DECISION MAKING IN WATER RESOURCE ALLOCATION

by

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Preface and Acknowledgments

This study is concerned with the decision process whereby water resources are allocated. The study team, composed of investigators trained in the social sciences, engineering, business and legal professions, was convinced that any in-depth investigation would require substantial contact, interviews, discussion, and involvement with a specific project so that every important aspect of the decision process could be explored. The Lower Amazon and Flat Creek Watershed Project (referred to in this report as the Junction City Project) was selected for study and offered the team all the complications and challenges it expected. Numerous individuals, organizations, and government agencies contributed their time and effort, and it is impossible to acknowledge them all. From the initial meetings with farmers who were "tired of being flooded out" through the numerous city, county, state of Oregon, and federal government officials in Washington, D.C., the assistance and cooperation on the project has been exceptional.

In particular, we are indebted to Mr. C. Bart Flanagan for recounting for us on tape some of the history of flooding in the area. Mr. Flanagan is an older farmer who was instrumental in initiating the project. Similarly, the clerks at the Lane County Courthouse deserve special thanks for finding and allowing our researchers to dig through endless stacks of property records covering the 42,000-acre water district. The eight water district, two city (Eugene and Junction City) and county (Lane and Benton) administrators involved all deserve our thanks also. At the federal level, we must certainly single out Mr. William H. Coffield and Donald Stettler of the U.S. Soil Conservation Service office in Portland, Oregon, for providing us with the Watershed Work Plan details and benefit/cost data on the project. Their patience and willingness to answer our questions on the numerous visits made by our researchers is greatly appreciated.

Our special thanks go to our multitalented research assistants (Mike Gadd, Won Gym, Ann Haberlach, Hassein Hassoun, Mike Hildenbrand, Walley Karstad, Mary Lemhouse, Chuck Saunders). Their perseverance in gathering data, alertness in interviewing, and insights in analysis contributed immensely to the study. Two political scientists, Clifford Kaufman and Peter Shockett, contributed appreciated ideas on political analysis. Glenda Petersen also deserves special thanks for the difficult tasks of editing and typing.

Finally, the project could never have been started had it not been for the financial assistance of the Office of Water Resources Research of the United States Department of the Interior. Bill Buckley, Executive Secretary of the Oregon State University Water Resources Research Institute, and his staff provided much appreciated assistance and cooperation throughout the course of the

study. Along with the federal support, we must acknowledge similar indebtedness to the state of Oregon which, through Oregon State University, provided matching funds to facilitate the project.

C. B.
J. G. M.
J. R. P.

Corvallis, Oregon

October 1972

Decision-Making in Water Resource Allocation

Maybe it sounded like a dream at first, but when we really got it in motion . . .

C. Bart Flanagan
Personal Interview, July 10, 1969

1 Introduction

In recent years many social-cultural as well as economic factors have exerted a strong influence on water resource development; however, the significance of social and political inputs to water resource decisions has been difficult to evaluate. A prime objective of this study was to attempt to delineate, classify, and assess the importance and relationship of these noneconomic as well as economic inputs to water resource decisions.

The major source of data for the study has been a $3.6 million improvement project funded largely by the Department of Agriculture under Public Law 566 (PL 566). The project, located north of the city of Eugene, Oregon, surrounds the small town of Junction City (see Figures 1-1 and 1-2). It was designed to provide flood protection and irrigation benefits and was in progress on July 1, 1969, at the time the study was begun. The original plans were to have construction completed by June 30, 1972 (the end of the study period), but delays in federal funding and land acquisition problems caused the project to slip behind schedule. Thus only about 50 percent of the construction was completed by spring 1972. Nevertheless, the project constituted an excellent vehicle for investigating water resource decisions; it involved the mutual interests of local citizens as well as state and federal agencies in the control and use of water. The investigation necessarily involved determining the source of demand for water resource development, delineating the complete decision-making network, and assessing the total decision process from a social-cultural as well as an economic perspective.

Project Objectives

More specifically and very briefly, the objectives of the project were to: (1) identify and classify the sources of demand for water resource development; (2) analyze the information process that transforms a demand into a recognized political/economic concern; (3) delineate the decision-making network within the legal framework of water resources development administration; (4) attempt to determine the decision-maker's perception of relative values and legal constraints; (5) evaluate the extent to which various network decisions influence the final decisions; (6) examine the impact of decision-making on public and private demands; (7) evaluate the legal safeguards protecting rights of persons traditionally "owning" resources; and (8) study the equity of the decision process with

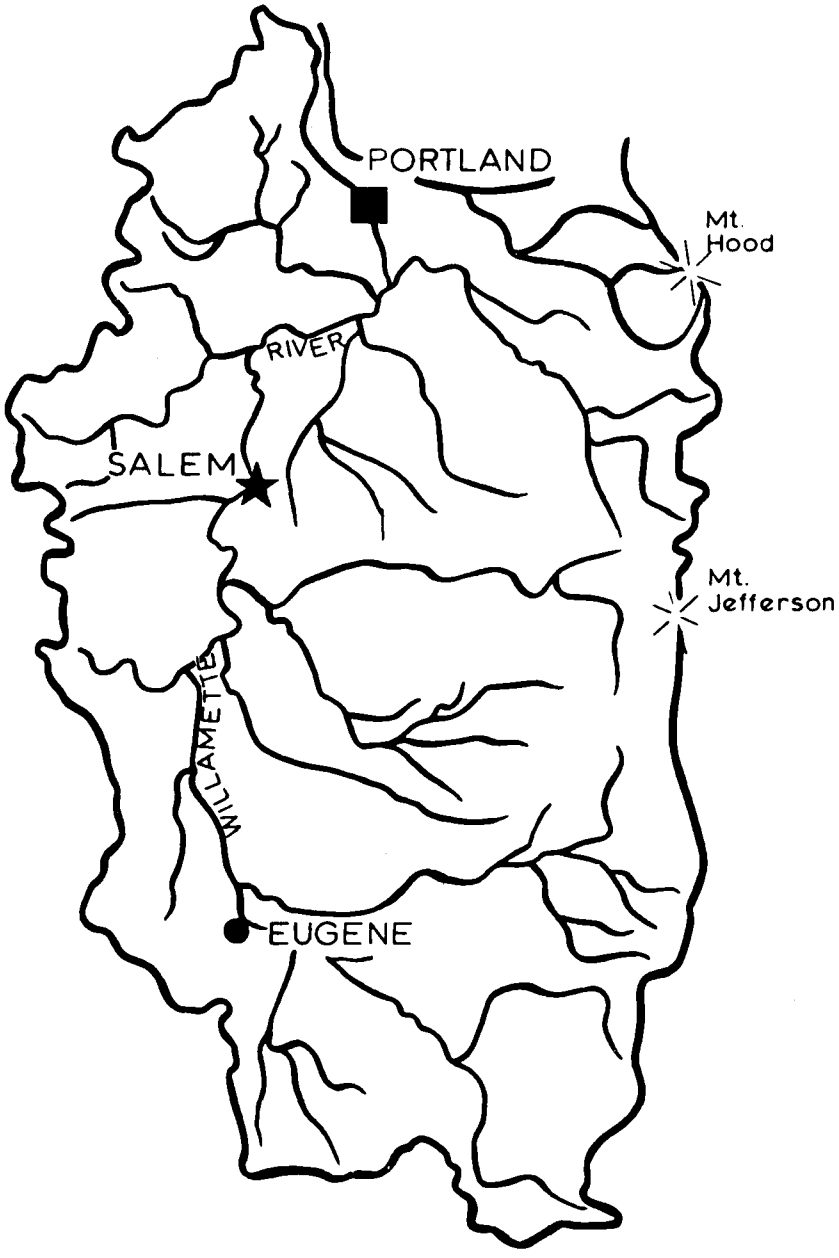


Figure 1-1. Willamette River Basin, Oregon.

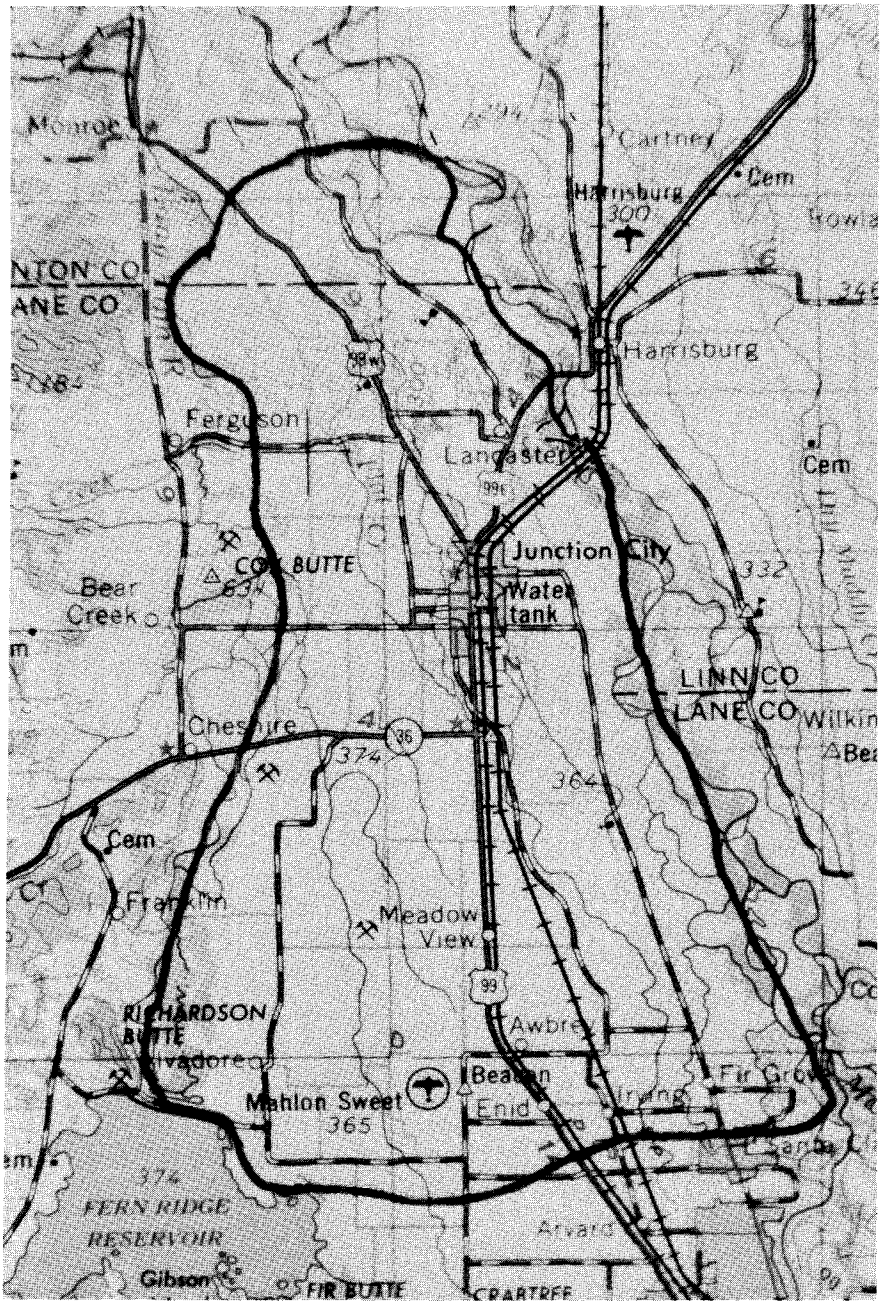


Figure 1-2. Map of Junction City Area.

respect to rights of the public vs. special interest groups. In addition, the feasibility of developing a model of the decision process was to be investigated.

Project objectives were substantially accomplished as planned. The body of this report discusses each of the specific areas mentioned above. Progress was, of course, greater in some areas than in others. Thus, for example, the sociological profile of the water district residents became well defined verbally, but difficulty was experienced, as expected, in incorporating social and political characteristics into a quantitative model. On the other hand, a linear programming model was developed to optimally allocate limited resources based upon selected social as well as economic benefits. Because of the delay in completion of the project, the assessment of the people's satisfaction within the construction area could not be fully validated. However, the January 1972 flood provided a reasonably good test of satisfaction to residents in several regions of the project, and followup interviews between January and June 1972 have contributed substantially to measurement of this variable.

Sources of Data

Standard techniques of data collection and analysis were employed throughout the study. Major sources of data were (1) persons living within or associated with administration of the Junction City Water Control District (JCWCD) and (2) various local, state, and federal government agency personnel.

Interviews with JCWCD Residents and Administrators

The primary goal of initial data collection activities was to determine the persons who were directly responsible for initiating the watershed project and to ascertain the attitudes and reactions of farmers and residents in the district. Figure 1-3 is a land use map of the Lower Amazon and Flat Creek Watershed study area. The watershed contains approximately 600 farms. About two-thirds of the land is devoted to agriculture, and the other third is in urban and industrial development, roads, railroads, etc.

Factual data on the project were obtained from officials of the Junction City Water Control District and key federal agency personnel. Attitudinal data from district residents was obtained by extensive personal interviews based upon a statistically selected sample. The sample questionnaire was designed, pretested, and modified before the in-depth field interviewing was done. A sample questionnaire is presented in Appendix A.

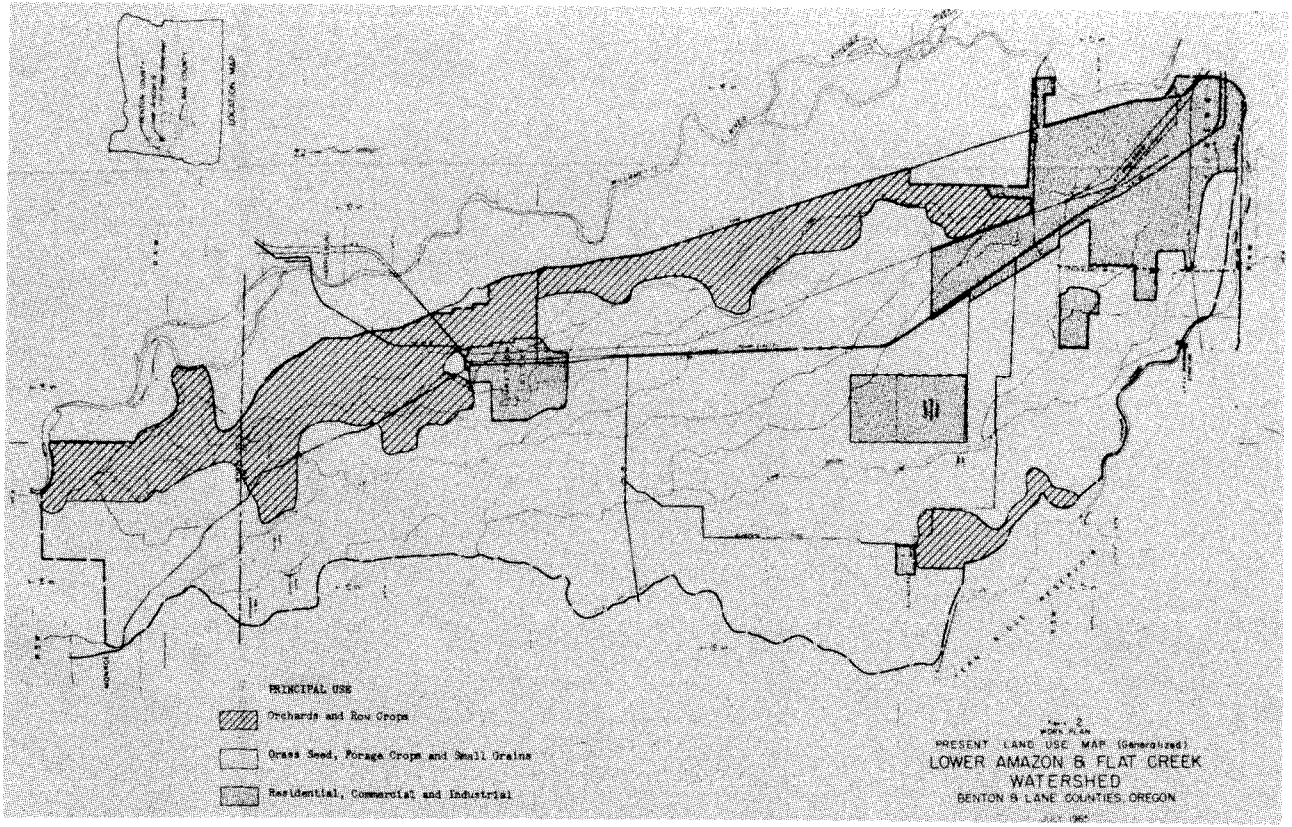


Figure 1-3. Lower Amazon and Flat Creek Watershed Soil Distribution.

Local, State, and Federal Government Agencies

Extensive personal interviews were carried on with those individuals and organizations directly (and, in some cases, indirectly) involved in promoting, planning and developing, and authorizing the project. These interviews ranged from the local project engineers and management personnel to congressional assistants and administrative personnel within the Department of Agriculture in Washington, D.C.

There are three distinct levels of government involved in the Junction City development, and attempts were made to develop information on the degree of involvement of each level. Local government units which were a party to the development consisted of the North Lane Soil and Water Conservation District, the Benton Soil and Water Conservation District, Mid-Lane Soil and Water Conservation District, Upper Willamette Soil and Water Conservation District, Junction City Water Control District, Amazon Water Control District, River Road Water District, Santa Clara Water District, the City of Eugene, Junction City, Lane County, and Benton County. Each of the foregoing organizations held some degree of authority regarding the way in which the drainage project was to be developed, even though in some cases it may merely have been approval of the work plan. The units of local government in most direct control of the development were, of course, the two city governments of Eugene and Junction City, which benefited from the reduction of surface waters invading their boundaries during periods of heavy rainfall; Lane County, which was responsible for road and bridge modification and was the general parent of the Water Control District; and the Junction City Water Control District, which was organized as the general developer and manager of the channelization and irrigation project.

State government as an entity was not directly involved in this particular project (although PL 566 provides the possibility of direct state development) except that the project was passed through and approved by the State Engineer's Office. This formality is done to comply with federal law and state law, for the office of the State Engineer is given authority to review and control any water development (ground or surface) within the state of Oregon.

The federal government is an active participant in this project both in the initial planning stage and the final funding and construction. The Department of Agriculture, acting through its Soil Conservation Service, is the primary developer of PL 566 projects, and as such is the agency which, in this instance, developed the initial engineering and work plans for the drainage project. It is also the agency through which the funds, after being appropriated by Congress, are administered and through which engineering assistance is provided during construction. The Soil Conservation Service, like most federal agencies, is multilayered, and the progress of the decision through this ascending level of govern-

ment and through the Department of Management and Budget and into the Congress was traced to establish the points of input into the decision process as well as the changes that occur in the nature of the decision.

2 Relevant Characteristics of the Study Area

Whereas any region and its inhabitants may be classified and studied in a multitude of ways, the characteristics of concern in this case study related specifically to those factors which in some way influenced the decision-making process. The decision influences may be grouped into the two categories of (1) characteristics of the watershed area itself and (2) characteristics of the residents of the area. In these categories, various ecological, technological, economic, cultural, and political factors exert an influence. Some of the more important influences are discussed below.

Physical Characteristics of the Watershed

The Junction City Water Control District is located in the Lower Amazon and Flat Creek Watershed in west central Oregon on the floor of the Willamette Valley. The watershed comprises an area of 94.1 square miles (60,230 acres), 5,230 acres in southern Benton County and 55,000 acres in north central Lane County. The area is 64 percent agricultural land and 36 percent urban, commercial, and industrial lands. The watershed head is in the northwest section of the City of Eugene. Junction City lies in the north central part and is the only other incorporated city within the watershed. The watershed is topographically a low, relatively flat plain which lies between the Willamette River on the east and the Long Tom River on the west and extends from Eugene to the north about 18 miles. Numerous drainage depressions and swampy areas are scattered throughout the region (see Figure 1-2).

The Lower Amazon Creek system begins at a diversion structure on the improved Amazon Creek channel northwest of the Eugene city limits. It drains approximately 41.8 square miles in a northwesterly flow and outlets into the Long Tom River a few miles west of Junction City. Flat Creek also flows northwesterly, beginning in the River Road area at the north edge of Eugene. An area of about 31.1 square miles is drained by the Flat Creek channel system, including Junction City proper. Flat Creek outlets into the Willamette River by way of Ingram Slough in Benton County. Hulbert Lake Creek drains an area of about 4.5 square miles and is the site of project clearing and snagging efforts. Its headwaters are in the agricultural area adjacent to the outlet of Lower Amazon Creek west of Junction City. The channel involved begins at the outlet to Hulbert Lake and flows northeast into the Willamette River by way of Ingram Slough.

The intermittent surface streamflow of the Amazon Creek and Flat Creek systems is a direct response to precipitation. The watershed's annual runoff averages about 20 inches, which is slightly over 1,000 acre feet per square mile. The distribution of this runoff is uneven throughout the year, with less than 1 percent occurring during the summer months. The ground water supply within the watershed varies greatly, depending upon which of the six distinct geologic formations is penetrated. Numerous wells located throughout the area have tapped all six formations.

The development of soils in the watershed area has been influenced by moderately high winter rainfall and dry summers without extreme summer or winter temperatures. Normal annual precipitation is about 40 inches, with 80 percent of this occurring during the months of October through March. The soils are seldom frozen even to a slight depth. The acid soils of the watershed are classed into four predominant series, and management of crops is adapted to these groups (see Figure 1-3). The humid climate provides an environment for good vegetative growth. The majority of the watershed acreage is used for production of grass seed, forage crops, and small grains. In these areas the cover is adequate to protect the soil surface from erosion during the winter runoff season. Watershed acreage used for producing orchards and row crops is located primarily in the southeast area of the Water Control District along River Road from the northern edge of Eugene north into Benton County. A smaller orchard and row crop area is located near Alvadore, a small community in the southwest portion of the District, a few miles northeast of Fern Ridge Reservoir.

Wildlife and sports fishery resources of the watershed are managed by the Oregon State Game Commission, while habitat and hunting access are controlled by individual landowners. The watershed supports considerable hunting effort for upland game, and contains some of the finest upland game habitat in Benton and Lane Counties. Migratory waterfowl are abundant during migration periods, and some ducks nest in the watershed area. The intermittent characteristic of the streams has restricted resident cold-water game fish so the watershed fishery consists primarily of warm-water fish.

The flood plain area, with the exception of Junction City, is primarily agricultural; about 15 percent of these agricultural lands (some 6,000 acres) are presently irrigated from ground water sources. Feasibility studies have shown that most cropland in the district could be economically irrigated if floods were controlled. The watershed contains approximately 600 farms, average size about 65 acres, with a range from less than 10 to over 500 acres. The majority of farms are less than 40 acres, and most smaller farms are operated on a part-time basis. Nearly all land in the watershed is privately owned, with the exception of public buildings, roads, and some local government operations. The major crops grown are wheat, oats, barley, rye grass seed, and pasture. Beans, corn, other vegetables, strawberries, and orchard crops are grown on presently irrigated lands. As irrigation has been developed in the District, vegetable, fruit, and forage crops have

increased, while grain acreages have decreased. The trend in land use is for a change from grains and grass seed production to more intensive crops.

Approximately 36 percent of the watershed land is in urban and industrial developments and in roads, railroads and airports. The area adjacent to Eugene is rapidly changing from being of agricultural use, primarily orchard crops, to urban and industrial use. Much of the land is being subdivided and prepared for house construction. The town of Junction City, near the center of the watershed, is primarily concerned with servicing the agricultural needs of the local area and is gradually increasing as a "bedroom town" for families of commuting university students and persons with jobs in the Eugene area.

Flooding in the watershed is directly related to the seasonal precipitation pattern. The floodwaters remain standing in many areas for several weeks during the winter, though high stream flows ordinarily last two or three days. Several conditions combine to cause frequent flooding in the watershed: low permeability of soils in the Amazon Creek drainage area; limited storage capacity due to clay pans; shallow and poorly defined natural channels, often congested by heavy vegetative growth and debris; inadequate size of bridges and culverts; drainage ways closed or obstructed by filling and grading for subdivisions. The depth and duration of floodwaters, rather than velocity of flows, determine the extent of damage to building foundations, overloading of storm drains, malfunction of septic tanks and drainage fields, and pollution of domestic wells. The major hazard of most floods is water pollution which creates an environment for disease-producing organisms. Loss of crops by prolonged inundation is the major agricultural damage. Debris deposition, spreading of weeds and undesirable plants, sheet erosion, excessive leaching, and loss of livestock are additional damages that increase operating costs. Roads are damaged; traffic is disrupted; bridges require repairs or complete replacement. Erosion and sediment damage in the watershed is generally minor, as overland flood flows do not have sufficient sustained velocities to cause serious erosion or transport significant sediment loads.

