levied and collected by the county.

The Edwards Underground Water District was created by the State Legislature for the purpose of protecting, conserving and recharging the Edwards Underground Reservoir. The District consists of Uvalde County, most of Medina and Bexar Counties and a small portion of Comal and Hays Counties. Three directors from each county compose a fifteen member Board of Directors for the District. This board, together with an Engineer-Manager and an Assistant Secretary, administer the District. A two-cent tax per $100 property evaluation provides operating funds. Operations for the District are primarily concerned with the study of recharge potential of the Edwards Aquifer. The U.S. Geological Survey often aids in these operations. The District has participated in several studies involving the Edwards Underground Reservoir.

Bexar County is authorized to issue bonds for flood control, navigation, irrigation and drainage improvement. The county also can levy ad valorem taxes as well as other authorized taxes for flood control improvements.

The Alamo Area Council of Governments (AACOG) is a regional planning organization of relatively recent development. Headquartered in San Antonio, the organization consists of nine member counties: Atascosa, Bandera, Bexar, Comal, Frio, Guadalupe, Kendall, Medina and Wilson. Each county pays dues to support the organization's activities. The general goal of AACOG is to promote the general welfare of the citizens of the region through coordinated planning. Although also interested in other problems, the AACOG has been especially active in studying the water resources of the area and in helping promote necessary programs aimed at improving water quality. One of the AACOG's major tools in promoting coordinated regional planning is realized through the regional master plan, a general plan for development of the region's resources, including water. To obtain federal assistance in development projects and studies, the AACOG must have approved the project with respect to the regional master plan. Water resource projects generally require large expenditures thus making federal assistance highly desirable. The AACOG therefore has the potential of becoming very influential in the development of water resources of the study area.

The State Level Organizations

At the state level, several agencies have a significant impact on water resources planning for the study area. These agencies are briefly described in the following paragraphs.

Soil Conservation Districts are created and supervised by the State Soil Conservation Board. Each district is governed by an elected, five-member Board of Supervisors and serves as an independent subdivision of the state. Among other concerns, the Districts effect flood control measures and furnish materials to assist farmers and ranchers in carrying out erosion control and water management. The Districts also cooperate with any agency to prevent erosion and water damage within the District.

The Texas Water Rights Commission is composed of three full-time members who are appointed by the Governor, and an Executive Director who serves as chief administrative officer. The primary functions of the Commission are regulating and permitting use of public water of the state. Its general responsibilities include the protection of public safety and private property from damage resulting from improperly designed dams and reservoirs. It also regulates the diversion and distribution of canals and has the power to declare any such project a public nuisance and order it abated if the project is found to be dangerous to public safety. The Commission also creates different kinds of water districts and approves the organization and feasibility of most water districts which propose to construct a project that is to be financed through the sale of bonds. Most water districts and river authorities of the state are subject to continuing supervision by the Commission. The Commission recognizes and provides local interests with opportunities to develop projects for local and regional needs. However, it generally considers the Texas Water Plan as the guide for authorizing projects. Resolution of any conflict with the Texas Water Plan is vested with the Commission although ultimate authority lies in the courts.

The Texas Water Development Board is charged with the formulation and development of a comprehensive, state-wide plan, the Texas Water Plan, which is to be used as a guide to select policies for water resource development within the state. Additionally, the Board will assist and advise local governments in undertaking different water development projects. The Board also has the responsibility to investigate all matters pertaining to the quality of groundwater in the state and reports its findings to the Texas Water Quality Board. The Texas Water Development Board consists of six members, appointed by the Governor on six year terms with confirmation by the State Senate; the Governor also has the power to designate the chairman of the Board. With respect to the San Antonio area, the Board has published several reports which have proven to be useful sources of water data. Also, numerous studies defining urban runoff and flooding studies are especially pertinent to the San Antonio area.

The Texas Water Quality Board is the principal authority in the state on matters relating to the quality of water in Texas. The Board is to be informed on all aspects of water quality and, particularly, water pollution and its control and abatement. The Board also assists in resolving questions as to the respective authorities and duties of state agencies which have a vested interest in water quality control functions, and in doing so, to minimize duplication of activities. The Board is composed of seven members, three of whom are appointed by the Governor. The remaining four are the Executive Director of the Texas Water Development Board, the State Commissioner of Health, the Executive Director of Parks and Wildlife Department and the Chairman of the Texas Railroad Commission.

The General Land Office is administered by the Land Commissioner who is elected to that office. Its authority in the supervision and management of state water includes (1) the power to assist and supervise level improvement and drainage districts, (2) the power to make and approve agreements or contracts for cooperating with any level of government, and (3) the power to regulate oil and gas development of public lands and to prevent pollution of water in areas where such development occurs.

The Texas Soil Conservation Board, as noted before, is a state agency which has as its primary function the administration of soil conservation districts. Additionally, the Board has power of approval or disapproval of applications for federal assistance in planning and implementing watershed protection and flood prevention projects. The federal government, through the Board, provides the entire financial support for the improvements of flood prevention.

Other state level organizations include the Department of Health, the Parks and Wildlife Commission and the Railroad Commission. The Department of Health is charged with minimizing water associated health hazards and is empowered to approve or disapprove the establishment of all water supply and sewage disposal systems in the state. The Parks and Wildlife Commission is concerned with the enforcement of pollution laws to protect wildlife and with the development of recreational potentials of the state's water resources. The Railroad Commission has jurisdiction over the gas and oil industry and is responsible for the prevention of pollution of surface and groundwater from oil and gas wells. All three agencies are represented on the Texas Water Quality Board.

The National Level Organizations

At the national level, the Environmental Protection Agency, the U.S. Army Corps of Engineers, the Bureau of Reclamation, the U.S. State Geological Service, the Soil Conservation Service and the Public Health Service are major organizations affecting water planning in the San Antonio area. A brief description of these agencies follows.

The Environmental Protection Agency (EPA) was formed to integrate the control and responsibility of different programs related to water, air, solid wastes and radiation pollution. It is the result of the consolidation of portions of several existing departments at the national level and is headed by an Administrator and Deputy Administrator appointed by the President. Its functions include (1) the establishment and enforcement of environmental protection standards consistent with national environmental goals, (2) the conduct of research on the adverse effects of pollution and pollution control methods, and (3) assisting the Council of Environmental Quality in developing and recommending to the President new policies for the protection of the environment, including pollution standards and control measures.

The Corps of Engineers is primarily responsible for navigation improvement of rivers and harbors, and flood control measures, although it is also concerned with such interests as soil and drainage conservation, water conservation, recreation, hydro-electric power, etc. Of recent importance is the selection of the Corps to administer Executive Order 11574 which provides for the establishment of a federal permit program to regulate, with enforcement provisions included, the discharge of waste into the waters of the United States.

The Bureau of Reclamation (Department of Interior) is concerned with providing irrigation facilities and with water resource development in general, particularly the provision of water supplies for municipal and industrial use. In Texas, the Bureau has conducted or participated in many comprehensive studies of state water problems.

The U.S. Geological Survey is responsible for determining, appraising and describing the nation's surface and underground water resources. These studies are financed on a federal-local matching fund basis. As noted earlier, the U.S. Geological Survey is active in studying the quality and quantity of the water of the Edwards Underground Reservoir and its structural conditions. The Survey also monitors eight stream gauging stations in the San Antonio

River Basin.

The Soil Conservation Service (Department of Agriculture) conducts exhaustive research into various aspects of soil erosion problems. It has the responsibility of administering the upstream watershed programs which provide assistance to local watershed groups for building flood control and erosion prevention structures when these programs are approved by Congress. The Service cooperates closely with the State Soil Conservation Board and the local Soil Conservation Districts in their respective activities.

The Public Health Service (Department of HEW) collects data to show the extent of pollution of the nation's waterways, and conducts research for finding more effective and efficient means of treating municipal and industrial wastes. The Service is authorized to provide monetary grants to municipalities for the construction of needed sewage treatment plants. Additionally, the Service conducts studies of the various state laws pertaining to pollution control. The Service also provides the states with model statutes that can aid the states in their attempts to abate pollution.

Numerous other federal agencies and congressional committees have interests in various aspects of water planning and development which eventually impact in the San Antonio area. Some of these are: the U.S. Weather Bureau, the Bureau of Mines, the Bureau of Census, the Federal Power Commission, the Forest Service, the Council on Environmental Quality and the Water Resources Council.

Indeed, because water is so pervasive in its uses, virtually all agencies at every level of government have responsibilities and/or interests for conserving and developing an area's water resources. This is indeed true of the San Antonio area. In view of the overlapping of responsibility and authority of the governmental agencies of the area, Table 3-4 is offered as a gross summary of the agencies and their interfaces.

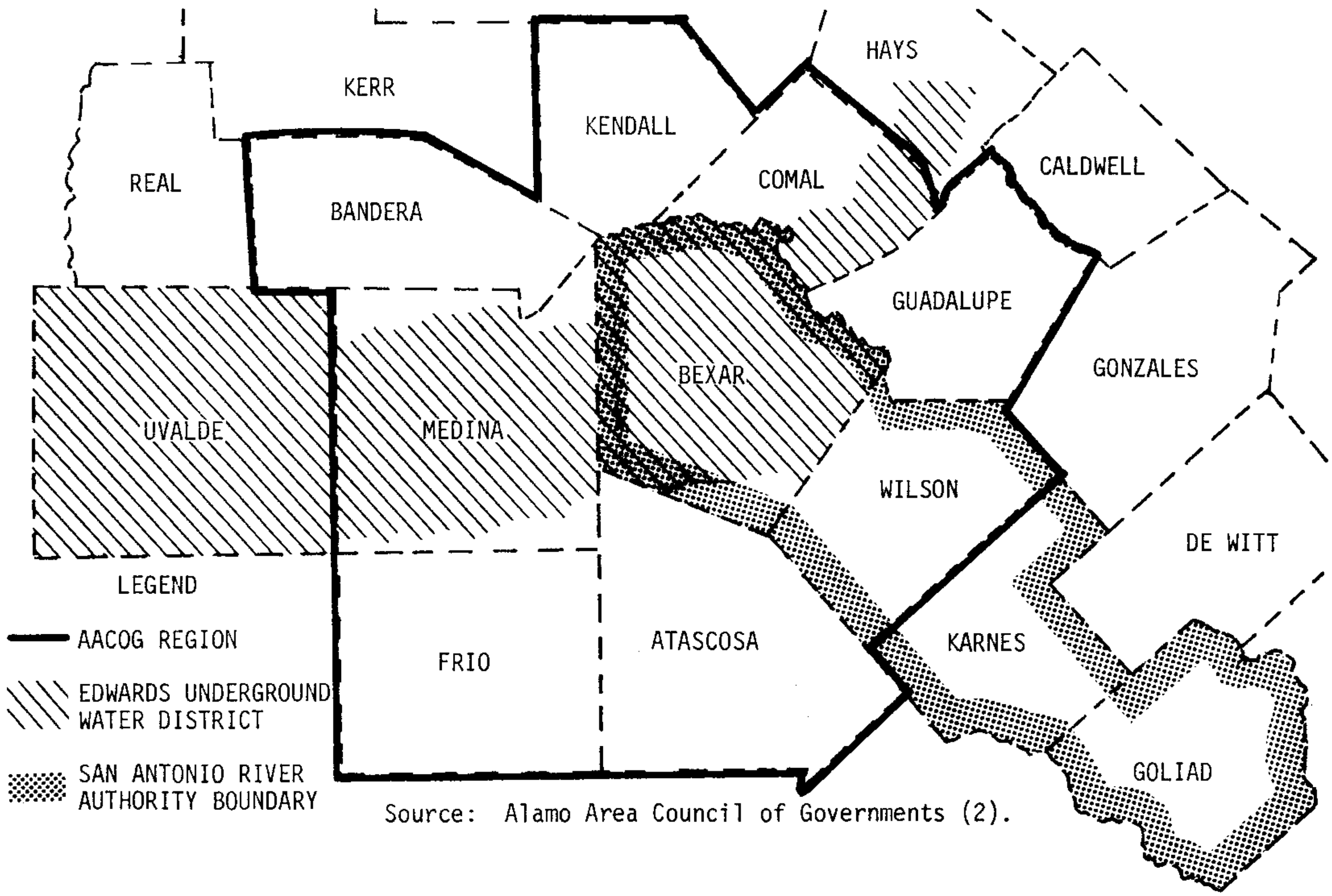
To illustrate the overlap of responsibility and authority, consider Figures 3-2 and 3-3. Figure 3-2 shows the AACOG planning area and some of the surrounding counties (those included in the demand and expenditure estimates cited earlier) with the authority areas of the San Antonio River Authority and the Edwards Underground Water District delineated. Figure 3-3 illustrates the San Antonio River as it winds its way through the Central Business District of downtown San Antonio. Any proposal to affect the San Antonio River in the Central Business District area would thus involve the following agencies at a minimum: San Antonio River Authority, Edwards Underground Water District, City of San Antonio, Bexar Metropolitan Water District, City Water Board, River Walk Commission, Bexar County and the Alamo Area Council of Governments (AACOG). Numerous special interest groups and the Chamber of Commerce of San Antonio would also have an interest in such a proposal. Depending on the nature of the proposal, state and national agencies such as the Texas Water Quality Board and the Environmental Protection Agency might also be involved.

In summary, there exists in the San Antonio area an intricate

Table 3-4: Most important management agencies in San Antonio

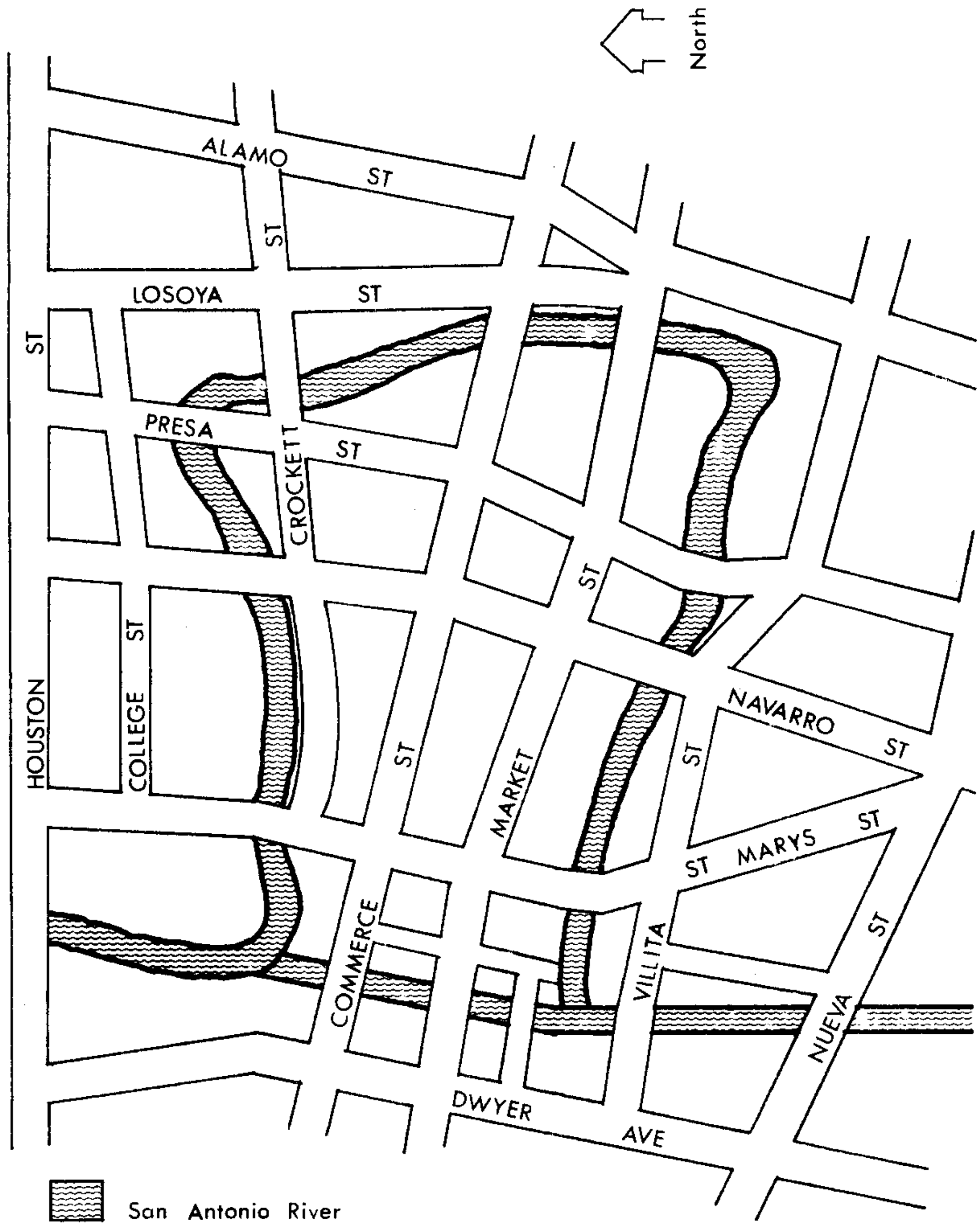
LEVEL OF FUNCTION	FEDERAL	STATE	REGIONAL	LOCAL
WATER SUPPLY	Environmental Protection Agency Water Resources Council Bureau of Reclamation U. S. Geological Survey Public Health Service	Water Control and Improvement District Texas Water Development Board Texas Water Rights Commission	Edwards Underground Water District San Antonio River Authority	San Antonio City Water Board
SEWAGE DISPOSAL	Environmental Protection Agency Public Health Service Council on Environmental Quality	Water Control and Improvement District	San Antonio River Authority	Bexar Municipal Water District Sewer Division (Dept. of Public Works)
WATER QUALITY MANAGEMENT	Environmental Protection Agency Water Resources Council Public Health Service Council on Environmental Quality	Texas Water Quality Board	Edwards Underground Water District San Antonio River Authority	
FLOOD CONTROL & DRAINAGE	Environmental Protection Agency U. S. Army Corps of Engineers Soil Conservation Service	Water Control and Improvement District Soil Conservation Service General Land Service Texas Soil Conservation Board	San Antonio River Authority	Bexar Metropolitan Water District Bexar County
WATERFRONT LAND USE	Environmental Protection Agency U. S. Army Corps of Engineers		Alamo Area, Council of Governments	San Antonio River Walk Commission City Planning Department
RECREATION & OPEN SPACE	Environmental Protection Agency Bureau of Reclamation U. S. Army Corps of Engineers Council on Environmental Quality	Texas Parks And Wildlife	San Antonio River Authority	San Antonio Parks And Recreation Department
REGIONAL & CITY PLANNING			San Antonio River Authority Alamo Area, Counicl of Governments	San Antonio City Planning Department
MONITORING	U. S. Geological Survey Weather Bureau			

Source: Garner and Shih (36).



