CONSOLIDATION OF IRRIGATION SYSTEMS PHASE II ENGINEERING, ECONOMIC, LEGAL AND SOCIOLOGICAL REQUIREMENTS

by

Evan C. Vlachos
Paul C. Huszar
George E. Radosevich
Gaylord V. Skogerboe

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by

Evan C. Vlachos
Professor
Department of Sociology

Paul C. Huszar
Associate Professor
Department of Economics

George E. Radosevich
Attorney and Assistant Professor
Department of Economics

Gaylord V. Skogerboe
Professor
Department of Agricultural Engineering

submitted to

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COLORADO WATER RESOURCES RESEARCH INSTITUTE
Colorado State University
Fort Collins, Colorado 80523

Norman A. Evans, Director

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ABSTRACT

This study is both a continuation of an earlier phase attempting to provide a general framework of crucial engineering, legal, and sociological factors (constraints and/or facilitators) involved in any effort of consolidating irrigation systems. This general thrust has been combined during Phase II with a consideration of economic criteria in the "interdisciplinary" effort of delineating the consolidation challenge not only as a simple task of merging adjoining irrigation systems into a single unit, but also as a necessary means for meeting the larger quest for efficient and effective utilization of water resources in the rapidly changing arid West.

Investigations conducted in eight areas of varied socio-economic, legal, physical, and irrigation conditions (Poudre and Grand Valleys, Colorado; Ashley and Utah Valleys, Utah; Eden and Riverton Valleys, Wyoming; the Truckee-Carson Irrigation District in Nevada, and the Salt River Valley in Arizona) have provided a comparative scheme of similar and dissimilar conditions for already consolidated and potential cases for consolidation. Factors of successful operation and management have been isolated and attitudes toward change have been delineated in areas of potential future action leading towards consolidation.

The findings point out that even though efficiency may be desirable from the engineering and economic point of view, questions of equity (fair access of resources to all segments of population) may lead to the decision of nonconsolidation. At the same time, key factors in consolidation include: the particular community environment and culture; appropriate organizational structure and network; and the general perception of change and of alternatives by individual users.

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0.0 PREFACE

0.1 General Introductory Remarks

This study is both part of a continuation and culmination of an earlier phase attempting to provide a general framework of crucial engineering, legal and sociological factors (constraints and/or facilitators) involved in any effort of consolidating irrigation systems. This general thrust has been combined also during Phase II with a consideration of economic criteria in the "interdisciplinary" effort of delineating the consolidation challenge not only as a simple task of merging adjoining irrigation systems into a single unit, but also as a necessary means for meeting the larger quest for efficient and effective utilization of water resources in the rapidly changing arid West.

More recently, the traditional preoccupation with the management of natural resources has been also accentuated by an increasing awareness on scarcity of resources, competing and conflicting demands, manifestations of environmental degradation, wasteful and highly consumptive uses and, finally, by a corollary quest for developing more cogent social policies for improving the welfare of regions and nations.

The present second Phase of the broad study attempts to describe in general terms an interdisciplinary effort directed towards questions of consolidating diverse irrigation systems in the Western United States. Thus, in addition to substantive points raised about consolidation, the study has also served as an example of how various disciplines can come together in order to develop the necessary thrust and means for meeting larger demands for efficient and effective utilization of water resources in arid regions. Competing and conflicting demands, as well as increased awareness of the negative spillovers of environmental disruptions, have made it imperative to develop new schemes for traditional irrigation practices.

A number of irrigated areas in the Western United States have faced serious problems not only because of inefficiencies involved in the running of their affairs or of losses of water resulting from obsolete and overlapping structures; equally important, rapid growth in salubrious environments has provided new challenges of survival in the midst of expanding populations and urban sprawls. It is in this context that a team of diverse disciplines attempted to answer the broad question of how to consolidate systems in order to maximize efficiency and in order to provide alternative organizational schemes for meeting social, economic and environmental demands aimed at successful agricultural enterprises.

There is no need to particularly underline the obvious observation that irrigation has played throughout history a strategic role in the continuous course of many national developments. Irrigated agriculture provided, and continues to provide, the agrarian basis of society and the essential means for the survival of many nations. However, an important point that needs to be brought always forward is that after the basic productive goals of an irrigation system are achieved (i.e., sufficient production for survival and economic growth), other social goals also appear which greatly complicate the institutional arrangements of an irrigation system. Such developments, goals and objectives carry with them both benefits and disadvantages. On the one hand, the control of water resources and the establishment of an irrigated system of agriculture in places where rainfall is inadequate or unreliable permit the establishment of highly productive agricultural practices, followed by an expansion of human population and economic growth. On the other hand, an irrigation system carries with it not only certain technological imperatives which cannot be ignored, but also important social constraints for the operation of what eventually becomes a highly complex system.

Thus, as societies become much more complex and diversified and demands continuously increase and expand in scope and intensity, the use of scarce water resources and the increasing preoccupation with preservation of the natural environment become much more important in concerted natural resources planning. It is in this general context, therefore, that we must also examine the rationale and importance of the question of consolidation as another expression of the concerted effort for managing in an integrated, holistic fashion our environment.

0.2 Recapitulating Phase I

Essentially, during Phase I (of what we may label for reasons of convenience the "consolidation study"--covering about five years of continuous research in both phases) preliminary investigations were conducted in eight areas of varied socioeconomic, legal, physical and irrigation conditions (Poudre and Grand Valleys, Colorado; Ashley and Utah Valleys, Utah; Eden and Riverton Valleys, Wyoming; the Truckee-Carson Irrigation District in Nevada; and the Salt River Valley in Arizona). These areas have provided a comparative scheme of similar and dissimilar conditions for already consolidated and potential cases for consolidation. Factors of successful operation and management have been isolated and attitudes toward change have been delineated in areas of potential future action leading towards consolidation.

It will be important to recapitulate briefly the essence of the thrust of Phase I, a necessary precondition for fulfilling the subsequent, present phase. In its broadest terms the first phase attempted to delineate in a descriptive fashion the following major categories of concern:

1. General problems in irrigation system development with particular emphasis on irrigation in the Western United States.

2. Explication of the consolidation problem, including necessary engineering, legal, and sociological investigations in order to meet the "consolidation challenge."

3. Detailed documentation of both substantive and administrative legal requirements concerning consolidation.

4. In-depth description of the research areas of the study, attempting to show characteristic problems, communalities of concern, aspects of water management, and specific irrigation organizational arrangements.

5. Comparative analysis of the research areas, with special emphasis on general operational principles of irrigation systems; advantages of consolidated and non-consolidated systems; and, finally, attitudes toward water use and consolidation in selected areas.

6. A contrast of engineering, legal and sociological material of the advantages of integrated water management schemes and the provision of a common vocabulary and approach as to what irrigated agriculture and consolidated systems entail.

7. A sharpening of the conceptual and methodological focus by a multidisciplinary design revolving around a systematic analysis of irrigated agriculture.

It should be particularly stressed that the general and predominantly descriptive character of the study was an intended result of the attempt to develop an "interdisciplinary" team and way of thinking that may help diminish the typical compartmentalized approaches to such investigations. In addition to substantive findings in each area of concern, there was also an overall gain of common problematization in the area of water resources and to action programs requiring multidisciplinary and multi-objective presence. Thus, Phase I (as well as the continuation of common work in Phase II) was essentially one of a process of sensitization to the holistic character of understanding the consolidation challenge; a process of mutual education in questions of water planning; finally, a part of the growing need to increase the dialogue and cooperation between "soft" and "hard" sciences.

Turning now to the content and argumentation in the document of Phase I, it should be emphasized that the extensive presentation of the eight areas was done not so much for providing equal depth analysis of each system, but more with an emphasis towards common problems and the creation of a continuum of conditions that would allow the delineation of crucial factors in potential future consolidation of presently non-consolidated systems. The selection of four areas for an in-depth look (especially during Phase II) underlines the key thrust of a comparison of small simple systems (Eden) to medium (Ashley), to expanding and fast urbanizing complex systems (such as Poudre and Utah).

As discussed in Part IV of Phase I, the research areas under consideration are semi-desert, with limited amounts of rainfall, served primarily by reclamation projects which provide water during the latter part of the irrigation year (Figure 0-1). All of these areas are valleys which have a mountain range relatively nearby in which the irrigation water is generally impounded or diverted. The climatic conditions of these areas are part of the typical arid regions, with rather harsh winters (Salt River Valley being the exception). The soil in the areas is generally fertile and productive, provided that it is given adequate water. Farming in these areas is mostly the family-size farm with some corporate farming occasionally appearing in a few cases (as again in Salt River). The larger of the family-size farms would be approximately 1,500 to 3,000 acres and the smaller farms would be cared by part-time farmers who are farming anywhere from 10 to 100 acres of land. The exclusive majority of the farms use modern machinery, with the larger farms investing great sums of money in very sophisticated machines used to prepare the land and harvest the crops. The products which are typically grown on these agricultural areas are small grains, corn, alfalfa, sugar beets, and in the case of the Salt River Valley citrus fruits and cotton. All of the areas with the exception of the Salt River Valley are capable of production for about 120-150 days of the year. The Salt River Valley is capable of producing two complete crops per year and the growing season there is approximately ten months.

But, before we proceed any further in recapitulating the overall characteristics of the irrigation systems of the study, we need to see closer the reasons for selecting the eight areas of the "consolidation study."

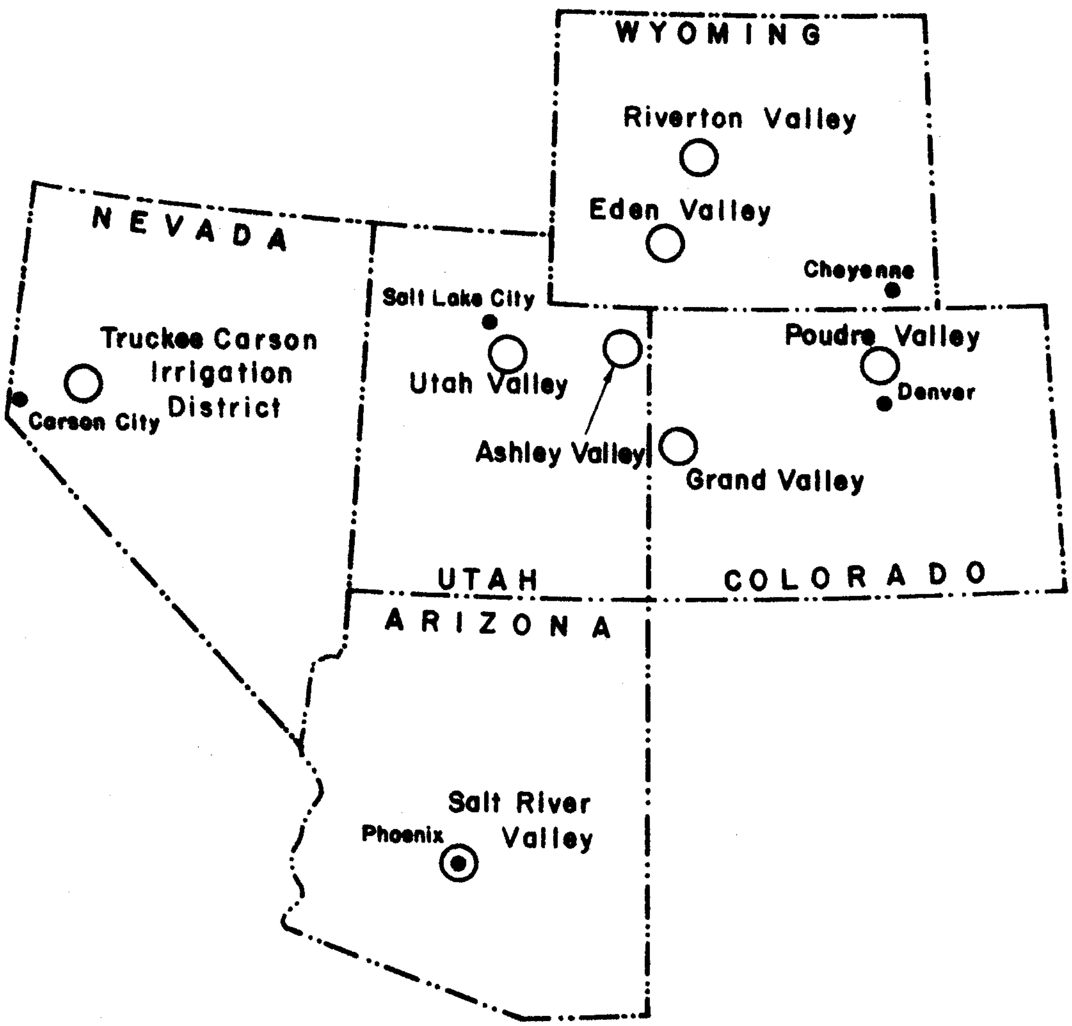


FIGURE 0-1. Consolidation of Irrigation Systems Study Areas

The research areas have been chosen to include irrigation systems which are already essentially consolidated in addition to systems which would appear to benefit considerably by consolidating. Thus, each area was not studied with the same intensity, but the amount of effort for any one study area was dependent upon whether or not the area operates as a consolidated system or contains some unique characteristic which provides leads toward an understanding of the consolidation process.

In addition, areas have been chosen that would include some similar and some dissimilar characteristics. For example, in some cases the area operates the irrigation water supply essentially as a consolidated system, while in others there is considerable fragmentation among a number of communities.

Poudre Valley, Colorado was chosen because of interest within the valley to consolidate the irrigation systems, along with incorporating rapidly increasing municipal and industrial water demands and urban sprawl. This system is unique in that it represents a high degree of cooperation among the major irrigation companies to meet the seasonal requirements for water. By trading or renting water within the system to take advantage of geographic conditions in the valley, these water entities have been able to circumvent certain rigid, complex and costly legal proceedings with respect to changing points of diversion and time of use.

Grand Valley, Colorado was chosen partly because of physical similarities with the Truckee-Carson Irrigation District which is located along the Lower Carson and Truckee Rivers in Nevada. Institutionally important in Grand Valley is the presence of both mutual and commercial irrigation companies, presenting additional possibilities in seeking more efficient water allocation and utilization. On the other hand, the Nevada system is essentially operated as an integrated system, but considerable improvements in the management of the water supply are still needed. The Nevada system is attractive as a research area because of a present confrontation involving conflicting demands upon the system for irrigation, recreation, and wildlife, which will probably necessitate improved management of the available water supply. Nevada has a unique statutory provision allowing the state engineer to determine the duty of water throughout the state to prevent waste and encourage efficient and optimum use of this scarce resource.

Ashley Valley, Utah is an area which has recently gone through the consolidation process with apparent success. The Vernal Unit of the Central Utah Project was constructed by the U.S. Bureau of Reclamation to provide supplemental water supplies for the irrigated lands in the valley. Following completion of construction, joint efforts by local irrigation company officials and Extension Service personnel resulted in the consolidation of the irrigation companies into a central office for operation and management of the surface water supplies.

Utah Valley, Utah contains a complex irrigation system involving approximately 50 irrigation companies. The water rights of the various companies vary considerably. Some irrigation companies are typically short of water during the late season, while some companies will rarely ever be short of water. The northern part of Utah Valley is rapidly changing from a rural to an urban society. The urban growth rate in this area is among the highest in the Intermountain West. In addition, this area will be affected in the very near future by the importation of additional water from the Colorado River Basin at a cost exceeding 300 million dollars.

The two areas in Wyoming were chosen to reflect two separate situations. The irrigation system in Eden Valley operates essentially on a call basis, which has become possible because of a recently completed U.S. Bureau of Reclamation (USBR) project. The project was recently taken over by a locally formed irrigation district, and presents an opportunity to observe the social reaction and ability to cope with physical and legal problems that are on the horizon. The area also represents an interesting manipulation of Wyoming water law which ties direct flow right to the land, but permits transfer of direct flow to storage rights.

Riverton Valley has also had the benefits of a recently constructed USBR project, but has some problems due to conflicting water demands. Here also, in addition to the three irrigation districts that encompass the area, the bordering Shoshone-Arapahoe Indian Reservation gives rise to possible water claims under the "reservation doctrine."

The Salt River Valley, Arizona has been included primarily as a success area in that the irrigation water supply is operated essentially as an integrated system. Also, the area is relatively progressive in seeking solutions to water management problems, we well as offering the special challenge of meeting water demands in the rapidly expanding metropolitan area of Phoenix.

More important, however, are the communalities and differences in all eight areas that can help us establish an appropriate comparative perspective, and, thus, deduce some broader principles of integrated water management.

To start with, the agricultural areas in isolated places such as Eden Valley appear to be losing population. On the other hand, large areas like Phoenix are growing very rapidly as part of the nation-wide trends of urbanization and metropolitanization. Similarly, the Utah Valley and the Poudre Valley, as parts of well-irrigated urban cases, are showing marked rates of growth, with the population differences between the 1960 and the 1970 censuses amounting to over 30 percent for the decade.

The distribution of the population in the various areas is typically around an urban place, of more than 2,500 people. The size of the urban population varies according to the valley and so does also the population in the rural hinterland. The largest population is that of the Salt River Valley, a total of approximately one million people. Most of these people are found in the city of Phoenix and the other urban places which are surrounding Phoenix (Maricopa County). The smallest population is to be found in Eden Valley. The population there was estimated to be approximately 400 people. The smallest area in terms of acres of land under cultivation would also be Eden Valley with approximately 16,000 acres of land under cultivation. The largest area once again would be the Salt River Valley with approximately a quarter of a million acres being served by the Salt River Project, and another 100,000 acres surrounding the area being served by other water sources. The juxtaposition of a number of characteristics and underlying dimensions of the various areas are summarized in Table 0-1.

The composition of the population in the various areas is fairly homogeneous. Riverton, Wyoming, on the other hand, includes an Indian reservation and a diversified population mix. The poorest area would probably be the Eden Valley and the best economically endowed area would have to be the Salt River region. Utah Valley, Fallon, Vernal, Poudre and the Riverton Valley could be characterized as financially reasonably well-off.

All of the areas with the exception of Eden Valley and to a lesser degree Ashley Valley have been characterized in recent years by in-migration. This in-migration in many cases would best be described as the urban refugees, part of a centrifugal movement of suburbanization, a new breed of "rurbanites" actively looking for a combination of rural stability and nearby urban amenities.

The settlement of all areas took place mostly in the mid or late 1800's. The first settlers who arrived in the areas of the study were agriculturally oriented and the first thing that they did was to clear and prepare the land in any way which was necessary so that crops could be planted. Typically, the first year that they were there preparations were started so that water could be diverted from the creek or river which they had settled close to. These diversions were usually plentiful in the spring. In fact, the water would be so abundant that many times the farmers had problems with flooding and, then, in the latter part of the irrigation year (July and August), the streams would dry down to a trickle and the crops would burn leading to a situation of very low productivity.

The introduction of irrigation projects in the research areas started after 1902. In 1902 the Newlands Bill was passed by Congress, a bill which provided the impetus for the construction of irrigation projects in the United States. The Newlands Bill resulted in the first project (Newlands Project) being built in Fallon, Nevada. Shortly thereafter the Salt River Project was also begun under the same bill. Most of the other projects of the study were completed after the Second World War, such as the Eden Project and the Colorado-Big Thompson Project, but the construction was stopped during the War because of the critical need for manpower. Projects in the Utah Valley (such as the Strawberry and the Deer Creek Reservoirs) were completed prior to the Second World War.

Historically, most of these systems could be described as areas which were developed through the Homestead Act, Desert Land Act and other legislation of the 1800's that opened up the Western lands to settlers and squatters. Phoenix was settled originally by traders who were travelling through the area and they began diverting the water onto the land simply because this was one of the few places that water was available. In Utah, both Vernal and

TABLE 0-1. Summary Characteristics of the Eight Valleys of the Study

General Characteristics	Eden	Ashley	Riverton	Grand Valley	Poudre	Utah	Truckee-Carson	Salt River
Sources of Water	Big Sandy Creek --held in Big Sandy Reservoir	Ashley Creek--held in Steinaker Reservoir	Bull Lake Boysen Reservoir	Gunnison and Colorado Rivers	Colorado Big Thompson and Poudre River	Provo River and series of reservoirs	Impoundments on Carson River and water from Lake Tahoe	Salt and Verde Rivers with series of dams and diversion.
Socio-Demographic Area	Population 500, estimated. No major town.	Vernal population 5,000, estimated, Ashley Valley population 12,000 estimated.	Freemont County 28,352 with Riverton Division, 12,244 strong rural character.	County population 54,374 with greater Grand Junction accounting for 28,527. Among the two counties on Colorado's West Slope showing trends of growing.	Weld County-89,086 Larimer County-88,654 Two major towns (Ft. Collins, 43,000, Greeley, 40,000) Sum both counties - 177,750	Utah County 137,776 with Provo and Orem accounting for over 80,000 people (urban 117,134 to 20,642 rural).	Churchill County 8,452 with the city of Fallon 2,734	Maricopa County; 967,520; Urban, 844,157; with metropolitan Phoenix accounting for most of the population.
Urban-Rural Water Use	Rural-All farmers are full-time. Drinking water from private wells.	Both--Many part-time farmers in the area.	Rural--All water diverted is used for irrigation.	Both--Many part-time farmers in the area. Many are employed in mineral extraction.	Both--Rural using most of water. Municipal water taken from Poudre River because it's better water and cheaper to process.	Both--the Provo River water users association supply domestic, industrial and agricultural water.	Predominantly rural--Drinking water is supplied by Fallon or the individual farmer so that all impounded water is used for electrical generation and irrigation.	Rural water users use most of the water, but there are 47,000 water users on less than one acre of land. High domestic use.
Large-Small	Small-71 users in valley. One irrigation company. Water almost exclusively for agriculture.	Medium--1,124 users. Five main irrigation companies in valley. All housed in one office.	Medium--545 users. 100,000 acres are under irrigation and 60,000 more could be opened up. About 600,000 acre-feet are available for agriculture use	Rather small with 44,000 acres irrigated from one consolidated office. The system has about 110 miles of ditches.	Large--6,200 users. Approximately 34 irrigation companies in valley. 90% of supply used for irrigation.	Large--with about 25 irrigation companies in the Valley. There are 115,000 acres of irrigated land, and two water users associations.	Fairly large--1,200 users. The company supplies 406,000 acre feet to 62,500 acres of cultivated land and 50,000 acres of pasture.	Large--One consolidated company, supplying electricity and water. Supplies about 1,000,000 acre feet per year to 57,000 users and households. Largest and most powerful company in study.
Complex-Simple	Simple--No water exchange due to attached water rights.	Complex--Water exchanges with CUP to Utah Valley area. Irrigation companies are forced to operate as one company.	Simple--There are three different companies operating independently.	Simple--The five old companies were consolidated into one company. The whole system has the complex problem of salinity in the Colorado River.	Complex--BOR, NCWCD, River Commissioner, Rural drinking water, City drinking water, water exchanges.	Complex--water must pass through the water users association to the irrigation company. There are electrical generators, and complex inter-basin exchanges. Utah Valley is one of focal points of the CUP.	Complex--The company operates a pasture rental system, a large drainage system and collects a drainage charge. The company leases a power plant at the dam site. The company has 45 employees	Complex--with no exchange, delivering both domestic and agricultural water. Industrial water is provided as a part of domestic supplies. SRP is a complex bureaucracy employing 2,262 of which 574 alone are in the water sector.
Organization Static-Dynamic	Dynamic--Board members change. Water poor area; innovations to get more use from water are common.	Static--Consolidation was not by choice. Dam forced de factor consolidation. Water board members seldom change.	The companies are fairly dynamic, because of land sales and the need to reorganize after such sales.	The company is fairly dynamic due to the challenge of salinity control but with little organizational change in recent years.	Static--Water rich area. Water board membership seldom changes.	The water companies have remained relatively static. CUP may force some some organizational change.	The water delivery system has been static and little change has been made from origind scheme.	SRP is a dynamic, expanding organization employing latest technologies.
Consolidated-Nonconsolidated	Consolidated--Under Government Irrigation Project.	Legally nonconsolidated, but in reality consolidated under Ashley Valley Water Users Association.	Nonconsolidated but some of the land in the Midvale Irrigation Company to be sold by the Government will probably result in consolidation.	Consolidated in 1894.	Not consolidated, but a complex system of water exchanges cause interdependence of companies.	Nonconsolidated--The irrigation companies have different appropriation dates, and to this day, honor the dates. Potential for consolidation through CUP.	Consolidated at the time of construction.	Consolidated at construction of Roosevelt Dam in 1911.

Utah Valleys were settled by the Mormons. There, although there have been settlers prior to the Mormons, the real development occurred after the Mormons arrived in the state. The other areas were settled between 1850 and early 1900's, mostly under the Homestead Act.

Again, the communities in the areas under consideration are rather homogeneous aggregations of fairly long-time residents mostly descendants of people who originally settled the area (Salt River is an obvious exception). As a result, the typical patterns of interest in water have been handed from father to son and any antagonisms or hatreds which the parents bore concerning water situations have been handed to the children. Many of the social activities of the community in the past centered around water and its importance to the community. The actual construction of the older projects was an important form of strong social bonds, as farmers had to band together forming their own organization. More recent projects, on the other hand, have led to a situation in which the relationships between the agricultural water user and the supplier of the water are of a secondary nature, as contrasted to the strong primary ties of earlier projects.

The material collected during Phase I pointed out once again that whatever the engineering solutions to consolidation, limited water supplies, increasing population, and the multiplicity of uses all call for new integrated forms concerning the interaction between policy determining institutions, local participants, and water users at large. More important, there was an early recognition of the need to provide a larger socio-economic framework that would relate the capability of present irrigation systems for new alternatives and for an understanding of the social climate of receptivity towards change. The last implies that in addition to potential physical developments, Phase I concluded that special attention should be paid to the following factors:

a. community environment and culture, or the normative resources within which the irrigation system is located;

b. organizational structure and networks, especially organizational recruiting, the distribution and span of authority, patterns of leadership and management, problems of resource development, and procedures of control and integration;

c. general perception of change and of organizational alternatives, including the individuals' knowledge and attitudes towards water use patterns, and general level of satisfaction;

d. economic analysis and evaluation of proposed alternatives, so that a final evaluation can be made as to the effectiveness and overall significance of proposed organizational rearrangements;

e. legal imperatives concerning levels of autonomy and of organizational integration.

It is to these factors and similar questions pertaining to the building of a basis for implementation that Phase II focused particular attention.

0.3 The Emphasis of Phase II

As indicated above, Phase I concentrated primarily on a general description of all eight irrigation systems of the study and on a preliminary collection of primary data (through an appropriate survey) for two smaller systems, i.e., Eden Valley, Wyoming; and Ashley Valley, Utah. Phase II, on the other hand, not only expanded the argument to include an in-depth examination of two more, larger valleys (Poudre Valley, Colorado; and Utah Valley, Utah); it also concentrated on elaborating a general theoretical framework and on building the basis for considering steps for implementing potential consolidation.

Key concerns and points of emphasis throughout Phase II have been:

a. the determination and evaluation of the engineering characteristics of the system, including:

   i) assessment of the hydrology of water supply to the areas in order to evaluate the magnitude of the supply, as well as its time variation;

   ii) assertion of the physical characteristics of the systems with respect to capacity, conveyance losses, water measurement and control structures, land served, and type of agriculture;

   iii) determination of the method(s) of operating each system with respect to delivery, flow measurement, operational losses, conveyance efficiency, farm efficiency, and operation and maintenance costs;

   iv) computation of water deficits and surpluses for each irrigation company in the two specific valleys in order to ascertain the need for water transfers within the total irrigation system; and

   v) study of alternative physical and operational systems for improving the efficiency of water use in each of the two areas of special attention (Poudre and Utah).

b. Identification and measurement of the economic benefits and costs of the alternative physical and operational systems which have been shown to be technologically feasible. Specifically:

   i) analysis and evaluation of both private and social economic effects;

   ii) consideration, wherever possible, of non-pecuniary considerations in the overall analysis;

   iii) incorporation of indirect as well as the direct effects of consolidation in the study;

   iv) besides optimization of the immediate water systems, inclusion of considerations pertaining to the maximization of welfare for the entire system; and

v) determination of whether or not any of the alternative consolidation systems is economically feasible within the context of all involved interests.

c. Analysis from a legal perspective of such general objectives as:

i) the project state's basic water laws and philosophies and their effect upon consolidation;

ii) Federal and state laws and court decisions which relate to local water organizations and determine whether they operate as impediments to consolidation;

iii) institutional arrangements which control the use of water and to determine possible organizational impediments to consolidation;

iv) state laws regarding business organizations and corporations to determine procedures for merger, along with possible impediments;

v) water rights held by selected irrigation organizations in order to establish the legal right of individual users in a consolidation proposal;

vi) institutional alternatives available to traditional agricultural irrigation companies in attempts of synthesizing rural operations with urban needs; and

vii) legal constraints in shifting from rural water uses to urban and industrial uses and the impact upon the water right.

d. Provision of a cogent framework for an understanding of the social factors involved in the irrigation systems under consideration. Among others, concentrate on an effort to:

i) explicate institutional arrangements which control the use of water and determine possible organizational impediments to consolidation;

ii) delineate the dimensions that define both the external environments and the internal organizational dimensions of the water management systems under study;

iii) examine the perceptions of satisfaction with the organization or the extent of positive expressions by members and/or officials and/or users in the irrigation system, in relation to rules, norms, roles, control and performance of the organization under a variety of ecological, social, legal and economic settings;

iv) explore the perception and presence of organizational alternatives, as expressed in new organizational schemes of consolidation, including general orientation towards change, beliefs associated with consolidation, perceived social risks and alternatives, and, finally, congruence between present states and perception of alternatives.

e. Consider organizational alternatives in actual or potential cases of consolidation by delineating:

   i) the differences between efficiency and effectiveness, especially through a juxtaposition of economic and social costs;

   ii) preparedness for consolidation by a systematic accounting of changes in the external environment (inputs), changes in organizational structures and procedures, and changes in output or goal alterations; and

   iii) the importance of an overall desirability of consolidation as related to the feasibility of probable change, in the context of a plan for implementation, which ideally incorporates design considerations, priorities of action, and specific recommendations enhancing any efforts for directed change.

The general objectives of Phase II contain, indeed, a rather large order. But as related repeatedly the present report builds in a cumulative fashion on the massive material outlined in Phase I. It is in this spirit that the areas of in-depth examination selected accentuate points raised in the document of Phase I. These areas present the most complicated cases of a maze of irrigation companies operating under changing conditions of increased land use transformation, population influx, the meshing of urban fringes with the rural hinterland, and industrial expansion in an ecologically fragile environment. Concentrated research efforts on Utah Valley and Poudre Valley, supplemented by the insight and information gained about the other areas during Phase I, provide the background for concrete proposals of consolidation, as a necessary consequence of four interrelated national and regional trends:

a. increasing population, particularly the continuous movement of people to the West;

b. increasing urbanization and the augmented demand for municipal services with a resultant conflict between farm and non-farm water uses;

c. increasing industrialization which affects both the total volume as well as the quality of water supply;

d. increasing concern with ecological mismanagement, with increased requirements and cost of pollution, which will affect both agricultural and non-agricultural water uses.

The special focus of the economic analysis in Phase II came about as part of the important concern to maximize the general welfare rather than provide a partial solution. Yet, the purpose of the study remains not only the effort to determine whether or not the different consolidation plans are economically effective, but also whether socially viable, legally acceptable, and physically feasible.

The maximum welfare of the entire system is the ultimate criterion of analysis. The welfare of the entire system is said to be maximized when it is impossible to increase the welfare of one part of the system without decreasing the welfare of some other part of the system. The point is that a particular consolidation plan cannot be judged as increasing general welfare if one group benefits at the cost of another.

While in Phase I the relative substantive water laws and corporation codes have been collected, analyzed and notations made of similarities and differences which are particularly beneficial or harmful to consolidation proposals, in Phase II, water right records of individuals within the selected irrigation organizations are analyzed in order to determine obligations of that entity to individuals concerned and how these obligations may be affected by consolidation. An institutional analysis is made of many organizational enterprises of concern within the project areas to determine the legal status and powers governing water use. Procedural and administrative law codes of each state have also been examined for the range of actual and probable impediments. Responsibilities of state agencies in administering the water laws have been delineated where they operate as a constraint or pose a threat to the existing operation.

Finally, the approach of Phase II utilizes also primary data collected by a questionnaire survey of a randomly selected sample of individual users. Thus, the general reconnaissance of the valleys selected is supplemented by in-depth interviews with officials and irrigation users. The primary data collected and the analytical techniques employed per selected socio-economic and ecological indices (together with the utilization of available data) provide the background for both an integrated analysis of major factors affecting consolidation and for an in-depth analysis of the four areas of special attention, namely, Eden, Ashley, Poudre, and Utah Valleys.

In order to proceed with the systematic analysis and successful development of water resources management alternatives (combining institutional rearrangement and successful implementation of technological breakthroughs), a series of interlocking propositions may summarize the thrust of the present interdisciplinary emphasis. Such an emphasis is part of the necessary effort for identifying the array of relevant variables, a wider range of alternatives, and broader intervention options for meeting the demands for increasing efficiency and effectiveness in multi-objective water schemes. In this sequence, the thrust of the study can be summarized as follows:

(1) Changing life situations require reconsideration of traditional irrigation conditions. One of them is the question of consolidation that involves both physical and organizational alternatives.

(2) Organizational rearrangements are most important because they involve not only the larger human community, but also successful implementation of technological innovations.

(3) As a result of the above, improvement of water management requires above all administrative and larger organizational rearrangements.

(4) In trying to implement change there are, however, serious constraints (and facilitators) as a result of cultural practices, historical factors, and ecological limitations in any given area.

(5) The knowledge and proper consideration of constraints/facilitators makes it easier to proceed with the introduction of alternatives to water systems.

(6) The implementation of new water management technologies entails two things: a) delineation of technologies; and b) some specific process of successful implementation.

(7) In implementing change of alternative water systems there needs to be a stronger consideration of the minimization of social costs in the proposed transformation and of a maximization of net economic benefits.

(8) What is needed, therefore, is to provide specific strategies and techniques for making the transition to new states by recognizing both physical and non-physical interdependencies.

(9) The answering of questions concerning the state of the system, critical variables, and proposed implementation strategies require an "accurate" measurement of the state of the system, the rate of change, priorities of attack, and beneficiaries of change.

In the context of developing a multi-faceted, complex, interdisciplinary approach towards holistic water resources planning, special attention must also be paid to the substitution of the traditional preoccupation with increased supply, to considerations of conservation and diminished demand. The last is becoming particularly important for regions that have been traditionally accustomed to economies and environments with abundant supply. Thus, the attempt of achieving a solution to water shortages involves also a critical examination of water use practices and reduction of wastages.

In attempting to answer the above questions and in outlining an approach that would coordinate a variety of disciplines and divergent critical variables, the researchers utilized as an organizing scheme the systems approach. The general orientation with the systems approach is part of an overall effort of integrating physical and non-physical dimensions of irrigation systems. As with any other system, an irrigation system implies a collection of people, devices and procedures intended to perform certain functions. A systems model is a working model of a social unit which is capable of achieving a goal and involves the systematic exploration, analysis, and evaluation of all the possible consequences of proposed alternatives to an on-going system.

Thus, a systems approach includes not only the conditions (facilitators and constraints) under which the particular irrigation organizations are maintained, but also the conditions or circumstances under which processes and activities contribute effectively to the achievement of given water resources goals.

A special effort was made to develop a "model" that would provide the grand scheme that the various disciplines in the project could use in analyzing, explaining and predicting performances in a given irrigation system. In line with this argument and in the attempt of delineating the factors facilitating or hindering irrigated agriculture, the primary focus has been on the following inputs or constraints of the irrigation system:

(1) *Engineering inputs* (part of natural resources inputs) having two major dimensions:

a. hydrology of water supply problems, such as time history, diversions and crop water demands;

b. network requirements (water facilities), such as canals pumps, delivery systems, and irrigation return flows.

(2) *Social inputs*, such as among others socio-ecological and demographic characteristics, the normative resources of the community, cultural practices, and organizational arrangements.

(3) *Legal inputs*, such as the substantive water laws, legal aspects of surface and groundwater, duty of water, administrative aspects of law, requirements and limitations and the specific allocations of individual water rights.

(4) *Economic inputs*, such as conditions of production and processing, forms of capital formation, credit, employment and labor, and diversified aspects of capital resource allocation.

The essential argument of such a systems approach contains the notion that the external environment, i.e., the ecological configurations and the conditions of an existing social structure, provide the constraints (and the facilitators) for the inputs characterizing any irrigation system. These input constraints include natural resources, demographic characteristics, normative and legal constraints, the economic viability and the potentialities of the area, the administrative apparatus, and the state of technology.

The inputs are then processed through institutional mechanisms, or the concrete organizational systems devised for maximizing desired goals. Thruput involves physical structures (buildings, canals, etc.) and organizational infrastructures such as rules of operation, patterns of leadership and command, efforts for control, information and communication, and generally ways of interacting within the organizational environment.

The crucial point in this approach is that the construction of any kind of a project is closely associated with all major components of any system: with its <u>inputs</u> (as expressions of the conditions of the external environment), with the organizational arrangements (<u>thruput</u> or "system"), and of course with desired objectives or goals and social policies which are the <u>output</u> in the conception of any system.

There is no need in this introductory part to devote any further discussion as to what such a systems analysis entails. The point that needs to be emphasized here is that such an approach and research paradigm made possible for the researchers to establish a common vocabulary, a shared framework of analysis, and a scheme that made possible a broader assessment of costs involved in the transformation of present arrangements and in the evaluation of larger natural resources policies.

0.4 An Overview of the Question of Consolidation

In completing the introductory remarks and in attempting to provide the continuity between phases of the "consolidation study," it is also important to recapitulate the background and rationale of the preoccupation with the question of consolidation.

An irrigation company is assumed to be a type of human organization. Like any human organization, it consists of specific organizational arrangements and by the perceptions of officials, members, and other related persons with respect to the goals, roles, and norms pertaining to the organizational structure. Thus, a major axis of theoretical and research interest is directed towards an understanding of the relation between what the organizational arrangements of irrigation companies are, and what the perceptions are about such arrangements.

Consolidation demands the structural as well as normative integration of X number of irrigation companies for the manifest purpose of obtaining a "greater good" (e.g., increased operational efficiency and increased availability of water supply).

The physical development of the canal system and appurtenant works, the legal development of the right to use water, the organizational entities which have been formed to operate and maintain the irrigation systems, and various social and economic problems have created a complex situation in many of our western irrigated valleys. In order to achieve maximum water resource benefits, something must be accomplished to facilitate increased water use efficiency. The consolidation of irrigation systems is among the important steps for achieving improved water management, since it provides the essential organizational framework to maximize water use efficiency within the total irrigated valley.

The problem of consolidation, however, is not only one involving careful consideration of physical potentialities, legal alternatives, and economic feasibility. Part of the problem involves a two-fold delineation of the organizational capability of present irrigation systems for new alternatives and the understanding and utilization of a social climate of receptivity towards change and new organizational forms.

Thus, consolidation requires not only changes in physical structures and in organizational arrangements, but also modifications among participants of the system in the perceptions of goals, roles, and norms required in new, expanding organizational schemes. These perceptions, and the extent of consensus between them, are among the crucial variables in explaining change, or the readiness for proposed organizational changes.

At the end, consolidation requires the acceptance of an ideational innovation. It implies the movement from a perceived situation of an existing interlocking system of values and roles to that of a new form of social arrangements. This, however, does not mean exclusive preoccupation with factors facilitating change, but also analysis of forces hindering innovative attempts.

In a broader analysis, an imaginative water resource program and an efficient and effective water management policy are necessary ingredients of meeting the challenges of growth and the required adjustments resulting from new and expanding demands. Water allocation involves very broad segments of society, and water must be managed in a manner that is a compromise between technical feasibility and competence and general public interests in order to insure the socially, as well as the physically, efficient utilization of this resource.

Consolidation of irrigation companies, in particular, seems to be an imperative for the intermountain region where perennial scarcity coupled with strong trends of population growth and new demanding economic activities provide both the impetus and the needed urgency for a prudent policy of water management under effective organizational structures and processes. As George Clyde has succinctly stated, there are seven direct benefits to be derived from consolidation of irrigation companies, benefits which in turn would be passed on to the farmer:

(1) Reduce conveyance and administrative water losses in a multitude of duplicating ditches.

(2) Decrease costs of water distribution by reducing the number of directors and watermasters.

(3) Increase flexibility and efficiency of available water supplies.

(4) Make it possible to employ trained men to operate, maintain, and improve the irrigation system.

(5) Strengthen the financial structure so that adequate financing for O&M, replacements and betterments may be secured.

(6) Make possible the effective integration and use of natural flow, surface storage and groundwater supplies.

(7) Provide a more effective organization to participate in basin-wide development and to contract with Federal Government or other agencies for additional water supplies to improve the distribution systems.

Similar advantages have also been discussed by Bishop (1961) who has underscored among others such items as: increased efficiency in the use of existing water supplies; increased effectiveness in the management of irrigation enterprises; increased efficiency in the operation of a given system through sufficient, expanded size; increased safety through improved physical facilities; and, most important, overall strengthening of the irrigation institution.

The limited literature on the topic, as well as general discussions of irrigation operations, seem to support the general notion that consolidation of small irrigation systems, the creation of a federation of irrigation organizations, and the subsequent expansion of the organizational span can contribute to the solution of many vexing irrigation problems in the arid West. These problems may be divided into four types:

a. problems concerned with the physical situation involving parallel canals, duplicate structures, multiple diversions, and costly operation and management;

b. legal problems concerning the right of the use of water involving complex combinations of priority, period of use, and water supply;

c. human problems involving the attitude of water users toward the development and use of water; and

d. economic problems connected with the physical development and value of the water supply.

As repeatedly emphasized, because of larger national and regional trends and new demands, while the supply and quality of water are vital in any future planning of resource utilization, equally important will be the organizational innovations applied to increased efficiency in the distribution of water. Thus, the problem of consolidation is not one of just changing attitudes of individuals. Such attitudes, and the process of the adoption of innovative forms of water use, are part of an understanding of the broader community culture and the institutional structures involved in the obtainment of water supply and its allocation to the members of the particular system. A central concern is the alternative organizational forms possible in a given community and the delineation of the process of adoption, communication, and diffusion through which implementation of consolidation plans becomes feasible.

We may at least begin with the assumption that consolidation of irrigation systems presents a viable alternative for more efficient utilization of water resources. Where consolidation can be achieved, existing water supplies can be more effectively and efficiently used by eliminating duplicate systems and organizational management can be improved through centralization of functions and reduction of enterprise personnel, while at the same time permitting employment of technically trained assistants. The resulting institution will enjoy less legal expenses per unit acre, greater visibility, voice and influence on political and lobbying issues of interest, taking full tax and insurance advantages and improved morale and safety by modernizing and improving company facilities and equipment.

Yet, even when larger, general studies have been made on the technical feasibility, economic desirability, and organizational preparedness for consolidation, there still remains the very central problem of individual receptivity to change, and of the effort of harmonizing conflicting interests involved in a unified purpose. Despite technical, economic and organizational evidence favoring consolidation, little progress has been achieved and public sentiment has not provided the momentum for an incorporation of the envisaged change. Attempts toward consolidation depend also on the individual's knowledge and attitude toward water use patterns, on the nature and extent of his relation with the particular irrigation company, his socio-economic background and property characteristics, and on a cluster of predispositions toward change and modernity, level of satisfaction and perception of alternatives.

The problem of consolidating irrigation companies in the West and the quest for an interdisciplinary approach of physical and social sciences provide an excellent opportunity for the application of macro-models, for handling organizations as units, and for the establishment of long-range policies of social intervention. However, in order to implement a program for consolidating irrigation systems in any particular valley, it is required to develop a comprehensive consolidation plan which will take into account the engineering, legal, organizational, and economic characteristics of the total irrigation system. An in-depth plan must be prepared to insure that all of the parameters have been accounted for in sufficient detail to engender confidence among the water users that the consolidation will be reasonable, practical, equitable and consequently successful.

This is why the present study has adopted such a broad interdisciplinary perspective and approach. We start from the assertion that in order to adequately present the facts to the water users involved, a careful appraisal must be made of each individual system. The existing physical facilities, water rights, water supply, legal problems, and social conditions in each community must be inventoried. Little should be said here about each of these areas of disciplinary concern, since the text that follows narrates exactly the various substantive inputs and common approach. Briefly, however, methods must be found for improving the efficiency of the existing supply sources and conveyance channels. Operational changes must also be considered. The water delivery sub-system must also be evaluated as to physical facilities, maintenance costs, and operational procedures. In addition, studies of on-farm water management should be made in order to assess the efficiency with which the present water supplies are being used.

State water laws, legal imperatives, administrative procedures, organizational arrangements, cultural practices are all parts of the concerted effort to understand the necessary background of the efforts toward consolidation. Similarly, the economics of consolidation must be clearly outlined: costs of construction and the benefits must be determined; savings must be evaluated; technological externalities must be measured; and, financial conditions of each company must be clearly delineated.

Of particular importance is the fact that advantages in consolidating irrigation systems pertain not only to benefits accruing to irrigators within the system, but that such benefits also extend beyond limited geographical bounds. Improved water use efficiency may release water for other demands. For example, increasing municipal and industrial water requirements, either inside or outside the bounds of the irrigation system, might be partially or entirely satisfied by continual improvements in the irrigation system. The costs of such improvement could be allocated among all beneficiaries, thus providing the interesting case of considering also the interface between rural and urban systems.

Finally, in any study of consolidation, a note of caution must be inserted. Because of the complex interrelationships of diverse factors each area of proposed consolidation presents both unique problems, but at the same time common principles of organizational intervention.

Although in every consolidating scheme the merits and advantages of consolidation must be considered individually, it is possible, when proper caution is exercised, to develop more general principles from common factors operating in different irrigation systems.

0.5 Consolidated vs. Non-consolidated Systems: Synthesizing Remarks

If one were to consider actual or potential consolidation of an irrigation system, immediate attention must be paid to existing water rights. These water rights can be satisfied in several ways. One is to build the project leaving the water rights untouched; divert to those holding water rights first and, then, with a "project water rights" for unappropriated water the water which is caught in the impoundment may be delivered as supplemental water to the people who wish to purchase it. Another way is to abolish all water rights and consolidate them as part of the new composite irrigation system. However, this type of merging disenfranchises the original settlers of the water rights which they had and would be hotly contested as being unconstitutional. A third way of dealing with potential merging is assigning all water rights to a water organization under a consolidated system.

The hierarchy of water rights under the priority system in a water rich year becomes superfluous because everyone will receive water and everyone will receive the water which they are entitled to. But during a water poor year the hierarchy precludes late comers from receiving water. Senior rights receive, but the junior rights do not receive water.

Retaining the priority system of water rights does overcome one of the main criticisms expressed when consolidation is discussed, namely the fear of senior rights in a water poor year. But does it necessarily maximize the water potentials or reflect the benefits of a stability in water delivery in a large area using public resources?

Most agricultural water users are very interested in new ways of using water, but they will not consider implementing changes unless they have tangible proof that a benefit will be derived from this alteration. This proof is sometimes very difficult to come by and many times the old timers simply will not look or will not discuss a solution which is on paper. They would have to see this benefit in actual practice before they would even consider using the innovation.

During the reconnaissance of the irrigation areas in Phase I of the study and in subsequent investigations, there seemed to appear some distinct differences between valleys which were consolidated and those which have a multitude of non-consolidated companies. Water users in non-consolidated areas were not as much concerned with water costs and they seemed to be quite satisfied with the prices they were presently paying. At the same time, they did not seem to be particularly concerned with water losses, such as seepage, phreatophytes, and any other loss which may be incurred. Their preoccupation was with water rights. The people who held senior water rights were extremely concerned that in times of water shortage or a poor water year, if they were under a consolidated system, they would not receive the amount of water which their present rights granted them. They wanted some form of clear-cut, hard, firm guarantee that they would receive their present water rights.

Overall, water users in unconsolidated areas expressed satisfaction with the amounts of water they were receiving, the modes and methods of delivery, and for the most part the large agricultural users seemed to be satisfied with the personnel of the irrigation company (see also later Section 4.4).

Agricultural water users in consolidated areas were much more capable of articulating the advantages of concerted action. Water delivery was one of the items of high satisfaction with water users in consolidated systems. They were able to receive their water in the amount which they order and more importantly they were able to order order the water. Water available on demand seems to be the major differentiating item between consolidated and non-consolidated systems. The consolidated canals were larger and capable of carrying more water so that they could receive their water when they asked for it. Again, in all areas where consolidation prevails, it has been brought about by external forces rather than internal, voluntary demand for merging. Eden Valley was designed as a consolidated project, Salt River Project was designed to be a consolidated project, and so was the Newland Project. Ashley Valley is a rather unique situation because the construction of the impoundment made consolidation desirable in order for the water users to obtain the water to which they were entitled.

The probability of new projects facilitating consolidation seems rather remote in most of the present areas simply because most of the water resources in the areas have now been exploited. The Central Utah Project will just about use all water available to the Utah Valley area as well as water which is available to the Ashley Valley area. Riverton and Eden Valleys have exploited their water. Eden does have an option of diverting water from the several mountain streams and tributaries to the Green River, but whether this will become a reality or not is a rather debatable point. The Salt River Valley and Poudre Valley both have exploited all the water that they possibly can. The Salt River Project will indirectly find a little relief from the Central Arizona Project but the water which will be available from the Central Arizona Project has already been filed for to such an extent that there are four times more applications than there is water potentially available to it. Thus, the external factor mentioned repeatedly above will be increasingly the changing socio-economic character of the areas, rather than massive schemes of water transfers or additional impoundments.

0.6 Looking Forward

The introduction to this study has been unduly long. Yet, it has been necessitated by the desire to relate the continuity of the two phases comprising the "consolidation study." This study has been an extended involvement in an interdisciplinary exercise of water resources planning. While the final findings and recommendations seem relatively timid, if not poor, in relation to the previously stated objectives, the experience gained and the sensitivity to the complex questions of irrigated agriculture permeate the entire text.

Perhaps it is important to state as soon as possible a major point that may be lost in the subsequent discussions: the findings about consolidation are relatively ambiguous, contradictory, and occasionally against the elegant hypotheses concerning size and efficient operation. Indeed, findings tend to suggest that even though efficiency may be desirable from an engineering, economic, and even legal point of view, consideration of equity (fair access of resources to all segments of population and potential social costs) may point to a decision of non-consolidation.

But such points will be raised not only throughout the general text, but also more succinctly in the last chapter containing conclusions and recommendations. It will be important, at this point, however, to briefly state the plan of presentation and the underlying thread of argumentation.

The study revolves around three major parts: Part One, the "Introduction" sets the general premises of the study, the general issues of irrigated agriculture, and an expanded chapter on the evolution of irrigation systems, especially in the Western United States.

Part Two, has as a core argument the notion of "systemic mapping," i.e., description and definition of the irrigation system, generation and evaluation of water resource alternatives, and an evaluation of proposed plans. It is in this part that special discussion is made of the variety of constraints/facilitators affecting consolidation and concrete suggestions are advanced vis-a-vis an organizational continuum related to levels of merger and consolidation.

Finally, Part Three attempts to develop a basis for implementation that raises specific points as to the process of transition, characteristics of organizational integration, and broader questions of water resources planning. This part includes also a more detailed discussion of three case studies (Poudre, Utah, and Grand Valleys) in order to illuminate general points made throughout the text. The recommendations of the final chapter are a distillation of agreements reached in the research team, as well as general findings in the existing literature.

1.1 Approaches to Water Development

The total hydrosphere of the planet, resulting from the evaporation/precipitation/exchange cycle and linking terrestrial, atmospheric, and marine environments in a massive interchange, constitutes 7.17 per cent of the biomass of our planet. Water is the vital link between physical and social environments. It is not only a commodity which is directly used for man's survival, but quite often the mainspring for extensive economic development and the backdrop for many social activities.

Water, the key resource in daily life, agriculture and industry, forms many great systems through myriad paths, alternatives and cultural practices affecting the course of history and impacting in varying degrees on earth and society. But water is not only a great natural resource: it has also increasingly become a technological and social system. A large share of the national wealth is invested in structures to alter the hydrologic cycle. Vast technical structures dot the countryside, and complex socio-political systems have been devised to regulate, allocate, or help use water resources.

While concern with water resources, especially in moisture-short regions, has been a historical preoccupation, growth trends and changing circumstances have underlined the concern that water in many world regions is in critical balance. It has been estimated that approximately 95 per cent of the fresh waters are presently used at a greater rate than their precipitation replacement in ground surface waters. Although much water use is of a multi-purpose "cycling" nature, continuous increases in each use have produced strains in the storage, replenishment, and in the natural recycling capacity of many areas.

Overall, two conditions converge in order to increase the problematic situation of water. First, varying water supplies in both time and space. And, second, diversity in water uses and water requirements. Thus, not only the variability in distribution of water provides us with a major difficulty in our quest for increasing agricultural production, but, at the same time, agriculture, as a major consumer of water, has to compete with increasing demands arising from municipal and industrial uses.

Thus, in any water resource development, three major problematic situations give rise to a continuous re-examination of parameters of the water use system:

a. continuously changing socio-economic conditions, such as increasing population, demands for more food, urbanization, and conflicting and competing water demands;

b. a strong presence of institutional constraints, the result of long, historical and cultural practices, embodied in laws and judicial doctrines and in traditions reflecting the norms and practices of a given society and community; and

c. increasing concern with adverse environmental impacts and consequences. This concern stems not only from an already ecologically fragile environment (pollution of natural resources), but also from man-made disruptions, such as the misuse of the land and the various forms of the despoliation of any given water supply.

Such trends and the quest for an overall social policy where natural resources will be aimed towards the improvement of the quality of life in any given region create new and different demands for existing and new water systems. The balancing of both supply and demand dimensions requires an integrated social system where water supply, patterns of water distribution, and water reclamation or reuse practices will depend not only on the nature, structure, and historical evolution of the system, but also on the specific ecological circumstances and on the technological breakthroughs that make possible further effective utilization.

There is no doubt that the tremendous increases in the number of uses of water by both agriculture and industry, as well as the pressures from geometrically expanding populations, all indicate a global possibility of critical shortages in the near future. Water is being withdrawn for use at a faster rate than its return to the streams, lakes, rivers and other sources of precipitation. An increased concern all over the world is how to return water to the source and at the same time guarantee that this return of water is not spoiled by waste, soil runoffs, and thermal discharges. Numerous studies and reports all over the world have repeatedly reflected on the very simple fact that increased demands cannot be met economically with existing supplies; even under the most optimum foreseeable developments in purification and engineering, there are going to be increased disparities between supply and demand.