Seasonal flow characteristics of Amazon Creek, Flat Creek, and Hulbert Lake Creek include large winter runoff volumes, rapidly decreasing during the spring. Lack of a dependable water supply during the growing season has made irrigation in the area limited. During summer months, the lessened stream flow is utilized by existing water rights. Water must be imported from outside the District or from wells developed along the eastern edge of the watershed for any expansion of irrigation. Most of the present irrigation water is supplied from wells. Ryegrass seed, small grains, and other relatively low-income crops with low-water requirements are produced in the larger portion of the watershed. The soils in the Amazon Creek area are fertile, but because of inadequate surface water removal and long saturation periods, their development for more diversified agricultural use has been limited. The Flat Creek area soils are generally more productive, with potential for more intensive and diversified crop produc-

tion, particularly for row crops. Frequent flooding and an inadequate water supply are the major limitations in this area. Many of the presently irrigated crops are being displaced by the encroachment of urban and industrial uses. The local food-processing industry is dependent upon the crops, such as green beans, sweet corn, other vegetables, and fruits produced in these areas. To maintain stable employment and an efficient food-processing industry, other areas must be converted to a more intensively irrigated farming system and the production of crops transferred to these areas. The major source of income in the watershed lies in the production and processing of agricultural products.

Sociocultural Characteristics of the Residents

In historical terms, the area encompassed by the Junction City Water Control District exemplifies the productivity and ensuing growth and development of the Willamette Valley. Community establishment in this area occurred in response to transportation developments, first those connected with river transportation, then others from the impetus of the railroad. In the early 1900s the complexion of the Junction City area began a change from that of a wide open railroad community to one with a quiet, rural atmosphere. This transformation is credited to the influx of Danish settlers who established themselves on some of the best farm lands east of Junction City, which their descendants still occupy. The balance of the area is occupied by a mixed Euro-American descent population with no noticeable ethnic or racial clusters.

Traditional continuity of the Scandinavian heritage is expressed through Junction City's quaint and somewhat profitable annual celebration called the Scandinavian Festival, a loosely planned community program involving a wide variety of groups and organizations.

Kinship ties within the Junction City region are most noticeable in the rural areas, where a family name is predominant in a particular place, and farm land ownership is passed through descent lines. A number of families boast of twenty to fifty relatives living in the district.

Agriculture has long been important to the area, although there is an ever-increasing wood products industry developing in more recent years. Land use adjacent to the city of Eugene is rapidly changing from agricultural (primarily orchard crops) to urban expansion and industrial, although the town of Junction City is still primarily concerned with servicing local agricultural needs.

Employers in the district rely primarily on local labor. Various aspects of agricultural production, harvesting, etc., are performed by personnel from the surrounding area, with dependence on local high school labor during the summer months. Some nonlocal migrant labor is employed during fruit and vegetable

harvest seasons. Sawmills and plywood plants located in and around the district rely to a large extent on the area's local labor.

Land Ownership, Occupation, and Income Patterns

Land in the Junction City Water Control District is classified for real property assessment as residential, agricultural, commercial, and industrial. Although as noted earlier, the Soil Conservation Service work plan indicates that the Junction City Water Control District is 64 percent agricultural land and 36 percent urban, commercial, and industrial lands, survey data indicate that households are not distributed in that ratio. Forty-three percent of the households are located on agricultural lands and 55 percent, on residentially classified property.

An examination of occupations indicates only 17 percent of the inhabitants of the district are full-time farmers. If we add part-time farmers, farm laborers, and those employed in farm-related occupations, then 22 percent derive some employment from agriculture. Seventy-eight percent derive no employment from any occupation directly related to agriculture. The largest occupational category for nonagricultural employment is the wood products industry, specifically plywood and sawmills.

Income distribution, however, indicates more inhabitants–37 percent–deriving some income from land. The difference between this percentage and the percentage of occupations related to agriculture is due predominantly to land rental, either for domicile or cultivation.

Household income figures cannot accurately be stated due to the relatively high rate (27 percent) of "no response" to questions of income. When people were asked for personal income, informants frequently mentioned the "nosiness" of the U.S. federal decennial census which occurred just prior to this survey. Incomplete data indicate that at least 9 percent of the households have an annual income of less than $3,000; 15 percent, between $3,000 and $6,999; 14 percent, between $7,000 and $9,999; 24 percent, between $10,000 and $15,000; and 10 percent, over $15,000. One-half of the households with an income over $15,000 obtain it from farming.

Age, Sex, Education Profile

The household survey of the Junction City Water Control District involved interviews with individuals at all adult ages and should, therefore, control for any age bias in the sample. Figure 2-1 indicates the age distribution of interviewees.

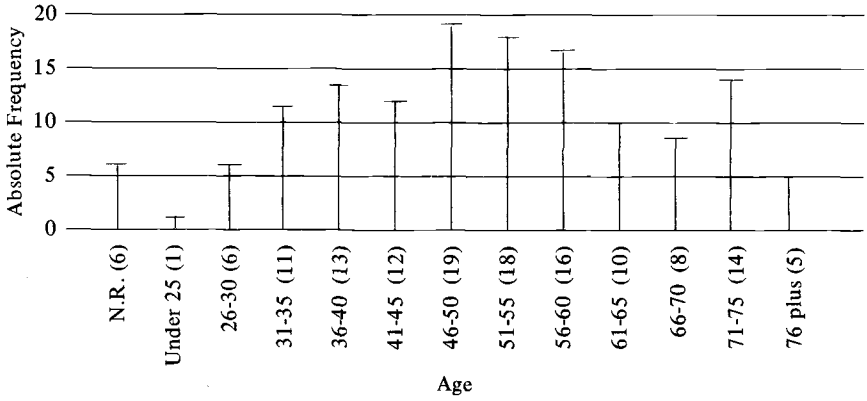


Figure 2-1. Age Distribution Profile.

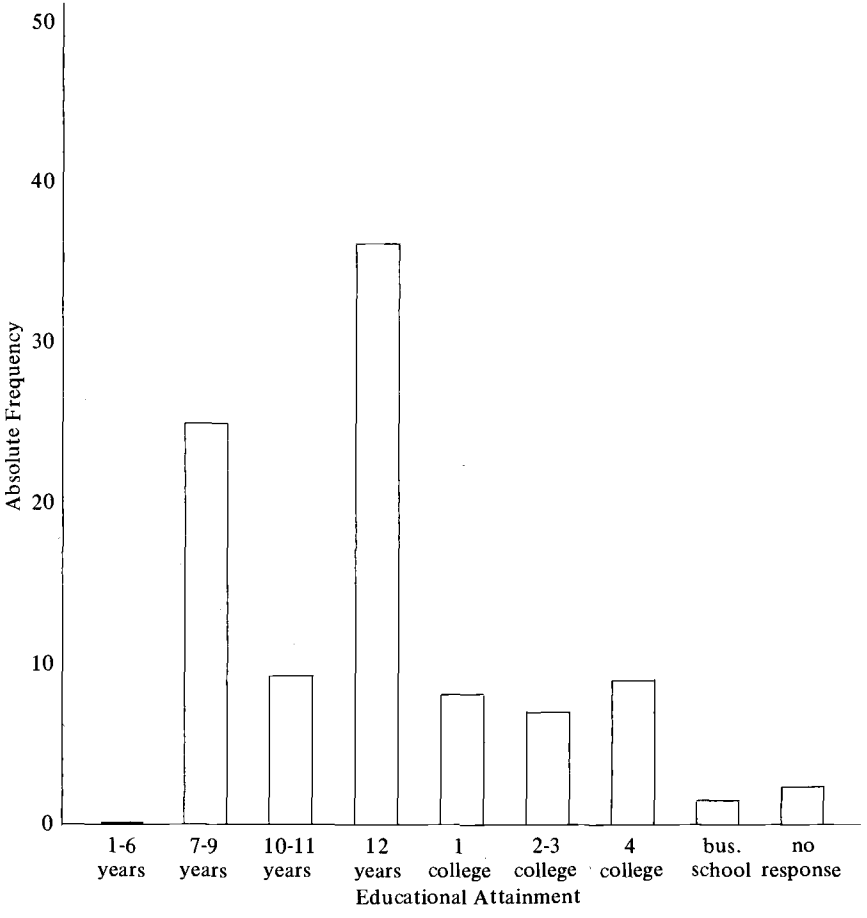


Figure 2-2. Educational Attainment.

This daytime-oriented sample (only a few evening interviews were performed) reveals a slight bias in sex distribution of respondents: sixty male (43.17 percent) and seventy-nine female (56.83 percent). The accessibility of working-age respondents during the hours of approximately 9 A.M. to 12 noon, and 1 P.M. to 4:30 P.M., was greater in these predominantly rural, suburban areas than might be expected in, for example, a predominately urban setting. Farmers, mill workers on swing or graveyard shifts, and retired men lend to the relatively close male-female respondent ratio.

Eighty-five percent of the interviewees were married; 9 percent, widowed; 5 percent, single; and 1 percent separated from spouse.

Figure 2-2 illustrates the educational attainment of the informants. The educational profile of spouses (not illustrated) is nearly identical to that of respondents. Only 9 percent of the sample indicated any special training in agriculture.

Social Organization and Communication

The widespread acceptance of any innovation is dependent upon communication, and information flows through networks of social organization. This section seeks to identify (1) significant features of social organization in the Junction City Water Control District, (2) the sources of information about the project utilized by the public, and (3) the extent of individual participation in the diffusion of information.

Households. Beginning with the household level of social organization, residents are found to have the marital status shown in Table 2-1.

These people exhibit stability of residence when asked, "How long have you resided at this address?" (see Table 2-2).

When asked for previous address, informants replied as shown in Table 2-3, which indicates household stability in membership and location.

The majority of residents have kindred living in the local area, as Table 2-4 indicates.

The area, then, is *not* characterized by rapid turnover of property and a mobile population that has no reference to kindred. Despite the above information, however, few residents indicate kindred as a source of information about the Junction City Water Control District (JCWCD) project.

Voluntary Associations. Voluntary associations seem not to have played a significant role in communication during project development. Whether through friends, civic organizations, or clubs, few residents received information about the Junction City Water Control District project from these sources. Only 19 percent of the residents indicated that they first heard of the project from a

	Percentage
Single	5
Married	85
Separated	1
Widowed	9
	100

Table 2-1. Marital Status.

Years	Percentage
1-3	7
3-5	11
5-10	28
11-15	18
16-20	17
21-25	4
26-30	2
31-40	7
41-50	4
Over 50	2
	100

Table 2-2. Length of Residence.

Previous Address	Percentage
Junction City-Eugene Area	71
Elsewhere in Oregon	11
Other western states	7
Eastern U.S.A.	4
Other	7
	100

Table 2-3. Location of Previous Residence.

	Percentage
None	31
1-3	19
4-5	15
6-10	11
11-15	6
Over 15	15
No response	3
	100

Table 2-4. Number of Relatives in Local Area.

friend or organization. When asked if the JCWCD project had been discussed at any group, club, or organization to which they belong, 86 percent replied negatively. Only 9 percent attended any meeting of any group before the April 1967 bond vote at which someone spoke about the project. Grange meetings account for most of this percentage, although the grange organization was not involved in promoting the project.

One voluntary association did develop as a result of the JCWCD project. The association known as the Flat Creek Committee has organized in opposition to a change in the construction work plan. Composed of about a dozen landowners, it assessed each member and hired an attorney in an attempt to use litigation to achieve its goal. Resistance to the construction change has affected construction scheduling. This conflict issue is still undecided, three years after initial project construction began.

Administrative Organization. The JCWCD board of directors is the most important governmental organization affecting the project at the local level. The board, composed of nine members elected annually by the residents of the district, is legally responsible for governing the water control district. It is incumbent upon the members of the board to familiarize themselves with the manifold legal, technical, and fiscal aspects of the district so that they may convey information to other residents. Most members of the board recognize their role as a formal group in the communication process, and they work closely with the attorney for the district and various governmental employees and engineers.

Communication and information dissemination problems began with the initial attempt to form an organized, effective group. Board members indicated immediate confrontation with a seemingly incomprehensible and expensive operation, that of conducting business within the legal framework. An attorney was hired to communicate legal procedure and advice in "understandable terms."

The interviews with members of the board generally indicate that the news media, primarily newspapers, are the bases for getting information about the project, elections, etc., to district residents. The members concede that for the most part their efforts at information dissemination are not adequate. They have attempted to increase the effectiveness of the communication process through personal contact, particularly with friends, neighbors, and relatives. One board member admitted that such individual efforts are quite selective. It was further noted that assuming a position on the board of directors implies concern and support for the district and the project. Thus, discussions concentrated on eliciting favorable explanations and further support. For example, the original members of the board were required to obtain signatures on petitions that would indicate the necessary local support to warrant district formation and project feasibility. The residents approached at that time were either in favor of the

proposed project or were expected to be favorably influenced by the board member. The process of gathering signatures involved initial communication endeavors between the board and residents of the district.

Members of the board have received numerous complaints, both personally and as a group during meetings and hearings, that they have not adequately informed the residents. In many cases, the person issuing the complaint became involved because he realized that ditch construction would occur on his land, or he questioned a board decision. These persons assume that it is the board's responsibility to approach them with the information, not vice versa. Members of the board realize that better public relations may have averted some problems. Yet, the information and aid is available, for those who seek it, from the board members, Soil Conservation Service employees, or local Rural Conservation and Development (R.C.&D.) group. Thc actual numbers or patterns of communication attempts by the board apparently make little difference in their effectiveness. That is to say, whatever information is made available, some persons will not choose to be informed unless they feel threatened or unnecessarily involved (through acquisition or rights-of-way or by paying district taxes); and other residents, by choice, will never be informed or "bothered."

Sources of Information

The planning process began with an advance of $25,000 by the Lane County Commissioners to pay for engineering and survey work because the State Legislature initially refused to give sufficient funds to the State Engineer's Office. During this early period, articles in the *Eugene Register-Guard* (the area's largest daily paper) discussed: project feasibility and state and federal SCS priorities (January 1962); a meeting announcement that the watershed project was given top priority as the next SCS project in Oregon (October 1962); Lane County's interest and participation (May 1963); and successive events, elections, and progress reports of the District. The *Junction City Times* (a weekly paper serving much of the surrounding area) also reported aspects of the project and processes of development, though not quite as extensively as the *Eugene Register-Guard*. Information and explanations about the project have thus been made available to district residents through these local news media. Further, all notifications of hearings and meetings, as well as elections, were publicized in these newspapers in accordance with the legal framework. In addition, annual reports of local soil and water districts included articles containing information and progress reports about the Junction City Water Control District.

Despite the formal, legal attempts to disseminate information to district residents, survey data indicate that the attempts weren't always effective and that the people remained, to a large extent, uninformed or only partially informed

about the district and project. The results of the attitudes expressed by residents in response to the statement, "The project leaders did a good job of explaining the purpose of the project before the vote," are given in Table 2-5.

When asked, "From whom or how did you first hear of the JCWCD project?" district residents made the responses shown in Table 2-6.

	Percentage
Agree	38
Disagree	31
No response	31
	100

Table 2-5. Attitude Toward Project Leaders.

	Percentage
Newspapers	36
Radio and TV	1
Friends and neighbors	12
Spouses and relatives	4
Organizations and agencies	9
Tax notice	7
Interviewer	10
On the job	1
Mail and/or phone canvass to vote	3
Other (seeing construction, seeing surveyors at a store, etc.)	9
NA (don't know)	8
	100

Table 2-6. First Source of Information About the JCWCD Project.

It is interesting to compare the above question with Everett M. Rogers' recent work on communication and development. Rogers [1969] finds that

> . . . it is useful to categorize communication channels as either interpersonal or mass media in nature and as originating from either *localite* or *cosmopolite* sources [p. 125].

These categories are defined as follows:

> Word-of-mouth communication from family members, neighbors and friends, storeowners and salespeople, schoolteachers, extension agents, and others is classified as *interpersonal*. All types of print and electronic channels are considered *mass media* [Ibid.].

Channels may also be categorized as either localite or cosmopolite, depending on the point of origin. *Localite* channels originate within the social system of the

receiver, and *cosmopolite* channels have their origins outside his immediate social system. For example, word-of-mouth channels may be either cosmopolite or localite, depending on whether or not the source is inside or outside the social system of the receiver. A neighbor is a localite channel, whereas an extension agent who has come from elsewhere is a cosmopolite channel; yet both represent interpersonal communication. Mass media channels are almost always cosmopolite [Ibid., p. 127].

Application of the above concepts to the JCWCD data and comparison to Rogers' work on the communication channels in the innovation-decision process for Iowa farmers and Colombian peasants during development is illustrated in Figure 2-3.

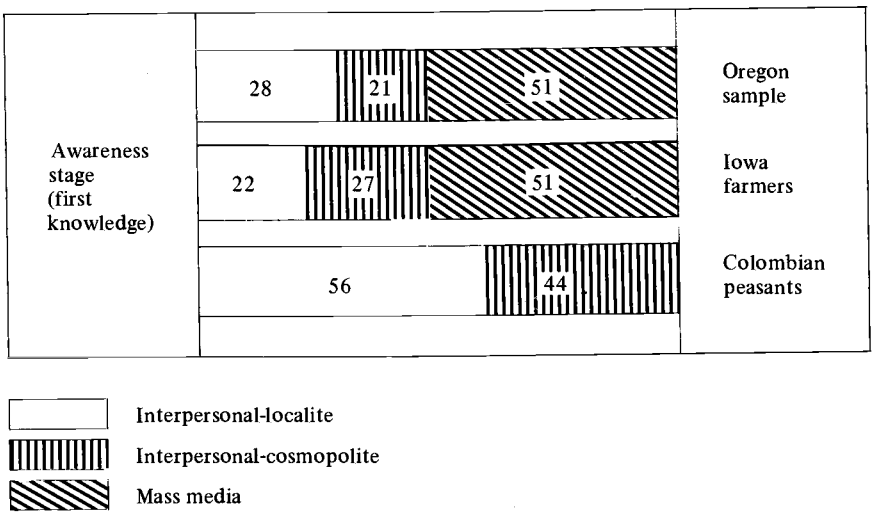


Figure 2-3. Communication Channels.
(Modified from Rogers [1969, p. 131])

The similarity in the Oregon-Iowa samples is startling and probably reflects similar impact of the industrial development in the U.S.A., in contrast to Colombia.

Individual Participation in Diffusion

Except for the innovators (discussed in chapter 6), one finds that only 3 percent of the district residents were involved in promoting discussion at any club group or organization to which they belonged. Prior to the bond vote in April 1967, 9 percent indicated that someone spoke at a meeting they attended. When asked the question, "Did you discuss the JCWCD Project with people

before the April, 1967, vote?" 62 percent replied no and 38 percent, yes. Household members and friends account for 20 percent of the 38 percent who answered yes. Neighbors account for another 8 percent, and the remaining 10 percent includes relatives, organizations, and people in work settings.

When asked, "Do you feel you may have in any way influenced the decision to proceed with this project?" 88 percent of the residents replied negatively and 12 percent, positively. Voting and talking to people were the most frequent answers to the question of how they may have influenced others.

Despite stability of residence and many householders having relatives in the area, little use appears to be made of kinship as a reference group in decision-making. Sources of information are predominantly exogenous when cosmopolite interpersonal communication is added to the mass media category. Few people are actively involved in persuading others to adopt the innovation. The voting behavior discussed in Chapter 6 further supports these conclusions. As one old timer in the district put it: "If you want to see the project done, don't advertise; just call your friends to go vote!" This advice indicates acute political insight.

Perceptions and Attitudes

Initially it should be noted that the name of the district creates misperceptions. Board members have indicated problems with the title of Junction City Water Control District. The title is a misnomer because the town of Junction City, though somewhat centrally located, is not in the district. By statute in Oregon, incorporated districts are not allowed to be part of a water district. The district, of course, covers more territory than that surrounding Junction City. Thus, numerous questions have been raised, particularly by residents with Eugene addresses, concerning the Junction City category on their tax statements; and many of these persons resent the title as well. Board members and other involved persons have expressed concern for the misunderstandings that result from such factors as the name of the district and boundaries of the district.

Despite numerous indifferent and uninformed residents, there was a sufficient number of persons interested in and supporting the district and its proposed drainage project to sign the necessary petitions and vote the district into existence. People became disillusioned because of time-consuming inspections and necessary approvals by local, state, and federal agencies. These were followed by application to the state (November 1961) and eventual state approval (December 1961); interagency and congressional committee approval (August 1963); and a long delay in the Bureau of the Budget, primarily due to the Bureau's opinion that approval of such programs and money appropriation should be part of the Presidential budget, not a congressional decision. July 1966 saw Bureau of the Budget approval. Finally in August 1966, formal authorization for con-

struction took place. Such delays, though perhaps commonplace to governmental agencies, are disturbing to many local citizens. Eventually, more and more persons lost interest in or became opposed to the project.

In addition, there has been the problem of the release of funds, even though they are appropriated. For example, when loan funds, through the Farmers Home Administration, were not available, the district could not buy rights-of-way. Even if rights-of-way were acquired, the nonavailability of construction funds, through the Department of Agriculture, delayed progress. When initial estimates were made on the necessary bonds and loans, an increased cost factor of 5 percent was added. This later proved to be inadequate because land values have risen at a greater rate, as indicated by the sale of land along some ditches.

Individual landowners more often than not attribute greater monetary value to their land holdings (that will become widened ditches and rights-of-way) than the actual appraised value. Damages resulting from ditch construction, particularly when they continue over a period of time, and loss of property use assume increasing importance when the individual realizes that *his* property is to be involved. On the other hand, it is expected that the land will be drained, production will improve, and therefore the whole area will advance financially. Many farmers whose land is cut in two have their doubts that all will be well in due time. Speculators and subdividers are principle objectors in several areas of the district. They fear the loss of any land and claim they won't be able to get sewage permits. Then there is an "ecology" point of view that insists that things should be left just as they are: "It's been this way for years, and we've gotten along just fine," as one interviewee sums it up.

Support of the Junction City Water Control District and the project has tended to be group-oriented, whereas opposition has occurred primarily on an individual basis. The board members, initiators of the project, and their families provide the most noticeable organized group of district residents who favor the project. The only discernible organized effort in opposition to the project is a group in the northern area. They support the ditch route approved in the work plan, though the district board members have decided to utilize an alternate plan that follows the natural drainage route.

Opinions of the project prior to the bond vote ran about 48 percent in favor, 7 percent opposed, and 45 percent indifferent or with no knowledge of the project. Only 6 percent of the residents have changed their attitude toward the project since it began. Five of that 6 percent became opposed to the project, and the remaining 1 percent became in favor of the project. Justifications for change to negative opinions included such reasons as inexperienced management, too much time for construction, faulty construction, or no personal benefits perceived.

When asked who they thought had initiated the project, 56 percent of the district residents either didn't know or didn't respond; 16 percent indicated farmers; 12 percent indicated government in general or a specific agency; and the

remaining 16 percent gave a variety of responses including mentioning specific individuals by name and designating voluntary associations.

When asked who they thought was paying for the project, 60 percent replied that the "taxpayer" was the benefactor; 5 percent indicated the federal government; 13 percent, a federal-local government split; 4 percent designated local government; 6 percent indicated local people. The remainder had no idea.

The following two agree-disagree statements were presented to the residents in an attempt to elicit attitudes concerning who should bear the costs of a project such as this one: "I think the cost of the project should be borne by landowners in proportion to the amount of land they own" and "I think the costs of the project should be borne by the federal government." The results are given in Table 2-7.

Landowners Should Bear Cost	Percentage
Agree	49
Disagree	33
No response	18
	100

Federal Government Should Bear Cost	Percentage
Agree	41
Disagree	40
No response	19
	100

Table 2-7. Opinion of Residents on Cost Allocation.

3 Sources of Demand for This Water Resource Development

The Junction City area—more specifically, the watershed of Amazon Creek, Flat Creek, and the Long Tom River—has historically been subject to flooding. Indian lore tells of the combined effect of the Willamette and the smaller streams combining into a lake creating slack water from the foothills of the Cascades to the base of the Coast Range. The lesser streams drain the foothills of the Coast Range and flow through what is primarily flat valley floor. The Willamette resides on the eastern half of the valley floor on what topographically is the high side of the valley. Western Oregon is notorious for the quantity of its rainfall, which, when combined with the snow melt from the mountains can, under the right circumstance, create food conditions. Although these floods are seldom disastrous, they are still an inconvenience to the residents, both farmer and urban dweller alike. Seldom does a school year pass when some days are not lost because the schools have to close—if not as a result of actual flooding in the school, then because transportation there is impossible.

This problem has been alleviated to some extent by the construction of major flood control dams and reservoirs on the upper portions of the Willamette River and by the installation of a dam and the creation of Fern Ridge Reservoir on the Long Tom River. However, the topography of the area still permitted periodic local flooding because, as is the case with most floods, the stream system was not efficient enough to carry the water away.

The feasibility of a channel system such as that presently being constructed, which was the basis for this study, awaited the completion of a number of interrelated elements. First, it needed the construction of the dam and flood control projects on the upper streams of the Willamette. Without them it would be useless to channelize the valley streams because they would then only become more efficient at carrying flood waters into the upper valley rather than away from it.

Second, there was a need for a legal entity that could undertake the construction of such a project without fear of the liability which it would create. A fact well known to every law student (and not unrecognized by most county commissions and some landowners) is that one who channels surface water away from his own land is subject to liability for damage caused by the rearrangement of the flow. Some of the earliest case law creating strict liability for tort developed this basic concept. There were few local governments and even fewer individuals who were willing to incur this type of liability. When the Southern Pacific Railroad was building its new main line down the heart of the valley

toward Eugene, some hoped that the dike created by the elevated road bed might reduce the local flooding problems, but the railroad's legal department, mindful of the problem involved, directed the engineer to place numerous "flow-through" passage ways through the road bed to permit the free passage of any ground water that might come along. It remained only for the legislatures to pass laws permitting the creation of water control districts which could then assume the liability without risk to the individual landowner.