Source: Alamo Area Council of Governments (2).

Figure 3-2. The planning area.



Source: Garner and Shih (36).

Figure 3-3. River Bend Area, San Antonio, Texas.

network of governmental units which has the responsibility of water planning. This network includes one major city, five smaller cities, one metropolitan water district, eleven water control and improvement districts, one water improvement district, two non-supplying water districts which cover several counties, and a host of regional, state and national organizations with their attendant purposes and regulations. Additionally, there are about thirty private water companies and several installations on military bases which are constructed and operated by the federal government. Compounding this network is the fact that Texas water law gives little support to public development of integrated ground and surface water systems. It may well be that this situation makes coordinated water planning impossible. At this point, then, it is advantageous to gain an overview of the current planning process of the study area.

The Current Planning Arrangement

The impact of state and national levels of government in the San Antonio area is primarily regulatory in nature, i.e., actual planning for the area occurs primarily at the local and regional level. Theoretically at least, this planning is accomplished through an elaborate structure of executive committees and sub-committees at AACOG and through primarily informal coordination with agencies which are not members of AACOG. This coordination is sometimes formalized by invited attendance at AACOG meetings of non-member agency representatives who make presentations of proposed ideas and projects.

At AACOG, planning is accomplished primarily at the sub-committee level through a process of discussion and political maneuvering with final decisions made at the executive committee level. Public opinion is represented through the executive committee members and by invited comments from interested parties (individuals and special interest groups) at both the sub-committee and executive committee level. The hope is that, through the committee deliberations, informal coordinations and generally common desire for advancing the welfare of the people of the area, coordinated planning will occur.

Planning is continuous; it begins with the statement or recognition of a goal, or with the recognition of a potential problem. Problems and goals present themselves at various times. Thus, at any one instant of time, applications of the planning process may be in any one of its phases on any one of a number of problems. For example, application A may be in the implementation phase, application B in the objective setting phase and application C in the design phase at a particular time. This phenomenon of planning obscures the visibility of the planning process in almost any environment and certainly does in the San Antonio area. Such obscurity of the planning process can lead to a lack of faith by the public in the planning function (11).

Little can be done to reduce the obscurity caused by the recognition of problems/goals over time. The only real hope is that potential problems can be identified through long-range forecasting and planning and thus be avoided or included in current planning process applications. For example, through long-range forecasting and planning it may be anticipated that the future volume of wastewater to be disposed may cause severe problems unless disposal means (water reuse, for example) are incorporated into current plans.

Obscurity of the planning process also arises, however, when different agencies plan for the same goal independently. The Alamo Area Council of Governments (AACOG) has adopted the policy of letting the individual agencies take the initiative in preparing proposals. This policy allows the agencies to begin the application of the planning process at a time of their own choosing. For example, the San Antonio Parks and Recreation Department and the City Public Service Board may both be seeking independently to achieve the goal of more efficient use of existing water sources. If these applications are begun at different times, the planning process is quite likely to be less visible to the public. Moreover, duplication of effort, money and time is likely to occur. Obscurity of this form can be reduced by coordinated planning.

Another factor in the lack of visibility of the planning process is the absence of a stated set of goals and sub-goals for the area as a whole. The AACOG Water Resource Master Plan (3) states as a goal "to provide the most cost effective water resource management strategies for meeting projected water uses and maintaining water quality criteria throughout the Alamo Area Planning Region." No sets of sub-goals are articulated. It is difficult therefore to relate the many individual projects to the overall goal and to judge their importance. These sub-goals may be said to be contained within the charters of the various agencies of the area. However, goals generally change over time; charters only rarely change over time.

Thus, it is very difficult if not impossible to trace the planning process for the study area as a whole, principally because the area does not yet plan as a whole. The individual agencies do use some variant of the rational planning process as described in Chapter 2. However, even in the individual applications of the process, there is generally a blurring of the phases.

For example, the problem definition phase is carried out piecemeal and accomplished through one or more studies, usually performed by consulting firms. These studies, however, generally include the investigation of some system concept, e.g., wastewater reuse (34), which take the studies into the design and evaluation/selection phases. The AACOG Water Resource Management Plan (3) is a type of problem definition but also slips into the design and evaluation/selection phases of the planning process. The objective setting phase is seldom recorded or displayed as a separate phase, the objectives being found in the charge to the design group.

Certainly one of the reasons for the consideration of system configurations in these early phases is the motivation to obtain estimates of the money required to solve the problem. Such estimates are almost always required for applications for federal/state assistance in funding projects. It is desirable to have separation of the phases to a major degree so that biases towards particular systems are not injected in order that all potential systems may be considered. There may be no practical solution to this problem as long as such estimates are required and then expected to be fairly close to final expenditures.

The phases of system design, evaluation/selection and activity delineation are generally fairly well documented through reports and are generally visible phases in the study area. Implementation of systems is similarly visible.

Practically speaking, it is not clear that the foregoing arrangements result in completely coordinated planning for the area. Because there is no central authority over all agencies of the area, there is ample opportunity for the more powerful agencies of the area to pursue their own desires irrespective of the desires of the remainder of the community. It is very difficult to foresee the creation of a super-agency with the requisite authority because of the political power of such an agency and because existing agencies have vested interests in their own continuation and have considerable momentum.

Further, because of the attractiveness of federal funds, it appears that much of AACOG and other agencies' activities are concerned with securing federal funds for the area. Once secured, these funds are often parceled out to private consultants who then perform a large portion of actual planning for the area. This process then frees AACOG and the agencies to pursue other funds and the circle continues. Moreover, in order to meet deadlines for applying for federal funds, decisions and plans are sometimes made somewhat hastily with the intention of modifying the decision or plan at a later time. Practically speaking, however, plans and decisions soon become entrenched and are seldom changed once put into writing.

Moreover, it is not clear that all agencies have a chance to influence a plan during the developmental stages. AACOG has adopted the policy of letting individual agencies take the initiative in preparing proposals which then are submitted to AACOG for approval. Practically speaking, it is often quite difficult to introduce major changes to completed proposals.

With respect to the setting of objectives in this environment, the most frequently used technique is that of the proposed "strawman" and subsequent discussion at the sub-committee level with informal coordination with interested agencies. Usually, such a technique does not methodically generate sufficient detail for the objectives. Moreover, there is a clear danger of misinterpretation or mis-communication in the technique. The statement of the objectives is actually translated twice before a decision is made: once in the mind of the sub-committee member as to what <u>he</u> thinks the agreed upon objectives are and secondly in a summary to the executive committee member who is the decision maker. Additionally, this often means that decisions are made without a detailed knowledge of the particulars involved on the part of the decision maker.

On the positive side, however, some important results are being achieved under the current planning arrangement. First, and most importantly, the agencies are beginning to communicate and work together for the solution of common problems; other agency viewpoints and problems are being seen by the involved agencies. Secondly, a unified approach to area water planning is being attempted and experience should help considerably. More specifically, a data storage and retrieval system for water related data, including rainfall, and data maps has been developed through the cooperation of local, regional, state and federal agencies. Thus, there is an efficient method to exchange data and information concerning the quantity and quality of water among government agencies of the region. Also, a regional waste water development plan was recently completed. Although reportedly completed somewhat hastily so as to meet deadlines for federal assistance, it represents a truly regional approach to the waste water problem of the area.

Indeed, the negative comments given above are not to serve as an indictment of the current planning arrangement. Many of the comments stem from the basic problem of the region containing several semi-independent agencies with overlapping areas of responsibility and authority. As noted above, it does not seem likely that a super-organization will be created to alleviate the situation. Thus, planning must and will continue to be accomplished in this environment. Procedures and techniques to assist the region's planners must, therefore, be developed with this environment in mind. This dissertation attempts to produce procedures for generating detailed objectives in such an environment.

CHAPTER 4

APPLICABLE TECHNIQUES

For the purposes of actually designing a system, it is not sufficient to give the designer a broad, sweeping statement of the objectives to be accomplished by the system. For any person, activity or organization, there exists a hierarchy of aims or purposes. As one proceeds from the top down, these aims range from the goal to the detailed objective, becoming less grand, more specific and of more use to the designer. To support a detailed design and evaluation phase (say, using mathematical models and computer-aided analysis), the objective setter must not only provide a statement of the general purpose of the system, but must also state the desired characteristics of the system as quantitatively as possible; he must state the scales of value against which the system is to be measured. If the objective setter does not supply such detail, the designer will quite likely attempt to supply such scales of value himself thereby increasing the probability that a system will be designed to solve the wrong problem. Additionally, to provide the designer with the opportunity of considering a full range of alternative systems, the objective setter must interject as few biases as possible into the objectives. A predilection for a certain system configuration, given with the objectives, will serve to severely limit the range of alternative systems to be considered by the designer. This may cause an excellent system to be ignored, resulting in higher costs and/or inefficiency than might have been attained otherwise.

The above remarks are not meant to advocate a complete separation of the designer from the objective setting phase. Indeed, the designer should be included in the objective setting phase. His participation can be quite valuable by indicating the types of information that are required for the system design phase. The participation of the objective setter and the designer are roughly illustrated by Figures 4-1 and 4-2, which show the amount of participation in each planning phase.

One additional source needs to be included in the objective setting phase for the urban planning process. This is the voice of a more informed and concerned general public. To propose a system based on objectives not acceptable, for any reason, to the affected community is to invite defeat of the proposed system at the polls, irrespective of the quality of the proposed system. Such defeats are wasteful of money and time, the latter a commodity which may also be scarce and therefore critical to the community's needs. Thus, it is important that the attitude of the general public be assessed and considered during the objective setting phase. This process of submitting objectives to the public for their opinion is an important but frequently bypassed function of the democratic process.

The purpose of this chapter, then, is to introduce and explain techniques which appear to be useful in the determination of detailed, coordinated objectives and in eliciting the attitudes of the public with respect to the objectives. The traditional strawman/discussion

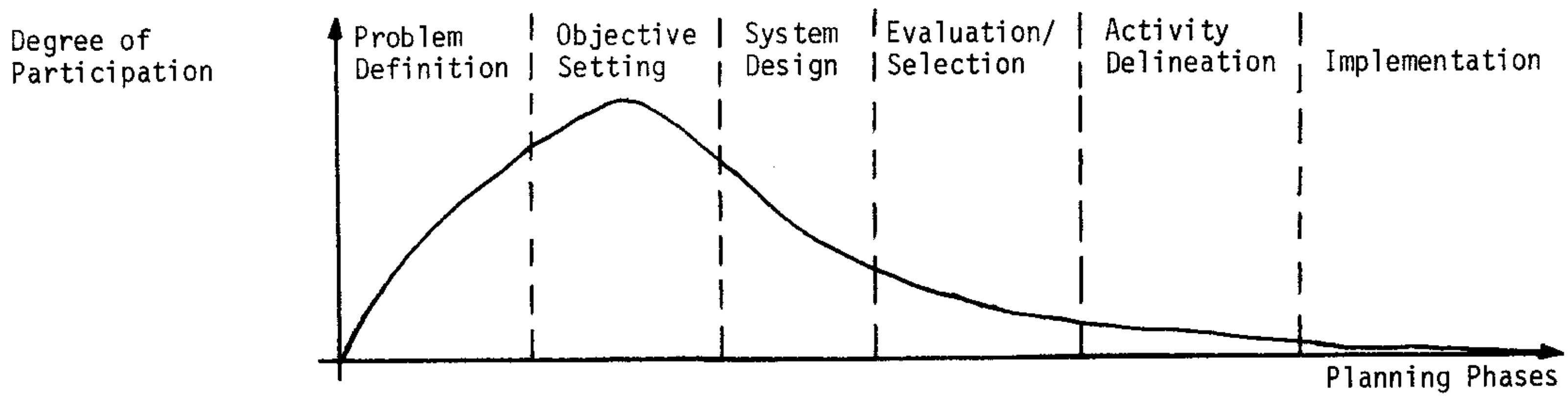


Figure 4-1. Participation of the objective setter in the planning phases.

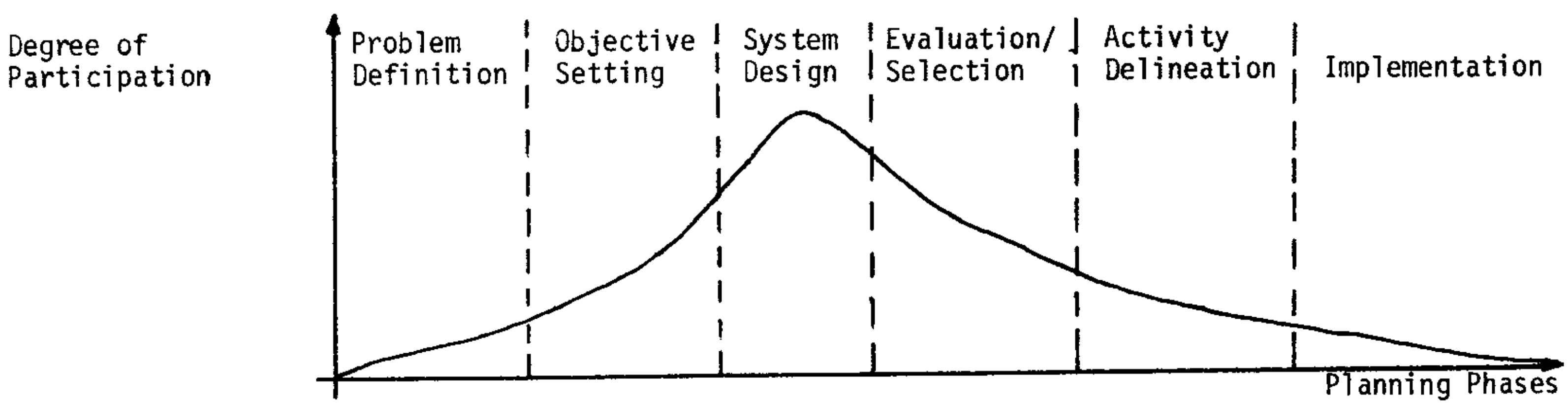


Figure 4-2. Participation of the designer in the planning phases.

technique is first briefly reviewed and then the concept of a tree structure is explained. This concept is then expanded to a discussion of relevance trees. Next, a class of methods involving "brainstorming" is introduced and critiqued. An explanation of the Delphi method follows and is in turn followed by a brief and general discussion of the techniques and problems of attitude determination. A brief summary concludes the chapter.

Strawman/Discussion Technique

This technique is frequently used in planning situations and fits well with the traditional committee/subcommittee structure often used in planning agencies. In this technique, some or all of the participants bring to the committee meeting a proposed list of objectives for subsequent review and discussion by the entire committee. The hope is that through discussion and review of all proposed "strawmen", a consensus will be reached on what the objectives are to be. The technique does provide a vehicle for introducing proposed objectives and does provide a structure, although generally loose, for ensuing discussion. This discussion <u>can</u> also serve to refine and detail the objectives.

The purposes of this technique, then, are to elicit ideas from a group and to promote consensus on the ideas through discussion. Depending on the individual strawman, a loose structure for attacking the problem may also be generated.

The disadvantages of the technique, however, are numerous. For example, it is well known that individuals become enamored with their ideas and tend to resist attempts to modify or delete the ideas. With a number of people involved, this phenomenon can easily lead to divisiveness of opinion rather than promote consensus of opinion. Moreover, in the discussion phase, an individual with a strong personality, good debating training, or in a position of power or command, etc., can significantly influence the outcome of the discussion. Other psychological factors such as specious persuasion, the unwillingness to abandon a publicly stated position and the bandwagon effect of majority opinion can significantly affect the choice of objectives. Additionally, the technique does not provide a systematic way of examining all facets of the problem under study, depending rather on the assumption that all facets will be covered by the proposed strawmen. The technique also has the problems of misinterpretation or mis-communication, as discussed in Chapter 3. Also, it does not appear that the technique methodically generates sufficient detail for objectives; the technique is probably better suited for the discussion of broader concepts, such as goals.

The Tree Structure

As the name implies, the tree structure, or, simply the tree, is a structure composed of branches arranged in successive levels, the highest level being the "zeroth" level, the next to highest being the "first" level, etc. There can be any number of levels and any number of branches on any level, except the zeroth level which has only one branch (the trunk of the tree). With respect to the formulation of objectives, the branch of the zeroth level represents the broad goal to be achieved; succeeding levels represent successively more detailed sub-goals and objectives at the lowest level. The tree is deduced by logically breading down each branch (goal) on a level into sub-goals which, when accomplished, will achieve the parent goal. An example is afforded by Figure 4-3, where the levels have been conveniently named to facilitate interpretation. For schematic convenience, only one branch at each level is broken down to a subsequent level. Thus, level 1 represents those "activities" which, when accomplished, will in turn accomplish the broad goal, and so forth with the other levels.

The purpose of the tree structure is to provide a strong structure for analysis of the problem. Such a structure retains focus on the overall goal (at the top of the tree) and facilitates discussion.