All in all, let us repeat the obvious: water is fundamental to all life forms; it affects all ecosystems; it is geographically and seasonably unevenly distributed; and, the various uses to which water is put often compete, both quantitatively and qualitatively, with one another. The paradox of water can, then, be stated simply: ample water exists in our world for all man's needs; but much of it is either in the wrong place or in the wrong form.

The emerging atmosphere of scarcity and concern with global water resources capabilities, especially in arid regions, has been documented abundantly in the literature. Historically, agricultural economies have always flourished in areas and regions with favorable ecological conditions for planned growth. Therefore, location and immediate ecology were key factors for agricultural production. The locational importance, however, has receded because control over the environment, technological innovations, transportation of water, etc., have provided greater flexibility for agricultural production in otherwise relatively hostile physical environments.

Yet, despite innovations and continuous promises of further physical breakthroughs, soil, water, and climate as given in the ecological configuration of a given region are prime physical constraints in agricultural production. Thus, it has been observed that in more than one-third of the land area of the earth, water is the chief limiting factor on human activity. About 21 per cent of the land area has arid climate, another 15 per cent is semi-arid, and an additional sizeable area has an uncertain water supply. The expansion of total food output in the form of cultivated crops can be brought about generally in two ways: by increasing the yield per acre of already cultivated lands, and by opening new lands to cultivation.

More important in discussing the general outlook for water management are a number of substantive problems that emerge in the discussion of various water uses. First of all, it is generally recognized that there is an increasing problem of scarcity of water in many lands, particularly in an arid and semi-arid belt that seems to comprise a large segment of the inhabited earth. Second, while scarcity of water seems to be a major problem, equally important for a number of countries is also the problem of excess water and the assorted floods that seem to plague countries who cannot regulate their supply of water. Thirdly, transcending the conditions of either scarcity or excess are problems of water quality degradation due to either natural or human practices. The poor quality of water is many times associated with a fourth problem in water management, namely misuse, and bad agricultural practices which accentuate complex problems of natural degradation. A fifth problem has to do with organizational ineffectiveness and the non-rational use of water supply. Even though water may be abundant, in many cases there do not exist the proper institutional mechanisms or the organizations that could effectively maximize allocation and use of existing natural resources. Finally, a persistent problem has to do in many cases with what one may describe as interregional and transnational interdependencies, and the fact that many water supply systems do not confine themselves within arbitrary boundaries or artificial political divisions. Problems of jurisdiction can become major handicaps for total natural resources planning.

The general problems described above are also accentuated by a variety of economic, social, and political situations in each area. Water resource problems, like most natural resources problems, are primarily of socio-economic nature. In other words, a technical solution can quite often be found. However, the costs both in economic and social terms are quite often prohibitive or the mechanisms for meeting them simply do not exist.

1.2 General Issues in Irrigated Agriculture

Today, almost seven thousand years after the beginning of irrigated agriculture in Mesopotamia, irrigation systems continue to be built and provide the basis for national wealth and power for many countries. In those countries, complex irrigation systems are associated with larger social political changes of the economy and culture of a given region. Irrigation projects, as well as other types of water resources development, have been associated with efforts for local growth and stability and with regional and national impacts by providing a diversified basis for choice commodities and solutions to the basic problems of community survival. Irrigation farming not only increases productivity, but it also provides flexibility which allows shifting from the relatively few dryland crops to many other crops which may be in greater demand. Irrigation contributes to strengthening other facets of a region's economy in that it creates employment opportunities in the processing and marketing of agricultural products.

Irrigation developments were the product of complex civilizations which have progressed beyond the subsistence stage of agriculture. These civilizations required the construction of enormous public works in order to control water supply for irrigation with an inevitable development of complex bureaucracies and of elaborate systems of social organization. Throughout history the undermining of the delicate, complex irrigation systems either through war, conquest, or the silting up of reservoirs and canals have been associated not only with the collapse of the physical infrastructure, but also with the decline of the particular civilization[†].

As the population of a nation increases, more and more land is cultivated, with the remaining lands usually being less suited to cultivation than the existing croplands. Once the valley floors are inhabited, further population increases in some civilizations have resulted in occupation and cultivation of higher watershed lands, which resulted in serious soil erosion problems. Also, soil erosion problems can result from plowing new lands having native vegetation, when rainfall is inadequate (e.g., rainfall may be inadequate during a drought period, thereby resulting in wind erosion of the soil). On the other hand, the denuding of tropical soils may result in serious soil erosion during intermittent periods of high intensity rates of rainfall. Also, the overgrazing of watersheds by animals has contributed to soil erosion in many regions of the world.

Early irrigation civilizations had to continually contend with the silting of canals in order to deliver water through the canal system. Even today many irrigation systems contend with the effects of soil erosion, either in the silting of canals or reservoirs, with large capital expenditures for irrigation projects being negated by the rapid silting of storage reservoirs.

In irrigation systems, maintaining agricultural productivity requires that the salts applied onto the croplands, which are dissolved in the irrigation water supplies, must be moved below the root zone in order not to retard plant growth. Thus, the amount of water supplied to a crop must exceed the water requirement of the plants plus soil evaporation (which is termed evapotranspiration) by the amount of water required to move the applied salts below the root zone, which is the leaching requirement. Therefore, the minimum water requirement for croplands is the sum of evapotranspiration plus leaching requirement.

In many, many cases, the quantity of irrigation water diverted from a river far exceeds the cropland water requirement. Seepage losses from canals and laterals throughout the irrigation distribution systems may represent a significant proportion of the diverted water. The excessive application of water on farm fields results in surface runoff from the lower end of the field (tailwater runoff) and/or large quantities of water moving below the root zone (deep percolation). The deep percolation losses cause groundwater levels to rise (waterlogging). In numerous cases the groundwater levels have reached the vicinity of the root zone which frequently results in the upward movement of groundwater due to capillary action. When upward moving water reaches the soil surface and evaporates, the salts contained in the moisture are left behind on the ground surface. This process of salinization has not only resulted in declining agricultural production, but has caused many lands to become essentially barren.

The quality of water draining from irrigated areas is materially degraded from that of the irrigation water applied. Agriculturists have viewed this as a natural consequence of the many processes involved, and little attention has been given to the possibility that progress could be made toward controlling or alleviating this quality degradation.

Some degree of salt concentration due to irrigation has been accepted as the price for irrigation development. However, there are areas where quality degradation has been a serious matter for some time. As pressures on water resources become greater due to increasing populations and the necessity to grow more food, there is a mounting concern for proper control of such serious water quality deterioration and soil salinization. The need for more precise information as a basis for wise action becomes essential.

The major problems resulting from irrigation are due to the basic fact that plants are large consumers of water resources. Growing plants extract water from the supply and leave salts behind, resulting in a concentration of the dissolved mineral salts which are present in all natural water resources. In addition to having greater concentrations of salts in the return flow resulting from evapotranspiration, irrigation also adds to the salt load by leaching natural salts arising from weathered minerals occurring in the soil profile, or deposited below. Irrigation return flows provide the vehicle for conveying the concentrated salts and other pollutants to a receiving stream or groundwater reservoir. It is necessary to examine the waterlogging and salinity problems resulting from this process and to develop and implement measures to control or alleviate the detrimental effects.

Impaired crop production resulting from salinity is not limited to the Western United States, but is a major problem in many areas of the world. The portions of the world facing the greatest population pressures are the same areas which have the least amount of additional land available for agriculture. In such areas, increased food production must come from more intensive farming with consequent increased yields. Although there is a great need to increase the productivity of such lands, agricultural production is being damaged due to rising groundwater tables (waterlogging) and increased salinity in the soils and groundwater supplies. It has been estimated that more than a third of the world's irrigated land is plagued by salt problems.

Whenever water is diverted from a river for irrigation use, the quality of the return flow is degraded. The return flow mixes with the natural flows in the river. This mixture is then available to downstream users to be diverted to satisfy their water demands. This process of diversion and return flow may be repeated many times along the course of a river. In the case of the original diversion, if the increase in pollutants contained in the return flow is small in comparison to the total flow in the river, the water quality would probably not be degraded to such an extent that it would be unfit for use by the next downstream user.

If the quantity of pollutants (e.g., salinity) in the return flow is large in relation to the river flow, then it is likely that the water is not suitable for the next user unless the water is treated to remove objectionable constituents. Since water is diverted many times from the major rivers, the river flows show a continual degradation of quality in the downstream direction. As the water resources become more fully developed and utilized, without controls, the quality in the lower reaches of the river will likely be degraded to such a point that the remaining flows will be unsuitable for many uses, or previous uses of the waters arriving at the lower river basin no longer will be possible.

On a broader scale a variety of problems have appeared with extensive irrigation practices. To start with, an underlying important reason that repeatedly comes throughout the literature is a lack of an awareness of the need for integrating engineering measures with agricultural practices. As it has been stated in many studies, often the engineering undertaking and the assorted socio-economic agricultural activities seem to operate in isolation to the detriment of the development objectives.

Second, it should be noted that in addition to the lack of an integrated approach and the demands for comprehensive development incorporating physical and non-physical dimensions, irrigated agriculture is characterized by the fact that it is the biggest consumer of water and as a matter of fact, one of the most inefficient. Irrigation accounts for more than 85 per cent of the total consumption of water controlled by man. It has been estimated that while most industrial processes use less than 100 tons of water for one ton of end product, agriculture generally requires several thousand tons. Other estimates show that both the application efficiency of most of the irrigation methods and, as a matter of fact, the overall project efficiency seem to sometimes be as low as 20 to 30 per cent in the less developed countries where management of water use is virtually neglected.

A third problem associated with irrigated agriculture (especially in developing countries) is the fact that generally irrigated schemes are very costly undertakings and the experience with many of them so far has proved to be both slow and low yielding. While one can understand the reasons for the slow flow of returns inherent in such irrigation projects, still in a number of cases their long so-called gestation periods are many times related to the inadequacies in engineering design criteria. This particular difficulty is also coupled with the lack of proper overall technical administration of project development and operation. As a result, irrigation and drainage facilities are seldom provided to make possible the practices of proper water management at the farm level.

A fourth problematic situation is associated with the fact that irrigation structures and irrigated water management are only part of a larger story: the eventual success of an irrigation project depends on the capability of individual farmers in adopting and utilizing a growth environment for agricultural production. Thus, well-conceived irrigation projects and appropriate physical structures can produce fruitful results only if the farmers make full use of them. Motivation, strategic initiative in utilizing a growth environment, and improved capability for sustained production are perennial problems appearing in any discussion of developmental efforts in agriculture.

We have underlined above quite a number of problems associated with irrigated agriculture. We should not forget of course that there are quite a number of social and economic benefits to be derived from irrigation development. Increased food production and its importance in alleviating population pressures need no further discussion. While in most cases the expenditures of public funds for irrigation projects are still made with the old historical intent of increasing wealth, there are also growing considerations of larger, broader social goals concerning a balanced attempt for the welfare of the nation as well as the welfare of the farmer and of the region in which he lives. Thus, the preoccupation with increasing wealth is now accentuated by an understanding of the larger effects of investments in irrigation projects in terms of their impact on local growth and stability. Indeed, when the initial period of heavy capital expenditures and growth are achieved, the economy is then able to reach a level of stability based on a continuing intensive application of land and water resources. The source of stability of a given region derives from a generally accepted principle that the more diverse the pattern of cropping in irrigation areas, the more the economic stability through a diversified product capable of withstanding wide price fluctuations .

1.3 Improving Water Management

Whether the goal is minimizing diversions to new croplands because of limited water supplies, reducing future diversions to irrigated agriculture to provide water supplies for new demands, minimizing water quality degradation in receiving streams resulting from irrigated agriculture, or maximizing agricultural production on existing croplands, the solutions are identical--improved water management practices.

Maintaining or increasing agricultural productivity in an irrigated area requires, first of all, that a salt balance be achieved in the root zone; and secondly, that not too much water is applied such that the groundwater levels rise until the water table is near the ground surface, thereby resulting in waterlogging and increased salinity levels in the root zone. Thus, a balance must be reached in order that sufficient water is applied to the croplands to leach salts from the root zone, but not so much water that groundwater levels nearly reach the ground surface. The history of hydraulic societies has been primarily one of applying too much water. And overirrigation continues today in most portions of the world.

Achieving high levels of water use efficiency in order to minimize canal deliveries and prevent or control waterlogging and salinity due to irrigation return flow is both difficult and expensive. Potential solutions and control measures involve physical changes in the system, which can be brought about by constructing sufficient improvements to new or existing systems, or by placing new institutional influences upon the system, or a combination of both. Since irrigation water deliveries and return flow are an integral part of the hydrologic system, control measures for managing the water deliveries and return flows from an irrigated area must be compatible with the objectives for water resource management and development in the total system.

In order to meet ever-changing societal goals, water resources planning, development and management must be a dynamic process. With new demands continually being placed on existing water resources, this challenge will require continued improvements in irrigation water management. Thus, the implementation of improved water management practices today must not become the problems of tomorrow, but rather be a part of the evolutionary process of achieving higher and higher levels of water use efficiency. Therefore, an irrigation system must retain flexibility in order to be responsive to public needs.

Let us elaborate, however, a little bit on some philosophical underpinnings of efforts directed towards improving water management. Among others we need to underline that:

a. all development is not necessarily good. At the heart of good water management is more than just economic gain, general growth, or simple physical efficiency. Non-commensurate dimensions, social costs and benefits, aspects of equity, and similar concepts all exemplify concerns and questions beyond simplistic pecuniary calculations.

b. Changes should be introduced into an irrigation system only when necessary and in the context of broader policies accentuating preoccupation with social benefits.

c. Where possible existing institutional arrangements and organizational structures should be used, rather than to create or superimpose new entities. This also implies respect for local culture, established normative patterns, and accepted social values.

d. Socio-cultural patterns and practices of the farmers which are compatible with improved practices and/or the implementing of new technologies should be conserved and encouraged. At the same time, a socio-economic and legal basis should be established that would permit flexibility in maintaining existing patterns or provide appropriate mechanisms for an orderly introduction of new or modified patterns.

e. Since change represents effort and social tension, its introduction should be gradual in order to avoid stressing limited individual and collective ability of absorbing and integrating the new.

In essence, the above emphasize a main point, namely that our effort is to preserve as much as possible the status and importance of irrigation in the arid West and recognize its value in the economy and life of the nation. The program that one can design in order to improve water management should allow potential beneficiaries to decide which option or combination of alternatives is most suitable to their ideals, conditions, and capabilities. At the end, the focus is on the individual farmer as a client, not as a specimen of research or as a patient in an ailing society.

As related previously, a variety of circumstances today coalesce to create water-related problems all over the universe. Increasing demands and the despoliation of the natural environment are major expressions of such concerns. Voluminous material has been already written concerning aspects of quantity and quality and the implications from the interrelationship between man, technology, culture, and environment.

It is in the context of these concerns that one must also understand the larger perspective of socio-cultural aspects of present and future water management schemes. Socio-cultural aspects in water resources should relate to the basic socio-economic activities of any region through the following water concerns: a) food production; b) urban water demands; c) industrial water demands; d) municipal waste disposal; e) power generation; f) recreation and wildlife demands; g) environmental enhancement. Thus, both technological and social responses to such concerns as well as legal mechanisms for carrying out management schemes would tend to fall under four major categories:

1. Strong incentives for efficient or new uses, including economic benefits, redefinition of the doctrine of beneficial use, etc.

2. Structural changes, such as new organizational arrangements, creation of new water agencies, etc.

3. "Regulatory counter-incentives," such as stricter enforcement and pricing policies.

4. Changes in "water intensive" lifestyles and cultural practices.

The above tend to emphasize what one may call non-structural developments and policies. Another major part of the story would be of course the technological solutions that would alleviate problems of supply. All the above, however, point out that essentially humanity as a whole and particularly regions of increasing demands and of arid conditions need to put into a proper perspective a pervasive attitude of people vis-a-vis water: "many people in arid environments express the belief that water should be made freely available to everyone who 'needs it'." Perhaps this might have been understandable earlier, but our times cry for changing this "water intensive" attitude --the result of the origin of the settlers of the region--or of changing the role of water as a means of survival in a rather "hostile" environment. In any case, either through increased supply or, more preferably, through diminished demand we should be affecting the extent and character of water use in the surrounding environment.

If one is to isolate some key items in policies and planning affecting water management, and in view of some of the impressionistic remarks made above concerning quantitative and qualitative aspects of water resource exploitation, the following concerns stand out:

a. the release of water for new demands;

b. the maintenance of agricultural productivity;

c. the minimization of water quality degradation;

d. an expanding economy highly dependent on water;

e. a developmental growth outlook; and

f. lack of appropriate institutional and legal infrastructures to meet new and competing water demands.

Proper water management organization, technological innovations, and the efficient (and effective) allocation and use of existing resources are crucial factors for the success of any water project. However, national growth policies, environmental concern for despoliation, and emerging natural resources policies are pointing also towards more comprehensive or integrated planning. The positive and intangible benefits to community development, which have always been tacitly recognized and acknowledged, must be articulated in more specific terms. Water, as an organizing concept, can play an active role in guiding and stimulating growth, in providing new standards and evaluation criteria, and in strengthening its potential as an additional means for achieving larger social goals. At the same time, future agriculture development raises such important questions as to how can more food and materials be produced with dwindling land and water resources? How will agricultural water use compete with other demands? How can limited economic resources be used in an efficient and equitable manner for the achievement of important social objectives?

Large as these questions may be, they are the necessary backdrop for understanding the more specific dimensions, problems, and opportunities in any narrow question of an effective system of water management.

In this respect and in trying to determine effective water management, as well as the trade-offs and options in changing the arrangements of present systems, three different conditions of "effectiveness" can be proposed.

Traditionally, the most widely used term has been that of *efficiency*, which attempts to relay in simple, economic benefit-cost analysis the relationship between existing resources (input) and proposed goals or attempted objectives (output). Various economic formulas and advanced techniques can relate economic costs to benefits and measure growth in material development so that a solid basis of economic sufficiency may be maintained. It should be also noticed that the term efficiency has been used as a synonym for improvement in performance and as a least-cost combination of methods for attaining specific targets.

Equity refers to the question of fair access of resources and consumption to different segments of the population (involving those directly affected by a project and the public at large). This concern is part of a larger preoccupation with the achievement of social justice among a wide spectrum of interests and social aggregates. Needless to say, opinions differ widely with respect to the equity of indiviaual projects. Some of the more difficult questions arise in the context of regional efforts for regional development, direct or indirect subsidization, competing uses, etc. Yet, there must exist some basic consensus concerning what is equitable in order to guide the variety of water resources policy decisions.

Finally, *effectiveness* concentrates on the overall significance of any water project, system, or policy vis-a-vis the pursuing of certain larger social goals. Effectiveness attempts to move beyond purely economic considerations by trying to answer the question of how a particular system can efficiently, and guided by principles of social awareness, meet broader goals of a given society or group. The term effectiveness (occasionally mentioned in the literature as *efficacy*) is associated with the measurement of intangible benefits as well as of larger social costs associated with any water system. Thus, the term effectiveness extends our horizon beyond the traditional quantitative criteria used in the measurement of benefits to be accrued from any type of irrigation project into new areas of qualitative considerations transcending purely utilitarian purposes.

The distinctions between efficiency, equity, and effectiveness may help us in forwarding an important point when we try to evaluate benefits and costs associated with irrigated agriculture. Irrigation systems, as well as other water systems, are not only abstract simulation models responding to general physical or broad economic imperatives. All irrigation programs include individuals and communities that have developed a pattern of life and whose welfare and future may even depend on inefficient water systems. Even a marginal or not particularly efficient agriculture fulfills the purpose of being a supportive social system for a number of individuals and part of an on-going life for quite a number of people in the society. In other words, because of the social costs of dislocation and disruption, many times a policy of continuing present practices may be dictated as a response to long established cultural practices and social arrangements. Thus, a basic task in our research was then directed to answer the general question of developing the kinds of organizations and of alternative water systems that could maintain themselves efficiently, and operate effectively in the context of equity.

It is in the spirit of such remarks that one can also examine the problem of consolidation, namely as a maximization of the welfare of the entire system. The welfare of the entire system is said to be maximized when it is impossible to increase the welfare of one part of the system without decreasing the welfare of some other part of the system. A particular consolidation plan demands the structural as well as normative integration of various aspects of the system and a careful consideration not only of changes in organizational arrangements but also modifications among the participants of the system in accepting and incorporating changes.

1.4 Interdisciplinary Integration

What makes much more urgent the consideration of alternative organizational systems is a two-fold expansion of the concern with water resources planning. First, there is an *expanded time horizon* in terms of moving from the preoccupation with the immediate, short-range, direct impacts of water systems on the surrounding environment to long-range, higher order, indirect consequences of any type of planning. Secondly, in addition to expanded time horizons we also have *expanded space and disciplines* involved in considering any type of water system. Recent legislation, especially in the United States with the National Environmental Policy Act of 1969 and similar "environmental" documents, have particularly emphasized the need to integrate physical and non-physical dimensions and to consider much more expanded areas upon which one can calculate the effects of any kind of resource utilization system. A three-fold emphasis, then, characterizes water management efforts:

a. Stronger "multidisciplinary" (if not interdisciplinary) commitment and the need to integrate quite a variety of "environments" in any planning effort.

b. Search for higher resolution in the calculation of project effects and in the establishment of alternatives.

c. Longer time horizon, especially a shift from the narrow enumeration of immediate impacts to a long-range estimation and forecasting of unanticipated and higher-order consequences of any kind of technological perturbation.

The problem that the present researchers had to tackle with may be very simply stated: in view of efficiencies involved in highly fragmented or segmentalized irrigation units serving a variety of interests in the Western United States, it may be appropriate to consider alternative schemes, especially consolidation, as a means for improving efficiency and effectiveness in water utilization. From such a simple statement of the problem, the researchers wanted to develop a system that would combine physical and non-physical factors affecting the degree of successful consolidation and would lead to effective water management preserving precious water supply. The study, therefore, focused attention to:

(1) the overall desirability of consolidation as an alternative means to the presumed ineffective traditional and segmentalized irrigation systems;

(2) the feasibility of probable change, including specific implementation steps, design criteria, and priorities of action; and

(3) environmental costs and benefits in the context of some major reconsideration concerning the role, significance, and impact of irrigated agriculture in arid regions.

In essence, what the project is attempting to delineate are answers to two key questions that seem to permeate the calculation and evaluation of any proposed environmental change, namely:

a. How do we balance in an *equitable* manner benefits and costs involved in the operation of a combined physical and non-physical system?

b. How do we make appropriate changes and transitions to new states without *unacceptable* disruption to all systems?

These two questions simply emphasize the need to see irrigated agriculture as a system where various physical and non-physical constraints, as processed through various organizational structures, contribute in various degrees to the achievement of desired goals.

Since the outcome of many programs depends both on the political decision-making process as well as on the availability and effective utilization of water resources, every major water program should be characterized by both an improvement of this political decision process and the resources-outcome ratios. This implies an understanding of the integration of both physical and non-physical dimensions in long-range development strategies aimed at maximizing resources-outcome considerations. Climatic constraints, physiographic features, engineering potentialities, the general social context, and multi-objective, multi-level planning are essential ingredients of efforts attempting to integrate physical and social goals and of shaping a socio-economic system which will facilitate increased production and provide diversified mechanisms of coordination and control leading to the creation of an appropriate "growth environment."

Such diversified questions of social policy and equity in water resources use are part of an increased awareness and commitment to holistic planning (or as some like to refer to as "total environmental planning"). There is no need at this point to spend an inordinate amount of time trying to develop from scratch the argument as to the ecological imperatives and the requirements for understanding the environment. What is most important here is to emphasize the idea of a harmonious relationship between three parts that compose what one may describe as the "total environment," namely *individual, culture* and *physical environment*. In doing so, we want to examine how individuals in creating culture affect both their individual lives and the surrounding natural environment. In turn, the natural environment provides certain constraints as to what individuals can do and how a given culture is shaped. In essence, then, the term environment may be defined as the system of spatial, temporal, and social regularities which influence the biological and behavioral processes of a given population. This broad definition has an important implication in that what is generally called the natural environment has meaning and utility only in the context of a social setting in which individuals (and their culture) interact with nature.

Both the physical and social environments at large are only descriptive categories of a complex set of interdependent relationships subsumed under the broad term of total environment, i.e., all conceivable systems affecting man as an individual and his community as a whole. The key argument of the above remarks is that what is usually called natural environment has meaning and utility only in the context of a social setting in which the individual interacts with nature. The individual-centered system is the heart of a total environmental approach and of the society-technology-nature symbiosis.

What needs to be emphasized from the above brief remarks is that technologically speaking, the development of water resources in a given region can be probably achieved with the existing level of scientific and technical knowledge. However, development is not a matter of technology alone. Technology, in the absence of relevant data, organization, planning, institutions, human skills, available capital, and more than anything else a clear understanding of the motivation of the people who are to employ it, can become a futile task of mimicry with no organic connection to the life of the region.

Further discussion of the question of integrated planning is made later on in Section 7.4. What we need to emphasize in concluding here is the need and utility of an interdisciplinary approach for alternative irrigation systems At each level and for each component, part and function of an irrigation system, problems of institutional order arise, difficulties of organizational arrangements, legal imperatives, economic exigencies, engineering prerequisites, as well as ecological and social consequences resulting from each stage or phase of a dynamically operating enterprise.

Given the complex arrangement of the interrelated parts of any system of irrigated agriculture, we need to re-emphasize some major points of concern:

(1) Successful development and management of water resources requires much larger institutional and organizational arrangements, quite succinct from the presently prevailing highly segmentalized and individualized approaches in agriculture in various parts of the world.

(2) Norms and cultural values concerning water use must be coordinated within a larger social planning domain, especially with regard to water rights and physical constraints.

(3) Each proposed irrigation system, independent of its level of operation, must develop unique patterns much more responsive to the specific people and cultural conditions found in a given region, rather than simply blindly accepting generalized findings and principles from other areas.

(4) The larger the scope of the irrigation system and the greater the scale of analysis, the more complicated the planning effort and, therefore, the more the need for coordinating powers and interdisciplinary integration.

1.5 Merger and Consolidation

Throughout the irrigation systems found in the Western United States, both legal mechanisms and organizational structures have been directed toward establishing the means, within state boundaries, for allocating distributing, and utilizing the water resource along with administering the system of control for the activity. The system of control has been the water laws governing allocation, distribution, and utilization of the resource as adopted by each state.

The institutions which have developed in the Western United States have been tailored to accommodate the appropriation doctrine of water law. That is, the recognizing of property rights to the use of water on a first come, first serve basis.

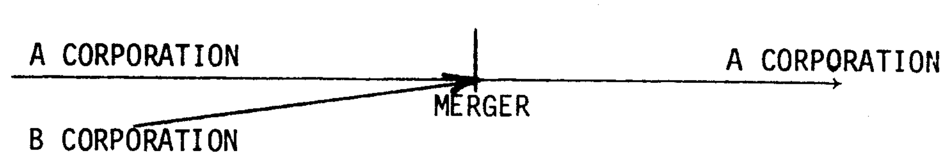
The appropriation doctrine is jurisdictionally limited to the individual state. When disputes arise between users of different states, the controvery is resolved either by litigation between the states in which an effort is made to recognize all existing rights on an equitable basis, or by interstate compact and in one case by congressional allocation. The main tools for administering water are, therefore, agencies which are created by the state.

In the process of attempting to exercise these private water rights and in establishing methods for delivering water to distant points from the major stream in an economic manner, the major institution was the irrigation company. The irrigation company took several forms which ranged from a federation of users joined for a single purpose, to mutual companies existing only to build facilities to deliver water, to its users to the company organized for profit. The existing thread tying all these companies together was that they all existed in order to develop the resource; that is, to provide a means by which more water could be used by delivering it to more people or to places farther from the main point of diversion.

Today, however, for practical purposes all the water has been allocated. Therefore, development of the water is no longer the primary concern. Rather, management of the allocated water is now of the utmost importance. To improve the management of water resources, the existing organizational structures have to be rearranged in some instances. The rearrangement is often necessitated by the need to be more efficient in delivering water or to incur less expense in the managing of the existing facility.

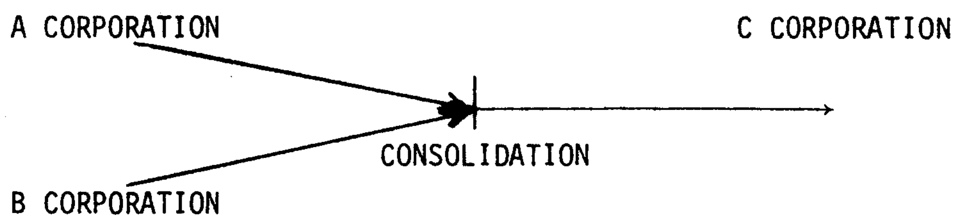
The traditional distinction between a merger or consolidation is that in the case of a marger one or more corporations merge into another corporation which is known as the surviving corporation. The result of this situation is that the former ceases to exist and the latter corporation exists in its continuance.

(a)



In the case of a consolidation, however, the two corporations (or more depending on the specific case) cease to exist and a new corporation is formed out of the consolidated corporations.[1]

(b)



In either case, the surviving corporation takes over the assets of the former corporation, assumes its liabilities, and issues its own shares and pays some value on a fair basis in exchange for the shares of the former corporation. Corporation statutes of Colorado and Utah authorize mergers and consolidations without the necessity of unanimous approval of the shareholders.[2] For shareholders who do not wish to go along with the merger and do not wish to approve the merger, there is an appraisal remedy provided by statute[3] in which their shares can be appraised and they can receive the fair market value of those shares. These mergers and consolidations usually require a resolution by the board of directors and the approval at a shareholders meeting of a specified number of the outstanding shares of each corporation at the time of the vote.[4]

The basic assumptions of the advantages of merger and consolidation relate to economic economies of scale, which is simply getting more for less money. This phenomenon occurs when bulk orders and large-scale projects are undertaken versus small-scale projects which relates to the advantage of using fewer people. That is to say that if one irrigation company has a set of administrators, officers, and ditch riders along with all the physical facilities necessary to deliver water, and this company's facilities are running alongside another irrigation company with its own set of officials, facilities, and ditch riders to deliver water to its customers, it is clear that there is a waste of manpower and a duplication of functions occurring. If these two can merge or consolidate, much of the water can be delivered by only one facility, thereby cutting down on the need for maintenance, cutting down on the need for ditch riders, and cutting down on the need for administrators.

Another advantage, particularly in areas in Colorado and Utah and in the urban areas, is that by consolidating and lining ditches and making things more efficient, water will be freed for other uses which is an appreciable consideration in light of the expanding population both on the front slope of Colorado and in the Salt Lake City area which is almost a mirror of the Denver strip city problem.[5]

It should be clear just from reflecting on the problem for a moment that a merger or consolidation would facilitate a unifying of physical structures and the money that is saved by the lack of need for personnel and the maintenance of these structures could well be spent in improving the facilities, and other activities which conserve water. Items which need to be purchased for two companies could be purchased by one company. Moreover, if the money saved would be spent in improving the facilities, the efficiency of water delivery to customers would be increased, thereby giving a substantial benefit to each shareholder of the company or each customer of the company. The assumed direct benefits to be derived from consolidation of irrigation companies have been discussed previously in Section 0.4 and need no further repetition here. Economies and organizations of "scale" seem to carry all the advantages of efficient institutional arrangements in order to meet the highly complex, interdependent problems of irrigated agriculture in the fast changing valleys of the West.

Yet, there are significant social and political disadvantages resulting from the merger or consolidation of irrigation systems. For example, if you remove a man from the presidency of a water company and deprive him of his status, understandably he will resist such a removal and status transformation. In addition, maintenance people and ditch riders whose services would no longer be needed could certainly be expected to resist merger or consolidation. It might be added parenthetically that not using as many workers may be an advantage or a disadvantage. This depends primarily on the employment situation in an area. Obviously, if there is a demand for workers, losing a job as a ditch rider will create no particular problem for the individual involved for he can simply go and find himself another job. However, if unemployment is very high, then consolidation of an irrigation company would not be very beneficial, in spite of all the economic savings for the company, for the social costs would be too severe.

The purpose of this report is not to dicate which alternative would be the better alternative for a particular area, or to answer the larger social status questions, but rather to simply set out perceived alternatives. The emphasis in the following pages will be on consolidation and merger as viable alternative organizational schemes. In such a discussion, however, it should be noted that there is a hierarchy of water organizations ranging all the way from the individual user, to a couple of users, to a small company, federations of companies, to irrigation districts, to state-owned water delivery systems. The choice of system to be used depends, of course, largely on the individual area considered, the desire and preparedness for alternative arrangements, and the urgency for meeting increasing demands, new uses, expanding populations, or growing economies.

Before describing the specific search for consolidation, especially in the case studies of Poudre and Utah Valleys, we need to provide some further notes on the process of irrigation development, the present understanding of irrigation systems, and the constraints or facilitators that prescribe the problem at hand.

Notes

1. Henn, Harry G. Law of Corporations. West Publishing Company, 1970, p. 713.

2. Colorado and Utah corporation statutes allowing merger and consolidation without unanimous shareholder approval.

3. Colorado and Utah corporation statutes on appraisal of shares for dissenting shareholders.

4. Need number of shareholders to approve mergers.

5. Clyde, G. D., "Consolidation of Irrigation Companies." Paper presented at the annual meeting of ASCE, Irrigation and Drainage Division, Salt Lake City, Utah, September 10, 1954.

2.1 The Evolutionary Perspective

The development of irrigation systems began thousands of years ago. Early civilizations were created and thrived near natural irrigable alluvial soils. Their success at developing an irrigation system that would produce agricultural products for their populations is well known. As early as 2627 B.C., the Chinese irrigated lands through a system of canals, the largest, the Imperial Canal, being 700 miles long and large enough to also be used for navigation. Large irrigation systems were developed by the Aryans in the naturally fertile arid valleys of the Tigris and Euphrates. Engineering skill was highly developed for the time as noted by the large irrigation reservoir, 42 miles across and 35 feet deep, which captured flood waters for use in the irrigation system, and by the high cement and brick embankments on both sides of the Euphrates, designed to protect ancient Babylon.

The history of Babylon also exemplified remarkable development in the legal area, particularly in water law. Local customs and practices in the art of irrigation were given specific provision in a written code, the Code of Hammurabi, promulgated about 2050 B.C. This code provided guidelines for water use and penalties for individuals violating rules within the water system.

Other civilizations have contributed greatly to the use of water and development of irrigation systems. The Egyptians, Carthaginians, Greeks, and Romans have added elements which combined provide a wealth of ingenuity and skill. Canals, aqueducts, reservoirs and tunnels for domestic, irrigation and sanitary uses were constructed, some of which are still in operation.

At this point one may ask the question as to what do we really know from the past that can act as a historical guidance for meeting problems of the present and of the future. All available records point out that the ancient water managers faced with parallel water problems have always tried relentlessly to match available water supplies to expanding needs of the economy, regardless of cost to the social and sometimes to the physical environment. Yet, while we may think that the environmental ethos that is currently prominent in water resources is something of a recent awakening, through history, despite the preoccupation with a developmental outlook, all hydraulic civilizations have showed an understanding of environmental perils resulting from intensive water development. Following some of the insightful remarks of Teclaff on this point, we may expand some historical precepts that seem to have universal validity. Such precepts include the observations:

(1) Wherever there has existed an ecologically sound water management system, evolved over a long period of time, it should neither be tampered with nor allowed to deteriorate through neglect or apathy.

(2) Wherever possible, resources should be administered in harmony with the total environment.

(3) Potential harms from further water resources development should be weighed against the potential benefit of a project, including aspects of social effectiveness.

(4) That the concept of public duty should extend to the entire population.

(5) That planning, ideally, is a centralized affair requiring integration and coordination.

Again, Teclaff has observed that the most significant lesson of history is that without a technological breakthrough that would provide new sources of water or reduce consumption in many of the tasks which water now performs, sufficient water for the needs of a growing economy can be provided only at ever-increasing costs to the physical environment or to the social environment, or both (Teclaff, 1973). We have to realize more and more that there is a point in natural resource development when water can no longer be matched to the economy, but the economy must be matched to the water available.

Continuing this brief historical exercise and evolutionary perspective in irrigation development, we find that on the American continents, the earliest developments appeared in Peru, a semi-arid country where canals and aqueducts conveyed and spread water over lowland deserts, as well as lands along the Gila River in Arizona, which were irrigated centuries ago by Indians. Irrigation was practiced in Mexico in the early Christian Era, and spread northward to the areas now comprising California, New Mexico and Arizona by the Spaniards and missionaries. Later, groups of Mormons entered the Salt Lake Valley in Utah and began diverting water through ditches to irrigate crops. Shortly thereafter, pioneers in Colorado and California developed irrigation systems that are still in existence.

As it will be discussed further in Section 2.3, early irrigation systems in the arid Western states grew from need, custom, and ingenuity of the settlers. Once built, the physical characteristics of the early systems were modified only to expand water supplies for system emlargement or provide low cost improvements. A concept of property rights to water was developed that further solidified the permanency of the system; and, concurrently, individual pride in, attachment for, and fear of loss of his segment of the system emerged.

Irrigated agriculture has an important role in development of the West. Without the application of water, these arid lands were usually worthless. Hence, development depended upon the availability of a water supply. Where an adequate supply and climatic conditions conducive to irrigated crop growth existed, settlement grew. The Federal Government, having adopted a policy of encouraging Western growth in the late 19th century, contributed greatly to the rapid increase of the agricultural sector.

Irrigated agriculture has been the backbone of many civilizations from the beginning of time; and its role in modern society is increasingly gaining importance as population increases and consumers' tastes shift.

Modern technology has increased the capability of food production through the artificial application of water and has greatly overcome the deficiencies in rainfall for crop production. In addition to internal development of irrigation projects, bilateral and multilateral agencies are providing capital, technology and manpower inputs into the design, construction and operation of irrigation systems ranging from improving the status of the small farmers to large-scale multi-purpose river basin projects. Water management and irrigation systems projects range all the way from designing, construction of water storage delivery and distribution networks, to such nontechnical, but direct water use and control topics as assistance in establishing water management departments, developing water codes and regulations for allocation, distribution and utilization, and economic analysis of alternative irrigation systems approaches.

2.2 The Process of Irrigation Development

The evolutionary process of an irrigation system is directly related to the social interaction, system of tenure, and state of technology of the civilization with respect to the availability of water supplies. Thus, an irrigation system is both the institution and physical facility by which the acquisition, distribution, use and reclamation of waters contribute to the increased agricultural production in a particular setting. Irrigation occurs under three main conditions. One, when the water supply is inadequate; two, when the water supply is unreliable; and three, when the water supply may be used as a supplemental means of control and regulation.[1]

The process of irrigation development has been examined by a variety of authors. Daumas in particular states with regard to agriculture: "The history of the evolution that occurred in the human societies between five thousand and three thousand years before our era can be understood only if the technological evolution is supported by a study of geographic and economic conditions in which this evolution occurred."[2] In this respect, Daumas and his colleagues examined every phase of technological development from the time predating Britain's history up to the present and his comments throughout the four-volume work imply a strong support for thoroughly evaluating the process of evolution as a means of developing solutions for present and future problems in irrigated agriculture.

Seven factors have been most often identified as playing a crucial role in the process of evolution of irrigation systems. These factors are: geographical, historical, socio-cultural, religious, physical, economic, and organizational. We intend to provide an overview of such factors in the context of some rearranged, summary categories in order to underline their importance as either constraining or facilitating conditions in the course of a given irrigation development.

2.2.1 Geographical

The geographical factor has, perhaps, the greatest initial significant effect on the type of agricultural practice that will be employed by any group within a given area. Two geographical classifications merit particular discussion. First, geographical classifications for precipitation and the effects that these have on irrigation practices. Such precipitation classifications involve humid, subhumid, arid, and semiarid cases. Secondly, in discussing the effect that geography has had on irrigation practices we may proceed along lines of specific geographical areas or localities.

When considering irrigation, it is easy to be preoccupied with the physical structures one sees, such as the impressive dams and long canals that are used to divert and store and deliver the water to users. But it must be remembered that irrigation is as much a reflection of human organization and adaptation to a particular physical environment as it is an achievement in technology. Landscape and irrigation patterns vary widely depending on the type and nature of the settlement in each area. While irrigation has been felt in areas of the world which are either humid or subhumid, the area in which irrigation has transformed the landscape to the greatest degree is in the arid and semi-arid regions.

In the discussion that follows, the movement of people in response to their surroundings should be kept in mind as a backdrop to the presentation of irrigation development as well as the marked differences between the landscapes seen around traditional small-scale irrigation and that of more modern large-scale projects.

It has been noted[3] that generally in the Eastern half of the United States and in the Western part of Europe, irrigation is largely supplemental in character. Under normal conditions there is sufficient rainfall to support plant growth. Irrigation installations of this type are usually very small and are rarely seen except for limited periods in the summer when supplementary water is deemed to be required. While this supplemental irrigation has increased crop yield, it has had little effect on the type of crops which are grown and equally a small effect on overall population distribution. Generally, it may be said that this small supplemental type of irrigation has had a minimal effect on the landscape and land use patterns, especially when compared to the effect of irrigation in the arid regions of the world.

To illustrate some contributions of irrigation to geography and the effects of geography on irrigation, it is helpful to examine some of the landscapes which have resulted from the application of irrigation practices in arid and semi-arid regions throughout the world. In these arid and semi-arid regions the introduction of irrigation has brought about almost a total transformation of the surrounding land with a related rearrangement of human population. The changes in the land vary from a little small green oasis in the Sahara and corresponding concentrations of the nomadic people around those oases and their travel patterns between them, to the literally millions of acres in the Imperial Valley of Southern California with the great population centers there.

An area which is particularly illustrative of the transformation that irrigation can bring about is the Nile Valley in Egypt. Nowhere else in the world is the transition from fertile watered land to barren desert so abrupt over great distances.[4] The cultivated land gives way to the desert within a few feet of the outermost irrigation canal. In the Nile Valley cultivation was restricted to a relatively narrow strip on either side of the river which is situated in a trough, or a narrow valley with an average width of about 12 miles and is bounded by a limestone escarpment. Only in the delta is the irrigated land extensive. Villages are located on the higher ground but on the edge of the irrigated area or within the cultivated land. They are found near standing waters and each village has its own pond or well.

Egypt is an example of traditional peasant irrigation farming. It combines the traditional features of small holdings and the primitive techniques of cultivation along with low yield. It is perennial irrigation which permits cultivation the year-round over most of the area. Since 1952, a program of agrarian reform has redistributed several million acres confiscated from large land owners. Unfortunately, this program has failed to improve the situation to any significant degree because Egypt's rapidly growing population and the consequent pressure on the land have prevented consolidation of holdings which would make more efficient farming possible.[5]

Contrasted with the Nile Valley is the other major irrigated area of the Nile, namely the Gezira Plain of the Sudan. In its land use, personnel, and economic organizations it provides a real contrast to the upper Nile Valley. Before the large-scale irrigation was introduced in this area, agriculture in the Gezira was nearly entirely restricted to narrow strips along the rivers from which water could be fairly easily withdrawn. Rainfall was uncertain and varied considerably from year to year and evaporation was high. Today, however, though the area covers less than one per cent of Sudan's land area, the Gezira contains 7 per cent of the population and produces 18 per cent of the gross national product.[6] The area is well suited to irrigation as it is level clay with the black clay preventing water from seeping away too quickly. In addition to the irrigation that exists, there is the fact that the terrain slopes away to the northwest and thus facilitates the flow of irrigation water from the Sennar Dam along the main canal which is situated on the east side of the irrigated area. About one million acres are under irrigation, approximately half of which are cultivated one year, and half the next.

The Gezira was divided into plots of 40 acres after completion of the Sennar Dam in 1945. Each plot consisted of four fields and these were handed over to tenant farmers. The plots are reissued to farmers each year only if they are farming them properly and they are not permitted to buy extra plots. This prevents a few wealthy men from gaining control of most of the land. An eight-year rotation is commonly used here. This consits of cotton, fallow, millet, fallow, cotton, fallow, fodder beans, and then fallow. Cotton is therefore grown only one year in four.

When comparing environments, the Imperial Valley of Southern California is in many ways similar to that of the Nile Delta. That is, it too lies in a desert and has a great river which rises in a distant, well-watered region. And it too suffers from extreme aridity and high summer temperatures which make agriculture impossible without irrigation.

The similarities with the previous valleys end, however, with natural topography. Agricultural practices, social and economic organizations in the Imperial Valley are vastly different. Farms in the Imperial Valley average about 100 acres in size, cultivation is highly commercialized, and large-scale farming operations employ a great amount of machinery in preparing fields, planting crops, cultivating, and harvesting. In spite of all this mechanization, however, a great deal of labor is required, causing an influx of population of seasonal and iternant workers consisting of Mexicans and Chinese, Philipinos, and Blacks.

Though the area was settled by white men and with irrigation systems developed at the turn of the century, it was not until 1940 with the development of the All-American Canal which diverted water from the Colorado River to the area that a great expansion of the irrigated area was possible. As the project involved the expenditure of vast sums of money, it was made possible only through the help of the Federal Government. The high cost of the water delivered led to cultivation of crops which for the most part have a high market value. While early market produce such as lettuce, carrots, cantaloupes and tomatoes as well as citrus fruits, barley, sugar and cotton are important, alfalfa which is a low cash crop (comparatively speaking) is also an important part of the classification, occupying perhaps up to 30 per cent of the cultivated area.

Because of the very sophisticated industrial machinery required, along with vast land and water holdings, cooperative marketing associations of which are among the best developed and the most influential in the world have grown up. Today, a large proportion of the land is owned by major investment firms, wealthy farmers, or banks which are able to provide the technical means for developing an area and economy unlike comparable regions in Africa and Asia.

Pakistan is a semi-arid region which in many ways resembles the Sudan Gezira. Until the end of last century, cultivation was restricted to relatively narrow strips along the main rivers as has been the pattern in the last two areas of study. Here, the water table is sufficiently near the surface to be tapped by a well. In the somewhat higher grounds the water table is too deep to be effectively utilized. The rainfall is light, irregular; land was given over to scrub land and nomadic farmers and to poor dryland farming, both of which support scant populations.

The transformation of this landscape was brought about by British irrigation engineers who completely changed the hydrographic character of the area starting about the 1880's. The canals which were built ran from main rivers and spread water across the doabs. After water was brought to the area, the land was divided into squares of 25 acres. Each such parcel of land expressed the amount one main ditch could water effectively. Families moved into the area and received land allocations which were fairly large by standards. The original allocations, however, in many of these regions have been divided up and others have been sold, so that today a great variation in size exists. Wheat and cotton are the main crops of the area, but some sugar cane and rice is also grown.

The coming of modern canal irrigation has brought about an enormous increase in population. It has been noted that whereas before irrigation the area had a population density of about 20 people per square mile, today the population exceeds 600 people per square mile. Clearly, the problems which have been created by such population growth and the expanding demands of feeding large numbers of people point to the need of a large-scale transformation of irrigation practices. In Pakistan, however, there are considerable problems with tradition and centuries old practices which stand in the way of consolidation of the holdings and the efficient use of water supplies.

The studying of a given evolutionary process of irrigation growth reflects both an understanding of the needs of an area and of particular irrigation institutions or arrangements that might be more appropriate for that area. For example, the basin might be used as a basic structure of irrigation systems. The idea of the drainage basin as a suitable framework for the study and organization of physical and human geography has a long tradition and history. To the academic geographers of the 19th century and to earlier researchers, the drainage basin seemed to offer a concrete and natural unit which could replace political units as the real context for geographical study. Although the theory that human movement population centers are linked directly to drainage basins has been for the most part rejected, there is indeed a close association between population and the hydrologic balance, or relief of slopes and stream networks of the drainage basin, as achieved through the operation of irrigation systems.

In the context of the drainage basin, the most important types of irrigation are those which involve some degree of communal action for their construction, operation, and maintenance. These are the irrigation systems which use water from a stream network through more or less elaborate systems of canals for the distribution of water to individual settlements.[7] Irrigation of this type has been characteristic of the great hydraulic societies of India and China. Limits are set to the extension of irrigation systems of this type by the availability of suitable terrain for cultivation or for the distribution of water usually within the context of a single drainage basin and by the volume and seasonal supply of water. It is also limited by the technology available and not least, limited by the scale and nature of the social and political organizations by which construction, maintenance and administration of water control must be carried out.[8] Small-scale and piecemeal irrigation may be possible within parts of the drainage basin in its early development, and such operations have been seen in Western Europe and in the Western United States. However, the competition for water supply and the pressures of population soon lead to demands for the extension of irrigation to new lands, thus frequently leading (at quite an early stage) to the integration of the small individual piecemeal systems within the drainage basin into larger units.

A parallel development involving the drainage basin as an interrelated unit is the integration of such functions as defense, religious purposes, administrative controls, and the supplying of urban centers, all of which point out to the extension of a single political authority in an entire region.

Though it has been noted earlier that the river basin has been rejected by many geographers as a major influence on the activity of the population, it is increasingly becoming more important as an input to the activity of the population because of the use of irrigation. Indeed, the idea of the drainage basin as an appropriate spatial unit for the organization of human activity and for regional planning has only recently been revised. The basin has been recognized as an interrelated system in which soil and vegetation cover, as well as hydrological balance, are involved with the recognition of the need for integrated plans and policies that deal with problems posed by flood control, sedimentation, hydroelectric production, and navigation, and even our conservation for stream pollution problems.

The Tennessee Valley Authority fulfilled such a need for regional authority transcending the boundaries of traditional units of government; and it was the prototype for other proposals and organizations in the United States. For example, the Missouri Valley Authority and the Columbia River Project are such projects in the United States. Recently, a project in the Mekong Valley which would transcend the political boundaries and is aimed at an integrated approach to the problem of water control and environmental planning was also proposed by Gilbert White.[9]

In Spain a regional approach has been undertaken which appears to even transcend basin boundaries. In the past, Spain has been oriented around the hydrographic approach to water management, which was satisfactory so long as water demands in a basin did not exceed the supply in that basin. Today, however, demands in several areas have exceeded the supply of the basin, and so planners have been faced with the necessity of either importing water or foregoing any more development. It has been observed that in the case of the Segura River in Southeastern Spain, the water resources are less abundant than in other areas of the country and development has proceeded to the limit of the resource in that area.[10] The Spanish government concluded that to gain maximum development from the Segura area it was necessary to import water. The closest and most economic source appeared to be the Tajo Basin, which includes the area around Madrid in which it was determined that there was water which could be used for the Segura area. The criteria used for developing the Segura area were: a) Segura had a water deficit and Tajo had a surplus; and b) that the climatic conditions in the Segura were some of the more favorable for depth agriculture and would produce a high income to the country. The transfer from the Tajo was the least costly alternative and the market for the Mediterranean area could produce a more favorable balance of payments.

Though the regional approach has been adopted by Spain in the above example, on an international level the trend is clearly for legalizing the river basin as the basis for cooperation between the states. In other words, the river basin not only becomes a natural unit for water resource development, but the legal unit as well.[11] This can be seen in a growing number of agreements entered into by interbasin states for a joint development of water resources.[12] The emergence of river basins as the physical framework of international cooperation extended in the operative area of international water administration can be seen, for example, in the jurisdiction of the La Plata River Commission, where the entire basin is embraced in the jurisdiction. Like other limited commissions, it has only the authority to advise and maintain the operation of water works already accrued. This limitation on the intergovernmental coordinating committee for the La Plata Basin is built on the proviso that collective action be taken without prejudice in projects which the basin states initiate within their own territories.[13]

On a national level, however, the importance of the river basin has been more dramatic as expressed in its influential role in developing domestic water supplies. In these cases, a river basin has spelt the mergence of a new administrative form which is the valley authority.

As can be seen, evolution in water development from the small farmer to a multi-irrigation project administration is necessitated over time and it is this concept which this particular report would like to stress. The importance of such an evolutionary development can be seen by viewing it backwards. For example, had the Tennessee Valley Authority ever been attempted when irrigation had just begun, it would not have succeeded at all. But pressures building from population on the existing water supply made possible that which would not be acceptable at one time become acceptable out of necessity at a later time.

As can be seen from the above, a major determinant of the shape and composition of an irrigation system is the physical features of the area. The topographic features determine the water resources flow and its other characteristics. All these combine to prescribe the geographical or physical features that eventually determine crop growth and cropping patterns. Early civilizations and subsequent major irrigation systems developed in areas where the diversion of water from the natural stream required a minimal effort to distribute it to subsequent low-lying lands. As the better land became occupied and placed under production, subsequent water users began diverting the water further and further from the stream beds and often times even out of the immediate watershed area.

In perspective, it is important to remember some of the remarks made about the evolutionary process and for what has been learned from helping developing nations in consolidating districts here in the United States. This is necessary in order that one does not impose particular systems which may be perfectly sound from an academic and engineering standpoint, but rather to take into account the needs of the area and to eventually use the system which the inhabitants of that area feel most comfortable with.

2.2.2 Historical

The precise origin of irrigated agriculture is not known, but there is no doubt that it has existed for many thousands of years in arid and semi-arid regions of Asia, Africa, and the Americas. As mentioned before, irrigation was practiced in the Nile Valley in 3025 B.C.[14] Many rulers of Egypt were instrumental in developing elaborate irrigations upon which their culture was based. Technical developments that were first used at this time include the artesian well, the nyometer for gauging streams, and the development of a great canal system for both irrigation and navigation. In addition, the earliest known mechanical aides for lifting water from one level to another were developed. These included such simple devices as use of waterproof baskets to lift water from the river, to irrigation ditches to more complicated devices such as the shadoof and the sakia which are still in daily use in the Nile Valley today. What is more important for the purpose of this report is to understand the evolving process as seen from history rather than taking a look at the technical development systems themselves. In other words, what we should recount is the flow of progress in a certain area from primitive to very developed methods of irrigation or, in the case of some areas, discussing why development in those areas has not gone beyond a certain point.

Essentially, what we refer to here as the historical factor becomes significant when attempting to discover why traditional practices within an irrigation system have been retained in the United States and to ascertain the roots of the strong resistance to change in the type of crop irrigation practice, organizational structure, irrigation community which have been deeply rooted in the past. While such a discussion reflects concerns with sociological dimensions, it is still part of a historical perspective.