Third, the project had to await the creation of a flood water storage facility on the valley floor itself to hold some of the excess water so that it could be dissipated slowly. Fern Ridge Reservoir was created primarily for the storage of irrigation water, but it does serve as an effective check on flood water in the Long Tom system (as well as a very useful recreation resource for the population of the city of Eugene).

With all of these factors satisfied, the channelization project became feasible. The nature of the soil in the area is such that, as noted earlier in this report, a major crop is grass seed production, which is not necessarily harmed by periodic flooding. The pressures of urban growth have begun to press the row crop farmer onto more marginal soil, and the flooding does work to his detriment. Furthermore, the urban pressure has begun to press what had been a cultivated land into alternative uses as sites for both residential and industrial development. This in turn made the flooding even less tolerable.

Local Residents and Their Organizations

As suggested in other portions of this report, the area is inhabited by a rather diverse population. Although the Water Control District adjoins a large municipality and surrounds another, it does not specifically include those incorporated areas, as indeed by law it cannot. The urban area does spill out into the district and encroaches upon the farm land. Since farming, at least in our society, seems to be a rather low priority of land use, the farm land is also usurped by industry and by numerous small nonfarming acreages, all of which tend to diversify the needs and desires of the residents. The majority of those residing in the area are no more organized than is any other comparable segment of American society. The farmers have their grange organization which seems normally active, that is, they hold meetings and exchange information but do little else. The retail businesses have their local Chambers of Commerce, the heavy industries have their trade associations, the land developers have their home builders association, the schools and their constituency utilize their PTA's; but none of these organizations was utilized to disseminate information about or to develop support for the channelization project. Indeed, interviews with the industrial managers and the developers in the area revealed almost total ignorance or at best only a passive interest in the subject. Only those whose lands were

directly affected seemed willing to take a stand on the issue, although all were affected by the revenue measures which were needed to support land acquisition and channel maintainance. The large nonagricultural employers in the area generally took no stand or did not in any way encourage their employees to vote either for or against the ballot measure. The basic organizational processes within the community seemed to be left in some state of neutrality in the decision to expend the community's resources.

The powers of government were mobilized to push the development of the project, and forces inherent in government were used; but it was rather late in the process before any organized resistance developed. Those opposed to the project did use the power of the legal process in that the courts are always available to the dissenter, but local opposition resorted to the courts only as a defensive mechanism as the power of eminent domain was employed by government. It was late in the process that a group was organized to try to change or modify the plans and to assess itself for the cost of legal council.

Local Attitudes and Lawsuits

The project, developed as a channelization, drainage, and irrigation project, obviously serves some members of the community more than others. Thus, some persons were quite willing to sacrifice land and value for what to them seemed to be a greater benefit. Land value is, however, in the eye of the beholder and involves the uses to which the land is placed. While some of the farmers were willing to donate land for right of way, not because of any sense of beneficence but because they could see increased value to their land, others were so unwilling to sell that they forced the Water Control District to condemn their land. In all cases the right of way was not purchased in fee but in two easements: one a temporary easement for construction and the second a permanent easement for right of way.

It has been said that you don't have to scratch a farmer very far before you find a subdivider. This is just as true in the agricultural areas of the Willamette Valley as it is in the citrus areas of southern California. Therefore, it was not surprising to find a diversity of opinion between those who appraised the land for the water control district and those who appraised the land for the landowners. Farm land, in the southern part of the Willamette Valley, is being sold for between $350 and $450 per acre, while land suitable for housing development is going for around $1,000 per acre. Land adjacent to a water course which, by any stretch of the advertiser's imagination, could be called a creek or lake is worth at least $1,200 per acre, undeveloped. True, the area is zoned for specific uses, but as every land developer and lawyer knows, zoning ordinances are not a bar to residential development—even those areas zoned agriculturally. Therefore, this difference of opinion in the value of land is a very real and

justified difference. The only determiner of land use, and therefore land value, is the intent of the landowner and the vagaries of the housing market.

A relatively small percentage of those landowners forced the water control district to exercise its power of eminent domain. Only thirteen suits were filed out of all of the land acquisitions needed for the construction of 72.3 miles of ditches. The nature of a condemnation suit is based upon the absolute right of the condemning agency to acquire the land for the benefit of the public. The only issue which the private landowner is permitted to litigate is the amount of money he is paid to compensate him for the taking of his land. The reasons cited by the landowners for their lack of satisfaction with the price offered for their land are varied, but the ultimate issue is still money. Some of the reasons cited in the cases filed by the water control district were the usual cases of landowners seeing their land as potential residential or industrial sites rather than agricultural land. In addition, some saw their land as more useful as a hunting preserve for migratory water fowl, or as a game habitat rather than as an area for cultivating crops. A few farmers objected to the division of their land by a wider channel which demanded either an expensive bridge or a long detour to reach all of their tillable acreage.

The procedure used by the district was to offer the landowners what they considered to be a reasonable price for the easements. This included the value of the land lost to use by the landowner, the value of the lost crops for the year of construction, and a fertilizer allowance to raise the fertility of the land adjacent to the ditch (which was used to spread the spoils from the ditch construction) back to its previous level. In some cases the ditching process actually increased the amount of arable land available to the farmer since the land on the banks was frequently covered with cottonwoods, willows, and swamp vegetation. When a landowner objected to the price offered, a suit in equity to condemn the right of way needed was filed; the parties would stipulate that a bond be filed by the district in the amount of the price difference, and the district would then be permitted to proceed with the construction pending the outcome of the suit. The attorneys for the district expressed satisfaction as to the number of suits that were filed, suggesting that a lesser percentage would indicate that their appraisers were offering too much money for the land and a greater percentage would indicate that their price offerings were too low.

One condemnation case was appealed to the Oregon State Supreme Court [*Junction City Water Control vs. Calvert*] on what was primarily an evidentury issue: first, whether the landowner should have been permitted to testify as to his "nonexpert" opinions of the value of his land and, second, whether one of the defendants' expert appraisers should have been permitted to testify as to the before and after values. Both are essentially questions of the competency of evidence admitted in the trial. Although both questions were settled in favor of the defendant landowner, this case does set out clearly at least one point central to the issue of resource development–that is, once the political decision is made

to develop the watershed to the benefit of one group, the total resources of the law are placed behind that decision at the discretion of the government agency given control. Perhaps one short statement quoted from the previously cited case helps to explain. "Both appraisers for defendant attach special value to the property for country homesites because of scenic and esthetic values of a meandering stream bordered by shade trees, which flowed through the property." These are the very elements that made the stream an inefficient conveyance of flood waters. When the land was cleared and the channel completed, the stream was no longer a tree-shaded, meandering creek, but a straight, well-engineered ditch. The trees were gone; the ditch banks were clear, sloping to a depth of perhaps fifteen feet and about forty-five feet from the top of one ditch bank to the top of the other. The land had been permanently committed to agriculture or in the long run to the type of subdivision that seems to be condemned by all but is ubiquitous to our urban sprawling society. In any event, the real estate value had very definitely been shifted downward from that of a rather high value homesite to very average farm land. True, the provisions of the Fourteenth Amendment were maintained, the property was not taken without "just . . . compensation" and "due process of law," but the nature of the land use has been permanently shifted with no guarantee that the cause of agriculture, which is the basis of PL 566, will be permanently protected.

Governmental Units

Resources and their allocations are usually subject to all levels of governmental decisions. It would appear from this study that the basic decisions relative to a specific resource are really made at low levels of government and at low levels within government. Interviews indicated that although this is recognized by most long-time civil servants, it is not admitted by their superiors and is generally denied in the official administrative charts published by agency chiefs. True, the rather monumental policy decisions—those regarding the philosophy of resource development—are generally filtered down from above, but the decisions affecting a specific water course press up from below. As shown by the decision network charts included in this report, the decisions are made at the lower levels; as the plans progress through administrative channels they become subject only to the veto of the administration. Public Law 566 is an excellent example of this process in action. It affects relatively small projects and usually involves all levels of government.

Local Government

The Junction City channelization project, the subject of this study, was administered by the Junction City Water Control District. This is a municipal body

established pursuant to Oregon law which permits the combination of the powers of all special-purpose water districts into one administrative body. Like most states, Oregon has provision in its laws for many special-purpose water districts for irrigation, drainage, diking, water distribution, sanitation, etc., all of which appropriately limit the activity of the district. The statute permitting creation of a water control district permits the combination of several of these functions into one body and provides for the power to bond long-term debts to tax for public improvement and the power of eminent domain. It is not permitted, however, to exercise any function or in fact to include within its boundaries any land within the incorporated limits of a city or municipality.

The Junction City Water Control District was created to administer the channelization project of the Amazon Flat Creek area. It includes within its boundaries approximately 94.1 square miles, but specifically excludes from its boundaries the city of Junction City which it surrounds. It is composed of all the residents within the boundaries of the district and is governed by a board of commissioners who are elected by the registered voters within the district. The method of election was not always this way; when the district was formed, only those who owned land within it were permitted to vote in the district election. An opinion of the State Attorney General in 1968 (340 Or. Ops. Atty. Gen. 283), however, forced the registrar of elections to enfranchise all registered voters residing within the district. To this district then was given the task of promoting the project locally, providing the local funds required (by borrowing the funds from the Farmers Home Administration and getting a bond issue passed by the voters to repay the loan), and applying for and then administering the funds for construction received from the Department of Agriculture's Soil Conservation Service.

Junction City and, to a lesser extent, the city of Eugene were eager to see the channelization project come to completion and agreed to complete any channelization work necessary within their boundaries.

The counties of Lane and Benton were also involved and agreed to, without charge to the district, modify any bridge and roads necessary because of the project.

The State Government

A complete, self-contained discussion of the decision-making network of Public Law 566 is found in Chapter 4; however, some aspects of the decision network under PL 566 are discussed here since they are deemed important for understanding sources of demand for water resource development.

PL 566 provides that an agency of the state can plan and initiate small watershed projects and then apply to the Department of Agriculture for funds. Indeed, the statute permits an agency of state government to duplicate the

process performed by the Soil Conservation Service and apply for funds independent of the Service. Oregon has established this authority within the State Engineer's Office, but by and large the state legislation has not provided the State Engineer's Office with the capability of performance. In the Junction City project the state was a very silent partner. The work plans were submitted for approval, as required by state statute, but the state government had little part in the initiation or planning of this project.

National Government

The processing of PL 566 projects is primarily through the Soil Conservation Service. The small watershed projects are theoretically supposed to benefit agriculture, and the Soil Conservation Service would seem to be the ideal agency for the task. It has agents in the field acquainted with the farmers and their local problems. It has an administrative establishment that reaches directly to Washington, D.C., and has some real friends in Congress. It has the facilities to provide the engineering and planning as well as the economic information to develop a project and get it through the web of bureaucratic and Congressional entanglements. Its agents are known by the local farmers and are accustomed to working with them. It would seem, then, that the Soil Conservation Service is a propitious choice to administer projects such as this. The project was reviewed and included in planning provisions both by the Department of Army, Corps of Engineers, and by the Department of Interior's Bureau of Reclamation before being picked up by the Soil Conservation Service.

The process by which the project found its way through the administrative processes to the point of federal funding is probably quite typical. The point of funding is chosen as the point of official allocation of the resource since it would seem that nothing short of insurrection or an act of God could stop a project once funds are allocated for construction. (The cross-Florida canal and the Everglade's jet port would appear to have fallen into one or the other of these categories.)

The idea to increase the flow of the slow-moving meandering sloughs and turn them into straight drainage ditches occurred with the area's early settlers. As suggested earlier, a flood problem was endemic to the area; and long before Congress had passed PL 566, the Lane County commission had discussed the problem. In the construction of the Fern Ridge Dam and Reservoir, the Corps of Engineers had channelized portions of the Amazon Creek to better drain into the reservoir. Once the project was conceived and a group from the area organized to act as the local sponsor, the total resources of the Regional Soil Conservation Service were available for the project development.

As with all projects where local political support is needed, there must be an individual or group that will take upon itself the task of pressing through the

political maze the issues inhibiting or creating competition for this type of project. Without this local support there would seem to be little chance for project funding.

The regional office of the Soil Conservation Service seems to be the prime source for the economic and engineering data and work plans needed for the appropriation. In fact, this is the level of government where most of the "how" decisions are made. This is where the work plan developed; this is where the engineering is planned; this is where the economic information necessary to justify the project is created. From this point also the work plan is sent to all agencies of government, both state and federal, that might have an interest in the resource development so that plans can be modified if necessary to satisfy any objections raised.

From this point the project work plan is sent on to Washington, D.C., for the approval of the national office of the Soil Conservation Service and the Secretary of Agriculture. All agency reviews from this point on possess only the power to say yes or no; for, as suggested before, the policy decisions have been handed down long before, and the working decisions were made at a lower level prior to the transmittal to Washington. Here the review by the Secretary of Agriculture involves primarily two questions: (1) Does the project meet the criteria established? and (2) Do we want to put the project in our budget requests for this year? The answer to the second question would seem to have some political overtones but this does not appear to be a great barrier and most of the projects that satisfy question 1 are put into the budget requests without much delay.

The three-part review in Washington involves: (1) the *requesting agency*, in this case the Department of Agriculture; (2) the *Department of Management and Budget*; and (3) the *Congress*. The path which the project follows through this review appears similar to the vacuum tube system used in a department store to send paper work from the sales counter to the central office. That is, if the project proposal is properly prepared, the Washington phase of the decision appears to be a mere conduit to "speed" the application through to Congress.

This is, of course, an oversimplification since each agency of government does thoroughly review the plans to be certain they do comply with the guidelines established by Congress. Basically the provisions of PL 566 itself and the principles of Senate Document No. 97 establish the requirement of the cost benefit ratios to be satisfied. In addition, the Department of Management and Budget sends the documents to an interagency review to see if there is any problem not satisfied in the work plan itself. This, however, would seem to be a mere formality since the Regional Soil Conservation Service Office has by this same process attempted to eliminate any such conflict.

In interviews with the agency staff within the Soil Conservation Service Office in Washington and with the staff of the Office of Management and Budget

each indicated that they tended only to review proposals for adherence to the rules, but that the real hardnosed review was in the office of the other two principals of this three-part review.

In this project the third phase of review was the House Committee on Agriculture (headed by Congressman Poag). Congressman Poag was a principal author of PL 566. The staff on Congressman Poag's committee suggested that it was the philosophy of the Congressman, and therefore of the committee, to pass every one of the small watershed projects submitted to it if they met the criteria established (again the requirements of PL 566 and of Senate Document 97) and if there were no significant local opposition to them. This reference to local opposition was the first to be made to a project in the Washington, D.C., phase of the planning-application process. The staff of the Office of Management and Budget made reference to investigations of any local opposition expressed by letters to the President, but this would seem to be an ineffective means to measure local support. The power exercised by the congressional committee resembles what the political scientists refer to as a congressional veto. The traditional veto power retained by Congress is that of withholding appropriation on a line-by-line review of proposed funding. Here, however, the appropriation is a lump sum grant to the Department of Agriculture, and the project authorization precedes the appropriation.

Opposition to a project seems to be measured by Congress in two ways: (1) that expressed at or through a public hearing held by the committee (in Washington) and (2) the lack of support by the congressman in whose district the project is situated. As to the latter, since in our political system it is unusual for a congressman to speak out against a federal project in his own district, it is rumored that this lack of support is evidenced by failure to appear at the public hearing and speak in favor of the project. (This rumor, however, was denied by the agency staff of the Agriculture Committee.) The Washington, D.C., public hearing itself would seem to be the only forum, other than the courts, in which local individuals or groups can express opposition to the funding of a projected development. There are two things that mitigate against the effectiveness of such an approach: one is location (the hearing is in Washington, D.C., the opponents are in western Oregon) and the other is notice (the Federal Register is not well read in western Oregon). Local opponents can register their protest by letter, but this fact again does not seem to be well recognized by residents of the Willamette Valley.

The process, though perhaps very efficient in the construction of small watershed development projects, is markedly different from that which the Corps of Engineers and the Bureau of Reclamation must follow. Admittedly, those agencies deal with much larger projects, and in their projects the political process seems to be of much greater impact. Seniority of the congressional representative bears an important part of the decision process, and the nature of the

projects seems to generate much more publicity, therefore creating an atmosphere in which opponents to a development may take the opportunity to vocalize their opposition and be heard.

4 Decision Network for the Watershed Plan Under PL 566

The Watershed Protection and Flood Prevention Act (83rd Congress; 68 stat. 666) authorizes the Secretary of Agriculture to aid local organizations in planning and carrying out works of improvement for flood prevention or for the conservation of watersheds or subwatershed areas. This Act, known as Public Law 566 (PL 566), is administered by the Soil Conservation Service (SCS) under the direction of the Secretary of Agriculture.

This Act provides an approach different from the usual project approach of the Corps of Engineers and the Bureau of Reclamation. Public Law 566, unlike many federal public works projects, places full initiative and maximum responsibility for any project on the local people and their organizations. It also places an emphasis on close cooperation with state agencies. The provisions of the Act require a partnership of local, state, and federal agencies in natural resource development, use, and conservation. Such a partnership helps insure that projects will not be conflicting among themselves nor conflict with projects of other agencies.

The PL 566 approach requires that a sound plan be developed which is both physically and economically feasible. Commitments are required from the local organizations for sharing the cost of installation and assuming the maintenance obligations of the completed project.

As a project develops from an idea to a reality, many individuals provide inputs that affect the final form of the project. The original idea may have been very simple and the solution obvious, e.g., a low-lands area that needs adequate drainage to prevent flooding. However, in order for a simple solution to become a completed project it must go through a complex and intricate series of events.

In the network created by those events there are many critical and interrelated decisions. These decisions arise from both public and private interests and are affected by social, political, and economic considerations. Based on a knowledge of the underlying social, political, and economic processes, adequate field research can identify and model the decision points and their interrelationship.

Schematic Representation of the Decision Network

In an attempt to formulate a decision network of a typical water resource project, field studies were made on the Lower Amazon and Flat Creek Watershed project in Oregon. The resultant network is summarized in Figure 4-1 and

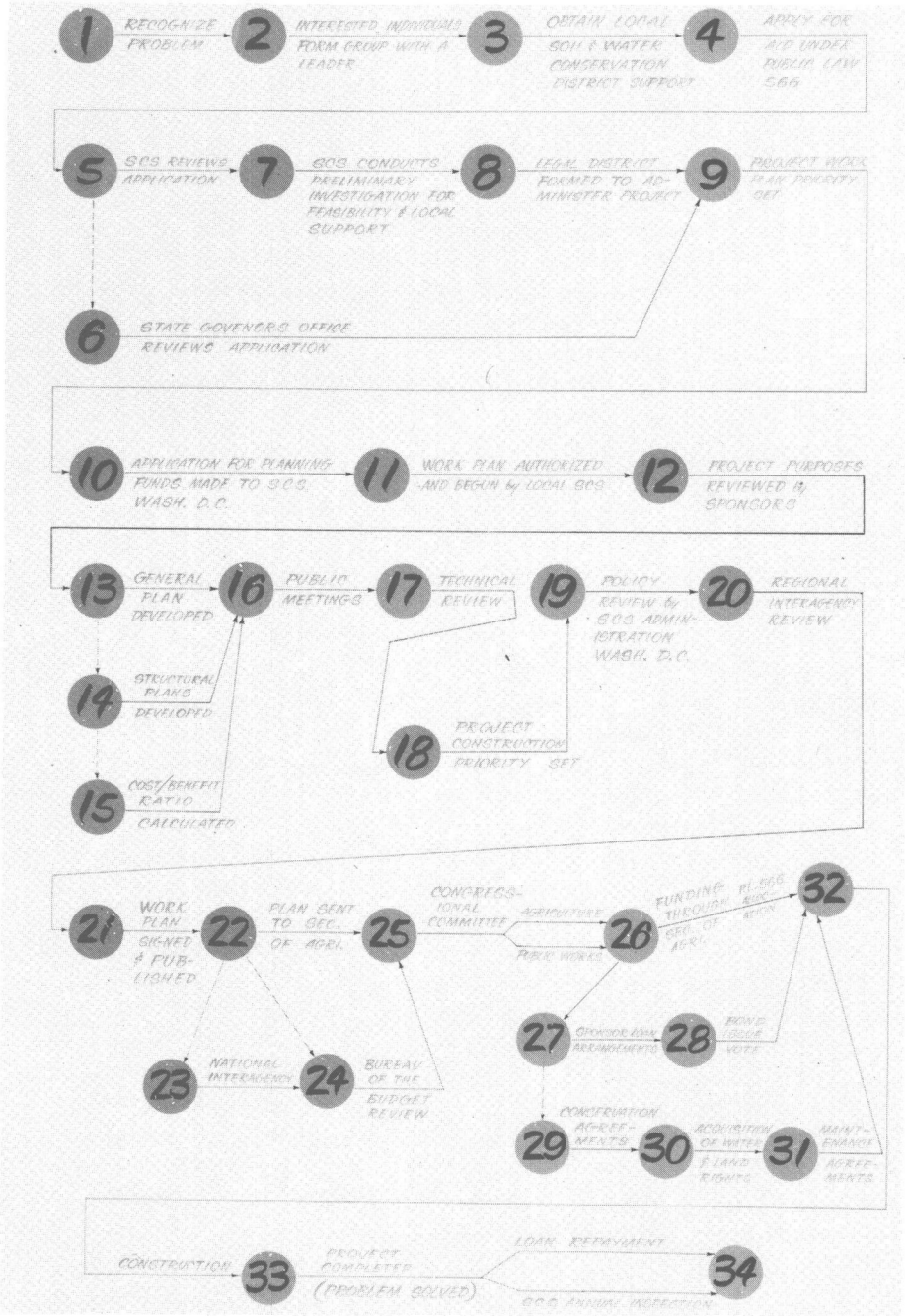


Figure 4-1. PL 566 Decision Network.

described in the following discussion. Although some repetition of factual material is included, the description is presented for the purpose of specifically delineating the decision network.

Decision Points

The following is a description of the decision network that a PL 566 project must traverse in order to be successfully completed. Some decision points seem so "bureaucratized" that the decision outcome is almost automatic; others clearly involve objective or subjective decision criteria which truly control the very existence of a project.

The local citizens, those living in the area, must first recognize that they have a problem. The recognition can come either from their own experience or it may be pointed out to them by a SCS representative. The problem solution must entail flood control and/or irrigation in order to come within the scope of PL 566. Most PL 566 projects involve farm or rural residential land; however, the drainages of some streams may require that industrial land and municipalities be included in a project.

Once the local people have discussed their problem and come to the realization that a PL 566 project might be feasible, they must get a local organization to sponsor or approve the project. Most areas of a state are organized into water conservation districts, and it is the support of these districts which the local groups must obtain first. The county water conservation district should approve the concept of a project and recommend the request of federal Soil Conservation Service aid. The interested local parties form an action committee which appoints a leader to expedite critical decisions. A strong leader appears to be critical to the success of a project, for without decisive leadership which will keep the project organized and moving, it will probably eventually stagnate and die. If there is a soil and water conservation district in the affected area, its support must also be gained. The soil and water conservation district is a classification of the Soil Conservation Service, as distinct from the water conservation districts, which are state designations. The SCS will not aid projects to which the local soil and water conservation districts are opposed.

The local committee now completes an application for assistance under PL 566 and submits it to the Soil Conservation Service. Engineers will review the application and conduct a field inspection of the area. The local committee will be contacted and the scope of the proposed project will be discussed. Many problems that are submitted can be solved without going through an extensive PL 566 project. Sometimes engineering assistance alone will solve the problem and eliminate the need for a large project.

With the determination that a water problem exists and a large project will be required to remedy it, the next step is to conduct a preliminary investigation.

The scope of the project is outlined and pertinent constraints are identified. The preliminary study includes engineering, economics, geology, and hydrology. Evaluation of the data collected in the survey will determine whether or not a project is feasible. If a proposed project is found to be unfeasible at this time, the district SCS office will review the project with local sponsors; the reasons are discussed, and other approaches that might be taken to make the project feasible are analyzed. If restating the goals of the project, enlarging the affected area, or decreasing the size of the project will make it feasible, these alternatives will be considered. However, the project will only be continued if the SCS and the local promoters agree completely on the new scope.

If a project is considered feasible, a sponsor with the legal authority to handle such a project must be found or created. A federal soil and water conservation district must also cover the project area, and if such a district does not, one must be formed. The local administration district should have the power to condemn property and to levy taxes in support of the project and subsequent maintenance. If the local citizens, for any reason, cannot create the necessary administrative district, the proposed project will end as far as the Soil Conservation Service or any federal involvement is concerned. Further, if the municipalities and counties in the area oppose the project, it has little chance of ever being approved.

The application is first sent to the state governor's office or his designated representative. In some states, such as Oregon, this would be the State Engineer's Office. State officials examine the application and the affected area to determine if the proposed project is in keeping with state development and generally beneficial to the state. Local political support has some bearing on this review in that the state may determine the desirability of the project in terms of the need and influence of the people who favor or oppose the project. Generally, most of the projects that the Soil Conservation Service judges as feasible are approved by the state.