The use of the tree in generating detailed objectives should now be clear. The participants in setting objectives begin by specifying the ultimate goal to be achieved and then begin systematically and logically deducing the major activities, functions, uses, characteristics, etc., which will accomplish the goal and sub-goals. To achieve detail, the participants attach values representing the needs of the organization to the lowest level of the tree, say, characteristics. Note the tree technique promotes a systematic consideration of all aspects of the problem. By deducing the tree as a group,

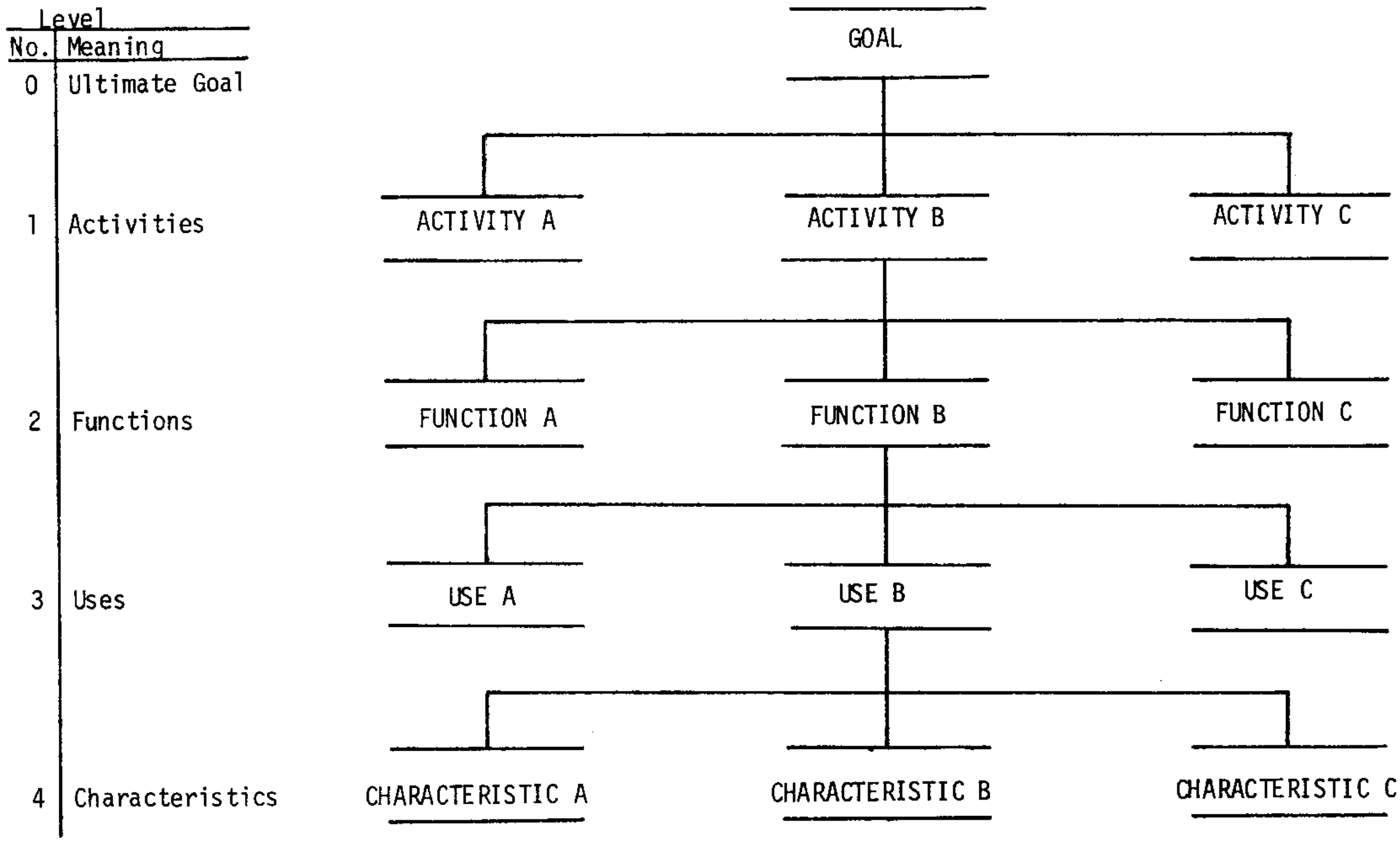


Figure 4-3. A general tree structure.

the tree technique promotes a cohesive approach to objective setting as opposed to the strawman/discussion technique which, as noted in the preceding section, can lead to divisiveness through the promotion of individual ideas. Obviously, the tree technique provides a strong structure for discussion of the problem by the participants. Such discussion should serve to establish the details of the objectives and to perhaps rank the objectives in importance. Moreover, discussion by the participants is a common method of establishing the levels and branches of the tree. However, such discussion can still suffer from the factors of specious persuasion, bandwagon effect, etc. A method for combating these factors will be introduced later.

Relevance Trees

As the name indicates, a relevance tree is a tree which is elaborated upon by appending values representing the relative importance of each branch at each level. By multiplying together the relevance numbers along any path (from the top of the tree downward), a measure of the relative importance of any branch at any level to the ultimate goal can be obtained. Relevance trees have been used extensively by Honeywell (55,56) in its PATTERN (Planning Assistance Through Technical Evaluation of Relevance Numbers) technique. North American, NASA and governmental agencies have also used relevance trees in their planning activities (55). These applications, however, have attempted to assess the importance of particular systems or technologies to the achievement of the ultimate goal; relevance trees have apparently not been used to generate objectives in a water planning environment.

A systematic procedure for obtaining the relevance numbers of each level is used and employs criteria, significance estimates and a matrix for matching criteria to the issues (or branches) a, b, c,..., n on a level. From the planning environment, a set of criteria $\alpha,\beta,\gamma,\ldots,\kappa,\ldots,\nu$ with weights $q_\alpha,q_\beta,\ldots,q_\nu$ are selected for each level of the tree. Practically speaking, a set of criteria are chosen for each "family" on level i+1, where each member of the family stems from the same parent of level i. These criteria are used to measure the "significance" of each branch (issue) of the family on level i+1. The significance of branch or issue j to criterion κ is denoted by S_j^κ. These concepts are effected and summarized by the matching matrix of Figure 4-4. The last row of this matrix shows the relevance numbers r_{i+1}^j which reflect the degree of attainment of the parent on level i by each issue on level i+1, i.e., the relevance of each issue to its parent.

Two norming conditions are assumed to insure homogeneity of logic. These are that the weights for the criteria for any matrix sum to 1,

$$\sum_{\kappa=\alpha}^{\nu} q_\kappa = 1$$

and the sum of the significance numbers for any criteria sum to 1,

$$\sum_{j=a}^{n} S_j^\kappa = 1.$$

The relevance number is defined as

$$r_{i+1}^{j} = \sum_{\kappa=\alpha}^{\nu} q_{\kappa} S_{j}^{\kappa}.$$

It is readily shown that, with the two norming conditions, the sum of the relevance numbers for any matrix is 1, i.e.,

$$\sum_{j=a}^{n} r_{i+1}^{j} = 1.$$

Obviously, if there are k families on a level, the sum of all relevance numbers on a level will be k. Further norming by division of each relevance number by k would insure that the sum of all relevance numbers on a level would be 1.

CRITERIA	WEIGHT OF CRITERIA	ISSUES ON LEVEL i + 1						
		a	b	c	...	j	...	n
α	q_α	S_a^α	S_b^α	S_c^α	...	S_j^α	...	S_n^α
β	q_β	S_a^β	S_b^β	S_c^β	...	S_j^β	...	S_n^β
$\vdots$	$\vdots$							
κ	q_κ	S_a^κ	S_b^κ	S_c^κ	...	S_j^κ	...	S_n^κ
$\vdots$	$\vdots$							
ν	q_ν	S_a^ν	S_b^ν	S_c^ν	...	S_j^ν	...	S_n^ν
RELEVANCE NUMBERS		r_{i+1}^a	r_{i+1}^b	r_{i+1}^c	...	r_{i+1}^j	...	r_{i+1}^n

Figure 4-4. Matching matrix for level i+1.

The total or overall relevance number of issue j on any level p is obtained by multiplying upwards to the top of the tree (level 0) from level p, or, down from level 0 to level p, i.e.,

$$R_j = \prod_{i=1}^{p} r_i.$$

To clarify these concepts, consider again the tree of Figure 4-3 and assume that criteria α, β and γ have been established for Functions A, B and C of the level 2 family stemming from Activity B. Assume further that criteria weights and significance numbers have been assigned as shown in Figure 4-5; the relevance numbers of each function are also shown. The relevance number of Function B is computed as

$$r_2^B = (.6)(.6) + (.6)(.3) + (.4)(.1) = .58.$$

The relevance numbers rank the Functions in importance or "relevancy" to attaining Activity B, with Function B being the most relevant, the Function A the second most important and Function C ranking third most important.

CRITERIA	WEIGHTS	ISSUES		
		FUNCTION A	FUNCTION B	FUNCTION C
α	.6	.3	.6	.1
β	.3	.1	.6	.3
γ	.1	.1	.4	.5
RELEVANCE NUMBERS		.22	.58	.20

Figure 4-5. Example matching matrix.

Now, assume that relevance numbers for the entire tree (as shown) have been similarly developed and are as shown in Figure 4-6. The relevance of Characteristic A to the ultimate goal is given by

$$R_A = (.5)(.58)(.4)(.3) = .0348.$$

Again, such overall relevance numbers serve to rank all characteristics of level 4 with respect to their importance in achieving the ultimate goal. A further illustration of the concepts of criteria, weights, significance numbers and relevance numbers is afforded by the example application in Chapter 5.

The purpose, advantages and disadvantages of relevance trees are generally those of the tree structure as discussed above. An additional advantage of relevance trees is that an ordinal ranking of sub-goals and objectives is automatically obtained by the technique. Such a ranking can be of value to the system designer and evaluator in making trade-off analyses. Moreover, the subjective values of the objective setters are made quite explicit through the technique. Whether or not the values are "right" or "wrong" in some absolute sense is immaterial. The point is that the values are <u>explicit</u> and any dissenting discussion can point directly to the values in question rather than attack the overall ranking without focus. This explicitness of values has a definite drawback, however. The technique calls for participants to expose their true values and feelings. As Raiffa (75) also notes, this may be politically untenable for some participants in certain situations. In such situations, the participants may desire to take refuge in the

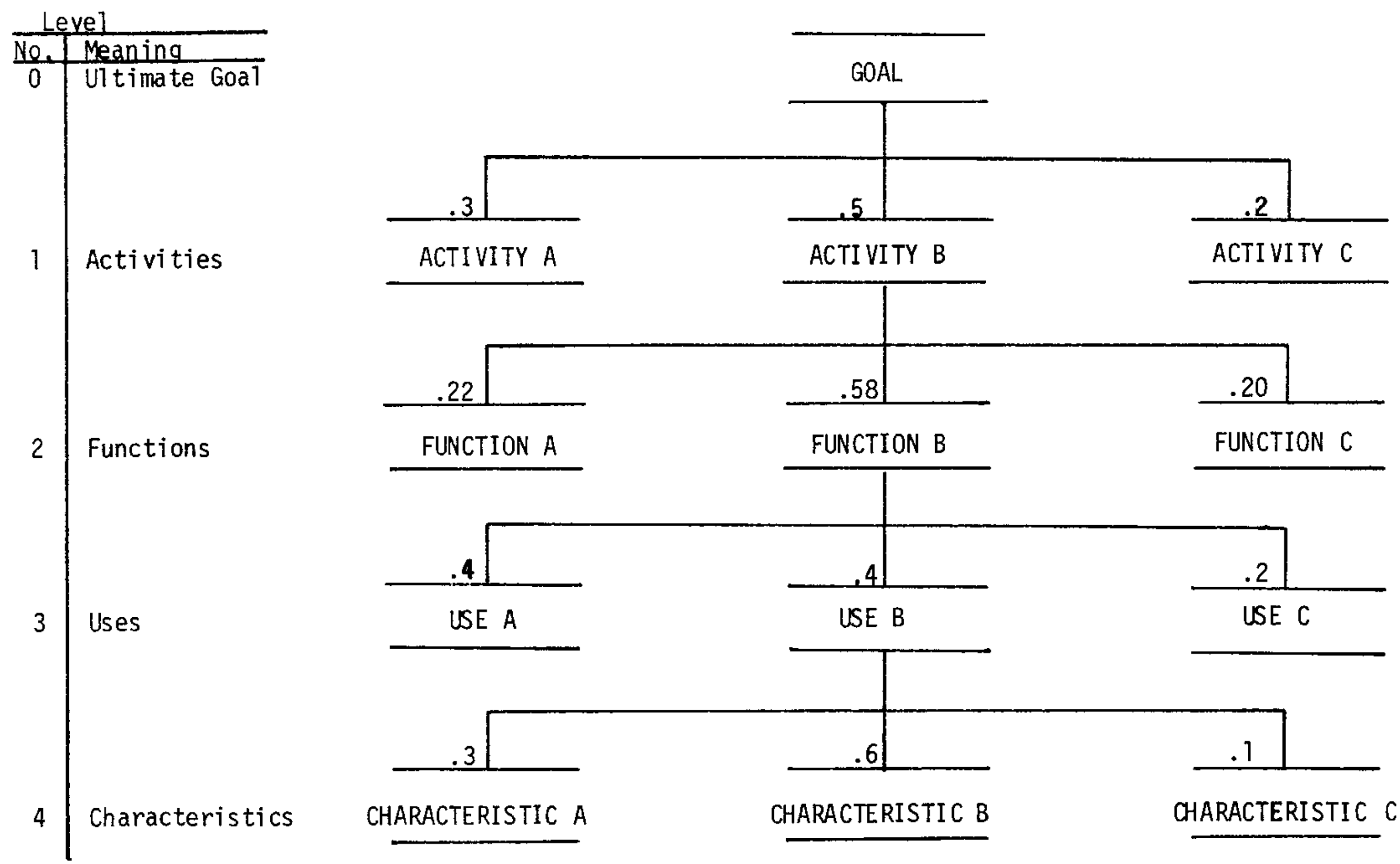


Figure 4-6. The completed relevance tree.

complexity and fuzziness of the problem.

One last advantage of the relevance tree technique is that it offers the opportunity to have the relevance numbers represent the values of all participants, if consensus can be obtained. With respect to coordinated planning in an environment of several participants with overlapping responsibility and authority, such consensus is highly desirable and important. Moreover, the relevance tree technique does not specify how the levels, branches and relevance numbers are to be obtained. The techniques discussed below address such topics.

Brainstorming Technique

Brainstorming is a technique wherein a basic problem is stated to a group of participants and potential solutions to the problem are solicited from the participants; all suggestions are retained for subsequent review. Brainstorming is not a new technique and has been used at various times for many years. It has found application in creativity training (19), technological forecasting (55), and in long-range planning (16). Little is known as to its effectiveness.

The purposes of the brainstorming technique are to elicit ideas from a group and to promote consensus on the ideas through subsequent discussion or other available means.

With respect to objective-setting, without the underlying structure provided by a tree, the technique appears to be best suited for the generation of broad goals. This suggests that the technique may be of use in deducing the levels of a tree structure and the branches on any level. With relevance trees, brainstorming may be useful in determining criteria and significance numbers although consensus among participants would probably be attempted through discussion, which as noted above, has its attendant drawbacks.

The Delphi Technique

The Delphi technique is simply described as a carefully designed set of sequential individual interrogations (generally accomplished by questionnaires) followed by feedback of a computed consensus of opinions of the group of participants. As illustrated by Figure 4-7, an initial questionnaire soliciting opinions on a topic is prepared and submitted to the participants. After the questionnaires are completed, a consensus is computed. A popular and convenient consensus formula is the median, applicable whenever the solicited opinions can be expressed in numeric form or linearly ordered. An obvious variant is the weighted median wherein the opinions of selected participants are given more weight. As an indication of the variability of the opinions, the interquartile range (the middle 50 percent of the responses after they have been ranked in numeric order) is often used. Next, the computed consensus indicator is checked to determine if consensus has been achieved. Definitions of consensus can be made almost at will. A common definition is that the interquartile range of the most recent responses be totally within the interquartile range of the initial

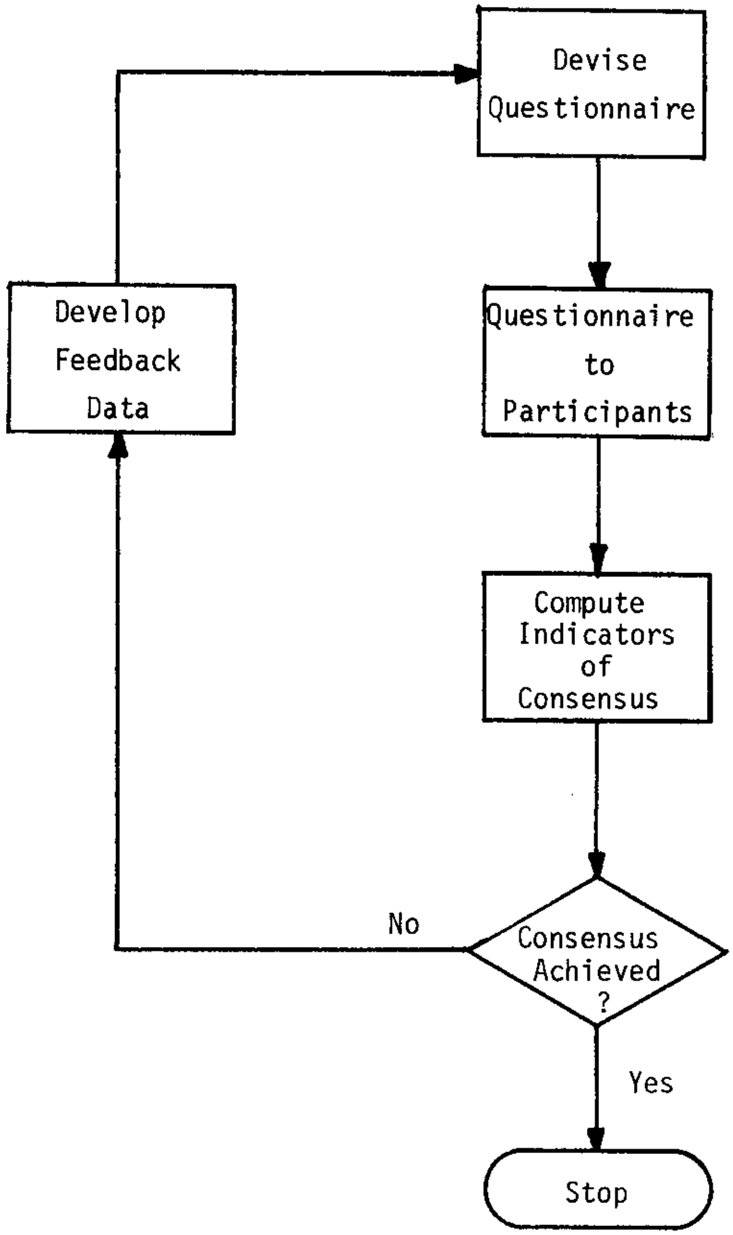


Figure 4-7. The Delphi technique.

questionnaire responses. Stricter definitions of consensus could be made, however. Usually, three to four iterations are sufficient to produce consensus if it is forthcoming. Further iterations sometimes cause divergence to begin. If consensus, however defined, has been achieved, the process stops. Otherwise, a feedback of information, the computed consensus indicator and questions is given to the participants via another round of questionnaires. Some of the questions directed to the participants might, for example, inquire into the reasons for expressed opinions and a collection of such reasons may then be presented to the participants, giving the participants an opportunity to reconsider and possibly revise their earlier opinions.