By approximately 3000 B.C. the civilization of the Indus Valley had developed a great variety of tanks and irrigation canals; and at much the same time the Great Babylonian empire flourished in a prosperous irrigated agriculture which drew its water from the Tigres and Euphrates Rivers, through an extensive system of storage tanks and canals. The Moslems, too, had also developed great irrigation works before the birth of Christ, but here the water was brought to arid lands by piles dug for many miles in the surrounding mountains by which the water flowed by gravity. These tunnels, called Kanats, often extended 100 feet below the surface and are still constructed and used in much the same manner as they were 2500 years ago. In India, too, irrigation developed considerably in the first centuries after Christ, both in the Ganges Valley and the South. In the deltas of the southern rivers, water control became a complex and large-scale undertaking made possible only by the existence of the large and well-settled states. Barrages, tanks and canals developed into these regions and were copied by neighboring countries as far away as Indonesia for the cultivation of rice.[15] Irrigated agriculture also flourished in the Americas before Christ. It flourished too in the New Mexico-Arizona area soon after the birth of Christ. It has been estimated that in the Salt River Valley in Arizona, for example, more than 250,000 acres of land were irrigated by more than 1,000 miles of canals and ditches.

These methods of irrigation were the products of complex civilizations which had progressed beyond the subsistence stage of agriculture. They required the construction of enormous public works, control of the water supply for irrigation, and the inevitable development of bureaucracy. Clearly, a prosperous irrigated agriculture depended upon a stable society. Once a society had been undermined by war, conquest, disease, or the clogging of reservoirs or canals, irrigated agriculture collapsed too.

On the other hand, the rejuvenation of irrigation has occurred in many places and many times. For example, the Moors were among the leaders in spreading knowledge about irrigation and they developed extensive irrigation systems in Spain during the 12th century with the result that some of the most arid regions in the country became the most productive. It is with regard to these invasions and conquests that the study of history can delineate the evolution of developed societies as it was with the Moors when they invaded Spain. They brought with them their own irrigation technology practices, along with some of the crops which they had grown. In such an evolutionary analysis, a stronger nation overtakes a weaker nation and brings in more people, advanced irrigation practices, and a shifting of populations occurs; suddenly a small area which was adequately served by a primitive means now requires a more extensive irrigation system just to provide food for their inhabitants.

2.2.3 Socio-cultural and economic factors

The previous brief remarks, as well as many of the introductory comments to this report, have underscored the importance of what we may summarily describe as the "evolutionary perspective." Such an approach simply underlines the notion that an understanding of present challenges and the delineation of alternatives are largely influenced by a host of pre-existing environmental, historical, socio-cultural, etc., conditions. Central in such an approach is the assumption that natural resources need always to be understood within the context and in relation to a surrounding social-cultural milieu. Water has meaning and importance where socially used for the achievement of certain objectives. Its physical availability and natural characteristics are certainly constraining factors, but it is its eventual social use that makes it a valuable resource.

Thus, as part of an integrated social system the use of water must be socially controlled through sets of institutions. This means that the way in which water supply, patterns of water distribution, and water reclamation or reuse practices are regulated in a given society will depend on the nature, structure, and evolution of its particular water system as affected by the larger social-cultural environment and the specific ecological circumstances of a given region. Perhaps it is important also at this point to emphasize that when we use the term larger social-cultural environment, we incorporate in that also the set of prescribed legal rules that govern what otherwise are accepted values or norms of a given society. The legal system is the written specification of the sets of rules that govern through custom and tradition or prescribe a set of behavior for the citizens of a particular society.

One of the critical problems for incorporating social factors in the water resources planning and management process is really an inadequate understanding of the nature and structure of what has been called the "social domain." There are, indeed, many questions to be answered here, such as for example, how many social factors should be considered? What is the nature of each factor? What is the relationship between one factor and another? Is this underlying structure relatively stable? Are such social factors specific only to certain circumstances and situations, or are they generally applicable? What are the values of the population that are incorporated in water resources planning values?

As it was emphasized in the introduction, aridity and irrigation were the central concern of early societies giving rise to the great variety of "hydraulic" or "fluvial" civilizations. One cannot really talk about water and society without once again emphasizing the extent to which water and community development have always existed in ecological zones where water seemed to be crucial to social organization. Indeed, a cursory perusal of history would point out that water has been one of the most defining influences on the size and distribution of human populations. Although tropical and arctic regions are also the other two geographic bands of low human density, it was only in arid zones that water managed to support highly dense populations and complex civilizations.

Aridity, therefore, is becoming a focal point of concern and a necessary catalyst for organizing our argument. Arid zones are useful locales for examining the ways in which environmental factors affect and are affecting the life and structure of human society. The arid regions combine sets of potentially rich resources with harsh environments that challenge the adaptive capacity of many societies.

Anthropologists tend to distinguish four general and often coexisting social forms that provide distinctive adaptive strategies in arid environments. First of all, there are the small hunter-gatherer bands such as the Kung Bushman of the Kalahari or the Shoshone of the Great Basin; secondly, tribal organizations such as the Rwala Bedouin; thirdly, emergent sedentary villages around oases and water courses such as those of the Zuni or Hopi of the Colorado Plateau: and finally, the major complex organizations of hydraulic civilizations such as the Aztec or Sumerians.

All these civilizations and examples of an almost linear scale of social evolution provide us with characteristic social mechanisms for maintaining community solidarity. At the end of the spectrum, hydraulic civilizations represent the culmination of an interplay and reinforcement between religious values and bureaucratic organizations when, finally, villages and tribesmen become classes and ethnic components of a new order. It is interesting to notice that hydraulic civilizations seem to have emerged at significant ecological edges. Thus, many of the edges around the Indus River, the Gobi Desert, and the Huang River, the Iranian and Turkestan Deserts, and the Tigris and Euphrates Rivers, as well as similar boundaries of water rivers and deserts have been always the earlier sites of hydraulic civilizations. Spreading out from such important points of energy concentration are the agrarian villages, the nomadic tribes, and the hunter-gatherer bands.

Irrigation activities are associated from early historical times with every civilized society. The first known irrigation took place in Mesopotamia and other areas of the Old World. The type of irrigation which took place in these early times was primarily one of river flooding which would cover the lowlands of the delta. The flood waters would prepare the soil for the forthcoming agricultural time, and would supply the early agriculture users with a new layer of fertile and productive silt. A good crop could be grown with a minimum of expertise on the part of the early agrarian people.

Irrigation developments were the product of complex civilizations which have progressed beyond the subsistence stage of agriculture. These civilizations required the construction of enormous public works in order to control water supply for irrigation with an inevitable development of complex bureaucracies and of elaborate systems of social organization.

An important point always to be discussed with a socio-cultural overview of irrigated agriculture is that after the basic productive goal of an irrigation system is achieved, i.e., sufficient production for survival and economic growth, other social goals also appear which greatly complicate the institutional arrangements of an irrigation system.

Such developments and goals, however, carry with them both advantages and disadvantages. On the one hand, the control of water resources and the establishment of an irrigated system of agriculture in places where rainfall is inadequate or unreliable permits the development of highly productive agricultural practices, followed by an expansion of human population and economic growth. On the other hand, an irrigation system carries with it not only certain technological imperatives which cannot be ignored, but also important social constraints for the operation of what will eventually become a highly complex system. The imperative of efficient organizational structure and of strong supportive institutional mechanisms for the operation of an irrigation system have been strongly associated throughout history not only with the success of the irrigation system, but with the whole rise and fall of many civilizations.

Throughout all the previous remarks it has been assumed that in any persistent human group activity society requires a set of adjustive mechanisms to environmental pressures. Indeed, any significant interference with the environment will require adjustments throughout the system and appropriate mechanisms which are maintained by human decisions via positive feedback. One of the most important hypotheses in the development of irrigation has been the role of population growth. It has been assumed that population growth increases resource scarcity and, therefore, increased scarcity brings about consequent socio-cultural structural changes and adjustments.

At this point one has to refer to a variety of historical works that have examined the rise and fall of hydraulic civilizations and the relationship between changes in the environment and socio-cultural changes. More than anything else, the seminal work of Wittfogel, elaborated in his Oriental Despotism (1967), has become in the literature a main organizing scheme for the understanding of the relationship of hydraulic society as a special type of agrarian society. The characteristics of this hydraulic society rest on five major conditions:

1. Cultural, i.e., the knowledge of agriculture.

2. Environmental, i.e., aridity or semi-aridity and accessible sources of water supply, which may be utilized to grow appropriate crops.

3. Organizational, i.e., large-scale cooperation among segments of the population.

4. Political, or the organizational apparatus of complex order that is taken over by leaders of the commonwealth who direct vital external and internal activities to the defense and maintenance of peace and order.

5. Social, or a complex system of stratification separating the men of the hydraulic government from the mass of the "people" and, therefore, the rise of professional, full-time bureaucracy.

Wittfogel has analyzed many civilizations and has developed a cogent theory of hydroagricultural and hydraulic civilizations.[15] Hydroagriculture is a term which he uses to apply to a situation in which members of a farming community resort to rainfall farming and use of limited irrigation work due to the scarcity and fragmentation of available moisture or delivery systems. Hydraulic agriculture, on the other hand, refers to the situation in which agricultural fertility is brought to a large water deficient area by management of substantial sources of water supply which leads to the creation of large productive and protected water works managed by some form of sanctioned authority. He notes that hydroagriculture encourages the evolution of multi-centered, small, fragmented societies. In hydraulic civilizations, on the other hand, resourceful institutions of law and land tenure and administration have created or contributed to centralized works of water control management.

Essentially, what Wittfogel asserts is that in order for agrarian society to exploit a dry environment, there is a necessity for large-scale hydraulic works. The emergence of large-scale hydraulic works brings about a new scheme of social organization and the development of highly complex and interrelated forms of social relationships. It should be noted that in addition to simply observing this phenomenon of irrigation systems, Wittfogel has gone further and given us what may be used as a critique of the results of centralization. He has provided the theoretical scheme accounting for the social and political implications of pre-industrial irrigation systems of water control in terms of coercion in the formation of what he calls "oriental despotism." The thrust of his argument may be summarized by saying that the construction and maintenance of large-scale irrigation requires the assembly of a considerable labor force which may be most efficiently created either by institution of force labor or the levy of tribute and taxation or both. As he also notes in his article "The Hydraulic Civilization," this centralized administration is needed for the maintenance of canals and to control water distribution in a system which has a large-scale irrigation. The administration of the control of the distribution of water is in effect complete control of agricultural activity and, thus, a position is created to demand complete authority and complete submissiveness. This submissiveness may be escaped or thrown off only by mass revolt and rebellion in the face of desperate conditions. And, as Wittfogel further observes, society, then, becomes polarized into a large illiterate and dependent peasantry with a powerful bureaucracy and a small elite group which controls the central administration of agriculture. His best example of such an historical analysis is the vast bureaucratic government of China.

There is, however, a great current theoretical debate not only as to the position of Wittfogel, but also as to the relationship between large-scale irrigation and centralized political authority. Three key variables seem to be particularly relevant here:

a. the size and density of population;

b. the size of irrigation facilities; and

c. the degree of centralization of the decision-making political authority.

Out of these three key factors (population, irrigation, and political authority), a variety of orderings can be taking place and explanatory schemes with all the attendant theoretical issues as to what has come first. Such schemes involve the extent to which we had first population, then irrigation, and then the rise of political authority, or any other permutation of these three factors.

This particular debate as to the rise and fall of hydraulic civilizations is close to the current debate in the literature about the so-called "ecological school" that describes the major revolutions that brought about increased social organization. Essentially, this broader argument points out that as a result of environmental, technological and cultural factors, a transformation in social activity has always taken place. The so-called ecological school assumes some complex interrelationship (without at the same time telling us the ordering of this relationship) between the size of total population (the minimum number required to sustain group life); the control of natural environment (minimal requirements for aggregate living); technological developments (inventions necessary for managing the environment); and developments in social organization (complex arrangements between the population and hinterland).

In any case, there is no need to discuss in detail the historical intricacies of the rise and fall of hydraulic civilizations. The point that must be made here is that the type of social factors that one needs to consider in water management and the background that gave rise to the protection of certain legal rights have alternative explanatory conceptualizations. Indeed, in a recent work by Kappel it has been emphasized that major changes in irrigation system size occur only after changes towards centralization have already been made. While we may not know exactly the sequence of events that brought about the rise of hydraulic civilizations, one thing remains sure: water development has always been related to complex systems of social organization.

Some special remarks must also be made about religious factors which in some cases were of prime importance in certain irrigation systems. As a matter of fact, religion has been among the impetus or constraint in the evolution of many irrigation systems. When the Mormons settled the Utah Valley, farmsteads were grouped in villages rather than being scattered around the cropland as was common in the rest of the United States. The cause, according to one analysis, was not defense or irrigation or any divine signs received by the church leaders, but rather "a sense of urgent need to prepare a dwelling place for the savior at his imminent second coming."[16] Each of these villages built their own irrigation company which served the area around the community. To a large extent the present pattern of many medium sized irrigation companies reflects this early development. The irrigation company became part of the community affairs; it was part of the cooperative endeavor of the village. Both village and church pressure could be exerted upon recalcitrant farmers in order to make the irrigation system operate smoothly.[17] The Mormons affected the pattern of land tenure by separating the farm buildings from the crop land. The idea of a unified farm which was common in the rest of the United States was weakened in the Mormon community.

Other factors, too, were positive in bringing about fragmented farms. The settlement in groups created local land shortages. The idea of self-sufficiency brought individual farms rather than communal farms. A doctrine of economic equality gave each farmer some of each type of land while large families caused further subdivision. The village form of settlement is more efficient socially than dispersed farm houses and education, which is important to the Mormons, and the interchange of ideas is made easier while facilities such as domestic water supply can be provided more readily.[18]

As a result of strong family ties which resulted from a village form of settlement, there has not been much migration of Mormons from Utah or even within Utah. This has resulted in the population of Utah being higher than it might have otherwise been. This, of course, has placed an extra burden on irrigation systems. Too, their group feeling has manifested itself in the church, which owns farms to help support welfare programs that the Mormons have for their own people of their own religion, and in recent years the number of such farms has increased in Utah with a number of results, one of which is to move these farms from the tax burdens of the state and increasing the tax burden upon the other land. Their religion goes into great detail in establishing the relationship between man and water and the rest of the surroundings. The Mormons have a high regard for rural life. Nelson labels this "agrarianism" and defines it as "the assignment of superior values to the agricultural way of life." This has resulted in, especially in the early days, a large amount of labor being devoted to the development of irrigation systems with farm land projects requiring cooperative labor and in many cases postponement of immediate benefits. The Mormon Utah Valley is a prime example of how a religion can directly affect the development of irrigation practices. This religion places a high value on farm life, and by virtue of its emphasis on living close together, farms were large and unified. Therefore, irrigation practices moved quickly along this valley from almost passing over immediately the small farm to large-scale irrigation.

Another religion which has strongly affected the irrigation practices is the Moslem religion by adoption of traditional practices. The commentaries and other Moslem documents have developed a basic water code which specifies the means of allocation, the rights of individual water users, and the penalties for misuse of this valuable resource. Many of the Islamic countries still apply this basic Moslem philosophy to the respective use of water. The Mormons, on the other hand, as far as water rights and water law are concerned, are governed by state statutes. Utah water law resembles much of the Western states in that it is an appropriation system, and nearly all of the decisions are similar to any Western state that would be under this type of water law.

2.2.4 Physical factors

When visualizing an evolutionary process, it is relatively easy to visualize a process whereby people need a more complex irrigation system; so the physical requirements of that system would necessarily become also more complex. For this purpose, the beginning phases of irrigation will be called uncontrolled irrigation using flood water in rivers, in turn are led through flood canals into fields and which subsequently drain back into the river of their own accord. Obviously, in this situation any controlled device is absent or, if present, totally inefficient. Clearly, there are disadvantages to this type of irrigation, such as flood waters gathering in a flood field before the crop is complete; or any channel which the farmer may try to open becomes clogged with silt and, therefore, totally ineffective; or, finally, the level of the river may not get high enough during the flood to reach the field and, thus, the field may go totally without water even though the river is nearby.

If a physical method of transferring water from the river is used, it is usually a crude method such as with a bucket, or a hand scoop. These obviously have their severe limitations in the amount of water which can be transferred and the area in which they can effectively be used. A system of natural flooding requires little if any artificial water control, but it suffers from the disadvantage that water cannot be restored for a long period of time, with the result that cultivation tends to be during the rainy season because the water immediately runs off and there is not enough remaining to use over an inactive period. Therefore, productivity is cut down. It is clear that this type of irrigation is not useful in the permanent societies where an increased population is going to need more food than this type of irrigation can provide. An additional disadvantage, over an extended period, is that it is not possible to grow many types of crops.

Until very recent times, in developing nations irrigation was based on relatively primitive systems with the use of simple devices for lifting and storing water. Even today many of these devices are extensively used in quite a number of countries. In Egypt one of the more common lifting devices is the Shaduf. It usually consists of two poles which stand upright with a turnback cross beam 8 to 10 feet or so above the ground. At right angles to the cross beam is attached a long pole at one end of which is hung the ropes according to a pail or bucket. At the other end a mass of clay or heavy weight acts as a counterbalance. The rope is pulled down manually and dropped into the stream or well. When the bucket is full of water the rope is released, the counterbalance falls, and the bucket rises. It is then pulled around in the cross beam and emptied into a canal and from there the water runs into a field. Typically, one of these devices can irrigate two acres effectively.[19]

A slightly more elaborate lifting device found in Egypt is the Sakia, or Sakiyeh, which is also known as the Persian wheel or in India as a Haret. It consists of a toothed wheel engaged to a smaller vertical wheel to which a series of buckets is attached. A beam is connected to the horizontal wheel and an ox or cow is yoked to the outer end of the beam. The animal then walks in a circular path revolving the horizontal wheel which in turn revolves the vertical wheel and the buckets dip in, scoop up water which is then emptied into a channel leading to a field. Depending on the size of the wheel, between 5 and 12 acres can be irrigated by this means. A similar device to this is found in the Middle East and Southwest Asia where a river current is used to lift the water by means of water wheels and the water is picked up in great wooden buckets on the wooden wheels and the water is then dumped into the fields. Windmills were another ancient device found more in Greek islands. The wind power turned the sails in the mills to lift the water into small reservoirs and then they were allowed to flow into irrigated fields.

Clearly, since these devices require for the most part human power or animal power, or in the case of the windmill wind, to get a small amount of water, they can irrigate only relatively small areas; and then only when the water in the river is sufficiently high to permit their use. For example, if the river is low the great wooden wheels in the Mideast would not be able to reach the upper levels of the river and they would simply be useless. Obviously, they are not necessary during flood times when flood canals were put to use. These are ditches constructed parallel to the river in the flood plains which fill with water as the river rises and, therefore, are directly dependent upon the volume of water brought down by the river

Up to this point the discussion has centered around delivery devices. But storage devices are equally as important in looking at the evolution of irrigation systems. Reservoirs are ancient and one of the early forms was the tank or earthen embanked reservoir of India. Some of these tanks have supported irrigated agriculture for a thousand years or more. Many have fallen into disuse as a result of the plagues, wars, and conquests. Malaria epidemics have been particularly troublesome. However, some have been restored and repaired and are currently in use. A tank may be small but it need not be, as indeed there is some evidence that there were tanks with reservoir capacity of 66,000 acre feet serving an area of 11,200 acres, which yield two rice crops a year in northeast Ceylon.[20] These tanks were formed as an earthen basin off a flood channel and quite often the arrangement was that there would be a string of these tanks connected by one canal and essentially the whole stream would then be reduced to simply a line of tanks with lowlands trapping and using water which has already been used in those above as it tried to flow back to the stream. These tanks lost a great deal of water by evaporation and seepage and, additionally, unless they were cleaned regularly, they became filled with silt and were eventually rendered unusable.

In the process of evolution in terms of physical dimensions, we do not see dramatic changes in the actual devices being used. We still use wells today, we still use lifting devices, we still use canals to transport water, and reservoirs to store it. The main change appears in the size of the facility and the quality of service. Rather than letting water simply flow across the land and picking up much silt, we now channel it into a canal; it is becoming more and more prevalent to see these canals lined. One improvement has been the elaborate pumping systems now in use so that water can be pumped from a lower river to a higher reservoir and brought down to the fields and back to the river for drainage. Too, more than one crop per year can be raised. In this manner it is clear that man has simply expanded and improved upon the things he developed at first to meet the challenges of increasing population and requirements for more food.

2.2.5 Organizational evolution and institutional crystallization

Just as there has been an evolution in the geography of these irrigation areas from small on-farm uses to basin uses and an evolution in the physical facilities from very primitive devices to the massive dams and canal systems seen today, so too has there been a metamorphosis from the mutual ditch company, through the irrigation district, to the water conservation district of today developing according to the needs of the times, the people in the area, and the magnitude of the projects. It is even possible today where the states are trying to become more active in the field that there will be multi-state districts cooperating together to construct and operate even larger projects than the conservancy districts known today.

It will be impossible to discuss in any detail such a complex topic as the organizational evolution of the myriad of irrigation institutions all over the world. The point we want to underscore is once again the increasing division of labor and complexity over time. Contrasted to the basic physical similarities between earlier historical times and today, the exigencies of modernization, increasing populations, new and expanding demands, all have contributed to an increased scale of organizational arrangements.

As an example, we may introduce here some brief remarks on the organizational evolution of Western irrigation systems.[21] The backbone of water associations in the West generally and especially in Colorado and Utah is the mutual ditch company. Ditches, canals and flumes have been held to include the headgates, the dams, reservoirs, reservoir beds, and the earth upon which a man stands and lands surrounding the reservoirs with the improvements thereon are integral parts of the irrigation system as a whole, and necessary for the proper maintenance and operation of that system.[22] All these companies began as community ditches which are still seen in Spanish settled parts of southern Colorado.

It was soon learned, however, that formal organizations made construction, maintenance, and delivery work easier. The collection of assessments was expedited and the necessary administrative machinery for making the transfer of water rights more convenient was provided. Water rights were now evidenced by stock, so a transfer is accomplished simply by a transfer of shares. These shares were issued according to the number of acres owned by the stockholder or by the amount of water rights which are contributed to the company by him when the company takes over an area. Usually the by-laws of the company permit rotating water in a manner which insures the maximum use which is consistent with the state policy of non-wastage of water. Water rights may also be subject to forfeiture for non-payment of assessment which is made against the stock by the company for improvements or maintenance and operation of the system. It is noted that nonpayment usually is not a problem because water may be withheld until the assessment is paid, and to avoid any inconvenience from withholding the water the customer usually pays. The stock in these corporations is assessable by its nature. This assessability and the usual size of the mutual ditch companies have made them an unsatisfactory entity for the construction of very large works because of the difficulty of obtaining adequate financing. This situation led to a need for some type of quasi-municipal corporation and out of this need grew the irrigation district.

The irrigation district is in essence a very large organization which resembles a company except that it takes in far more irrigators and has much more land to tax. The mechanics of setting up an irrigation district are simple. What is simply required is a petition of a majority of the landowners in a district, boundaries of a district are set, and this is brought to the board of county commissioners who, after a hearing, establish the district. A board of directors is then elected and bonds are then voted for the construction of the necessary work.[23] In this way by selling bonds to independent purchasers, the great limitation of the mutual ditch company, i.e., its inability to secure major financing, is overcome. It should be noted that bondholders who find the people delinquent on the bonds may only resort to the delinquent lands within the district to recover their security and, thus, any landowner who pays his tax is secure regardless of his neighbor's failure to pay.

In such an evolutionary perspective described above, the tendency is that along with the demands for more water, larger and more improved facilities are needed and so a necessary development takes place from the small user, to the small company, and now to the irrigation district.

The ultimate step in this hierarchy of evolving magnitude and complexity is the conservancy district. In response to the needs for a larger entity, one that has primarily a larger financial base, the conservancy district was created. It is, in effect, the super district taking in many irrigation districts. While these are presently the result of developments in water irrigation, they are also formed for domestic use, manufacturing and power, and other beneficial uses. It is not unusual for these districts to be formed under the Reclamation Act of June 17, 1902 which provides basically for federal planning. Quite often when there is a dam built by the Bureau of Reclamation, the benefits are distributed throughout the area.

Let us recapitulate the thrust of the argument attempted under the general premises of the evolutionary process of irrigation development. As it has been repeatedly stated, in many areas of the world conditions of water surplus have never existed. The inhabitants of these areas have struggled throughout history to develop workable doctrines to accommodate the conflicting interests and to provide at the same time a sound legal base for continuous growth and survival. One may truly learn from the experiences of the various social and legal institutions and develop valuable guides for other people faced with similar problems. In this respect the experience of the arid West in the United States is a particularly poignant example of intense social development and of the creation of particular doctrines for facing the question of survival in an arid environment.

2.3 The Case of Western Irrigation Systems: Some Specific Remarks

2.3.1 Background notes

The Western United States is comprised of a number of regions formed by natural river drainage basins, not necessarily coinciding with administrative boundaries. To generalize, however, one may say that with the exception of the Columbia-North Pacific region and some portions of the California and Missouri regions, the area known as the Mountain and Western States simply lacks an abundance of water. Water that is produced there is not available where needed or when needed. The northwest region may be the exception, but even the great Columbia River flows through large expanses of semi-arid land.

Historically, it took only a nominal amount of demand to exceed the low flows occurring from July or August through the winter months to early spring. Therefore, it was not long--well before the turn of the century, in fact--that the most easily developed storage sites were constructed, and the search for additional water was well underway.

This early development not only provided a stable domestic supply for the emerging population centers, but also permitted concurrently an irrigated agriculture. While mining was the main stimulus which precipitated the great westward migration after 1850, it was irrigated agriculture which gave it stability. While promulgated as a means for food self-sufficiency in support of a booming mining industry, irrigated agriculture soon became the focal point for settlement in various regions of the West, all the way from Colorado to California.

During the pioneer development period, settlements were formed on the streams where water supplies were available. Even the smallest creeks have a small community at their mouths and much of the water for irrigation in the West comes from small mountain streams.

The early pioneers in the West engaged in the construction of diversion structures and canals in order to irrigate reclaimed lands. Initially, the lands placed under irrigation were located adjacent to the river, thereby minimizing the effort required to deliver water to the fields. Later settlers would then undertake the construction of diversion works and a water delivery system to serve newly cultivated lands immediately above the original canal (Figure 2-1). Usually, this accomplishment resulted from a cooperative effort among the farmers to be served by the new canal. This process was continued until either land or water resources became limiting. As a result, an irrigated valley would consist of a series of fairly parallel canals traversing the valley. Most of these early canals are still in existence today.

Although the organizational framework for constructing the early canal systems offered a very practical means for developing irrigated agriculture, the lack of change after completing this development has resulted in a number of present-day problems. The addition of each canal usually resulted in the formation of a new irrigation enterprise with the

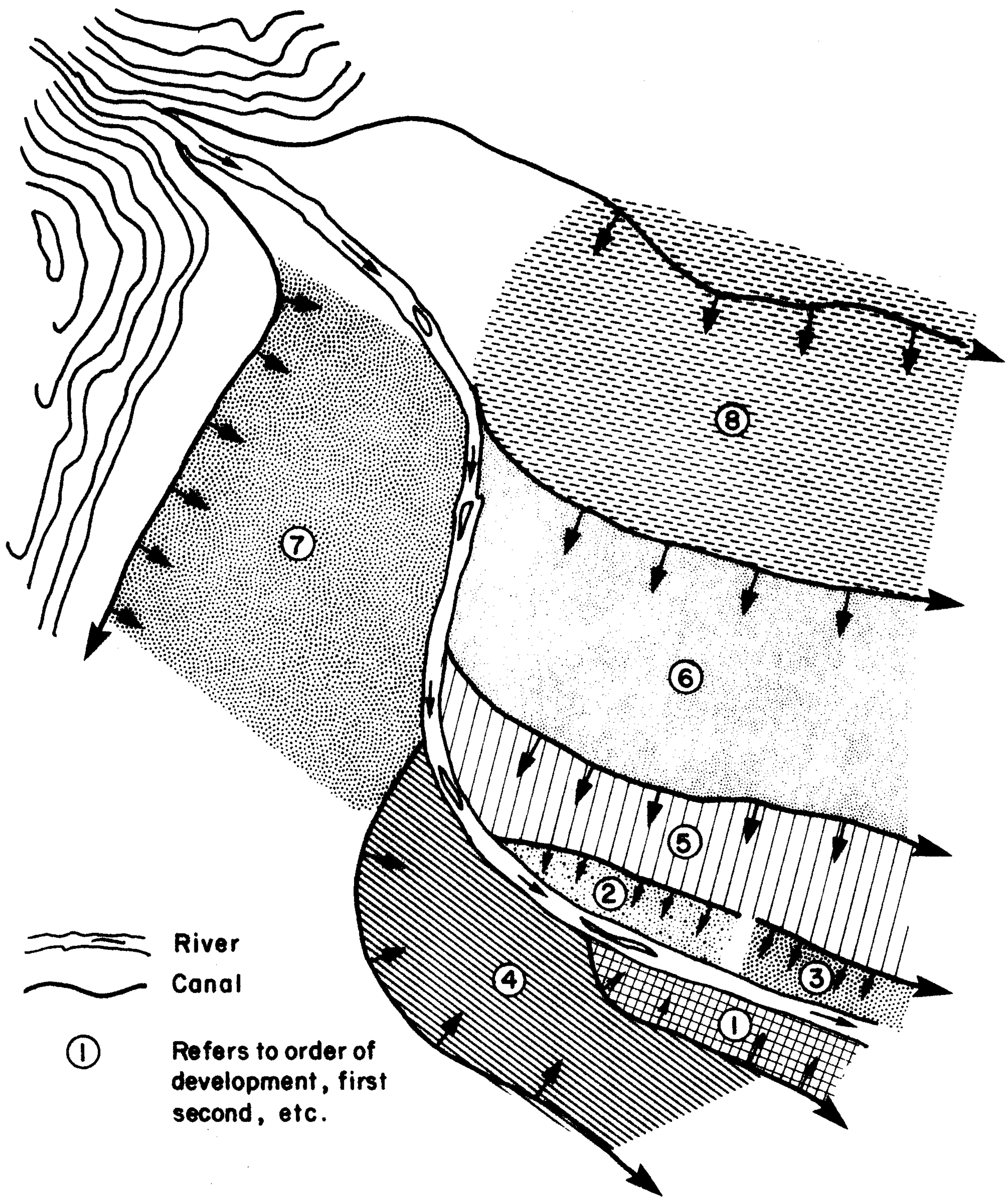


FIGURE 2-1. Schematic of Irrigation Systems Development

result that many irrigated valleys in the West have a multitude of entities managing the delivery of water in the valley. Problems involving the lack of cooperation among the various entities in bringing about improved water use efficiency appear to be inherent among many groups. In addition, the duplication of water delivery systems has resulted in higher costs for irrigation system rehabilitation, increased operation and maintenance costs, and greater water losses such as seepage, operational by-passing or spillage, and surface and subsurface return flows.

The historical roots of irrigation system developments in the West, along with the emerging needs for meeting large-scale organizational objectives, make it early imperative to consider technological alternatives for improving a number of cumbersome water use systems. Alternatives for improvement included lining of canals to prevent seepage losses and transpiration by phreatophytes; installation of closed water distribution systems; small storage or regulation ponds along the water delivery system to allow improved timing of delivery and conservation of water during periods of precipitation; use of more and better flow measuring devices to improve the control and equitable distribution of water supplies; and improving the efficiency of water use in the farm by land leveling, use of modern irrigation practices, provisions for allowing field runoff to be used on lower fields or recirculated, and use of sprinkler irrigation on fields not suited for surface irrigation.

The physical infrastructure for irrigation consisting of seasonal storage facilities, diversion works, and canals was well developed by the turn of the century. The institutional infrastructure was developed, too, with a multiplicity of mutual irrigation companies which provided a management capacity for gruops of farmers to build, finance and maintain irrigation works. Furthermore, the companies could engage in litigation to both protect and procure water rights. And later, with the advent of reclamation, these companies also were in a position to provide an organizational vehicle to express interest in additional water supplies to the U.S. Bureau of Reclamation.

Coinciding with the physical development of water resources was the legal development of the right to use water. Initially, water was regarded as community property available for use by all. But as development in the semi-arid West took place, investments made upon a dependable water supply resulted in the early miners and settlers respecting a property interest to the water user. At this point, the benefits of a predictable water supply exceeded the costs of internalizing externalities prevalent in the community property status of this resource. The pioneer was willing to recognize an interest in others in order to gain the same treatment for his use of the water. Through custom, miners had previously developed a moral code prohibiting claim jumping, and this same respect was accorded the use of water. As a consequence, a firm "property right" developed, subject to certain restraints (i.e., beneficial use and non-waste), and accorded the same protection under the law as real property. Legally described as a usufructary right, the possessor could use the water once it was captured and it then became his personal property, but this right did not attach to any specific waters because of the resource's fugitive nature.

Since the inception of the property right concept in water, there have emerged several basic doctrines. The humid East has adopted the English "riparian water law" giving owners of land adjacent to a water body a proportionate right to use the water. In the 18 Western states, the doctrine of prior appropriation was adopted. The gold rush days of 1849 in California provided its foundation. Colorado was the first to include the doctrine in its constitution in 1876; since that date it has been adopted by constitution or statute in the other Western states.

More than anything else, the prior appropriation doctrine provided the needed security of a water supply for mining, agricultural, municipal and industrial interests, so that they eventually proceeded to mold institutional sophistication to meet their needs and economic motivation for investment and subsequent growth.

Parallel also to physical (and legal) developments, water use in the West was also determined by changes in the surrounding social environment. Essentially, the pattern of settlement in the West, as well as in other parts of the country, followed a series of interrelated stages of development. Initially, individual farmers would settle in small parcels of land close to the water sources, followed by small services for farmers, such as blacksmiths, wagon and wheel makers, etc. Agri-business was the next order of development, serving the farmers through such services as mills, farm implements, etc. The small settlements of the early pioneers were then augmented by the influx of other people. By the turn of the century, a major part of the initial settlement phase had been largely completed. The West was changed within the span of fifty years from a virgin territory to a set of communities and economic activities, towns, cities, industries, irrigated farms, and ranches, all layed out on a vast pristine national hinterland. The transformation from primary to secondary industry began towards the end of the last century. As in the rest of the nation, but to a lesser degree in Western states, creeping urbanization and the meshing of the urban fringe with the rural hinterland characterize the more recent history of community development.

There are two additional considerations in the analysis and understanding of the social environment in the West in relation to water resources. First, part of the cultural background and customary use is shaped by the presence of an indigenous population with senior rights under the "reservation doctrine." Secondly, the Spanish legacy has left a distinct cultural tradition and customary practices and attitudes toward water use. Thus, to speak of the social environment of the West, one should consider quite a variagated combination of normative resources, community environments, cultural traditions, water management systems, sources of social conflict, and images toward water resources.

No attempt has been made, of course, in the few preceding pages to present a comprehensive history of water resources development in the Western United States. The cursory examination of some of the conditions of development in the region was needed in order to reemphasize the point that water in the arid West remains a central point of concern and a sensitive issue, reinforcing a widely shared conviction about the need for control and coordination and repeating the truism that "water and land in the West are inseparable."

Irrigated agriculture, in particular, has played and is still playing an extremely important role in the development of the West. Without the application of water these arid lands were usually worthless. Hence, development depended upon the availability of a water supply. Where an adequate supply and climatic conditions conducive to irrigated crop growth existed, settlements grew. The Federal Government, having adopted a policy of encouraging Western growth in the late 19th century, contributed greatly to the rapid increase of the agricultural sector.

With agricultural development, there also followed population increases with eventual urban, industrial and recreational encroachments which have placed even greater constraints on the existing water supply, thereby requiring a more conscious use of this valuable resource. However, the irrigation systems and agricultural communities have grown accustomed to an untampered use of their water; storage and conveyance facilities, which have been constructed and the associated costs repaid, are deemed sufficient for the needs of the particular communities, despite conflicting demands for other uses.

It is worth noting, too, the special attitude toward water prevalent in the Western United States. Water is regarded as a scarce resource and is treated as such. Innumerable litigations have resulted in a highly complex system of water rights based upon case law, interstate compacts, and legislation. Central to this is the tradition of the states to develop and control their own water and hence shape their destinies as may be limited by the availability of water.

2.3.2 Trends and policies

Water is considered a "public good." While economic forces do indeed provide the context for development of the resource and perfection of water rights, and for transfers of stock, water is not treated as a market commodity (except insofar as stock in a mutual company can be bought and sold via the market process, upon approval of the Board of the mutual company). The administration of water rights, and the legislative perogative, is a function of state government. As such the resource has been developed to maximize its social utility, which until recent years has been seen as synonymous with economic development and domestic need.

Because water is not an abundant resource in the Western United States, its allocation and development are guided by public policy. Such policy, while not in the form of a specific single declaration, is nevertheless deeply embossed in two disparate but sometimes complimentary themes: 1) states' water rights; and 2) federal legislation. The first is an extension of the laissez-faire traditions of a "frontier" economy. The second is an expression of a national purpose as seen by various regional factions having influence in the United States Congress.

Recognizing the necessity of water as a means of survival and further growth, one can also understand how the Western water rights system provides the specific mechanism for allocating water as a scarce resource. Such a system provides also mechanisms for adjudicating conflicts among users and for administering the system.

The well-known phrase, "first in time, first in right," captures the essence of the prior appropriation doctrine. The concept of *beneficial use* further elucidates whether a right can be *perfected* to the extent desired. Beneficial use has not been defined in the statutes but adjudication of water rights by the courts and state engineers is based upon the concept. Thus, an irrigator may be restricted from applying wasteful amounts of water to his land if the State Engineer or the courts decide otherwise. One of the main themes permeating Western tradition and extending the beneficial use concept is that water should not flow unused to the sea. Every drop should be put to beneficial use. Generally municipal use, agricultural use, industrial use, and power generation are unquestioned. In-stream uses such as maintaining a fishery or enhancing aesthetic attributes have not been considered beneficial uses. The law also embodies a "higher use" concept which permits municipal uses to usurp other uses in time of need.

There is no doubt, whatsoever, that Western water law is indelibly woven into the fabric of Western culture. It has provided the guidelines for orderly development and use of a scarce resource. The nature of the law was molded by these circumstances of scarcity and the ethic of laissez-faire development. The law has set Western development upon a course of full productive use of its water resources. This had had a certain *ecological* characteristic in that the nature and characteristics of the law have preordained and reinforced a certain rural orientation to Western culture and heavy emphasis on agricultural production.

In the past, when water shortage problems appeared, all efforts were geared toward exploring and creating additional water supplies, rather than developing programs to deal more effectively with existing supplies. By continuously emphasizing increased supply, rather than appropriate demand levels, a paradox soon emerged: by continually importing additional water supplies from adjacent river basins it usually forestalled development of efficient water management, resulting in highly consumptive, inefficient or "non-beneficial" practices.

Thus, the region is increasingly presented with a rather stark situation. On the one hand, there exists an established culture, legal, and institutional system of water resources with many of its beneficiaries satisfied and unwilling to change. On the other hand, scarcity, increasing new demands, and a more complex political and social structure clamor for attention and press for drastic changes. The early cozier relationship between water and agriculture has been changing through the forceful presence and expanding power of municipal and industrial interests either upstream or downstream of a given valley. At the same time, the demands for abetting pollution and the strident voices of conservation are forcing significant changes in the earlier isolated water resource development and on the preeminence of agriculture in the region.

2.3.3 Forces of change

Two key factors are becoming important in further water resources development: first, most Western rivers are fully controlled; they are essentially loci for water diversions and returns--often having little hydrologic resemblance to a natural stream. Second, due to increasing development activities new water resources development projects are being viewed in a different light. A project will cause both aesthetic and ecological disruption to the natural environment upon which it is superimposed.

Emerging social conflicts in the West can be better understood in the context of the traditional efforts for survival and the attendant traditions codified in the form of protective laws and regulations. Once established, formulating a structural basis for community (e.g., agriculture-urban), traditional ethic is not easily changed,for change will indeed cause new equilibriums to take place. For example, transfers of water use from agriculture to urban or from agriculture to mineral extraction and energy production (e.g., oil shale development, coal gasification, etc.) will certainly cause changes in regional character from "western-rural" to "western-industrial." So, change is resisted by established factions who see their economic welfare affected for better or worse.

The previous brief exposition of developments in the Western United States points out also that cultural institutions usually evolve slowly and are shaped by religion, history, language and the surrounding natural environment. The shared values about the relationships among individuals and between the individual and the group, assumptions about motivation and initiative, concepts about justice, attitudes toward the environment, policies regarding water, and many other cultural precepts will determine whether any given institutional arrangement vis-a-vis irrigated agriculture will succeed or fail. By understanding these cultural institutions as well as in studying the general community system we are also able to provide clues as to institutional support for alternative water management schemes.

In any case, all of the above add up to a picture that underlines how the course of the future has been set to a large degree by events, trends, and policies of the past. The institutionalization of the water rights system and the Federal involvement in water resources development have provided the management infrastructure through which water decisions are made and most probably will continue to be made. A number of further, more specific remarks will be made throughout the following chapters, especially in Chapter 9, where three case studies are discussed in some depth. As we conclude this section on some prominent features of Western United States irrigation systems and their development, we may summarily bring forward a number of key observations that describe past events, present conditions, and underscore potential future consequences:

a. The appropriation doctrine is associated with resource scarcity. It sets up priorities in use and provides for appropriate administration.

b. The social character and structure of the West has been purposefully shaped by water allocation policies through water rights and Federal financing policies directed primarily towards the benefit of agriculture.

c. The water rights system of the West was originally born out of a laissez-faire frontier economy. The Federal involvement is characterized by centralized planning albeit directed by regional interests. Although ideologically antithetical, these two systems have been complementary. While the Federal involvement has financed, developed and organized new water supplies, the existing water rights system and the various districts created have administered the new supplies.

d. The thrust of existing water policy is changing, among others, due to increasing recreation demands; pressures for the maintenance of minimum stream flows; inter-regional growth trade-offs; and, increasing efforts for controlling disruptions and spillovers in the surrounding environment.

e. In the West, a predominantly agriculture-related water policy has set the direction as to how this natural resource is allocated, financed, and developed. This has influenced the cultural practices of Western communities, often foreclosing options for alternative futures.

f. Federal criteria have reflected broader concerns and questions of social equity, thus being more comprehensive and more oriented towards an accounting of social costs and non-economic benefits. At the same time, while Federal projects have undergone extensive scrutiny, projects at other levels have had no other requirements except to comply with existing state laws (and Federal laws when the Federal Government is involved). Thus, there has been no long-range accountability relative to disbenefits for non-federal projects.

The above are a few key points attempting to capture in broad strokes highly complex issues and a long historical horizon. By now enough has been said on the evolution of irrigation systems all over the world. What we need is some further elaboration of organizational arrangements and a concentration to the problem at hand, namely the challenge, advantages, and process of consolidation.

2.4 The Spectrum of Organizational Arrangements

The proper organization of any unit designed to carry out various complex functions integrating agricultural production into irrigation systems is a most difficult, and often unappreciated, task. Despite commitment of funds and technological breakthroughs, many projects have failed or have operated non-optimally because of a lack of organizational preparedness, administrative defects, or lack of appropriate legal framework.

An efficient irrigation organizational network involves a variety of interrelated tasks and functions, key among which are:

a. legal rules of conduct;

b. administrative procedures vis-a-vis control, personnel, organization, etc.;

c. maintenance of structures and facilities;

d. preparation and integration of farmers in the irrigation system;

e. regular provision of necessary inputs, including adequate water, soil, cultivation techniques, etc.

f. economic credit and financial control; and

g. effective commercialization and marketing of agricultural products.

These are only but a few of the many interrelated considerations making up for the organization and administering of an irrigation network. At the same time, in all irrigation projects there are usually, in varying degrees and presence, three parties: the government, the farmers, and a private sector willing to provide services for an economic renumeration. Yet, in real practice, while in most countries two participants are recognized (the government and the farmers), there are quite a few "actors." The government acts through a variety of agencies, institutions, or supra-organizations, while the farmers associate in and organize in quite a spectrum of representative groups, coalitions, or interest formations. In this respect irrigation systems can be distinguished by the degree of intervention of the above participants, such as:

a. predominant government presence, which appears in centralized economies and in cases of agrarian reform or colonization;

b. predominant private sector involvement, indicating commercial irrigation or private exploitation of one's own resources;

c. predominant farmer control, as in the variety of irrigation districts in the Western United States, syndicates in Spain, and similar organizations in other parts of the world.

Needless to say, exclusive or pure types of organizational arrangements rarely exist. Quite often there is an overlapping of forms and administrative types as well as mixed arrangements of control and participation. An interesting observation here, however, is that despite long historical evolution, traditional organizational arrangements are not necessarily, by reason of long practice, guarantees of efficient administration. Many types of antiquated and cumbersome procedures, entrenched practices, and even ossified values lack exactly the flexibility required for today's necessary streamlined administration and complex social demands.

We may now see a little bit closer some of the more specific dimensions of organizational arrangements, especially in the Western United States. At the local level, there are two major organizational entities designed and developed to accomplish the task of water resources utilization and management within a system. The dominant type of public entity is the mutual irrigation company. It is divided into unincorporated voluntary associations and incorporated entities under state law. The second type of organization at a quasi-private/public level is the water user association. The following materials define and elaborate on the features of these entities regarding their ability, agility, or legal constraints to consolidation.

2.4.1 Unincorporated voluntary associations

In General. These organizations may be described as voluntary associations of persons--usually along the same water supply source--who organize for the purpose of better protecting their rights and the division of water of the stream between respective owners, without formally incorporating. Such associations construct the necessary works for the diversion of water and transport it only to the lands of members of the association and not for hire.[24] The principal difference between these mutual voluntary associations and mutual corporations, discussed later, is that the latter are formally incorporated under law but the former are not.[25] This type of organization is suited to communities where irrigation problems are fairly simple.[26]

Membership Qualification. As a general rule, there are no personal qualifications for stock ownership or membership in a mutual or voluntary organization, although an ownership of land or participation in agricultural production may be required.[27] This requirement is logical inasmuch as the purpose of the association is to provide water for land which results, in turn, in increased agricultural production.

Organization*. These associations are often organized with a considerable degree of formality, officers being elected, and by-laws, rules, and regulations being adopted for the government of the respective rights

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* There is a good general discussion of mutual company and voluntary association organizations in a pamphlet by Wells A. Hutchins, entitled Organization and Operation of Cooperative Irrigation Companies, published by the Farm Credit Administration as Circular Number C102, Washington, D.C., 1936.

of the members, and of the general affairs of the association.[28] Though verbal agreements may be made easily enough between members, it is easy for misunderstandings to arise so it appears best to have a written agreement (which may be called the articles of agreement) signed by each member.[29] Though much formality may attend the organization, title to the water rights remains with the individual members and not in the association.[30]

By associating in this manner, the water users become tenants in common[31] of all the waters owned or controlled by all the members of the association and also of the diverting works ditches, and canals used in connection with this water, and each landowner of such association is entitled to his distributive share of the water, according to his rights. The legal title to the water rights not being in the association (as is the case where there is a corporation), but rather with the individual members according to their respective shares,[32] certificates may be issued by the association to these members as evidencing the share of water to which each member is entitled.[33] But whether the individual member's shares are represented by such a certificate or not, he has the right to sell or assign his interest--or any portion thereof--with or without the consent of the other members and the purchaser or assignee succeeds to all the rights of the vendor.[34]

2.4.2 Statutorily defined voluntary associations

In some jurisdictions, the status of voluntary associations is defined by statute.[35] This is the case where a community ditch or "public acequia" was the usual means for diversion and distribution of water. Here, each village or group of farmers constructed its own common ditch.[36] Elections, management, construction and control of these ditches was regulated by law,[37] and under statutory provisions every landowner under such a ditch, whether he used the water or not, was required to contribute his quota of labor or money substitute, required to maintain and preserve the ditch.[38] Associations formed around community ditches are considered political subdivisions of the state,[39] but, anomalously, the ditches themselves are considered to be the private property of the persons who completed the ditch,[40] which necessarily means those who live under its irrigation. In these jurisdictions it is provided that all community ditches (or perhaps more accurately, the communities using them), shall be considered as corporations, or bodies corporate, with power to sue, to be sued as such.[41]

2.4.3 Tenancy in common

Often, in arid lands the owners of several neighboring farms construct ditches and diversion works and make the appropriation of water necessary for irrigation of all their lands, without formal organization of any company or association.[42] Where a ditch through which water is appropriated and applied to beneficial purposes is owned by several proprietors, and their relationship is not defined by special agreement to the contrary, they are regarded as tenants in common[43] of the ditch and their rights are determined by the law governing the same. Too, as each ditch may have a number of priorities, appropriators with different priority dates may be tenants in common in the dam, ditch, or other works without losing their priority and without there being any tenancy in common in the water rights themselves.[44] Tenants in common may also agree among themselves as to how and when the water appropriated by all may be used by said co-tenants.[45]

Two definitions of tenancy in common may be of some help. Black's Law Dictionary, 4th Edition (Revised, 1968) defines tenancy in common where property is held by several and distinct titles by unity of possession, neither knowing his own severally and therefore all occupy promiscuously. The holding of property* is by different persons under different titles, but there must be unity of possession,** and each must have the right to occupy the whole in common with his co-tenants.

Burbey*** describes the same material as a sole and several tenancy. Each tenant in common is the owner of an undivided interest in the whole estate, not a joint owner of the whole estate. Only the unity of possession is essential to the existence of a tenancy in common. Upon the death of a tenant, his undivided interest passes to his heirs of devisees--there is no right of survivorship in the other tenants.

Rights Between Tenants in Common. Where the relationship between proprietors is one of tenancy in common, it appears settled that where one tenant diverts a greater quantity of the water than belongs to him by right and damages others in so doing, he will be enjoined from further so diverting.[46] Too, each member or co-tenant has the right to assign or sell his interest or any portion thereof without the consent of his co-tenants,[47] except, of course, that he may not transfer more than he owns.[48]

Majority Interest Has Right of Control. Generally, it has been held in the past[49] that as to general policy the majority of members has the right to control matters of the organization with the caveat that a person joining such a voluntary association does not vest in the majority the power to injure the rights of such person.[50] It can be seen that from the nature of water there may be times when it may be indispensible to the success of the operation that where all cannot agree, the majority have the right to control policy to avoid working at a disadvantage. Where this policy which the majority adopts does not materially injure the vested rights of the minority, a majority of tenants in common have the right to control the affairs of the ditch. Neither law nor equity will aid a stubborn minority in preventing the majority from doing an act for the manifest good of the whole community, where no one is injured, but all are benefitted.[51] Also, an association--though composed of a majority of water users from a certain source--has no right to interfere with or regulate the use of the water of the minority owners who did not join the association.[52]

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* May be real or personal. Drum vs. Molloy, 22 C.2d 132, 137 P.zd 18 (1943).

** The association provides the unity of possession.

*** Burbey, William E. Handbook of the Law of Real Property (2nd Edition). St. Paul, Minn.: West Publishing Co. (1954), p. 338.