After state approval, the project is assigned a work plan development priority among other SCS projects in the state. This priority is based on need, local support, and feasibility. Need is determined by the flood and/or water damage done to the area and the number of people affected. Local support is defined as the leadership and organization the local citizens have established for the project. The local sponsoring groups must actively support the project, and their leadership and organization must be competent to the task ahead. Field studies suggest that the extent of local support is particularly important in obtaining the necessary priority for development. Feasibility is an engineering decision based upon what is needed and the economics and practicality of filling the need. The priority ranking given a project by the SCS is a very important step because it determines when funds will be allocated to develop the project. Assignment of the priority is made by the regional SCS conservationist (i.e., the federal government representative).

The regional SCS conservationist must make the determination when a project has progressed far enough to warrant detailed planning. Once this decision has been made, the application is forwarded to Washington, D.C., for administrative approval by the administrator's staff. If the review is satisfactory and the funds are available, the state Soil Conservation Service office will be given approval to commence work on a work plan.

The work plan is developed by the staff of the state Soil Conservation Service office. The plan includes engineering, economics, hydrology, surveys, and, more recently, recreation considerations. As actual data are gathered and analyzed in the form of a work plan, the project's scope may be expanded or narrowed, depending on how closely the actual data conform to previous estimates. The sponsors review the changes suggested, and any differences must be resolved. Agreement must be reached.

Once the scope is firmly established from the data gathered and analyzed in the initial phase of the work plan, the work plan is expanded into a general plan that combines the data and prescribes the best solutions. Structural needs are forecast and structural plans developed. At this point the Soil Conservation Service engineers discuss the structural plans with state engineers to insure that the sites and building plans meet state regulations.

As the general work plan and structural decisions are tentatively drawn up, they are presented to the sponsors in a series of public meetings. Meetings are held throughout the planning stages, usually once a month. All sponsors and all residents or landowners in the affected area are notified of the meetings, and there individuals and/or groups can publicly defend or attack the proposed project. Differences of opinion on the general work plan are handled informally in private meetings between the sponsors and the Soil Conservation Service. As a result of the meetings, the sponsors formally accept the general plan as it is developed.

When the general plan is tentatively set, the cost-benefit ratio is calculated by staff economists. Many factors, such as the size of the area and the structures used, affect the cost/benefit of a project. The economists survey the area of the proposed project to determine the current land usage. They then interview the residents of the area to determine if they will change the land usage after the project is completed. Changes in land usage will result in a benefit if the change will lead to increased land value or income. An example of such an improvement would be the conversion of a flood plain (which is costing its owner taxes and producing little or no income) to land that can be used for higher value crops. The increase in income that will result from the land being used for row crops results in economic benefit.

Numerous other factors are also considered in the economist's cost/benefit calculation. These include such items as the reduction of river bank erosion, increase in recreational facilities, decreased flood damage, and crop value increased due to irrigation. Costs that enter into the calculation include land

clearing, the construction cost of the project, land lost from construction, and maintenance. When costs and benefits are totaled, the dollar ratio of costs to benefits is determined. A ratio of less than one indicates that the project will generate benefits worth more than the project will cost. The Soil Conservation Service will not accept a project that has a cost/benefit ratio more than one. Such a project must be abandoned or restudied and a new general plan developed. The changes and the new plan must again go through sponsor approval and new cost/benefit calculations must be made.

Where a favorable cost/benefit ratio is established, sponsor and public meetings are held for plan approval. These meetings constitute a complete project review, and all concerned parties are permitted to comment on the plans. Any final differences in opinion must be settled. Again, the sponsors must agree on the project plans before further progress can be made. If any changes are made in the plans, the cost/benefit ratio must be recalculated. Upon approval of the work plan by the sponsors, the structures and engineering are finalized, permitting more concise cost figures to be determined. The final cost/benefit ratio is now calculated and reevaluated to insure that it is still greater than one.

The plan, including all technical data and project feasibility analysis, is now reviewed by the regional technical staff of the Soil Conservation Service. The technical staff then makes a recommendation to the state office of the Soil Conservation Service as to whether or not the project should be forwarded on to request funding. If the recommendation is favorable, the local Soil Conservation Service conservationist sets the construction priority of the project in the state. As with the work plan priority, the construction priority is also determined by the same three criteria–need, local support, and feasibility. At this point local support seems to be the primary factor for which the conservationist is searching, for by the time a project reaches this point the need and feasibility have been well established. The conservationist is concerned with the organization of the groups sponsoring the project. If the project is approved by Washington, the sponsoring groups must be ready to manage the actual construction of the project.

When the conservationist feels the project is ready, he sends the plan to the staff of the Soil Conservation Service Administrator in Washington, D.C., for policy review. This review is conducted to insure that the project complies with the Law, the cost/benefit ratio is correctly calculated, and that congressional policy is not violated. If the project needs revision to meet policy considerations, it is sent back to the regional office for correction.

The regional SCS office now holds a regional interagency review. All federal agencies that could in any way be concerned with the plan are sent copies of the project proposal and asked to respond to them. These agencies normally would include such interests as the U.S. Corps of Engineers, U.S. Bureau of Reclamation, U.S. Fish and Wildlife, U.S. Forest Service, and, more recently, the Environmental Protection Agency. Relevant state agencies are also included in this

review. The project is intentionally delayed until all concerned state and federal agencies indicate no objections to the project. If an agency does object, meetings are held to discuss the objection. It is imperative that the regional offices of the federal agencies approve the project, for without their approval the project will probably not receive funding; therefore, every attempt is made to correct objections raised.

After the regional agency review, the work plan is signed by the sponsors and is formally published. It is then sent on to the Secretary of Agriculture, who again circulates among the concerned federal agencies. These federal agencies in turn forward the plan to their regional offices. It is the regional offices of the federal agencies that now make the decision to approve or disapprove the project; but since preliminary approval has already been received, this stage very seldom creates any problems. Any interagency disagreement at this point, however, would still stop the project.

The plan is next submitted to the Office of Management and Budget for approval. Here again there is review of the cost/benefit ratio and checks for objections by other federal agencies. If any of the federal agencies included in the interagency review has objected to the project, this conflict must be resolved before approval can be obtained from the Office of Management and Budget. Again, this emphasizes the importance of the regional interagency review.

Upon approval of the Office of Management and Budget, the plan is sent to Congress, where one of two possible committees must act on it: the Public Works Committee if a project has a structure which holds more than 4,000 acre-feet of water, or the Agriculture Committee if the capacity of the proposed structure is less than 4,000 acre-feet. The committees hold public hearings on the project at which all who have an interest are given the opportunity to comment on the proposal. The congressional committees, if they approve the project, recommend to the Secretary of Agriculture that he fund the project from his general appropriation for PL 566 projects. The Secretary of Agriculture then gives the Soil Conservation Service Administrator permission to distribute PL 566 funds to the project because the work is ready to be done.

Now the main administrative burden settles on the local organization. PL 566 requires the local organization to pay a portion of the project costs and arrangements must be made to cover this local share. The amount of local expense varies from project to project and depends upon ultimate use of project benefits. The most common method used by local organizations is a Farmers Home Administration loan, backed by a local bond issue. When financing is arranged, the construction plans are also finalized.

Before the Soil Conservation Service will release federal funds, the local sponsors must provide guarantees that: (1) at least 50 percent of the landowners located upstream from a federally financed structure must agree to practice certain soil and water conservation methods; (2) all land and water rights needed for the construction of the project must be acquired; (3) all building codes must

be observed; (4) maintenance of the project will be carried out as planned; (5) local sponsors must pay for all work involving municipal or industrial water supplies.

When the financial and technical problems have been taken care of by the sponsors, the contracts are let. The Soil Conservation Service will assist the sponsors in handling the bids and also provides technical assistance and inspection during the construction. Then the project is complete; maintenance procedures are begun. The Soil Conservation Service will make annual maintenance inspections to insure that proper procedures are being used.

Generalized PL 566 Project Questionnaire and Computer Model Input Format

A generalized decision process computer simulation program has been developed which may help to further extend the results of this study to other water resource projects. A major purpose of formulating this program was to facilitate the analytical process which brought to light relevant decision points and their interrelationships described above. The model has been written in Fortran IV, and a questionnaire has been prepared to organize input data. To obtain a preliminary feasibility analysis of a potential PL 566 project, a user need only answer the questions in terms of yes (answer I) or no (answer O). The decision point analysis program is illustrated in Appendix B.

The questionnaire is designed to help local groups who are seeking SCS help in solving a flood control and/or irrigation problem become acquainted with some of the major factors with which they will have to contend before they can successfully complete a project under Public Law 566. This is not a complete test by any means, but it does point out the areas with which the local sponsoring group will have primary responsibility in getting things done.

If, in the questionnaire, questions are answered with a negative response, the respondent should go to the appropriately marked explanation to determine the consequence of this negative reply. In some instances a negative reply can be overcome; in others it may well mean that there is little chance of a proposed project succeeding. The following are sample questions from the complete listing given in Appendix B.

	YES	NO
1. Is the project for flood control and/or irrigation?	____	____
2. Are there interested local groups who will support the project?	____	____
3. Has a leader been identified to head the local group?	____	____
4. Does the local soil and water conservation district support this project?	____	____

	YES	NO
5. Will a soil and water conservation district sponsor this project if the U.S. Soil and Conservation Service finds it feasible?	____	____
8. Is there a sponsor with legal authority to handle the project?	____	____
13. Do water control districts, municipalities, counties and soil and water conservation districts agree on project objectives?	____	____
14. Do a majority of water control districts, municipalities, and counties in the area support the project?	____	____
15. If any of the three parties in (14) are against the project, can they be persuaded to support the project?	____	____
22. Do sponsors agree on the general plan?	____	____
23. Do participating parties agree on structures required?	____	____
24. Is the cost-benefit ratio less than one?	____	____
25. Does or will any affected party threaten a suit to stop the project?	____	____
26. Will affected parties support the project after compromising agreements have been made?	____	____
33. Will the plan be accepted by regional interagencies in project review?	____	____
38. Do political candidates from the local area favor the project?	____	____
43. Will the financing bond issue be passed by local residents?	____	____
45. Do 50 percent of landowners agree to follow conservation practices?	____	____
46. Will water and land rights be successfully acquired?	____	____
47. Can maintenance agreements be set up and followed?	____	____

Explanations of the consequence of unfavorable replies to the above questions follow. The numbers correspond to the questions above.

1. The problem is not acceptable—no possibility of success as presently defined.
2. Interested groups *must* be found to sponsor the project; without them there is little chance of success.
3. You *must* find a leader—most projects have been found to fail without strong leadership.
4. You *must* get support from local soil and water conservation district; without it no further advance can be made.
5. The soil and water conservation district must sponsor this project; without their sponsorship, the project will fail.
8. A legal district must be created if the project is to progress.

13. Project will be delayed until water control districts, municipalities, counties, and soil and water conservation districts agree on project objectives.
14. Project will be delayed until a majority of water control districts, municipalities, and counties in the area support it.
15. If opposition cannot be persuaded, there is a small chance of success.
22. Project will be delayed until sponsors agree on the general plan.
23. Project will be delayed until participating parties agree on structures required.
24. Project is not acceptable. The cost-benefit ratio is greater than one. Redevelop your general plan.
25. A suit by affected party will delay or stop the project.
26. Project will be delayed until a majority of affected parties support it or a compromising agreement on the general plan.
33. Plan must be developed so as to meet regional interagency requirements.
38. Project will be delayed or stopped if it is not favored by local congressional delegation.
43. Project will be delayed until bond issue passes.
45. Project will be delayed—federal money will not be available unless landowners agree to follow conservation practices.
46. Project will be delayed until water and land rights are required.
47. Project will be delayed until affected parties agree to follow certain maintenance practices.

Discussion of Network Influences

Local support seems to be a main force behind a successful project. During field research on the Lower Amazon and Flat Creek project in Oregon, all the SCS officials interviewed emphasized the importance of local support. Leadership is very important. A project with a strong and active leader will progress much faster than one that depends upon committees. Projects that have no identifiable leadership are likely to fail.

The cost/benefit determinations are flexible enough to allow any reasonable project to pass. Changing the area involved, evaluating intangible benefits, or reevaluating the flood control probabilities (projects with flood control are built to handle floods that probabilistically occur only once in a hundred years) can lower the cost or raise the benefits enough to make many projects acceptable.

Research has indicated that a major decision center for PL 566 projects is the local federal office of the Soil Conservation Service. This office determines the feasibility and sets priority levels among projects. When the Soil Conservation Service office considers a project ready, it is sent to Washington, D.C. In many cases, it appears that projects are rubber-stamped through to congressional approval as long as all concerned parties receive proper notification and all forms

are correctly filled out. The various participants in the approval process appear to rely upon others to make the controlling decisions. The only control that would likely delay or stop a project at this point is a shortage of funds in the Department of Agriculture allocation.

This phase of defining an existing decision network is necessarily largely descriptive. However, an accurate description of the variables that affect decisions quickly penetrates to the value systems and so-called intangibles that must be subjectively evaluated as inputs to the decision process. This decision network study has attempted to identify the social, political, and economic factors that influence a single type of water resource decision. The next chapter discusses some of the relationships among these factors.

5 Objectives of Water Resource Management – Can They Be Achieved Through Legislation?[1]

Neither current events nor history show that the majority rules or ever did rule.

Jefferson Davis
July 17, 1864

Within our democratic society, there are numerous ways of accomplishing social objectives. Some of the most vital objectives relate to our use of natural resources. In particular, we are concerned with optimizing the benefits inherent in our water resources.

One means of increasing the benefits derived from water resources has been for society to enact legislation to govern their development and use. But how effective is legislation in achieving the objectives of water resource management? Some of the problem areas of defining objectives and designing and controlling equitable laws are cited in this chapter. Data from the Amazon Flat Creek project of the Junction City Water Control District illustrate how these problems manifested themselves in this actual case study. Finally, the findings and observations lend themselves to some conclusions concerning the adequacy of legislation to achieve water management objectives.

Legal Structure of Water Management Objectives

Man's natural environment includes air, water, and land resources (see Figure 5-1). As a being in this environment, man exists in a social system which has many cultural patterns including religious, artistic, economic, and legal components. Legislation is a form of social control. When enacted to govern water resource development and usage, its purpose is to manage this resource better so that man can realize benefits that will ultimately raise his level of existence, or his culture. Thus, the legal enactments have the ultimate objective of benefiting the society in general.

Within the legal subsystem of our culture, a portion of the law relates to our water resources (see Figure 5-2). If laws are to be successful in achieving water management objectives, three requirements must be met: (1) societal objectives must be legally delineated; (2) equitable laws must be designed and imple-

[1] Portions of the material in this chapter were presented in a paper given at the Annual Symposium of the American Water Resources Association, June 19, 1972, at Fort Collins, Colorado.

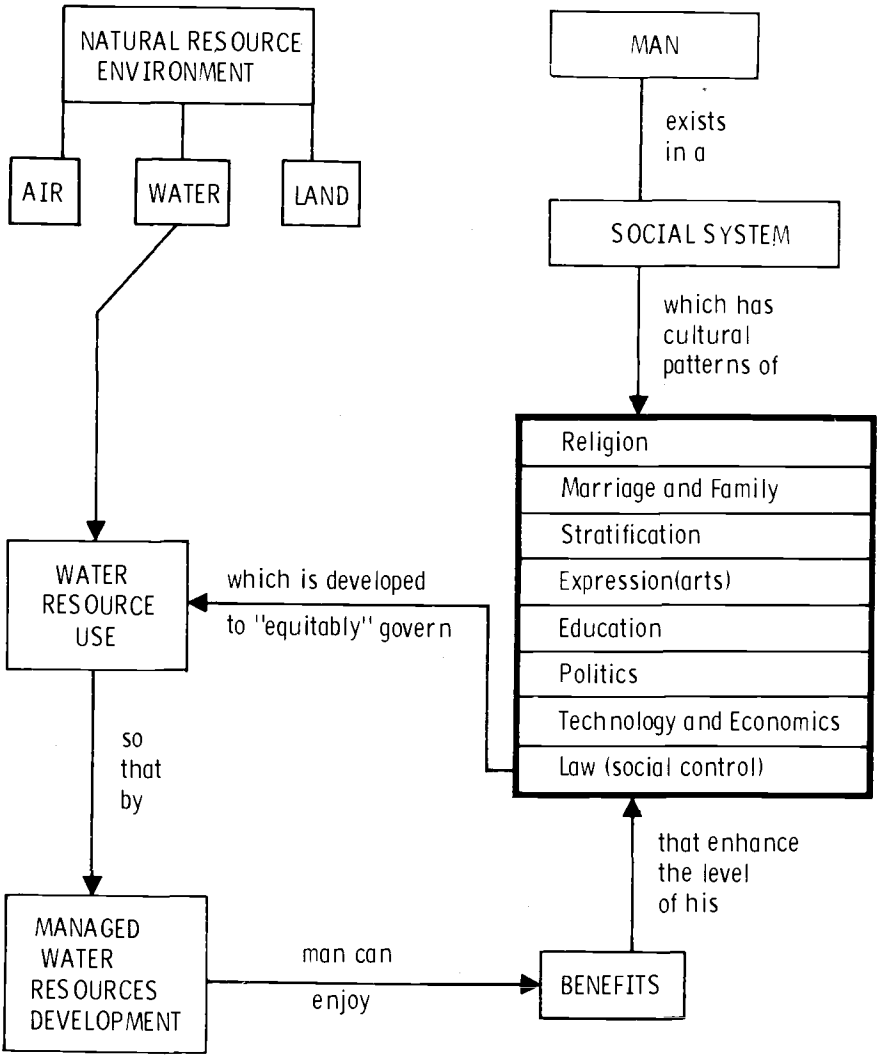


Figure 5-1. Macro Objectives of Water Resource Legislation.

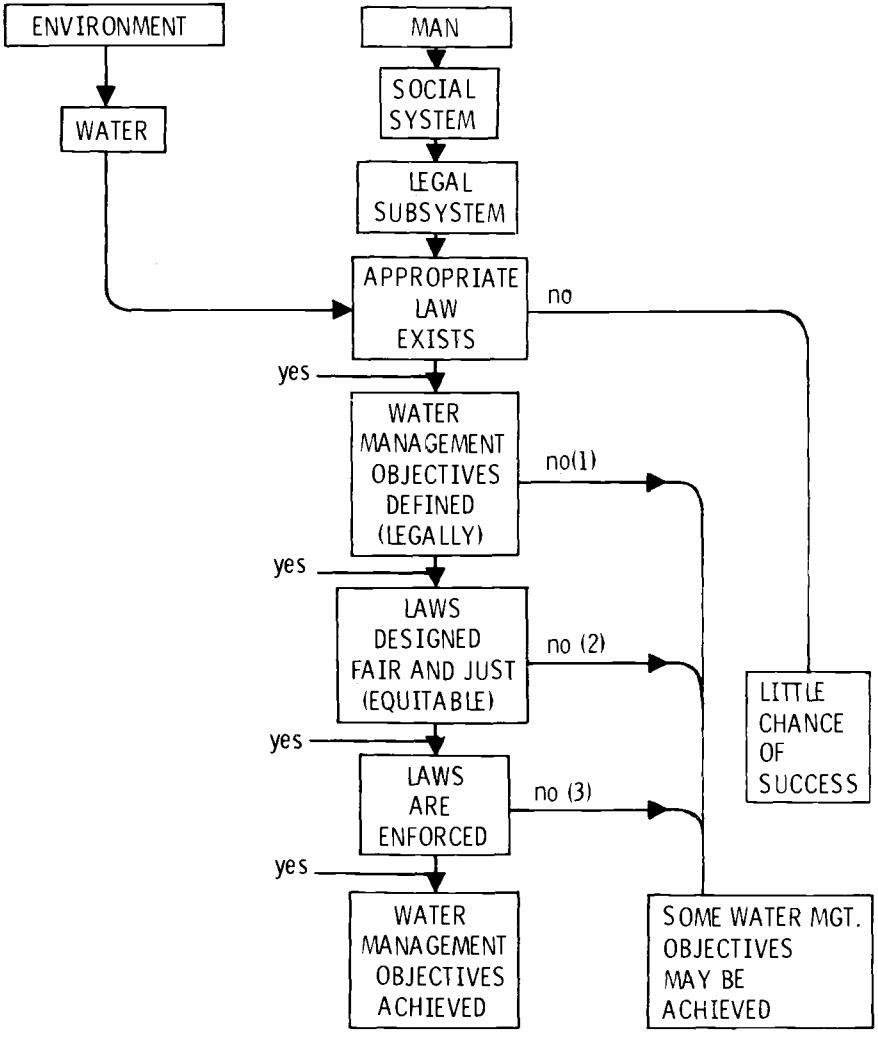


Figure 5-2. Legal Structure of Water Management Objectives.

mented; and (3) these laws must be enforced. If any one of these requirements is not fulfilled, we may still achieve some water management objectives but perhaps more by accident than by design. Let us consider each of these problem areas in more depth.

1. Defining Objectives

Although economic objectives have traditionally received the most consideration, intangible objectives and outcomes do exist; and society is insisting that the developers and users of our environment recognize these social-cultural effects more formally. Mr. James Sears, speaking as Chief of the Environmental Resources Branch, Corps of Engineers, has aptly pointed out that a monetary unit as a measure of utility is only a partial evaluation in that it does not include benefits or regional interest nor, in a measureable way, the social or non-monetary costs and values associated with environmental quality. [Sears, 1968].

Taking intangible factors into account in a specific and legal way raises difficult problems of definition. Can the noneconomic objectives be delineated and in what units are they to be stated? Whether or not these objectives are specifically defined, almost any project has social and/or political impacts upon the community. These inevitable outcomes should be taken into account when defining objectives (see Figure 5-3). Attempts have been made to use general classifications such as number of acres of open space, number of jobs generated, man days of fishing available, etc. However, most of these measures are ultimately converted to monetary values. The typical result is a monetary scale with a questionable weighting scheme. More than likely it still omits many esthetic values and emphasizes quantifiable objectives rather than actual outcomes.

2. Designing Equitable Laws

What do we mean by equity? Do we simply mean the "due process" concept of procedural fairness? Or do we mean absolute equity, in that each person has an equal share or right? Or are we going to suggest that those who have some natural ownership or perhaps geographic proximity to the resource have a greater right than others?

Our democratic system of government gives all persons the right to represent themselves in the process of decision–theoretically, at least. A democracy is a government *of* all the people, *by* all the people, and *for* all the people. Within this framework, our total legal system has developed upon the basis of concepts that have gained legitimacy with age. One such concept is that of private property. Thus it is not surprising that our resource laws are based in large part upon private ownership of land.

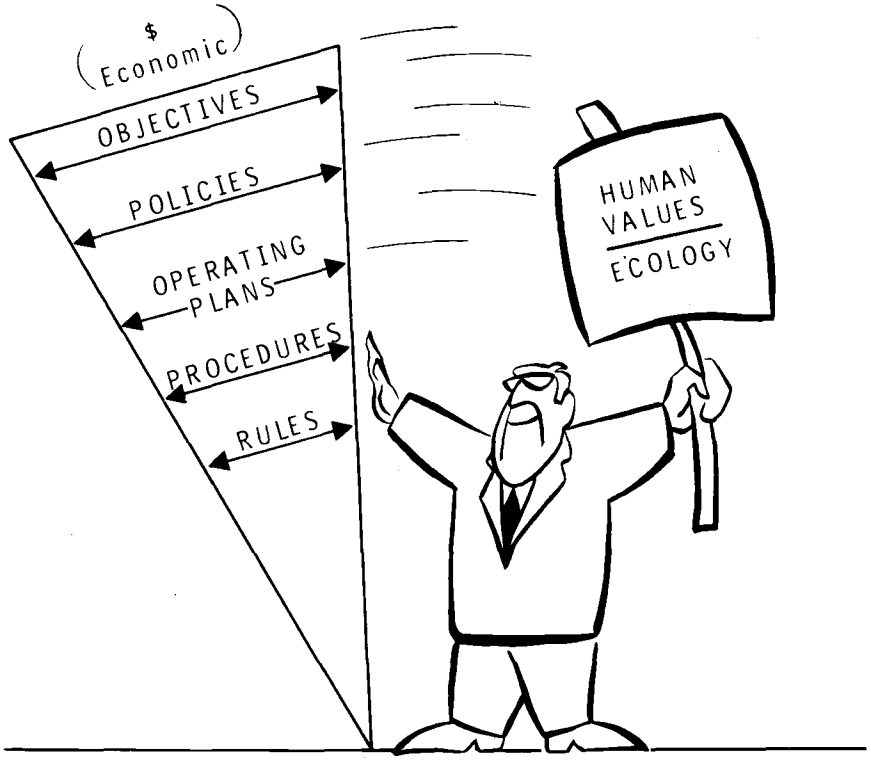


Figure 5-3. Social and Cultural Objectives Become of Age.

At the current time, principles of private ownership are being challenged by a society suggesting that certain resources should belong to all–that water resources are a part of nature and should be managed for the use of everyone in society, including those yet unborn. The difficulty of designing "equitable" laws for water resource management quickly raises issues of balancing private property rights against democratic ideals of fairness and justice. If the democratic ideals are in fact to prevail, the decision process must give true representation to all those who are affected by the decision.

3. Control (Enforcement) of Project Outcomes

Thus far we have said that if water management objectives are to be achieved, they must be defined and equitable laws must be designed. The third requirement is that these laws effectively control the project outcomes (see Figure 5-4).