The purposes, then, of the Delphi technique are to elicit ideas from a group and to promote consensus on the ideas through a series of written questionnaires.

The Delphi technique, originally developed at RAND by Olaf Helmer, has received fairly wide use at various organizational levels. It has been used at the corporate level by such firms as TRW Systems (55), Institute for the Future (28), and RAND (55, 40, 45, 47), at the local level by Erskine (29), at the state level in Connecticut (46), at NASA (9), and at various offices of the U.S. Government including the intelligence community. These uses have been primarily in the field of technological forecasting (for which it was originally developed) but also include application to determining the group opinion on proposed water planning objectives (Erskine (29)) and the assessment of threat nation's goals.

With respect to the generation of objectives when a tree structure is not used, the technique is probably best suited for generating a coordinated set of goals, i.e., for broad concepts. When used in conjunction with a tree structure, the Delphi technique can clearly be used to deduce the levels and the branches of each level of the tree. With respect to relevance trees, the technique can be used to develop the criteria and significance numbers.

The advantages of the technique are numerous. For example, the individually executed questionnaires eliminate the need for face to face confrontation of the participants and thereby reduce or eliminate the need for committees, thus reducing the influence of the psychological factors of specious persuasion, the unwillingness to abandon a publicly expressed opinion and the bandwagon effect of majority opinion. Further, the Delphi technique substitutes a computed consensus for a verbally agreed consensus wherein misunderstanding of actually what is being agreed upon can exist.

One of the most important features of the technique is that it tends to automatically promote consensus on the opinions solicited, if consensus is forthcoming at all. It also offers the opportunity of including consulting experts (say, the system designer) in the formulation of objectives. Moreover, opinion leaders and/or special interest group representatives could easily be included so as to provide an entry for public opinion in the generation of objectives. And, as noted earlier, public attitudes, once determined, should be included in the process of generating objectives.

Attitude Determination

To determine public opinion, it is necessary to first determine the public or the representatives thereof, i.e., it is necessary to determine the population of interest. For economic reasons and from a data-handling standpoint, it appears more reasonable to choose as the population the opinion leaders of the public. The problem thus is to determine these opinion leaders.

Mustafa (66), in summarizing the works of Dahl (21) and Hunter (53), noted that there are basically three approaches used in determining opinion leaders - the positional approach, the reputational approach and the issues-analysis approach. These three approaches are briefly described and discussed in the following paragraphs.

The positional approach theorizes that the power in a community depends upon the position held by the individual in the community's economic, political and/or civic structures. In applying this approach, a thorough search is made of the potential power offices in these structures and a list of individuals holding those offices comprises the opinion leaders of the community. The great advantage of this approach is its simplicity; the very simplicity, however, results in many disadvantages. For example, the relationship between formal positions in governmental structures and the actual power in a democratic community has not been proven conclusively. However, the positional approach completely disregards those individuals not occupying official positions, i.e., it does not distinguish between authority and control. Sociologists have long understood that informal social structure is often as important as, or more important than, formal structure. Additionally, this approach does not necessarily bring to light the community's views on a subject. Instead, it shows what the bureaucrats think the community is thinking. Although this approach is often propagated by the bureaucracies themselves, it is clear that the approach by itself is not a suitable method for determining the opinion leaders.

The most widely employed approach to the study of community power is the reputational approach. In general, the procedure determines the community power structure on the basis of judgements by community members considered knowledgeable about community life. These "judges" select names from lists of potential power structure candidates on the basis of their imputed influence in the community. The persons most frequently selected according to given criteria are said to constitute the power structure and thus are the desired opinion leaders. The approach thus involves two tasks: (1) the preparation of the list, say, from a positional analysis accompanied by a survey of the community to discover the informal leadership, and (2) the analysis of the list, which includes the task of selecting the "judges". Preparation of the list is a cumbersome, but accomplishable task. Hunter, who is the main contributer on the reputational approach, has not clarified how "judges" are selected;

presumably, these would be local respected elders whose views are heard with attention in the community. According to Hunter, a very important characteristic of the opinion leaders ultimately selected is their standing in the business community. This is plausible since a business executive's direction of business enterprise and participation in informal social groupings gives him a significant place in community life. The reputational approach has been in vogue for approximately 20 years and is still the generally accepted approach to community power structure analysis. Its advantage lies mainly in economy of researchers and time. This approach was used in a study of the Susquehanna River Basin for the U.S. Corps of Engineers by Borton, Warner and Wenreich (11). This study showed the need for developing a basis for communications and public participation which includes confidence and trust in the planning process.

The third approach, the issues-analysis approach, is used whenever the personalities are not the key factors as in the other two approaches. Rather, the process of decision making is theorized as the nucleus of the phenomena of power and it is this process that is the object of study. In this approach, issues are selected and analyzed to determine the decision makers for a particular issue. Participation in community decisions is not equated with power but the relative power of the decision makers is obtained by analyzing the impact of each participant on the decisions made. This approach necessitates limiting the number and range of issues to be analyzed.

Moreover, the material to be analyzed consists chiefly of public hearings, debate, discussion, etc. This excludes the researchers from private conversations concerning the issues and, as noted above, these private discussions can be quite important. An additional problem resides in the choice of issues to analyze. Although the approach has many disadvantages, it should be clear that a list of people and/or organizations most concerned (and powerful) about a particular issue could be developed using the issues-analysis approach.

In summary, each of the three approaches to determining opinion leaders has its advantages and disadvantages, with perhaps the reputational approach being the strongest approach. In reality, a blend of the three would probably be most effective in determining whom to survey in a community. Now, how are these opinion leaders to be used with respect to the generation of objectives?

One clear method of using these individuals is to include them in the procedural steps of generating objectives. For example, they might be participants in a Delphi experiment to deduce the levels and branches of a relevance tree. This blend of planners and public opinion leaders has the capability to produce balanced objectives. For on the one hand, the planners will be able to provide a feasible set of objectives, but these objectives may be unacceptable to the community, as represented by the opinion leaders. On the other hand, the opinion leaders should be able to express acceptable community goals but not be able to detail those goals into feasible objectives. The two groups, through an appropriate planning procedure, could complement each other to a high degree.

Another method of using the opinion leaders is to ask them to review and comment on sets of objectives independently prepared by the planners. While this may be wasteful of time if the objectives are unacceptable, the planners may be able to work more rapidly and effectively by themselves. A mix of the two methods is probably the best approach. In both methods, the reviews and comments could be accomplished by either personal, verbal interview or questionnaire. In either case, there are some dangers of which to be aware.

One of the most difficult problems in designing any questionnaire (verbal or written) is in determining what questions to ask. Obviously, if the "wrong" questions are asked, the response is useless. Nothing but a careful and honest analysis of proposed questions can guard against asking the wrong questions. Indeed, some questions quite likely will be asked inappropriately anyway due to the wording of the questions. In this regard, it is convenient to have a small set of opinion leaders and to have some idea of their sociological backgrounds.

Also, in verbal interviews, the manner in which the question is asked can have great importance. It is well known, for example, that a skilled interviewer can frequently obtain any results he desires from the interview by asking questions in a particular manner, e.g., sarcastically, politely, enthusiastically. Written questionnaires are not as sensitive to this problem, though not completely immune.

Summary

In summary, this chapter has dealt with many topics applicable to the objective setting phase of general planning. The chapter first dealt with the general level of detail desired of objectives and then briefly examined the interaction of the roles of the objective setter and the system designer. Next, a number of applicable techniques were defined and critiqued namely, (1) the strawman/discussion technique, (2) trees, (3) relevance trees, (4) the brainstorming technique, and (5) the Delphi technique. Public attitude, its importance and methods for determining and using public opinion leaders were also discussed. In each case, an attempt was made to state how they relate to objective setting in general. It is instructive to note that these topics can be divided into three basic components of objective setting: (1) techniques for structuring the approach to objective setting (the structuring component), (2) techniques for eliciting ideas and promoting consensus (the consensus component) and (3) techniques for determining the public's attitude toward the objectives (the public opinion component). Any technique fitting into any of these components is therefore of potential use in objective setting.

It remains to show how these techniques fit into existing objective setting philosophies and how the techniques might be used in an actual planning situation, e.g., an urban water planning environment. These are the topics of Chapter 5.

CHAPTER 5

OBJECTIVE SETTING PROCEDURES IN AN URBAN WATER PLANNING ENVIRONMENT

Three of the four components of objective setting procedures were discussed in the previous chapter, namely, (1) structuring the approach to objective setting, (2) promoting and generating consensus, and (3) determination of the public's attitude. The fourth component, the inventory/forecast component, concerns an inventory of current capabilities and a forecast of future requirements. This component is more easily discussed in terms of some commodity, e.g., water, and was therefore delayed until this chapter.

In a water planning situation, an inventory of the current water related characteristics (e.g., supply level, quality, etc.) is mandatory, i.e., the "current state" of water must be defined. This current state will normally include those water-related projects under construction. Forecasts of water-related needs must then be made so as to determine future water-related requirements. These forecasts can be obtained from a variety of techniques which are outside the scope of this study. By taking the difference between the forecasted requirements and the current inventory level, a detailed statement of needs can be derived. These needs, generally functions of time, are then associated with the objectives at the lower end of the hierarchy of objectives, e.g., at the lower end of the tree if such a structure is employed. It should be recalled that trees do not automatically quantify such needs but rather only structure the problem so that such needs are systematically considered. Thus, forecasts and inventories of current capabilities form an important component of objective setting procedures. Because techniques associated with this component are fairly well documented in the literature, this component will not be further considered. It is therefore assumed that the water-related needs of the planning environment are known or can be readily generated when desired.

The purpose of this chapter is to state and illustrate an objective setting procedure for the generation of objectives in the San Antonio water planning environment. To this end, techniques from the first three components of objective setting procedures are embedded in Granger's framework (41), as discussed in Chapter 1, to develop an example objective setting procedure. The procedure is then illustrated in the San Antonio water planning environment. Concluding the chapter is a summary which includes a discussion of how to generate other objective setting procedures.

The Techniques in Granger's Framework

Granger's first step, stating the broader goal(s), can be accomplished by three of the techniques described in Chapter 4. That is, the strawman/discussion, brainstorming and Delphi technique can all be used, as noted in Chapter 4, for stating broad goals. Consider now the third step of Granger's framework, deducing alternative submissions or subgoals for each broader goal. As this step is accomplished at succeedingly lower levels of the hierarchy of objectives, a tree structure is deduced, relating subgoals on each level to the preceding level, and ultimately, to the uppermost goal. As in step 1, the strawman, brainstorming and Delphi techniques can be used for step 3. Now, Granger's second step calls for the development of criteria for measuring the success of the subgoals at each level. This second step can also be accomplished by any of the three techniques useful in steps 1 and 3. Indeed, this second step is precisely the phase of the relevance trees technique wherein criteria for each level (or family on a level) of the tree are formulated. Step 4 of Granger's framework calls for analyzing the effectiveness of the alternative sub-objectives. In relevance trees, this step is analogous to the assignment of significance numbers and the calculation of relevance numbers for each branch on the level. Such assignment of numbers can be accomplished for a group by the strawman/discussion, brainstorming or Delphi techniques although the Delphi method appears best suited for generating consensus. Granger's fifth step calls for the selection of the preferred sub-objectives, which could be done on the basis of the relevance numbers of the relevance tree technique. Step 6 is essentially a review step and step 7 merely selects the final objectives which again could be done on the basis of relevance numbers.

Thus, Granger's framework can be readily interpreted as a procedure wherein the techniques of strawman/discussion, brainstorming, Delphi and relevance trees are used. The relevance tree structure is used to delineate the relationships of the goals and sub-goals, and the relevance numbers are used in gauging the effectiveness of each sub-goal and in the selection of preferred objectives. The actual deduction of the sub-goals, the selection of criteria and assignment of significance numbers are accomplishable by any of the three techniques of strawman/discussion, brainstorming, and/or Delphi. The use of these three techniques at any point in the procedure will depend heavily on the specific environment encountered. A procedure, based on Granger's framework and employing the techniques of Chapter 4, will now be defined and then illustrated in the San Antonio, Texas water planning environment.

An Objective Setting Procedure

The objective setting procedure now to be defined, hereinafter termed the Procedure, is obtained primarily through the selection of techniques from the structuring component and the consensus components of objective setting procedures. (Use of the other two components are addressed in the example following this section). For the Procedure, the relevance tree technique is chosen from the structuring component and the brainstorming and Delphi techniques are selected from the consensus component. As illustrated below, the techniques interact to form the Procedure.

The choice of techniques to use and when to use them is a judgement based on several considerations. First, the choice is dependent on the planning environment wherein there exists a spirit of cooperation between the participants and a dedication to achieve coordinated planning. In an area such as San Antonio where such an environment exists, the less formal techniques of brainstorming and strawman/discussion may be more frequently used than the more formal Delphi technique. Conversely, the Delphi and formal committee procedures will probably be of greater value in an environment where such a spirit and dedication are lacking. Secondly, the difficulty of the problem will have an impact on the selection of techniques. For a familiar problem or for one that is very well defined, the more informal techniques will quite likely be of adequate service. For ill-defined or unfamiliar problems, the Delphi technique is likely to be of more value in promoting consensus since it requires a written, logical justification of extreme views. In any situation, the use of a tree structure is recommended as an excellent method of retaining focus on the overall goal and structuring the approach to setting objectives to achieve that goal. In the following definition of the Procedure, further justification is given for the choice of a technique at a particular step in the Procedure.

A flow diagram of the Procedure is given in Figure 5-1. The first step is to define the overall goal to be achieved; this goal is placed on level zero of the tree. As shown in Figure 5-1, this goal is assumed known; if unknown, it can be obtained via the strawman/ discussion, brainstorming or Delphi techniques.

Secondly, the nature (sub-goal, function, etc.) of the first level and the branches of the first level must be deduced. In the

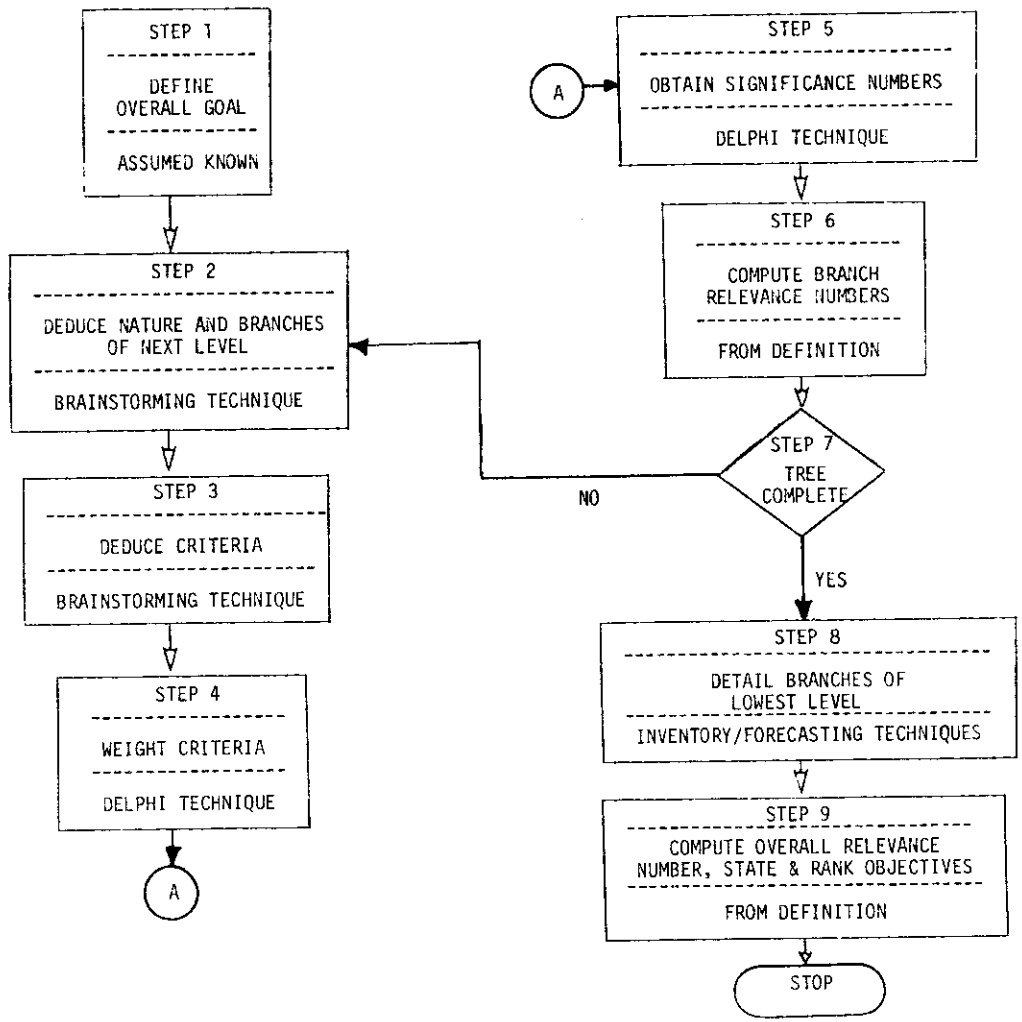


Figure 5-1. The Procedure

Procedure, this will be accomplished through the brainstorming technique. The brainstorming technique is selected principally because of the spirit of cooperation and dedication to coordinated planning that exists among the agencies of San Antonio. This spirit and dedication should serve to minimize the amount of dissension over the nature of the level and branches on the level. Moreover, the nature of the level is not too critical as long as it is logical and pertains to the sub-goal on the next higher level. The only critical point about the levels of the tree is that all relevant levels be eventually introduced on the tree, i.e., the order of levels is not critical as long as it is logical. (This point is further discussed in the section following the example illustration.) Lastly, because the participants (especially the agencies) are exceedingly familiar with the planning area, it is unlikely that any category will be overlooked during the deduction of the branches of the level.