It has been held that co-tenants are entitled to use all the water appropriated to them. Therefore, a wrongful diversion injures all co-tenants. It follows that all co-tenants have preventative powers to stop acts of a trespasser without joining the rest of the co-tenants in the action--they may act alone.[53]

Contributions for Necessary Expenses. Each tenant in common is individually bound to keep the ditch or other works in repair, and those making such repairs may compel a contribution upon the part of those who failed to bear their share of the expense or labor.[54] Too, because assessments are the chief means of raising revenue for these associations and corporations, the companies may compel the members to pay their share of assessments,[55] and may stop water delivery to insure compliance.[56]

Control of the Organization by Member. The stockholders, or members of mutual companies--including voluntary associations--have the final control of its policies through the vote. Their functions are few but vitally important. They elect the directors,[57] and may remove them from office.[58] They may make and amend or repeal by-laws,[59] or may leave this power to the board of directors. All amendments to the articles of incorporation require their approval.[60] Such fundamental steps as consolidation with other corporations or unincorporated associations,[61] and voluntary dissolution of the corporation or association can be taken only with their consent.[62]

Stockholders Meetings. The stockholders of such corporations and associations usually meet at least once a year.[63] Each stockholder has the right to vote at any election.[64] The voting is done on either a one vote per share basis,[65] or a one vote per member basis.[66] If different classes of stocks are issued, the voting privileges of these classes may be varied,[67] though there is nothing compelling an arrangement of this sort.[68]

Management by Board of Directors. Sole responsibility for managing the affairs of such associations or companies is given to the board of directors.[69] This board has the power to formulate policies, make contracts, levy assessments, incur obligations, approve expenditures, and make rules and regulations for operation of the irrigation system and delivery of water to users.[70] From the operational point of view, all activities of the board should be designed and carried out to provide effective delivery of water to the former stockholders. The flow of authority from stockholder to board to company is shown in Figure 2-2. Generally speaking, to avoid dissension it is best to limit the number of members on the board of directors to as few as possible.[71] The terms of office for directors and officers may be statutorily prescribed,[72] or may be determined by the articles of incorporation or by-laws.[73]

Executive Officers. The president is usually selected from the board of directors,[74] but in cases where a vacancy occurs the position may be filled by the members or stockholders in a special election.[75] Other officers might include a vice-president, secretary and treasurer--those offices may be occupied by the same person.[76] The president's function is to generally supervise affairs, approve vouchers and sign papers. A manager may be required to supervise operation and maintenance, construction,

FIGURE 2-2. Voting Control of Mutual Company Emanating from Stockholders

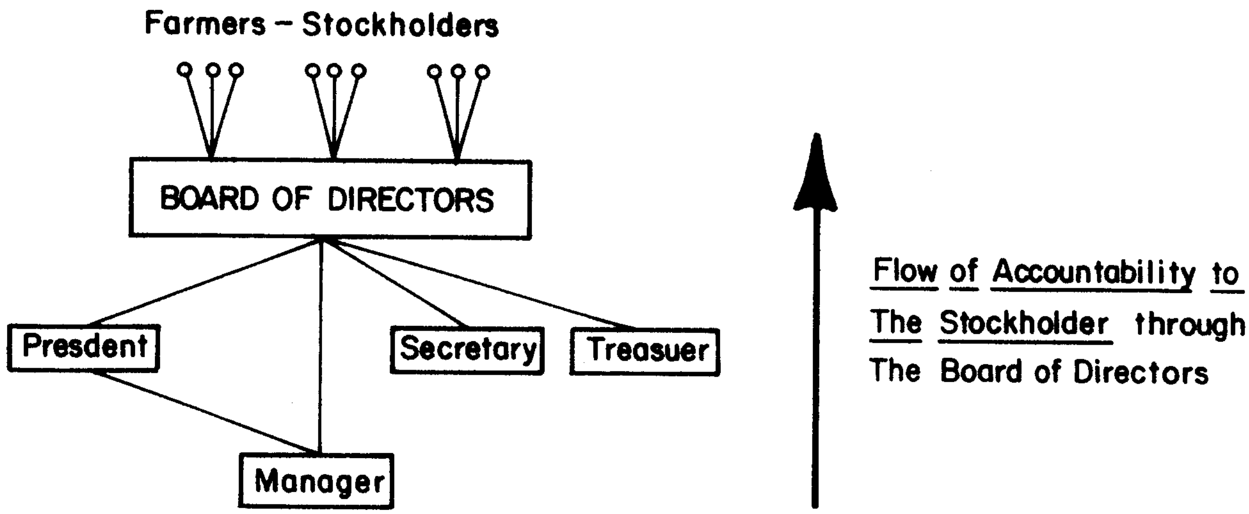
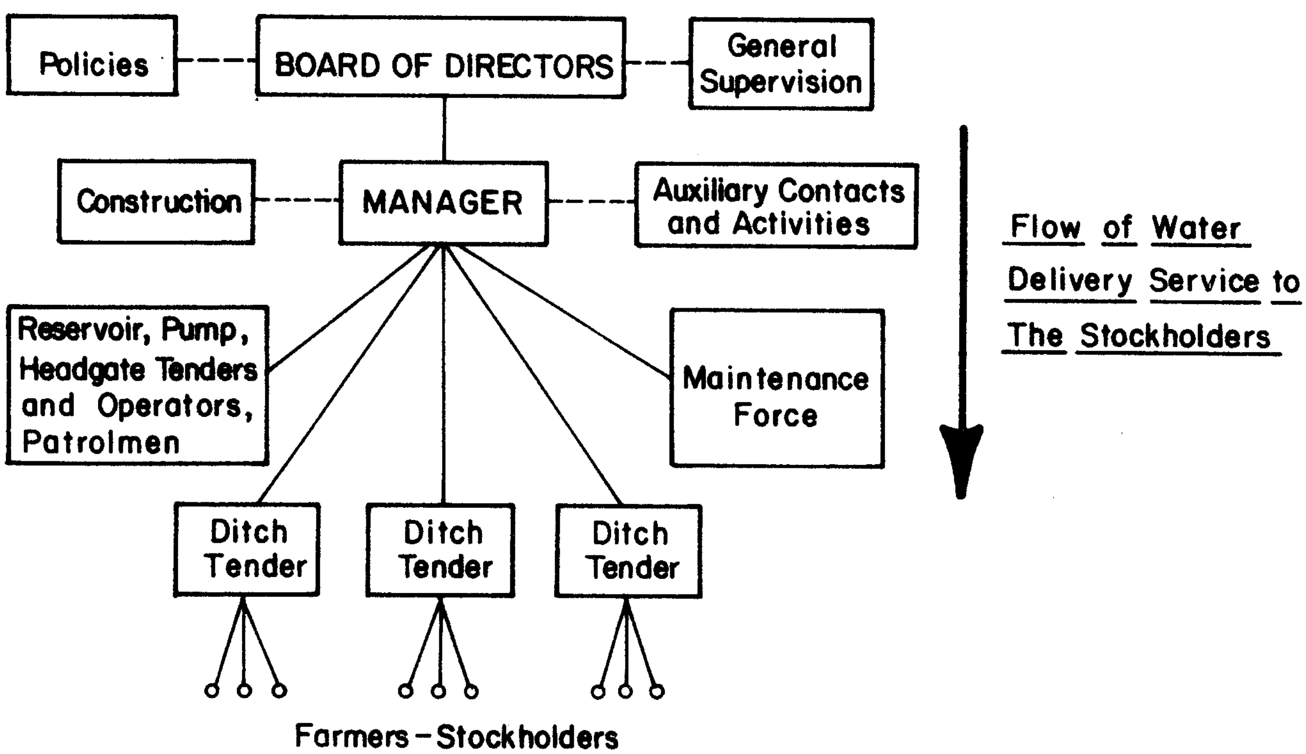


FIGURE 2-3. Control of Water Service to Stockholders of Mutual Company Emanating from Board of Directors



land, farming and contracts with other organizations. Obviously, in small companies the office of president and manager might easily be combined.[77] Clerical functions such as recording and disbursing to members the minutes of stockholders meetings can be taken care of by the secretary, who does not need to be a director or member.[78]

Removal of Officers and Directors. The control emanating from the stockholders (Figure 2-3) would be little more than an illusion if the only direct control available to them was through the ballot box at the annual elections. To allow greater control, sections for removal of undesirable[79] directors and officers are provided in the statutes of the various Western states.[80]

2.4.4 Incorporated mutual irrigation companies

General. A mutual water company may be defined as a private association[81] which is organized for the express purpose of furnishing water to the shareholder or members thereof at cost,[82] and not for hire for uses or irrigating the stockholders' lands and for use of the corporation works to conserve, treat and reclaim waters.[83]

The mechanics of organization are the same as for any private corporation[84] as the articles of incorporation must so provide. Additionally, the stock certificate must describe the lands to which the shares are appurtenent as well as any other special provisions such as the source of water, point of diversion, etc., which may be required.[85]

Mutual companies possess such powers as are conferred on them by statute,[86] and may engage in such enterprises, and such only, as are set forth in the certificate of incorporation; all other powers beyond those given are by implication excluded.[87]

Generally speaking, a mutual company is distinguished from the normal corporation organized for profit by only two major features:[88]

a. assets are limited primarily[89] to water rights and canal systems and sometimes to canal systems alone; and

b. the corporation is not organized for profit, but rather to distribute water to shareholders.[90]

Public Utility Status. In some jurisdictions the matter is covered by statute,[91] but even where statutes are lacking a company which holds itself out generally to serve for compensation[92] those who may apply for water[93] within the area served by its irrigation system is not a mere private corporation, but is affected with a public interest and is subject to regulation and control as a public or quasi-public corporation.[94]

A company may retain its private status if it is organized for the purposes of delivering water to its stockholders and members at cost or those with which it has fixed contractual obligations.[95] It is to be noted that a water company which has become a public agency may not discontinue its service in whole or in part so as to regain its private status.[96] However, a private corporation may, with the consent of the owners of the rights to receive water for private use, change the use to a public use so as to make the service and terms of delivery subject to regulation and control by public authorities.[97]

Factors to be taken into account in determining the public or private nature of a corporation include the following:[98]

1. What are the provisions of the articles of incorporation and by-laws;[99] are they broad enough to permit public sale of water?

2. To whom has water been sold, aside from shareholders, and in what quantities?

3. What has been the intent of the shareholders in selling to other persons than themselves?[100]

4. What amount of water has the corporation agreed to supply to its members and others?

5. What degree of acquiescence to public sale is evidenced by shareholders?

6. Has the corporation directly or indirectly used codemnation?[101]

7. Are there close financial director or other corporation relations with admitted public utilities?

8. Has there been a dedication to a public use by positive action of all or any part of the whole water rights?

<u>Relationship Between the Corporation or Its Officers and Shareholders--Rights and Duties</u>. The relationship between private corporations, whether organized as mutual or commercial corporations, and their shareholders is that of contract, and the rights and duties of both parties grow out of the contract implied in a subscription for stock, and construed by the provisions of their charters, or articles of incorporation.[102] From this contract springs a trust relation between the company and its stockholders, with the corporation being charged to conduct the common business in the interests of the stockholders.[103] Being trustee for its stockholders, the corporation is bound to protect their interests.[104] It follows that a duty is uncumbent upon the corporation to prosecute actions in the matters of protecting water rights or other company property, as representing its stockholders, without joining them in the action.[105] The officers, managers and boards of directors also hold trust relationship to both the corporation and its stockholders. This means that the validity of a contract entered into by a board of directors may be challenged by the stockholders.[106] Also, officers are bound to avoid dealings where there is a conflict of interest between them and their stockholders, though they may have dealings in company matters where there is no conflict.[107]

In the formation of mutual corporations, it is common--though not universally the case--for owners of the original water rights to deed to the corporation their water rights and rights to the works, and then to take shares of stock for the same in exact proportion as the value of the individual rights granted bears to the whole value of the property granted by all. Where this is done, the legal title is transferred to the company but equitable title remains in the original owner.[108] In other words, the company holds the legal title for its respective shareholders. The terms of this trust are governed by the articles of incorporation or by-laws of the same.[109]

Stock in Mutual Company. The shares of stock which are received for legal title to an individual's water rights represent those water rights. These shares are said to be miniments of title to an interest in the property of the association, and as evidencing the proportional amount and extent of the appropriation of water which each holder possessed.[110]

There is some split of opinion as to whether stock is personal property or real property. The more persuasive authority holds that where the title to water rights, and the ditch, canal and other works is in a mutual corporation which issues shares of stock representing both the water rights and works of the company, such stock is considered personal property and a sale of such operates as a sale of both water rights and the interest in the works.[111] However, a minority maintains that stock represents water rights and is real property.[112] The general rule is that for the sale and transfer of water rights--except those represented by stock shares--all the formalities of a transfer of real property must be observed.[113] In any case, it is important to remember that the right to the use of water follows the shares of stock.[114]

Duties. From the contractual relationship established by the transfer of legal title to water rights to the corporation, a duty evolves to deliver to each shareholder that amount of water to which he is entitled by virtue of his stock.[115] The shareholder does not need to depend on an implied contract for his water right as this right is an adjunct of his membership in the corporation--membership means water.[116] The corporation is under a duty to use reasonable care and diligence in making ratable distribution.[117] It is also the duty of the corporation to keep ditches, canals and other works in repair. This duty is imposed in order that the property may be utilized as far as present needs are concerned, and to preserve the property and prevent its future destruction.[118]

Liability. Where a corporation fails to furnish the proper proportion of water to one of its shareholders, it is liable for the damages resulting from such failure.[119]

Suggested Plans for Stock Issue. Generally, there are two types of plans for issuance of stock. These are where stock represents land and is appurtenant, or where stock represents a part of the total water supply.

(1) Generally, where stock represents acres of land and where the stock is appurtenant to the land, there are at least two options available:

a. the first option is to have a share of stock fix by amount the definite quantity of water which is allowed[120] to each unit in the area of land represented by the stock certificate;[121]

b. divide the available water in a given period among the shareholders in proportion that the number of acres owned by any one individual bears to the total acreage of all shareholders in the company--or proportionately by shares of stock of the total issued.

(2) Stock may also represent a specific part of the total supply owned by the corporation or subject to its control for purpose of distribution. This plan is advantageous where the company's supply varies and where the stock is not to be appurtenant to any specific land.

Levy and Enforcement of Assessments. One of the main objects of incorporation is to obviate the difficulties arising in enforcing the prorata contributions of the co-owners of the water rights for the maintenance of the works and other necessary expenses. By merging individual rights, each shareholder may be compelled to contribute his proportion of all necessary expenses or forfeit his right to use of the water.[122] The same implied contract which obligates the company to deliver water[123] implies also the reciprocal duty on the part of the shareholders to pay their assessments.[124] Of course, in order to render such assessments valid, the purpose for which they are levied must come within the purposes of the corporation as set forth in the articles of incorporation or charter and, also, must meet the statutory requirements.[125]

When assessments are made, they become liens on the water stock itself rather than on the land.[126] However, where stock is appurtenant to land, there is authority that the assessment becomes a lien on the land,[127] superior to the lien of a mortgage on that land.[128] A more direct method of enforcement of payment is to simply refuse delivery of water. Such methods are recognized in New Mexico (see: New Mexico Stats. 75-14-24 and 75-14-41, 1953) (in the case of community ditch or co-operative association) and in Wyoming (see: Wyo. Stats. 36-106 and 41-221, 1957). In New Mexico a fine may be assessed before the water is denied (New Mexico Stats. 75-14-34, 1953).

Stockholders may be exempt from assessments if it is so provided by the terms of their agreement made at the time they purchased their stock.[129] Further, it has been held that an assignee of a water right on which a past assessment is due is not personally liable for such past assessment unless expressly assumed.[130]

Power to Make Rules and Regulations. Mutual corporations may adopt such rules and regulations not in violation of law governing the distribution and use of the water furnished among their shareholders as are equitable and reasonable. But all rules and regulations have no effect unless authorized by the charter or articles of incorporation or are assented to by the stockholders whose rights are affected.[131]

Implied Powers. In some cases, in the absence of express restrictions implied powers are seen to be inherent in the company to enable them to exercise the powers expressly conferred and to accomplish the objects for which they were created. Subject to charter restrictions, companies have been allowed to borrow money to finance an authorized project, or may guarantee bonds issued therefore.[132] More important, a power to sell water rights may be implied from the power acquired and own water rights.[133]

Limitations. As has been noted, a corporation may not act to the prejudice of the water rights of any one of its stockholders.[134] Pursuant to this position, it follows that where stock with water rights is sold on the theory that water users buying such rights are to have a reasonably dependable supply of water,[135] the company may not dilute such rights by selling more shares of stock when water actually available is barely sufficient for present holders of water rights.[136]

As an aside, it should be noted that where a corporation is formed, it has no rights--even if it comprises a majority of co-owners of a ditch or water supply--to control or regulate the use of owners who did not come into the corporation.[137]

2.4.5 Water users' associations

General. Water users' associations are incorporated associations,[138] organized by actual or potential water users in a specific area who contract with the government[139] in order to build irrigation works pursuant to reclaiming or improving land. These arrangements are made pursuant to the appreciation by the government of the potential of land that might be realized by conserving and storing the surplus waters of the rainy seasons and more efficiently utilize these waters for irrigation. The advantage of such a system is that it provides a means for many poor landowners of small parcels to pool their limited funds to enable them to irrigate their lands and increase their crop yields, thereby increasing their incomes. Indeed, such a plan encourages purchases of arid but fertile land which can be purchased often at low prices. After irrigation, the land should support itself and increase in value, thus adding to the well-being of the farmer.

Generally, the object of these associations is three-fold:

a. to provide for irrigation in an area where individuals do not have the money to finance such a venture independently;

b. To allow the government to deal with one organization representing all water users in an area rather than having to deal with many users on an individual basis; and

c. to have a responsible organization to which management of an irrigation organization, as contemplated by a reclamation act, may be turned.

The organization of a water users' association must be in such a form as will be acceptable to the arbiter[140] though the government takes no active role in operating and managing the works.[141]

Essential features of the articles of incorporation should include providing a means of effecting the reclamation law regarding ownership of the reclaimed area, and for guaranteeing repayment to the government of the cost of the reclamation works.

It must be recognized that a water users' association of this type is merely a temporary arrangement. All groups of persons using water are, in effect, water users' associations. When the governmental agency responsible for overseeing these projects transfers the works entirely to a water users' association of this type, the organization is reclassified according to the successor-type of association such as a mutual company or district.

2.4.6 Acquisition of lands

Public Lands. The reclamation laws give the Secretary of the Interior broad authority to withdraw from public entry those public lands required for irrigation works, as well as those believed to be susceptible to irrigation from the works.[142] The current practice is that Reclamation withdrawals shall embrace all lands required for the construction, operation and maintenance and protection of main irrigation works and minor structures. All public lands apparently susceptible to irrigation from a project or probable of being required in connection with the development of the project are included in the withdrawal. This decision by the Secretary raises a nearly insurmountable barrier to reversal. Fraud appears to be the only grounds recognized by courts for review.[143] However, where the question of withdrawal involves lands which are already properly devoted to federal purpose, there is a serious question raised as to the Secretary's power.[144]

Private Lands. Purposes of reclamation involve the acquisition of land and water through exercise of the eminant domain power. Ample authority is provided for this purpose.[145] Pursuant to this, Congress has provided that, "The Secretary...shall pay just compensation, including severance damages, to the owners of private land utilized for ditches or canals in connection with any reclamation project."[146]

Rights of Water Users.* The U.S. Supreme Court regards as settled that a project user has a vested property right which cannot be withdrawn at the will of the Government.[147] However, the Secretary has authority to restrict water uses to those which are "beneficial,"[148] and to protect project lands against deterioration due to improper use of water.[149] Too, requirements have been upheld limiting users to a certain quantity per irrigated acre as a means of preventing waste.[150] He also has power "to make general rules and regulations governing the use of waste in the irrigation of the lands within any project."[151]

The conflict arising under private systems of appropriation has not arisen under reclamation. This appears to be due largely to the practice of apportioning available water during shortages rather than using a seniority scheme which totally cuts off junior users.[152] In addition, matters often litigated are commonly handled by the Secretary or his representative.[153]

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* For a discussion of this, see R. E. Clark, Id., 118.2 through 118.4.

Repayment of Costs to the Government.* The costs of these works fall into two general categories: 1) construction costs; and 2) operation and maintenance costs. The difference is important in light of the construction contract. Once a repayment contract is executed, the government is powerless to impose any liability upon the water users to pay for additional or supplemental construction--unless the users willingly contract to pay such additional costs.[154] However, the costs of operating and maintaining the works may be imposed on the water users whether or not they want to pay and whether or not they want the maintenance work done.[155] Further, the necessity of the work is at the discretion of the governmental agency (in the case of the United States, it is the Bureau of Reclamation).[156]

Repayment of Construction Costs. One of the distinguishing features of reclamation is the requirement that water users reimburse the Government for at least part of the cost of building the project.[157] A recurrent problem is that of deciding which costs shall be subject to repayment by the water users. It appears best to recover the actual--as distinguished from estimated--cost of construction.[158]

Deferment of Charges Due. As noted, the basic provision for repayment of construction costs is forty years. In addition, the Secretary is authorized to defer the time for repayment of any installments of construction charges in order to adjust payments to the ability of water users to pay.[159]

Plans for deferment of payments are extremely desirable because of the nature of a reclamation project. These projects are composed of farmers who are in a precarious position because of lack of water. Any setback is likely to put them in financial ruin. In explanation, these water users associate under the pertinent laws of incorporation and issue shares of stock to each member. These shares usually represent land--one share for one acre, for example. The shares have a par value based on the value of land which they represent. This stock is then committed to secure the cost of a reclamation project which they desire the government to build.[160] Since the stock usually represents land, this means that the land is mortgaged, in effect, to secure the repayment of the estimated cost of construction.[161] Failure to make the payments results in a selling of the security --which is the farmer's land if the stock is made appurtenent to the land. Thus, the purpose of the project is defeated.

A plan for deferment of payments would eliminate much of the problem of forfeiture. For example, if a poor settler was induced to buy arid land, but after living expenses had no money for seed, fertilizer and future living expenses, he would be unable to produce crops on his land when the water arrived. A crop failure would have the same result; the land would be unable to support itself and the farmer would forfeit everything.

This problem could be resolved by extending the time of payment and allowing a low interest rate on the principal for the first few years-- say, five years. Settlers need more than watered land. They need money to live and time--time to prepare the land, plant, cultivate and harvest.

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* See R. E. Clark, Id., 123.1 through 123.4.

A plan with deferred payments with a small interest charge would allow this.

In cases where it is feasible to irrigate parts of a project before the entire project is completed, it may be advisable to defer payments for these small sub-areas. The purpose of such a provision is to give water users an extra margin of time to establish themselves during the difficult beginning years on a farm when production is being developed and cash return is likely to be low.[162]

Because of the variability in farm income from year to year, a program for repayment which sets fixed sums for repayment years in advance is likely to prove unsatisfactory. A combination of long repayment period and variable repayment formula permitting a variance in the required annual payments in light of economic factors pertinent to the ability of the water users to pay would probably be best.[163] This variable formula can be based on any number of considerations--price indices, crop production, etc.--and it may provide for both lower payments in below average years and increased payments during good years.

In allocating the costs of repayment among water users of a project, the measure of ability to pay is based on productive capacity per acre of farms, cost of operation, and net income. From this it is obvious that classification of land is essential for good land can support a higher debt burden per acre than poor land.[164] The per acre burden can be assigned on the basis of the water users' association classification of each farmer's land and the Secretary's classification for all the project land in total. After a repayment burden has been established for the entire project by the Secretary, the water users can assign burdens to individuals based on the projected productivity of each farmer's land.[165]

These same arrangements can be made to pay operation and maintenance costs as well as construction costs.

Finally, in terms of the enforcement of payment, persons delinquent in paying their annual share of expenses face several possible sanctions. These are an imposition of an additional charge;[166] shutting off the water supply;[167] or cancellation of the water right with forfeiture of payments already made.[168]

2.5 Communalities and Differences in Organizational Features

The rather detailed discussion in the previous section attempted to highlight organizational, especially legal, features pertaining to a broad spectrum of arrangements related to existing irrigation systems. As we come now to the end of this descriptive chapter, we need to emphasize in particular key communalities as well as important differences among organizational types in order to accentuate their constraining or facilitating role in potential consolidation.

Figure 2-4 summarizes in a truncated form many of the points raised above. We may note from this table that there are quite a few communalities in the organizations described. For example, these are all institutions which are in the business of constructing facilities and diverting water or transporting water to the members of a particular organization. Another important feature of all of them is that the title to the water remains in the individual member even though in the case of the incorporated mutual irrigation company the legal title, as distinguished from the equitable title, can be transferred to the company with the stockholder receiving a share. Such a share of his title to the water and the giving of that share is important to remind everyone that the equitable title and the element of title belongs to the stockholder. The share is simply representative of his right. Also, it should be particularly noticed that only one of the associations is profit motivated. The incorporated mutual irrigation company may make a profit but much of that profit is invariably returned to the stockholders in the form of additional water or perhaps a dividend, or, finally, be plowed back into the facilities and from that investment the stockholder will receive a direct benefit in terms of increased efficiency.

It has been noted that in unincorporated voluntary associations and in incorporated mutual companies there is a power in the company to collect money for the running of the organization and for the operation and maintenance of the organization by assessment. The usual way of enforcing this assessment is just to discontinue delivery of the water until the assessment is paid. However, the assessment has been held to become a lien on the land of the particular stockholder who is in arrears, but this is a more clumsy arrangement than simply shutting off the water until the assessment is paid.

At the same time, the organization through its directors owes a duty to all the members of the organization. It has a duty to deliver the water in a timely fashion and in a reasonable fashion. This implies that it may not destroy the farmers' diversion works or flood his land in an unreasonable manner. Thus, there is liability on the part of the association to that person for any failure to deliver water under contract or any unreasonable delivery which results in damages to his property. Finally, as is described under the irrigation and conservation district column, since the purpose of these larger districts is to construct facilities which would involve extensive obligations if they were not done without governmental help, there is also a contractual duty for the government to have the facilities for the contract that is entered into.

FIGURE 2-4. Differences and Communalities of Characteristic Organizations

Organizational Activities or Dimensions	Unincorporated Voluntary Association	Unincorporated Mutual Irrigation Company	Irrigation Districts and Conservation Districts
Constructs diversion and transportation facilities	Yes	Yes, with implies power to borrow money or guarantee bonds for a necessary project.	Yes, by contract with federal government and users in a large, specified area.
Membership qualifications	Ownership of land or agricultural production.	Be member or stockholder in the company.	Be a landowner with a proposed district.
Voluntary or compelled membership	Voluntary	Voluntary	May be compelled by Secretary of Interior by eminent domain.
Title to water	Remains in members	Can remain in stockholders or be transferred to the company with stockholders getting a share of the water.	Remains in owners, but the Secretary of Interior can restrict the uses to those deemed "beneficial." Also, in times of shortage, water is apportioned so junior users are not cut off.
Member status in relation to other members	Tenant in common in water and facilities (priority to water not affected).	Independent of other members except that all own a share of the company.	Same as Title to Water
Control of policy of the Association	Controlled by majority vote of membership (except that rights may not be injured).	Policy set and controlled by board of directors subject to shareholder approval.	Rests with Secretary of the Interior or his designate.
Power to assess members	Yes, may stop water delivery to compel compliance.	Yes, forfeiture of use of the water enforces assessment. Stockholders can be exempt by contract.	No, the repayment program is set by contract with a policy of not requiring payment if the payment would ruin a farmer

(continued)

FIGURE 2-4 (continued)

Organizational Activities or Dimensions	Unincorporated Voluntary Association	Unincorporated Mutual Irrigation Company	Irrigation Districts and Conservation Districts
Management and implementation of policy	Board of Directors elected by members.	Board of Directors elected by stockholders.	Board of Directors acting under Secretary of Interior.
Motivation for establishing the organization	Goals of small group for more efficient water delivery to their private membership.	Furnish water to stockholders at cost. Can also use its facilities to treat, store and reclaim water.	1) Gives irrigation to an area otherwise unable to afford it; 2) Allows government to deal w/ one entity rather than many; 3) To have a responsible organization to which to turn over a project once it is completed.
Profit motivated	No	No	No, however it is assumed that the beneficiaries will profit from the water provided.
Assets	Owned by members individually.	Water rights or delivery system, or both.	Land in the district and the conveyance facility.
Public status	No	Yes, if it holds its services out to others than its stockholders and for compensation.	Yes
Liability of directors or officers to members or stockholders	Must provide water under contract. Liable to stockholder for failure to do so. Too, reasonable care must be used in delivery.	Same as unincorporated voluntary society.	Same as unincorporated voluntary society. In addition, there may be enforceable duties to construct the facilities.

Communalities in all such organizations are pervasive, but there do exist also some important differences. Among important differences is the purpose of the unincorporated voluntary association and of the incorporated mutual irrigation company versus an irrigation district or a conservation district. In the case of the first two the purpose is to delivery water and maintain the facilities or even construct on a major scale appropriate works for the members of the association. In dealing with the latter two, the purpose is strictly construction of major facilities. It is true that the purpose of constructing these facilities is to deliver more water to the users, but the purpose of forming an irrigation district or a conservation district is for financial ability to build the facility. Once the debt is paid, usually the superior district is dissolved and many smaller organizations such as the mutual irrigation company are formed to administer the water delivery by the constructed facilities.

Another important difference is the membership, or the voluntariness of membership. In an unincorporated voluntary association or in an incorporated mutual irrigation company, membership is voluntary. But in an irrigation district or conservation district membership may be compelled by a voted majority of people living in the area or even by more than a majority. The requirements for such a condition are usually set by statute. Land can be also taken by eminent domain for inclusion in the district whether or not the owner wishes to be included. This is necessary because the magnitude of these projects requires a broad tax base; if people are able to just leave at their will then the funding of large reservoirs and dams could easily fall through.

As far as title to water is concerned, it always remains in the individual members or people in the district. However, an important difference is that in an unincorporated voluntary association or an unincorporated mutual irrigation company, when there is a shortage of water the laws of appropriation are brought to bear and junior rights' holders are cut off so that "seniors" may receive their full entitlement. In an irrigation district or a conservation district, water may be apportioned so that the juniors are not completely cut off. One of the major selling points for these districts is that everybody will have enough water and one of the ways to assure this is to apportionment in time of shortage. Where unincorporated voluntary associations or incorporated mutual irrigation companies have the power to assess its members for money needed, the method of payment for the irrigation district or conservation district is one where each person is under contract and has a right of payment under contract rather than a right of payment by assessments.

It is also important to note the differences between a public and a private entity. In the case of an unincorporated voluntary association, it is strictly a private entity that is motivated by the goals of the small group that formed it; its only obligation is to the members of that group and there is no obligation to anyone else. In an incorporated mutual irrigation company the same holds also true. If it is motivated by the group goals, and if it continues to deal strictly with its own stockholders and does not deliver water to anyone other than stockholders, it maintains private status. If it holds these services out to others, then it is quasi-public in status with responsibilities to the public at large. More importantly, these responsibilities to the public are often followed by public regulation, so that control of the company which would be in the stockholders is now abrogated and it is brought under a public utility status. As it might be deduced, this is a very unpopular state of affairs with the private stockholders who have lost the control of their association because of such a public status. It might be added that the public status cannot simply be ended by cessation of delivery to the non-stockholder. Private status can only be recovered by cessation of delivery to the nonstockholder and by approval of the governmental regulatory body. Finally, where assessment or contract is a major way of financing private bodies, assessments can still be placed upon stockholders but land within a district can also be taxed in the public treasury. Thus, there are many disadvantages, particularly in an area where people's independence has been historically honored, to attaining a public status in irrigation organizations.

With these summary remarks on communalities and differences in features among existing organizational arrangements, we may now turn attention to a systematic mapping of the irrigation enterprises and a description and analysis of potential solutions concerning the challenge for renovation or innovation.

NOTES

1. See the extensive discussions in such works as Robert M. Hagan, et al (eds), Irrigation of Agricultural Lands, Madison, Wisc., American Society for Agronomy, 1967.

2. Daumas, Maurice (eds) History of Technology and Invention: Progress Through the Ages, N.Y. Crown, 1969.

3. Cantor, Leonard M., A World Geography of Irrigation, Praeger Publishers, New York, 1970, pp. 81-82.

4. Ibid., p. 64.

5. George, P., La Campagne, Presses Universitaries de France, Paris, 1956, pp. 161-164 as cited in Cantor, Leonard M., A World Geography of Irrigation, see above, p. 65.

6. Ibid, p. 66.

7. Forbes, R. J., Irrigation and Power; Studies in Ancient Technology, Vol. 2 (Leiden), 1965, p. 220 as cited by Chorley, R. J., see footnote 6 above.

8. Wittfogel, Karl A., "The Hydraulic Civilization," Man's Role in Changing the Face of the Earth, edited by W. L. Thomas, Jr., et.al., The University of Chicago Press, Chicago, 1956, pp. 152-164.

9. White, Gilbert F., "Contributions of Geographical Analysis to River Basin Development," Geographical Journal, Vol. 129, pp. 412-436.

10. Mendiluce, Jose Maria Martin, "The Regional Development Approach for Managing Water in Spain," Water Management, Organization for Economic Co-Operation and Development, Director of Information, O.E.C.D., 2 rue Andre-Pascal, 75775 Paris Cedex 16, France. 1972, p. 335-336.

11. See, Teclaff, L., The River Basin in History and Law, (Martinus Nidhoff, The Hague, 1967, pp. 169-170.

12. For example, see the Indus Waters Treaty between the governments of India, Pakistan, and the International Bank for Reconstruction and Development, Sept., 19, 1960, 419 U.N.T.S. 126 and Treaty between Canada and the United States relative to the Columbia River Basin, Jan. 17, 1961, T.I.A.S. No. 5638, 542 U.N.T.S. 244.

13. All that is required of the basin states is "due respect for international law" and the carrying out of projects "in accordance with acceptable practice among friendly and neighboring nations." See Art. V of the Treaty Concerning the Plata Basin, 8 International Legal Materials 905 (1969).

14. Cantor, Leonard M., A World Geography of Irrigation, Praeger Publisher, New York, Washington, 1970, p. 11-21. This historical discussion is based heavily on Mr. Cantor's work.

15. Cressey, G. B., Crossroads: Land and Life in Southwest Asia, Lippincott, New York, 1960, p. 149. See also Spate, O.H.K., India and Pakistan, Methuen, London, 1953 at p. 13.

16. Nelson, Lowry, The Mormon Village: A Pattern and Technique of Land Settlement, University of Utah Press, Salt Lake City, 1952, p. 28.

17. For a general discussion of Utah's situation, see James Hudson, "Irrigation Water Use in the Utah Valley," University of Chicago, Chicago, 1962. Research Paper 79.

18. Nelson, Lowry, Some Social and Economic Features of American Fork, Utah, "Brigham Young University, Studies No. 4," Brigham Young University, Prove, 1933, pp. 26-28. See also Smith, T. Lyson, The Sociology of Rural Life (3rd ed.) Harper & Bros., New York, 1953, pp. 216-223.

19. Cantor, Leonard M., A World Geography of Irrigation, Praeger Publishers, New York, Washington, 1970, p. 14.

20. Ibid., p. 16.

21. This discussion is drawn from the article "Irrigation Corporations" Raphael J. Moses, 32 Rocky Mountain Law Review 527 (1960).

22. Logan Irr. Dist. v. Holt, 110 Colo 253, 133 P. 2d 530 (1943).

23. Act of June 17, 1902, 32 Stat. 388.

24. "Not for hire" is used here to mean not for profit and limiting delivery to members only except in very unusual circumstances.

25. Another difference is that legal title does not vest in the association as with mutual companies. See footnote 6 supra, this section.

26. This type of organization is an apparent rarity in the United States. The cooperation--so familiar in agricultural communities--is founded for a different reason than are mutual irrigation associations. The mutual irrigation organization is not a business to foster business relations and its existence does not depend on the patronage and good will of its members. Its business is to distribute water to members--the title to which is held by them. In light of this observation, this discussion will present an organization which, though title to water remains in the individual, the sporit of the association is that of a cooperative. This is so unless the government chooses to formalize the arrangement by law. Such an organization may have the right blend of formality and informality for developing nation such as Pakistan which is trying to move forware but still needs some of the old customs to hold on to.

A statement of policy which might be pertinent to Pakistan's problems in agricultural development and to which this type of organization is directed is found in Utah Code Annotated, § 3-1-1 (1953).

27. Utah Code Ann., § 3-1-10 (1953). The qualifications for an incorporator may be similar. See, Id., § 3-1-3 (1953).

28. Suggestions as to what items might be covered in such articles may be found in Utah Code Ann., § 3-1-5 (1953). Too, provisions for amending these articles and for establishing by-laws as well as delineating the powers of such an association. See, Utah Code Ann., § 3-1-9 (1953). Also, see the discussion of organization, supra., this section.

29. This formal signing of a document may well act as More of a deterrent to wrongdoing than a mere formal agreement.

30. Note that this is not a corporation which has a life of its own but merely an association of persons who may leave at any time they wish. Not having a life of its own requires no submission of rights to create the separate entity.

31. For definition of a tenancy in common, see footnote no. 19, infra, this section.

32. Shares would, of course, be based on the amount of water right that an individual brought to the association as his rights bore on the total rights of all members. See, Smith v. North Canyon Water Co., 16 U. 194, 52 P. 283 (1898), Candelaria v. Vallejos, 13 N.M. 140, 81 P. 589 (1905).

33. Tangible, physical evidence of a water right may provide helpful in dealing with people not familiar with conceptual rights and mere entries in ledgers.

34. This right to sell or assign flows from the nature of a tenancy in common (which see) which dictates that each tenant owns his individed interest in the total individually--not jointly--and so he is free at all times to dispose of it. See, Biggs v. Utah Irrigation District Co. 7 Ariz. 331, 64 P. 494 (1901).

35. New Mexico Stats. § 75-14-25.1 (1953) defines them as political subdivisions of the state.

36. This may be pertinant to Pakistan's situation of many small farmers on one ditch off a minor canal.

37. New Mexico Stats. § 75-14-1 et. seq. (1953).

38. Id., § 75-14-31 through 75-14-37 (1953).

39. Id., § 75-14-25 (1953).

40. Id., § 74-14-7 (1953).

41. Id., § 75-14-11 (1953), Utah Code Ann., § 3-1-9 (1953). See also, Slosser v. Salt River Valley Canal Co., 7 Ariz. 376, 65 P. 332 (1901).

42. Members of unincorporated associations are usually regarded as tenants in common of the combined properties, and their rights and responsibilities as against each other are limited by the original agreement. Therefore, while this agreement (which may be termed the "articles of agreement" in cases of unincorporated entities or "articles of incorporation" in corporate bodies) need not be elaborate, it should contain a clear statement of the purpose of organizing and of the respective interests, duties, obligations and rights of members. Also, note that some statutes allow the by-laws to provide for these items in cases of incorporated associations. Colo. Rev. Stats. § 30-3-10 (1963), Utah Code Ann., § 3-1-8 (1953) are examples of this.

43. A tenant in common is described in one case where two or more hold the same (property) with interests accruing under different titles, or accruing under the same title, but at different periods, or conferred by words of limitation importing that the grantees are to take in distanct shares. The only unity which is vital is the unity of possession. Whyman v. Johnston 62 Colo. 461, 163 P. 76 (1917). See also, Binning v. Miller 56 Wyo. 129, 102 P. 2d 64 (1940) rehearing denied 56 Wyo. 129, 105 P.2d 278 (1940).

44. Farmers' High Line Canal and Reservoir Co. v. Southworth, 13 Colo. 111, 21 P. 1028 (1889), Nicholas v. McIntosh, 19 Colo. 22, 34 P. 278 (1893).

45. Johnston v. Little Horse Creek Irrigation Co., 13 Wyo. 208, 79 P. 22 (1904). Note that this relationship is built and depends on a mutual trust. Violation of this "fiduciary relationship" will be enjointed. Webster v. Knap, 6U.2d 273, 312 P.2d 557 (1957).

46. Fry v. Lowden, 70 Cal. 550, 11P 838 (1886); Nichols v. McIntosh, 19 Colo. 22, 34 P. 278 (1893). It appears that the basis for these rulings is the fiduciary relationship, i.e., the trust between members inherent in tenancies in common. By gaining unfair advantage over fellow members, this fiduciary relationship is breached and, if allowed to go unchecked, would lead to the disintegration of the association. See, Webster v. Knop, 7 U.2d 273, 312 P.2d 557 (1957).

47. Biggs v. Utah Irrigation Ditch Co., 7 Ariz. 331, 64 P. 494 (1901); Rose v. Mesmer, 142 Cal. 322, 75 P. 905 (1904); Gray v. Quiller, 144 Colo. 54, 344 P.2d 99 (1960). The question of abandoning a water appropriation is relevant. Though the general rule of law is that real property must not be abandoned, exceptions are made in the case of appropriate water rights because of the scarcity of the commodity and because of the demand for the product. A Colorado court has held that each of several water appropriators using a ditch in common may separately abandon his right thereto, and an injury to one by virtue of the others abandonment of all or part of the ditch by change of point of diversion of place of use is not an actionable injury. See, Brighton Ditch Co. v. City of Englewood, 124 Colo. 366, 237 P. 2d 117 (1951).

48. Arnett v. Linhart, 21 Colo. 188, 40 P. 355 (1895); Buller v. Buller 62 Col. App. 2d 694, 145 P. 2d 653 (1944).

49. There were no more recent cases on this point discovered than the two cited below.

50. Candelaria v. Vallejos, 13 N.M. 140, 81 P. 589 (1905); Bartholemew v. Fayette Irrigation Co. 31 U.1, 86 P. 481 (1906). See also, Kinney on Irrigation and Water Rights, 2nd Ed. § 1462 (1912) for a discussion of this point. The test seems to be whether vested rights will be injured by the majority. If they will be, and the change requested cannot be effected without hurting a minority, the rule seems to be as stated--that the majority cannot run roughshod over the minority. But where no injury would result, a minority may not stand in the way. Too, where maintenance of the ditch becomes impossible--therefore the good of the community is at stake--without a change which will adversely affect a minority, the good of the community at large will prevail and the minority's objections will be to no avail.

51. Id.

52. Bartholemew v. Fayette Irrigation Co. (see above); Fisher v. Bountiful City, 21 U. 29, 59 P. 520 (1899).

53. The duty to maintain the ditches and works may be statutorily imposed. See, Colo. Rev. Stats., § 31-14-8 (1971). See also, Arnett v. Linhart, 21 Colo. 188, 40 P. 355 (1895); Smith v. North Canyon Water Co., 16 U. 194, 52 P. 283 (1898); Compton v. Knuth, 117 Colo. 523, 190 P.2d 117 (1948) and First National Bank of Denver v. Groussman, 28 Colo. App. 215, 483 P.2d 398 (1971).

54. Colo. Rev. Stats., § 31-14-4(1) (1965); New Mexico Stats., § 75-14-23 35. seq. (1953).

55. Colo. Rev. Stats., Id.; Wyo. Stats. s 36-106 (1957) and s 41-221 for stockholders using water on land under the line of the same ditch.

56. Cache La Poudre Irrigation Co. v. Weld Reservoir Co., 25 Colo. 144, 53 P. 318 (1898).
It is to be noted, too, that loss of water by seepage or evaporation, after diversion from the stream or ditch, is not an injury to or a loss of a water right as between ditch contenants. Brighton Ditch Co. v. City of Englewood, 124 Colo. 366, 237 P. 2d 116 (1951).

57. Colo. Rev. Stats. § 30-3-12 (1963); Utah Code Ann., § 3-1-13 (1971), New Mexico Stats., § 75-15-3 (1953). For convenience, the first directors may simply be appointed with elections held thereafter. It is usually provided that directors and executive officers be chosen from the members or stockholders. See Utah Code Ann., § 3-1-3 (1953); Colo. Rev. Stats., § 30-3-12 and 30-3-13 (1963). From this it is obvious that the job is usually not full-time so the member can also pursue his agricultural activities. Salary, therefore, is not great and a per diem basis may be best, i.e., $10 per meeting plus travel expenses. This may be varied depending on the amount of time an individual is required to devote to company business.

58. Colo. Rev. Stats., § 30-3-16 (1963); Utah Code Ann. § 3-1-14 (1953). It is to be noted that the whims of the members are controlled by requiring at least ten percentum of the members to join in the petition to request an election for removal of a director. In addition, officers appointed by directors may also be removed by this method. See Utah Code Ann., § 3-1-16 (1953) and Wyo. Stats., § 17-175 (1957).

59. Colo. Rev. Stats., § 30-3-10 (1963); Utah Code Ann., § 3-1-8 (1953); Wyo Stats., § 17-159 (1957); West's annotated Corporation Code, § 12900 (1955).

60. Colo. Rev. Stats., § 30-3-9 (1963); Utah Code Ann., § 3-1-7 (1953); Wyo. Stats., 17-169 (1957).

61. Utah Code Ann., § 3-1-32 (1953). However, members may lose their vote if they do not respond to a public notice for impending election within the prescribed time or if their stock is not fully paid or if they are delinquent in payment of their assessments. See Utah Code Ann., Id., New Mexico Stats., § 75-15-3 (1953); and West's Annotated Corporation Code, § 12801 (1956).

62. Utah Code Ann., § 3-1-20 (1953).

63. Colo. Rev. Stats., 30-3-11 (1963) which provides for one annual meeting or more meetings per year if desired; Utah Code Ann., § 3-1-12 (1953); Wyo. Stats., § 17-174 (1957). Notice of meetings must be sent to members in order to give them adequate time to adjust their schedules and prepare to attend. See Utah Code Ann., Id. (10 day requirements) and Wyo. Stats., Id. (20 day requirement).

64. West's Annotated Corporation Code, § 12702. But note that this section provides that any member who has voting rights may vote. Members may lose their rights by not paying for their stock certificates or by being delinquent in payment of their assessments. See footnote no. 37, supra. Too, stock may be issued with no voting rights.

65. New Mexico Stats., § 75-15-3 (1953).

66. Colo. Rev. Stats., s 30-3-15 (1963); Utah Code Ann., s 3-1-10(b) 1953); Wyo. Stats., s 17-172(s)(1957); West's Annotated Corporation Code, s 12702. Digression: As can be seen, this arrangement is more popular than the one allowing voting shares to be determined by the amount of water rights. There are dangers in both positions, of course. Where voting shares are allotted by amount of water rights, it is immediately apparent that the large land holders will probably control things. Where reform is sought and the vast majority of persons affected by the proposed reform are small landholders as is the case in Pakistan--this drawback would likely impunge the entire effort.

On the other hand, the inequities of allowing the small owner to dictate policy to one who has a much larger investment and interest at stake, too, is immediately apparent.

Some middle ground would be best. As a suggestion, it might prove feasible to establish a system of cumulative voting. In this suggestion, voting stock would be distributed on the basis of water rights owned byt in an election, a stockholder may cast as many votse in the aggregate as he holds shares of stock multiplied by the number of directors or issues upon which he is voting. He may cast the whole number for only one candidate or issue or he may divide them. This makes it possible for minorities to organize and elect a representative or push an issue through but it would not give them total control. Neither would the major owners have absolute control.

67. Utah Code Ann., § 3-1-11 (E) (1953); Wyo. Stats., § 17-172(7) (1957).

68. Colo. Rev. Stats., § 30-3-15(7) (1963); West's Annotated Corporation Code, § 12404 (1956). It is also to be noted that assessments may vary according to the class of stock held. It has been held that no problem arises so long as assessments are made on a pro-rata basis which assumes an equal burden per share among each class of stockholder. See Robinson v. Booth-Orchard Grove Ditch Co. 94 Colo. 515, 31 P.2d 487 (1934).

69. Colo. Rev. Stats. s 30-1-4 (1963); Utah Code Ann., s 3-1-13 (1953); Wyo. Stats., s 17-173 (1957).

70. C.R.S., s 30-3-3 also 30-3-6 (1963); U.C.A. s 3-1-9 (1953); Wyo. Stats. s 17-171 (1957).

71. Three is obviously the smallest number possible as provided for in Utah Code Ann., § 3-1-13 (1953). Five, however, is not uncommon, Colo. Rev. Stats., § 30-3-12 (1963). Larger boards may be allowed and designed to represent geographical districts or special interests. See Colo. Rev. Stats., § 30-3-12 (1963) and Wyo. Stats., § 17-173 (1957). Allowance for district delineation may be provided for in the by-laws.

72. Utah Code Ann., § 3-1-13; 3-1-15 (1953) and Wyo Stats., § 17-173 (1957).

73. Colo. Rev. Stats., § 30-3-10 (1963).

74. Colo. Rev. Stats., § 30-3-12 (1963); Utah Code Ann., § 3-1-13 (1953); Wyo. Stats., § 17-173 (1957).

75. Colo. Rev. Stats., § 30-3-12(4) (1963); Utah Code Ann., § 3-1-13(111) (b) (1953).

76. Colo. Rev. Stats., § 30-3-13 (1963); Utah Code Ann., § 3-1-15 (1953).

77. In small companies the two offices probably would be combined because there would not be enough duties to deep two people busy. Too, in the interests of policy stability, it is best to simplify the managerial structure where possible.

78. Colo. Rev. Stats., Id.

79. To eliminate the petulant and baseless harassment of officials, it is usually provided that, to remove an officer or director, the action must be based on cause. See West's Ann. Corporation Code § 12600 (1955) and Utah Code Ann., § 3-1-16 (1953).

80. To ensure that an action for removal is based on solid complaints (see above), it is generally provided the charges must be in writing (Colo. Rev. Stats., § 30-3-16 (1963); Utah Code Ann., Id. and Wyo. Stats., § 17-175 (1957) and that a petition for removal must be signed by a percentage of members, usually five (Colo. Rev. Stats., Id.) or ten percent (Utah Code Ann. Id., Wyo. Stats., Id.). In cases where directors come from districts, a larger percentage of members of that district is required. Upon filing a valid petition with the secretary of the association, the director against whom the charges are filed is notified of the charges to allow time to prepare rebuttal or defense. At the next regular meeting of the association, a general election is held (presumably after the merits of each side are considered) to put the matter to a vote. A majority of votes cast (not of total membership) determines the outcome. See Colo. Rev. Stats., Id., Utah Code Ann., Id. and Wyo. Stats., Id.

81. They may or may not be incorporated. See section on unincorporated Voluntary Associations.

82. "at cost" means not for profit. See West's Ann. Calif. Public Utilities Code §2705.

83. West's Ann. Public Utilities Code § 2725 (Supp. 1972); Combs v. Agricultural Ditch Co., 17 Colo. 146 28 P. 966 (1892).

84. In some states, these are organized under special statutes for non-profit corporations. See Utah Code Ann., § 16-6-18 through 16-6-53 (Supp. 1971); Wyo. Stats., § 17-122.1 through 17-122.14 (1957).

85. In some areas stock is statutorily and judicially prohibited from being appurtenent. Utah Code Ann s 73-1-10 (1953); Hatch v. Adams 7 U.2d 73, 318 P.2d 633 (1957).

86. Colo. Rev. Stats. § 31-14-1 (Supp. 1967); Wyo. Stats. 17-188 (1969). See also, Wiley v. Decker, 11 Wyo. 496, 73 P. 210 (1903).

87. Corporations are creatures of statutes. See Colo. Rev. Stats. 31-14-1 (Supp. 1967).

88. Zion's Savings Bank and Trust Co. v. Tropic and East Fork Irrigation Co. 102 U. 101, 126 P.2d 1053 (1942).

89. Russell, Theodore W., Mutual Water Companies in California, X11 Southern California Law Review 157-158 (1939).

90. There are the usual small assets such as office equipment but this description is of the assets comprising the corporation primarily.

91. Profits are reflected in extra water on a pro rata basis for shareholders.

92. West's Ann. Public Utilities Code § 2701 (1956).

93. Not necessarily for profit.

94. Even supplying surplus water left over after all shareholders had been taken care of has been sufficient to create a public interest. Yucupa Water Co. no. 1 v. Public Utilities Commission, 9 Cal. 239, 357 P.2d 295 (1960).

95. West's Ann. Public Utilities Code § 2701 (1956).

96. Id. § 2705 (Supp. 1972); J.M. Howell v. Corning Irrigation Co., 177 Cal. 513, 171 P.100 (1918); Allen v. Railroad Commission 179 Cal. 68, 175 P. 455, Cert denied 249 US 601, 63 L Ed. 797 (1918).

97. Leavitt v. Lassen Irrigation Co. 157 Cal. 82, 106 P. 404 (1909).

98. Francioni v. Soledad Land and Water Co. 170 Cal. 221, 149 P. 161 (1915).

99. Williamson v. Railroad Commission, 193 Cal. 22, 222 P. 803 (1924).

100. Merely providing the bylaws or articles that a corporation will or will not be affected with a public interest will not of itself be dexisive. Allen v. Railroad Commission, 179 Cal. 68, 175 P. 466, cert. denied 249 US 601, 63 L. Ed. 797 (1918).

101. There are some situations which allow mutual company to sell to outsiders. Among these are delivering to others in a bona fide water emergency for the duration of the emergency. Companies have also allowed to deliver to lessees of their stock and to outside land leased by one of the company stockholders. West's Ann. Public Utilities Code § 2705 (1972 Supp.).

102. Using concenmation is in the nature of eminent domain and is affected with public interest. Though the cases are not entirely in harmony (see, Nash v. Clark 27 U. 158, 75 P. 371 affirmed 198 US 361, 49 L Ed. 1085 (1904)) there is a serious danger that such a use will result in public status and regulation as seen in Lamb v. California Water and Telephone Co., 21 C.2d 33, 129 P.2d 371 (1942).

103. Supply Ditch Co. v. Elliott, 10 Colo. 327, 15 P. 691 (1887).

104. Rocky Ford Canal Co. v. Simpson, 5 Colo. App. 30, 36 P. 638 (1894); Miller v. Imperial Co. No. 8, 159 Cal. 27, 103 P. 227 (1909).

105. Supply Ditch Co. v. Elliott (see above); Farmers' Independent Ditch Co. v. Agricultural Ditch Co. 22 Colo. 513, 45 P. 444 (1896). The trust spoken of is a revocable trust during the lifetime of the grantor. He may sell his shares at any time unless a lien has attached as a result of non-payment of an assessment. Title does not vest. East River Bottom Water Co. v. Boyce, 102 U. 149, 128 P.2d 277 (1942).

106. Supply Ditch Co. v. Elliott (see above); Farmers' Independent Ditch Co. v. Agricultural Ditch Co. (see above); Montrose Canal Co. v. Lautsenhizer Ditch Co. 23 Colo. 233, 48 P. 532 (1896).

107. Goodell v. Verdugo Canon Water Co., 138 Cal. 308, 71 P. 354 (1903; Butterfield v. O'Neill, 19 Colo. App. 7, 72 P. 807 (1903)). Officers may also be ordered to do something on a writ of mandamus issued pursuant to a complaint by a stockholder. Along the same lines, quo warrants may issue to face an officer to explain his action.

108. Farm Investment Co. v. Alta Land and Water Co., 28 Colo. 408, 65 P.22 (1901).

109. The trust is revocable and the corporation does not have the right, generally to sell a shareholder's stock. East River Bottom Water Co. v. Bouce, 102 U. 149, 128 P. 2d 277 (1942). To sell the stock would be a violation of the trust duty to act in the interests of the stockholders. However, in the absence of implied restrictions, a power to sell stock has been implied from the power of the corporation to acquire and own water rights. Old Mill Ditch and Irrigation Co. v. Estell, 65 Or. 586 133 P. 90 (1913). This is a danger avoided by using care in drafting the charter or articles of incorporation. See also, Consolidated Peoples' Ditch Co. v. Foothill Ditch Co. 205 Cal. 54, 269 P. 915 (1928); and Billings Ditch Co. v. Industrial Commission, 129 Colo. 69, 253 P.2d 1058 (1953). However, some courts still have difficulty ignoring the corporate firm. See Denver Joint Stock Land Bank v. Markham, 106 Colo. 509, 107 P.2d 313 (1940): Big Goose and Beaver Ditch Co. v. Wallop, (Wyo.), 382 P.2d 388 (1963).

110. Rocky Ford Canal Co. v. Simpson, 5 Colo. App. 30, 36 P. 638 (1894); Fuller v. Azusa Irrigation Co., 138 Cal. 204, 71 P. 98 (1902); Genola Town v. Santaquin, 96 U. 88, 80 P.2d 930 (1938); Locke v. Yorba Irrigation Co., 35 Cal. 2d 205, 217 P.2d 425 (1950).

111. Biggs v. Utah Irrigation Ditch Co. 7 Ariz. 331, 64 P. 494 (1901). Thus stock represents ownership of the corporate assets. It follows that this stock represents part of the irrigation system that delivers the water. But in mutual companies--as opposed to commercial companies--this stock also represents the right to the service of water from the company's system.

112. Cache La Poudre Irrigation Co. v. Larimer and Weld Reservoir Co., 25 Co.o. 144, 53 P. 318 (1898); "Stock not appurtenant is personal property." Denver Joint Stock Land Bank v. Markham, 106 Colo. 509, 107 P.2d 313 (1940). Similarly where stock is not appurtenant, a deed or mortgage to the land carries with it no right in a ditch company supply water thereto. Oligarchy Ditch Co. v. Farm Investment Co., 40 Colo. 291, 88 P. 443 (1906).

113. Stone v. Imperial Water Co. No. 1, 173 Cal. 39, 159 P. 164 (1906); Woodstone Marble and Tile Co. v. Dunsmore Canyon Water Co., 47 Cal. App. 72, 190 P. 213 (1923); Wheat v. Thomas, 209 Cal. 306, 287 P. 102 (1930); See also, Bank of Visalis v. Smith, 146 Cal. 398, 81 P. 542 (1905); Kennard v. Binney, 62 Cal. App. 732, 217 P. 808 (1923).

114. Colo. Rev. Stats. § 188-1-2 (1963); Wyo. Stats. § 41-254 (1957); Stesel v. Santa Ana River Water Co., 35 Cal. App. 2d 117, 94.2d 1052 (1939).

115. Cache La Poudre Irrigation Co. v. Larimer and Weld Reservoir Co., 25 Colo. 144, 53 P.318 (1898).

116. Colo. Rev. Stat. 31-13-7 (1963); Rocky Ford Canal Co. v. Sampson, 5 Colo. App. 30, 36 P. 638 (1894); Wheeler v. Northern Colorado Irrigation Co., 10 Co.o. 582, 17 P. 487 (1888); Millver v. Imperial Water Co. 156 Cal. 27, 103 P.227 (1909); Lindsay-Strathmore Irrigation District v. Wutchumna Water Co., 111 Cal App. 688, 296 P. 933 (1931) and Sherwood Irrigation Co. v. Vandework (Colo.), 331 P.2d 810 (1958).