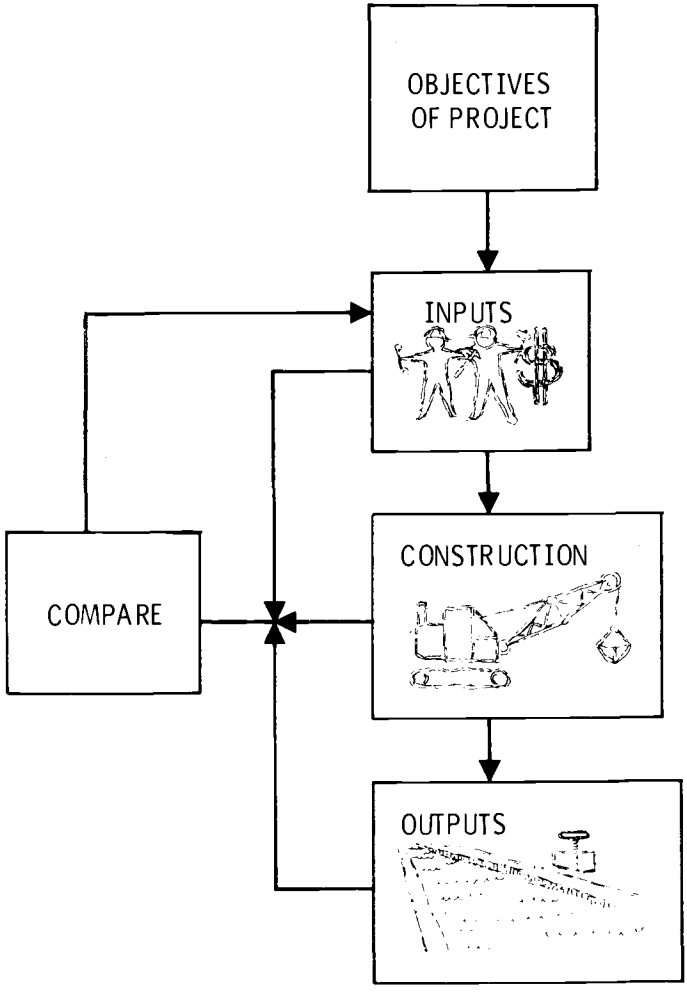
In theory, any control system requires four elements if it is to function effectively. Control first requires some form of quantitative measurement of the variable under consideration. Second, these data must be fed back in a timely and accurate manner. Third, a comparison must be made with the standards originally established in the design phase. Finally, if the actual achievements are not according to plan, the system must incorporate both the authority and ability to correct activities so that stated objectives will be achieved.

In speed law enforcement, the policeman's radar scope (measurement and feedback), the sixty-mile-per-hour speed limit (standard), and the county jail (correction) constitute an effective control system. The control components of water resource development legislation are not nearly so easy to define. This is particularly true of the social and political impacts of water resource development projects upon the community. These less tangible outcomes of a project may or may not be desirable. The problem is that unless the impacts are delineated and measured, no effective control over them can exist.

Case Study Data: The Junction City Project

The Junction City project was studied with respect to assessing the effectiveness of legislation to accomplish water management objectives. As indicated previously, this project is primarily and ostensibly a flood control effort, funded partially under PL 566 ($3.6 million) and administered by the U.S. Soil Conservation Service.

Public Law 566 is intended to provide funds for resource development projects that are beyond the scope of individuals but are not of a major public works type. Projects should have the full support of a large majority of landowners and citizens of the community.



ANY CONTROLLED SYSTEM REQUIRES

1. MEASUREMENT
2. FEEDBACK
3. COMPARISON WITH STANDARD
4. CORRECTION WHEN NECESSARY

Figure 5-4. Elements of Control.

The U.S. Soil Conservation Service's intention is not to benefit a particular individual or small number of individuals but to help the people accomplish projects that will benefit them *as a whole*. Soil Conservation Service philosophy is, in essence, substantially democratic, for it aims to have the people decide on a course that will bring the greatest benefits from resource development to all of the people of the area. [U.S. Soil Conservation Service, 1967].

Project Objectives and Outcomes

Let us in turn examine the following: (1) the stated objectives of the Junction City project work plan; (2) the objectives as seen by residents of the area; and (3) selected social, political, and economic outcomes which come about whether or not they are planned. Figure 5-5 gives one perspective of the source of project objectives.

Work Plan Objectives

The watershed work plan was developed under the technical direction of Soil Conservation Service personnel. It is a comprehensive evaluation of the physical and economic conditions of the area. The Junction City project involves about $4.2 million of federal funds and is designed to provide flood prevention for approximately 17,200 acres "frequently flooded" and deliver a dependable supply of irrigation water to 3,000 acres of irrigable land. The work plan states that drainage is generally an "on-farm problem that will be handled by individual landowners" [U.S. Soil Conservation Service, 1965]. Fifty percent of the cost of irrigation facilities (i.e., half of $368,500) is funded by the local residents through bond issues and taxes.

Objectives As Seen by Local Residents

A statistical sample of 139 area residents was taken by personal interview. Each resident was asked who he thought would benefit most from the project. Forty-eight percent of the respondents answered "farmers." Other responses included urban and suburban dwellers (14 percent) and people adjacent to the water ditches (9 percent). When asked specifically what they saw as benefits of the project, only 17 percent replied "flood control" whereas 45 percent responded "drainage." Other major responses were "don't know" (11 percent), "irrigation" (9 percent), and "agricultural diversification" (8 percent).

Residents were also asked what they regarded as the project's drawbacks, and 48 percent had no response, 28 percent indicated that there were no drawbacks,

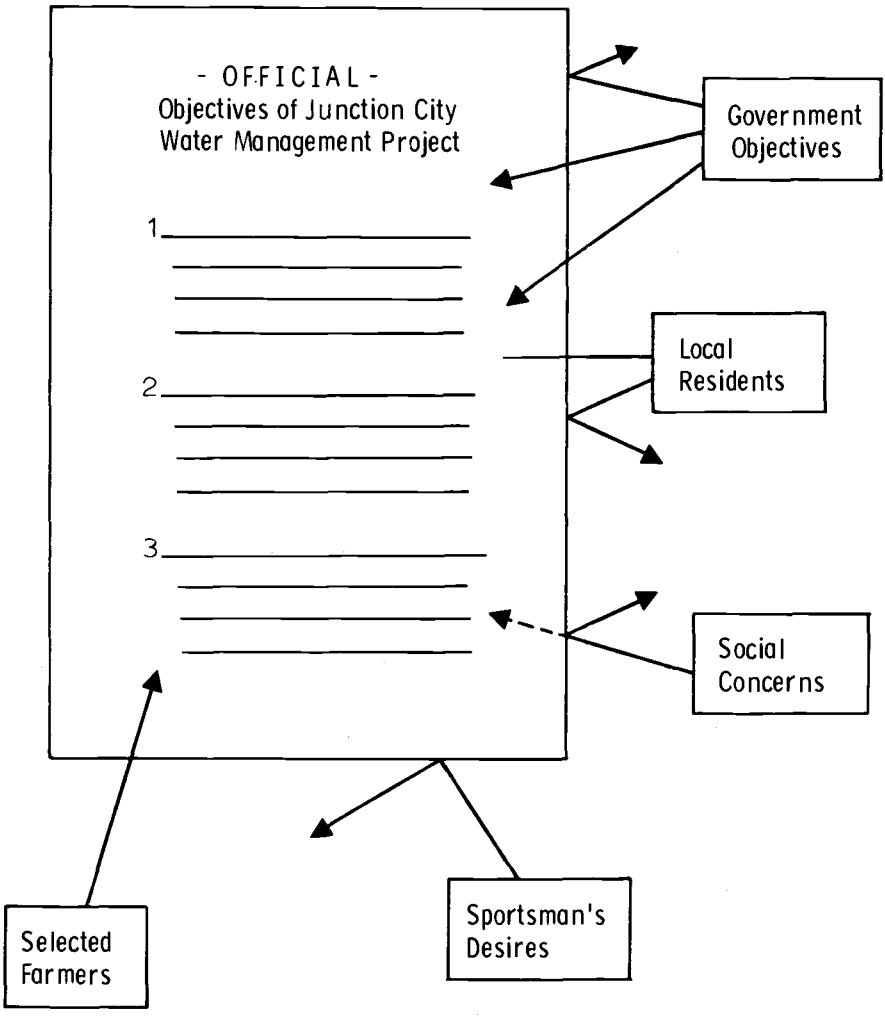


Figure 5-5. Project Objectives Determination.

and 9 percent cited higher taxes. Other responses referred to the land being divided by a ditch, to physical hazards, to poor soils spreading, and to a waste of money. When asked to express an opinion on whether the benefits derived from this project were worth the changes in physical landscape, only 4 percent agreed, 33 percent disagreed, and 18 percent declined to respond. Nevertheless, 57 percent of the respondents expressed overall satisfaction with the project, with the remaining 43 percent either expressing dissatisfaction (14 percent) or declining to respond (29 percent).

In summary, residents viewed the prime objective of the project as drainage rather than flood control. Yet the work plan emphasized flood prevention, which satisfied the conditions for federal funds under PL 566.

Social, Political, and Economic Outcomes

In addition to the esthetic concerns over the appearance of ditches on their land, residents of the watershed area voiced concern over other noneconomic outcomes, such as damage to wildlife habitat in the area, safety hazards, etc. Public Law 566 does not explicitly deal with all such intangible outcomes, and the extent to which vague and ill-defined objectives should be incorporated into legislation is open to question.

Equitability of Methods for Achieving Project Outcomes

Although we live in a democratic society, the specific means of attaining objectives of water resource management are not all democratic. Case study data of the Junction City project have revealed some interesting insights into the actual techniques used to achieve water management objectives. We focus attention now upon the techniques, the overall equitability of this system, and the implications of this upon legislative controls.

Every society must adopt some techniques for allocating scarce resources to alternative ends. A society that wants to manage its water resources so that flood protection, irrigation, recreation benefits, etc., ensue must have some means of determining who gets how much benefit. As indicated previously, there is no universally equitable technique for reaching such a decision; one tends to formulate an idealistic continuum that extends from the free-pricing system on one end to strict authoritarian planning on the other. In reality, however, such a continuum does not exist, and societies use a mixture of techniques to allocate resources. Four central sociopolitical processes for economizing are (1) the pricing system, (2) hierarchy, (3) polyarchy, and (4) bargaining [Dahl and Lindbloom, 1963].

The Junction City case study has revealed that elements of all four major economizing techniques are present in the PL 566 decision network for allo-

cating water resources. Some examples are shown in Figure 5-6. This observation is particularly relevant to our concern, for it means that truly effective controls

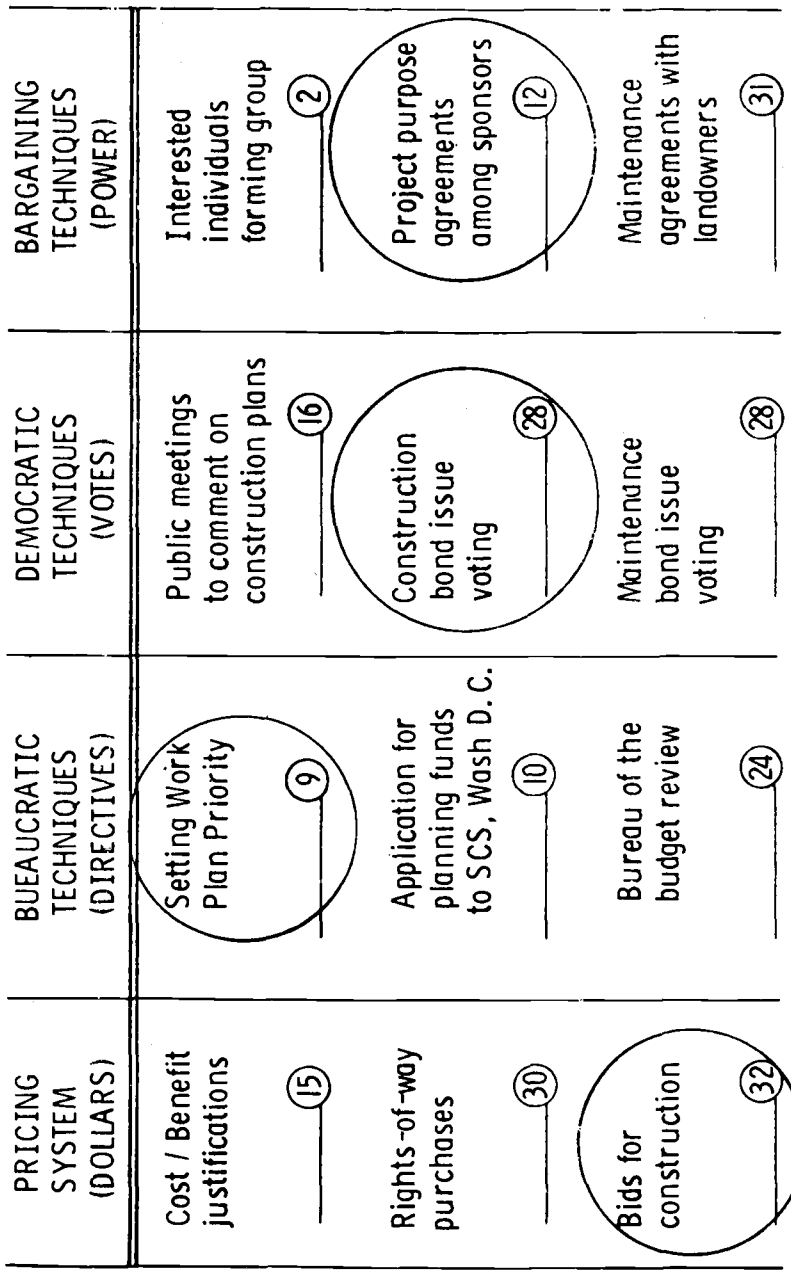


Figure 5-6.

must be capable of accommodating such techniques within their legislative framework while still facilitating accomplishment of certain goals. The examples will illustrate the presence of the various techniques.

The Pricing System

The pricing mechanism operates in conjunction with the economic laws of supply and demand, with goods allocated according to dollar votes. Prices form a common denominator and eliminate the need for a central authority. The use of this technique is aptly illustrated by the method whereby construction funds are actually allocated. Bids for channel construction are obtained under a competitive bidding system, and contracts are awarded on the basis of the lowest price for performing the specified work. The pricing system thus functions within the PL 566 framework to insure that project construction funds are efficiently utilized.

Hierarchy (Bureaucracy)

Hierarchy results from control *by* leaders. Although contrary to democratic ideals, hierarchy in the form of bureaucracy is well accepted in the United States. Authoritarian and bureaucratic decisions are widely used techniques for economizing. The PL 566 projects routinely pass through budget reviews, congressional committees, and other hierarchial approvals, as was shown in the decision sequence diagram. A particularly significant authoritarian decision that rests with the local Soil Conservation Service office is that of setting the work plan priority for one project relative to others in the area.

Polyarchy (Democracy)

Polyarchy, as illustrated by a democracy, might be characterized as control *of* leaders. This system, which offers one vote to each individual, corrects the inherent pricing system deficiencies of allocating goods on the basis of wealth. It requires an accurate and timely information flow to the voter and an absence of any intimidation or bribery [Braybooke, 1968]. But the frequency and extent to which a citizen can express his individual preference by voting is limited. Also, the democratic process necessitates a collective preference, whereas in our pluralistic society it is difficult to establish uniformly satisfactory goals. Let us examine some democratic requirements in more detail relative to the Junction City project.

In order for the democratic process to function effectively, the voter must be

informed. He must know (1) that there is an election, (2) what the issues are, and (3) how the outcome will affect him. A bond election authorizing $85,000 for purchase of land and easements to get the Junction City project underway was held on April 18, 1967. Of the 2,151 landowners who were eligible to vote, only 306 voted and 196 voted in favor of the project. This initial approval was thus accomplished by less than 10 percent of the eligible voters.

A second follow-up election for a $27,000 tax levy was held on the same day as the national election, November 5, 1968. The state of Oregon voter turnout was over 70 percent, whereas the turnout for the water control district tax levy was only 4 percent. One of the reasons for this discrepancy may be due to the fact that the polling places for the water control district issues differed from those for the national elections. Regular county polling places could have been used, but they were not. A voter had to go to two different polling places if he wanted to vote in both elections. Lane County, where 85 percent of the eligible voters resided, had only one polling place—in a grange hall. Benton County had two polling places—at private residences.

Perhaps a word of explanation is needed to explain some of the circumstances surrounding the initial vote. The Oregon statute permitting creation of a water control district enfranchises only landowners within the district. (As suggested earlier, this was changed by opinion of the state attorney general.) The water control district election was scheduled at the same time as the fall general election. Because the water control district required seperate poll books identifying those entitled to vote, the local county registrar of elections requested the district to establish polling places other than those used in the general election. Statute required the polling places to be within the boundaries of the district, and the scarcity of public buildings dictated the use of private residences.

Interviews with the sample of 139 residents brought to light additional concerns over the basic information availability.[2] Only 40 percent of the sample claimed to have an awareness of the project prior to the April 1967 vote, whereas 23 percent said they had no knowledge and 37 percent made no response. The residents learned about the project primarily through newspapers (34 percent), organizations (34 percent), and relatives and friends (16 percent). Some of them first learned of it when they noticed the new assessment in their tax statements.

Concerning their attitude toward the project, about 50 percent of the respondents either were opposed, indifferent, or knew nothing of the project prior to April 1967. Only 14 percent admitted that they felt strongly enough about it

[2] From a statistical standpoint, the percentage of those in the sample who voted in the April 1967 election (12.9 percent) was relatively close to the actual population percentage (14.2 percent). Ninety-five percent confidence limits about the sample percentages are 8.0 percent to 17.8 percent, and the difference between the sample and population percentages is not statistically significant.

to attempt to convert others to their beliefs. Of nine respondents who indicated that they had changed their mind about the project since April 1967, six had changed it by being against the project by the summer of 1970.

Some of the survey results suggest that voting support for the project was largely from the agricultural sector. A majority of respondents (96 percent) owned land in the district, but most of them (59 percent) owned five acres or less and the primary use was nonagricultural. Sixty percent of the respondents derived no income from their land. Of the eighteen respondents who did actually vote (as verified by voting records), only one was from the nonagricultural sector. A larger turnout might be expected from the nonagricultural sector since it represents 56 percent of the sample population.

In summary, the facts suggest that a democratic result was *not* obtained. Voters were not sufficiently informed, and the locations of the polling places very likely influenced results. Those nonagricultural landowners, who had least to gain from the project, were largely uninformed (or apathetic) and did not express a collective preference. The 9.1 percent of eligible voters who were able to pass the initial bond issue hardly constitute a democratic majority.

Bargaining

Bargaining is a form of reciprocal control. It is not necessarily a clear alternative for some other technique but often works within the framework of the pricing system, bureaucracy or democracy. In order to bargain effectively, each side must have a comparable measure of power. The large number of social groups with different objectives illustrates the existence of bargaining in the United States. In lieu of coordinated planning in this country, much of our national policy is made in a bargaining context.

Bargaining facilitates decisions at several points with the PL 566 network. One decision of particular importance is the agreement on project purposes among the sponsors. The Junction City project is jointly sponsored by eight water districts, two cities (Eugene and Junction City), and two counties (Lane and Benton). Although each group has its own interests, the groups must mutually agree on project purposes or else the Soil Conservation Service will not support the project. This knowledge places the sponsors in a forced bargaining situation where those groups who have most to gain must reckon with those who have little to gain. This bargaining technique has proven to be an effective means of facilitating group decisions related to water resource allocation.

Control over Project Outcomes

We have thus far considered the problems of defining objectives and designing equitable laws. Furthermore, the Junction City data have demonstrated that the

legislation must function satisfactorily within the constructs of several different economizing techniques. We now turn briefly to the problems of control over project outcomes. The elements of control were previously defined to include *measurement*, *feedback*, *comparison with standards*, and, when it was necessary, *correction*.

Adequate control of projects requires continuous *measurement* of economic and noneconomic costs and benefits. The Junction City study suggests that some of the social and ecological outcomes are not adequately controlled. Perhaps this is because there is little, if any, quantitative measurement of the extent to which social and ecological outcomes are being effected. This, in turn, may be due to the failure to state more explicitly the anticipated outcomes as objectives in the project work plan or, perhaps more importantly, in the enabling legislation.

Should vague and ill-defined social objectives be incorporated into water management legislation? If they are, this places a heavy burden upon the judicial system. However, precedence exists for calling upon the courts to arbitrate differences and place a measure of value on social action. The Sherman Act is an example of this. It was simply a broad declaration that restraint of trade is illegal. However, recognizing that *any* contract restrains trade somewhat, the courts have forced quantitative definitions of product lines, market share, etc., to the point where this antitrust legislation now exerts substantial social control over our economic system. This is accomplished by having courts consider the merits of each case individually. Over time, the courts extract and delineate the type of behavior that society feels is equitable. If water project benefits are to be equitably assigned to all segments of society, they must ultimately stand the test of the courts.

Nevertheless, the measurement activity for social outcomes should logically follow from a declaration of objectives, even if it is at first only a broad declaration. The National Environmental Policy Act of 1969 is such a first step. The more precisely defined and explicit the declaration of objectives is, however, the easier the measurement activity will become.

Feedback of the measurement data is necessary to maintain effective control. Economic control of PL 566 projects is facilitated by budget and accounting procedures which provide cost data to project administrators. If social and political objectives are to be attained, data of environmental analysts, social scientists, the courts, and other such parties must also be fed back to project designers and lawmakers.

Project objectives should constitute the *standards for comparison* of project outcomes. Actual economic costs are, of course, more easily compared to budgeted forecasts than are the less tangible social costs. However, if conditions of equitability are to be attained with respect to social outcomes of water resource projects, the actual social costs and benefits will have to be compared with project objectives.

A final and crucial element of control involves correction of activities that are not functioning according to plan. Economically, this may mean cutting costs or

revising budgets. Socially, this may require arbitration over environmental and other issues or even legal action to enforce objectives. Correction can function properly only when the enforcing entity has both the authority and ability to correct. In many cases, authority stems from a legal definition of rights and responsibilities. This, again, points up the need for incorporation of social objectives into legislative enactments and project work plans.

6 Public Good, Innovation, and Decision-Making

The translation and elevation of private wants into public needs has long been a trademark of *our* political system. In one of the earliest American political documents, *Federalist #10*, James Madison argued that given human nature and the propensity of man to aggregate himself with other men in order to better pursue similar interests, factions or groups should be allowed to follow their own interests with the government acting as a sort of referee to provide the ground rules and prevent any one faction or group from dominating the rest. Since Madisonian times, two things of significance have occurred with respect to government that have import for our interests here: (1) although the private sector has continued to remain the largest economic sector, the public sector has enlarged as well; and (2) we now realize that government plays a much greater role than referee in managing competing interests groups. Government itself is now an active participant in the game as well.

These two facts have import here because water resource development today involves this active participation by government in pursuing or helping others pursue their own interests, and it also involves the articulation of a framework borrowed from the economists on the nature and dispersal of public goods.

The Public Good

Almost 200 years ago Adam Smith, writing in *The Wealth of Nations*, outlined the three major functions of government. First, government was to make sure that threats from the international environment were handled adequately; second, government was to insure that justice was administered and enforced domestically; and third was the duty of erecting and maintaining certain public institutions which it can never be for the interest of any individual, or small number of individuals, to erect and maintain because the profit could never repay the expenses to any individual or small number of individuals, though it may frequently do much more than repay it to a great society. This from a man who epitomizes the laissez-faire attitude of government vis-à-vis the economy. Even Smith realized that certain goods, either in the form of a service or a tangible item, are better financed by the public sector–by the people generally–than through the private sector.

What qualifies a good as being public, private, or something inbetween? Economists differ in terms of what they call a good: some differentiate between a private and collective good, meaning that collective good is the same as a public

good. Collective goods share two common properties: (1) they are usually supplied to a group of people rather than to individuals; and (2) they can ordinarily not be held back from someone who wants to utilize them. To put the latter point another way, the benefit from the good is shared by anyone who wants to utilize it; none can exclude the individual from using the good.

If we conceptualized a continuum from a purely private to a purely public good, we would think that the purely private good would be derived solely from private wants; the funds would be allocated by the private sector; and the output from that sector would be consumed on the basis of those who can pay for the product. On the other side of the coin is the purely public or collective good which stems from public wants. The funds are allocated by the public sector, and the "product" is consumed by the populace. An example of a purely public good might be national defense.

It is obvious that most "goods" are either quasi-public or quasi-private, depending on whether the wants are generated from either a public or private source, or whether the funds are allocated by either the public or private sector. The Amazon Flat Creek project is just such a case of a mixed type of good.

Since public goods, just like private goods, cost money, a way has to be found to raise the necessary revenues to pay for the public good. Now, a problem immediately arises when we try to examine the cost side of the picture as to who will pay for this public good. Since the nature of the good is its indivisibility as well as the fact that no one can be excluded from using it, why should the individual pay any of the costs when, upon production of the public good, he will be able to utilize it? This problem is known in political-economical terms as the free-rider problem: simply, that the individual acting in a self-interested fashion sees incentives to withhold his resources, hoping that the efforts of others will suffice to provide the good. In other words, let someone else pay for it, but I'll enjoy it—not an uncommon approach within the American culture.