Next, the criteria, used to judge the contribution of each branch on level 1 to its parent on the next higher level (the general goal in this case), must be deduced. The Procedure will accomplish this through the brainstorming technique. This technique is selected because it is a good technique for the elicitation of ideas. Ideas will be forthcoming because of the spirit of cooperation and the dedication mentioned above. It is felt that consensus on the criteria will not be a problem because it is generally easier to agree with an idea than to agree on a specific quantity. Moreover, because the problem is not exceedingly difficult and because of the familiarity of the agencies with existing supply sources, the use of the more formal Delphi technique is not warranted.

The next step consists of weighting the criteria with constants between zero and one such that the weights sum to one and reflect the relative importance of the criteria. Because of the potential difficulty in arriving at a consensus on a specific quantity, the Delphi technique will be used to narrow the range of weights for each criterion. The mean of the responses for each criterion will be used as the single value for the weight; these means will always sum to one as desired (See Appendix for a proof of this property).

Next, the significance numbers for each criterion are obtained, again through the Delphi technique. There will thus be one set of Delphi questionnaires for each criterion. Since the significance numbers must also sum to one for any criterion, this application of Delphi is very similar to the application in the preceding step. Again, the Delphi technique is selected because of the potential difficulty in generating a consensus on a particular quantity.

The next step is that of computing the relevance number of each branch using the definition given in Chapter 4. This step follows readily once the criteria are weighted and significance numbers obtained, i.e., no special technique is needed.

The next step of the Procedure is to decide if the tree has been sufficiently deduced, i.e., to decide if a sufficient structure for analyzing the goal of level zero has been deduced. An important criterion on which to base such a decision is if the branches (issues) of the current lowest level of the tree can be adequately detailed (quantified) by data obtained from the current inventory/forecasting component of objective setting procedures. To clarify, if forecasts/inventories can be made (or already exist) such that the issues on the current lowest level of the tree may be adequately detailed, then the tree has been sufficiently detailed. Otherwise, as indicated in Figure 5-1, the Procedure returns to step 2 and begins deducing a new level of the tree.

Assuming the tree is complete, the Procedure next requires that the branches (issues) on the lowest level of the tree be detailed as much as possible by data obtained from a current inventory and forecasts of the issue. As earlier noted, consideration of such techniques is beyond the scope of this study and therefore no particular techniques for this step of the Procedure are cited.

Lastly, the overall relevance number for each lowest level branch (obtained by multiplying all branch relevance numbers along the path from the top of the tree to the selected branch) is computed and the final objectives are stated. There may be a one-to-one correspondence between the number of objectives and the number of branches on the lowest level of the tree, or there may be fewer stated objectives representing an aggregation of some type. The overall relevance numbers can be used to ordinally rank the objectives in order of relative importance to the overall goal of level zero of the tree.

An Example Application of the Procedure in San Antonio

The following is a realistic (though hypothetical) example chosen to illustrate a situation wherein the Procedure can be applied, and to illustrate the Procedure itself. For the sake of brevity and to retain focus on the situation and Procedure, the example does not consider all facets of the problem, e.g., it does not consider all possible water sources of the area which is necessary in an actual application. To consider all facets of the problem would generate a lengthy discussion which might obscure the visibility of the Procedure and its application.

Of the many agencies of the San Antonio area, those most concerned with the water supply of the area are the City of San Antonio, the City Water Board, the Bexar Metropolitan Water District, the San Antonio River Authority and the Edwards Underground Water District. One of the commonly held goals of these agencies is to make more efficient use of existing water supply sources. In the following it is assumed that the agencies have come to the point in the planning process where they desire to devise a set of objectives to accomplish this common goal. Further, it is assumed that two local businessmen of the area have been identified through reputational analysis as opinion leaders and are to be included in the objective setting sessions along with a representative of the local chapter of the Sierra

Club, a conservation and environmental-protection oriented organization. Lastly, it is assumed that the sessions are to be led and administered by a representative of the Alamo Area Council of Governments (AACOG).

In the first meeting of all ten representatives, the common goal is reaffirmed and a brief explanation of the Procedure is given. The group immediately sets the goal of level zero as: "to make more efficient use of existing supply sources." Step 1 of the Procedure is thus accomplished.

Embarking on Step 2 of the Procedure, the group logically deduces that the sources of the area constitute level 1 and turn to the brainstorming technique to determine the branches of level 1. At the conclusion of the brainstorming round and subsequent discussion, the representatives conclude that the sources with the most potential for increased use are the Medina River watershed and reclaimed wastewater. Thus, the deduced tree at this point appears as in Figure 5-2 and Step 2 of the Procedure is complete.

Step 3 of the Procedure calls for the establishment of criteria with which to judge the relative contribution of each source to the next highest level (the overall goal in this case). Turning again to the brainstorming technique, the following agreed-upon criteria are elicited from the group: (1) potential for increasing usage, (2) ease of increasing usage and (3) dependability of supply. Step 3 is thus complete.

Now, the Delphi technique is to be used to establish a consensus

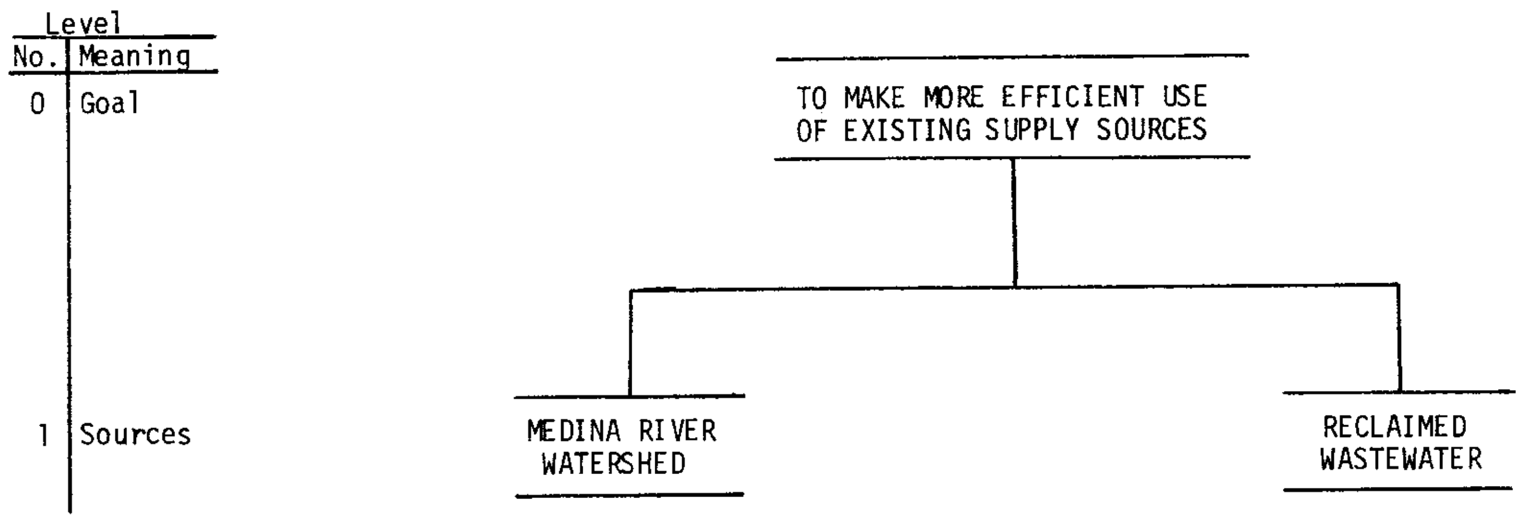


Figure 5-2. The deduced tree to level 1.

on the weights to be associated with these criteria, as requested by Step 4 of the Procedure. The group decides to adjourn, planning a subsequent meeting one week hence. During the first part of the ensuing week, the AACOG representative prepares and administers the Delphi questionnaires to determine the weights. Sample questionnaires for this purpose are shown in Figures 5-3 through 5-5. Illustrative values for the mean and interquartile range for each criterion by questionnaire are found in Figure 5-6. Taking the mean of the responses to the last questionnaire for each criteria as the actual weight and norming to one, the weights for criterion 1, 2, and 3 are determined as .5, .25 and .25, respectively. Step 4 is complete.

In the second part of the intervening week, AACOG prepares and administers three sets of questionnaires, one set for each criterion. Each set is designed to generate consensus on the significance numbers assigned to each source on the basis of its criterion. As with the weights, the mean of each range is used as the agreed-upon significance number. Since these applications of the Delphi technique are extremely similar to that of Step 4, the questionnaires are not shown. Step 5 is now complete.

With the weights and significance numbers obtained in the preceding steps of the Procedure AACOG then executes Step 6 of the Procedure and computes the relevance number for each source. The data of Steps 4, 5, and 6 are summarized in the matching matrix of Figure 5-7; these data are presented to the representatives at the next meeting.

QUESTIONNAIRE I

Presented below is the list of criteria derived at the last meeting. You are requested to evaluate each criterion by weighting each with a number between 0 and 10. The only requirement that is absolutely necessary is that the numbers (or weights) for all the criteria sum to 10. If you feel two or more are equivalent or you are indifferent toward them, rate them the same. For example, if you felt that criterion one was the most important in evaluating the sources of water supply, then you would rate it higher than the rest, say 4. If the other two were equally important but not as important as criterion one, you might rate them both 3, making the sum 10. A zero weighting indicates the criterion is unimportant and a 10 weighting indicates the criterion is all-important.

CRITERIA	WEIGHT
1. Potential for increasing usage at the source.	______
2. Ease of increasing usage at the source.	______
3. Dependability of supply from the source.	______
SUM	10

Figure 5-3. First sample questionnaire.

QUESTIONNAIRE II

This questionnaire, the second in this series, presents a summary of the weightings of the criteria obtained from Questionnaire I. Presented below are your original weighting, the group mean, and the middle 50 percent of the responses for your new ratings.

After considering the group's statistics on the criteria, if you wish to reassess your rating, please do so in the blanks provided. Again, these new weights should also sum to 10. If your previous value was outside the 50 percent range and you do not wish to change that value, please give your reasons on the back of this questionnaire.

CRITERIA	YOUR PREVIOUS VALUE	GROUP MEAN	50% RANGE	NEW WEIGHT
1. Potential for increasing usage at the source.	5.5	6.0	2.0-8.0	______
2. Ease of increasing usage at the source.	3.0	3.0	1.0-7.0	______
3. Dependability of supply from the source.	1.5	1.0	.0-5.0	______
			SUM	10

Figure 5-4. Second sample questionnaire.

QUESTIONNAIRE III

This final questionnaire gives the results of Questionnaire II and reasons for assessments outside the 50 percent range. Please reconsider the weightings of each criterion in the light of the listed reasons and reassign weights for the criteria, if you so desire.

CRITERIA	YOUR PREVIOUS VALUE	GROUP MEAN	50% RANGE	FINAL WEIGHT
1. Potential for increasing usage at the source. No points outside the range.	5.5	5.5	2.5-7.5	______
2. Ease of developing usage at the source. Reason for lower rating: We can do whatever we put our minds to, therefore, ease is not important.	2.5	3.0	2.0-5.0	______
3. Dependability of supply from the source. Reason for higher rating: If there is no water at the source, you have no uses from the source.	2.0	1.5	1.0-4.0	______
			SUM	10

Figure 5-5. Third sample questionnaire.

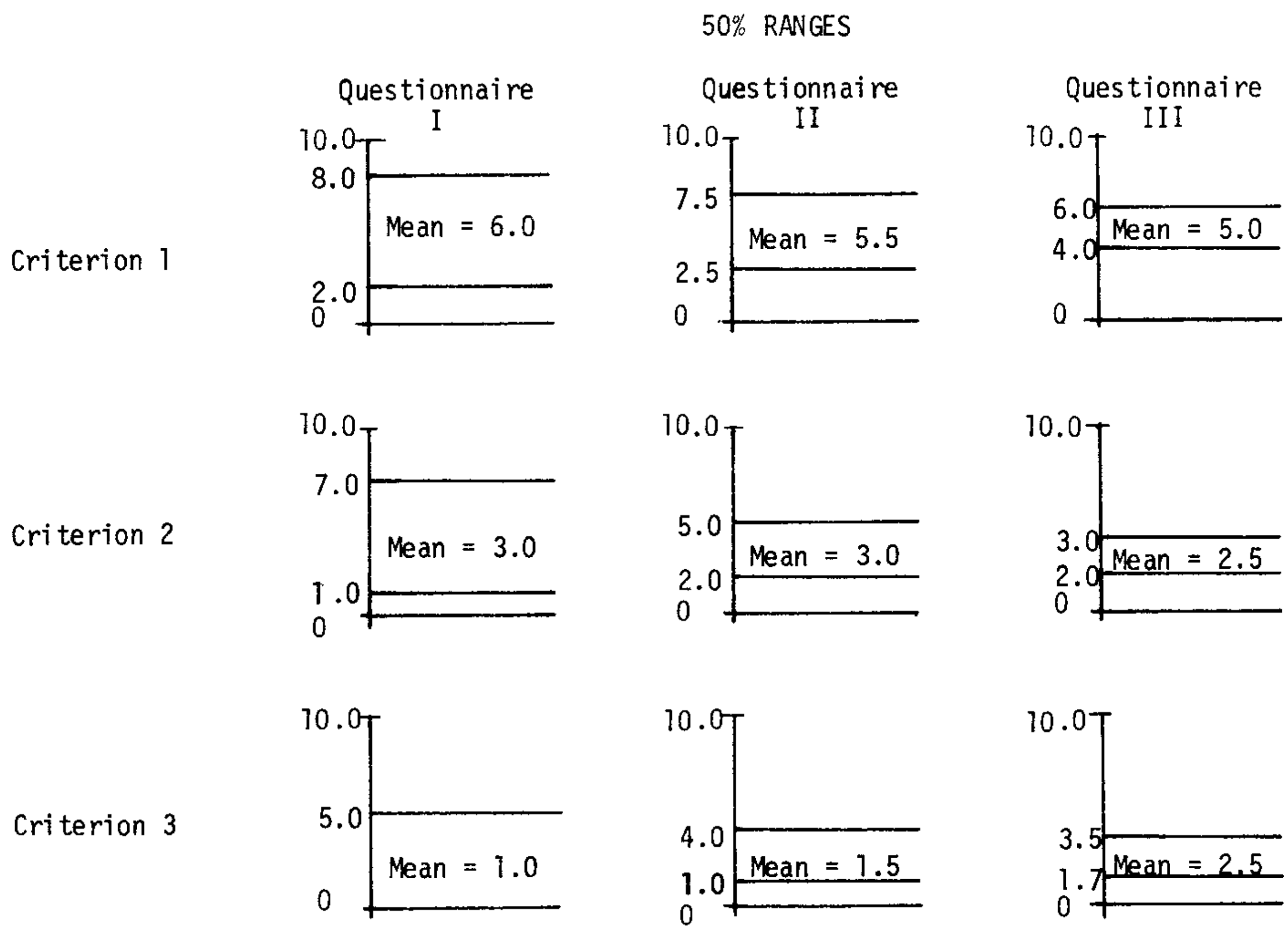


Figure 5-6. 50% range and mean of response by criterion and questionnaire.

CRITERIA	WEIGHT OF CRITERIA	SOURCES	
		MEDINA RIVER WATERSHED	RECLAIMED WASTEWATER
1. Potential for increasing use.	.5	.3	.7
2. Ease of increasing use.	.25	.6	.4
3. Dependability of supply.	.25	.2	.8
RELEVANCE NUMBER		.35	.65

Figure 5-7. Matching matrix for level 1.

At this meeting, the participants review the relevance data and concur with the data. It should be noted that, if for any reason concurrence was not achieved, the Delphi technique could again be applied, perhaps this time directly to the relevance numbers. The representatives then address Step 7 of the Procedure, determining if the tree is complete. The group quickly decides that meaningful forecasts cannot be made until the nature of the use(s) of the water at each source is known. Thus, the decision is made to return to Step 2 and begin detailing a new level of the tree; Step 7 is complete.