117. Miller v. Imperial Water Co. (See above).

118. Mountain Supply Ditch Co. v. Lindekugel, 24 Colo. App. 100, 131 P. 789 (1913).

119. Colo. Rev. Stats. § 31-14-8 (1971); Wyo. Stats., § 41-217 (1957); Mountain Supply Ditch Co. v. Lindekugel, 24 Colo. App. 100, 131 P. 789 (1913); Engel v. Henry, 59 Cal. P.U.C. 457 (1962).

120. O'Connor v. North Truckee Ditch Co. 17 Nev. 245, 30 P. 882 (1883); Rocky Ford Canal Co. v. Sampson, 5 Colo. App. 30, 36 P. 638 (1894). This is qualified in some instances and can be provided for in a company's contract. For example, Acts of God, forcible entry, hostile diversion or temporary damage by flood or accident may excuse a failure to deliver water. However, if a shortage might have been prevented by judicious action on the part of the company, liability for damages suffered as a result of that shortage might have been prevented by judicious action on the part of the company, liability for damages suffered as a result of that shortage may result. Pawnee Land and Cattle Co. v. Jenkins, 1 Colo. 425, 29 P. 381 (1892).

121. Wyo. Stats. § 41-181 (1957) provides a limitation of one cubic foot per second for every seventy acres of land.

122. Necessarily, these plans can only be used where the land area to be supplied is fixed in advance and where the supply of water is more than adequate to cover the stockholders' demands. Too, existing stockholders must have the right to veto the issuance of new stock if their water supply will be diminished by such issuance. Where a company is a public or quasi-public concern, a public agency will make the determination of sufficiency. See West's Ann. Public Utilities Code § 2708 (1956); Sunkist Homes Inc. v. Southern California Water Co. 54 Cal. P.U.C. 204 (1955).

123. Colo. Rev. Stats. § 31-14-4 (1965); Wyo Stats. § 36-106 (1957); Fuller v. Azusa Irrigation Co., 138 Cal. 204, 71 P. 98 (1902). See also Wyo. Stats. 41-221 (1969) for stockholders using water on land under the line of the same ditch.

124. See footnote 22, supra and discussion following.

125. Calahan v. Chilcott Ditch Co., 37 Colo. 331, 86 P. 123 (1906); McHale v. Goshen Ditch Co., 49 Wyo. 100, 52 P. 2d 678 (1935); Henderson v. Kirby Ditch Co. (Wyo.) 373 P. 2 d 591 (1962). The assessment may sometimes be in labor or money. Colo. Rev. Stats. § 31-14-4(1); New Mexico Stats., § 75-14-23 35. seq. in cases of community ditches.

126. Colo. Rev. Stats. § 31-14-4 (1965); Wyo. Stats. § 36-106 (1957).

127. See Colo. Rev. Stats. § 31-14-14(4). Also, Stevens v. Curtis, 122 Col. App. 2d 30, 264 P. 2d 606 (1953).

128. Green and Griffen Real Estate and Investment Co. v. Salt River Valley Water Users' Association, 25 Ariz. 354, 217 P. 945 (1923). It should be noted that appurtenancy is being gradually abrogated in the districts which recognized it pursuant to a policy of making water available in the most advantageous places rather than "lock" it to one piece of land. See Ariz. Rev. Stat. § 45-172 (1972).

129. Federal Land Bank v. Bissonette, 51 Idaho 219, 4 P. 2d 364 (1931).

130. Farmers' Pawnee Canal Co. v. Henderson 46 Colo. 37, 102 P. 1063 (1909). Since however, assessment is the only way to raise extra revenue for mutual companies, this type of provision will rarely, if ever, appear.

131. Laramie Rivers Co. v. Watson, 69 Wyo. 333, 241 P. 2d 1080 (1952). A more direct method of enforcement of payment is to simply refuse delivery of water. Such methods are recognized in New Mexico (see; New Mexico Stats., § 75-14-24 and 75-14-41) (in the case of the community ditch or cooperative association) and in Wyoming (see, Wyo. Stats. § 36-106 and 41-221 (1957)). In New Mexico, a fine may be assessed before the water is denied (New Mexico Stats. § 75-14-34 (1953)).

132. Under this category it has been held in early decisions that a company may make it a ratable reduction in the amount of water to shareholders in time of a drought. Since then, this has been codified in at least one state. West's Ann. Public Utilities Code, § 2711 (1956). Fuller v. Azusa Irrigation Co. 138 Cal. 204, 71 P. 98 (1902); Goodell v. Verungo Canon Water Co., 138 Cal. 308, 71 P. 354 (1903).

133. Bethune v. Salt River Valley Water Users" Association, 26 Ariz. 525, 227 P. 989 (1924).

134. Old Mill Ditch and Irrigation Co. v. Estell, 65 Or. 586 133 P. 90 (1913); There is tension between this ruling and the general duty imposed on a company to restrain from acting to the detriment of its stockholders, and, in deed, to act for their benefit under the trust arrangement resulting from the contractual relationship discussed in § 3 and 4 supra.

135. Again, note the discussion in §§ 3 and 4 supra. See also, Stuart v. Davis, 25 Colo. App. 568, 139 P. 577 (1914).

136. Note the suggested plans for stock issuance and the assumptions attendant to each in § 4, supra.

137. Laramie Rivers Co. v. Watson, 69 Wyo. 333, 241 P. 2d 1080 (1952).

138. Bartholomew v. Fayette Irrigation Co., 31 U.1, 86, P. 481 (1906).

139. See, for example, Colo. Rev. Stats., § 31-16-3 (1971 Supp.).

140. It may be the state government or federal government. See 32 U.S. Statutes at Large 388 § 5 (1902) New Mexico Stats. § 75-17-1 (1953) and West's Annotated California Water Code § 51000 (1966).

141. It may be one person such as the Secretary of the Interior in the case of the United States or may be composed of persons with appropriate backgrounds.

142. 32 U.S. Statuts at Large 388 § 6 (1902), 43 U.S.C. 416.

143. Act of June 17, 1902, 32 Stat. 388, 43 U.S.C. 416. See also, West's Annotated California Water Code, § 43530 through 43559 (1966).

144. Donley v. West (Cal. App.), 189 P. 1052 (1920).

145. Act of April 11, 1956, 70 Stat. 107, 43 U.S.C. 620b; Act of July 9, 1965 79 Stat. 217, 16 U.S.C. 4601-18(c). The problem of such vast power does not exist may be found in R.E. Clark, Waters and Water Rights, Vol. 2, § 116.1 (1967). This volume contains an extended discussion of the Reclamation program in the United States and is relied heavily upon herein.

146. Act of June 17, 1902, 32 Stat. 389, 43 U.S.C. 421, Broad authority is also provided to the Secretary in acquiring lands for relocation. See Act of Aug. 4, 1939, 53 Stat. 1197, 43 U.S.C. 389.

147. Act of Sept. 2, 1964, 78 Stat. 808, 43 U.S.C. 945a.

148. Fox v. Ickes 137 F. 2d 30 (C.A.-D.C., 1943), certiorari denied 320 U.S. 792, 64 S.Ct. 204 (1943).

149. Act of June 17, 1902, 32 Stat. 390, 43 U.S.C. 372.

150. Act of August 4, 1937, 53 Stat. 1191, 43 U.S.C. 485e.

151. In re Bridges Valley Water Conservation Dist., 401 P. 2d 289 (Wyo. 1965).

152. Act of June 17, 1902, 32 Stat. 390.

153. This provision for apportionment may either appear in the statute or may be provided for in contracts for water or in the rules and regulations of the association.

154. It is to be noted, however, that a procedure whereby interested parties might submit and hear evedence in a lawsuit proceeding is probably desirable as a check on power abuse.

155. Act of August 13, 1914, 38 Stat. 687, 43 U.S.C. 469. See also, Fox v. Ickes, 137 F 2d 30 (C.A.-D.C., 1943), certiorari denied 320 U.S. 792, 64 S.Ct. 204 (1943).

156. Act of August 13, 1914, 38 Stat. 687, 43 U.S.C. 492; Swigart v. Baker 229 U.S. 187, 33 S. Ct. 645 (1913).

157. Except on a showing of fraud or on a decision so arbitrary, capricious or grossly erroneous as to constitute bad faith. See United States v. Fort Belknap Irrigaiton District, 197 F. Supp. 812, (D. Mont., 1961). This case delineates the two uses as follows: "construction costs" are those incurred constructing an irrigation system and putting it in condition to furnish and properly distribute water or where expenditures are necessary because of faulty original construction in violation of contractual or statutory requirements or where the capacity of the original system must be expanded. However, when conditions must be remedied because of the use of the system or to maintain it as an efficient, effective going concern, they are chargeable to "operation and maintenance."
It is to be noted that under this rule the same work may be "construction" in one situation and "maintenance" in another. For instance, construction to increase capacity may be a result of an oversight in one case but may be necessary to fulfill needs which develop incident to normal and ordinary operation in another case. From this, it can be seen that the facts of each case determine the result of the applied test. See Nampa and Meridian Irrigation District v. Bond, 268 U.S. 50, 45 S.Ct. 383 (1925) for an illustration of this problem.

158. The Act of June 17, 1902, 32 Stat. 389, provided that the entire cost of construction was to be assessed on a per acre basis on project land and paid in not more than ten annual installments. Nothing is mentioned about interest, however, so there is a considerable public underwriting. Also, the ten year requirement has now been extended to a more realistic forty year limit. See Act of August 4, 1939, Ch. 418, § 9(d), 53 Stat. 1195. 43 U.S.C. 485 h (d).

159. The actual and estimated costs often vary. Because the contract limits the cost of repayment, this cost may not be raised automatically. However, construction may be haulted until an amended cost estimate is inserted in the contract. It is interesting to note that an action by the artiter for the difference between actual and estimated cost will not lie on a theory of unjust enrichment. Fox v. Ickes (see above). The question of duress and bad faith involved in stopping construction has apparently never arisen.

160. See footnote 20, supra.

161. Act of June 17, 1902, 32 Stat. 388 § 5.

162. Id.

163. Act of August 4, 1939, Ch. 418, § 9(d)(1), 53 Stat. 1195, 43 U.S.C. 485(d)(1).

164. Act of August 8, 1958, 72 Stat. 542, 43 U.S.C. 485h(d)(3).

165. See, for example, West's Annotated California Water Code, § 51231 (1966) and Hawley v. Reclamation District No. 730 220 Cal. 271, 30 P.2d 505 (1934).

166. Objections can be made on the grounds of disparity between the Commission's estimate and the local users association's estimate. Honegger v. Reclamation District No. 1619, 190 C.A.2d 684, 12 Cal. Reptr. 76 (1961).

167. Act of August 4, 1939, Ch. 418 § 6, 53 Stat. 1191, 43 U.S.C. 485e and West's Annotated California Water Code, § 57522 (1966).

168. Act of August 4, 1939, Ch. 418, § 6, 53 Stat. 1191, 43 U.S.C. 485e.

3.1 Definition of Subsystems

That water is essential for the support of life needs no further debate. Especially in areas of scarce water resources, the entire life support system, the very existence of communities depends on the presence of water. Furthermore, water is a major "factor of production" in the overall metabolism involving economic sectors of society. The output of water as a resource commodity permits a higher level of economic and community metabolism. Thus, two major corrolates can be identified with water resources; first, the capacity for sustaining life for existing population and social activities; and, second, the potential for further expansion and growth.

There are many ways that one could proceed recounting the variety of activities and functions related to water, all the way from food production and agriculture, to the services and necessities of urban life, to the basis for industrialization, to the exploitation of other natural resources, and to the secondary services provided for recreational or leisure activities. On top of these, if not before all of these, water is also part of the ecological cycle by providing the necessary basis for the survival of wildlife and the vast array of species that sustain the balance of the biospheres.

In its varied expressions and presence, water systems usually meet four major goals:

a. Guaranteeing the survival of given populations and the carrying out of activities supported by supplemental water supplies.

b. Assist overall growth by providing an expanded capacity, wealth, as well as local and regional stability.

c. Through ancillary features, adjunct to a specific project, facilitate a multi-purpose policy for intergrated efforts of development (e.g., irrigation development may be coupled with hydroelectric power, flood control, fish and wildlife conservation, recreation, etc., that together provide the framework for the development of a given society).

d. Upgrade "quality of life" through improved services and contribute to the overall "social well-being."

In past years the challenge of water resources development was met primarily as a basic physical problem. Elements of this traditional space included:

a. hydrologic delineation of the water resources;

b. development of a plan--economically viable, financially feasible, and technically sound;

c. appropriate design of the physical facilities; and

d. pertinent institutional arrangements.

In recent years, however, because ecological and social externalities of water resource development are becoming incrementally more significant, the planning space has begun to broaden. Indeed, diversified questions of social policy and equity in water management have underlined an increased preoccupation with expanded time horizon, the search for a higher resolution in any project effects, and multi-disciplinary integration.

As it has been repeatedly stated, water has meaning and importance where socially used for the achievement of social objectives. It is exactly because of the above observation that a consensus seems to emerge concerning the appropriate elements in any assessment of water resources development and management, namely the estimation of physical potential, the determination of technical and economic feasibility, and the evaluation of social desirability.

The use of the above terms may help us begin to delineate a variety of key factors and variables involved in the systematic analysis of water management. On the one hand, the physical or natural environment includes the water supply, airshed, minerals, and land and it is often referred to as the *geosphere*. As important as the physical environment, however, is also the social environment or what we may call here the *sociosphere*. This last environment contains the common patterns of interaction between people in the physical environment, historical and community values, and all aspects of human resources as well as knowledge and skills. These two major environments (physical and non-physical) or major resource systems are only descriptive categories of a complex set of interdependent relationships subsummed under the broader rubric of *total environment*, i.e., all conceivable systems affecting man as an individual and his community as a whole.

Given the fact that there is little agreement among various disciplines as to how to approach systematically the study of "total environment" or any component subsystem, it will be futile to embark upon any detailed exposition of such a concept in the present study. Yet, both Phases I and II had as a common denominator the establishment of a common framework and the related effort of a widely shared systems analysis vocabulary. If nothing else, we recognize at least two key "environments," i.e., physical and non-physical. The first was elaborated by the engineering representatives in the project, while the latter involved diversified representatives of what one may broadly call "social sciences" (in our present effort sociologists, lawyers, and economists).

In this respect, the definitions of the physical scientists were pretty straight-forward and close to widely accepted concepts. In the non-physical environment analysis, more questions were raised as to how to describe this entity. Although multiple usages of a variety of terms may be unavoidable and part of the elusive character of social phenomena, nevertheless they make things difficult for those who seek to study communities and understand their importance as crucial mechanisms of social organization in any water management scheme.

Thus, such terms as "community," "social structure," "social system," "society," and "social organization" are part of diversified definitions as to how men organize their activities in some systematic fashion. Perhaps it would be appropriate to adopt another term, "social environment," as a more relevant definition in environmental studies whereby we recognize three key variables: the *territorial* variable (physical environment), the *sociological* variable (social interaction and organizational and institutional networks), and the *cultural* variable (common ties and the normative system).

The key question in all studies that attempt to develop a systematic framework for incorporating physical and social factors is not only the definition of all those ambient conditions that one identifies with the so-called total environment, but also the inclusion of all important variables which are potentially or likely to be affected by any scheme of water management. No doubt, it is almost utopian to believe that any particular approach can include all the important variables, since a selectivity always operates as to which ones are considered as important in any given water resource project, at any given time, in any particular locality, or at any particular culture. Since apparently it is very dificult to examine all appropriate variables that make up any water management system, there is the need for developing a preliminary conceptual map which exemplifies an overall scheme for a more cogent analysis of irrigation systems.

It has been pointed out in Section 0.3 that the study has adopted a systems approach, where an input-thruput-output model required a dynamic analysis which emphasized:

a. delineation of objectives and goals as well as of alternatives;

b. description of the system (boundaries);

c. constraints of the system (inputs);

d. time constraints and diachronic considerations (short versus long-range consequences);

e. techniques for systems analysis; and

f. evaluation of the performance of the system.

There is a great variety of water resources systems resulting from different geographical conditions and cultural circumstances. Yet, despite great variations in scope, extent and organizational form all systems encompass common elements and mechanisms which result from the following crucial questions:

1. How will the water resources be used in the productive process?

2. Who will plan and how will the production facilities be installed and organized?

3. Which individuals or groups will exercise control over the acquisition, distribution, use, and reclamation of water resources?

4. What will be the distribution and marketing of goods and services produced, including also the installation and operation of distribution facilities?

Any coordinated plan for the exploitation of water resources recognizes at least three major parts in water-related activities: supply, use, and reclamation. More specifically, the overall structures of a water resources system may be seen as involving five major functions and dynamic processes, exemplified in Figure 3-1.

(1) Water supply and water source considerations, including new or potential sources of supply.

(2) Water control aspects and characteristics of diversion, such as storage, reservoirs, and wells, and the assorted institutional forms of regulation.

(3) Water distribution systems, or the means of transmission and patterns of water flow.

(4) Water utilization systems, including cultural practices and the spectrum of diversified uses.

(5) Water reclamation, including return flows, waste treatment, and recycling.

More specifically, the irrigation system can be subdivided into three major subsystems (Figure 3-2): a) the water delivery system; b) the water use (farm) subsystem; and c) the water removal system. The water delivery system can be further subdivided into two components, namely, a) the transport of water and pollutants from the headwaters of the watershed to the cross-section along the river where water is diverted to irrigate croplands, and b) the transport of water and pollutants from the river diversion works to the individual farm. The farm subsystem begins at the point where water is delivered to the farm and continues to the point where surface water is removed from the farm. Also, the farm subsystem is defined vertically as beginning at the ground surface and terminating at the bottom of the root zone. The water removal subsystem consists of a) the surface runoff from the tail end of the farm (which is called "tailwater"), and b) water moving below the root zone (which is called "deep percolation").

Despite the apparent simplicity of the above broad observations, there are many ways of proceeding to answer the question of how to systematically organize the various dimensions of a water management system per any particular water use. Briefly, water management is perceived as a system operating within a given environment where inputs (physical and social) processed through a particular "system" (thruput) result in goals established for the functioning of the system (output). Input considerations include such variables as the physical environment, population characteristics, normative resources, economic viability, political networks, and technological developments. System or thruput considerations are various structures and processes identified with organizational arrangements, such as personnel, facilities, and procedures (or "rules of the game"). Finally, output considerations are variables referring to the established goals or objectives

FIGURE 3-1. Dynamic Water Functions

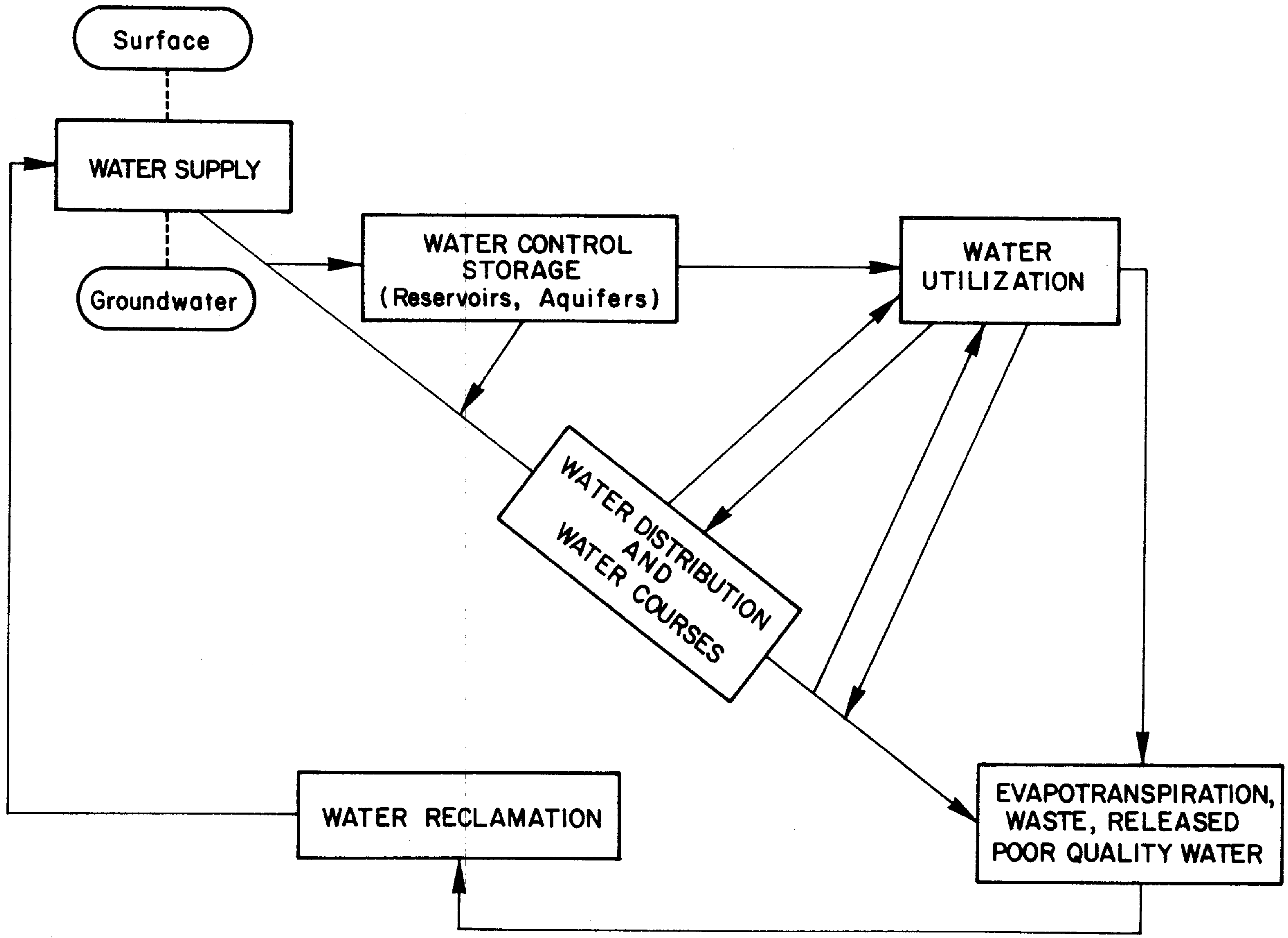
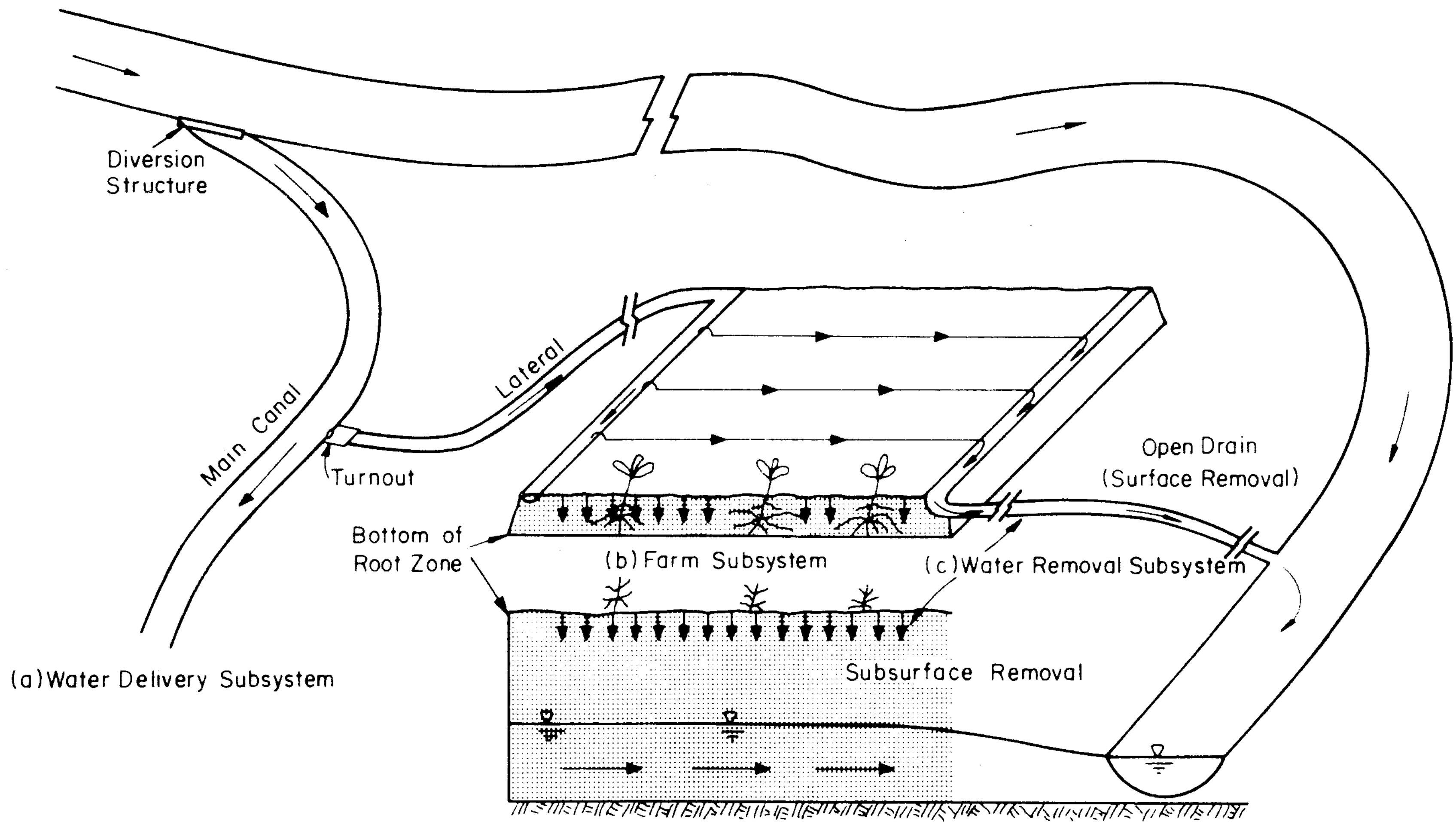


FIGURE 3-2. The Water Delivery, Farm and Water Removal Subsystems



of a water management system, revolving around such goods or services as the total volume of water supply, water quality, flow and distribution, enhancement of life, and long-range water resource development.

By using the basic notions of systems analysis introduced above, we may also proceed to apply the systems approach in the organization of the socio-cultural aspects of water management. To start with we may recapitulate the kinds of problems concerning water resources management by using a simplified version of analysis summarized in Figure 3-3. By using this general descriptive framework of analysis as a springboard we can delineate in greater detail the variety of socio-cultural dimensions of various management schemes in the spectrum of diversified water uses. For example, Figure 3-4 represents a simplified version of a local irrigation system designed to achieve maximum agricultural productivity through the application of water by human agencies in order to assist the growth of crops and grass.

Figure 3-4 indicates that four major environments provide the necessary inputs for the operating of a system or organization, namely socio-demographic, economic, physical, and normative. In a typical systems analysis approach the variety of inputs from these environments are processed through structures and procedures which attempt to maximize desired goals. These organizational structures or thruputs, varying in size, scope, integration, and complexity from country to country, from basin to basin, and from region to region, including physical facilities developed for meeting the need for increased productivity; and, various dimensions of infrastructure, such as rules of operation, patterns of leadership and command, efforts of control, integration, information, communication, and ways of interacting with other organizational environments.

The various linkages and component parts incorporated in Figure 3-4 can become much more complicated if we try to develop a more comprehensive analysis of a large array of irrigation systems (rather than the local irrigation system depicted in such a descriptive figure) and their intra- and inter-system dependencies.

What the previous two figures try to emphasize is the multiplicity of the levels of analysis as well as the multiplicity of functions in any water management system. Most important, at each level and for each subsystem, component part and function, problems of institutional order arise, difficulties of organizational arrangements, and need for specific understanding of the normative rules involved at each stage or phase of a dynamically operating water management system. The major sociological remark to be made at this point is that each system function is associated with important organizational and institutional considerations and aspects of decision-making. Independent of their essential connection with the physical or engineering aspects, each dynamic water function presented in the previous figures requires considerations emanating from the larger socio-cultural context.

While the above gave us a way of approaching in a systematic fashion aspects of water management, we need to again emphasize that the advantages of systems analysis as a tool for identifying and understanding the complex interactions of a total water management scheme include:

FIGURE 3-3. A Simplified Version of Water Resource Problems and of Water Management

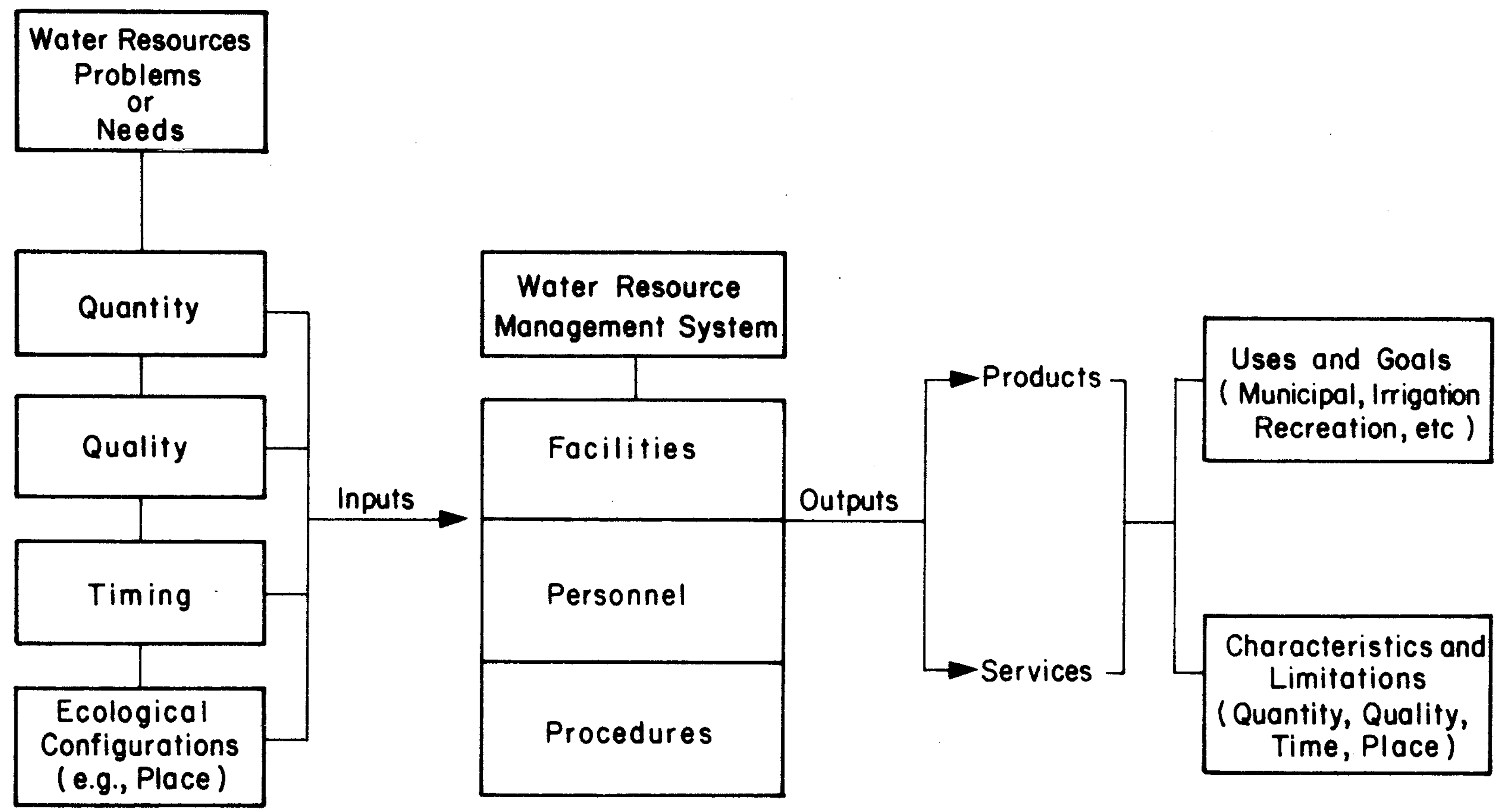
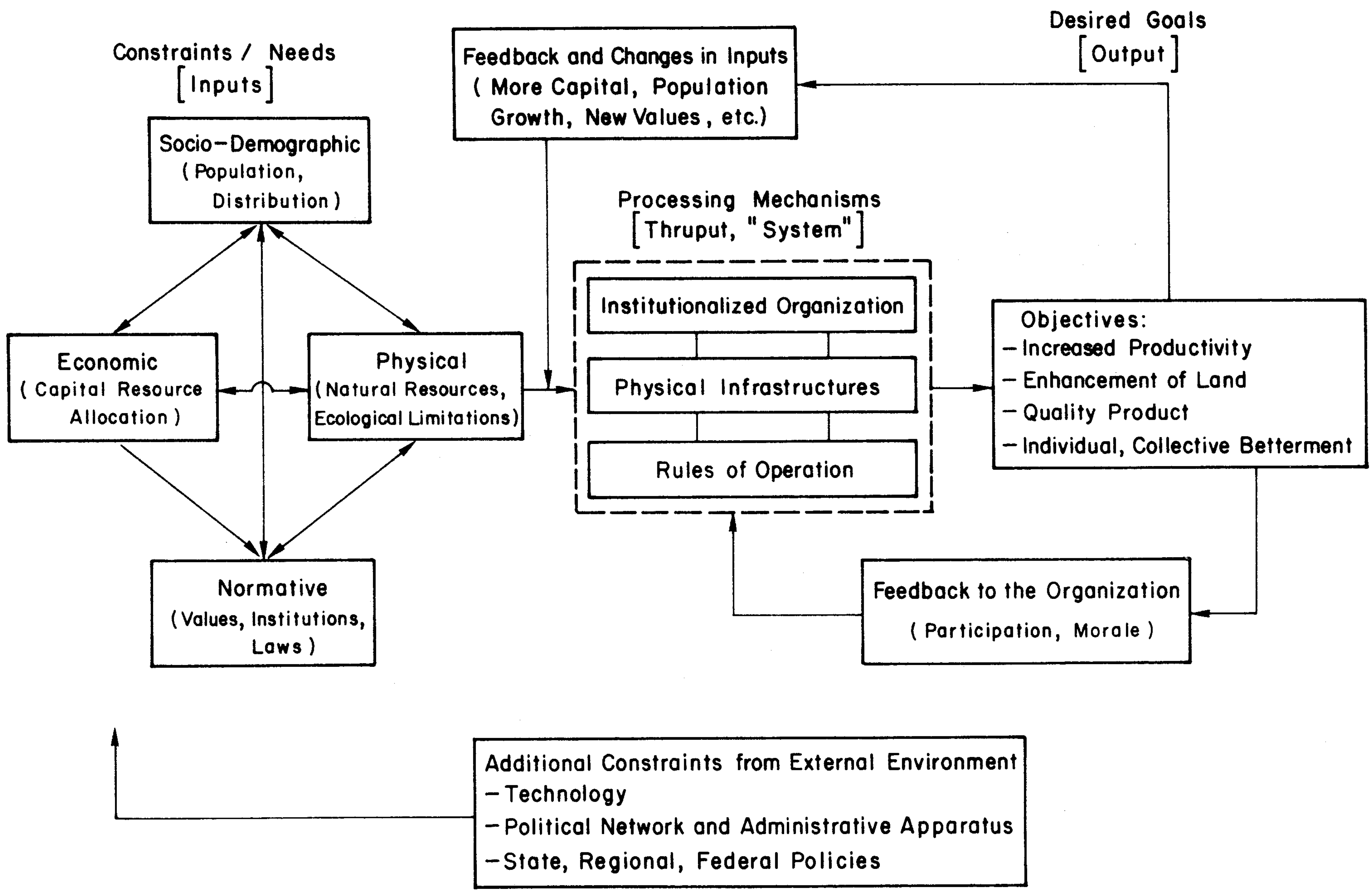


FIGURE 3-4. Simplified Version of a Local Irrigation System



a. a balancing of social science with physical solutions to water problems;

b. intergration of technological ("hardware") and non-technological ("software") solutions;

c. modeling of complex problems;

d. improvement of design of the total environment; and

e. definition of standards and cost factors for action alternatives and desired ends.

3.2 Interaction Between Subsystems

After a general, more or less theoretical, discussion concerning the establishment of a coherent framework to describe component parts of an irrigation system, we may also briefly explore the key question of interaction between subsystems. To focus the discussion, we may utilize some specific functions, such as delivery or removal, to illustrate critical points.

In most instances, the quantity and quality problems in the water removal subsystem are minimized by having highly efficient water delivery and farm subsystems. Minimizing the quantity of surface runoff will assist in alleviating quality problems due to sediments, phosphates, and pesticides; whereas minimizing deep percolation losses from irrigated lands will reduce waterlogging and quality problems due to salts, including nitrates.

The most significant improvements in reducing water requirements and controlling waterlogging or salinity will potentially come from improved on-farm water management. This will be particularly true for areas containing large quantities of natural pollutants, such as salts, in the soil profile. In such situations, the key is to minimize the subsurface return flows, thereby minimizing the quantity of pickup. Poor irrigation practices on the farm are the primary cause of overly large water diversions, as well as being the primary source of present return flow quality problems. Besides improvements at the source, other improvements can be accomplished in the water removal system. Due to the nature of irrigated agriculture, whereby salts must be leached from the root zone, an optimum solution will, in most cases, require improvements in on-farm water management. Numerous technological and institutional concepts could be utilized to accomplish improved water quantity and quality management.

3.2.1 Planning for effective water management

The resource base for irrigated agriculture has not substantially changed since its inception thousands of years ago. Over the last century there has been little incentive for any major innovation to improve efficiency in the use of this most priceless of all commodities--water. The provision of irrigation water since ancient times has been considered a governmental or collective responsibility, and the direct charges made for water have usually not been high enough to encourage innovation. This custom of undercharging for water has continued to this very day, and few regions charge the farmer for the real cost of water. However, there are a few examples of extremely water scarce areas in the world where considerable ingenuity has been applied in effectively utilizing water supplies.

Aggravating this situation is the fact that most all of irrigated agricultural development, even in the last few decades, has focused upon the construction of water delivery subsystems. This preoccupation with the installation of "hardware" results from a naive single-discipline approach to water management. Probably the greatest deterrent to improved water management in most irrigation systems in the world is that this same discipline controls the operation of the water delivery subsystem. Thus, many aspects of agricultural production have been neglected, such as the need for improved production and techniques, or adopting new institutional approaches. As a result, a wide gap frequently exists between hardware development and agricultural production.

The approach which has been applied to irrigated agricultural development in the past is characterized by separating the development from the management aspects of water resources exploitation, with development being emphasized while management is neglected. This approach has been used almost exclusively in the Western United States with reasonable success. However, as the water resources become more fully utilized, the necessity for meeting new water demands, along with problems of water quality degradation, this approach becomes unsatisfactory. And even more importantly, this approach is completely unacceptable in most portions of the world.

In contrast, the "management" approach attempts to achieve water development objectives by applying a variety of measures after studying the entire system, thereby attempting to modify the system to meet changing demands. Therefore, instead of constructing new engineering works to meet new demands, the focus is upon water resources management, with construction works being considered only as a tool when necessary to meet water management objectives. Unfortunately, in most cases water management is relegated to a post analysis of engineering works (since much of the future emphasis will be geared towards improving existing irrigation systems), which aggravates not only the implementation of technology, but really constrains or makes extremely difficult the implementation of institutional measures.

3.2.2 Designing the irrigation system

The "heart" of an irrigation system is the farm subsystem. The purpose of an irrigation system is to grow food and this "action" takes place in the root zone. The purpose of the water delivery subsystem and water removal subsystem is to support this "action." Therefore, the proper design of an irrigation system requires, first of all, that the farm subsystem be adequately designed. Then, the water delivery subsystem can be designed to provide the quantities of water at the times required by the plants. The most important constraint in the design procedure is the necessity for assuring adequate drainage through the root zone in order to maintain a root zone salt balance to insure continued long-term agricultural productivity.

Farm subsystem. The first important variables in designing the farm subsystem are climate, soils, and crops. The interrelationships between these variables dictate the capability of the land resource for producing food and fiber. Besides the physical aspects of land capability, an important question at this point is the economic demand for various crops, unless the land will be irrigated strictly by subsistence farmers. Then, the question may be, "How many people can the land support?"

The next important variable will be water and its physical availability. Frequently in arid areas of the world water is the most limiting factor. However, the capability of the available water supplies (precipitation, surface runoff and groundwater) for plant production is highly dependent upon the efficiency with which the water is used, which in turn is a function of both economic and institutional factors. Besides physical limitations, the questions of economics in supplying water must be answered to insure that costs are commensurate with planning goals.

Once the general scope of an irrigation project has been determined, then the more detailed design procedures can follow. The critical factor at this point becomes the infiltration characteristics of the soil. Unfortunately, infiltration is a complex phenomenon and the intake function of a particular field will vary during the irrigation season, as well as varying from season to season. There are a number of laboratory and field methods available for determining the intake characteristics of a soil.

Using climatic data, the potential evapotranspiration of the various crops can be calculated. These computations will provide the information regarding water consumption with time, provided sufficient moisture is made available in the root zone.

The next important step is designing the farm irrigation layout so that sufficient moisture will be available in the root zone when required by the plants. The root zone is capable of storing moisture for future plant use. Again, soil characteristics determine the amount of storage as well as the capability of the plant to extract the moisture from this "reservoir." At the same time, the leaching requirement for maintaining a salt balance in the root zone must be kept in mind. Consequently, the farm irrigation layout must be capable of supplying not only the plant water requirement, but also the leaching requirement.

The proper design of the farm irrigation layout is crucial for: 1) uniformly distributing the necessary moisture throughout the field; and 2) minimizing deep percolation losses so as not to aggravate problems in the water removal subsystem.

Generally, the development of irrigation projects has not entailed the design of farm irrigation layouts suited to the individual characteristics of each field. Instead, only the general method of irrigation may be adopted (e.g., basin or furrow irrigation). The farmer is usually left to his own means in irrigating his fields, without having the benefit of technical (or economic) assistance. The situation is further aggravated because, along with adopting a general method of irrigation, an average irrigation efficiency for this method is "pulled out of the air." If this so-called average water use efficiency was even close to being correct it would be most fortunate--let alone taking into accoun the variability from field to field. Usually the application of this average efficiency results in large quantities of deep percolation during the early part of the irrigation season, which in turn contributes to waterlogging of the soils and consequent poor crop yields (or eventual failure of the irrigation enterprise).

Water delivery subsystem. The design of the individual farm irrigation layouts should dictate the design of the water delivery subsystem. The irrigation layout design, if properly accomplished, will show the necessary quantities and timing of water deliveries at the farm inlets. The water delivery network must be designed to meet the farm water requirements. Except for alluvial channels conveying large sediment loads, the design of the conveyance works is rather "mechanical."

One of the essential facilities for successfully operating an irrigation conveyance network is adequate and numerous flow measurement devices. To begin with, since each farm has a particular water requirement, then the only means by which the proper amount of water can be delivered is by measuring the water at the farm inlet. After all, the farmer cannot be expected to use good water management practices if he doesn't even know the quantity of water being managed. Besides each farm inlet, a flow measurement structure should be provided at all division points in the water delivery subsystem.

The real problem in the water delivery subsystem is the *institutional* framework controlling the operation of this portion of the irrigation system. Generally, the operation of the conveyance facilities has not been related to the requirements for sustaining a long-term productive agriculture. In particular, institutional factors have acted as constraints to improved water management or increased agricultural production.

The primary requirement for sustaining an irrigation system is an institutional framework that is compatible with the design requirements for the water delivery subsystem, which in turn has been dictated by the proper design of the farm irrigation layouts, as well as any constraints imposed by the water removal subsystem. Thus, even if all three components of the irrigation system have been properly designed, the lack of an adequate institutional framework for operating the system in accordance with the design criteria will likely lead to either failure of the system, or at least having agricultural production levels below (or far below) expectations.

Water removal subsystem. The principle function of the water removal subsystem is to allow proper drainage below the root zone so that adequate leaching of salts from the root zone will occur. The most satisfactory mechanism for insuring adequate drainage is proper operation of the water delivery subsystem. By so doing, a drainage problem will probably not occur. This is much better than allowing the problem to occur, then constructing drainage facilities to correct the damage. Unfortunately, the usual solution consists of constructing additional facilities to correct the damage. Frequently, project reports will state "drainage facilities will be designed after the project has been in operation for a number of years in order to more precisely ascertain drainage requirements." This is the same naive single-discipline thinking referred to in the previous section, which is the rule rather than the exception.

Another important consideration in the water removal subsystem is water quality. If canal seepage and cropland deep percolation losses result in water quality degradation of the underlying groundwater supplies, then the use of these supplies may become impaired. Also, the return flows to the river may limit the usefulness of the river water to downstream users.

When all is said and done, at the heart of the irrigation system one finds the individual water user. Product of his culture, shaped and influenced by the surrounding environment, and conditioned by a long history he stands at the center of the quest for an effective water operation, a true subsystem by himself.

3.3 Importance of the Water User in the Subsystem

The historical evolution of irrigation in the Western United States described in the previous chapter has also indicated the centrality of the user in the irrigation subsystem and the institutions that emerged as a response to the exigencies of a demanding environment.

The early pioneers in the West engaged in the construction of diversion structures and canals in order to irrigate their claimed lands. Initially the lands under irrigation were located adjacent to the river, thereby minimizing effort required to deliver water to the fields. Later settlers would undertake to construct diversion works with delivery systems to serve newly cultivated lands immediately above the original canal. Usually this accomplishment was the result of a cooperative effort among the farmers who would benefit by the services provided by this canal. This process was continued until either the land or the water resource became a limiting factor; i.e., until the land of the settlement extended to where the land was no longer productive or until water was no longer plentiful.

As a result of this step-by-step irrigation process--that is, one group coming in and building a canal out to their land and a later group coming in and building up another canal up to their lands--an irrigated valley would consist of a series of parallel canals traversing the land. Needless to say, such customary practices and the lack of any major changes after completing such developments has resulted in a number of present-day problems.

The addition of each canal usually resulted in the formation of a new irrigation enterprise with the result that many irrigated valleys in the West have a multitude of irrigation entities managing the delivery of water in the valley. Problems involving the lack of cooperation among the various entities in bringing about improved water use efficiency appear to be inherent among many of these groups. In addition, the duplication of water delivery systems has resulted in higher costs for irrigation system rehabilitation, increased operation and maintenance costs, and greater water loss through seepage, operational by-passing or storage, along with evaporation and surface and subsurface deterent of flow.

Coinciding with the physical development of water resources was the legal development of the right to use water. As the development of the semi-arid West took place, the idea that water was community property available for use by all gave way to a recognized property right in the face of the need created by investments made on the basis of dependable water supply. This property right, which was first seen developing in miners' claims, looked much like the right that miners had developed respecting their claims and also looked like the prohibition against claim jumping. As a consequence, the property right which developed was subject to certain restraints. It had to be used for beneficial use and it was not permissable to waste the water. It was accorded the same protection and had the same formalities as real property rights. It is legally described as usufructary right which means that one had the use of the water but not the water itself. This follows from the fugitive nature of the resource; once it is used it just flows down the stream and it is impossible to "lay claim" to a particular parcel of water.

Individual farmers soon realized that they could not, on an individual basis or even in small groups, build adequate diversions, storage and transmission systems for water conveyance. Out of this realization there was created the ditch company. Initially these companies consisted of a few farmers bound by a general agreement to cooperate in construction and maintenance of a simple irrigation system with no monetary profit noted. The individual farmer owned the water rights and the cooperative owned the diversion and the conveyances.

Coinciding with the development of the mutual organization was the privately owned commercial company which was profit motivated and organized to construct irrigation, storage, and delivery systems as well as to reclaim land all for the purpose of delivering water to their customers. The legislatures provided the legal mechanism for including larger areas of farmland under organized control in the form of irrigation districts and later on conservancy and conservation districts. These districts, which require landowner voter consent for organization, allowed expanded development and improvement through taxes on the value of the land within the area.

The situation today, however, is a situation where property right has become vested, a property right which was necessary in the development of water. Most of these property rights are owned by agricultural communities. On the other hand, there is rapid expansion of population and the political and social structure has changed with rapid urbanization and changing water demands. The present water owners and water users are satisfied with their life as they know it and they are, for the most part, unwilling to change. In this respect, there are a couple of alternatives that seem immediately rather obvious. To start with, the state government could exercise its right of eminent domain, implying that the water rights would be purchased and simply taken away from the present owners. Such an alternative is not only unpopular for the people of the region, but given the political realities in most Western states (strongly dominated by agricultural interests) quite an unrealistic solution. On the other hand, consolidation of irrigation companies, or some form of bringing together various users in order to save water, may prove to be a feasible partial solution.

The effort here is not to recount the social realities of the region, the political obstacles to alternatives, or the constraining character of long-established practices. We want only to emphasize or particularly underscore the notion that the irrigation system must be tailored to the water user. It is obvious that if we only needed to focus on water as a physical system, then all irrigation problems would simply be engineering problems. Yet, as repeatedly emphasized this is not, indeed should not be, the case. Irrigation problems are problems which involve people, people with rights, people with inputs and demands to the political system. It is important to visualize the water user as a client rather than as a patient who simply needs specified "treatment" or appropriate scientific response in order to gain particular results or desired "outputs." In other words, approaching the problem in a the rapeutic manner implies a conceived optimal solution, with little or no choice from the potential beneficiary. We may extend the simplistic term "client" to propose an alternative approach, i.e., "participatory planning" where sets of alternatives are presented, with subsequent analysis of advantages and disadvantages among both proposing parties and involved water users.

In the context of the present analysis is is also important to remember the evolutionary perspective described previously. Users will change whenever they can perceive that there is a need of doing so and demonstrable advantages for altering present practices. After all, such water practices have evolved, changed, and reshaped over time. What is rather different today is the dramatic, rapid change engulfing the West, the result of population influx, transformations in the social character of the region, strains from ecological spillovers, all within a very short time span. To put it otherwise, while change, constant change, has been and is part of everyday life, many areas of the region face both a "culture" and a "future" shock, as their traditional way of arranging their affairs is severely tested.

But let us return to the present argument and to the more specific dimensions of irrigated agriculture in the West. The major social transformations taking place are accentuating the political character of water resources, hence the more the required sensitivity for presenting and explaining proposed organizational alternatives. If, for example, the major advantage of consolidation is in saving water, it means that present users will not have to sacrifice any of their water, or be detrimentally affected by the change. To the people that have established legal rights and who are reluctant to change the state of affairs, some benefits of proposed alternatives need to be stressed. The economics of scale and physical efficiency which have been traditionally emphasized as motives for change are still valid arguments for supporting alternatives. To both senior and junior water users it could be stressed that consolidation in all likelihood will result in more water and therefore senior users will not, in a consolidated company, be affected. In all probability the juniors who are now faced with water shortages or who must completely do without water in a year of drought, may find themselves in a position where enough water has been saved, so that they do not have to do without water because of their junior status. In this manner it could be pointed out that agricultural production will be increased, dangers of financial distress caused by drought will be decreased. Thus, general beneficial effects of consolidation can be brought home in terms of thousands of dollars saved that otherwise would have to be paid each and every year by farmers.

To sum up: while an integrated approach to irrigation systems requires quite a configuration of physical and social dimensions, their ultimate utility and effectiveness has meaning in the context of a social setting in which individuals become the nodal point. The individual-centered system, the individual water use, and the on-farm water practices are really the heart of what we described as the total environmental approach. It is to this proposition that we must now pay attention and concentrate our efforts in order to explicate concrete suggestions for potential consolidation.

4.1 The Need for Preserving Traditional Equilibrium

4.1.1 The socio-cultural context

The title of this section may sound pretensious and perhaps grandiose. It attempts to direct attention, in the shortest form possible, to a number of remarks made both in the introduction and in the analysis of the evolution of irrigated agriculture. Institutions evolve slowly, in many respects they represent collective wisdom of experience and custom, and, for good or bad, by their survival and tenacity represent "optimal"solutions and well-tried responses to constant demands of the environment.

Yet, as it has been repeatedly stated we are facing strong and urgent demands from expanding populations, transformation of water uses, etc., which require both new approaches to collective survival and adjustment to changing circumstances. The character and rate of change present us with such fundamental dilemmas as how to balance growth and stability, dynamism and equilibrium, preservation of the old and flexible responses to the new.

The clash and dilemmas of traditionalism and modernization are particularly acute in agriculture and in the region of the U.S. with strong established cultural responses to such a vital resource as water. All over the world the search for irrigated land is relentless, result of both the increasing world demand for basic crops and the diminishing good unused arable land available. At the same time, coupled with increasing demand for irrigation, the remaining water resources which can be developed inexpensively are dominishing. In such a situation present inefficient schemes are not only anachronistic, but also highly detrimental to developmental efforts.

Three interrelated items exemplify at this point the definition of our problem:

a. both in developed and development countries large projects attract always attention and sympathy as a response to the quest of producing higher crop yields. Mega-structures, large hydraulic features, and, generally, engineering solutions in the form of magnificient water projects tend to ignore actual field irrigation and the unglamorous task of everyday operation.

b. given the above preoccupation, field irrigation is given little attention in funds and interest. On-farm water management is left to the farmer himself with the feeling that the task of efficient irrigation has been accomplished as long as water reaches the boundaries of the farm in ample quantity and relatively good quality. Low efficiency of water application becomes the order of the day, in view of highly atomized, fragmented, and in many respects idiosyncratic approaches to irrigation.

c. competing and conflicting demands as well as present inefficiencies cry for radical solutions or at least for significant changes. However, little is known not so much about change per se but about the <u>process</u> of change, i.e., its oritical variables, nature, points of intervention, strategic inputs, desired ends, etc.

We intend to make here a few more remarks about inefficiency and the process of desired change, since they represent two critical questions for understanding the present problem. To round up this argument, two sub-sections that follow relate legal rights and responsibilities in present arrangements; and, an attempt is made to describe some potential re-arrangements as attributes of change.

Throughout the literature estimates of efficiency of water supply for irrigation has been reported as low as 10 per cent. Presumably systematic planning and a high degree of organization and management should enable efficiencies as high as 60-70% and should ensure the minimum practicable wastage. But what does such an efficiency mean? In broad terms the efficiency of irrigation schemes is affected by all aspects of planning, design, operation, and management. Specifically, among others, inefficiencies may arise through:

a. water distribution to the farm;
b. losses during transmission;
c. losses in the fields;
d. maintenance of canals and drainage;
e. aspects of engineering management;
f. on-farm management;
g. lack of incentive to save water;
h. local cultural practices of agricultural communities;
i. desire and ability of individual farmers to adopt efficient irrigation techniques.