The financing of public or collective goods has traditionally been the role of government or the polity. It is through this mechanism that the free-rider problem is overcome. By empowering a third party to raise, levy, and collect taxes, everyone shares in the burden of paying for the good.

We can see that resolution of the free-rider problem is through the creation of a special district government. These constitute a specific class of separate governmental units which possess substantial fiscal and administrative independence and are not merely parts of other governments. The needs for special district governments are multiple. Bollens [1957] suggests seven:

1. Unsuitability of other local units in terms of the area.
2. Unsuitability of other local units in terms of finance and function.
3. Unsuitability of other local units in terms of administration and attitude. If administrative situation is poor, then the function is entrusted to a special district or, in some cases, the function already being performed is officially moved.
4. Desire for independence.

5. Advocacy by existing governments. As Bollens suggests, and which is most salient here, "One of the most important means is through the impact of professional functional specialists. Their primary objective is the enhancement of a single public activity and their promotional work may be undertaken with little consideration of its effect on existing government."
6. Expediency and area condition–setting up a district is an easy method of responding to a need, and it can be done quickly.
7. Unadorned self-interest.

Further, Bollens states, "There are several reasons for the establishment of drainage districts. The problem became more and more of a governmental one as it became apparent that landowners who would benefit from a drainage project could not reach agreement, especially on the method of apportioning costs. A governmental mechanism was frequently necessary to provide enforcing and financing the methods" [1957, p. 169].

Borrowing heavily for our initial concepts from the economists on the nature of public and private goods, we have also begun to realize that it is impossible to talk of public goods without some understanding of the significant role that government plays in the financing and allocating of those public goods. Governmental agencies and personnel do not take passive, reactive roles, but are aggressive in the creation of "public" needs and wants as well as in the execution of those needs and wants into publicly supported and completed goods.

Innovation and the Need for Advocates

Development has come to be viewed as a specific category of change. It is, nevertheless, a form of culture change–a change ultimately based upon the innovative process in the minds of men. An innovation is a new mental construct. The locus of a new idea is a real person, not a *heuristic system*. All people innovate, but it is the fate or consequences of innovations with which society and scientists concern themselves. It is important to note that if diffusion of an innovation is to occur, the recipient or adopter of the innovation must go through a mental process similar to that of the original innovator–he, too, is an innovator. It should also be noted that "in by far the majority of cases only the inventor needs what he invents" [Barnett, 1953, p. 298].

The development of the Amazon Flat Creek project of the Junction City Water Control District can be traced to one or two specific individuals. These farmers, like many others in the area, had a great deal of standing water on their farmland during the winter. These two men attempted to build drainage ditches themselves in order to improve their farmland; at one time they were able to induce the county to undertake some work for them, but since the county had no funds for individual projects, they bonded themselves to levy term debt to get the work done. These two individuals desired more improvement than their

own resources would allow; and on being informed of the provisions of Public Law 566, they learned that their personal costs could be minimized.

In order to obtain the good—not the dollars, but the product—a legal district had to be created in order to apply for construction funds. The special Junction City Water Control District was created. This special district has the power to tax property. It requires only a majority of those voting to pass a bond or create a tax base. On April 18, 1967, a bond was passed by public election in the district for $685,000 in order to qualify for $3.6 million from the federal government for construction of the project.

What had been a private desire was transformed into a public issue. The effective control of water, of course, requires extensive control of a watershed. One person attempting to control water on his own property may be at the mercy of conditions of up-drainage and down-drainage; that is, he may have minimal control over the environment affecting him. Creating a special district and applying for funds for a large-scale project is a strategy for ultimately obtaining more private good; the advocate of this strategy is, in economists' terms, operating in self-interest.

It was stated above that in the majority of cases the inventor only needs what he invents. If this were not so, his creation would require no advocacy. When the original advocates in the Junction City area learned about Public Law 566 and began to develop a proposal, they automatically obtained the aid of professional advocates. Governmental agencies act as powerful surrogate advocates. Barnett explores this situation:

> Governments as well as private groups among their citizens utilize promotional machinery to advance or suppress new ideas. Autocrats occupy an enviable position in this respect; but the heads of democratic governments operating under popular mandates, however acquired or interpreted, act as surrogate advocates with a powerful organization at their disposal. Promotional methods differ; but whether the authorization for a change is Hitlerian decree or a parliamentary enactment, its face-to-face protagonists as far as its acceptors are concerned are the personnel or the governmental agencies assigned to institute it. Although the praise or blame for reforms is directed at corporate bodies, such as political parties and administrations, the real advocates must take the shape of individual human beings who represent them and individually subscribe to their programs. Bureaucrats and other public servants therefore make up an important category of paid advocates of change who, like investors and professional publicists, are interested as much in the fact of acceptance as they are in the social consequences of it. In other words, getting the idea across is a job for them. They are professional advocates.
>
> Professional advocates are experts in persuasion. Their activities, more than anything else, support the popular fancy that inventions are prompted because people need them. In fact, need is an individual condition, and a mass concentration of it is a relatively infrequent occurrence. In by far the majority of cases only the inventor needs what he invents. If this were not so, his creation would require no advocacy. A simple announcement of its availability to a waiting

world would be and sometimes is sufficient. But when organized advocacy by specialists and vested interests is called for, it can scarcely be maintained that group necessity is the mother of invention [op. cit., p. 298].

In the creation of the proposal and work plan for the Junction City project, twelve local sponsoring organizations and the Soil Conservation Service were the professional advocate agencies involved—a considerable resource for the individual farmers desiring water control in the Junction City area.

Participation in the Decision Process

The earlier discussion of social organization and communication (Chapter 2) indicated that district residents were far from being uniformally informed and rarely were active in attempting to influence one another. Voting data also indicate a great lack of participation in decision-making. The voting statistics referred to earlier in Chapter 5 are set out in more detail in Table 6-1.

Date:	April 18, 1972	Yes	196	
Amount:	$685,000	No	110	
Result:	passed		306	Voting: approx. 2,000 eligible
Date:	November 5, 1968	Yes	55	
Amount:	$27,000	No	73	
Result:	defeated		128	Voting: 2,532 eligible
Date:	May 26, 1970	Yes	73	
Amount:	$27,000	No	136	
Result:	defeated		209	Voting: approx. 2,600 eligible
Date:	July 23, 1970	Yes	47	
Amount:	$6,930	No	55	
Result:	defeated		102	Voting: approx. 2,600 eligible
Date:	November 3, 1970	Yes	103	
Amount:	$27,000	No	97	
Result:	passed		200	Voting: approx. 2,600 eligible

Table 6-1. Voting Data.

The bond vote was held on April 18, 1967; later votes were to establish a tax base for annual maintenance of the drainage system. The November 5, 1968, voting records were used as a basis for the survey sample of the district residents. Due to problems of district/county record-keeping, it was impossible to obtain an accurate list of eligible voters for the April 18, 1967, bond vote. It should also be noted that the criteria for voting eligibility changed after the April 18, 1967, vote. Persons voting on that date had to be property owners within the district. Later, Oregon law made *all* registered voters eligible. This change en-

larged the universe of voters in the Junction City Water Control District but has had no discernible effect on the number of people actually voting.

Voting indicates low participation by district residents in this legal decision-making process. Clearly, the issues involved that need to be voted on are what the political scientist labels "low salience" in terms of voting behavior.

Who Benefits: Satisfaction with the Results of the Decision Process

During the survey, residents were asked who they thought would benefit the most from the project. As Table 6-2 shows that farmers were the ones most frequently identified.

	Percentage
Farmers	46
Eugene-Junction City urban-suburban areas	4
All landowners	14
People adjacent to ditches	9
Other	8
No response	19
	100

Table 6-2. Who Will Benefit Most?

Property owners and government can be identified as the legal benefactors, but, as one can see above, the public perceives differential beneficiaries. The free-rider problem is overcome, but there remains a question of equity among beneficiaries. If the public is dissatisfied with conditions, the only control they can exert once the district is created with the power to bring sanctions against people (power to tax) is to vote against future issues.

7 Feasibility of Models To Evaluate Water Resource Allocation Decisions

This study has explored the feasibility of describing the water resource decision process in terms of a model. Models attempt to describe the essence of a situation or activity without actually duplicating reality. If the model duplicated reality in all respects, then it would not reveal anything new. Therefore, models abstract from reality so that the decision makers can study relationships among relevant variables in isolation.

The decision network described earlier constitutes one type of model—a graphic flow schematic model. Other types of models include scale, pictorial, verbal, mathematical, and statistical models. Decision situations which are very complex are often best described in the words or policies that go together to make up a verbal model. If the data can be quantified, mathematical, and/or statistical, models may be useful.

Mathematical and Statistical Models

Mathematical models derive their value from being useful tools to interpret and predict real-world events. If a mathematical system can satisfactorily depict the essence of the real-world situation, then proven rules of logic can be used. That is, valid deductive reasoning can take place to arrive at conclusions. This approach is depicted in Figure 7-1.

In many cases, complete data cannot be obtained about the variables that affect decisions. Decisions must be made on the basis of partial, or sample, information. Statistical models offer a means of valid inductive reasoning when decisions must be made on the basis of sample information.

In general, for mathematical and statistical models, the objective of the model is some function of controllable and uncontrollable variables, and any random error is introduced by virtue of working with a sample rather than a whole population.

$$\begin{matrix}\text{OBJECTIVE} \\ \text{CRITERIA}\end{matrix} = f\left(\begin{matrix}\text{Controllable} \\ \text{Variables,}\end{matrix} \quad \begin{matrix}\text{Uncontrollable} \\ \text{Variables,}\end{matrix} \quad \text{Error}\right)$$

Constructing Quantitative Models

The construction of mathematical models requires that the model builder correctly (1) identify the controllable and uncontrollable variables involved, (2)

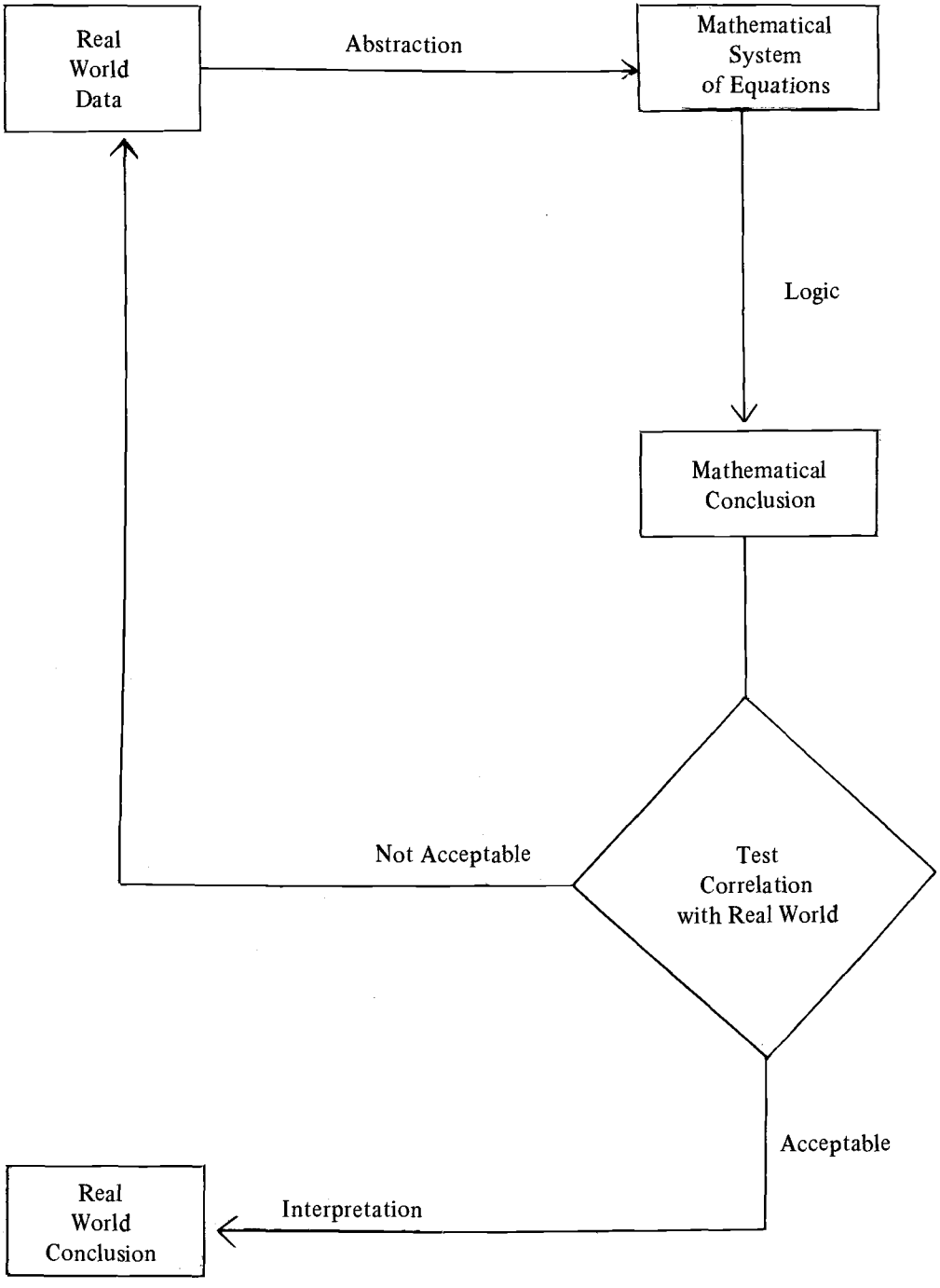


Figure 7-1. Mathematical Models.

assign appropriate numerical values to the variables, and (3) determine the logical relationships among the variables. In many cases the relationship consists of mathematical equations that link the variables to each other and to the resultant objective output of the model. The analyst can vary the values assigned to the controllable variables and observe the effect on the resultant objective criteria. In this way an analyst uses a model for experimentation.

The mathematical-statistical model inherently relies upon the manipulation of quantitative symbols or numbers to arrive at alternative values of the objective criteria.

Applicability to Water Resource Decision-Making

A simple model of water resource decision-making would state that the outcomes of water resource decisions are a function of the inputs to the decision process (plus any sampling error):

$$DO = f(CV, UV, \epsilon)$$

Where: DO = Decision Outcome (including Benefits [B's] and Costs [C's])
CV = Controllable Variables
UC = Uncontrollable Variables
ϵ = Error term

The difficulties of formulating mathematical and statistical models arise from trying to identify and assign quantitative values to all the input variables and outputs, and to establish accurate empirical relationships between the variables and the outputs.

Numerous attempts have been made to formalize various aspects of resource decision systems. A systems approach by Toebes [1969] characterizes the physical resource system and its environmental bonds in terms of three types of functions, namely, the cost-input, the transfer, and the output-benefit functions.

Cost-Input. The cost-input functions stem from the economic system and are of the form:

$$C_{ik} = K(X_{ik}) + \Theta_i M(X_{ik})$$

Where: C_{ik} = present value of the k-th input into system component i ($)

$K(X_{ik})$ = capital cost of the k-th input into system component i ($)

$M(X_{ik})$ = annual operation, maintenance and repair costs, ($/yr).

$\Theta_i = \Theta_i (r,t)$ = single period present value factor dependent on interest rate, r(%), and component life T (yrs).

Transfer or Input-Output. The transfer functions are mathematical models that represent systems components and consist of a set of functionals, since the components are subsystems of some complexity. A symbolic form is:

$$f_i = f_i(X_{ik}, Y_{ij}, S_{is})$$

Where: f_i = the set of functionals descriptive of system component i

X_{ik} = the k-th input to systems component i

Y_{ij} = the j-th output from systems component i

S_{is} = the s-th state variable of systems component i

An obvious difficulty of systems modeling results from imperfectly known transfer functions. Frequently they pertain to ecological relationships involving large time lags. Furthermore, a system results only when transfer functions have been combined into an interactive, mutually constraining systems function set. This necessitates formulation of alternative equations that relate to systems objectives.

Output-Benefit. The output-benefit functions are also part of the economic system and are of the form:

Tangible:

$$B_{ij} = \Theta_i \int W_{ijl} D(Y_{ij}) dY_{ij}$$

Intangible:

$$B'_{ij} = W'_{ijl} Y_{ij}$$

Where: B_{ij} = present value of benefit from j-th output of component i ($)

$D(Y_{ij})$ = demand price for a unit of the j-th output of component i ($/unit)

W_{ijl} = Weighting factor for addition of B_{ij} to the budget of the l-th objective, dimensionless. If $W'_{ijl} > 0$, the output is in effect a cost.

Some demand price values, such as the price of irrigation water (acre-feet/year), are more tangible than others. Imputing other demand price functions can be difficult. In addition, systems outputs are generally variable, which leads to the need for statistical evaluation of output, e.g., flood control reduction benefits. The output-benefit functions for the intangible benefits (as just shown) account for large, long-range systems, where the $D(Y)$ function cannot be determined. When $W'_{ijl} < 0$, these equations represent nonmarket costs.

Utility Functions, Objectives, and Criterion. A measurement parameter, or utility function U, must be developed to measure the degree to which the alterna-

tives satisfy stated objectives. Typically, a convenient but imperfect unit used is the monetary value, dollars. Nearly always, however, in modern resource development, more than a single objective is pursued. Unambiguous ranking for more than one objective is considered impossible. However, making a prejudgment as to the relative significance of one objective as compared to another can lead to iterative adjustment of single objective optimization. If the utility equations are written in terms of preselected minimum benefits, their partial differentials may be obtainable.

Whereas a semiformal framework can be established by expanding the above, Toebes [op. cit.] points out that such an approach has greater didactic value than practical value for several reasons:

1. Public resource systems developments involve several objectives. If these are noncommensurate, even though quantifiable, optimization of utility is impossible.
2. Systems with essential intangible outputs cannot be ranked unambiguously.
3. Even if one assumes that differentiable functions are obtainable, some of the equations are valid economic criteria only if the variables involved are subject to no or only a few constraints (but see the following section on a Linear Programming Model for Water Resource Decisions). In general, there are numerous constraints of the functional, level, or regional type that derive from physical, technological, budgetary, institutional, legal, and/or political conditions.
4. The differential-calculus methods, though useful for algebraic or quadratic forms, may lead quickly to nonsoluble equation sets.

Other Analytical Approaches

In addition to the graphic-schematic and systems approaches discussed earlier, other approaches to modeling the water resource decision process were investigated. A linear programming approach appeared to hold some promise if certain limitations could be efficiently circumvented. The application of network theory methods was also investigated. A discussion follows of the linear programming and network theory approaches.

A Linear Programming Model for Water Resource Decisions

Economic and Social Benefits

The Junction City project, like many other water resource development efforts, claims a number of primary and secondary benefits. Among them are

flood control, irrigation, drainage, land stabilization, and wildlife benefits. The project involves both economic and social values, the latter being, of course, traditionally difficult to take into account in planning decisions.

Using the Junction City project as a basic reference point, a linear programming model has been developed for use in evaluating water and related land resource planning decisions. The model is essentially an attempt to optimally allocate limited resources based upon social, as well as economic, benefits. In addition to the flood control and other benefits cited above, the model has been expanded to include water supply, water quality, and recreation benefits as well as electric power and navigation benefits.

The Model

The linear programming model is described in detail in Appendix C. An objective function of the following form is maximized: the total maximum benefit possible is equal to the sum of the products of the amount of benefit per unit of the j^{th} type of benefit and the number of units of that benefit type. A computational technique is presented which eliminates several of the limitations that the standard simplex algorithm possesses.

Concluding Remarks

In the linear programming approach, a common unit of measurement for all the various benefits was desirable. Strong consideration was given to utilizing "need coefficients" and other types of units, but the most workable unit turned out to be dollars. Thus the assumption is that defined social benefits can be converted to dollar values by means of opportunity cost, cost of the most likely alternative, or some other method.

The water resource planning model being developed is still in the experimental stage, and not all questions have been answered. For example, how can nonlinear decision variables be handled and how can the unique solution method described (the B.B.D.O. technique) be programmed on the computer for extremely large problems while maintaining the flexibility of a manual solution? Also, is it safe to assume that all linear programming water resource planning models will take on the special characteristics necessary to apply the B.B.D.O. solution procedure? At this point it would seem that an attempt to make water resource allocation decisions using a predetermined mathematical model (which takes into account both economic and social benefits) is both a feasible and potentially practical approach to water resource management. Additional effort along these lines would seem justified in order to explore this further.

Network Flow Model Feasibility

The decision network discussed in Chapter 4 seems to possess many of the characteristics of network flow models. Schematically, the network is a sequence of links and nodes which advance from an initial state to a final state. However, the network does not technically meet the mathematical requirements of network flow, and efforts to formulate the network in terms of the language and symbols of network flows were unsuccessful. The efforts did provide additional insight into the feasibility of constructing probabilistic models of water resource decision-making.

Applicability of Network Models

The decision sequence network discussed previously is effectively a series of decision processes rather than a single decision process. Each node represents a decision point where input variables must be weighed in relation to the decision criteria. If the variables and decision criteria were constant throughout the network, with only the weighting factors changing, the development of a mathematical model of this process would be made easier. However, both the input variables and the decision criteria may differ from one node to the next in the PL 566 network. This factor mitigated against formulating a "clean" mathematical model of the system.

Of more significance, perhaps, was the difficulty associated with substituting some water management objective utility function in place of the tangible physical flow optimized in conventional network flow models. Within the PL 566 decision network, no physical entity flows throughout the system, other than paperwork. Efforts to use monetary units or psychological needs as a transfer entity were largely unsuccessful due to the fact that decision criteria change from one node to another. Finally, the network flow technique is designed to optimize flow from source to sink. This characteristic cannot be utilized until a satisfactory transfer entity is determined.

Probabilistic Model Feasibility

The Junction City study has revealed that many ill-defined and uncertain inputs may affect decisions at various nodes in the PL 566 network. In addition to dealing with a massive number of variables, many of them are time dependent and are based upon human values and attitudes which may change from day to day. Whereas in theory it may be possible to develop an accurate predictive model of the PL 566 decision-making process, in practice the possibility of doing so must be questioned at this time.

Theoretically, since each point in the decision network is, in itself, a decision process, the input variables and decision alternatives should be identifiable. Viewing the process from a classical long-run frequency perspective or from a Bayesian viewpoint, one could theoretically assign subjective probabilities to the various alternative outcomes at each decision point. Via simulation, expected values could be arrived at for each node and conditional probabilities developed for the network in total.

To illustrate the practical feasibility of this, let us consider one node only, e.g., a bond issue vote. Some of the inputs that influence the outcome are: existing tax level, economic situation in the country, income level of the community, educational level, amount of advertising by the sponsor of the bond issue, level of awareness of the community to the problems and perspective of what problems the project is going to solve, weather on election day, and (as brought out earlier in this study) location of polling places. Voters may consider such things as costs, flooding damage, wildlife effect, and taxes in making their decision, or they may overlook these issues completely. A predictive model, founded on fact, should incorporate all factors, such as those just listed, which may affect the decision.

Other nodes in the network could be reviewed in similar fashion. A case may be made for statistical sampling of voters and for prediction at some nodes based upon correlation and regression analysis. However, in view of the multitude of uncertain and ill-defined variables and the changing decision criteria at each node, it is doubtful that mathematical formulation of the decision network, utilizing subjective probabilities and expected values, would result in additional benefits which would justify the time and effort to accomplish such a formulation. Investigation into means of aggregating social values and attitudes and applying them to water resource decision-making would seem justified at this time. With progress in this area, the prospects for better predictive decision mechanisms will improve substantially.

8 Summary and Implications

> Democracy is the recurrent suspicion that more than half of the people are right more than half of the time.
>
> E. B. White

The Junction City project, or more correctly the Amazon Flat Creek Watershed development, was chosen for two reasons: first, because it contained all levels of government participation and involved a degree of a democratic input into the decision by the general populace; and, second, because it was near the home base of the investigators. Being funded under PL 566, the project should have been planned and carried out jointly by local, state, and federal agencies with the full understanding and support of a large majority of the landowners and citizens of the community. This made the project an ideal vehicle for the study of local input into the type of resource development decision-making where a large percentage of money comes from the federal government.

In this project a local agency of government was created to administer and to manage the construction. It was necessary to submit a tax base to the voters of the area, and therefore an election was held. The study of this complete process from the local elections to gain local approval through the administrative processes of a bureaucratic system into the political system of the Congress provided an excellent vehicle for the study of decision-making in a compact situation.

Conclusions and Recommendations

This study brought to light some new insights about water resource decision-making. It also tended to reinforce some ideas and concepts which perhaps had been alluded to before but had not been validated by empirical evidence. The empirical data here tend to question the validity of the democratic process and due process as it is actually administered in the development of water development projects. Some key observations which were noted are:

1. Very few persons actually participated in the decision process even though the democratic process provided them the legal right to do so. Voting data support this observation. Analysis of this situation suggests that the communication of information to those persons who have the right to vote satisfies the legal criteria but does not provide the actual notice necessary to stimulate the majority of voters to get out and take a stand on the issues.

2. The information flow by those in authority and control did not permit appropriate development of opposition until it essentially became too late for such opposition to be effective. An illustration is the Flat Creek Committee. It was organized to oppose the direction in which the channelization was going but did not get started until about three years after the project was funded and after extensive construction had been completed. Other individuals were remotely aware of the channelization project but did not become actively involved until it began to affect their pocketbook or their property.