As a consequence of the decision at Step 7, the group has determined that level 2 should be the water uses at each source. The group then returns to Step 2 and enters a brainstorming round to determine the potential uses at each source. For brevity's sake, assume that this execution of Steps 2 through 6 yields the tree of

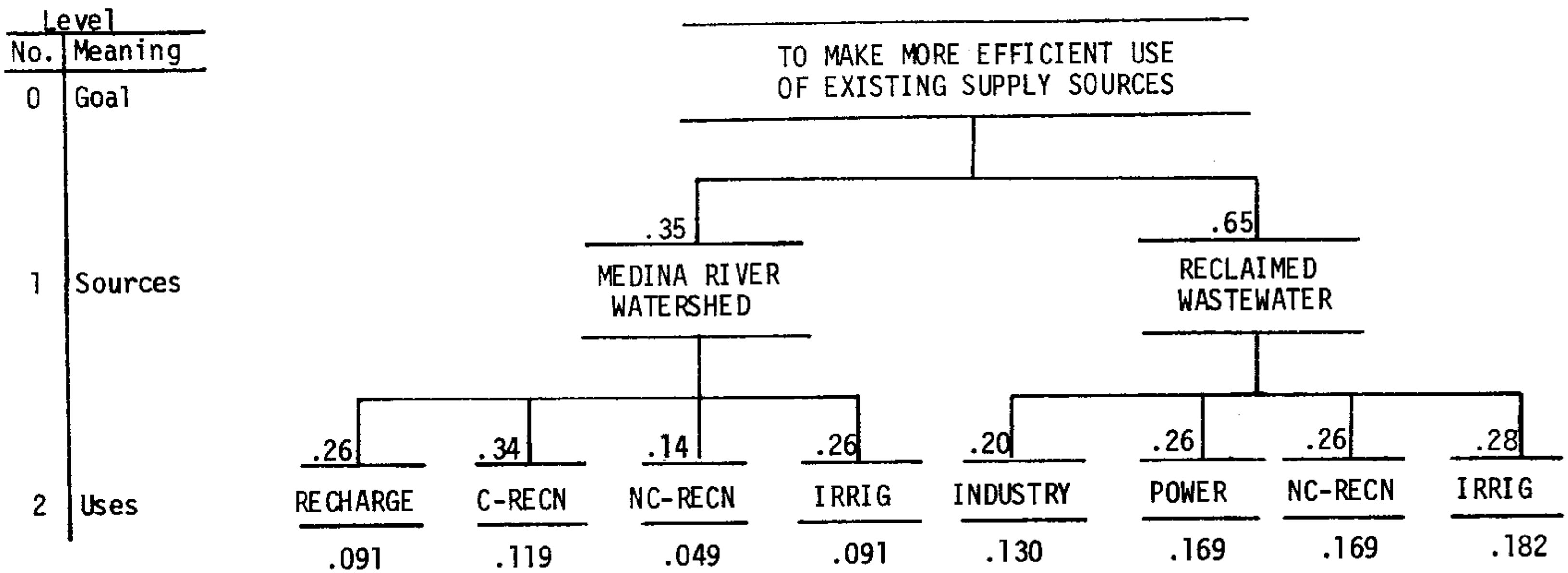
Figure 5-8 and the matching matrices of Figures 5-9 and 5-10. The numbers above the branches of Figure 5-8 are the branch relevance numbers and the numbers below the branches of level 2 are the overall relevance numbers (to be discussed shortly). Thus, the group again finds itself at Step 7 of the Procedure, the point at which a decision is made to continue deducing the tree or to go to Step 8.

The agencies involved check with their staffs and determine that sufficient data is available to accurately describe the uses in terms of required quality and/or quantity. The decision is thus made to continue to Step 8. To provide time for inventory and forecasting studies to be performed, the group adjourns for one week.

During the intervening week, the staffs of the agencies represented work together informally to determine the requirements for each water use at each source. This is accomplished by surveying past or current reports for the area (say, by consultants), checking legal requirements, and/or making studies (inventories/ forecasts) of relevant factors. At the end of the week, the staffs meet informally, pool their results, and agree upon the collected data. Of course, if agreement was not immediately reached, the Delphi technique could be used to generate consensus on the data.

At the next meeting of the ten representatives, the data are presented and concurred with by the group. This data is summarized by Tables 5-1 and 5-2. Step 8 is now complete.

To begin Step 9 of the Procedure the AACOG representative



Legend

RECHARGE: Recharge of EUWR

C-RECN: Contact Recreation (e.g.,swimming)

NC-RECN: Non-contact Recreation (e.g., boating)

IRRIG: Irrigation

POWER: Power, Cooling & Dilution

INDUSTRY: Industrial Waters

Figure 5-8. The relevance tree completed.

CRITERIA	WEIGHT OF CRITERIA	USE			
		RECHARGE OF EUWR	CONTACT RECREATION	NON-CONTACT RECREATION	IRRIGATION
1. Contribution to continuing current level of public welfare.	.4	.4	.1	.1	.4
2. Contribution to increasing level of public welfare.	.4	.2	.4	.2	.2
3. Increasing favorable public opinion.	.2	.1	.7	.1	.1
RELEVANCE NUMBERS		.26	.34	.14	.26

Figure 5-9. Matching matrix for Medina River watershed family.

CRITERIA	WEIGHT OF CRITERIA	USE			
		INDUSTRY	POWER COOLING AND DILUTION	NON-CONTACT RECREATION	IRRIGATION
1. Contribution to continuing current level of public welfare.	.4	.2	.4	.0	.4
2. Contribution to increasing level of public welfare.	.4	.2	.2	.4	.2
3. Increasing favorable public opinion.	.2	.2	.1	.5	.2
RELEVANCE NUMBERS		.20	.26	.26	.28

Figure 5-10. Matching matrix for reclaimed wastewater family.

Table 5-1: Inventory/forecast data

USE	REQUIREMENTS	
	QUALITY*	QUANTITY
1. Recharge of URWR by Medina River Watershed (MRW).	Standard A	Approximately 14,000 acre-ft per annum, at a minimum.
2. Contact Recreation at MRW.	Standard B	Maintain Lake Medina at 90 percent of capacity.
3. Non-contact Recreation at MRW.	Standard A	Maintain Lake Medina at 90 percent of capacity.
4. Irrigation by MRW.	Standard C	25,000 acre-ft/year at a minimum if reclaimed waste-water is not used.
5. Industrial supply from reclaimed wastewater (RW).	Standard D	100 acre-ft/year at a minimum.
6. Power cooling and dilution from RW.	Standard D	Approximately 20,000 acre-ft/year.
7. Non-contact recreation from RW.	Standard A	10,000 acre-ft/year.
8. Irrigation from RW.	Standard C	25,000 acre-ft/year at a minimum.

*See Table 5-2 for definitions of the standards.

Table 5-2: Quality standards

STANDARD A:	The geometric mean of the number of fecal coliform bacteria should be less than 1000 per 100 milliliters with no more than 10 percent of the samples during a given month to exceed 2000 fecal coliform bacteria per 100 milliliters (31).
STANDARD B:	The geometric mean of the number of fecal coliform bacteria should be less than 200 per hundred milliliters and not more than 10 percent of the samples during any thirty day period should exceed 400 fecal coliform bacteria per hundred milliliters (89).
STANDARD C:	See requirements set by Texas Water Quality Board (89), summarized in Freese, Nichols and Endress (34).
STANDARD D:	See Freese, Nichols and Endress (34), pp. 5.3.

computes the overall relevance number for each use on level 2; these numbers are shown below each use in Figure 5-8. To illustrate the calculation, the overall relevance number for use 1 (Recharge of EUWR by Medina Watershed) is computed as

$$R_1 = (.35) \cdot (.26) = .091.$$

These relevance numbers are then used to rank the uses (and ultimately the objectives) in order of their importance to the overall goal of level zero.

To continue with Step 9, the group next states (verbalizes) the objectives by linking the data of Table 5-1 with the corresponding use of level 2, adding connecting phrases, etc., as needed. The objectives, ranked by the overall relevance numbers in order of decreasing relevance, are stated as follows: To design systems and/or management policies

1. To provide a minimum of 25,000 acre-ft/year of irrigation water of quality Standard D from reclaimed wastewater.
2. To provide approximately 10,000 acre-ft/year of water of Standard C from reclaimed wastewater for purposes of non-contact recreation.
3. To provide approximately 20,000 acre-ft/year of water of Standard F from reclaimed wastewater for the cooling of power generation equipment and for the dilution of cooling waters.

4. To provide approximately 100 acre-ft/year of water of Standard E from reclaimed wastewater for industrial purposes.
5. To maintain Lake Medina at approximately 90 percent of capacity of Standard B so as to support contact recreation.
6. To provide a minimum of 14,000 acre-ft/year of water of Standard A for the recharge of the Edwards Underground Water Reservoir.
7. If reclaimed wastewater is not used for irrigation purposes, provide a minimum of 25,000 acre-ft/year of water of Standard D for such a purpose from the Medina River Watershed.
8. To maintain Lake Medina at approximately 90 percent of capacity at Standard C so as to support non-contact recreation.

These, then, are the objectives that would be given to the design staffs of the agencies (or to a private consulting firm) to guide the development of systems and/or management policies to satisfy the goal of making more efficient use of existing water supply sources.

Discussion

The objectives produced by the Procedure are statements of purpose accompanied by a description of precisely what is to be achieved, i.e., detail in terms of quantity and quality. The detail was furnished by the inventory/forecasting component and the object of the detail was provided by the tree structure of the relevance tree technique.

The objectives also are ranked in importance of achieving the overall goal. This ranking was obtained from the definition of relevance and from the consensus generated by the use of the brainstorming and Delphi technique. The ranking is valuable information for planners. For example, if preliminary design shows that achieving all the objectives is infeasible, non-cost efficient or limited by funds, certain objectives could be deleted from further consideration by dropping the one(s) with the lowest overall relevance number. The ranking can also give the general public a clear indication of what priorities are being set by their planners. Indeed, surveys could then be made to check that the public agreed with the ranking. Because the public was represented in their formulation through the two public opinion leaders and the Sierra Club member, it is quite likely that the majority of the public will agree with the ranking.

It is interesting to note that a cost efficiency ranking (if one could be obtained) of the objectives might indicate another ordering of the objectives. However, pursuing the objectives in this order would not solve the original problem. For example, it may be cost efficient to use reclaimed wastewater for industrial purposes only, but pursuing this objective first would not satisfy the more important needs (as determined by the planners through the relevance numbers) of irrigation and power cooling and dilution.

The feedback mechanism of the planning process can be easily demonstrated through the preceding example. Assume now that information becomes available through design studies that demonstrates infeasibility or that invalidates the ranking. Then, the objective setting phase would be reentered and the Procedure could again be used. However, the Procedure may not really be needed in toto. More than likely, only an adjustment in the tree will be required. Moreover, because a tree structure was used initially, the previous work is well documented and required adjustments to the tree and/or relevance numbers should be easily identified and made.

As noted earlier, the order of levels of the tree is relatively unimportant. In the example, the first level could have been deduced as the uses of water from existing sources and the second level as the sources. Thus, each use would have a family of sources stemming from it. The overall relevance numbers would remain the same (assuming branch relevance numbers remained unchanged) because of the commutivity of multiplication, i.e., $r_1 \cdot r_2 = r_2 \cdot r_1$. Thus, the ordinal ranking of objectives would be unchanged.

Note that another level for the tree could have been deduced of a characteristics nature with quality and quantity as branches. Relevance numbers could have been obtained for these so that, if desired, a comparison could be made of the relative importance of the quality of irrigation water to the quality (or quantity) of cooling/dilution water. Indeed, the tree could be extended for levels of systems, subsystems, components of systems, etc. In fact, relevance trees have been used by NASA and in technological forecasting to such levels (although it does not appear that such an application has been made in water resources planning). These levels, however, carry one into the design and/or evaluation phases of the planning process. The designer and/or evaluator indeed may use the relevance tree for these purposes. However, for the generation of objectives, the idea is to terminate the tree at the level preceding actual consideration of systems.

Other variations in the example are possible and plausible. For example, on level 2, different criteria could have been used for each family in the development of the branch relevance numbers. Also, a branch could have been terminated at some level while other branches were continued. In this situation, the overall relevance numbers for the lowest level of the tree will only apply to the branches detailed to that level. To gain an ordinal ranking including the terminated branch, the overall relevance numbers to the level containing the terminated branch could be computed and the branches on that level could be ranked accordingly. In general, it is best to deduce the tree evenly, i.e., deduce all branches to the same level.

Other Objective Setting Procedures

Thus far, only a single objective setting procedure has been defined, the Procedure illustrated and discussed by the preceding sections. The Procedure evolved principally from the choice of techniques from each of the first two components of objective setting procedures, as previously discussed. Obviously, other procedures can be generated by the selection of different techniques. Indeed, a different procedure is obtained if the technique used at some step of the Procedure is changed. As another example, using the strawman/discussion technique for both the structuring and consensus components and an occasional sample of public opinion through public hearings yields essentially the current San Antonio objective setting procedure. As noted earlier, the choice of which techniques to choose is dependent upon the planning environment in which the procedure is to be used and the nature of the problem at hand. In any environment, the use of a tree structure is recommended as an excellent method of retaining focus on the overall goal and structuring the approach to setting objectives to achieve that goal. With the selection of this technique for the structuring component, the procedure can be further developed by the choice of techniques to generate consensus on the levels and branches of the tree (and relevance numbers if a relevance tree is used) and identify and use public opinion leaders.

Thus, many procedures are potentially available from different combinations of the small number of techniques cited in Chapter 4. As other techniques for structuring, generating consensus and determining public opinion leaders are devised or discovered in the literature (from the fields of social and political science, for example), the number of objective setting procedures will increase.

Summary

To summarize, this chapter has identified and illustrated an objective setting procedure for use in San Antonio, Texas. This procedure was created by selecting techniques from the four components of objective setting procedures: (1) structuring the approach, (2) generating consensus, (3) selecting public opinion leaders and (4) inventorying/forecasting to establish detailed statements of need. Although not addressed in this study, the latter component is also quite important. Lastly, a methodology for generating different procedures was briefly stated.

Thus, a procedure has been stated and illustrated. It might well be asked if this procedure is better than the existing procedure used in San Antonio. This topic is addressed in Chapter 6.

CHAPTER 6

AN EVALUATION OF THE PROCEDURE

To evaluate a concept is to make a judgement as to the value or worth of that concept. In this study, a concept of a procedure to set objectives has been proposed and its applicability in a hypothetical though realistic situation has been presented. It is desirable now to evaluate the Procedure, to obtain an estimate of the value of the Procedure. However, how can one "objectively" evaluate objective setting procedures?

One way is to compare the objectives generated by the proposed procedure with the objectives generated by another procedure of known value. Ideally, this would be accomplished by examining the systems resulting from two sets of objectives generated by the two different procedures under identical conditions. This has obvious drawbacks in water planning in that it often takes years for a set of objectives to be translated into concrete systems. Because of the scope of this study and time limitations, this method is not feasible.

Another method is to identify an actual problem and sequentially apply the two procedures to the problem to generate two sets of objectives which then could be judged according to some criteria. This method also has drawbacks such as determining an appropriate problem and securing the cooperation of the involved agencies to participate in such an experiment. Moreover, there is the additional problem of transference of information from one application of a procedure to the next application of the other procedure. Such a transference would seriously impair estimates of relative efficiency, for example.

The evaluation of new concepts is not unique to water planning, however. It is found in long-range forecasting where two or more new or developing technologies must be evaluated. Long-range forecasters often meet this problem by asking a group of knowledgeable persons to evaluate the concepts on the basis of a set of criteria, i.e., the opinions of a group of experts is utilized to evaluate the concepts. This approach to evaluation of concepts is to be used in this study; the exact evaluation methodology is discussed more fully in a following section.

The purpose, then, of this chapter is to evaluate the currently used objective setting procedure of San Antonio and the Procedure of Chapter 5. To this end, this chapter first presents the evaluation methodology and then reviews the experimental conditions under which the evaluation takes place. The results of the evaluation are then presented and analyzed. Chapter 6 closes with a statement of conclusions obtained from the evaluation.

Evaluation Methodology

As noted above, the basic idea of the methodology to be employed is the utilization of expert opinion. The exact steps of the methodology are discussed in the following paragraphs.

Step one of the method is to select a panel of experts on planning who are familiar with the San Antonio planning environment and who are familiar with the objective setting procedure currently in use in the area. To keep the application and analysis manageable, a panel size of six was determined. Half of the six are experts from the San Antonio area who daily work in water planning for the area. The other three experts are consultants and acadamicians who, through research projects and interest, are familiar with the planning environment of San Antonio.

Step two calls for the selection of a set of criteria with which objective setting procedures can be judged. The panel will be provided an initial set of criteria and will be asked to supplement this set with criteria of their own choosing.

In step three, each expert will familiarize himself with both procedures to be evaluated. It is assumed through his familiarity with the San Antonio planning environment that he is aware of the current planning procedure. To familiarize himself with the Procedure, each expert will be required to read Chapters 4 and 5 of this study. Following this reading, any questions will be concisely yet thoroughly answered.

In step four, each expert will individually weight the criteria and then score both procedures according to the criteria generated in step two. As with the significance numbers of relevance trees, the sum of each expert's weights and scores over any particular criterion should both be unity. No attempt will be made to generate a consensus among the experts on the weights of the criteria or the scores applied to each procedure.

Step five calls for the computation of two relevance numbers from each expert's scores, one relevance number for each procedure. Each expert will then be asked if he concurs with the ranking afforded by these two relevance numbers, i.e., if the two relevance numbers reflect his overall, subjective comparison of the two evaluated procedures. Comments on the two procedures will then be solicited.

Step six consists of the analysis of the six pairs of relevance numbers, the individual significance ratings and the effects of different weightings of the criteria on the outcome of the evaluation.

It should be clear from the preceding that the methodology is essentially an application of relevance trees as illustrated in Chapter 5, with one major exception; no attempt is made to generate a consensus on the weights of the criteria or relevance numbers. The goal on level zero of this tree is "to generate urban water planning objectives" and the two procedures being evaluated form level one of the tree. The criteria, weights, scores and relevance numbers obtained in steps two through five of the evaluation methodology are analagous to the weights, significance numbers and relevance numbers of the matching matrix of Chapters 4 and 5. At this point, the similarity ends in that there will be six sets of significance numbers and relevance numbers generated, one for each expert on the panel.

Experimental Conditions

In the following, the six respondants (experts) are identified as R1, R2, ..., R6. Respondants R1, R2 and R3 are university associated personnel familiar with the San Antonio area through their interest, consulting contracts and studies. Respondants R4, R5, and R6 are personnel from San Antonio who are currently working in water planning for the area.

The evaluation was conducted over a two week period. At the first meeting with each respondant, an initial set of proposed criteria with which objective setting procedures could be judged was specified. Additions to the list were then solicited and added to the initial set. After some rewording and consolidation to prevent duplication, a final list of nine criteria was prepared as shown on Figure 6-1. The initial set was composed of criterion numbers 1, 2, 3 and 5.