When changes on irrigation practices are introduced into an established agricultural area, the existing pattern of agriculture will be also greatly altered. Changes will take place in the types of crops raised, the kinds of cultural practices, the intensity of use of labor and machinery and credit, and the kind of work skills that are required for any farmer in order to succeed in an irrigation agricultural economy. Many existing organizations and institutional pattern will be subject to pressure to change and adjust to the needs of new circumstances. Pressures for adjustment of individuals, groups, organizations and institutions will also lead to the establishment of new and appropriate structures. These new forms may produce a counter-reaction on the part of those in established roles and positions of power, influence or authority. Two contending forces seem to emerge in established agricultural areas with the introduction of innovations in irrigation projects. On the one hand, there must be a mobilization of the people, their organizations, and their resources to protect old goals and established traditional procedures. On the other, innovative schemes are required in order to meet the changing conditions of agricultural production, as well as new institutional forms for adopting to changing socio-economic conditions. It has been observed that in many projects not only of irrigation but of other forms of innovation and change opposition and resistance to changes seems to come from the following elements or conditions of the social structure:

1. Beliefs, feelings, values. Those people who live and share certain beliefs and feelings about the present ways and the appropriate way of life unless persuaded by a new rationale or a new set of knowledge and beliefs, they will block the acceptance of the change.
2. A new arrangement may produce goals which are incompatible with pre-existing objectives and goals of people in a given agricultural area. Unless aspirations of both individuals and groups can be redefined or adjusted as be supportive of the new arrangement, we may expect opposition in the implementation of changes.
3. Normative structure. Rules, expected behavior, and laws are inherent in any social structure, groups or organizations. The normative structure includes not only the definitions of appropriate behavior in relation to farming practices, but also laws or specific rules regulating the distribution, use, and control of water. Such long-established practices and legal requirements are important forces of resistance to curisaged changes in irrigation projects. Therefore, a whole new series of norms regulating the relationship among water users plus definition of the means for the systematic distribution of rights and obligations to serve the needs of all the people in the project must also emerge in order to insure control and regulation.
4. Roles, statuses, and power. It should also be realized that changes in irrigation projects in already established agricultural areas clashes with ongoing social situations of individual members of the group and of communal groups. New irrigation practices not only produce a new set of goals but additional roles and positions as well as new sources of authority and influence. In many instances existing roles and positions of power become inappropriate and in many respects dysfunctional. Thus, those who are to lose from the introduction of new organizational schemes, unless they become part of needed new roles and positions, they are expected to provide resistance to a new irrigation project. Any new program, therefore, needs to introduce new power arrangements which will not be suspected and resisted, but will be defined and understood as part of a well-thought plan of water use and control.

The preceding brief remarks point also out that the nature and impacts of proposed changes in irrigation projects can not be adequately characterized by only lists of critical variables and static condition. An irrigation organization is a dynamic system of on-going processes and transactions between individuals, groups, structures, environmental objects, and events. This means that one must consider an increased awareness of the complex ways in which changes react on one another. This may resolve, not merely simple casual chains, but networks of interactions, and sometimes cycles of mutually reinforcing or mutually cancelling process (i.e., positive or negative feedbacks). Thus, a change process must make an attempt to go beyond a billiard ball casual model to capture the dynamics underlying a static situation.

4.1.2 Aspects of Potential Re-arrangements

In introducing the need for potential re-arrangement of existing water systems, one must consider first of all the useful features of the established system. Second, one must articulate the need for improvement contrasted to the maintenance of the traditional irrigation system. And, finally, an account must be made of welfare economics, of the costs and benefits revolved, the internalization of externalities and the balanceing of economic efficiency with social equtiy.

The central, simple question at this point has two facets. First, what are the attributes of change? Particularly to what extent we may have and what has been referred as "encumbered knowledge", i.e., knowledge that requires widespread acceptance by the social system, as contrasted to "unencumbered knowledge" which permits individual knowledge. The second aspect of our central question reads simply: "will the changes that accompany consolidation be able to be absorbed into the existing social system?" The answer to the last can be further divided into two parts: a) by asking how much change is expected, result of the size and scope of operations, the need to acquire new skills, and changing goals and values; and b) by asking the kind of change, namely whether we have a case of substitution, alterations in existing structure, additions without changing old elements, complete restructuring of the system, reinforcement of old behavior, etc., etc.

4.1.3 Rights and Responsibilities

Central to any discussion of the need for maintaining (or partly preserving) the traditional equilibrium in water organization is the consideration of the legal rights and responsibilities.

It is noted that the appropriation doctrine as recognized in Colorado[1] and in other parts of the West and that the right to appropriate water for a beneficial use shall never be denied.[2] The principle of the appropriation doctrine is the priority and right. This principle has been stated as "first in time is first in right."[3] It means, basically, that when a water deficit occurs allocation diversions among users are closed in an inverse order, i.e., the latest allocation right granted is the first to be closed. This is followed regardless of the type of use being made of the water.[4] Operation which is properly perfected gives rise to a water right. A water right is defined as a right to use in accordance with its priorities a certain portion of the water of the state by reason of appropriating the same.[5] It should be emphasized that it is the use of the water to shich the priority dates and not to the water itself. The right to a use of the water is called a usufractary right.[6] A right of the physical facilities required can be granted on a conditional basis and a water right is a conditional water right which is a right to perfect the claim with a certain priority upon completion with reasonable diligence of the appropriation upon which the right is based.[7] The water right so granted is a right considered to be a real property right.[8] And in Colorado it has been held that a right to divert water is an interest in the real estate.[9] The right granted gives the individual user the right to put the water to a specified beneficial use.[10]

Beneficial use is defined as that amount of water that is responsible and appropriate under reasonably efficient practices to accomplish without waste the purpose for which the diversion was lawfully made and, without limiting the generality of the foregoing, shall include water for recreation purposes including fishery or wildlife.[11] What is a beneficial use is a fact question and depends on the circumstances of the case.[12] Obviously what is beneficial today may not be beneficial in the future. However, even if a person is using water for a use which is no longer deemed beneficial for new corporations, he still has the right to use it for a use that was deemed beneficial in the past.

Up to this point the discussion has centered around waters which are part of the natural stream flow or the natural ground-water deposit. There are also rights of recapture and reuse in Colorado relating to foreign waters. Foreign waters are those imported into a basin from another watershed.[13] The rights which in here in the importer of these waters are different from these relative to waters originating in the basin in which they are incorporated.[14] Colorado Supreme Court has ruled that the importer of waters into a basin in Colorado has the right to make successive uses[15] of the diverted transmountain waters while the importer maintains dominion over the diverted water and he also may reuse the water.[16] A Colorado court quoted with approval a section from a California case holding:

> ...that waters brought in from a different watershed and reduced possession are private property during the period of possession. When possession of the actual water or corpus has been relinquished or lost by discharge without intent to recapture property in it ceases. This is not the abandonment of a water right but merely an abandonment of specific portions of water. Past abandonment by a defendent of certain water as distinguished from a water right does not confer upon a junior appropriator any right to compel a life abandonment in the future.[17]

Thus, the principle which evolves from the Fulton case and its forerunners is that contributors to a natural stream which would not have been in that stream had it not been for the efforts of those who contributed the water belong to the one who made the contribution.[18] It follows that appropriators on a strem have no vested right to a continuation of importation of foreign waters which another has brought to a watershed,[19] and that the importer may discontinue his activities at any time with impunity.

Along with the above rights of the water user there are some correlative responsibilities. Included in the appropriation doctrine, of course, is the idea that a user has a responsibility do not impinge upon a senior appropriator and if he does the senior appropriator may obtain an injunction against the further use or, if damage has been incurred by the wrongful water use, then the senior appropriator may have monetary damages for the harm caused.

The water user also may not waste water under the appropriation doctrine and in Colorado it is a public policy to maximize the beneficial use of all water by discouraging waste.[20] In this policy the division engineer is empowered to order discontinuance of the diversion within his division to the extent that the water is not needed for beneficial use. That is to say that a use requires 6 cubic feet a second and the user is diverting 10 cubic feet a second under a right given him by the state, the diversion engineer may order a discontinuance of 4 cubic feet a second. Along with this responsibility not to waste water, the owner of any irrigation ditch or mill ditch is charged with keeping the ditch in good repair to prevent the water from wasting.[21]

A concomitant of the public policy against wasting water is the requirement that the water user use his right on a regular basis or run the risk of losing it by abandonment or adverse possession. The non-use of water rights in Colorado for a beneficial purpose for a period of ten years creates a rebuttable presumption of abandonment.[22] Abandonment of water right means the termination of a water right in whole or in part as a result of the intent of the owner of that right to discontinue permanently the use of all or part of the water available under a given right.[23] The question of abandonment of a water right is one that turns on intent and intent must be shown, by clear and unequivocable evidence. The mere lapse of time will not suffice and most questions of abandonment are determined from surrounding facts.

From all the above, it becomes obvious that legal rights and obligations, historical and socio-cultural circumstances, and, finally, the dynamics of change itself, all require prudent approaches to questions of organizational re-arrangements and careful consideration of traditional practices. Even more, however, is a whole series of specific constraints that make the consolidation question a vexing one.

4.2 The Complexity of Constraints

4.2.1 Physical constraints

The early pioneers in the West engaged in the construction of diversion and structures and canals in order to irrigate reclaimed land. Initially the lands placed under irrigation were located adjacent to a river, thereby, minimizing the effort required to deliver water to the fields. Later settlers would then undertake the construction of diversion works and a water delivery system to serve newly cultivated lands usually above the original canal. This process was continued until either land or water recourses ran out. As a result, an irrigated valley would consist of a series of fairly parallel canals traversing the valley. Most of these early canals can still be seen today. Although the organizational framework for construcing the early canal systems offered a very practical means for developing irrigated agriculture, the lack of change after completing this development has resulted in a number of present day problems.

The addition of each canal usually resulted in the formation of a new irrigation enterprise with the result that many irrigated valleys in the West have a multitude of entities managing the delivery of water in the valley. The lack of cooperation among the various entities in bringing about improved water use efficiency appears to be inherent among many groups. Adding to these problems, the duplication of water delivery systems has resulted in higher cost for the irrigation system rehabilitation, increased operation and maintenance costs and greater losses through seepage, operational bypassing or spillage and surface and subsurface deterent flows. Clearly one of the important jobs that needs to be accomplished is to consolidate some of these physical facilities in order that more efficiency be obtained, evaporation can be cut down and that operation and maintenance costs along with managing costs can be reduced.

The historical roots of irrigation system development in the West along with the emerging need for meeting large-scale organizational objectives, make it imperative to consider technological alternatives for improving a number of cumbersome water use systems. Alternatives for improvement include lining of canals to prevent seepage, losses and transpiration, installation of closed water distribution systems, small regulatory ponds along the way to improve the timing of delivery and conservation of water during periods of low precipitation, use of more and better flow measuring devices to improve the control and equitable distribution of water supplies and improving the efficiency of water use on the farm by land leveling. In consolidating, or merging the various physical facilities found in an area, it is necessary to find out which facilities are most efficient in delivering water at a lower cost to the user and, at the same time, which facilities can be consolidated without aggravating the political or social problems which exist in a green valley.

4.2.2 Social Constraints

Parallel to physical developments, water use in the West was also determined by changes in the surrounding social environment. Development in the West was primarily shaped by the deliberate policy of concentrating the areas of available water supply and surrounding relatively fertile lands. The federal government itself with the Reclamation Policy initiated in 1902 the impetus for settling of the land in family size parcels. On the other hand, states like Utah were part of a deliberate colonization and intensive agricultural development.[26]

The pattern of settlement in the West followed a series of interrelated stages of development. Initially, individual farmers would settle in small parcels of land close to water sources followed by small services to farmers such as blacksmiths, wagon makers, etc. Agri-business was the next order of development serving the farmers through such services as mills and farming implements. Then small settlements of the early pioneers were augmented by the influx of other people. A transformation with primary and secondary industries began toward the end of the last century.

Consolidation of irrigation companies or any other form of change requires a broad view of natural resources along with careful delineation of individual and aggregate levels of analysis. A complicating factor in combining irrigation systems is the attitude of the present owner of a canal or water right. He has a special relationship to water rights; that is, he developed the right. He has had to guard it jealously for fear of losing his right and has adapted his farming to the waters that are represented by his right. He will probably resist any combination--that is consolidation--because of the uncertainty of the results. He knows what to expect from the present state of affairs, and this is true of the owners of an irrigation company or an individual.

Changes and consolidations of companies or systems may require modifications in practices and it is understandable that the owners of water rights would resist change. Owners of a water supply and obtaining a water right at some time entails jealousies and hard feelings among adjacent water users and even though the original settlers may in many cases be long dead, the antagonism, fears and jealousies of the original pioneers have been passed on to their heirs and successors and the problems remain down to the present time. Thus, an attitude or a viewpoint toward the existing system has developed that is deeply rooted accentuating the difficulties involved in any action toward consolidation.

4.2.3 Legal Constraints

Coinciding with the physical development of water resourses is the legal development of the right to use water. Initially water was regarded as community property available for use by all. But as development of the semi-arid West took place, investments made upon dependable water supplies as well as recognizing the value of water resulted in the early miners and settlers respecting the property interest of water users. The pioneer was willing to recognize an interest in others in order to gain the same treatment for his use of water.

Through custom miners had previously developed a moral code prohibiting claim jumping and this same respect was accorded the use of water. As a consequence, the property right developed was subject to certain restraints. For example, it had to be used for a beneficial use and waste is not permitted. The property right was accorded the same protection under the law as real property. The right was described as a usufractary right which means that the possessors and the use of the water captured but the right could not attach to any specific water because of the fugitive nature of the resource. Since the inception of the property right concept of water there has emerged several basic doctrines, several institutes and arrangements, and volumes of cases and agency rules to protect and insure the existence of that property right.

The history of water rights prior to this time developed in the East which patterned its water law after the English riparian water law which gave owners of land adjacent to the water body, that is riparian, a proportion of right to use the water. This right had no amount limitation to it nor did it have a time attached to it, rather each land owner could use the water as it came by his land for a "reasonable use" and the use was beneficial to be reasonable. The doctrine originally said that the owner of the land was entitled to water in the same quantity and the same quality as existed when he purchased his land. However, this soon gave way in the face of the development that was taking place since it was clear that each landowner could not insist upon a pure, pristine stream. This water right, such as it be, was independable and indefinite and existed by virtue of land location alone. Once the land has been severed from a stream it is no longer entitled to any water.

In the Western states, the doctrine of prior appropriation was adopted. This doctrine found its beginnings in the gold rush days of 1849 in California. The miners customary law pertained to a place in a stream; that is, first in time and first in right was recognized and adopted by the court when pertaining to water rights.[27] Irwin J. Phillips recognized the right of use of the person who was first to appropriate and divert water from the stream for mining purposes regardless of land proximity to the water source. This is the case departing from the riparian doctrine. Colorado was the first to include this doctrine in this constitution in 1876. Since that date it has been adopted by constitutional statute in the other 17 Western states. Basically, this doctrine is stated as first in time is first in right.[28] This doctrine means basically that when a water deficit occurs, allocation diversions along rivers closed in an inverse order. That is to say, the latest allocation right granted is the first to be closed. This order is followed regardless of the type of use being made of the water.[29] The early pioneers who first developed the water obtained the first rights to use the stream, while later settlers acquired junior rights. Many of the original water rights are for direct flow only while some of the latter rights combine storage rights with flood or diversion.

There are certain basic principles which exist in all the appropriation states even though statutes in cases have modified the doctrine in some small degree. The first is that a beneficial use must be made of the water. The doctrine of beneficial use was developed to limit the amount of water diverted to that reasonably needed for use, the assumption being that if the use is reasonable it is beneficial.[30] A precise definition of beneficial use that can be applied to all water users is not possible so the measure of reasonableness is crucial. It becomes circular, then: what is beneficial is reasonable and what is reasonable is beneficial. Many different uses have been recognized, some even given statutory preference, such as domestic and municipal uses and recent trends witness accepting of such uses as aesthetic and recreation as being beneficial. Emphasis seems to have been placed on the type of use rather than the method to determine beneficial use with the non-waste concept permeating the entire field.

The third principle of appropriation is that the water in question must be the subject of diversion. This is usually a man-made mechanical diversion but not necessarily so.[31] The fourth principle in appropriation doctrine is that an appropriated right of water must exist for a definite amount.[32] This requirement is known as the duty of water and serves to quantify the doctrine of beneficial use by setting a maximum consumption which will be recognized as a reasonable beneficial use. This right or duty of water is usually expressed in terms of quantity of flow per second. It may also be stated in terms of acre feet, time, or season of the year or the amount of beneficial use that can be made of the water. Statutory provisions prescribe the maximum amount allowable but it is understood that, if a reasonable beneficial use is less than this amount, the need will prescribe the limit. It should be added that this right for a definite amount does not depend on the amount flowing in the stream. The property rights still exist even though there may not be enough water in the stream to satisfy all the adjudicated or the approved appropriations on a stream. Finally, this is a right in real property. The property right is not absolute but is rather a usufractary right in a stream consisting of the right to have the water flow. However, some portion of it may be reduced to possession and be made the private property of the individual during the period of possession. It is, therefore, simply the right to divert water from the natural stream by artificial means and apply the same to a beneficial use.

The appropriation doctrine provided the needed security of the water supply for mining, agricultural, municipal and industrial interests. Using this security of the water supply as a base for development, the institutional arrangements needed for delivery of water and needed to meet changing demands began to grow. The farmers soon realized that, as individuals, they could not financially build adequate diversions, storage, transmission systems for water conveyance and hence created ditch companies. Initially, these companies consisted of a few or more farmers bound by gentlemen's agreement to cooperate in the construction and maintenance of the simple delivery systems with no monetary profit. This is the so-called mutual ditch company. The farmers owned the water rights, the diversion and the conveyance work. Coinciding with the development of the mutual organization was the privately owned commercial company, profit motivated and organized to construct irrigation, storage, and delivery systems as well as to reclaim land for prospective farmers. Unfortunately, the profit margin in the early days of this development did not prove sufficiently high and the investors took their capital elsewhere for a better return, thereby leaving the mutual ditch company as the dominant organization in the irrigated land.

4.2.4 Political and Economic Constraints

Political and economic considerations are also essential to an understanding of the development of irrigation systems in the West. In considering the economics of the old irrigation systems, one must recognize the fact that most of the development was done by the owners of the land who benefited from the work. The early settlers diverted water directly from the streams by means of individually constructed dams and ditches which were planned and built for the purpose of solving their individual irrigation problems. Irrigation works constructed by individual or small groups were considered private property. Subsequent developments were seldom combined with existing systems. The resulting development in many cases is wasteful and redundant. Original construction charges have been repaid. The present cost to the water user is for operation and maintenance of the system.

After the initial canal construction, the later water resource development projects were primarily concerned with furnishing supplemental water supplies to irrigation companies which frequently encountered water shortages during the late stages of crop growth in July and August. Often a new organization was formed still retaining the separate irrigation companies, that is, there was no consolidation, in order to operate the new facility and be responsible for repayment of construction costs. Again, facilities were merely added on to the older irrigation systems with few changes being made to the original water delivery systems.

Economic development is also evident upon examining the growth pattern of agriculture within a system. Lands near the population center or market were subject to an intensifying higher degree of cooperation among water users resulting in greater organizational sophistication. In areas further from the market economies of scale were gained by cooperative effort of landowners constructing diversion and conveyance structures. Since cash was scarce, farmers placed high value on labor and time and savings acquired in joint efforts. The construction of each diversion structure and associated canal system usually resulted in the formation of an irrigation company. Each irrigated valley, therefore, contained a multiplicity of companies which frequently competed with one another for rights to river flows. In the valley system these joint enterprises served as a political and economic base around which the members became active in local and state politics.

As these organizations grew in size and structure, they gained the political power necessary to become influential in establishing policy guidelines and forcing legislative action. In the history of an irrigation system, one can find many important court battles fought between two or more enterprises which decisions affected the operation of all other companies in that state. The competition for water supplies included cities and industries in the valley and other agricultural, municipal and industrial interests either upstream or downstream of the valley. The increased competition for water resulted in combining of interests among separate irrigation companies combat outside interests but has seldom led to the consolidation of irrigation companies. Instead, a water user's organization might be formed which represented the interests of the separate irrigation companies, thereby providing more political strength in the water arena.

4.3 The Consolidation Question

The challenge facing us is this: One one hand there is an established legal and institutional system consisting of many water users satisfied and unwilling to change. On the other hand, water is a scarce resource. Water requirements have multiplied rapidly in recent years and the political and social structure of our society is undergoing significant change. Physical development of the canal system and pertinent works, the legal development of the right to use water, the organizational entities which have been formed to operate and maintain irrigation systems, and various social and economic problems have created the present predicament which exists in many of our Western irrigated valleys.

In order to achieve maximum water resource benefits, something must be done to facilitate increased water use efficiency. The consolidation of irrigation systems is among the steps for achieving improved water management since it provides the essential organizational framework to maximize water use efficiency within an irrigated valley. To implement a program for consolidating an irrigation system in any particular valley requires the development of a comprehensive consolidation plan which will take into account the engineering legal, organization, economic and political characteristics of the total irrigation system.

The water delivery subsystem for each irrigation company must be evaluated including the physical facilities, maintenance costs, and operation procedures. Where present conveyance channels would appear to benefit by being combined, designs and cost estimates for a unified conveyance should be prepared. Existing structures should be inventoried and evaluated as to their adequacy in managing and controlling water delivery. Additional structures required to control and measure the water should be delineated. Possibilities for improving canal lining should also be studied. The operation and maintenance costs of the existing physical facilities must be evaluated. Cost of the operation and maintenance practices should be eliminated. Essential water supplies must also be investigated. With regard to storage, ground water development and transbasin diversions, methods must be found for improving the efficiency of the existing conveyance through canal lining or changes in administrative procedures. The economics of consolidation must also be more clearly outlined. The costs of construction and the benefits must be determined. Savings of water affected by eliminating overlapping systems must be evaluated in light of the savings anticipated and the costs of the construction required to bring about the savings. Savings in water and operation, savings in maintenance must all be evaluated in terms of dollars. Construction, costs of new programs, and changes necessary to modernize the existing systems must carefully be estimated. The financial conditions of each company must be determined and dead obligations liquidated or adjusted within the frame of the proposed consolidation. The economics of the area and the economics of the company must also be given consideration.

Studies of on-farm water management should be made in order to assess the efficiency with which the present water supply can be used.

Improvements in the design of surface irrigation systems may be possible in many of the fields by either land leveling or shortening the length of irrigation loans. Also, a change in irrigation methods may be feasible. Water runoff could nearly be eliminated by careful management of the water supply to the farm or ranch or completely eliminated by use of the pump-back system to recirculate the water. The program for irrigation scheduling could be utilized to pay for itself in increased crop productions while at the same time the water use efficiency would be increased thereby providing an opportunity for better distribution of the water supply.

Of particular importance are the legal restrictions to consolidation in either the water or corporation codes or corporation documents such as the articles of incorporation or the by-laws. The legal relationship of the water rights and needs along with the methods of combining the water rights for integrated companies must be determined to implement a consolidation or merger plan. Under the present legal philosophy in the Western states, the identity of the water rights must be maintained. The water represented by a water right should be combined and distributed according to the requirements of water users under a combined system. To accomplish this in a company or corporate structure, a pooling of stocks representing water rights with different priorities and therefore different basic values must be worked out and the stock reissued even in different classes or having an equal par value representing the same quantity of water per acre. Consolidation of irrigation systems presents a viable alternative for more efficient utilization of water resources.

Consolidation can be achieved, existing water supplies can be more effectively and efficiently used by eliminating duplicate systems and organizational management. There can be improvement through centralization of function and reduction of enterprise personnel, while at the same time, permitting employment of technically trained assistants. The resulting institution will enjoy less legal expenses per unit of use and greater influence on political and lobbying issues of interest as a result of greater visibility. There are tax and insurance advantages available along with improved morale and safety through modernizing and improving company facilities and equipment.

Because of the complex inner relationship of the various factors, each consolidation presents unique problems but at the same time common principles of organizational structuring can be applied. Although in every consolidation scheme the merits and advantages of consolidation must be considered individually, it is possible with proper caution, to develop general principles and common factors operating in different irrigation systems. To be able to provide the common ground and extract general guidelines for consolidating, each area of concern where duplicating irrigation systems exist must be given the same detailed examination and consideration with regard to engineering facilities, political economic factors, legal principles and implications of water rights along with social conditions which influence present arrangements and provide the background for a measurement of the benefits to be derived from consolidation.

The problem of consolidation, however, is not only one involving careful consideration of physical potentialities, legal alternatives, and economic feasibility. Part of the problem involves a two-fold delineation of the organizational capability of present irrigation systems for new alternatives and the understanding and utilization of a social climate of receptivity towards change and new organizational forms.

As repeatedly emphasized, because of larger national and regional trends and new demands, while the supply and quality of water are vital in any future planning of resource utilization, equally important will be the organizational innovations applied to increased efficiency in the distribution of water. Thus, the problem of consolidation is not one of just changing attitudes of individuals. Such attitudes, and the process of the adoption of innovative forms of water use, are part of an understanding of the broader community culture and the institutional structures involved in the obtainment of water supply and its allocation to the members of the particular system. A central concern is the alternative organizational forms possible in a given community and the delineation of the process of adoption, communication, and diffusion through which implementation of consolidation plans becomes feasible.

Even when larger, general studies have been made on the technical feasibility, economic desirability, and organizational preparedness for consolidation, there still remains the very central problem of individual receptivity to change, and of the effort of harmonizing conflicting interests involved in a unified purpose. Despite technical, economic and organizational evidence favoring consolidation, little progress has been achieved and public sentiment has not provided the momentum for an incorporation of the envisaged change. Attempts toward consolidation depend also on the individual's knowledge and attitude toward water use patterns, on the nature and extent of his relation with the particular irrigation company, his socio-economic background and property characteristics, and on a cluster of predispositions toward change and modernity, level of satisfaction and perception of alternatives. In essence, then, we are talking about three major categories of social factors which may operate as either facilitators or constraints to a proposed consolidation scheme: community environment and culture, organizational structure and networks, and general perception of change and of organizational alternatives by indivudual users.

Consolidation of irrigation systems presents a viable alternative for more efficient utilization of water resources. Where consolidation can be achieved, existing water supplies can be more effectively and efficiently used by eliminating duplicate systems and organizational management can be improved through centralization of functions and reduction of enterprise personnel, while at the same time permitting employment of technically trained assistants.

Despite all obvious theoretical and socially enticing advantages, one should not underestimate the difficulties in realizing consolidation. There are major obstacles in obtaining the necessary court decrees for changing points of deversion; in alleviating pervasive fears of a potential diminution of water supplies; in merging the financial affairs of diverse organization; and, in overcoming the feelings of autonomy and pride of individual organizations in maintaining long-established and cherished operation.

4.4 Attitudes and Opinions About Consolidation

By now it is once again becoming obvious that a crucial element in the consideration of consolidation questions is the predisposition to change and the attitudes of the affected constituences. In this regard, part of the investigation in both phases of the project a questionnaire survey was also undertaken in order to illuminate questions of predisposition to and orientation towards change of individual users and officials towards change.

From the sociological point of view, attempts towards consolidation will also depend on the individual's knowledge and attitudes towards each of the major clusters of constraints and/or constraints (engineering, legal, socio-economic), as well as his overall orientation towards change and the future. This implies:

a) an understanding of the individual's interpretation of engineering, legal, and socio-ecomomic constraints and/or facilitators;
b) an understanding of the individual's proclivity towards change (both organizational and socio-economic); and,
c) an understanding of the individual's perception of alternatives in the context of his knowledge of the irrigation system and of his level of satisfaction with present arrangements.

Emphasis in all the above is placed on the degree of congruence between satisfaction with present arrangements, the predisposition towards change, and the perception of alternatives that may affect in particular organizational effectiveness or an irrigation system's performance. Organizational effectiveness indicates the extent to which an organization, given certain resources and means, achieves its objectives without incapacitating its means and resources and without placing undue strain on its members.

The basic design of the survey was originally presented in Phase I and is reproduced in Figure 4-1. The basic approach of the study and the design of the resultant questionnaire (reproduced in Appendix I) contained information around two major clusters of independent variables: socio-economic background of irrigation users and property characteristics of their holdings; and the relationship and identification of the individual user with the particular irrigation company. An intermediate variable of particular significance contains a cluster of questions around water use patterns of individual users. Finally, three clusters of variables contain the dependencies of the present research: the degree of traditionalism - modernism, the extent of satisfaction with present arrangements, and the perception of alternatives to present irrigation system arrangements, or future course of action.

The research design of the study provided the basis for the deriviation of a series of hypotheses using the categories of variables of Figure 4-1 an extensive number of hypotheses can be generated. Indicative of the vast number of relationships tested are the central hypotheses listed in Table 4-1 originally devised for Phase I of the study.

FIGURE 4-1. Schematic of Irrigation Systems Development

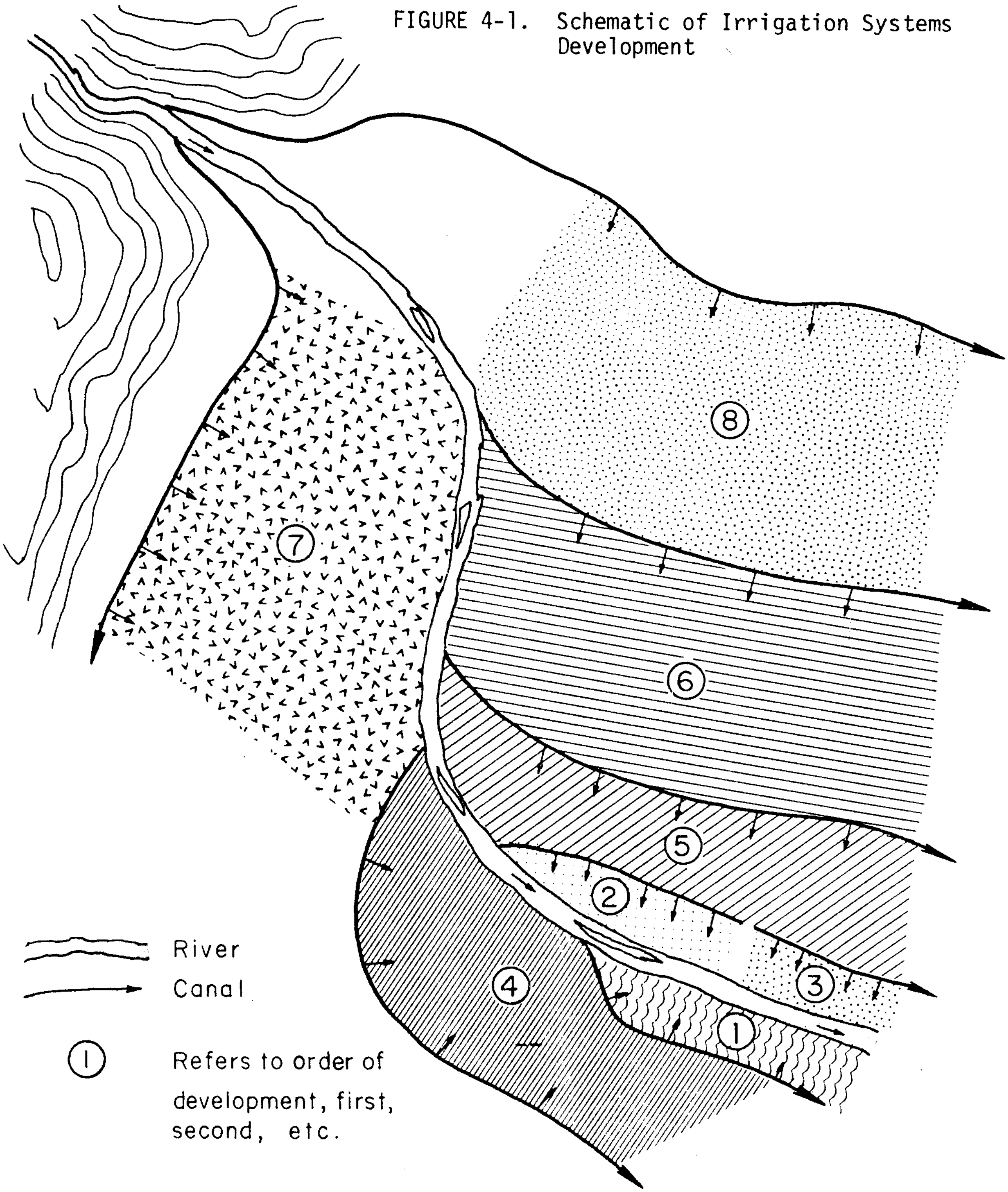


Table 4-1. Central Hypotheses Developed for General Model.

I → III

Socio-Economic Background (Level of Living Scale) → Water Use Patterns (Struc-tural | Attitu-dinal)

1.0 The higher the level of living the lower the tendency to keep the old irrigation policy.
1.1 The higner the level of living tne higher the water satisfaction.
1.2 The higher the level of living the higher the modernism score.
1.3 The higher the level of living the higher the water knowledge.

I → III

Property Characteristics → Water Use Patterns (Struc-tural | Attitu-dinal)

2.0 The higher the total acres operated the higher the tendency to keep the old irrigation policy.
2.1 The higher the total acres operated the higher the water satisfaction.
2.2 The higher the total acres operated the higher the modernism score.
2.3 The higher the total acres operated the higher the water knowledge.
3.0 The higher the sum of ownership the higher the tendency to keep the old irrgation policy.
3.1 The nigher the sum of ownership tne higher the water satisfaction.
3.2 The higher the sum of ownership the higher the modernism score.
3.3 The higher the sum of ownership the higher the water knowledge.

II → III

Irrigation Company (Relation | Knowledge | Anxiety) → Water Use Patterns (Struc-tural | Attitu-dinal)

1.0 The higher the feeling of belonging to the company the higher the tendency to keep the old irrgation policy.
1.1 The higher the feeling of belonging the company the higher the satisfaction score.
1.2 The higher the feeling of belonging to the company the lower tne modernism score.
1.3 The higher the feeling of belonging to the company tne higher the water knowledge.
2.0 The higher the water knowledge the higher the tendency to keep the old irrigation policy.
2.1 The higher the water knowledge the higher the satisfaction.
2.2 The higher the water knowledge the lower the modernism score.
3.0 The higher the administrative effectiveness score the higner the tendency to keep old irrigation policy.
3.1 The higher the administrative effectiveness score the higher the satisfaction.
3.2 The higher the administrative effectiveness score the lower the modernism score.
3.3 The higher the administrative effectiveness score the higher the water knowledge.

III → IV

Water Use Patterns (Struc-tual | Attitu-dinal) → Traditionalism Modernism

1.0 The higher the tendency to keep old irrigation policy the lower tne modernism score.
2.0 The higher the water satisfaction the lower the modernism scale.
2.2 The higher the water knowledge the lower the modernism score.

III → V

Water Use Patterns (Struc-tural | Attitu-dinal) → Satisfaction

3.0 The higher the tendency to keep old irrigation policy the lower tne satisfaction.
4.1 The higher the modernism score the lower the satisfaction.
4.2 The higher the water knowledge the higher the satisfaction.

III → IV

Water Use Patterns (Struc-tural | Attitu-dinal) → Traditionalism Modernism

5.0 The higher tne tendency to keep the old irrigation policy the lower the alternatives to system.
6.0 The higher the water satisfaction the lower the alternatives to the system.
7.0 The higher the modernism score the higher the alternatives to the system.
8.0 The higher the water knowledge the lower the alternatives to the system.

II → VI

Irrigation Company (Relation | Knowledge | Anxiety) → Perceptions of Alternatives

1.0 The higher the tendency to keep the old irrigation policy the lower the alternatives to the system.
3.0 The higher the admisistrative effectiveness the lower the alternatives to the system.

Despite the presence of "arrows" no causative model of analysis was attempted. The data collected and the tables constructed are, indeed, voluminous. It would take an inordinate amount of space to present each and every hypothesis tested. Instead, we have concentrated on a few characteristic tables that summarize and exemplify the thrust of the findings. In reading the following tables it should be kept in mind that there are two underlying domensions:

a) The rows in each table represent an "idealized" continuum from the smallest valley (Eden) to the most complex, urbanized case in our study (Poudre Valley). These references can be made along an implicit dimension of increased socio-political and organizational complexity.
b) The columns in each table represent the traditional methodological differentiation of "within" differences per the item asked (compared to "between" differences in previous items). Columns simply reflect differential responses per each of the four valleys examined.

As an introduction to selected findings one should point out towards some general repression.

Despite their intensive use of water most users can be generally described as relatively uninformed as to water rights or how much water the company is entitled to. Such a measure of the lack of general water knowledge is not necessarily a reflection of ignorance as to their own personal property or as to the water allocated to their land. Most of them had a fair idea of the amount of water which they were entitled to, but they were not really informed in terms of how the irrigation company allocated the water to them, how the irrigation company came about deciding as to how much water was allocated to them; and, finally, they had little knowledge of the workings of the company or the officials in the organization.

At the same time, a great deal of satisfaction was expressed concerning the water master, the irrigation company and the ditch rider. Almost universally,the water users described the activity of these three categories as being quite satisfactory, with only a few complaints against the procedures used by the administrators in the company for delivering their water. Yet, when the water users were questioned concerning their knowledge of such people as the river commissioner, the state engineer's office, the bureau of reclamation, and generally about the larger environment affecting irrigation in their valleys, a pervasive negativism tended to characterize responses concerning "outsiders."

In order to provide more specific flavor as to attitudes and opinions towards consolidation, we have selected a series of tables that follow a progressively unfolding scheme. This entails a summary presentation of certain background characteristics, feelings of identification with the company, opinions as to potential improvements , complaints about present arrangements, evaluation of their irrigation companies, attitudes toward change and the relative advantages or disadvantages of consolidation.

To start with, two summary tables provide clues as to the ownership of land and water in the two areas (Tables 4-2 and 4-3). The pattern conforms to the expectation of social structure ranging from high ownership in the small Eden Valley to the significant percentage of the fast urbanizing Poudre Valley. Of particular importance in the last is the noticeable difference between Utah and Poudre Valley. The last is already becoming part of an expanding megalopolitan strip agglomeration along the eastern slope of the Colorado Rockies, while the earlier is still characterized by the early historical emphasis of private ownership. This observation goes also hand in hand with the amount of shares of water owned. More than three quarters of the farmers in the Eden Valley irrigate tracts which are larger than 100 acres (76.5 percent). Contrasted to that Poudre Valley has 70.7 percent of irrigators owning 100 or less shares. Yet, one should not forget that the price of a water share in the Poudre Valley has reached astronomical heights.

One way of rounding up part of the background of irrigators in the various areas, is to examine the way in which they could be described as knowledgeable or well-informed as to the water situation in their company. A composite index was constructed in order to test the extent of knowledge around such items as holdings of company, administrative details, rules of operation, cost assessment, etc. (question 19-27 of the questionnaire in Appendix I). When the results tabulated the percentages present us with the striking picture of Table 4-4. Even in such a small area as Eden Valley a large segment of the population has been found as relatively poorly reformed. This percentage becomes quite significant in the larger valleys (for up to 82.0 percent labelled "ignorant" in Poudre Valley). When added to the previous tables the replication emerges that alternatives to the present system becomes difficult to propose or discuss when knowledge of the current situation is limited.

Another cluster of questions may help us understand both the feelings of identification with the present system as well as the reasons for satisfaction and dissatisfaction with present arrangements. Looking at Table 4-5 one can detect some interesting but not significant differentiations. Given the above remarks one should underline the relatively high proportion of Poudre Valley irrigators (19.8 percent) indicating quite a bit or more influence. Part of the explanation lies with the organization of the particular system (including the heavy role of the federal government in the case of Eden Valley) as well as with the surrounding socio-cultural circumstances (the urban, business-like unlien of Poudre Valley), for example.

The importance of the above can also be seen in the juxtapposition of Table 4-5 to Table 4-6 containing the response to the question of belonging or identifying with the irrigators major company. In all cases there is a high degree of identification, despite the earlier misgivings as to the extent of one's influence on the affairs of the company (interestingly enough quite a large number of respondents attend regularly the annual meetings--as high as 68 percent in the case of Eden Valley).

Table 4-2. Type of Land Ownership

	Eden	Ashley	Utah	Poudre
Mostly Owner Operated	44 (86.3)	151 (82.1)	215 (84.6)	146 (65.8)
Mostly Part Owner	2 (3.9)	13 (7.1)	13 (5.1)	9 (4.1)
Mostly Rented	2 (3.9)	14 (7.6)	16 (6.3)	61 (27.5)
Other	2 (3.9)	3 (1.6)	3 (1.2)	4 (1.8)
No Answer	1 (2.0)	3 (1.6)	7 (2.8)	2 (0.9)
TOTAL	51 (100.0)	184 (100.0)	254 (100.0)	222 (100.0)

Table 4-3. Shares of Water Owned.

	Eden	Ashley	Utah	Poudre
Large Owner (301 or more)	14 (27.5)	13 (7.1)	7 (2.7)	7 (3.2)
Medium Owner (101-300)	25 (49.0)	17 (9.2)	20 (7.9)	22 (9.9)
Small Owner (100 or less)	8 (15.7)	134 (72.8)	210 (82.7)	157 (70.7)
No Answer	4 (7.8)	20 (10.9)	17 (6.7)	36 (16.2)
TOTAL	51 (100.0)	184 (100.0)	254 (100.0)	222 (100.0)

Table 4-4. Composite Index of "Water Knowledge."

	Eden	Ashley	Utah	Poudre
Highly Knowledgeable	2 (3.9)	8 (4.4)	15 (5.9)	9 (4.0)
Knowledgeable	7 (13.7)	10 (5.4)	17 (6.7)	14 (6.3)
Somewhat Knowledgeable	14 (27.5)	25 (13.6)	38 (15.0)	17 (7.7)
Ignorant	28 (54.9)	138 (75.0)	183 (72.0)	182 (82.0)
No Answer	0 (0.0)	3 (1.6)	1 (0.4)	0 (0.0)
TOTAL	51 (100.0)	184 (100.0)	254 (100.0)	222 (100.0)

Table 4-5. Feelings of Influence on Own Company.

	Eden	Ashley	Utah	Poudre
Very Much	0 (0.0)	6 (3.2)	11 (4.3)	12 (5.4)
Quite a Bit	2 (3.9)	15 (8.2)	17 (6.7)	32 (14.4)
Some	16 (31.4)	41 (22.3)	49 (19.3)	59 (26.6)
Very Little	22 (43.1)	66 (35.9)	86 (33.9)	69 (31.1)
None	11 (21.6)	50 (27.2)	81 (31.9)	40 (18.0)
No Answer	0 (0.0)	6 (3.2)	10 (3.9)	10 (4.5)
TOTAL	51 (100.0)	184 (100.0)	254 (100.0)	222 (100.0)

Table 4-6. Degree of Identification with One's Major Irrigation Company.

	Eden	Ashley	Utah	Poudre
Very Much	9 (17.6)	14 (7.6)	20 (7.9)	38 (17.1)
Quite a Bit	11 (21.6)	32 (17.4)	43 (16.9)	42 (18.9)
Somehow	9 (17.6)	41 (22.3)	60 (23.6)	58 (26.1)
Very Little	17 (33.4)	63 (34.2)	70 (27.6)	45 (20.3)
None	5 (9.8)	26 (14.1)	48 (18.9)	32 (14.4)
No Answer	0 (0.0)	8 (4.4)	13 (5.1)	7 (3.2)
TOTAL	51 (100.0)	184 (100.0)	254 (100.0)	222 (100.0)

Following the general questions of identification and involvement one may inquiry as to the extent of satisfaction and dissatisfaction with the present system. The survey contained a number of items as well as composite scales of satisfaction with present arrangements. One interesting item has to do with the types of complaints about water conditions (Table 4-7). The absence of answers and of no complaints is an indirect indicator of satisfaction with the present system. For a more direct analysis two more items can help the discussion. In Table 4-8, the data presented are self explanatory. Indeed, rarely if ever we could locate individuals that would even be somewhat dissatisfied with water arrangements. At best, a proportion of them (the highest being 25.5 percent in Eden Valley) were undecided. It is this context that one could read the results of Table 4-9, where respondents were asked to rate their own main irrigation companies to other companies. Again high percentages indicate the general satisfaction along a wide spectrum. The last is true when specific questions are asked per operational procedures, personnel or facilities of their irrigation companies. Finally, two other items may help us round up this brief picture of satisfaction with present arrangements. Per questions 48 and 49 of our questionnaire two composite indices were constructed. The first is summarized in Table 4-10 and reflects the extent to which water users perceive a pressing need in their main irrigation company for improvements. Here, despite their earlier high degrees of satisfaction respondents have indicated significant agreement for improvements, especially in the smaller valleys (noticeably Eden Valley). In contrast, complicated as they may seem on the surface, the Pouder Valley arrangements all, in the eyes of the respondents for little improvement. But the data becomes quite interesting with the results to the question of evaluating the overall water administration. (Table 4-11). Large segments of respondents expressed dissatisfaction (again, despite earlier overall high scores), particularly with such items as the water master or the ditch rider. In all cases, about or close to 50 percent of users provided negative commentary as to the present administrative effectiveness.

We may want to ponder for a minute on the replications of the above. While there is overall satisfaction with the present systems, there seems to be room for administrative and organizational improvements. The general good will towards the present does not negate another tendency for potential improvements. And if there is a need for improvements where would they be most appropriate. Table 4-12 summarizes expressed opinions for improvements. All across the board the heaviest emphasis was on physical improvements, notably control of seepage.

Since at this point attention is focused on expressed opinion about improvement it is important to relate two other dimensions of the survey. One has to do with the extent of traditionalism vs modernism; and, the other, with proposed alternatives to present arrangements.

For the first dimension we may introduce three specific items. One has to do with the expressed opinion as to the needs for rewriting

Table 4-7. Types of Complaints about Water Conditions.

	Eden	Ashley	Utah	Poudre
High Assessment	6 (11.8)	24 (13.0)	10 (3.9)	5 (2.2)
Poor Service	0 (0.0)	8 (4.4)	36 (14.2)	9 (4.0)
Poor Management	4 (7.8)	11 (6.0)	12 (4.7)	7 (3.1)
Unequal Treatment to Users	4 (7.8)	3 (1.6)	11 (4.3)	5 (2.3)
Measurement Troubles	5 (9.8)	10 (5.4)	12 (4.7)	13 (5.9)
Special Fees/Assessments	3 (5.9)	4 (2.2)	1 (0.4)	2 (0.9)
Other	9 (17.7)	11 (6.0)	24 (9.5)	21 (9.5)
No Answer	20 (39.2)	113 (61.4)	148 (58.3)	160 (72.1)
TOTAL	51 (100.0)	184 (100.0)	254 (100.0)	222 (100.0)

Table 4-8. Degree of Satisfaction with Present Water Arrangements.

	Eden	Ashley	Utah	Poudre
Highly Satisfied	4 (7.8)	12 (6.6)	11 (4.3)	9 (4.1)
Satisfied	34 (66.7)	124 (68.5)	184 (72.4)	173 (77.9)
Undecided	13 (25.5)	42 (23.3)	58 (22.8)	40 (18.0)
Unsatisfied	0 (0.0)	1 (0.5)	0 (0.0)	0 (0.0)
Highly Unsatisfied	0 (0.0)	2 (1.1)	1 (0.4)	0 (0.0)
TOTAL	51 (100.0)	181 (100.0)	254 (100.0)	222 (100.0)

Table 4-9. Rating of One's Own Irrigation Company to Others.

	Eden	Ashley	Utah	Poudre
Far Better	1 (2.0)	8 (4.3)	11 (4.3)	36 (16.2)
Somewhat Better	8 (15.7)	11 (6.0)	30 (11.8)	45 (20.3)
Just As Good	24 (47.0)	130 (70.7)	148 (58.3)	107 (48.2)
Not As Good	3 (5.9)	14 (7.6)	19 (7.5)	8 (3.6)
Somewhat Worse	1 (2.0)	2 (1.1)	7 (2.8)	1 (0.5)
Far Worse	2 (3.9)	2 (1.1)	9 (3.5)	3 (1.3)
Don't Know	5 (9.8)	0 (0.0)	0 (0.0)	0 (0.0)
No Answer	7 (13.7)	17 (9.2)	30 (11.8)	22 (9.9)
TOTAL	51 (100.0)	184 (100.0)	254 (100.0)	222 (100.0)

Table 4-10. Expressed Need for Improvement in Current Arrangement.

	Eden	Ashley	Utah	Poudre
High Improvement	7 (13.7)	18 (9.8)	5 (1.9)	0 (0.0)
Some Improvement	11 (21.6)	40 (21.7)	77 (30.3)	23 (10.4)
Medium Improvement	19 (37.3)	66 (35.9)	68 (26.8)	69 (31.1)
Low Improvement	12 (23.5)	39 (21.2)	70 (27.6)	102 (45.9)
Don't Know	2 (3.9)	21 (11.4)	34 (13.4)	28 (12.6)
TOTAL	51 (100.0)	184 (100.0)	254 (100.0)	222 (100.0)

Table 4-11. Extent of Administrative Effectiveness.

	Eden	Ashley	Utah	Poudre
Very Effective	2 (3.9)	13 (7.1)	3 (1.2)	7 (3.2)
Somewhat Effective	6 (11.8)	21 (11.4)	25 (9.8)	24 (10.8)
Undecided	6 (11.8)	33 (17.9)	32 (12.6)	34 (15.3)
Relatively Ineffective	20 (39.2)	36 (19.6)	33 (13.0)	25 (11.3)
Absolutely Ineffective	12 (23.5)	51 (27.7)	68 (26.8)	62 (27.9)
Don't Know	5 (9.8)	30 (16.3)	93 (36.6)	70 (31.5)
TOTAL	51 (100.0)	184 (100.0)	254 (100.0)	222 (100.0)

Table 4-12. Areas of Needed Improvements

	Eden	Ashley	Utah	Poudre
Seepage	14 (27.5)	79 (42.9)	89 (35.1)	88 (39.6)
Phreatophytes	3 (5.9)	10 (5.4)	34 (13.4)	31 (13.9)
Operating and Maintenance Costs	5 (9.8)	17 (9.2)	11 (4.3)	11 (5.0)
Inadequate Canal Maintenance	4 (7.8)	14 (7.6)	28 (11.0)	11 (5.0)
Inadequate Control	2 (3.9)	8 (4.4)	13 (5.1)	8 (3.6)
Erosion	1 (2.0)	2 (1.1)	3 (1.2)	8 (3.6)
No Need	2 (3.9)	0 (0.0)	0 (0.0)	0 (0.0)
No Answer	20 (39.2)	54 (29.4)	76 (29.9)	65 (29.3)
TOTAL	51 (100.0)	184 (100.0)	254 (100.0)	222 (100.0)

a given State's water laws. The striking element in Table 4-13 is the high percentage of "undecided" indicating the overall ambivalence for both established legal rights as well as changing circumstances. But how, then, about the ubiquitous prior appropriation doctrine? Is it (in the opinion of the respondents) still useful for today's complex society? Throughout all valleys (but more so in Eden and Poudre--the two extremes of our continuum), there is agreement that the prior appropriation is both useful and relevant. Yet, again, significant numbers are undecided, (Table 4-14). So, should the present system of water rights be changed in any way? The results to such a question (Table 4-15) are somewhat ambiquous, of one contrasts those who prefer the status quo with the combined percentages of those who advocate change or offer no opinion.

But beyond all such responses, there are widespread feelings that the old ways of irrigation policies are not the best as it is attested from Table 4-16. Indeed, the data of the survey, formal interviews, and participant observation pointed out that water users in the areas were willing to listen and if a proposed activity seemed feasible, they were willing to try it and make every attempt to use their water to the absolute best. Here, very significant numbers of respondents, indicated their dissatisfaction with established ways or current company policies. This observation is reinforced by the expressed need that water development should be a collective responsibility and not be left to individual farmers. (Table 4-17).

Putting all this information together, one would have to ask as to the orientation towards change and the degree of attachment of present users to traditional or established ways of water organization and use. Table 4-18 is a result of a composite index of "modernism." Agreement indicates orientation towards change and alternative ways. It's, indeed, striking to see all valleys a high degree of "modernism" and a predisposition for innovative schemes of water organization.

But what are the alternatives? Again, one should remember from the above, that there already exists widespread satisfaction with present arrangements (although with some complaints as to the administration of companies). Thus, even many of those surveyed did not express any opinion as to alternatives (Table 4-19) there is a number (in descending order from the small areas to the more complex) who believe that there is a range of alternative, to present arrangements. Furthermore, of the few who offered certain organizational alternatives (Table 4-20), there appear a few who volunteered the response of consolidation. This is particularly pronounced in the case of Ashley Valley and it may be explained by the experience gained by the merging of the five irrigation companies at the time of the construction of the Steinaker Canal.

What remains now is the central and direct question of consolidation. Two tables summarize the direct findings for the specific item concerning advantages and disadvantages of consolidation. Table 4-21 summarizes the main advantages indicated (of any) for consolidating irrigation companies. Excluding those who see no

Table 4-13. Opinions as to Need for Rewriting State Water Laws.

	Eden	Ashley	Utah	Poudre
Strongly Agree	6 (11.8)	9 (4.9)	17 (6.7)	10 (4.5)
Agree	8 (15.7)	22 (12.0)	55 (21.7)	62 (27.9)
Undecided	19 (37.2)	96 (52.2)	117 (46.1)	75 (33.8)
Disagree	14 (27.4)	47 (25.5)	56 (22.0)	57 (25.7)
Strongly Disagree	3 (5.9)	5 (2.7)	9 (3.5)	18 (8.1)
No Answer	1 (2.0)	5 (2.7)	0 (0.0)	0 (0.0)
TOTAL	51 (100.0)	184 (100.0)	254 (100.0)	222 (100.0)

Table 4-14. "The Prior Appropriation Doctrine Is Not Useful for Today's Society."

	Eden	Ashley	Utah	Poudre
Strongly Agree	2 (3.9)	4 (2.2)	4 (1.6)	2 (0.9)
Agree	8 (15.7)	27 (14.7)	36 (14.2)	27 (12.1)
Undecided	11 (21.6)	79 (42.9)	117 (46.0)	69 (31.1)
Disagree	20 (39.2)	51 (27.7)	77 (30.3)	93 (41.9)
Strongly Disagree	8 (15.7)	17 (9.2)	19 (7.5)	31 (14.0)
No Answer	2 (3.9)	6 (3.3)	1 (0.4)	0 (0.0)
TOTAL	51 (100.0)	134 (100.0)	254 (100.0)	222 (100.0)

Table 4-15. Changes to Present System of Water Rights.