3. The legal channels of communication are inadequate even when they are supplemented by news stories and public hearings. It appears that large numbers of the people did not hear about the project until it began to affect them physically in some way.

4. Residents within the water control district perceive that a specific category of people is receiving the most benefit from the project. Occupation and settlement patterns most probably account for the perception.

5. Decision-making criteria change at local, state, and federal and congressional levels. The decision initially concerns the physical capabilities of development and is primarily an engineering question. As the proposed project gets to the federal agencies, it becomes an economic question in that it must satisfy the cost-benefit analyses and other requirements for funding. When those tests have been satisfied, it becomes a question for Congress to determine whether or not it is politically expedient to fund this particular project. These categories are not distinct in themselves, and there is overlap from one category to the other, but generally they seem to apply. Even the local justifications seem to change as individuals' perceptions of the need for the project affect their own economic situation.

6. Understanding the nature of a public good and identifying advocates were found to be fruitful approaches to this study. Technical and cost-benefit analysis on the one hand and leadership on the other were found to offer little explanation of the dynamics observed in this project.

7. The Junction City project was initiated as a flood control and drainage project, but when the concept of irrigation was introduced, some people began to look at the potential gain resulting from irrigation more than at the potential loss resulting from floods and standing ground water. The issue of profits became paramount and subordinated the original issue of damages and loss.

8. The local administrative unit (that is, the water control district) is composed of residents who act as directors but do not necessarily see themselves as government officials. They appear to see themselves as exercising a degree of authority which is necessary to accomplish their own aims.

9. The name of the local administrative unit was misleading to many residents. These people equated the proper name of the district (the Junction City Water Control District) with the municipality of Junction City. In some instances this led to apathy or opposition. Those persons living in what is predom-

inantly the suburban area of Eugene did not look favorably upon something which they, at least by terminology, thought benefited those in Junction City rather than themselves. They erroneously assumed that Junction City residents were the beneficiaries of the project. Some other label for the construction project may have facilitated greater acceptance.

The study of the Junction City project suggests that legislation is not functioning in a totally equitable manner. The Watershed Protection and Flood Prevention Act (PL 566) was utilized to obtain funds for the project. The Act is intended to provide federal funds for multipurpose resource development projects that have the full support of a large majority of landowners and citizens in the communities. It is administered by the Soil Conservation Service, which provided technical assistance in drawing up the work plan. Their stated aim is to "bring to bear the interests and activities of the entire natural, political, social, and economic elements of any community to effect the area's development." [U.S. Soil Conservation Service, 1967].

From an applied standpoint the Act's objectives are not sufficiently defined, its economizing techniques are being circumvented, and control over social outcomes is virtually nonexistant. An analysis of the decision process has revealed that techniques of the pricing system, bureaucracy, democracy, and bargaining all play a role in the allocation of water resources under a PL 566 project. Whereas aspects of the pricing mechanism have functioned effectively, the democratic requirement of the legislation was clearly not fulfilled unless one can assert that 9.1 percent of the eligible voters constitute *full support of a large majority of landowners and citizens of the community*. A large portion of the voters appear to have lacked sufficient information about the project to take a stand on its issues. A study of resident attitudes toward the project suggests that it was pushed through by a small group of farmers who had much to gain. Their main purpose in doing so was apparently drainage of their lands. This was construed as primarily a flood control effort which qualified for funds under PL 566. (Some flooding concerns were justified, however.) The bargaining process has facilitated group decisions among the sponsors about project objectives. A significant control over PL 566 projects appears to lie in the bureaucratic organization of the Soil Conservation Service—the key decision point being the setting of a project's priority relative to other projects in the area.

The individual who was not a direct party to the project had little opportunity to influence the decision. Perhaps this is because of the inertia natural to the body of people which we classify as the public, but it was at least aggravated by the difficulties of the information flowing to the individual. He could attend and speak at a public hearing, but field interviews suggest that he most likely knew nothing of the project because there was no one to inform him directly of the proposal. The individual could vote *yes* or *no* on a tax measure, but again evidence suggests that he did not vote because he was not informed. After the hearings and elections the only avenues of dissent available to him were the

courts of law. The individual could refuse the price offered him for his land and force the administration unit to condemn his land and litigate price. This is not normally an effective means of opposition unless a majority of landowners in the path of the project successfully challenge the price so that the cost of construction becomes no longer feasible. A second alternative is to initiate a class action suit. This often costs the individual more than he can afford, and it is limited to those who, in desperation, have no other resource. Perhaps a solution lies in demanding the notice requirement of litigation, e.g., personal notification by means of a summons to the public hearing process. At that point the individual would be hard-put to say, "I didn't know anything about it until I saw the bill on my tax notice."

Finally, we must ask the question, "Can legislation effectively achieve the objectives of water resource management?" Clearly, the legislation is not currently adequate. Social objectives are not sufficiently defined; no universal agreement exists on what is "equitable"; and without measurement of social costs and benefits, an effective control system is impossible. The absence of control is further evidenced by the failure of democratic procedures as suggested in the Junction City study.

Perhaps a more fruitful question to consider is, "Could the legislation be improved to achieve water resource objectives more adequately?" The answer to this would appear to be *yes*, if lawmakers insist upon more delineation of social outcomes in statements of project objectives. Even if these statements are not totally quantifiable at first, they will provide the basis for measurement within our judicial system.

The effects of the National Environmental Policy Act (N.E.P.A.) of 1969, particularly the requirement of an environmental impact study (and the public disclosure of that study) as required by Title 1 102 (2) (c) of that act, are now becoming apparent; and perhaps they may help overcome some of the deficiencies of the former legislation. Certainly the N.E.P.A. will permit those environmental oriented groups, who are aware of what is happening, to enter their protests at an earlier stage and in a more informal manner. Whether this will help to awaken the local citizenry and jar them out of their Laodicean attitude is not yet known. One effect is becoming apparent, however. In the past, the Soil Conservation Service in their development of the small watershed projects has maintained a very low profile and has avoided much criticism. Now, the N.E.P.A. (and the parallel Executive Order 11514) is forcing the SCS to raise their colors and be prepared to defend their recommendations. Any threat of public controversy is likely to cause a governmental agency to proceed more cautiously, more thoroughly. It seems reasonable that the increased visibility of federal agencies will tend to bring "locals" to an awareness of projects at an earlier stage.

The environmental impact studies required by N.E.P.A. will not affect those projects under construction, such as the Amazon Flat Creek project (the subject

of this study). But it does affect all new projects and has forced some projects which are funded (but on which construction has not yet begun) to stop, file the necessary environmental impact study, and then proceed under the new rules.

With the incorporation of more environmental and social objectives into legislation and the feedback of their measured effects through various studies and through the judicial system into subsequent legislation, better control will be attained; and the water management activities will more equitably serve the interests of our total society.

Appendix A

JCWCD Resident Questionnaire

1. Name
2. Age
   Sex M F
3. What is your present occupation?
   a. Where do you work? (COMPANY & LOCATION)
   b. Are you married? Yes No
   c. (IF WIFE INTERVIEWED) What is your husband's occupation?
4. What is your address?
   a. How long have you lived at this address?
      (IF VAGUE, ASK) Did you live at this address when the April 1967 water project bond issue vote was held? Yes No
   b. Where did you live previous to this address?
5. How many relatives do you have living in the Junction City area?
6. How many years of school have you completed?
   a. (IF MARRIED) How many years of school has your spouse completed?
   b. (FOR FARMERS) Is there anyone in your household who has any special training in agriculture? Yes No
      (IF YES) What?
7. Type of land (CHECK APPROPRIATE RESPONSE)
   a. Farming
   b. Residence only
   c. Commercial
   d. Industrial
   e. N.R.
      (IF NOT SURE) How is your land classified for taxes?
8. Do you own this property? Yes No
   (IF YES) How many acres do you have?
   (IF NO) Do you rent? Yes No Other
9. Do you own or lease any other property within the Junction City Water Control District? Yes No
   (IF YES) Where?
   How much?
   What kind?
10. Do you employ any people to work on your property or any leased property? Yes No
    (IF YES) How many?
11. Do you derive any income from your land? Yes No

(IF YES) In what ways? (FARMING, RECREATION, OTHER)
What percent of your total yearly income does that amount to?

12. What is the approximate total income of your household per year?
13. (FOR EVERYONE) Were you reared on a farm? Yes No
(FOR FARMERS) Did you inherit this farm? Yes No
14. Did you vote in the April 1967 bond issue election for construction of the water project? Yes No N.R.
(IF NO) Why didn't you vote?
(NOTE): a. Interest, but not sure how to vote
b. Indifference
15. When did you first hear about the JCWCD project? (PROBE FOR EXACT DATE; NOTE LACK OF REMEMBERING)
(IF VAGUE) Did you hear about the project before the April 1967 vote? Yes No
16. From whom, or how did you first hear about the JCWCD project? (CHECK APPROPRIATE RESPONSES)
Friend Relative Newspaper Radio or TV Through organization Other
17. Did you discuss the JCWCD project with people before the April 1967 vote? Yes No
(IF YES) With whom? (CHECK APPROPRIATE RESPONSES)
Household members
Relatives
Friends
Neighbors
Organizations
At work
Other (SPECIFY)
18. Were you in favor of, opposed to, indifferent to, (or) knew nothing of the project when the April 1967 vote was held? (CHECK APPROPRIATE RESPONSES)
N.R.
a. Why did you feel that way about the project?
19. Did you attempt to convince others of your viewpoint before the April 1967 vote? Yes No
20. Have you changed your attitude about the project since you first heard about it? Yes No
(IF YES) When and why did you change your attitude?
21. Do you think you and your family *personally* will benefit from this project? Yes No N.R.
(IF YES) In what ways?
(IF NO) Why not?
22. Has the JCWCD project been discussed in any organization, groups, or clubs

to which you belong? Yes No
(IF YES) What organizations, groups?
(IF YES) Were you involved in promoting this discussion? Yes No

23. Did anyone *speak to* any meeting of a club, group, or organization you belong to or attended before the April 1967 vote? Yes No
(IF YES) What organizations, groups?
24. Did anyone from the Soil Conservation Service, State Extension Service, Corps of Engineers, or any other governmental agency visit or talk with you *personally* about the project before the April 1967 vote? Yes No
(IF YES) What agency?
What did they discuss?
Do you remember when they visited with you? (BE AS EXACT AS POSSIBLE)
25. Do you feel you may have in any way influenced the decision to proceed with this project? Yes No
(IF YES) In what ways?
26. Do you think your property has increased, or will increase, in value as a result of the JCWCD project? Yes No N.R.
(IF YES) How much?
(IF NO) Do you think it has decreased? Yes No N.R.
(FOR FARMERS) Do you think you will derive more income from your land as a result of the project? Yes No N.R.
(IF YES) How much?
27. Who do you think will benefit the most from this project?
28. Have you signed up any irrigation property for the project? Yes No
(IF YES) When? (PROBE FOR EXACT DATE)
How many acres?
29. Does a drainage and irrigation channel which is to be improved pass through your property? Yes No N.R.
(IF NO) Does a channel run through adjacent property? Yes No N.R.
(IF NO) How far is it to the nearest drainage or irrigation channel?
30. Do you think this project has any influence on fishing, hunting, or other recreation in this area? Yes No N.R.
(IF YES) What or how? (LOOK FOR POSITIVE AND NEGATIVE INFLUENCES)
31. Who do you think initiated this project?
Why?
32. Who do you think is paying for this project?
33. What do you think are important factors in making a project such as this one a success?
34. What do you think hinders the success of a project such as this one?
35. What do you see as benefits of the project?

36. What do you see as drawbacks of the project?
37. (FOR LANDOWNERS) What are your future plans for use of your property? (PROBE FOR PLANS TO CHANGE PRESENT LAND USE)
38. How do you feel about absentee ownership of land?
39. A. The Soil Conservation Service, Corps of Engineers, and other governmental agencies take into account problems of people such as yourself in their planning of water projects. Agree Disagree N.R.
    B. The District has the right to condemn property for projects such as this one. Agree Disagree N.R.
    C. The project leaders did a good job of explaining the purpose of the project before the vote. Agree Disagree N.R.
    D. I think the presently used method of construction is the best possible. Agree Disagree N.R.
    E. Overall, I am satisfied with the project. Agree Disagree N.R.
    F. I think the benefits derived from this project are worth the changes in physical landscape. Agree Disagree N.R.
    G. I think the major benefits of this project are flood controls for the farmers. Agree Disagree N.R.
    H. I think the cost of the project should be borne by landowners in proportion to the amount of land they own. Agree Disagree N.R.
    I. I think the costs of the project should be borne by the federal government. Agree Disagree N.R.

Interviewer
Date
Length of interview
Between which hours
From _____ A.M. (P.M.) to _____ A.M. (P.M.)
Number of callbacks
Completed? Yes No
How cooperative was the informant?
Completely cooperative
Generally cooperative (DESCRIBE PROBLEMS)
Noncooperative (DESCRIBE PROBLEMS)
INTERVIEWER COMMENTS:

Appendix B

Generalized Computer Model Input Format For Water Resource Project Decision Point Analysis

Answer the following questions, A(1) through A(49). If the answer is yes, enter a one (1) in the appropriate column on the input data card (as explained below). If the answer is no, enter a zero (0).

A(1) IS THE PROJECT FOR FLOOD CONTROL AND/OR IRRIGATION
A(2) ARE THERE INTERESTED LOCAL GROUPS WHO WILL SUPPORT THE PROJECT
A(3) HAS A LEADER BEEN IDENTIFIED
A(4) DOES THE LOCAL SOIL & WATER CONSERVATION DISTRICT SUPPORT THIS PROJECT
A(5) WILL A SOIL & WATER CONSERVATION DISTRICT SPONSOR THIS PROJECT IF THE U.S. SOIL CONSERVATION SERVICE FINDS IT FEASIBLE
A(6) DOES THE SOIL CONSERVATION SERVICE FEEL THE PROJECT JUSTIFIES 566 ASSISTANCE
A(7) DOES THE SOIL CONSERVATION SERVICE FEEL THE PROJECT IS FEASIBLE
A(8) IS THERE A SPONSOR WITH LEGAL AUTHORITY TO HANDLE THE PROJECT
A(9) HOW MANY WATER CONTROL DISTRICTS ARE THERE IN THE AREA
A(10) HOW MANY MUNICIPALITIES ARE THERE IN THE AREA
A(11) HOW MANY COUNTIES ARE THERE IN THE AREA
A(12) HOW MANY SOIL & WATER CONSERVATION DISTRICTS ARE THERE IN THE AREA
A(13) DO WATER CONTROL DISTRICTS, MUNICIPALITIES, COUNTIES, AND SOIL & WATER CONSERVATION DISTRICTS AGREE ON PROJECT OBJECTIVES
A(14) DO A MAJORITY OF WATER CONTROL DISTRICTS, MUNICIPALITIES, AND COUNTIES IN THE AREA SUPPORT THE PROJECT
A(15) IF ANY OF 3 PARTIES IN A(14) ARE AGAINST THE PROJECT, CAN THEY BE PERSUADED TO SUPPORT THE PROJECT
A(16) IS THE PROJECT DESIRABLE FROM THE STATE GOVERNORS STANDPOINT
A(17) WILL THE SOIL CONSERVATION SERVICE SET A PRIORITY FOR DEVELOPMENT OF THE WORK PLAN

A(18) WILL THE STATE SOIL CONSERVATION SERVICE FORWARD THE PROJECT TO WASHINGTON D.C. FOR PLANNING APPROVAL
A(19) WILL PLANNING FUNDS BE APPROVED
A(20) WILL A WORK PLAN BE INITIATED BY THE SOIL CONSERVATION SERVICE
A(21) WILL SPONSOR APPROVE THE PURPOSES OF THE PROJECT
A(22) DO SPONSORS AGREE ON THE GENERAL PLAN
A(23) DO PARTICIPATING PARTIES AGREE ON STRUCTURES REQUIRED
A(24) IS THE BENEFIT-COST RATIO GREATER THAN 1
A(25) DOES OR WILL ANY AFFECTED PARTY THREATEN A SUIT TO STOP THE PROJECT
A(26) WILL AFFECTED PARTIES SUPPORT THE PROJECT AFTER COMPROMISING AGREEMENTS HAVE BEEN MADE
A(27) WILL THE FINAL STRUCTURE DIFFER FROM THAT INITIALLY PLANNED
A(28) WILL ALL CONCERNED PARTIES AGREE ON THE FINAL STRUCTURE
A(29) WILL THE BENEFIT-COST RATIO STILL BE GREATER THAN 1
A(30) WILL THE SOIL CONSERVATION SERVICE REGIONAL OFFICE APPROVE TECHNICAL DATA
A(31) WILL THE SOIL CONSERVATION SERVICE SET A PRIORITY FOR PROJECT CONSTRUCTION
A(32) WILL THE PLAN BE ACCEPTED BY SOIL CONSERVATION SERVICE IN WASHINGTON D.C. IN POLICY REVIEW
A(33) WILL THE PLAN BE ACCEPTED BY REGIONAL INTER-AGENCIES IN PROJECT REVIEW
A(34) WILL THE PLAN BE SIGNED BY LOCAL SPONSOR AND PUBLISHED
A(35) WILL THE PLAN BE SENT TO THE SECRETARY OF AGRICULTURE
A(36) WILL THE PLAN BE APPROVED BY THE FEDERAL GOVERNMENT INTER-AGENCIES
A(37) WILL THE PLAN BE APPROVED BY THE BUREAU OF BUDGET
A(38) DO POLITICAL CANDIDATES FROM THE LOCAL AREA FAVOR THE PROJECT
A(39) WILL THE STRUCTURE HOLD MORE THAN 4000 ACRE-FEET OF WATER
A(40) WILL PUBLIC WORKS COMMITTEE APPROVE PROJECT (INPUT DATA SHOULD BE 1 IF THE STRUCTURE HOLDS MORE THAN 4000 ACRE-FEET AND WILL BE APPROVED, OTHERWISE ZERO)
A(41) WILL AGRICULTURE COMMITTEE APPROVE PROJECT (INPUT

DATA SHOULD BE 1 IF THE STRUCTURE HOLDS LESS THAN 4000 ACRE-FEET AND IS APPROVED, OTHERWISE ZERO)

A(42) WILL THE SECRETARY OF AGRICULTURE AUTHORIZE FUNDING

A(43) WILL THE FINANCING BOND ISSUE BE PASSED

A(44) DOES F.H.A. AGREE ON LOAN AND REPAYMENT CONDITIONS

A(45) DO 50 PER CENT OF LAND OWNERS AGREE TO FOLLOW CONSERVATION PRACTICES

A(46) WILL WATER AND LAND RIGHTS BE SUCCESSFULLY ACQUIRED

A(47) CAN MAINTENANCE AGREEMENTS BE SET UP AND FOLLOWED

A(48) WILL CONSTRUCTION BE ACCOMPLISHED IN ACCORDANCE WITH WORK PLAN AND APPLICABLE BUILDING CODES

A(49) WILL SOIL CONSERVATION SERVICE PROVIDE ANNUAL INSPECTION

A(50) WILL CONSTRUCTION LOAN BE REPAID

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OS? FORTRAN  VERSION ?.1          04/09/71  2235

OS3 FORTRAN  VERSION 2.1  H2OPROJT  04/09/71  2235
      GO TO 193
   44 WRITE(61,404)

OS? FORTRAN  VERSION ?.1  H2OPROJT  04/08/71  2235
   70 FORMAT(10I5)
  999 FORMAT(1H1,9X,*THE PROJECT IS FEASIBLE ON THE BASIS OF CURRENT INF
     *ORMATION.*/)

OS3 FORTRAN  VERSION ?.1  H2OPROJT  04/09/71  2235
C      1(37)  WILL THE PLAN BE ACCEPTED BY REGIONAL INTER-AGENCIES IN PROJECT

OS3 FORTRAN  VERSION 2.1  H2OPROJT  04/09/71  2235
  104 CONTINUE
      KICK=I
      GO TO(3,3,3,6,6,6,13,13,13,13,13,13,13,15,15,17,17,18,19,20,21,22,
     2,43,44,

OS? FORTRAN  VERSION 2.1  H2OPROJT  04/08/71  2235
  919 FORMAT(10X,*PROJECT WILL BE DELAYED UNTIL PLANNING FUNDS ARE APPRO
     *VED.*/)
  220 FORMAT(10X,*PROJECT WILL BE DELAYED UNTIL A WORK PLAN IS INITIATED
     * BY THE SOIL CONSERVATION SERVICE.*/)
  221 FORMAT(10X,*PROJECT WILL BE DELAYED UNTIL SPONSORS APPROVE THE PUR
     *POSES OF THE PROJECT.*/)
  222 FORMAT(10X,*PROJECT WILL BE DELAYED UNTIL SPONSORS AGREE ON THE GE
     *NERAL PLAN.*/)
  223 FORMAT(10X,*PROJECT WILL BE DELAYED UNTIL PARTICIPATING PARTIES AG
     *REE ON STRUCTURES REQUIRED.*/)
  224 FORMAT(10X,*PROJECT IS NOT ACCEPTABLE. THE COST-BENEFIT RATIO IS L
     *ESS THAN 1. REDEVELOP YOUR GENERAL PLAN.*/)
  225 FORMAT(10X,*A SUIT BY AFFECTED PARTY WILL DELAY OR STOP THE PROJEC
     *T.*/)
  226 FORMAT(10X,*PROJECT WILL BE DELAYED UNTIL A MAJORITY OF AFFECTED P
     *ARTIES SUPPORT IT OR A COMPROMISING AGREEMENT ON THE GENERAL PLAN.
     **/)
  228 FORMAT(10X,*ALL CONCERNED PARTIES DO NOT AGREE ON THE FINAL STRUCT
     *URE. GENERAL PLAN SHOULD BE REDEVELOPED.*/)
  229 FORMAT(10X,*PROJECT IS NOT ACCEPTABLE. THE COST-BENEFIT RATIO IS L
     *ESS THAN 1. REDEVELOP YOUR GENERAL PLAN.*/)
  330 FORMAT(10X,*REVISE YOUR TECHNICAL DATA TO MEET THE SOIL CONSERVATI
     *ON SERVICE REGIONAL OFFICE TECHNICAL REVIEW CRITERIA.*/)
  331 FORMAT(10X,*PROJECT WILL BE DELAYED UNTIL THE SOIL CONSERVATION SE
     *RVICE SET A PRIORITY FOR PROJECT CONSTRUCTION.*/)
  332 FORMAT(10X,*REVISE YOUR PLAN TO MEET POLICY REVIEW REQUIREMENTS AS
     * DEFINED BY THE SOIL CONSERVATION SERVICE IN WASHINGTON D.C.*/)
  333 FORMAT(10X,*REVISE YOUR PLAN TO MEET REGIONAL INTER-AGENCY REQUIRE
     *MENTS.*/)
  334 FORMAT(10X,*PROJECT WILL BE DELAYED UNTIL LOCAL SPONSORS SIGN AND
     *PUBLISH THE WORK PLAN.*/)
  336 FORMAT(10X,*PROJECT WILL BE DELAYED UNTIL ALL CONFLICTS WITH OTHER
     * FEDERAL PROGRAMS ARE IRONED OUT.*/)
  337 FORMAT(10X,*PROJECT WILL BE DELAYED. FEDERAL BUDGET FUNDS ARE NOT
     *CURRENTLY AVAILABLE.*/)
  338 FORMAT(10X,*PROJECT WILL BE DELAYED OR STOPPED BECAUSE IT IS NOT F
     *AVORED BY LOCAL CONGRESSIONAL DELEGATION.*/)
  440 FORMAT(10X,*PROJECT WILL BE DELAYED OR STOPPED. PLAN HAS NOT APPRO
     *VED BY PUBLIC WORKS.*/)
  441 FORMAT(10X,*PROJECT WILL BE DELAYED OR STOPPED. PLAN HAS NOT APPRO
     *VED BY AGRICULTURE DEPARTMENT.*/)
  442 FORMAT(10X,*PROJECT WILL BE DELAYED UNTIL THE SECRETARY OF AGRICUL
     *TURE AUTHORIZES FUNDS.*/)
  443 FORMAT(10X,*PROJECT WILL BE DELAYED UNTIL BOND ISSUE PASSES.*/)
  444 FORMAT(10X,*PROJECT WILL BE DELAYED UNTIL AGREEMENT IS REACHED WIT
     *H F.H.A.  ON LOAN AND REPAYMENT CONDITIONS.*/)
  445 FORMAT(10X,*PROJECT WILL BE DELAYED. FEDERAL MONEY WILL NOT BE AVA
     *ILABLE UNLESS LAND OWNERS AGREE TO FOLLOW CONSERVATION PRACTICES.*
     */)
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Appendix C

A New Approach to Water Resource Planning Using Linear Programming

Since the early 1800s federal and state governments have carried on many programs to develop the water resources of the United States. At first, the main emphasis was on improvement of navigable streams. Then, beginning in the twentieth century, project planners turned their attention to other objectives such as control of floods; irrigation of land, generation of hydroelectric power, and supply of water for domestic and industrial uses. Today, impressive advances broaden the outlook of planning and water management. [See for example Eckstein 1968, McKean 1958, Mier 1967, National Academy of Sciences 1968, Revelle et. al., 1968] However, much of the current policy and practice has limited consideration of alternatives to those aspects of development that are easily evaluated in terms of economic production rather than those in which nonmarket values dominate. With the increasing emphasis on social values, such as the quality of the water and land environment, recreation, restoration of scenic and historic sites, and maintenance of our fish and wildlife resources, planning processes in water resource management must change to take such factors into account.