At the beginning of the following week, the respondants were given the list of criteria and copies of Chapters 4 and 5 of this dissertation. Four days later, each respondant was asked to execute the evaluation form shown on Figures 6-2 and 6-3. The two relevance numbers were immediately computed and shown to the respondant to determine if he concurred with the ranking they provided; comments were then solicited. The actual evaluation took between 30 and 60 minutes.

1. Provides easy input for public opinion.
2. Promotes consensus of participants on the objectives.
3. Provides a definite, well-defined structure for generating objectives.
4. Flexibility of application: procedure can be used for different types of problems and facilitates revision of objectives due to changes in the problem definition.
5. Provides specific, detailed objectives.
6. Ease of application: can be implemented without massive institutional overhaul.
7. Can provide interface with other types of planning (e.g., transportation planning and housing planning).
8. Amount of time required by procedure.
9. Documentation: procedure automatically documents decisions, value judgements and results of application of the procedure.

Figure 6-1. The evaluation criteria.

Evaluation of Objective Setting Procedures

The purpose of this questionnaire is to evaluate two objective setting procedures for urban water planning: (1) the procedure currently used in San Antonio, Texas and (2) the procedure proposed by the two chapters of B. M. Thornton's dissertation. It is assumed that you are familiar with the currently used procedure and have read the two chapters defining the proposed procedure. The evaluation will be based on a set of criteria which you have helped develop.

On the following page, you are asked first to weight the criteria with numbers between zero and one such that the sum of the weights over all the criteria is one. The weights are entered in the column entitled, "Weights of Criteria." Next, you are asked to judge the significance of both procedures according to each criterion with numbers between zero and one such that the sum of the two significance numbers for each criterion is one. Thus, the sum of the two significance numbers for each row (excluding the criterion weight) must be one. These data will be used in the evaluation of the two procedures. After you have completed the questionnaire, the evaluation will be performed and you will be asked to comment verbally on the outcome. Thank you for your cooperation in this research.

Figure 6-2. Introduction to the questionnaire.

CRITERIA	WEIGHT OF CRITERIA	CURRENTLY USED PROCEDURE	PROPOSED PROCEDURE
- Provides easy input for public opinion.			
- Promotes consensus of participants on the objectives.			
- Provides a definite, well-defined structure for generating objectives.			
- Flexibility of application: procedure can be used for different types of problems and facilitates revision of objectives due to changes in the problem definition.			
- Provides specific, detailed objectives.			
- Ease of application: can be implemented without massive institutional overhaul.			
- Can provide interface with other types of planning (e.g., transportation planning and housing planning).			
- Amount of time required by procedure.			
- Documentation: procedure automatically documents decisions, value judgements and results of application of the procedure.			

Figure 6-3. The questionnaire.

Results and Analysis

Of the six respondants initially chosen, only five were able to complete the evaluation. Respondant R6 was unable to complete the evaluation because of business commitments and an associated lack of time. The relevance numbers from the remaining five respondants are shown in Figure 6-4. In Figure 6-4 and for the remainder of this chapter, CURR denotes the currently used procedure and PROP denotes the proposed Procedure. As noted in the summary of Figure 6-4, all five respondants ranked PROP above CURR. Additionally, all five respondants concurred with their ranking, i.e., each respondant felt that the two relevance numbers generated from his response reflected his overall, subjective comparison of the two procedures.

R1		R2		R3	
CURR	PROP	CURR	PROP	CURR	PROP
.288	.712	.280	.720	.355	.645

R4		R5		SUMMARY	
CURR	PROP	CURR	PROP	CURR	PROP
.445	.555	.26	.74	0	5

Figure 6-4. Results of the evaluation.

From the individual significance ratings, a summary of the number of times that CURR was rated above PROP (CURR > PROP), that CURR was rated equivalent with PROP (CURR = PROP) and that PROP was rated above CURR (PROP > CURR) with respect to each criterion is shown in Figure 6-5. Of the possible forty-five rankings, CURR was rated above PROP only six times, equal eleven times and less twenty-eight times. Thus, PROP was rated at least equal to CURR a total of thirty-nine times (over 86 percent of the responses).

CRITERIA	CURR > PROP	CURR = PROP	PROP > CURR
1.	0	1	4
2.	0	1	4
3.	0	2	3
4.	1	0	4
5.	0	3	2
6.	2	1	2
7.	0	1	4
8.	3	1	1
9.	0	1	4
TOTALS	6	11	28

Figure 6-5. Summary of individual significance rankings.

The respondants did not rate the criteria identically, suggesting that different weightings might significantly affect the outcome of the evaluation. This possibility was examined by varying the criteria weights and, using the significance ratings of the original responses, calculating new relevance numbers for both PROP and CURR. The results of an essentially equal weighting of all criteria by all respondants is shown in Figure 6-6. As shown, the results unanimously favor PROP over CURR.

CRITERIA	1	2	3	4	5	6	7	8	9
WEIGHT	.11	.11	.11	.12	.11	.11	.11	.11	.11

R1		R2		R3	
CURR	PROP	CURR	PROP	CURR	PROP
.3295	.6705	.3735	.6265	.3780	.6220

R4		R5		SUMMARY	
CURR	PROP	CURR	PROP	CURR	PROP
.4780	.5220	.3000	.7000	0	5

Figure 6-6. Results of equal weighting of criteria.

Now, PROP was designed with criteria 1, 2, 3 and 5 in mind. It is not surprising to find, therefore, that an equal rating of these criteria also provides a unanimous decision of PROP over CURR, as shown by Figure 6-7. However, it is surprising to note that an essentially equal weighting of criteria 4, 6 and 8 (which had CURR rated higher than PROP) still does not give CURR a majority of favorable rankings, as shown by Figure 6-8. Indeed, it is difficult

CRITERIA	1	2	3	4	5	6	7	8	9
WEIGHTS	.25	.25	.25	0	.25	0	0	0	0

R1		R2		R3	
CURR	PROP	CURR	PROP	CURR	PROP
.2875	.7125	.4125	.5875	.3000	.7000

R4		R5		SUMMARY	
CURR	PROP	CURR	PROP	CURR	PROP
.4250	.5750	.3250	.6750	0	5

Figure 6-7. Results of a pro-PROP weighting.

CRITERIA	1	2	3	4	5	6	7	8	9
WEIGHTS	0	0	0	.33	0	.33	0	.34	0

R1		R2		R3	
CURR	PROP	CURR	PROP	CURR	PROP
.3325	.6675	.3700	.6300	.5340	.4660

R4		R5		SUMMARY	
CURR	PROP	CURR	PROP	CURR	PROP
.6020	.3980	.4670	.5330	2	3

Figure 6-8. Results of a pro-CURR weighting.

to construct a weighting of the criteria (for all respondants) such that CURR is preferred to PROP for a majority of the rankings.

The primary conclusion from the preceding analysis is that the panel of experts preferred the Procedure to the currently used procedure of San Antonio for the setting of urban water planning objectives. The results do not state that the Procedure is necessarily the best objective setting procedure, showing only that the Procedure is judged to be comparatively better than the currently used procedure of the San Antonio area. Moreover, this conclusion holds over a fairly wide range of weightings of the criteria. Equally important is that the evaluation results held for all respondants, both acadamicians and practicing planners.

This conclusion is substantiated by the comments received during the evaluation process. Two of the respondants commented that the Procedure at least provides a definite procedure for setting objectives, a vast improvement over the currently used procedure. Two other respondants commented that the Procedure offers a significant improvement over the current procedure with respect to the input of public opinion. Another commented that the Procedure has high potential for interfacing with other types of planning (e.g., transportation and housing). Another comment noted that the Procedure forces value judgements to be made and documents these judgements, a characteristic which would tend to make objective setting somewhat less political in nature. He further noted that the documentation afforded by the relevance tree could serve as an excellent orientation device for new employees.

One caveat on the conclusion must be made. Since only a sample of five expert opinions was taken, it is quite possible that a larger sample would not display the definite preference obtained in the evaluation described above. An evaluation with a larger number of experts is therefore recommended.

CHAPTER 7

CONCLUSIONS AND RECOMMENDATIONS

The specific objectives of this research were to:

1. Devise a procedure for the establishment of unified and consistent objectives, in a rational and objective manner, for urban water resources planning involving more than one governmental agency and the general public.
2. Illustrate the applicability of the devised procedure to a realistic problem encountered by the San Antonio, Texas metropolitan area.
3. Indicate how other such procedures could be generated, depending on the planning environment and the problem at hand.
4. Provide an assessment of the devised procedure.

These objectives have been attained through the preceding chapters of this report.

Chapter 1 introduced the urban water planning problem and surveyed the relevant literature. Chapter 2 presented and justified a form of the planning process and indicated the importance of the objective setting phase to planning. The third chapter introduced the study area of metropolitan San Antonio, Texas through a discussion of the area's geography, demography, water-related organizations and current planning arrangement. Chapter 4 introduced and explained potential techniques for use in objective setting. These techniques were woven into the Procedure for setting objectives in Chapter 5. Chapter 5 also illustrated the Procedure and indicated how other such procedures could be generated by selecting techniques from the four components (or classes of techniques) of objective setting procedures: (1) techniques for structuring the problem, (2) techniques for eliciting ideas and promoting consensus of opinion, (3) techniques for determining the public's attitude toward the objectives and (4) techniques for providing an inventory of current resources and for estimating an inventory of current resources and for estimating future requirements. Objective setting procedures can be generated by the judicious selection and combination of techniques from each component. Finally, Chapter 6 presented an evaluation methodology and reported the results of the evaluation of the Procedure.

Conclusions

The major conclusions of the research are as follows:

1. Urban water planning is now and will continue to be a complicated, difficult yet indispensible process for urban water management.
2. The objective setting phase is an important phase of the planning process; indeed, objectives lead and provide important information to the design and subsequent phases of the planning process.
3. Despite numerous references to the importance of

objectives, there are few stated procedures for the development of objectives and these few do not specify the techniques to be employed.

4. The San Antonio, Texas area is characteristic of urban areas wherein urban water planning problems are found.
5. Objective setting procedures can be viewed as having four basic components; a specific procedure can be formed by the judicious selection and combination of techniques from each of the four components. Indeed, the Procedure, as described in Chapters 4 and 5, was so developed.
6. In an evaluation of the Procedure by five experts in water planning for the San Antonio area, the Procedure was unanimously ranked above the currently used procedure of the San Antonio area.
7. The Procedure is an attractive and potentially useful procedure for determining urban water planning objectives.
8. Formal techniques and procedures are applicable to the more subjective phases of the planning process, phases which have traditionally been slighted by the operations analyst.

Recommendations

There are five broad recommendations for further research that should be noted. These recommendations are as follows:

1. Methods for more thoroughly evaluating the Procedure should be devised and implemented. Two such methods are briefly mentioned in Chapter 6, but more efficient and appropriate methods can undoubtedly be constructed. Such evaluation methods, once applied, could serve as a basis for improving the Procedure.
2. Methods for "selling" the Procedure to existing managers of planning agencies should be devised so that the Procedure has a chance of being applied. Such efforts should include training programs to educate potential users of the Procedure in its application.
3. It is highly recommended that the Procedure receive actual application in urban water planning situations such as encountered in the San Antonio area. Such applications would serve to validate the Procedure and provide a valuable feedback of information that could be used to improve the Procedure.
4. It is further suggested that the Procedure be applied to other planning fields, e.g., transportation and housing planning. It should be clear that the techniques and devised Procedure are applicable to other fields of planning.
5. Finally, it is highly recommended that further efforts be made to bring some kind of order and procedure to the more subjective aspects of the planning process.

> The consequences of inefficient or incomplete planning are too high to permit these aspects to remain unstudied.

In closing, a rough framework for generating objective setting procedures has been established and utilized to generate the Procedure for setting urban water planning objectives. It remains for the framework and Procedure to be applied, evaluated and improved so that more consistent, unified objectives reflecting the desires of the general public may be generated for urban water resources planning.

APPENDIX

THREE MATHEMATICAL PROPERTIES

The purpose of this Appendix is to present three mathematical properties not fully developed in the main body of the dissertation. The first property is that the sum (over all issues of a family) of the means of significance number estimates for any single criterion is one. The second property is that the sum of the relevance numbers for any family on a level is one. The third and final property is that the overall relevance numbers also sum to one, given that the sum of the branch relevance numbers for all families of the tree is one.

First Property

In Chapter 5 of this dissertation, the mean was chosen as the single figure to represent the various significance number estimates (obtained by the Delphi technique) for an issue. It was also stated that the sum of all such means over all issues of the family would be one. The proof of this property is as follows.

Let S_{ia}^{κ}, S_{ib}^{κ}, ..., S_{in}^{κ} be the significance number estimates of the i^{th} individual (i = 1, 2, ..., N) for each of n issues, a, b, ..., n with respect to criterion κ. By definition, the sum of these significance numbers for any individual is one, i.e.,

$$\sum_{j=a}^{n} S_{ij}^{\kappa} = 1, \; i = 1, 2, \ldots, N. \qquad [1]$$

Now, the mean of all N estimates for issue j was used as a representative significance number for the issue and is defined as

$$\frac{1}{N} \cdot \sum_{i=1}^{N} S_{ij}^{\kappa}, \; j = a, b, \ldots, n.$$

It must be shown that the sum of such means is one, i.e.,

$$\sum_{j=a}^{n} \left(\frac{1}{N} \cdot \sum_{i=1}^{N} S_{ij}^{\kappa}\right) = 1.$$

Now,

$$\sum_{j=a}^{n} \left(\frac{1}{N} \cdot \sum_{i=1}^{N} S_{ij}^{\kappa}\right) = \frac{1}{N} \cdot \left[\sum_{j=a}^{n} \sum_{i=1}^{N} S_{ij}^{\kappa}\right], \text{ or,}$$

$$'' \qquad = \frac{1}{N} \left[\sum_{i=1}^{N} \sum_{j=a}^{n} S_{ij}^{\kappa}\right], \text{ or,}$$

$$'' \qquad = \frac{1}{N} \sum_{i=1}^{N} (1) \text{ from [1], or,}$$

$$'' \qquad = \frac{1}{N} (N), \text{ or,}$$

$$\sum_{j=a}^{n} \left(\frac{1}{N} \cdot \sum_{i=1}^{N} S_{ij}^{\kappa}\right) = 1 \text{ as desired.}$$

Second Property

Let a, b, ..., n be the family of issues on level i+1 (of a relevance tree) stemming from a common parent on level i and let $\alpha, \beta, \ldots, \nu$ be the criteria with weights q_κ, $0 \leq q_\kappa \leq 1$, such that

$$\sum_{\kappa=\alpha}^{\nu} q_\kappa = 1, \qquad [2]$$

and, let S_j^{κ}, j = a, b, ..., n be the significance numbers measuring the significance of issue j with respect to criteria κ, where $0 \leq S_j^\kappa \leq 1$ and

$$\sum_{j=a}^{n} S_j^\kappa = 1. \qquad [3]$$

The relevance number r_{i+1}^j, representing the relevance of issue j on level i+1 to the parent issue on level i, is defined as

$$r_{i+1}^j = \sum_{\kappa=\alpha}^{\nu} q_\kappa S_j^\kappa.$$

It is desired to show that the sum of the relevance numbers for this family is one, i.e.,

$$\sum_{j=a}^{n} r_{i+1}^j = 1.$$

Now,

$$\sum_{j=a}^{n} r_{i+1}^j = r_{i+1}^a + r_{i+1}^b + \ldots + r_{i+1}^n, \text{ or,}$$

$$" \quad = \sum_{\kappa=\alpha}^{\nu} q_\kappa S_a^\kappa + \sum_{\kappa=\alpha}^{\nu} q_\kappa S_b^\kappa + \ldots + \sum_{\kappa=\alpha}^{\nu} q_\kappa S_n^\kappa, \text{ or,}$$

$$" \quad = \sum_{\kappa=\alpha}^{\nu} q_\kappa (S_a^\kappa + S_b^\kappa + \ldots + S_n^\kappa), \text{ or,}$$

$$" \quad = \sum_{\kappa=\alpha}^{\nu} q_\kappa \left(\sum_{j=a}^{n} S_j^\kappa\right), \text{ or,}$$

$$" \quad = \sum_{\kappa=\alpha}^{\nu} q_\kappa (1) \text{ from [3], or,}$$

$$\sum_{j=a}^{n} r_{i+1}^j = 1 \text{ from [2].}$$

In passing, it should be noted that it is not absolutely necessary for the sum of the significance numbers S_j^κ for criterion κ be one, or, that the sum of the weights q_κ be one. The important principle under such conditions is that the sum of the significance numbers for each criterion be the same, i.e., if K is a positive constant,

$$\sum_{j=a}^{n} S_j^\kappa = K \text{ for every } \kappa = \alpha, \beta, \ldots, \nu.$$

The weights of the criteria should be from the same scale.

For example, the weights of the criteria could be chosen such that $0 \leq q_\kappa \leq 10$ and the significance numbers for each criterion could sum to 80 as shown in the simple numerical example of Figure A-1. These data indicate that $r^a > r^b$ so that issue a is ranked above issue b. Of course, the numbers of Figure A-1 can be normalized by dividing each significance number by 80 and each weight by 8, the sum of the weights. The results of such a normalization are shown in Figure A-2 where again the relevance numbers rate issue a superior to issue b.

The normalizations of q_κ and S_j^κ to one are commonly found in the literature and thus were used in the dissertation. Of course, under such normalizations the sum of the relevance numbers for any family is one (as shown above). This characteristic provides the user with a convenient computational check.

CRITERIA	WEIGHT OF CRITERIA	ISSUES	
		a	b
α	6	50	30
β	2	20	60
RELEVANCE NUMBERS		340	300

Figure A-1. Non-normalized matching matrix.

CRITERIA	WEIGHT OF CRITERIA	ISSUES	
		a	b
α	.75	.62500	.37500
β	.25	.25000	.75000
RELEVANCE NUMBERS		.53125	.46875

Figure A-2. Normalized matching matrix.