	Eden	Ashley	Utah	Poudre
Yes	10 (19.6)	34 (18.5)	45 (17.7)	26 (11.7)
No	21 (41.2)	84 (45.6)	129 (50.8)	123 (55.4)
Don't Know	20 (39.2)	62 (33.7)	74 (29.1)	72 (32.4)
No Answer	0 (0.0)	4 (2.2)	6 (2.4)	1 (0.5)
TOTAL	51 (100.0)	184 (100.0)	254 (100.0)	222 (100.0)

Table 4-16. Agreement with Polity Per Established Old Ways.

	Eden	Ashley	Utah	Poudre
Strongly Agree	1 (2.0)	5 (2.7)	2 (0.8)	1 (0.5)
Agree	6 (11.8)	28 (15.2)	46 (18.1)	34 (15.3)
Undecided	4 (7.8)	20 (10.9)	35 (13.8)	57 (25.7)
Disagree	35 (68.6)	116 (63.1)	149 (58.6)	123 (55.4)
Strongly Disagree	2 (3.9)	12 (6.5)	20 (7.9)	7 (3.1)
No Answer	3 (5.9)	3 (1.6)	2 (0.8)	0 (0.0)
TOTAL	51 (100.0)	184 (100.0)	254 (100.0)	222 (100.0)

Table 4-17. Water Development Should be Left to Individual Farmers.

	Eden	Ashley	Utah	Poudre
Strongly Agree	2 (3.9)	6 (3.3)	6 (2.4)	12 (5.4)
Agree	10 (19.6)	62 (33.7)	62 (24.4)	77 (34.7)
Undecided	5 (9.8)	21 (11.4)	39 (15.4)	47 (21.2)
Disagree	30 (58.8)	79 (42.9)	137 (53.9)	82 (36.9)
Strongly Disagree	3 (5.9)	10 (5.4)	9 (3.5)	4 (1.8)
No Answer	1 (2.0)	6 (3.3)	1 (0.4)	0 (0.0)
TOTAL	51 (100.0)	184 (100.0)	254 (100.0)	222 (100.0)

Table 4-18. General Index of Agreement for New Ways of Water Organization.

	Eden	Ashley	Utah	Poudre
Strongly Agree	4 (7.8)	15 (8.2)	16 (6.3)	6 (2.7)
Agree	35 (68.6)	119 (64.7)	152 (59.8)	155 (69.8)
Undecided	10 (19.6)	47 (25.5)	81 (31.9)	60 (27.0)
Disagree	1 (2.0)	1 (0.5)	2 (0.8)	1 (0.5)
Strongly Disagree	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
No Answer	1 (2.0)	2 (1.1)	3 (1.2)	0 (0.0)
TOTAL	51 (100.0)	184 (100.0)	254 (100.0)	222 (100.0)

Table 4-19. Agreement as to Other Alternatives to Present Water Arrangements.

	Eden	Ashley	Utah	Poudre
Yes	19 (37.3)	62 (33.7)	68 (26.8)	47 (21.2)
No	19 (37.3)	49 (26.6)	84 (33.1)	86 (38.7)
No Opinion	13 (25.4)	63 (34.3)	92 (36.2)	85 (38.3)
No Answer	0 (0.0)	10 (5.4)	10 (3.9)	4 (1.8)
TOTAL	51 (100.0)	184 (100.0)	254 (100.0)	222 (100.0)

Table 4-20. Organizational Alternatives to Present Arrangements.

	Eden	Ashley	Utah	Poudre
Private Profit Organization	1 (2.0)	1 (0.5)	6 (2.4)	2 (0.9)
Local District	5 (9.8)	10 (5.4)	15 (5.9)	8 (3.6)
State Run System	0 (0.0)	0 (0.0)	2 (0.8)	4 (1.8)
Convert to Private Water Association	4 (7.8)	8 (4.4)	16 (6.3)	10 (4.5)
Consolidate	2 (3.9)	32 (17.4)	18 (7.1)	7 (3.2)
Other	7 (13.7)	8 (4.4)	14 (5.5)	16 (7.2)
No Answer	32 (62.8)	125 (67.9)	183 (72.0)	175 (78.8)
TOTAL	51 (100.0)	184 (100.0)	254 (100.0)	222 (100.0)

Table 4-21. Advantages (if any) for Consolidating Irrigation Companies.

	Eden	Ashley	Utah	Poudre
More Water	1 (2.0)	7 (3.8)	8 (3.1)	7 (3.2)
Cheaper Water	3 (5.9)	21 (11.4)	8 (3.1)	3 (1.4)
Better Management	2 (3.9)	36 (19.6)	22 (8.7)	18 (8.1)
Better Service	2 (3.9)	15 (8.1)	18 (7.1)	7 (3.1)
None	20 (39.2)	47 (25.5)	93 (36.6)	108 (48.6)
More Power	0 (0.0)	0 (0.0)	3 (1.2)	10 (4.5)
Other	4 (7.8)	13 (7.1)	21 (8.3)	18 (8.1)
No Answer	19 (37.3)	45 (24.5)	81 (31.9)	51 (23.0)
TOTAL	54 (100.0)	184 (100.0)	254 (100.0)	222 (100.0)

particular advantage and those who refused to answer, the most pronounced agreement (especially in Ashley Valley) is for better management. With regard to responses to the main disadvantages of irrigation companies were to consolidate, the central preoccupation has to do with the loss of control by water users, or the fears from a highly centralized and concentrated structure net responsive to individual needs.

Finally, we may see all the above analytical remarks in the context of what are perceived as the most significant future problem for water organizations in each of the study areas. Table 4-22 contains three expressed choices of future water problems. The replies there, emphasize three particular preoccupations, namely maintenance of adequate water supply, protection of existing water rights, and flaws as to greater governmental regulation. Such findings are quite consistant with the prevailing culture in the arid West and with the historical contrasts affecting alternative schemes for effective water management.

The data collected through this survey are abundant and rich in references. Beyond descriptive statistics correlational matrices were prepared and a series of hypotheses were tested. When all is said and done, however, despite the wealth of positive relationships and correlation, little statistical significance was found between many variables of the study. It would be safe to offer the overall conclusion that while segements of users may have particular complaints about some aspects (especially administrative) of the present arrangements, no overwhelming support is offered for consolation. And the clue for such a conclusion can be seen in the items of Table 4-23. In the arid West of precarious water supplies and of increasing new demands, the maintenance of the status quo (as expressed in the protection of existing water rights) is a necessary means for survival in the midst of an urbanizing and industrializing region. And on top of these, organizational re-arrangements such as consolidation evoke the spectre of monolithic, centralized and concentrated organizations, part of a broader distrust towards the massive presence of governmental units.

Table 4-22. Disadvantages from the Consolidation of Irrigation Companies.

	Eden	Ashley	Utah	Poudre
Increased Management Levels	4 (7.8)	5 (2.7)	18 (7.1)	36 (16.2)
Less Voice in Company Management	5 (9.8)	23 (12.5)	31 (12.2)	23 (10.4)
Loss of Control by Water Users	4 (7.8)	12 (6.5)	55 (21.6)	53 (23.9)
None	17 (33.4)	61 (33.2)	49 (19.3)	46 (20.7)
No Answer	21 (41.2)	83 (45.1)	101 (39.8)	64 (28.8)
TOTAL	51 (100.0)	184 (100.0)	254 (100.0)	222 (100.0)

Table 4-23. Ranking of Significant Future Problems for Water Organizations.

	First Choice				Second Choice				Third Choice			
	Eden	Ashley	Utah	Poudre	Eden	Ashley	Utah	Poudre	Eden	Ashley	Utah	Poudre
Maintenance of Water Quality	1 (2.0)	22 (12.0)	17 (6.7)	6 (2.7)	1 (2.0)	15 (8.2)	13 (5.1)	6 (2.7)	2 (3.9)	16 (8.7)	14 (5.5)	12 (5.4)
Maintenance of Adequate Water Supply	26 (51.0)	45 (24.5)	87 (34.3)	58 (26.1)	10 (19.6)	32 (17.4)	50 (19.7)	45 (20.3)	5 (9.8)	18 (9.8)	20 (7.9)	36 (16.2)
Efficiency of Water Delivery System	5 (9.8)	16 (8.7)	24 (9.4)	7 (3.2)	8 (15.7)	29 (15.8)	58 (22.8)	31 (14.0)	0 (0.0)	37 (20.1)	37 (14.6)	44 (19.8)
Protection of Water Rights	5 (9.8)	38 (20.7)	55 (21.7)	84 (37.8)	12 (23.5)	47 (25.5)	55 (21.6)	53 (23.9)	9 (17.7)	32 (17.4)	48 (18.9)	22 (9.9)
Protection Against Greater Government Regulation	6 (11.7)	43 (23.4)	32 (12.6)	35 (15.8)	11 (21.6)	25 (13.6)	34 (13.4)	52 (23.4)	12 (23.5)	23 (12.5)	40 (15.7)	34 (15.3)
Developing Adequate Planning Program	2 (3.9)	6 (3.2)	9 (3.5)	10 (4.5)	3 (5.9)	8 (4.3)	7 (2.8)	8 (3.6)	13 (25.5)	19 (10.3)	25 (9.8)	25 (11.3)
Maintenance of Fair Rate Structure	3 (5.9)	6 (3.2)	1 (0.4)	4 (1.8)	4 (7.8)	14 (7.6)	4 (1.6)	3 (1.3)	6 (11.8)	19 (10.3)	20 (7.9)	16 (7.2)
Other	2 (3.9)	0 (0.0)	4 (1.6)	2 (0.9)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.4)	0 (0.0)	0 (0.0)	1 (0.4)	1 (0.5)
No Answer	1 (2.0)	8 (4.3)	25 (9.8)	16 (7.2)	2 (3.9)	14 (7.6)	33 (13.0)	23 (10.4)	4 (7.8)	20 (10.9)	49 (19.3)	32 (14.4)
TOTAL	51 (100.0)	184 (100.0)	254 (100.0)	222 (100.0)	51 (100.0)	184 (100.0)	254 (100.0)	222 (100.0)	51 (100.0)	184 (100.0)	254 (100.0)	222 (100.0)

4.5 The Challenge for Renovation or Innovation

Despite all the fears expressed previously, by many water users in the various valleys, the apprehensions for centralized structutes, the need for maintaining the traditional cultures and the complex system of physical, social, legal, political and economic constraints, there is still room for improvements, for both innovation and renovation. But the challenge for change (result of both internal and external circumstances) must be seen as a difficult combination of such items as:

- commitment to action
- maintenance of identity
- flexibility in organizational response
- retention of the democratic, participatory process
- social motivation for collective representation
- equitable cost sharing and benefit distribution
- economic efficiency of representation
- appropriate incentives for physical consolidation.

This is a long list of items and concerns some of which have been discussed in other parts of this document. We want only to accentuate further here two concerns, namely problems faced in trying to develop a commitment to action and questions as to the retention of the democratic process.

The major difficulties when attempting to consolidate irrigtion organizations is committing everyone to action. The problem lies in the fact that the people that run the irrigation organizations many times resist a change. Also, the consumer who knows what his right is now and knows what the situation is naturally resists change. Often the state government itself will resist change. Put more simply, it is one of the points in American society that there is no agency which can couple existing facts with new and developing knowledge. We can plainly see or theoretically outline what the advantages would be in consolidating irrigation companies or irrigation districts. But there is no agency that can couple existing and new and developing knowledge with advanced planning so as to minimize the unintended and unwanted consequences of transformation in the surrounding environment. There are countless numbers of individuals and groups which have defined irrigation efficiency or water quality for themselves and efforts on the parts of these individuals are legitimized by American idealogy which gives everybody a right to their point of view. It does not in turn permit one segment of the population to impose its image of the best state of affairs or the growth upon the rest of the nation. This foundation of American society applies no less to irrigation entities than it does to any other facet of American politics.

Since there is no agency which can simply impose its will on a sector of society, a change towards alternative organizational schemes is going to have to be a process of education if it is to be effective at all. This would be an education of the administration. It would be an implemental process. It may have to be a process accomplished by demonstration, i.e., showing in a concrete manner, in a subplot or a plot what the benefits of consolidation would be and convincing people that they will not be injured by merging or consolidating their rights with someone else's right. The commitment to action is the first step and it is difficult to say on whose part the first commitment to action will be. Certainly the water user will have to be convinced. But as indicated also in section 4-4 the people who own the water and those who run the water companies do not want to change. Those people who are committed to changing things have no vested interest in the water but they have a desire to see more water available so the population can expand. This may be the stumbling block of a ture consolidation program; those who own the waters do not desire change and those who want to change simply do not own very much of the water.

An impediment to committing a group of companies to action and consolidating is the disagreement between those involved, even groups of planners. For example, it has been pointed out that there is general agreement among planners both in irrigation and domestic agencies that there will not always be enough water available to meet the needs of the area.[33] On that much they can agree. Too, there is a clear consensus among the planners that the problem of relative scarcity in the water system will intensify. There is also very broad agreement that the conflict between farm and non-farm users is growing and will continue to grow. It is clear that rural and urban problems must be solved simultaneously because of the basic interdependence of the water systems. There is apparently general support in at least an abstract sense for the development of solutions to these problems that would take into account the needs and the interests of all sectors of the system. There is even general agreement among the water agency planners that urban and industrial growth should be regulated to protect the farmer's water. However, the most negative reaction to increased regulation is found in the smaller irrigation agencies where there is apparently some fear that any increase in regulation will threaten their interests. Any support for increased regulation is based on the assumption that the primary focus of the regulation would be upon the reduction of waste in the system rather than any general reorientation of the system. This is consistently opposed by the irrigation sector. Hence, disagreements between the planners in the irrigation and rural sector and the planners in the urban sector are related to the substantive issues of water law and attitudes toward major changes in the substance of the law.

The domestic agency planners very strongly agree that most of the water laws in the state should be rewritten and that the prior appropriation doctrine has outlived its usefulness. Additionally, these domestic planners agree that the basic configureation of present water law doctrines is contrary to their interests and, therefore, they should be redesigned. On the other hand, irrigation planners firmly believe that any major reordering of the basic concepts presently followed would be dangerous to their interests. These findings clearly indicate that persons within the irrigation agencies in a given area are quite fearful of change in the basic doctrines regarding the water laws of the state (see also supporting attitudes as well as ambivalence in the survey results of section 4.4). This is understandable since under the basic doctrines of the state they have appropriated most of the water rights in many of the areas. And, as it happens, these water rights are in areas where large population growth is projected.

Fear of change which would be detrimental to the irrigation interests presents a very substantial barrier to any major innovation in the water law and of course is a major stumbling block to getting commitment to action and changing the configuration of an irrigation organization. The domestic officials appear to believe that there has been a substantial shift in the structure of power in the system and that any basic changes in water laws are more likely to be favorable to their interests rather than the present configuration that dominates the system of water law in the state. Therefore it is clear that the major source of support for change is likely to come from domestic agencies while irrigation officials strongly feel that the substance of current water law is more compatible with their interests and, therefore, they can be expected to give intense support for maintenance of the status quo. Yet, one should notice here that the results of our survey are often contraditory to opinion of planners or officials. For example in Table 4-13 it was indicated that a significant segment of the respondents expressed agreement to the opinion that there is a need for rewriting state water laws (in this regard the strongest opinion for rewriting was expressed in Eden Valley, the most "rural" of the valleys examined). Even more, another table, 4-14, showed a portion of the respondents questioning the relevancy of the prior appropriation doctrine for today's society.

A long and deeply rooted tradition in the United States is support for local decision-making with a concomitant emphasis on political and administrative decentralization and on the utilization of check, and balances scheme, all promoting a present system of atomized decision-making. This is one of the most obvious and salient characteristics of the American government.

The degree to which decision-making authority is dispersed is well-known. Combining the federal, state, and local levels of government provide for a total of approximately 100,000 units of government. Employment of the principles of separation of powers and bicameralism within many of these units, fragments decision-making authorities still further.[35] Many of these governmental units feature numerous boards, commissions, agencies or offices and none of the decision centers or decision-makers within them is fully autonomous. Decision-making prerogatives are restricted by such factors as the availability of resources, constitutional, statutory and administrative rules, political relationships with other public and private decision centers and, of course, public opinion center and decision-maker does possess some degree of autonomy; moreover, the decisions produced by each have both internal and external consequences and so, as in the market system, each decision made in each decision center affects not only that center itself but the external environment.

The collective result of such a state of affairs is that no decision-maker and no decision center is capable of exercising full control over the environment. This is also true in the area of irrigation entities. However, in the deep American tradition of democracy, it will continue to play an important part and the feeling is among irrigation and users today is that they have some control and say over their own water and the use that is being made of it. The organization which smacks of centralization and which attempts to get away from individual opinion is going to have difficulties and it will probably continue to be this way in the foreseeable future as a number of political socialization studies document that behavior is based largely upon belief systems and is directed by them.[36] American support of state's rights and municipal rights of local entities appears to preclude any substantial reduction in the vast array of decision centers and while it is at least as true in the vast array of decision centers for irrigation as it is for any other governmental entity.

As has been noted,[37] the effectiveness of reorganization in the political sense and governmental sense will be doubtful at any rate in that a consolidation of a decision center simply results in a reduced number of larger organizations which are, then, themselves characterized by semi-autonomous subsystems. In turn the new system becomes so cumbersome that it simply does not work for the envisaged advantages of an interdependent unit.

But despite all well-known tendencies of autonomy, dispersal, democratic fragmentation and centrifugal forces of decentralization, the question of consolidation remains a central one. Its basic attraction rests not only on the obvious advantages of an efficient and effective organizational scheme; but, also a required response for coordinating the competing and conflicting demands of a changing socio-economic environment and of the necessity to reduce demand through conversation rather than increase supply as traditionally had been the case in water development in the arid west.

NOTES

1. Colo. Const. Art. XVI, §5, 6, C.R.S. §148-2-1, 148-21-2, 148-21-34(f). See also Black v. Taylor, 128 Colo. 449, 264 P.2d 502 (1953).

2. Colo. Const. Art. XVI, §6.

3. Reagle v. Square S Land and Cattle Co., 733 Colo. 392, 276 P.2d 235 (1954).

4. Id.

5. C.R.S. §148-21-3(8) (1971).

6. R.E. Clark (ed.), Waters and Water Rights, §5.16 at 295 (1967).

7. C.R.S. §148-21-3 (9) (1971).

8. R.E. Clark (ed.), <u>Id</u>, §18.3 at 83 and 53.1 at 345.

9. West End Irrigation Co. v. Garney, 117 Colo. 109, 184 P.2d 476 (1947). The priority date is also a property right. See Brighton Ditch Co. v. City of Englewood, 124 Colo. 366, 237 P.2d 116 (1951).

10. C.R.S. §148-21-3(6) (1971), Four Counties Water Users Association v. Colorado River Water Conservation District, 169 Colo. 416, 425 P.2s 259 (1967).

11. C.R.S. §148-21-3 (7) (1971).

12. City and County of Denver v. Sheriff, 105 Colo. 193, 96 P.2d 836 (1939).

13. Trelease, F., <u>Cases and Materials on Water Law</u>, p. 100 (1967).

14. For example, see Farmers Highline Canal and Reservoir Co. v. City of Golden, 272 P.2d 629, 631 (Colo. 1954), holding that junior appropriators have vested rights in the continuation of stream conditions as they existed at the time of their appropriation, and subsequent to such appropriation they may successfully resist all proposed changes in points of diversion and use of water from that source which in any way materially injures or adversely affects their rights.

15. "Successive Use" is defined as a subsequent use by the water importer for a different purpose. See City and County of Denver v. Fulton Irrigating Ditch Co. 506 P.2d 144, 146 (Colo. 1972).

16. "Re-Use" means a subsequent use of imported water for the same purpose as the original use. See footnote 15 above.

17. Stevens v. Oakdale Irrigation Dist., 13 Cal. 2d 343, 90 P.2d 58 (1939).

18. Along with the <u>Fulton</u> decision, see Ripley v. Park Center Land & Water Co., 90 P.75 (1907).

19. Brighton Ditch Co. v. Englewood, 237 P.2d 116, 122 (Colo. 1951).

20. C.R.S. §148-21-1; 148-21-35(2) (f). See also Fellhauer v. People, 167 Colo. 320, 447 P.2d 986 (1968).

21. C.R.S., §148-21-35(2) (1971).

22. C.R.S., §148-21-28(2) (j) (1971). In Utah the time is 5 years U.C.A. 73-1-4 (1953).

23. C.R.S., §148-21-3(13)(1971).

24. Knopp v. Colorado River Water Conservation District, 131 Colo. 42, 279 P.2d 420 (1955).

25. Act of June 17, 1902, 32 Stat. 388, 43 U.S.C. 372.

26. "Consolidation in Irrigation Systems," by Gaylord Skogerboe, George E. Radosevich and Evan C. Vlachos, Colorado State University, 1971.

27. Irwin v. Phillips, 5 Cal. 140 seems to be the beginning of the appropriation doctrine. As such, it is a genuine American contribution to the common law.

28. Reagle v. Square S. Land and Cattle Co., 733 Colo. 392, 276 P.2d 235 (1954).

29. Id.

30. R.E. Clark (ed.) Waters and Water Rights, §54.1 at 367 et. seq., R. L. Dewsnup, "Legal Aspects of Water Salvage," pp. 13-15 (report to the National Water Commission, 1971); City and County of Denver v. Sheriff, 105 Colo. 193, 96 P.2d 836 (1939).

31. Colorado River Water Conservation District v. Rocky Mountain Power Co. 158 Colo. 136, 406 P.2d 798 (1965).

32. R.E. Clark, (ed.), Id, §51.7 at 296.

33. G. E. Radosevich, K. C. Nobe, R. L. Meek and J. E. Flack, "Economic Political and Legal Aspects of Colorado Water Law," report submitted to the Office of Water Resources Research, U.S. Department of Interior, Washington, D.C., 1973, pp. 23-28.

34. Analysis of the same data indicated that the "influentials" in the irrigation system recognized as need for change but strongly support the notion that the prior appropriation doctrine is adequate to deal with future problems. Too, the data indicated that the irrigation sector is better integrated into the decisional structures involving water matters than are the domestic agencies which again supports the conclusion that there are substantial barriers present in the system to any major reordering of water law doctrine. See also Duane W. Hill and R. L. Nash, Local Water Agencies, Communications Patterns and the Planning Process, (Fort Collins, Colorado, Environmental Resources Center, OWRR Completion Report, 1971).

35. John A. Straayer, Roy R. Meek, "The Iron Law of Environmental Disorder" in The Politics of Neglect (Houghton, Mifflin), New York, 1971, pp. 237-243.

36. Robert Lane, Political Ideology (Glenco & The Free Press, 1962); David Easton and Robert D. Hess, "The Child's Political World," Midwest Journal of Political Scinece, Vol. 6 (August, 1962), pp. 229-246; and Herbert McClosky, "Consensus and Ideology in American Politics," The American Political Science Review, Vol. 58 (June, 1964), pp. 361-379 as cited by Straayer and Meek, footnote 35 above.

37. Straayer and Meek, op. cit.

5.1 Developing Alternatives

Irrigation organizations do not begin ex nihilo. There is an evolutionary process of development which involves a period of transition from an initial awareness of a problem by individuals or organizations to concrete demands for changing the present state of affairs to a different state of affairs, the last hoped for being able to handle the problems which have made themselves known in a changing environment. The remarks that follow aotline in a truncated form the process of becoming aware through various stages, from the very simple organization to one very comples requiring interlocking levels of organizational interdependence.

The first part of the process of change in water management has already been discussed in other parts of this report, i.e., the process immediately following settlement of a valley by a number of individuals. Each individual becomes aware that he has irrigation needs; that is to say, he becomes aware that he as a farmer needs water and that the natural rainfall every year is not sufficient to support his crops. Therefore, he attempts to build simple irrigation ditches along the rivers to ,his land. This is why irrigation first takes place historically along the rivers because the individuals are people who are settling an area and they stay closest to the source of the water in order to make their irrigation project simpler and easier and quicker to build.

The beginning point, then, of this process is quite simple: a private individual irrigating his own field. It's beyond this simple point, however, that an emerging complex community and society requires other alternatives for meeting collective (rather than individual) needs. A simplified diagram may help us pursue the agrument as to the organizational evolution beyond the private individual on his own simply to irrigate his own fields. Figure 5-1 contains three different levels of argumentation. On top, one can follow the legal evolution of an "organizational continuum" with its associated nomenclature. In the middle row, are aspects of the process of change ranging from the simple individual awareness of a problem to a final evolution in hte absorption of a consolidated new organizational scheme. Finally, the bottom row represents in a simplistic graphic form the range of organizational arrangements in each of the various evolutionary stages of proposed alternatives. It should be also noted in this simplified diagram, that the important juncture is the cutting point between merger and consolidation, where also a loss of organizational usually takes place.

With the help of Figure 5-1, we may be able to trace the historical argument as to development of alternatives. As has been pointed out earlier in this report, it becomes necessary to construct diversion work and irrigation works, in order to move the water further away from the river. Thus, it becomes necessary to raise more money for this purpose. In this case, a number of individuals joined together or put themselves into unincorporated, voluntary associations to which they all belonged, the purpose of which was to construct the work for the diversion and transportation of water only to the land of the members of the association and the association was not

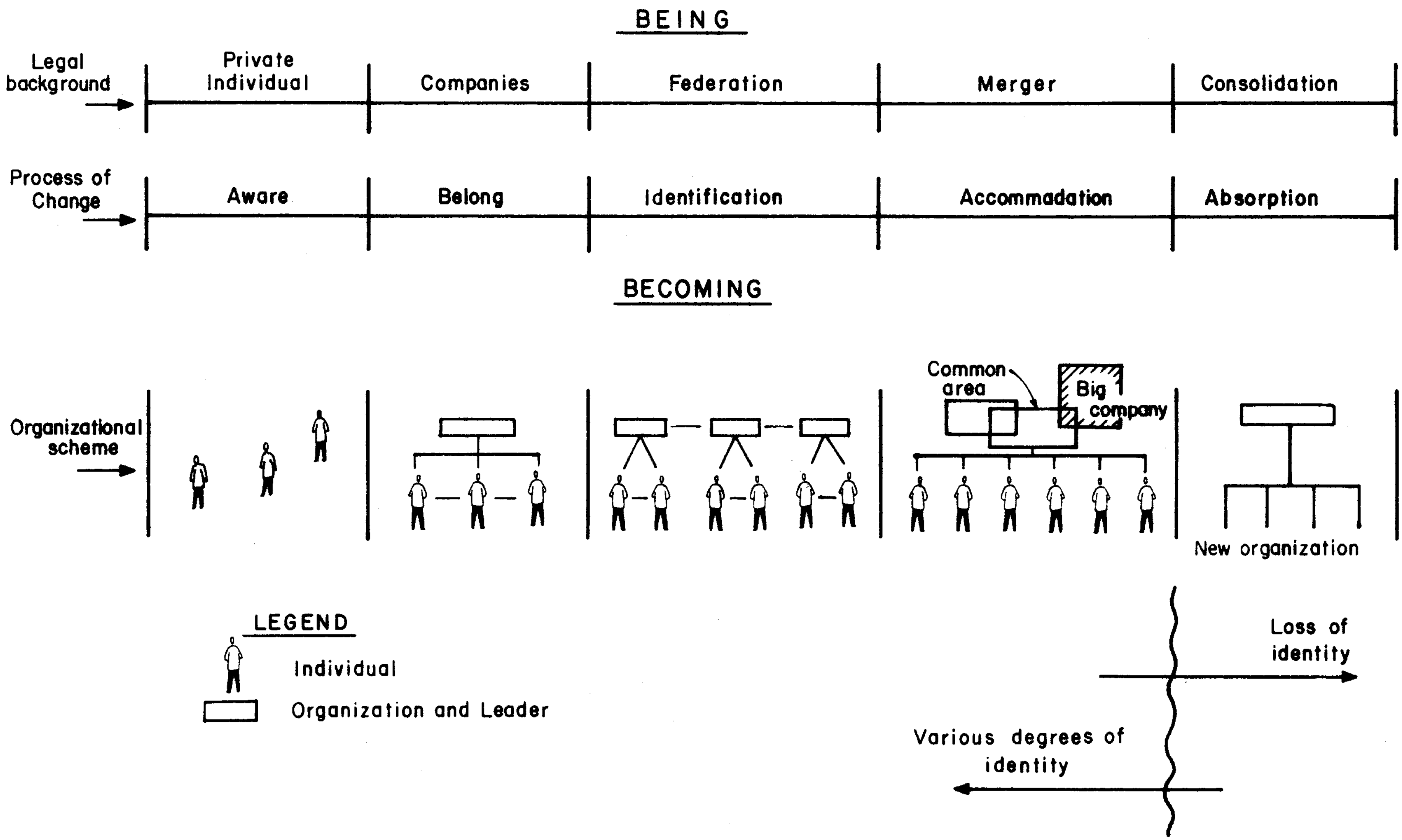


FIGURE 5-1. The "Organizational" Continuum in Irrigation Organizations

for hire.[1] Here, a number of individuals join together and, thereby, belong to an entity which then becomes an unincorporated, voluntary association. The mutual ditch companies were much the same process except that mutual ditch companies were incorporated and the purpose for which the incorporation occurred was exactly the same, that is, building diversion works and transportation works and better protection of water rights. In addition, mutual ditch companies are often formed for the purpose of making a profit. This profit can be made either from its own stockholders, in which case the dividends are redistributed to the stockholders in terms of cash or extra water, or the profits can be made by delivery of water to people, to customers, other than the stockholders. If this is done, then the private nature of the company is lost and a quasi-public entity is created.

The next step in the development of alternatives occurs when several companies join together for a single purpose and then disband when the purpose if fulfilled. This is called a federation. The process is simply one of companies being substituted for individuals in a process similar to the first state here, i.e., each company perceives a need and they join together with other companies in a federation, an identification process with each other, for completion of a particular project. After the project is completed, then they are no longer confederated or combined for any other purpose.

In the final stages encompassing both merger and consolidation, the needs of an entire group are taken into account and they are organized in a more permanent situation. There will be a permanent change of configuration whereas in a federation, once the purpose is achieved, the individual companies all maintain their identity as they disband. Within the consolidation there will be a permanent change of identity in at least some cases. As Figure 5-1 indicates there are important differences between a merger and a consolidation. In merger there are several companies which are joined together with one company remaining. The company that remains will have the name of one of the companies which has been joined together, that is one of the joined companies will provide. Whereas in a consolidation, several companies join toghther and all of them lose their identity and a <u>new organization</u> emerges. The importance of the difference between a consolidation and a merger lies really in the social sphere. In merger there is a maintaining of identity of at least one organization; whereas in a consolidation there is a complete loss of identification with a completely new organization being formed which can have some considerable social impact on the surrounding environment and on the future course of water development in a given area.

5.2 Levels of Merger and Consolidation

5.2.1 Private and Quasi-Private

The organizations from the individual, to the mutual company, to the merged companies to irrigation districts move along a continuum of private to quast-public organizations. Unincorporated or voluntary associations clearly begin with an individual who is irrigating his own land, simply a private entity. Moving along the continuum the unincorporated voluntary associations is a private organization such as the mutual ditch company. So long as the delivery of water is only to the lands of the members of the association or the stockholders of the company and not for hire, the private nature will be maintained. Not for hire is used to mean that it is not for profit and that the water is delivered to members and only members except in very unusual circumstances such as an emergency.

An organization which holds itself out generally, that is to say as a general practice holds itself out to serve for compensation[2] those who may apply for water[3] within an area served by an irrigation owned by an organization or company, is no longer merely a private organization but by virtue of the holding out of general services, is affected with a public interest and is thereby subject to regulation and control as a quasi-public corporation or a public entity.[4]

A company may retain its private status if it is organized for the purpose of delivering water to its stockholders and members at cost or those with which it has fixed contractual obligations.[5] It is to be noted that a water company which has become a public agency may not discontinue its services in whole or in part so as to regain its private status.[6] However, a private corporation may, with the consent of the owner to the rights, receive water for public use, change the use to a public use so as to make the service in terms of delivery subject to regulation and control by public authorities.[7] The significance of this, of course, is that most private corporations do not want to lose their private status because they do not want to be regulated by a public body. Factors to be taken into account in determining the public or private nature of a corporation include the following:[8]

1) What are the provisions of the articles of incorporation by-laws[9] and are they broad enough to permit public sale of water?
2) To whom has water been sold, besides the shareholders, and in what quantity?
3) What has been the intent of the shareholders in selling to other persons and themselves?[10]
4) What amount of water has the corporation agreed to supply to its members and others?
5) What degree of acquiesence to public sales is evidences by shareholders?
6) Has the croporation directly or indirectly used condemnation?[11]

7) Are there close financial director or other corporation relations with admitted public utilities?
8) Has there been a dedication to a public use by positive action of all or any part of the whole water rights?

Another alternative which is imbued with a quasi-public nature is the irrigation district or the conservation district which is an incorporated association[12] which is organized by actual or potential water users in a specific area in contract with the government,[13] to build irrigation works for the purpose of reclaiming or improving the land. Generally, the object of these associations is a three-fold object. One, to provide for irrigation in an area where the individuals do not have the money to finance the venture independently or they cannot form together in the form of, say, a federation, because, even in this form, they would not have sufficient financing for the project to be undertaken. Two, to allow the government to deal with one organization representing all water users in the area rather than having to deal with many users on an individual basis. Three, to have a responsible organization to which management of an irrigation organization as contemplated by the Reclamation Act may be termed. This is simply an organization for administering government funds and for coordinating the building projects. It is funded by the federal government, though the government takes no active role in operating and managing the actual irrigation works.[14] An essential feature of the Articles of Incorporation of these associations includes a means of effecting the reclamation laws regarding ownership of the reclaimed areas and guaranteeing repayment to the government for the cost of the reclamation works. This arrangement is a temporary arrangement and all groups of persons using the water are in effect water user associations. When the government agency responsible for overseeing these projects transfers the works entirely to a water users association, the organization is reclassified according to the successive type of association, such as a mutual company or a district, and in many of these instances there are several of these entities because the conservancy district encompasses a hugh area.

5.2.2 Mechanism for Transition

Corporations organized formally under state codes have two alternative methods of uniting. They are merger and consolidation. Merger is defined as two or more companies combining into one, with an original company continuing to exist. Consolidation on the other hand, is the case when two or more companies combine into a new corporation with all of the original companies ceasing to exist. The combining companies are the constituent corporations, the new company is the consolidated corporation. Irrigation companies organized under the state corporate act resemble any other business corporation thereunder and are required to law to adhere to the same standards and proceedings. Therefore, although no specific mention is made of incorporated irrigation enterprises, by definition they are included in the law.

Utah and Colorado allow merger and consolidation and corporations under their respective business corporation codes pattern after the model business corporation code.[15] The Colorado Corporation Act and the Utah Business Corporation Act are adoptions of the model act with minor variations. The merger and consolidation statutes are virtually identical with the model act.[16]

To easily accomplish consolidation or merger of business corporations, the states require a resolution be passed by the board of directors and notice given to the shareholders. Notice of the planned merger or consolidation must be given to the shareholders ten days or more depending upon the state prior to when they are required to vote on the matter. In each of the states, all of the shareholders are permitted to vote even though they do not hold voting stock in a normal sense of the word. For the companies to merge or consolidate the majority of the shareholders of each company must vote in favor of the plan.[17] In Colorado, two-thirds of the shareholders of each company must be in favor of the plan. Both states have buy-out provisions allowing a dissenting shareholder who voted against the merger or consolidation to force the company of which he is a shareholder to purchase his shares of stock at fair market value. The model act provisions on the effect of merger or consolidation have been adopted in Colorado and Utah to the effect that "surviving or new companies shall possess all rights, privileges, immunities, and franchises as well public as of private nature...."

The following requirements are representative of those required for merger:

1. Any two or more domestic corporations may merge into one of such corporations assumed to require merger approved by statute. The board of directors of each corporation shall, by resolution, adopted by each such board, approve a plan of merger setting forth:

   a. the names of the corporations proposing to merge;
   b. the name of the corporation to which they propose to merger which is hereinafter designated at the surviving corporation;
   c. the terms and conditions of the proposed merger;
   d. the manner and basis of converting the shares of each merging corporation into shares or other securities or obligations of the surviving corporation;
   e. a statement of any changes in the articles of incorporation of the surviving corporation to be effected by such merger;
   f. such other provisions with respect to the proposed merger as are deemed necessary or desirable.

The procedure for consolidation is as follows:

Any two or more domestic corporations may consolidate into a new corporation according to a plan of consolidation approved in the manner provided by statute. All directors of each corporation shall, by resolution adopted by each such board, approve the plan of consolidation setting forth:

a. The names of the corporations proposing to consolidate; the name of the new corporation into which they propose to consolidate which is hereinafter designated as the new corporation;
b. The terms and conditions of the proposed consolidation;
c. The manner and basis of converting the shares of each corporation into shares or other securities or obligations of the new corporation;
d. With respect to the new corporation all of the statements required to be set forth in the articles of incorporation, for corporations organized under statute;
e. Such other provisions with respect to the proposed consolidation as are deemed necessary or desirable.

Examination of the state corporation code fails to reveal any constraints to consolidation or merger on irrigation companies organized according to statute other than the fact that they must comply with the statute for consolidation.

5.3 The Transitional Process in Irrigation Water Management

While the previous remarks have sketched briefly the main features of the legal conditions and mechanisms for alternative water management shcemes (especially merger and consolidation), we need also to indidate the basic premises of building the basis for implementing innovation. he general background of such a transition and process of implementing was contained in Figure 5-1 and can be now further elaborated in the categories of Figure 5-2.

The challenge of building the basis for implementing alternative water schemes (be they merger or consolidation) enterlies five interlocking steps of cumulative building towards comprehensive strategies and specific recommendations. These steps include:

a. definition of the problem of consolidation in terms of its legal, physical economic, and social parameters;
b. generation of alternatives, or the identification and analysis of the scope, extent and policy thrust of new or improved water management schemes;
c. the assessment of alternatives for adverse situations and a critical analysis of total system effects per certain criteria for weighting the alternatives, as well as design requirements;
d. decision making and the specification of trade-offs in those alternative management schemes which are considered most efficient or effective;
e. consideration of actual implementation procedures, including mechanisms for monitoring and correcting the progress of the solution selected; appropriate steps for effective implementation, the timing of change, etc.

Looking at these major phases that characterize a transitional process in irrigation water management one should underscore the sequential scheme of a progressive but mutually reinforcing cycle of problem description, identification of potential solutions, assessment and the building of the basis for implementation. The building of a credible process of implementation can be achieved in a combination of what is theoretically sound, realistically practicable, and socio-economically attainable. In this regard, we are also describing a process of "specification" with a number of associated concepts, which are summarized in Figure 5-3.

The concept of implementation has always been perceived as a central social and political problem. If we are supposed to systematically pursue implementation efforts and the overall transitional process in alternative irrigation management schemes, we must also understand the current incapabities for executing proposed policies, including:

a. the capabilities that bear directly on the problem at hand;
b. the organizational incentives for overcoming adjustment problems in organizing, expanding, or redirecting current policy;
c. public pressures and the relationship between rhetoric and action;

FIGURE 5-2. Stages of Implementation

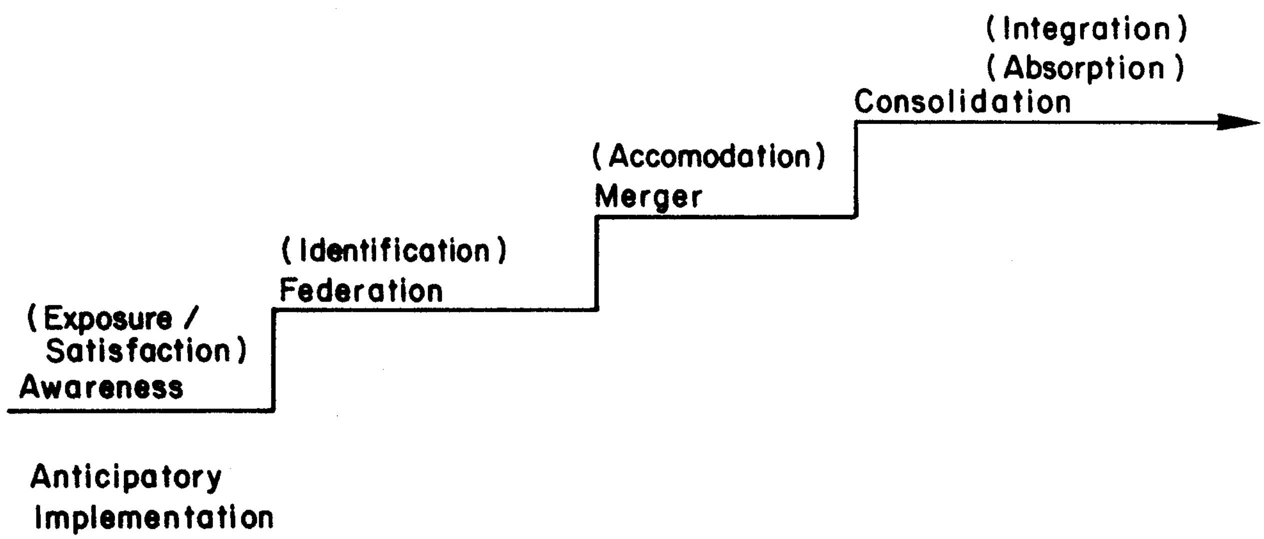
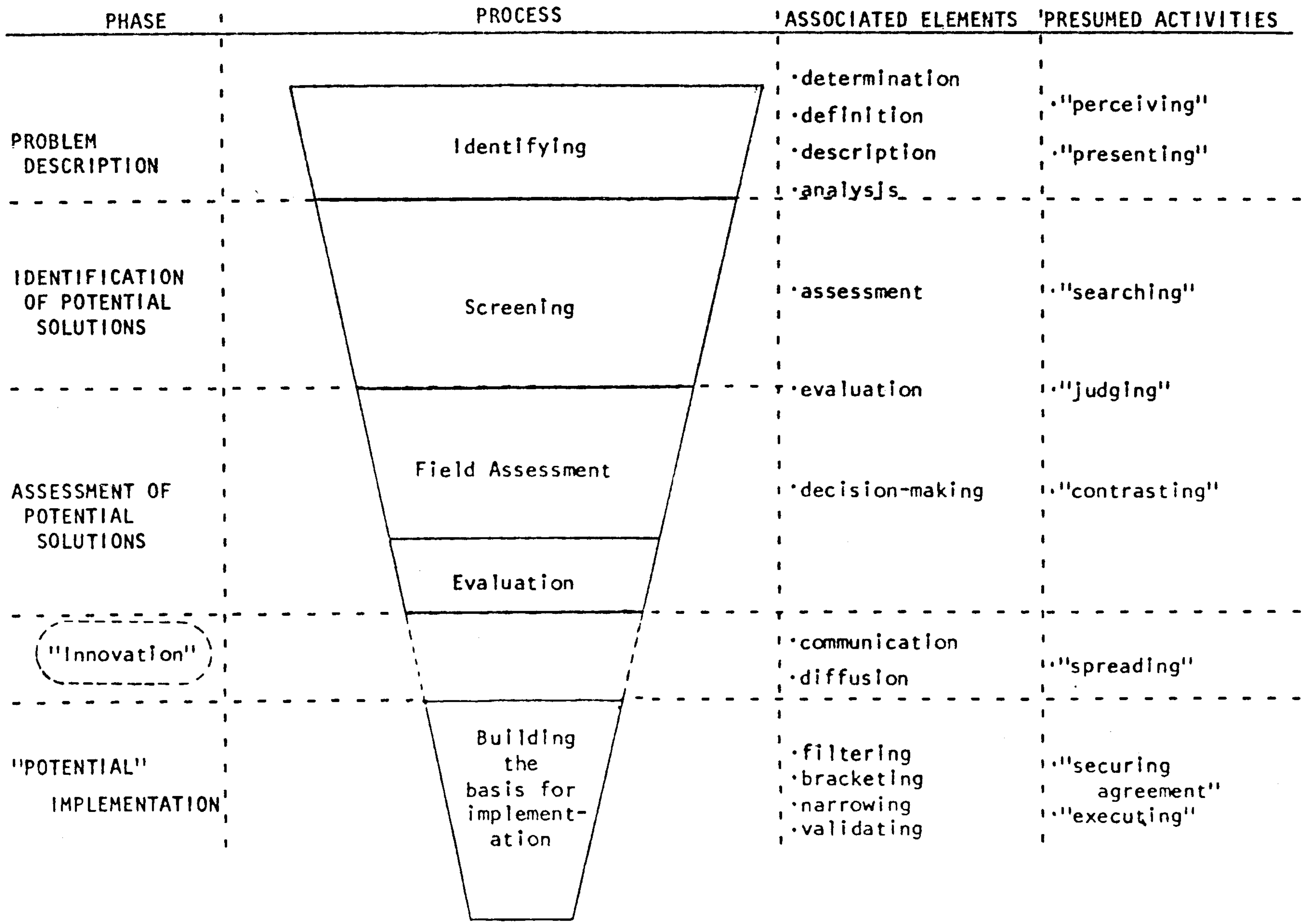


FIGURE 5-3. Specifying the Process for Building the Basis for Implementation



d. the recognition that decisions must be flexible in order to include escape clauses for postponement and/or compromise;

Important for our argument are the factors which contribute to a resistance to innovation. Such factors in the context of alternative irrigation schemes are particularly important because they exemplify potential threats to the established social structure. The resistance to innovation is proportional to the amount of change required in the social structure as well as proportional to the strengths of social values challenged. In other words, changes associated with new irrigation organizational arrangements provide us with an important case of resistance to innovation by threatening vested interest, established lifestyles and existing networks of long-established social values and practices.

Perhaps it is also of importance to underline a broader item, namely the characteristics of "good" institutional arrangements identified with proper water resources management. In particular:

1. A good institutional arrangement for water resources policy and the basis for implementation is one that ultimately facilitates social choice.
2. Institutional arrangements must recognize a decision-making process which takes into account the preferences and interests of those clearly affected by those particular policy decisions.
3. An ideal type of institutional arrangement must have some constraints on the losses that it can impose on the individual and on the costs required for its implementation.
4. A good institutional arrangement must produce decisions which not only are accepted as legitimate, but are also the result of a balance between what is desirable and what is acceptable.

To successfully implement new organizational schemes, we need to understand not only existing dimension of the problem, but more important, the dynamic process of assessing and evaluating alternatives through which implementation becomes feasible. Two key aspects of this process are especially important:

1. the structural features that make effective implementation possible (i.e., the institutional infrastructure that guarantees efficient operation in a given socio-economic environment).
2. the dynamic process of implementation which coincides with the more general question of bringing about change (i.e., the stages necessary for bringing about desired alternations in the way people do things).

All of these imply that the implementation process as related to the larger understanding of change and diffusion of innovation requires quite a complex system of interlocking factors whose modeling is quite difficult, especially if one is considering the varying circumstances of many valleys in the arid West. Assuming, however, that we have the right problem, the appropriate approach, and sensitivity to local conditions, then implementation efforts become more feasible given broader policies for new organizational schemes and increased awareness that changing circumstances may require (even demand) both innovative schemes and the creation of a general climate of cooperation for meeting competing and comflicting water demands.

NOTES

1. "Not for hire" is used here to mean not for profit and limiting delivery to members only except in very unusual circumstances.

2. Not necessarily for profit

3. Even supplying surplus water left over after all shareholders have been taken care of has been held sufficient to create a public interest. See Yucupa Water Co. No. 1. v. Public Utilities Commission, 9 Cal. 239, 357 P.2d 295 (1960).

4. West's Ann. California Public Utilities Code §2701 (1956).

5. Id., §2705 (Supp. 1972).

6. Leavitt v. Lassen Irrigation Co., 157 Cal. 82, 106 P. 404 (1909).

7. Francioni v. Soledad Land and Water Co., 170 Cal. 221, 149 P.161 (1915).

8. Williamson v. Railroad Commission, 193 Cal. 22, 222 P.803 (1924).

9. Merely providing in the bylaws or articles of incorporation that the corporation will not be affected with a public interest will not of itself be decisive. See Allen v. Railroad Commission, 179 Cal. 68, 175 P.466, cert. denied 249 U.S. 601 (1918).

10. There are some situation which allow mutual companies to sell to outsiders. Among these are delivering to others in a bona fide water emergency for the duration of the emergency. Companies have also been allowed to deliver to lessees of their stock and to outside land leased by one of the company stockholders. See West's Ann. California Public Utilities Code §2705 (1972 Supp).

11. Using condemnation is in the nature of eminent domain and is affected with a public interest.

12. For example, see Colo. Rev. Stats. §31-16-3(1071).

13. It may be the state government or federal government. 32 U.S. Stat. at Large 388 §5 (1902); New Mexico Stats. §75-17-1 (1953).

14. 32 U.S. Statutes at Large 388 §6 (1902), 43 U.S.C. 416

15. Consolidation and merger provisions are covered in the following: Colo. Rev. Stats. §31-7-1 to 31-7-8 and Utah Code Ann. 16-10-66 to 16-10-76.

16. Pertinent sections of the Model Act are

Section No.	Title
71	Procedure for merger
72	Procedure for consolidation
73	Approval by shareholders
74	Articles of merger or consolidation
75	Merger of subsidiary corporation
76	Effect of Merger or Consolidation
77	Merger or Consolidation of domestic and foreign corporations
80	Rights of shareholders to dissent
81	Rights of dissenting shareholders

17. Utah Code Ann. §16-10-68, Colo. Revised Stats., §31-7-8.

6.1 Model for Analytic Decision-Making

Modern society is undergoing a fundamental change in the relative values it places on economic activities. In general, there is a shifting emphasis away from efficiency as the sole criterion of desirability to a more balanced concern with questions of equity and social effectiveness.

Indicative of this shifting emphasis is the increasing proliferation of interdisciplinary studies--such as this one--which attempt to evaluate economic activities in terms of multidimensional social objectives. Prerequisite to such an integrated evaluation, however, is the need for an essentially new evaluation format.

The traditional means of evaluating resource-development projects, especially those relating to water use, has been benefit-cost analysis. But since it is basically an efficiency-oriented means of evaluation, benefit-cost analysis is increasingly losing touch with the values of modern society. Moreover, the poor performance of benefit-cost analysis in dealing with intangibles, incommensurables, and uncertainty and its failure to properly consider distributional effects has resulted in extensive criticism and skepticism as to its meaningful usage.

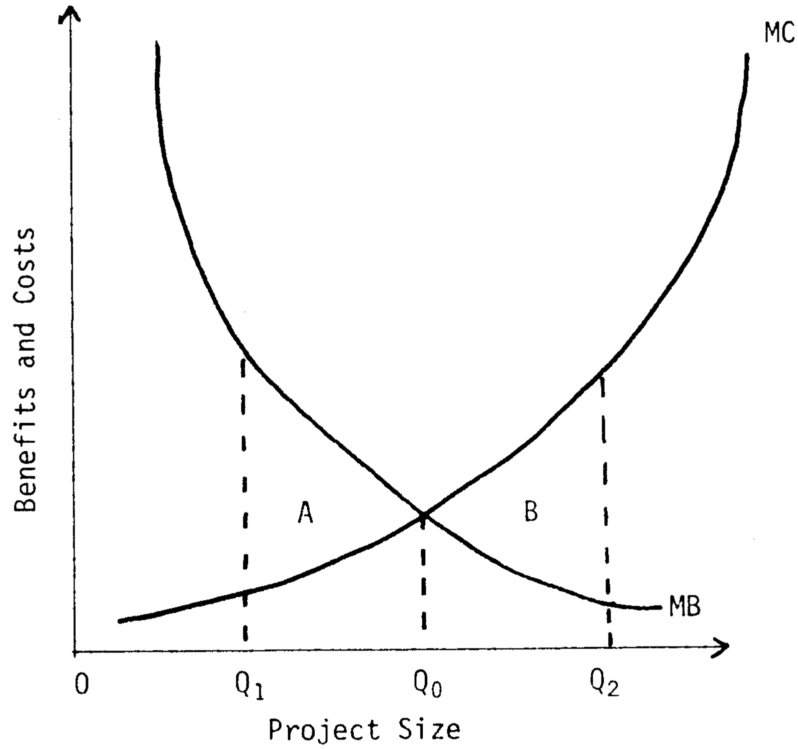
The purpose of this chapter is to develop an evaluation framework for assessing alternative water management plans in terms of multidimensional objectives. What is needed is a systematic approach which makes explicit the trade-offs existing within and among different water management plans. The following discussion develops a model for analytic decision-making, conceptualizes the necessary form of the analysis, and formulates a practical method for the evaluation of water management plans.

As indicated repeatedly, efficiency has traditionally been the overriding concern of water development projects. The basic decision rule has been to select that alternative project which maximizes net benefits. It is argued here that the economic efficiency criterion provides a valuable tool for analytic decision-making, but that it represents only a necessary and not a sufficient condition for project selection.

6.1.1 Economic efficiency model

When considering only a single project, net benefits are maximized by equating marginal costs (MC) to marginal benefits (MB). Assuming diminishing marginal returns and increasing marginal costs from increasing project size, then Figure 6-1 depicts the optimum project size to be Q_0. That Q_0 represents an optimum can be demonstrated by the fact that less than Q_0, say Q_1, results in $MB > MC$ such that a movement to Q_0 contributes benefits in excess of costs equal to area A. The converse holds for larger projects, say Q_2, where $MB < MC$ and a net savings equal to area B results from a project size reduction to Q_0.

FIGURE 6-1.



When considering more than one project, the decision-maker may either select the project with the greatest net benefits or he may maximize total net benefits by selecting a mix of projects. Often a decision is of the "either...or..." form such that one project must be selected to the exclusion of all others. In this case, the decision rule is to simply select that project with the largest net benefits, where each project's net benefits are maximized by equating MB to MC.