Obviously many of the social objectives may not appear to be consistent with the most economical use of water and related land resources. The public is apparently willing to forego the opportunity to spend money in a way that necessarily yields the highest benefit-cost ratio. New methods are needed for the evaluation of water and related land resources that take into consideration both economic and social benefits.

At present, water resource planners do not have available a well-defined set of general procedures by which dissimilar alternatives and constraints may be evaluated and compared on a common basis. It is the purpose of this section to present a technique to aid water resource planners in this decision process.

The methodology developed employs a linear programming model for allocating specific water and land uses to specific parts of a water resource project. The distinctive character of this model is found in its use of a solution technique developed by Batten, Barton, Durstine, and Osborn, Inc. [Buzzell, 1964]. Their particular approach to the solution of linear programming circumvents certain limitations presented by the simplex algorithm.

We begin by reviewing the basic linear programming model. The model is then defined in terms of water resource allocation and applied to a hypothetical water resource project where the two solution techniques are compared and analyzed.

Model Development

Although it is assumed that linear programming is a familiar problem-solving technique, a brief description is presented here to assure that there exists a common base for analysis.

Linear programming deals with the problem of allocating limited resources among competing activities in an optimal manner. This problem of allocation can arise whenever one must select the level of certain activities which must compete for particular scarce resources necessary to perform those activities. Linear programming uses a mathematical model to describe the problem of concern. For example, the general form of the linear programming problem is the following:

Find $x_1, x_2, \ldots\ldots, x_n$ which maximizes the (linear) objective function,

$$z = c_1x_1 + c_2x_2 + \ldots\ldots + c_nx_n$$

subject to the constraints,

$$\begin{array}{lll} a_{11}x_1 + a_{12}x_2 + \ldots\ldots + a_{1n}x_n & & b_1 \\ a_{21}x_1 + a_{22}x_2 + \ldots\ldots + a_{2n}x_n & \left.\begin{array}{c}\leqslant\\ =\\ \geqslant\end{array}\right\} & b_2 \\ \cdot \quad \cdot \quad \ldots\ldots \cdot & & \cdot \\ \cdot \quad \cdot \quad \ldots\ldots \cdot & & \cdot \\ \cdot \quad \cdot \quad \ldots\ldots \cdot & & \cdot \\ a_{m1}x_1 + a_{m2}x_2 + \ldots\ldots + a_{mn}x_n & & b_m \end{array}$$

and the restrictions,

$$x_1 \geqslant 0, x_2 \geqslant 0, \ldots\ldots, x_n \geqslant 0$$

where the a_{ij}, b_i, and c_j are given constants, and the x_j's are the decision variables.

This model can be interpreted as follows: given n competing activities, the decision variables; $x_1, x_2, \ldots\ldots, x_n$, represent the levels of these activities. If each activity is the production of a certain product, then x_j would be the number of units of the j^{th} product to be produced during a given period of time. Z is the chosen overall measure of effectiveness, that is, profit over the given time period. The constant c_j represents the increase in the overall measure of

effectiveness that would result from each unit increase in x_j. The number of relevant scarce resources is m, so that each of the first m linear inequalities and equations corresponds to a restriction on the use of one of these resources. The constant b_i is the amount of the i^{th} resource which is available to the n activities. The constant a_{ij} is the amount of the resource i consumed by each unit of activity j. Therefore, the left side of these inequalities is the total usage of the respective resources. The nonnegativity restrictions ($x_j \geqslant 0$) rule out the possibility of negative activity levels.

The simplex method is the technique used for solving any linear programming (L.P.) problem. This method is an algebraic procedure which progressively approaches the optimal solution through a well-defined iterative process until optimality is finally reached. Since the procedure is well suited for an electronic computer, this was the method of solution first employed. Because of certain limitations of the simplex method and the special characteristics of the water resource L.P. model, a modified solution technique was developed and successfully used.

The linear programming model will now be defined in terms of a water resource optimizing model.

The decision variables (x_j's) of a water resource allocation problem are represented by the levels of activity devoted to the development of a particular water and/or land benefit. The following list defines the primary water and land benefits to which the decision variables of our model refer. All of the information presented in this list was derived from a government report on the evaluation of water and related land resource projects [U.S. Water Resources Council, 1969].

1. *Flood Control Benefits*

   One of the most important variables of any water resource project is the benefit obtained from flood control. Flood control benefits are defined as follows: benefits are obtained by the reduction in all forms of damage from inundation (including sedimentation) of property, disruption of business, hazards to health and security, and loss of life; and by the increase in the net return from higher use of property made possible as result of lowering the flood hazard.

2. *Irrigation Benefits*

   Benefits are obtained by the increase in the net income of agricultural production resulting from an increase in the moisture content of the soil through the application of water or reduction in damages from drought.

3. *Drainage Benefits*

Benefits are derived from the increase in the net income from agricultural lands or increase in land values resulting from higher yields or lower production costs through reduction in the moisture content of the soil (exclusive of excessive moisture due to flooding), and the increase in the value of urban and industrial lands due to improvement in drainage conditions.

4. *Electric Power Benefits*

Benefits are measured by the amount the users are willing to pay for such power. The usual practice is to measure the benefit in terms of the cost of achieving the same result by the most likely alternative means that would exist in the absence of the project.

5. *Navigation Benefits*

Benefits are obtained by the reduction in losses due to hazardous or inadequate boat operating conditions and enhancement in land values from the placement of dredged soil. Also, benefits are measured by the savings as a result of the project in the cost of providing transportation service.

6. *Land Stabilization Benefits*

Land stabilization benefits are those occurring to landowners and operators and the public resulting from the reduction on the loss of net income, or loss in value of land and improvements, through the prevention of loss or damage by all forms of soil erosion including sheet erosion, gullying, flood plain scouring, streambank cutting, and shore or beach erosion, or conversely in terms of advantageous effects of land stabilization.

7. *Water Supply Benefits*

The term *water supply* refers to the provision of water for domestic, municipal, and industrial purposes. Benefits shall be accounted for under this term whenever the quantity, quality or reliability of the supply is favorably affected as the result of programs or projects. Favorable effects shall be considered as any change which facilitates or enhances the useful-

ness, serviceability, or functions of the water bodies for the water supply purpose.

8. *Water Quality Benefits*

Benefits are measured by the net contribution to public health, safety, economy, and effectiveness in the use and enjoyment of water for all purposes which are subject to detriment or betterment by virtue of a change in water quality.

9. *Recreation Benefits*

Benefits are defined as the net increase in the quantity and quality of boating, swimming, camping, picnicking, winter sports, hiking, horseback riding, sightseeing, and similar outdoor activities.

10. *Fish and Wildlife Benefits*

Benefits are obtained as a result of the net increases in recreational, resource preservation, and commercial aspects of fish and wildlife.

Although there exist other primary and secondary benefits, to simplify this presentation we have limited our consideration to those given above. The units of the decision variables (x_j's) used to measure the amount of these benefits could be expressed as acres of land, cubic feet of water, or miles of waterway depending on which benefit is being considered.

In order to assign a degree of benefit (constant c_j) for each benefit type, a common unit for all of the various benefits is required. This unit could take the form of a "need coefficient" as determined from some sort of preliminary field research in the area of the proposed water project. On the other hand, any of several techniques could be used to convert social benefits as well as economic benefits to dollar values (e.g., opportunity cost, cost of the most likely alternative). This sort of approach is detailed in the government report previously mentioned [U.S. Water Resources Council, op. cit.]. In this study the assumption is made that the degree of benefit is measured in dollars per acre of land, dollars per mile of waterway, and dollars per cubic foot of water, depending on which benefit is being considered. The objective function can now be interpreted as follows: the total maximum benefit possible (in dollars) is equal to the sum of the products of the amount of benefit in dollars per unit of the j^{th} type of

benefit and the number of units of that benefit type. Symbolically we have:

$$\text{Max } A = \sum_{j=1}^{n} c_j x_j$$

Thus j refers the j^{th} benefit where there are n types of possible benefits, c_j represents the dollars benefit per unit of the j^{th} type, and x_j represents the number of units of the j^{th} benefits type. For example, we might have the following where there are two types of possible benefits:

x_1 = the number of acres of land protected from flooding

x_2 = the number of acres of irrigated land

c_1 = the amount of benefit in dollars per acre of flood controlled land ($1,000 per acre)

c_2 = the amount of benefit in dollars per acre of irrigated land ($300 per acre)

The objective function is,

$$\text{Max } Z = (\$1{,}000/\text{acre})\, x_1 + (\$300/\text{acre})\, x_2$$

The development of any water resource project is subject to many constraints stemming from the social, economic, and legal environment. Since these three areas are interrelated and interdependent, no attempt is made to differentiate between them in the following constraint classifications of either budgetary restrictions or land and water area restrictions. Budgetary restrictions are determined from the amount of money granted to the development of any water resource project by federal, state, and local government bodies. Many social, economic, and legal factors are involved in the granting of such funds. However, for the purposes of an optimizing model, the concern is only with the end result. Land and water area restrictions are derived simply from the physical characteristics of a potential project and the desires of those individuals residing in the project area and in the control of this area.

The constraints are then interpreted as follows: the total amount of resource i (in dollars, land, or water area) available is less than or equal to, greater than or equal to, or equal to the sum of the products of the amount of the i^{th} resource

to develop one unit of the i^{th} benefit and the number of units of the j^{th} benefit type. Symbolically, we have:

$$\sum_{j=1}^{n} a_{ij}x_j \left\{ \begin{matrix} \leqslant \\ = \\ \geqslant \end{matrix} \right\} b_i \qquad \begin{matrix} i = 1, \ldots, m \\ j = 1, \ldots, n \end{matrix}$$

$$x_j \geqslant 0$$

Thus, i refers to the i^{th} resource where there are m types of resources, a_{ij} represents the amount of resource i to develop one unit of the j^{th} benefit, and b_i represents the number of units of the i^{th} resource. Referring to the previous example, we might have the following where there are three types of resources:

b_1 = the amount of money granted to the water resource development project ($100,000)

b_2 = the amount of land available for flood control (100 acres)

b_3 = the amount of land available for irrigation (100 acres)

a_{11} = the cost (in dollars) to protect one acre of land from flooding ($900 per acre)

a_{12} = the cost (in dollars) to develop one acre of irrigated land ($200 per acre)

a_{21} = the amount of land available for flood control to develop one acre of flood-controlled land (1 acre/acre)

a_{22} = the amount of land available for flood control to develop one acre of irrigated land (0 acres/acre)

a_{31} = the amount of land available for irrigation to develop one acre of flood-controlled land (0 acres/acre)

a_{32} = the amount of land available for irrigation to develop one acre of irrigated land (1 acre/acre)

The constraints would then take the following form:

$$(\$900/\text{acre})x_1 + (\$200/\text{acre})x_2 \leqslant \$100{,}000$$

$$(1 \text{ acre/acre})x_1 + (0 \text{ acres/acre})x_2 \leqslant 100$$

$$(0 \text{ acres/acre})x_1 + (1 \text{ acre/acre})x_2 \leqslant 100$$

Application to Water Resource Project

In order to investigate further the use of this problem-solving technique with respect to water resource planning, the technique was applied to a hypothetical resource project.

All pertinent information concerning the project is summarized in the following sections.

General Characteristics

The project area contains approximately 10,000 acres of land and one medium-sized river. The climate in this area is similar to that of the Pacific Northwest. Five small cities are located on high mounds off the valley floor. Except for the city area, nearly all of the land is used for agricultural purposes. The valley area is bordered on the east and west by mountain ranges.

Applicable Decision Variables

The following is a list of the applicable decision variables (X_j's). Only those variables with a positive benefit value (C_j) for this particular project are included.

X_1 = the number of acres of land affected by flood-control measures

X_2 = the number of acres of land affected by irrigation developments

X_3 = the number of acres of land devoted to recreational areas

X_4 = the number of acres of land devoted to a fish and wildlife reserve

X_5 = the number of miles of cleared navigable waterway

X_6 = the number of acres of land affected by land-drainage developments

Benefit Values Associated with Decision Variables

The values below were subjectively determined. They represent hypothetical rather than actual values.

C_1 = \$1,000 per acre (flood control)

C_2 = \$ 300 per acre (irrigation)

C_3 = $ 500 per acre (recreation)

C_4 = $ 150 per acre (fish and wildlife)

C_5 = $ 350 per mile (navigation)

C_6 = $ 350 per acre (drainage)

Project Constraints

The following resource limitations and requirements were assumed to prevail:

b_1 = total budget granted by various government agencies = $3,000,000

b_2 = maximum area requiring flood control or prevention = 6,000 acres

b_3 = minimum area requiring flood control = 2,000 acres

b_4 = area available for recreation development = 100 acres

b_5 = area requiring drainage = 10,000 acres

b_6 = maximum river transportation route = 90 miles

b_7 = area requiring irrigation = 4,000 acres

b_8 = minimum area requiring irrigation = 2,000 acres

b_9 = area available for fish and wildlife reserve = 50 acres

The costs of the development of each benefit type were assumed to take on the following values:

a_{11} = $ 300 per acre (flood control)

a_{12} = $ 200 per acre (irrigation)

a_{13} = $ 400 per acre (recreation)

a_{14} = $ 150 per acre (fish and wildlife)

a_{15} = $1,000 per acre (navigation)

a_{16} = $ 250 per acre (drainage)

A sketch illustrating the general layout of the project area is shown in Figure C-1.

The linear programming problem to optimally allocate the resources of this project to the six benefit areas was set up in the following manner:

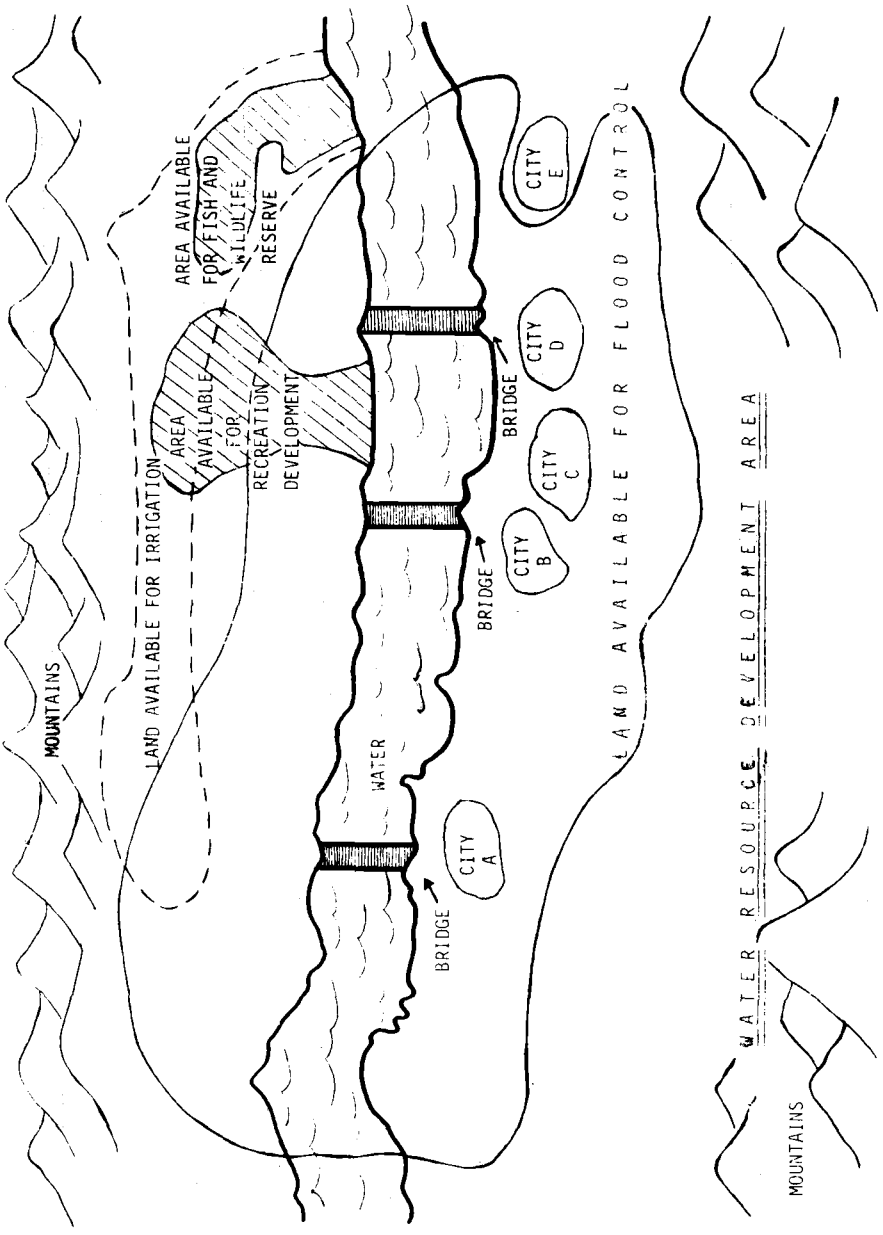

Figure C-1. Water Resource Development Area.

The objective function,

$$\text{Max } Z = 1000x_1 + 300x_2 + 500x_3 + 500x_{3a} + 150x_4 + 350x_5 + 350x_6$$

The constraints,

$$\begin{aligned}
300x_1 + 200x_2 + 400x_3 + 400x_{3a} + 150x_4 + 1000x_5 + 250x_6 &\leqslant 3 \times 10^6 \\
1x_1 + 0x_2 + 0x_3 + 0x_{3a} + 0x_4 + 0x_5 + 0x_6 &\leqslant 6 \times 10^3 \\
1x_1 + 0x_2 + 0x_3 + 0x_{3a} + 0x_4 + 0x_5 + 0x_6 &\geqslant 2 \times 10^3 \\
0x_1 + 0x_2 + 1x_3 + 0x_{3a} + 0x_4 + 0x_5 + 0x_6 &\leqslant 40 \\
0x_1 + 0x_2 + 0x_3 + 1x_{3a} + 0x_4 + 0x_5 + 0x_6 &\leqslant 60 \\
0x_1 + 0x_2 + 0x_3 + 0x_{3a} + 0x_4 + 0x_5 + 1x_6 &\leqslant 1 \times 10^4 \\
0x_1 + 0x_2 + 0x_3 + 0x_{3a} + 0x_4 + 1x_5 + 0x_6 &\leqslant 90 \\
0x_1 + 1x_2 + 1x_3 + 0x_{3a} + 1x_4 + 0x_5 + 0x_6 &\leqslant 4 \times 10^3 \\
0x_1 + 1x_2 + 0x_3 + 0x_{3a} + 0x_4 + 0x_5 + 0x_6 &\geqslant 2 \times 10^3 \\
0x_1 + 0x_2 + 0x_3 + 0x_{3a} + 1x_4 + 0x_5 + 0x_6 &\leqslant 50
\end{aligned}$$

And the obvious restriction,

$$x_1, x_2, x_3, \ldots, x_6 \geqslant 0$$

The decision variable (x_3) was divided into two variables to take into account the fact that 40 acres of the land available for recreation was also available for irrigation. The land cannot be used for recreational and agricultural purposes at the same time. The problem was solved using the simplex algorithm resulting in the following solution:

$$\begin{aligned}
\text{Max } Z &= \$7{,}760{,}000 \\
x_1 &= 6{,}000 \text{ acres} \\
x_2 &= 4{,}000 \text{ acres} \\
x_6 &= 1{,}600 \text{ acres} \\
x_3 &= x_{3a} = x_4 = x_5 = 0
\end{aligned}$$

It is interesting to note at this point that if the water resource planner is only concerned with the optimal allocation of limited resources, he need only estimate the benefit values (C_j's) associated with the decision variables so that each

particular benefit value is in the correct proportion to every other benefit value. In this case the water resource planner would be optimizing the objective function

$$\text{Max } Z = k\,(Cx)$$

where k is any positive real number.

The foregoing description of the application of linear programming to a water resource project is not without its limitations. Referring to the sketch of the water project (Figure C-1), we see that certain portions of the land requiring flood control overlap the land requiring irrigation and the land available for recreation. Obviously, if the area requiring flood control is not part of the optimal solution and irrigation and recreation are, the answer is incorrect. It is of little value if the irrigation ditches and recreation area are both flooded out the first or second year after being built. Statisticians feel that this sort of overlap problem cannot be taken into account through the use of the standard simplex method of solution [Wagner, 1969]. The overlap limitation may not be too serious, however. A study of several actual water resource projects revealed that in many cases where flood control was needed, it was nearly always the first thing to be developed. However, this conditional relationship could exist between other combinations of decision variables which do involve flood control, thus resulting in a situation where the problem could take on an erroneous solution.

Another possible limitation is that the decision variables may have physical significance only if they have integer or discrete values. The standard simplex algorithm is not designed to handle this situation either. Some statisticians have suggested that a solution should be generated ignoring the integer restriction. If this answer satisfies the integer restrictions, then an optimal solution has been found. Otherwise, an integer solution may be obtained by rounding off the appropriate decision variables to whole numbers. Although this approach may succeed for some applications, it cannot be successfully applied in general [Ibid.].

A primary requirement of linear programming is that the objective function and every constraint function must be linear. As defined in this study, all the constraints except the cost constraint obviously satisfy this restriction. The objective function and the cost constraint will most likely take on some degree on nonlinearity. Although one may assume that these two functions are approximately linear, certain circumstances will likely arise in which this assumption cannot be made.

In concluding this discussion of the limitations of linear programming and the simplex algorithm, note that a practical problem which completely satisfies all the restrictions of the solution technique is very rare indeed. Nevertheless, the linear programming model is often the most accurate quantitative representation

of the problem available. It will very often yield a reasonable recommendation for action.

B.B.D.O. Solution Technique

Because the water resource linear programming model possesses special characteristics, a solution technique developed by Batten, Barton, Durstine, and Osborn, Inc. [Buzzell, 1964] can be adapted to it. This solution technique can adequately handle the overlap limitation, the integer restriction, and the nonlinearity characteristics of the model. Upon examination of the linear programming problem presented earlier, we observe that the constraints contain only one equation having variable coefficients other then 0 or 1. This is the main requirement necessary for the implementation of the B.B.D.O. solution technique.

The following is the suggested procedure for solution of the water resource linear programming model based on the B.B.D.O. technique:

1. Divide the benefit value (C_j) for each decision variable by its corresponding cost (A_{1j}) as listed in the budgetary constraint. This is the value of each benefit per dollar of cost, abbreviated BPD.

2. Include in the solution first, each decision variable that has a minimum value specified.

3. Select as many units as possible of the decision variable (X_j) with the highest BPD value up to the limits imposed by the constraints. If any budget remains, it should then be used to select units of the variable with the next highest BPD value, and so on until the total budget is exhausted or until the restrictions prevent further use of a particular variable.

4. If a tie exists between the BPD values of two or more variables, the technique must be rerun for each combination of these tied variables.

In applying this method to the previous example, we have the following:

1. Solving for the BPD for each decision variable,

$$(BPD)_j = \frac{C_j}{A_{1j}}$$

$(BPD)_1 = 3.33$

$(BPD)_2 = 1.50$

$(BPD)_3 = 1.25$

$(BPD)_{3a} = 1.25$

$(BPD)_4 = 1.00$

$(BPD)_5 = 0.35$

$(BPD)_6 = 1.40$

2. Since decision variables X_1 and X_2 have a minimum value specified in the constraints, we initially include them in the solution at their respective minimum values.

$X_1 = 2{,}000$ acres $\qquad A_{11}X_1 = \$600{,}000$

$X_2 = 2{,}000$ acres $\qquad A_{12}X_2 = \$400{,}000$

At this point we still have $2,000,000 in the budget.

3. The variable with the highest BPD value is X_1, thus we have,

$X_1 = 6{,}000$ acres $\qquad A_{11}X_1 = \$1{,}800{,}000$

continuing this procedure until the total budget is exhausted or until the constraints prevent further use of a particular variable, we have;

$X_2 = 4{,}000$ acres $\qquad A_{12}X_2 = \$800{,}000$

$X_6 = 1{,}600$ acres $\qquad A_{16}X_6 = \$400{,}000$

The total budget of $3,000,000 is exhausted at this point.
The optimal solution is the same as we arrived at using the simplex algorithm.

$$\text{Max } Z = \$7{,}760{,}000$$

$$X_1 = 6{,}000 \text{ acres}$$

$$X_2 = 4{,}000 \text{ acres}$$

$$X_6 = 1{,}600 \text{ acres}$$

$$X_3 = X_{3a} = X_4 = X_5 = 0$$

This solution procedure has several advantages over the simplex algorithm. If a decision variable is required to take on only integer values, we need only keep this fact in mind when bringing that variable into solution. In step 3 of the

solution technique one would increase the value of the decision variable up to the limits imposed by the constraints while maintaining an integer value. Also, if there is an overlap problem between decision variables, this can be taken into account as one sequence through the solution. Using the B.B.D.O. technique, one can actually observe what is taking place while the optimal solution is being derived; and thus one can make allowances for special situations. Of course, if this algorithm is programmed for solution using a computer, the method loses some of its flexibility since one cannot continuously observe and control the solution as it is being derived. However, since the solution procedure involves only a few calculations even for large problems and only one iteration, hand calculations would not be an unreasonable task.

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