Third Property

The third property is that the overall relevance numbers R_j also sum to one, given that the sum of the relevance numbers for each family is one. A formal proof for this property is not given because the required notation is far too unwieldy to permit a clear exposition of the property. The property is easily demonstrated by reference to Figure A-3, which illustrates a simple relevance tree with the branch relevance numbers shown as r_i and the overall relevance numbers shown as R_j.

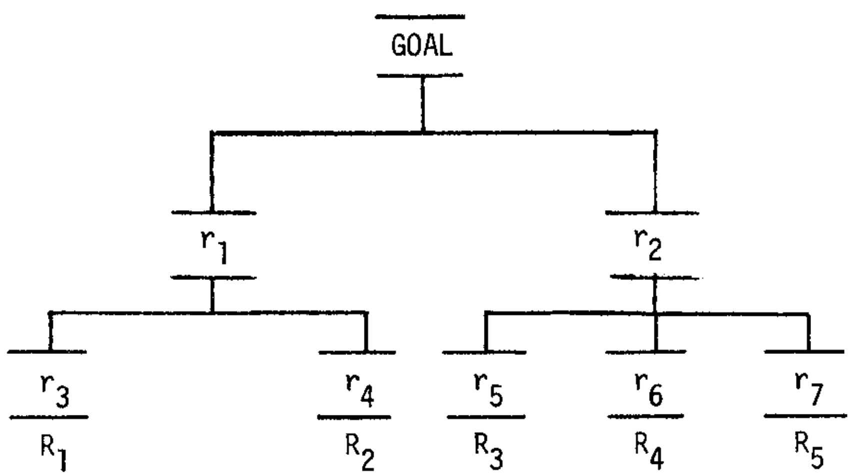


Figure A-3. A simple relevance tree.

Recalling that the sum of the relevance numbers of each family on a level is one, it is clear that

$$r_1 + r_2 = 1, \qquad [4]$$

$$r_3 + r_4 = 1, \text{ and} \qquad [5]$$

$$r_5 + r_6 + r_7 = 1. \qquad [6]$$

Now, by definition

$$R_1 = r_1 \cdot r_3,$$
$$R_2 = r_1 \cdot r_4,$$
$$R_3 = r_2 \cdot r_5,$$
$$R_4 = r_2 \cdot r_6, \text{ and}$$
$$R_5 = r_2 \cdot r_7.$$

It is desired to show that

$$\sum_{j=1}^{5} R_j = 1.$$

Now,

$$\sum_{j=1}^{5} R_j = R_1 + R_2 + R_3 + R_4 + R_5, \text{ or,}$$

$$\text{"} \quad = r_1 \cdot r_3 + r_1 \cdot r_4 + r_2 \cdot r_5 + r_2 \cdot r_6 + r_2 \cdot r_7, \text{ or,}$$

$$\text{"} \quad = r_1 (r_3 + r_4) + r_2 (r_5 + r_6 + r_7), \text{ or,}$$

$$\text{"} \quad = r_1 (1) + r_2 (1) \text{ from [5] and [6], and}$$

$$\sum_{j=1}^{5} R_j = 1 \text{ from [4].}$$

The same logic applies to larger trees as well. Again, the property that the sum of the overall relevance numbers is one provides the user with a convenient computational check.

BIBLIOGRAPHY

(1) Alamo Area Council of Governments, "Program..'71," AACOG, San Antonio, Texas, October 1971.

(2) Alamo Area Council of Governments, Regional Wastewater Development Plan, AACOG, San Antonio, Texas, April 1971.

(3) Alamo Area Council of Governments, The Water Resource Management Plan for the AACOG Planning Region, Volume I, AACOG, San Antonio, Texas, December 1971.

(4) Altshuler, Alan, The City Planning Process, Cornell University Press, Ithaca, New York, 1965.

(5) Altshuler, Alan, "The Goals of Comprehensive Planning," Journal of the American Institute of Planners, Vol. 31, August 1965.

(6) American Society of Civil Engineers, "Urban Water Resources Research," Report of the ASCE Urban Water Resources Research Program, New York, September 1968.

(7) Ayres, Robert U., Technological Forecasting and Long-Range Planning, McGraw-Hill Book Co., New York, 1969.

(8) Banfield, E. C., "Ends and Means in Planning," in S. Mailick and E. H. VanNess (eds.) Concepts and Issues in Administrative Behavior, Prentice-Hall, Englewood Cliffs, New Jersey, 1962.

(9) Beller, William S., "Technique Ranks Space Objectives," Missiles and Rockets, February 1966.

(10) Bollens, John C., and Schmandt, Henry J., The Metropolis: Its People, Politics, and Economic Life, Harper, New York, 1965.

(11) Borton, Thomas E., Warner, Katherine P., and Wenrich, J. William, "The Susquehanna Communication-Participation Study," IWR Report 70-6, Institute for Water Resources, U.S. Army Corps of Engineers, December 1970.

(12) Branch, Melville C., "Delusions and Diffusions of City Planning in the United States," Management Science, 16, 12, August 1970.

(13) Branch, Melville C., Planning: Aspects and Applications, John Wiley & Sons, New York, 1966.

(14) Branch, Melville C., The Corporate Planning Process, The Riverside Press, 1962.

(15) Branch, Melville C., and Robinson, Ira M., "Goals and Objectives in Civil Comprehensive Planning," The Town Planning Review, Vol. 38, January 1968.

(16) Bush, G. A., "Prudent-Manager Forecasting: New Approach to Long-Range Planning," Harvard Business Review, Vol. 39, May-June 1961.

(17) Casbeer, Thomas J., and Trock, Warren L., "A Study of Institutional Factors Affecting Water Resource Development in the Lower Rio Grande Valley, Texas," Technical Report No. 21, Water Resources Institute, Texas A&M University, September 1969.

(18) Claire, W. H., Urban Planning Guide, Report of the ASCE Urban Planning and Development Division, American Society of Civil Engineers, New York, 1969.

(19) Clark, Charles H., Brainstorming--the Dynamic New Way to Create Successful Ideas, Doubleday & Co., Inc., Garden City, New York, 1958.

(20) Collier, James R., Effective Long Range Business Planning, Prentice-Hall, Englewood Cliffs, New Jersey, 1968.

(21) Dahl, Robert A., Modern Political Analysis, Prentice-Hall, Englewood Cliffs, New Jersey, 1963.

(22) Dalkey, N. C., "The Delphi Method: An Experimental Study of Group Opinion," Report RM-5888, The RAND Corporation, Santa Monica, California, June 1969.

(23) Darracott, H. T., et al., "Report on Technological Forecasting," Joint AMC/NMC/AFSC Commanders Report Prepared by the Inter-Service Technological Forecasting Methodology Study Group, Department of Defense, Washington, D.C., June 30, 1967.

(24) Davidoff, Paul, and Reiner, Thomas A., "A Choice Theory of Planning," Journal of the American Institute of Planners, 28,2, May 1962.

(25) Davis, W. B., "Water Resources Management--Problems and Perspectives," Proceedings of the 14th Annual Conference on Water for Texas, Water Resources Institute, Texas A&M University, October 1969.

(26) Dyckman, J. W., "Planning and Decision Theory," Journal of the American Institute of Planners, November 1961.

(27) Ehlrich, Howard J., and D'Antonio, William V., Power and Democracy in America, University of Notre Dame Press, South Bend, Indiana, 1961.

(28) Enzer, Selwyn, "A Case Study Using Forecasting as a Decision Making Aid," Working Paper WP-2, Institute For the Future, Middletown, Connecticut, December 1969.

(29) Erskine, Thomas Clark, "Subjective Decision-Making for Water Resource Development," Unpublished Master of Engineering study, Texas A&M University, December 1971.

(30) Ewing, David W., The Practice of Planning, Harper & Row, New York, 1968.

(31) Federal Water Pollution Control Administration (now the Federal Water Quality Administration), "Water Quality Criteria," Washington, D.C., April 1968.

(32) Fischer, Manfred, "Toward a Mathematical Theory of Relevance Trees," Technological Forecasting, 1, 4, 1970.

(33) Fisher, Sethard, "Community Power Studies," Social Research, Vol. 29, Winter 1962.

(34) Freese, Nichols and Endress, Consulting Engineers, Report on Reclamation and Re-Use of Municipal Wastewater, 811 Lamar Street, Fort Worth, Texas, March 1971.

(35) Friedman, John, "Regional Planning as a Field of Study," in John Friedman and William Alonso (eds.) Regional Development and Planning: A Reader, M.I.T. Press, Cambridge, Massachusetts, 1964.

(36) Garner, Joseph K., and Shih, C. S., "Identification of Management and Planning Problems of Urban Water Resources in The Metropolitan Area of Greater San Antonio," Technical Report No. 39, Water Resources Institute, Texas A&M University, September 1971.

(37) Garza, Sergio, "Groundwater Resources of the San Antonio Area, Texas: A Progress Report on Studies, 1960-64," Report 34, Texas Water Development Board, Austin, Texas, November 1966.

(38) Gidez, Robert M., "Objectives in Water Resource Development," Proceedings of the 15th Annual Conference on Water for Texas, Water Resources Institute, Texas A&M University, November 23-24, 1970.

(39) Goodman, William I. (ed.), Principles and Practice of Urban Planning, International City Managers' Association (ICMA), 1140 Connecticut Ave., N.W., Washington, D.C., 1968.

(40) Gordon, T. J., and Helmer, Olaf, "Report on a Long-Range Forecasting Study," Report P-2982, The RAND Corporation, Santa Monica, California, September 1964.

(41) Granger, Charles H., "The Hierarchy of Objectives," Harvard Business Review, 42, 3, May-June, 1964.

(42) Hall, Arthur D., A Methodology for Systems Engineering, D. Van Nostrand Company, Inc., Princeton, New Jersey, 1962.

(43) Hall, Warren A., and Dracup, J., Water Resources Systems Engineering, McGraw-Hill Book Company, New York, 1970.

(44) Hansen, William B., "Metropolitan Planning and the New Comprehensiveness," Journal of the American Institute of Planners, 34, 5, September 1968.

(45) Helmer, Olaf, "Analysis of the Future: The Delphi Method," Report P-3558, The RAND Corporation, Santa Monica, California, March 1967.

(46) Helmer, Olaf, "Development of Long-Range Forecasting Methods for Connecticut: A Summary," Report R-5, Institute For the Future, Middletown, Connecticut, September 1969.

(47) Helmer, Olaf, "Systematic Use of Expert Opinion," Report P-3721, The RAND Corporation, Santa Monica, California, November 1967.

(48) Hill, Morris, "A Goals-Achievement Matrix for Evaluating Alternative Plans," Journal of the American Institute of Planners, May 1968.

(49) Huchingson, R. D., Unpublished lecture notes for Industrial Engineering 619 (Analysis and Prediction), Texas A&M University, 1971.

(50) Hufschmidt, Maynard M., "Field Level Planning of Water Resources Systems," Water Resources Research, 1, 2, 1965.

(51) Hufschmidt, Maynard M., "Research on Comprehensive Planning of Water Resources Systems," Natural Resources Journal, Vol. 5, October 1965.

(52) Hughes, Charles L., Goal Setting, American Management Corporation, Inc., New York, 1965.

(53) Hunter, Floyd, Community Power Structure, University of North Carolina Press, Chapel Hill, N.C., 1953.

(54) Hyman, Herbert, Survey Design and Analysis, The Free Press, Glencoe, Illinois, 1955.

(55) Jantsch, Erich, Technological Forecasting in Prospective, Organization for Economic Co-Operation and Development, Paris, 1967.

(56) Jestice, Aaron L., "Long Range Corporate Planning," A Lecture Presented as Part of a Two-Week Short Course on Operations Analysis and Research, September 18-29, 1967.

(57) Kindsvater, C. E. (ed.), Organization and Methodology for River Basin Planning, Proceedings of a Seminar Based on the U.S. Study Commission--Southeast River Basins, Water Resources Center, Georgia Institute of Technology, Atlanta, Ga., 1964.

(58) LeBreton, Preston P, and Henning, D. A., Planning Theory, Prentice-Hall, Englewood Cliffs, New Jersey, 1961.

(59) Likert, Rensis, "A Technique for the Measurement of Attitude," Archives of Psychology, No. 140, 1932.

(60) Lindblom, Charles E., "The Science of Muddling Through," Public Administration Review, 19, 2, Spring 1959.

(61) Maass, Arthur, et al., Design of Water Resource Systems, Harvard University Press, Cambridge, Massachusetts, 1962.

(62) McPherson, M. B., "Prospects for Metropolitan Water Management," Report of the ASCE Urban Water Resources Council, American Society of Civil Engineers, New York, December 1970.

(63) Meier, Wilbur L., and Beightler, C. S., "An Optimization Method for Branching Multistage Water Resource Systems," Water Resources Research, 3, 3, 1967.

(64) Miller, Ernest C., Objectives & Standards, AMA Research Study 74, American Management Association, Inc., 1966.

(65) Moreno, J. G., Top Management Long-Range Planning, Vantage Press, New York, 1963.

(66) Mustafa, Syed, "Decision Making in Community Environment--Identification of Decision Makers for the Community on Specific Issues," Unpublished Master of Engineering Study, Texas A&M University, August 1972.

(67) National Academy of Sciences, Alternatives in Water Management, Report of the Committee on Water, National Research Council, Washington, D.C., 1966.

(68) National Academy of Sciences, "A Strategic Approach to Urban Research and Development-Social and Behavioral Science Considerations," Report of the Committee on Social and Behavioral Urban Research, Division of Behavioral Sciences, National Research Council, Washington, D.C., 1969.

(69) National Academy of Sciences, "Long-Range Planning for Urban Research and Development--Technological Considerations," Report by the Committee on Urban Technology, Division of Engineering, National Research Council, Washington, D.C., 1969.

(70) National Academy of Sciences, Waste Management and Control, Publication 1400, GPO, Washington, D.C., 1966.

(71) Office of Water Resources Research, A National Urban Water Resources Research Program, OWRR, U.S. Dept. of Interior, Washington, D.C., 1971.

(72) Payne, Bruce, "Steps in Long-Range Planning," Harvard Business Review, 35, 2, March-April, 1957.

(73) Pill, Juri, "The Delphi Method: Substance, Content, a Critique and an Annotated Bibliography," Socio-Economic Planning Science, Vol. 5, 1971.

(74) Pollard, William S., Jr., and Moore, Daniel W., "The State of the Art of Planning," Journal of the Urban Planning and Development Division, ASCE, UPI, April 1969.

(75) Raiffa, Howard, Decision Analysis: Introductory Lectures on Choices Under Uncertainty, Addison-Wesley, Reading, 1968.

(76) Rawson, Jack, "Reconnaissance of the Chemical Quality of Surface Waters of the San Antonio River Basin, Texas," Report 93, Texas Water Development Board, Austin, Texas, April 1969.

(77) Rothblatt, Donald N., "Rational Planning Reexamined," Journal of the American Institute of Planners, 37, 1, January 1971

(78) Rudwick, Bernard H., Systems Analysis for Effective Planning, John Wiley & Sons, Inc., New York, 1969.

(79) Selltiz, Claire, et al., Research Methods in Social Relations, Henry Holt and Company, Inc. 1959.

(80) Shaeffer, John R., et al., Metropolitan Water Resource Management as an Emerging Specialized Technical Area: A State-of-the-Art and Literature Review, Center for Urban Studies, University of Chicago, 1969.

(81) Siegel, Sidney, Nonparametric Statistics for the Behavioral Sciences, McGraw-Hill Book Company, New York, 1956.

(82) Simon, H. A., Administrative Behavior, The MacMillan Co., New York, 1954.

(83) Summers, Gene F., Attitude Measurement, Rand McNally and Company, Chicago, 1970.

(84) Taft, M. I., and Pollack, J. L., "Systems Analysis in Urban Planning," Software Age, June 1970.

(85) Teitz, Michael B., "Cost Effectiveness: A Systems Approach to Analysis of Urban Services," Journal of the American Institute of Planners, Vol. 34, September 1968.

(86) Texas Water Development Board, "A Summary of the Preliminary Plan for Proposed Water Resources Development in the San Antonio River Basin," Austin, Texas, July 1966.

(87) Texas Water Development Board, "Systems Simulation for Management of a Total Water Resource," Report 118, Austin, Texas, May 1970.

(88) Texas Water Development Board, The Texas Water Plan (Summary), November 1968.

(89) Texas Water Quality Board, "Water Quality Requirements, Volume I, Inland Waters," Austin, Texas, June 1967.

(90) Thurston, L. L., "Attitudes Can be Measured," American Journal of Sociology, Vol. 23, January 1928.

(91) Thurston, L. L., and Chave, E. J., The Measurement of Attitudes, The University of Chicago Press, 1929.

(92) "A Study of Development and Management of Water Resources in The Area Surrounding the Edwards Aquifer," Unpublished Report, Water Resources Seminar, Lyndon B. Johnson School of Public Affairs, University of Texas, Austin, Texas, May 1971.

(93) Water Resources Council, "A Summary Analysis of Nineteen Tests of Proposed Evaluation Procedures on Selected Water and Land Resource Projects," Report to the Water Resources Council by the Special Task Force, Washington, D.C., July 1970.

(94) Water Resources Council, "Principles for Planning Water and Land Resources," Report to the Water Resources Council by the Special Task Force, Washington, D.C., July 1970.

(95) Whipple, William, et al., "Evaluation Processes in Water Resources Planning," Report of the AWRA Research Conference, American Water Resources Association, University of Wisconsin-Milwaukee, July 1970.

(96) Wilson, William Feathergail, "History of Water in the San Antonio River Valley," Alamo Area Council of Governments, San Antonio, Texas, mimeographed, September 1970.

(97) Wortham, A. W., "Long Range Planning--A Review," Unpublished Paper, Department of Industrial Engineering, Texas A&M University.

(98) Young, Robert C., "Goals and Goal Setting," Journal of the American Institute of Planners, 32, 2, March 1966.