Sometimes, however, it is feasible to select a combination of projects. When this is possible, economic efficiency is achieved by applying the equi-marginal principle. That is, total net benefits from all alternative projects are maximized when the values of the returns from the last dollar spent on each are equal. That is, for n projects:

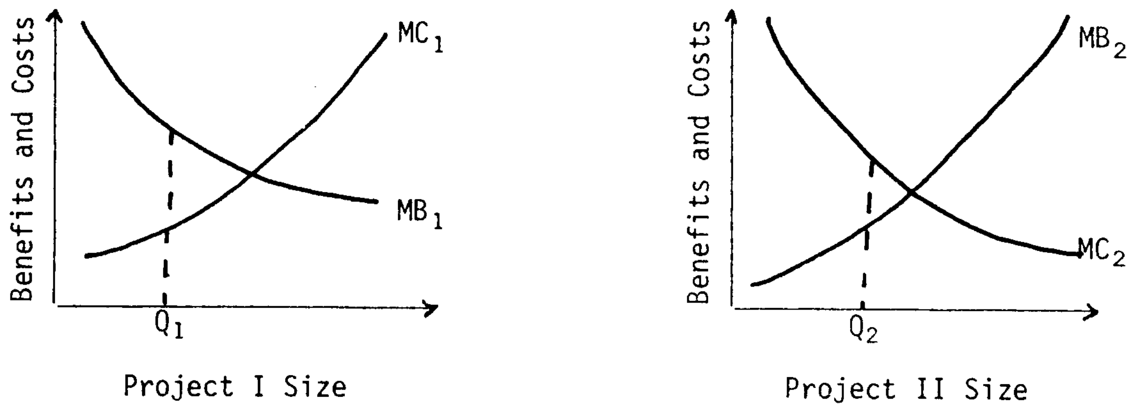
$$\frac{MB_1}{MC_1} = \frac{MB_2}{MC_2} = \ . \ . \ . \ = \frac{MB_n}{MC_n}$$

or simply,

$$\frac{MB_i}{MC_i} = \lambda \text{ for } i = 1, 2, \ldots, n$$

With an unlimited budget, the equi-marginal principle simply implies equating the marginal benefits and marginal costs of each project. On the other hand, a limited budget may be exhausted before each project is optimized. Application of the equi-marginal principle subject to a budget constraint, however, will still maximize the total net benefits producible by all the projects, even though each is sub-optimized. For example, the equi-marginal principle is graphically shown for two alternative projects in Figure 6-2, where a limited budget constrains Project I to Q_1 and Project II to Q_2.

FIGURE 6-2



The equi-marginal principle is applicable whether or not the projects are independent of each other, though the Lagrangian becomes more complex for the case of interdependence. Obviously, many water management plans will be either complements or substitutes to each other. The importance of this fact is that the relative benefits and costs of alternative projects will vary with the pursuit of any one project.

6.1.2 Welfare criterion

Use of the economic efficiency criterion has generated an essentially utilitarian approach to questions of water development and management. The implicit, if not the explicit, assumptions under which water use plans have been considered are of a utilitarian welfare nature.

An important utilitarian proposition is that the welfare of society is the sum of the individual welfares of each person in that society.[1] In other words, if I_t is the welfare of individual t in a particular society, which has a total welfare of S, then:

$$\sum_{t=1}^{n} I_t = S, \text{ where n is the number of individuals in the society.}$$

This proposition has two important implications, both of which are present in previous water use studies. First, it implies that S is maximized if and only if each I_t is maximized. If the welfare of the society is maximized, then the welfare of each individual in that society is maximized. If the welfare of each individual in a society is maximized, then the welfare of the society is maximized. Secondly, the utilitarian proposition implies that the welfares of different individuals are independent. If a particular society consists only of two persons A and B, then the welfare of A is not connected to the welfare of B, and conversely. If the welfare of A increases, decreases or stays the same, the welfare of B is not affected. The same is true for changes in the welfare of B with respect to the welfare of A.

Previous studies of proposed irrigation consolidation plans, for example, have been conducted solely in terms of the system to be consolidated. All the water diverted by the system, however, is not permanently held by it, because a substantial amount of the diverted water is lost during its transportation and use. A large proportion of this lost water returns to the river via deep percolation and runoff from the land, and downstream users become the recipients of this return flow.

In general, previous studies of the consolidation question have been conducted in terms of maximizing the welfare of the upper system. By ignoring the effects to the lower system, they implicitly assumed that the two systems are independent, and that the welfare of the two systems taken together would be increased by increasing the welfare of the upper system.

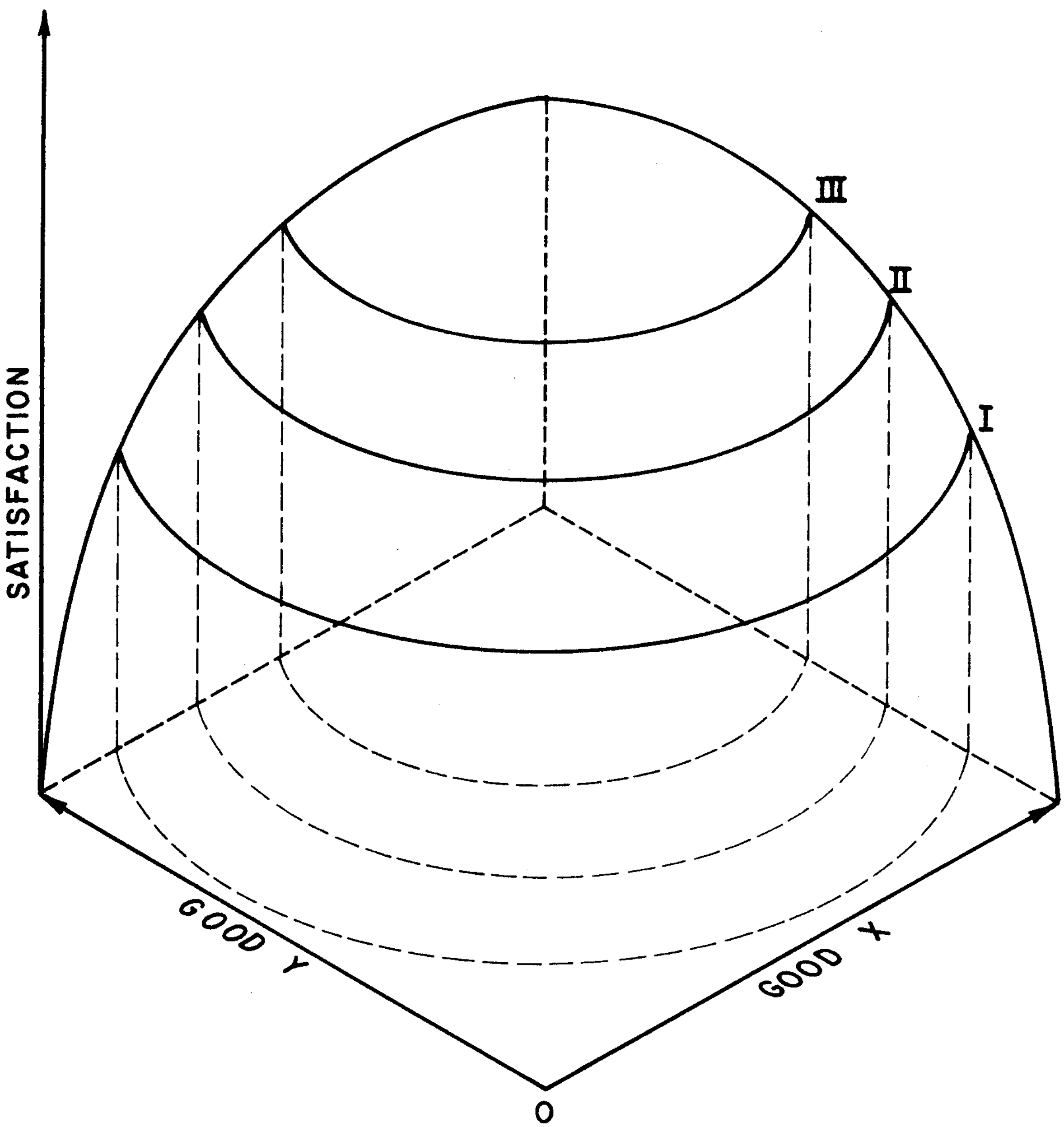
This undoubtedly is not the case. The operations of the upper and lower systems are not independent. Assuming for the moment that the relative welfares of the two systems are measurable, as the utilitarian concept contends, the algebraic sum of the welfares of the two systems would not necessarily be increased by a consolidation plan intended to increase the welfare of the upper system. This result could occur because the damage done to the lower system might more than offset the benefit received by the upper system.

Welfare cannot, of course, be measured in a cardinal sense. That is, one cannot count how much welfare someone has. I.M.D. Little refutes the utilitarian proposition by pointing out that zero amount of satisfaction cannot be defined and so there can be no unit of satisfaction which can be added to derive the total welfare of an individual. Since there is no cardinal measure of the welfare of an individual, there can be no summing of welfares to arrive at a cardinal measure of the welfare of society.[2]

On the other hand, there is a "rough and ready" sort of method by which the welfare of an individual can be measured--the indifference curve. This analysis is ordinal, rather than cardinal, in nature. An individual maximizes his welfare by reaching the highest indifference curve, rather than by increasing his total units of satisfaction. In this framework it is illogical to refer to welfare as a definite amount of anything.

An indifference curve is a locus of points in space which yields the same amount of satisfaction. All points on an indifference curve are preferred equally; a higher indifference curve is always preferred to a lower one. "Satisfaction is like a hill; one can say that one is higher up, or lower down, or at the same height. Like a hill, contour lines can be drawn which mark the same height, but, unlike an ordinary hill, these contour lines are not marked in feet, or units of satisfaction. They are simply given ordinal numbers, first, second, third contours, and so on."[3] A higher contour represents a greater amount of satisfaction or level of welfare and is preferred to all lower levels of satisfaction. For example, in Figure 6-3 indifference curve II yields more satisfaction than indifference curve I.

FIGURE 6-3.



The underlying premise of modern welfare economics is that the welfare of the community should be maximized. The welfare of a community is said to increase whenever one or more individuals become more satisfied without any other individuals becoming less satisfied.[4] An individual becomes more satisfied when he moves to a higher indifference curve. Welfare is increased when at least one individual moves to a higher indifference curve without disturbing any other individual's position. An optimum position is reached when it is impossible to move any individual to a higher indifference curve without causing someone else to drop to a lower one.[5]

The limitations of this criterion are immediately apparent when the problem at hand is considered. A reorganization of the upper system may be beneficial to the upper system, i.e., cause it to move to a higher indifference curve. The same reorganization, however, may have adverse effects upon the lower system.

The welfare criterion cannot deal with this situation. Therefore, if the welfare criterion were strictly followed, welfare economics would be quite sterile, because few economic reorganizations do not involve injury to someone.[6] Because of this, the idea of compensation has been introduced to widen the scope of the problems to which welfare economics can be applied.

The compensation principle states that if the gainers in an economic reorganization are able to compensate the losers so that the latter remain on at least the same indifference curve that they occupied before the reorganization, and the gainers are still able to move to a higher indifference curve, then welfare is increased. The compensation principle makes it possible to judge the welfare effect of reorganizations that increase the satisfaction of some individuals, while decreasing the satisfaction of others.[7]

Compensation is defined as the process of canceling the effect of an economic reorganization. Welfare is said to increase, decrease, or stay the same depending upon whether those benefited by the reorganization are on a higher, lower, or the same indifference curve after they have compensated those individuals who are damaged by the reorganization. For example, suppose a reorganization of the existing irrigation system benefits the upper system and harms the lower system. If the upper system is still better off after compensating the lower system for its loss, then the reorganization is judged to increase welfare.

The compensation idea can be considered from the other side, too. A reorganization increases welfare if it is impossible for the damaged parties to bribe the benefited parties to cancel the reorganization. Logically, the amount of the bribe cannot exceed the amount of the loss if the reorganization occurs.[8] If the lower system were capable of bribing the upper system not to consolidate, the benefits of the consolidation to the upper system would be less than the losses to the lower system, and welfare would be decreased by such a consolidation.

6.1.3 Economic efficiency and welfare

By definition, publicly undertaken projects are supposed to benefit social welfare. In general, while the economic efficiency criterion is sufficient for private welfare maximization, the social welfare is not always advanced by strict adherance to this rule. The decision-rule for public projects is to maximize social welfare and only secondly to maximize efficiency.

The economic efficiency criterion, however, does provide a valuable paradigm for analytic decision-making directed towards maximizing social welfare. The equi-marginal principle of selecting between alternative projects is applicable to trade-off decisions between various objectives. As will be seen below, the social welfare function is multidimensional such that trade-off decisions are required. In this task, the efficiency decision-model is invaluable.

6.2 Form of Analysis

If maximizing social welfare is to be the objective, then an essentially new evaluative format is required. Traditional benefit-cost analysis fails to provide the relevant information for such an objective. A new analysis format must be utilized. Three issues central to the form of the analysis are: 1) values and trade-offs; 2) social weighting; and 3) evaluative measures.

6.2.1 Values and trade-offs

Application of the economic efficiency criterion to actual decisions may and, in fact, has created serious difficulties and misunderstandings. The source of the problems appear to be the restricted interpretation of the criterion such that only pecuniary considerations are included in the analysis. That is, the conventional application of the economic efficiency criterion requires a common numeraire and the one normally utilized is the dollar. The product of such an analysis is, then, the maximization of pecuniary net benefits.

Obviously there is more to be considered than simply the dollar values of benefits and costs. The divergence between the theoretical and the real world decision is, therefore, one of values. The importance of this observation merits further discussion.

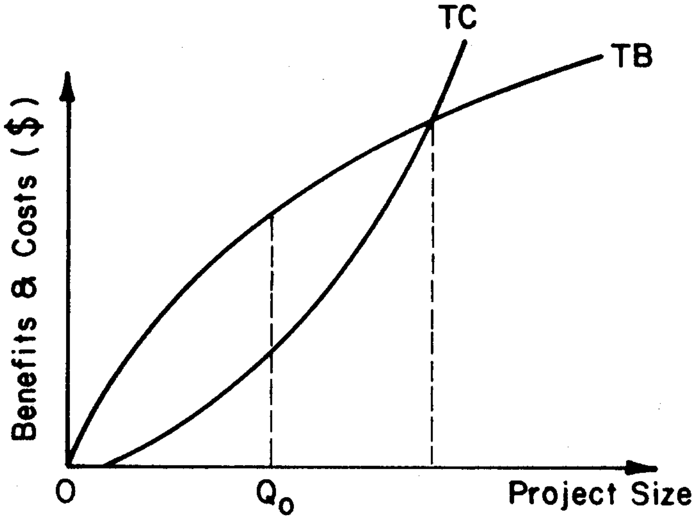
In Figure 6-4(a), two theoretical curves representing the total benefits (TB) and the total costs (TC) for increasing project sizes are drawn. According to the economic efficiency rule, equating marginal benefits to marginal costs maximizes net benefits or, equivalently, determines that project size, Q_0, which maximizes the difference between total benefits and total costs.

The problem can be considered in yet another way. The difference between total benefits and total costs is represented by the net benefit curve (NB) in Figure 6-4(b). Use of the MB = MC rule defines the maximum of this curve at point A.

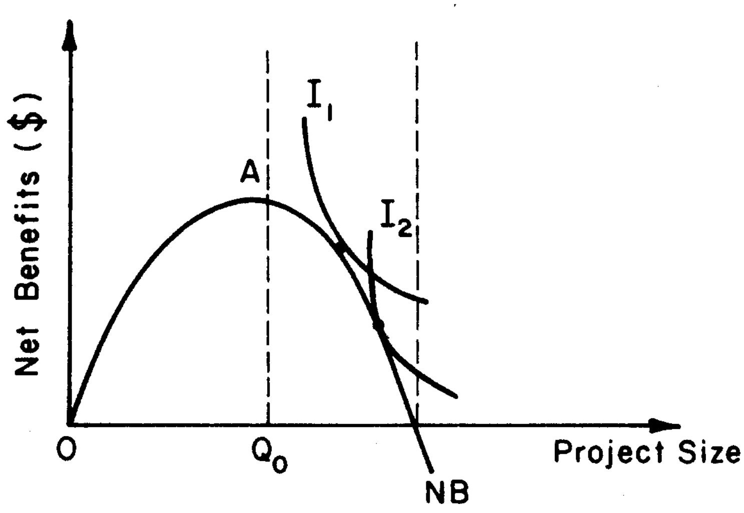
Obviously, increasing project expenditures may yield more than simply larger pecuniary profits. Other products include greater equality of income distribution, conservation of the natural environment, accommodation of growing urbanization, and regional development.

Consider for a moment only the relation between pecuniary private profits and increasing regional development. If project size and regional development are directly related, then the two are complementary up to point Q_0 in Figure 6-4(b). That is, larger projects over this range contribute positively to both profits and regional development. Beyond Q_0, however, the two objectives compete such that the net benefit curve from point A to D represents a trade-off or transformation curve between more profits and greater regional development.

FIGURE 6-4.


TC
TB
Benefits & Costs ($)
O
Q_0
Project Size

(a)


Net Benefits ($)
I_1
A
I_2
O
Q_0
Project Size
NB

(b)

Application of the efficiency criterion in strictly pecuniary terms dictates point A as the optimum solution. Social values, however, may not correspond to this choice. To the extent that regional development is valued, the socially optimum solution may be beyond point A on the trade-off curve. That is, the social value function or indifference curve for profits and development, which relates willingness to forego one for the other, may be tangent to the transformation curve to the right of point A. Indifference curves I_1 and I_2 are two such possibilities.

The situation is analogous to one discovered by William Baumol[9] while consulting for some private business firms. Utilizing the profit maximization rule, he had determined the optimum path for each firm, but was dismayed at their reluctance to follow his advice. As it turned out, the difficulty stemmed from the firms' desire not only to maximize profits, but also sales, in order to increase their market power. Beyond a point, profits and sales became conflicting ends, so that Baumol's suggested solution did not correspond to the values of these firms.

6.2.2 Social weighting

In the case of water management, we are dealing with both multidimensional trade-off surfaces and value functions. The appropriate shape of the value function is a social decision and belongs properly in the realm of politics. Specification of the trade-off function, however, is within the scope of this study and is the objective of its analysis.

Trade-offs exist both within and among the various water management plant. Not only may profits and regional development compete, but also such things as environmental quality, social stability and quality of income distribution. Different levels of a particular project may yield varying mixes of these considerations. Similarly, adoption of different mixes of projects will produce assorted combinations of the desired objectives.

Mathematical specification of the multidimensional trade-off function would be a Herculean task. The goal of this study's evaluation is the more realistic objective of specifying an array of points which defines the trade-off surface.

6.2.3 Evaluative measures

The evaluation of water management alternative poses several constraints to the utilization of conventional modes of economic analysis. The payoffs from such plans are often intangible or incommensurable and their success is frequently highly uncertain. Moreover, important questions of equity are involved.

A significant component of the evaluation deals with the pecuniary benefits and costs emanating from each alternative project. The form of this portion of the analysis is essentially a conventional benefit-cost approach. Due to the constraints of the evaluation, however, the benefit-cost analysis is limited to a necessary, though not a sufficient, ingredient of the evaluation.

Indicative of the intangible considerations are the environment and, perhaps, social disruption. These considerations have no quantitative measure, though subjective evaluations are possible. That is, projects may be compared in terms of their "high," "medium," or "low" effect on preserving or enhancing natural amenities of social arrangements.

Problems of incommensurates arise when comparing individual values with those of the market. For example, it is one thing to say that a worker will earn $500,000 during his life, but it is quite another to say his life is worth this amount. Similarly, the value of farm produce does not necessarily represent the value of the farm to the individual farmer or, even, society. Again, an ordinal evaluation may be appropriate for such considerations.

Uncertainty pervades the entire analysis. Not all projects undertaken are successful; trade-offs exist between high-risk, high-payoff projects and low-risk, low-payoff projects. If the risk is known, the probability of success can be entered in the matrix. If the problem is one of uncertainty, subjective evaluations of the expected success ratio must be made.

Various projects will result in different income distributions. One espoused goal of society has been equity of income distributions, though the exact meaning and implementation of this policy has generally been unclear. Various economic changes, however, can be judged in terms of their effects on the relative shares of total income which different groups receive. That is, one measure might be the relative levels of lower income families.

Finally, it will often be the case that nothing is known. When this is the case, it is best to inform the decision-maker of the fact, so that he may evaluate the consequences of this hole in the trade-off surface. A common fault of many analyses is to hide the hole with erroneous or inconsequential information.

6.3 Method of Evaluation

The method of analysis is similar to cost-effectiveness analysis. The purpose of the analysis is to explicitly state trade-offs both within and among various water management plans (WMP). The trade-offs are measured in terms of predetermined social objectives and are presented in a decision tableau. Evaluations of alternative plans are subject to several constraints and these are also stated.

The decision tableau is a rectangular array listing alternatives vertically and objectives horizontally. Each element of the matrix is a measure of the success of a particular objective for a certain alternative management plan. The form of the tableau is shown in Figure 6-5.

Evaluations down columns give the relative trade-offs between alternative projects in terms of a constant numeraire. Cross-column or row evaluations are for trade-off relationships within alternative adjustment schemes.

Utilizing the concept of economic efficiency in its broadest sense, the decision-maker can now evaluate the various alternatives. Given social values, the decision-maker attempts to determine that ordering and combination of adjustments such that the last unit of cost (in terms of dollars, equity, etc.) yields equal or equivalent units of benefits (defined in the same general terms as costs). The equivalences of the various objectives are based purely upon value judgments. Solutions, therefore, are unique only within defined value parameters.

Economic efficiency is basic to rational decision-making. By utilizing a decision tableau enumerated in terms of a multiplicity of objectives and measures, the decision-maker has an explicit statement of trade-offs to which to apply the efficiency criterion. Value judgments remain the prerogative of the decision-maker.

The clarity of this approach commends its application to decisions concerning water management plans. The difficulty of assembling evidence from which the benefits can be estimated hinders its balanced application. Significant errors of logic and rationality can be corrected by utilizing this method, however, if it is operationalized.

FIGURE 6-5

	Objectives				Constraints		
Water Management Alternatives	Net Pecuniary Benefits	Physical Efficiency	Social Effectiveness	Equity	Legal Feasibility	Political Feasibility	Uncertainty
WMP_1							
WMP_2							
.							
.							
.							
WMP_n							

6.4 Analysis of Alternatives

This project is particularly concerned with four main alternative water management plans for two different geographical areas. The four alternative water management plans can be divided into structural and non-structural adjustments to the present irrigation systems. Basically, the structural adjustment is the physical consolidation of the irrigation system with the possible inclusion of technological improvements in water delivery and control. The non-structural adjustments include the three organizational rearrangements of merger, federation and consolidation. The two irrigation systems considered are located in the Cache la Poudre Valley and the Utah Valley.

The purpose of this section is to evaluate more specifically the economic benefits and costs of either structurally or organizationally rearranging the present systems to increase the efficiency and effectiveness of water deliveries and usage. The economic evaluation is primarily concerned with the pecuniary value of benefits and costs of the alternative water management plans. Benefits are calculated in terms of the value of improved temporal water availability, while costs are mainly associated with the means of implementing such a plan. Further analysis of Utah and Poudre Valley elements is made in 9.0 as well as in such specific sections as 4.4 (concerning attitudes and opinions about consolidation); 2.4 (concerning the spectrum of organizational alternatives); and, specific points raised in the part regarding "Recommendations."

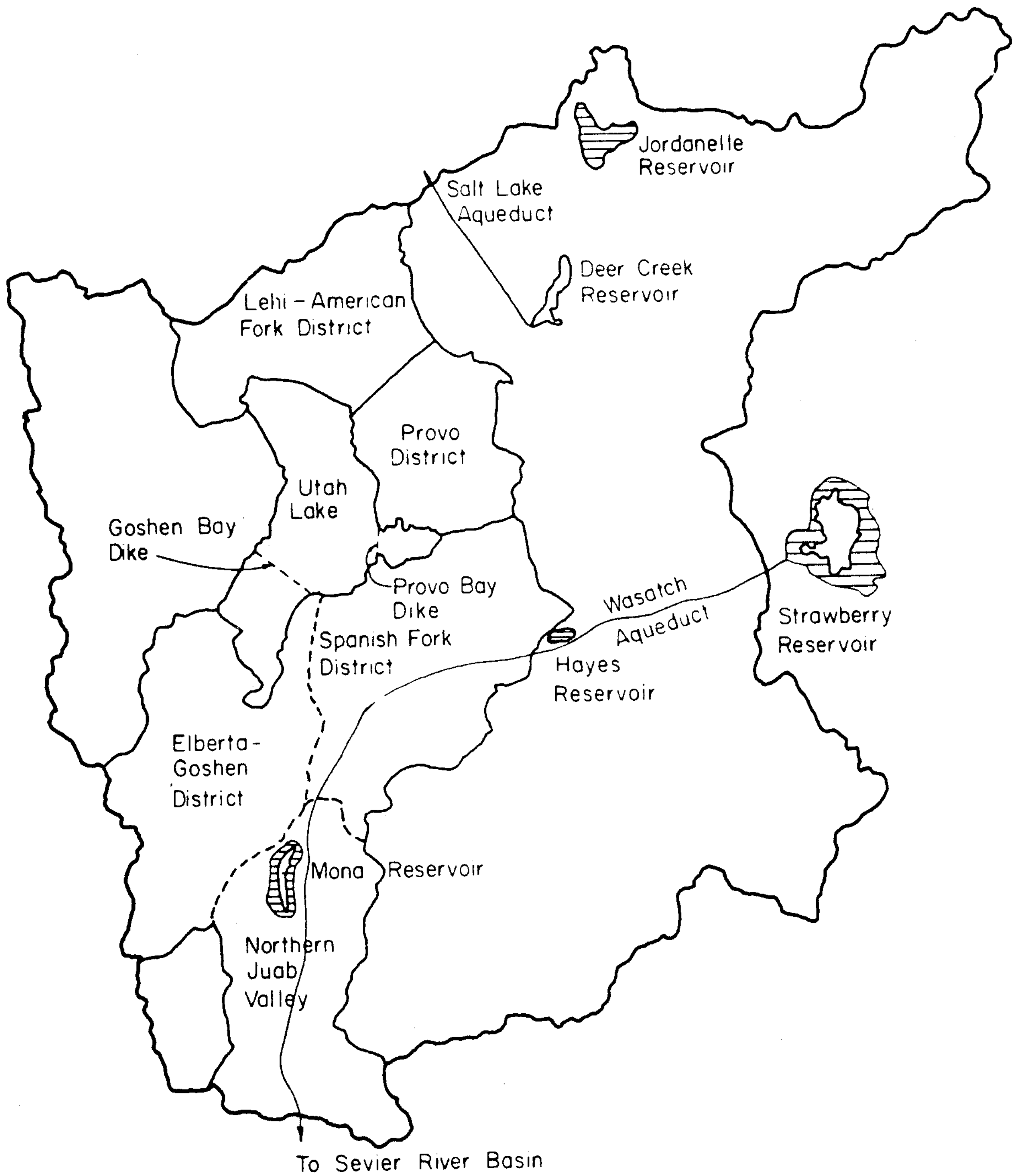
6.4.1 Utah Valley

The study area includes the irrigated land bordering Utah Lake in Utah County and the irrigated land in northern Juab County. The study area is divided into five separate hydrologic districts (shown in Figure 6-6) known as the Lehi-American Fork, Provo, Spanish Fork, Elberta-Goshen, and Northern Juab Valley Districts.

The five districts are part of the Jordan River Hydrologic Area and return flow from all of them, except the Northern Juab District, flows directly into Utah Lake. The return flow from Northern Juab is used in the Elberta-Goshen District before finally reaching Utah Lake. Utah Lake water then is released into the Jordan River, which flows north through Salt Lake County where diversions are made for both irrigation and urban uses. Water not consumed finally empties into the Great Salt Lake.

The analysis is complicated by plans to build the Bonneville Unit of the Central Utah Project (CUP) which will affect the water supplies of the study area. Construction has begun on CUP but has been discontinued at the present time because of a suit filed by the Sierra Club. Contact with the U.S. Bureau of Reclamation in Provo, Utah in April, 1974 indicated that the dispute was still in the hearing stage and there was some doubt whether or not the CUP would be completed. Because of this, the following analysis includes conditions projected to exist in 1990 with the CUP completed and also without the CUP. It was estimated that the CUP could be completed and in full operation by 1990.

FIGURE 6-6. The Bonneville Unit of the Central Utah Project



The CUP will import water from the Colorado River Basin into Utah Valley and also provide a means of exporting water north to Salt Lake County and south to the Sevier River Basin. In the following analysis, no export water is assumed to be taken out of the Utah Valley system, but export demand is taken into account either through urban demand or excess water.

Figure 6-6 shows the major features of the Bonneville Unit of the CUP. The project will create two new reservoirs--the Jordanelle and the Hayes--and enlarge two others--the Strawberry and the Mona. The Wasatch Aqueduct will be constructed to interconnect the water supplies of the Spanish Fork, Elberta-Goshen and Northern Juab Districts. In addition, two dikes will be constructed on Utah Lake to reduce evaporation losses. Agricultural engineers at Colorado State University estimate that evaporation losses will be cut by 30 per cent.

The Lehi-American Fork District will receive no new water from CUP. The Provo District will receive water from the new Jordanelle Reservoir. The remaining three districts receive water from the new Hayes Reservoir and the enlarged Strawberry and Mona Reservoirs. The Wasatch Aqueduct allows water to be transferred among the three reservoirs and, thus, interconnects the water supplies of the three districts.

The operation of these hydrologic districts was simulated in a master's thesis at Colorado State University.[10] The computer simulation modeled both the CUP and the existing systems without the CUP. These models are a basic part of the analysis to follow.

The simulations used hydrologic inflow data for the 21 years from 1945 through 1965. This data was then used to calculate the available water on a month by month basis while allowing for such losses as evaporation from reservoirs and reservoir spills. The 21 different supply situations were then applied to future urban, agricultural, and phreatophyte demands in the five districts before the inflows to Utah Lake were determined.

The simulation models make the assumption that the available water is used to meet urban demand first and agricultural demand second. This assumption is also made in this analysis, but requires explanation. The assumption is theoretically correct in that an acre-foot of water in urban use is usually worth more than in agricultural use. However, the assumption ignores institutional and legal problems common in the Western United States that make it difficult at times to transfer irrigation water to urban usage.[11] Because of this, it has been suggested that irrigation systems could be improved in order to release excess water for urban use. This suggestion hopes to treat the symptom rather than the cause of the problem--inflexible institutions. Such a course subsidizes inefficient institutional arrangements and increases their social costs by prolonging their life.[12]

Utah water law makes water the property of the public and allows changes in the nature of the water usage.[13] If these laws do not provide for water transfers by 1990 then the assumption of urban demand taking priority will serve to make agricultural water estimates less than will actually be the case.

The analysis is calculated in terms of 1990 values. Water demands are adjusted to reflect conditions in that year. Urban--municipal and industrial (M and I)--demand projects are probably the most uncertain of the uses. The M and I demands, as well as the population increases, used by Huntzinger[14] appear to be high. The M and I diversions utilized for this analysis are shown in Table 6-1. The population increases are shown in Table 6-2. Both these tables represent different total projections for the Jordan River Hydrologic Area. These have been allocated to the five districts in question and used in the model in the same proportions as in the original model.[15]

The total projections are the median values of six different projections used in a doctoral dissertation.[16] They include: 1) The Framework Studies (Pacific Southwest Inter-Agency Committee, Great Basin Study, Appendix XI 1971; and Upper Colorado Study, Appendix XI, 1971); 2) The Office of Business Economics, Department of Commerce (U.S. Water Resources Council, 1969), and Economic Research Service, Department of Agriculture (1967) (commonly known as OBERS); 3) Utah Division of Water Resources projections (1970); and 4) 1972 revisions of the above three projections.

The M and I water diversion projections are considered to be an upper limit on the actual use. This is because of a drop in the rate of population growth and a rising marginal cost which will reduce the quantity of water demanded. The "Framework" estimate is very close to the median value,[17] though it may be an overestimation of actual water use since a 2.2 per cent annual increase in population was projected. The 1970 Bureau of Census returns found the actual population increase in the Jordan River Basin for 1960 to 1970 to be 1.9 per cent per year.[18] This estimate also assumed per capita residential water requirements to increase at 0.5 per cent per year. This does not seem correct in light of rising cost. The 1972 OBERS revision uses a 0.5 per cent annual population growth, as indicated by the national mean in recent census data, and arrives at projections 20-30 per cent below the median.[19]

Another adjustment made to M and I water use levels is in upward adjustment of the M and I water use levels in the Provo District. This reflects the growing demand for M and I water caused by increases in population and industry in the Provo area and increasing transfers to Salt Lake City. The demand for export water will probably be greatest in the Provo area due to its low marginal value of water compared with the Lehi-American Fork District. Table 6-3 lists the marginal water values potential M and I users would have to pay to transfer water after 1990.

It is likely that Salt Lake County M and I water demands will be met by imported water due to the limited capability of water transfers within the county caused by poor water quality. The amount of dissolved solids in the 269,000 acre-feet annual outflow from Utah Lake averages twice that of the inflow of the lake.[20] The quality of this water is doubtful for irrigating many high cash value crops due to possible salt damage from Jordan River water.[21]

Data on the water sources and uses in Salt Lake County is not very complete. A hydrologic inventory by The Utah Water Research Laboratory at Utah State University was in process at this writing. Contact with

TABLE 6-1

ANNUAL MUNICIPAL (M) AND INDUSTRIAL (I) WATER DIVERSIONS

District	1960		1990		2020	
	M	I	M	I	M	I
Lehi-American Fork	6,500	1,000	11,512	1,537	21,216	2,767
Provo	18,000	64,500	32,200	98,082	60,513	132,833
Spanish Fork	2,000	6,000	4,863	7,273	7,195	13,837
Elberta-Goshen	250	--	353	--	692	--
Northern Juab	1,400	1,300	2,036	2,327	3,413	1,476
Salt Lake	90,000	110,000	200,000	201,054	368,980	392,041
Total M and I	300,950		561,237		1,004,963	
Provo Adjusted for Salt Lake Export Demand			250,000			

TABLE 6-2

POPULATION

District	1965	1990	2020
Lehi-American Fork	27,707	41,260	63,520
Provo	72,039	115,507	181,234
Spanish Fork	17,733	18,164	21,588
Elberta-Goshen	1,108	1,338	1,954
Northern Juab	5,098	6,743	10,661
Salt Lake	443,315	727,447	1,243,760
Total	567,000	910,459	1,527,294

TABLE 6-3

MARGINAL WATER VALUES PER ACRE-FOOT PER YEAR IN AGRICULTURE 1990

District	Without CUP	With CUP
Lehi-American Fork	18.68	18.68
Provo	5.45	3.68
Spanish Fork	6.16	4.55
Northern Juab	21.37	7.56
Elberta-Goshen	13.05	3.22
Salt Lake	7.72	2.08

the people at the laboratory, the U.S. Bureau of Reclamation, and engineers at Colorado State University indicate that Salt Lake County M and I water demands are presently near the limit of its supply and additional water will have to be imported in the future. Only about 140,000 acre-feet annually flow into Salt Lake County from streams other than the Jordan River and M and I use is presently over 200,000 acre-feet annually.[22]

Thus, the estimated M and I water use in the Provo District for 1990 was increased by 120,000 acre-feet to account for projected transfers to Salt Lake City. This estimate includes 20,000 acre-feet already transported to Salt Lake City,[23] 50,000 acre-feet to be transported by the CUP,[24] and 50,000 acre-feet which sources at the Salt Lake City water department say has been sold by the Provo Reservoir Water Users Company for use in Salt Lake County. The same adjustment to Provo M and I uses was made for estimates without the CUP. This leaves about 80,000 acre-feet of M and I water that Salt Lake County has to obtain in 1990 from other sources such as increased treatment on the Jordan River, recycling, etc. Part of Salt Lake City's demand for water might be met by transfers from Weber County, but M and I demand is predicted to increase rapidly there also.[25]

Agricultural water demands were estimated for each district in the year 1990 with and without the CUP. The corresponding irrigated acreages are shown in Table 6-4. Two adjustments were made to the present acreages to arrive at the 1990 figures. First, the CUP plans call for an increase in irrigated acreages in the Provo, Spanish Fork, Elberta-Goshen, and Northern Juab Districts. Second, the decrease in irrigated land due to urbanization was accounted for by using population increases estimated in Table 6-2 and the relationship that 34 additional people decrease farm land by one acre.[26] The 1968 acreages were derived from Hyatt, et al.[27] and Anderson.[28]

The demand functions for consumptive agricultural water are shown in Table 6-5. These functions are for the acre-feet needed annually at the root zone for consumption by crops. The consumptive water requirements were estimated from the acreage estimates and annual average per acre consumptive requirement.[29] The demand functions were estimated by disaggregation of a function previously developed for the entire Jordan River Hydrologic Area.[30]

There are both institutional and physical methods which can be used to improve irrigation efficiency. The analysis considers physical methods first. Water related benefits are compared to expected construction costs. The water supplies are determined by varying the efficiency of the irrigation systems in the simulation models. In order to reduce the number of computer simulation runs, the lowest efficiencies are a compromise between present day average efficiencies and those related to the CUP. The difference in efficiency is small because the CUP will provide a distribution system for only the new land in the project area and will not improve the present system.[31]

Benefits are net of the value of any other water losses or gains in the system. That is, as the effective water supply increases in one district due to agricultural efficiency increases, there may be costs

TABLE 6-4

IRRIGATED LANDS IN ACRES

District	1966	Urbanization Decrease	1990 w/o CUP	CUP Increase	1990 with CUP
Lehi-American Fork	20,492	399	20,093	--	20,093
Provo	23,495	1,278	22,217	9,500	31,717
Spanish Fork	62,417	13	62,404	4,600	67,004
Northern Juab	12,391	48	12,343	13,090	25,433
Elberta-Goshen	11,356	8	11,348	19,270	30,618
Salt Lake	52,000	8,357	43,643	--	43,643

TABLE 6-5

DEMAND FUNCTIONS FOR CONSUMPTIVE AGRICULTURAL WATER IN ACRE FEET PER YEAR

District	1990 w/o CUP	1990 w/CUP
Lehi-American Fork	q = 31,746 - 756p	same
Provo	q = 34,436 - 820p	q = 49,161-1171p
Spanish Fork	q = 90,486 - 215p	q = 97,156-2313p
Elberta-Goshen	q = 18,270 - 435p	q = 49,294-1174p
Northern Juab	q = 20,983 - 500p	q = 43,236-1029p
Salt Lake	q = 70,702 - 1683p	same

where

q = quantity of water demanded

p = price of water per acre-foot in 1972 dollars downstream in Salt Lake County due to reduced water flows. Similarly, in the case of the three districts interconnected by CUP, another district may receive more water. The areas under the agricultural demand curves were used to calculate the water values. The district benefit curves are, however, mutually exclusive of each other.

An evaporation rate of inflow to Utah Lake during the agricultural season of 83 per cent without the CUP and 58 per cent with the CUP was utilized. This, in effect, reduced the cost of agriculture downstream in Salt Lake County. Data from the simulation models indicate that agriculture in 1990 in Salt Lake County will be short about 12,966 acre-feet per year without the CUP and 3,500 acre-feet with the CUP. This is determined by estimating the effect of a reduction from present levels of inflow to Utah Lake would have on outflow, if Utah Lake is not to have a long term drop in water level. It is possible that agriculture in Salt Lake County will not be as short as indicated if a decision is made to draw down Utah Lake. If that is done, then there will be offsetting costs to recreation, aesthetics, and water quality since Utah Lake is very shallow and the water level would drop drastically.[32]

The benefit estimates are in terms of a 95 per cent confidence interval around the difference of the mean at the present agricultural efficiency and the mean at the efficiency in question. Data for 21 years from the simulation models are used as paired samples. Confidence intervals are calculated using the following formula:

$$\overline{D} \pm t_{0.05} \left(\sqrt{\frac{\Sigma(D_i - \overline{D})^2}{n - 1}} \right)$$

where:

$\overline{D}$ = difference of the means;

D_i = difference of the individual parts;

n = 21; and

$t_{0.05}$ = t value at 20 degrees of freedom.[33]

Discounting of the benefits is at 6 per cent for 30 years without the CUP and 45 years with the CUP. These time periods are used because all of the agricultural water will be transferred to M and I uses by then if the projected M and I diversions of Table 6-1 hold true. This assumes marginal agricultural water values to be roughly equal in the five districts after 1990. The discounting factors also accounted for the increase in marginal agricultural water value over the years as the transfer to M and I continues by use of a uniform-percentage-gradient-series present-worth factor.[34] All water values without the CUP are increased by 1 per cent annually, except those for Lehi-American Fork and Northern Juan Districts where 2 per cent is used. With the CUP completed, the Lehi-American Fork and Northern Juab water values are the only ones increased and those are at 1 per cent annually.

Although the benefits for the Provo District do not indicate a large water shortage in 1990, it may be that the shortage increases very rapidly after that year. This is because of the likelihood that a larger and larger portion of Salt Lake demand will settle there as time passes. In that case, the benefits should not differ greatly as all water will be rapidly taken from agriculture. That is, agricultural water may be gone in this district well before the full 30 or 45 years. After that, treatment costs of M and I return flow would have to be borne if agriculture is to continue.

Construction costs were estimated for the physical consolidation and the lining of irrigation canals and for a sprinkler system. An average cost of $234 per acre for the physical consolidation and lining of canals, which represents the average cost per acre adjusted to 1972 prices estimated for similar construction in the Poudre Valley, Colorado.[35] This cost estimate, however, may be low. Another estimate using the cost for the entire distribution system,[36] and a percentage of cost due to lining,[37] gives a figure of nearly $300 per acre. Other studies, however, indicate that $300 per acre is too high for Utah Valley.[38]

Cost estimates used for a sprinkler system are $230 per acre.[39] This estimate includes operating costs and is adjusted to 1972 prices. A maximum application efficiency of approximately 90 per cent is assumed.[40] This gives an overall efficiency of about 73 per cent. Tables 6-6 through 6-10 summarize the results of the analysis.

In conclusion, the results indicate that it is not economically feasible to physically increase the efficiency of irrigation in the Utah Valley. This conclusion is reached even when comparing the maximum benefit with the minimum cost estimates. The findings indicate that capital intensive improvement methods are not feasible.

The analysis does not, however, rule out the feasibility of institutional changes to improve irrigation efficiency. The distribution of irrigation water within the five districts is very uneven.[41] Others have seen institutional changes and a free market system, in particular, as the best means of alleviating this distributional problem.[42] This analysis tends to reinforce that belief.

The feasibility of water transfers in Utah Valley can be considered in terms of potential transfers: 1) within the north valley (i.e., Lehi-American and Provo districts); 2) within the south valley (i.e., Spanish Fork, Elberta-Goshen and Northern Juab Valley districts); or 3) between the north and south sections of the valley.

In part, the feasibility of such transfers depends upon the availability of surplus water in one area at a time when shortages are occurring elsewhere. Tables 6-11 to 6-14 show the estimated average monthly irrigation water shortages and surpluses for the five Utah Valley water districts for projected conditions in four time periods.[43] Due to uncertainty surrounding the CUP, estimates are calculated for four possible capacities of the Jordanelle Reservoir and three capacities of the Wasatch Aqueduct.

TABLE 6-6

LEHI-AMERICAN FORK BENEFIT-COST ANALYSIS

BENEFITS

Efficiency		Consumed Water (Acre-feet/Year)	Water-Related Benefits	Consumed Water (Acre-feet/Year)	Water-Related Benefits
		Without CUP		With CUP	
.3682	High	17,626	$ 0	17,626	$ 0
	Low	17,626	0	17,626	0
.4182	High	19,063	427,063.0	19,063	445,211.4
	Low	18,811	351,965.9	18,811	368,024.7
.5182	High	21,585	1,066,401.5	21,585	1,111,198.3
	Low	20,938	907,593.4	20,938	948,035.8
.7300	High	25,766	1,830,499.9	25,766	1,902,639.6
	Low	24,917	1,692,925.2	24,917	1,763,668.2

CONSTRUCTION COSTS

Efficiency		Cost	Cost
		Without CUP	With CUP
.5182	Lining and consolidation	$2,692,462	$2,692,462
.7300	Sprinklers	$4,621,390	$4,621,390

TABLE 6-7

PROVO BENEFIT-COST ANALYSIS

BENEFITS

Efficiency		Consumed Water (Acre-Feet/Year)	Water-Related Benefits	Consumed Water (Acre-Feet/Year)	Water-Related Benefits
		Without CUP		With CUP	
.3870	High	29,965	$ 0	44,847	0
	Low	29.965	0	44,847	0
.4370	High	30,316	38,690.6	46,215	56,301.4
	Low	29,957	-52,262.4	44,617	-123,299.6
.5370	High	34.167	208,041.4	50,494	101,888.7
	Low	27,715	-345,711.6	43,564	-434,368.4
.7300	High	33,072	231,305.0	53,454	51,369.5
	Low	29,975	-138,237.7	43,806	-693,559.5

CONSTRUCTION COSTS

Efficiency		Cost Without CUP	Cost With CUP
.5370	Lining and consolidation	$2,977,078	$4,250,078
.7300	Sprinklers	$5, 109,910	$7,294,910

TABLE 6-8

SPANISH FORK BENEFIT-COST ANALYSIS

BENEFITS

Efficiency		Consumed Water (Acre-feet/Year)	Water-Related Benefits	Consumed Water (Acre-feet/Year)	Water-Related Benefits
		Without CUP		With CUP	
.4074	High	77,214	$ 0	86,621	$ 0
	Low	77,214	0	86,621	0
.4574	High	87,141	526,463.9	93,992	336,133.0
	Low	81,487	209,076.1	91,479	61,776.9
.5574	High	95,033	361,331.9	100,361	202,971.8
	Low	85,720	156,986.1	93,497	-87,130.4
.7300	High	95,183	124.8	100,878	-278,522.7
	Low	85,743	-223,737.3	93,383	-603,146.5

CONSTRUCTION COSTS

Efficiency		Cost	Cost
		Without CUP	With CUP
.5574	Lining and consolidation	$8,362,136	$8,978,536
.7300	Sprinklers	$14,352,920	$15,410,920

TABLE 6-9

NORTHERN JUAB BENEFIT-COST ANALYSIS

BENEFITS

Efficiency		Consumed Water (Acre-feet/Year)	Water-Related Benefits	Consumed Water (Acre-feet/Year)	Water-Related Benefits
		Without CUP		With CUP	
.4658	High	10,299	$ 0	35,456	$ 0
	Low	10,299	0	35,456	0
.5158	High	11,207	192,483.0	37,177	185,198.5
	Low	11,115	135,565.5	37,011	141,145.4
.6158	High	12,956	442,888.6	41,334	435,143.0
	Low	12,722	293,789.1	38,881	226,599.1
.7300	High	14,783	534,031.4	42,636	558,065.9
	Low	14,485	309,021.9	41,052	306,882.0

CONSTRUCTION COSTS

Efficiency		Cost	Cost
		Without CUP	With CUP
.6158	Lining and consolidation	$1,653,962	$3,408,022
.7300	Sprinklers	$2,838,890	$5,849,590

TABLE 6-10

ELBERTA GOSHEN BENEFIT-COST ANALYSIS

BENEFITS

Efficiency		Consumed Water (Acre-feet/Year)	Water-Related Benefits	Consumed Water (Acre-feet/Year)	Water-Related Benefits
		Without CUP		With CUP	
.5420	High	12,592	$ 0	45,509	$ 0
	Low	12,592	0	45,509	0
.5920	High	13,530	163,472.9	47,717	311,343.0
	Low	13,481	153,057.4	47,351	196,608.5
.6920	High	15,185	374,732.9	49,860	457,789.5
	Low	15,088	357,639.6	48,429	306,906.8
.7300	High	15,798	428,617.4	49,891	467,543.0
	Low	15,650	407,499.0	48,676	306,373.6

CONSTRUCTION COSTS

Efficiency		Cost Without CUP	Cost With CUP
.6920	Lining and consolidation	$1,520,632	$4,102,812
.7300	Sprinklers	$2,610,040	$7,042,140

TABLE 6-11. Average Monthly Irrigation Water Shortages(+) and Surpluses (-), Utah Valley Water Districts, 1960 Estimates

Area	Oct.	Nov.	Dec.	Jan.	Febr.	Mar.	Apr.	May	June	July	Aug.	Sept.	Average Annual
Lehi-American Fork District	485	-1508	-1379	-1229	-1137	-1654	-7126	-7888	3291	13450	14325	-1944	7686
Provo District													
Jordanelle Capacity													
150,000 ac.ft.	0	0	0	0	0	0	0	0	0	0	0	0	0
225,000 ac.ft.	0	0	0	0	0	0	0	0	0	0	0	0	0
325,000 ac.ft.	0	0	0	0	0	0	0	0	0	0	0	0	0
1,000,000 ac.ft.	0	0	0	0	0	0	0	0	0	0	0	0	0
Total North Utah Valley													
150,000 ac.ft.	485	-1508	-1379	-1220	-1137	-1654	-7126	-7888	3291	13450	14325	-1944	7686
225,000 ac.ft.	485	-1508	-1379	-1220	-1137	-1654	-7126	-7888	3291	13450	14325	-1944	7686
325,000 ac.ft.	485	-1508	-1379	-1220	-1137	-1654	-7126	-7888	3291	13450	14325	-1944	7686
1,000,000 ac.ft.	485	-1508	-1379	-1220	-1137	-1554	-7126	-7888	3291	13450	14325	-1944	7686
Spanish Fork District													
Wasatch Ag. Capacity													
9,000 ac.ft.	-3426	-6045	-5893	-5848	-6346	-8928	-25235	-40845	-14260	2073	0	-14119	-128872
10,000 ac.ft.	-3426	-6045	-5893	-5848	-6346	-8928	-25235	-40845	-14260	2073	0	-14119	-128872
11,000 ac.ft.	-3426	-6045	-5893	-5848	-6346	-9828	-25235	-40845	-14260	2073	0	-14119	-128872
Northern Juab Valley District													
Wasatch Ag. Capacity													
9,000 ac.ft.	2132	- 528	- 394	- 437	- 389	- 618	-2521	702	8871	9449	10715	-1566	25416
10,000 ac.ft.	2132	- 528	- 394	- 437	- 389	- 618	-2521	702	8871	9449	10715	-1566	25416
11,000 ac.ft.	2132	- 528	- 394	- 437	- 389	- 618	-2521	702	8871	9449	10715	-1566	25416
Elberta-Goshen District													
Wasatch Ag. Capacity													
9,000 ac.ft.	82	0	0	0	0	0	0	0	100	0	138	0	320
10,000 ac.ft.	82	0	0	0	0	0	0	0	100	0	138	0	320
11,000 ac.ft.	82	0	0	0	0	0	0	0	100	0	138	0	320
Total South Utah Valley													
Wasatch Ag. Capacity													
9,000 ac.ft.	-1212	-6573	-6287	-6285	-6735	-9546	-27756	-40143	-5289	11522	10853	-15685	-103136
10,000 ac.ft.	-1212	-6573	-6287	-6285	-6735	-9546	-27756	-40143	-5289	11522	10853	-15685	-103136
11,000 ac.ft.	-1212	-6573	-6287	-6285	-6735	-9546	-27756	-40143	-5289	11522	10853	-15685	-103136
Potential North Utah Valley Water Transfer*													
Jordanelle Capacity													
150,000 ac.ft.	0	0	0	0	0	0	0	0	0	0	0	0	0
225,000 ac.ft.	0	0	0	0	0	0	0	0	0	0	0	0	0
325,000 ac.ft.	0	0	0	0	0	0	0	0	0	0	0	0	0
1,000,000 ac.ft	0	0	0	0	0	0	0	0	0	0	0	0	0
Potential South Utah Valley Water Transfer*													
Wasatch Ag. Capacity													
9,000 ac.ft.	1713	0	0	0	0	0	0	702	7130	0	0	0	27046
10,000 ac.ft.	1713	0	0	0	0	0	0	702	7130	0	0	0	27046
11,000 ac.ft.	1713	0	0	0	0	0	0	702	7130	0	0	0	27046

*Assuming 50 percent shrinkage rate.

TABLE 6-12. Average Monthly Irrigation Water Shortages(+) and Surpluses (-), Utah Valley Water Districts, 1980 Estimates

Area	Oct.	Nov.	Dec.	Jan.	Febr.	Mar.	Apr.	May	June	July	Aug.	Sept.	Average Annual
Lehi-American Fork District	1860	-1192	-1063	-913	-821	-1338	-6506	-3245	12972	23125	22646	-1556	43969
Provo District													
Jordanelle Capacity													
150,000 ac.ft.	392	0	0	0	0	0	0	0	1481	2842	3458	270	8443
225,000 ac.ft.	392	0	0	0	0	0	0	0	1481	2842	3458	270	8443
325,000 ac.ft.	392	0	0	0	0	0	0	0	1481	2842	3458	270	8443
1,000,000 ac.ft.	392	0	0	0	0	0	0	0	1481	2842	3458	270	8443
Total North Utah Valley													
150,000 ac.ft.	2252	-1192	-1063	-913	-821	-1338	-6506	-3245	14452	25967	26104	-1286	52412
225,000 ac.ft.	2252	-1192	-1063	-913	-821	-1338	-6506	-3245	14452	25967	26104	-1286	52412
325,000 ac.ft.	2252	-1192	-1063	-913	-821	-1338	-6506	-3245	14452	25967	26104	-1286	52412
1,000,000 ac.ft.	2252	-1192	-1063	-913	-821	-1338	-6506	-3245	14452	25967	26104	-1286	52412
Spanish Fork District													
Wasatch Ag. Capacity													
9,000 ac.ft.	-3226	-5735	-5583	-5538	-6036	-8618	-24931	-40509	-14020	2145	0	-13767	-125818
10,000 ac.ft.	-3226	-5735	-5583	-5538	-6036	-8618	-24931	-40509	-14020	2145	0	-13767	-125818
11,000 ac.ft.	-3226	-5735	-5583	-5538	-6036	-8618	-24931	-40509	-14020	2145	0	-13767	-125818
Northern Juab Valley District													
Wasatch Ag. Capacity													
9,000 ac.ft.	2253	- 399	- 265	- 308	- 260	- 489	-2397	842	8996	9563	10840	-1428	26948
10,000 ac.ft.	2253	- 399	- 265	- 308	- 260	- 489	-2397	842	8996	9563	10840	-1428	26948
11,000 ac.ft.	2253	- 399	- 265	- 308	- 260	- 489	-2397	842	8996	9563	10840	-1428	26948
Elberta-Goshen District													
Wasatch Ag. Capacity													
9,000 ac.ft.	82	0	0	0	0	0	0	0	0	0	16	0	98
10,000 ac.ft.	82	0	0	0	0	0	0	0	0	0	16	0	98
11,000 ac.ft.	82	0	0	0	0	0	0	0	0	0	16	0	98
Total South Utah Valley													
Wasatch Ag. Capacity													
9,000 ac.ft.	-891	-6134	-5848	-5546	-6296	-9107	-27328	-39667	-5024	11708	10856	-15195	-98772
10,000 ac.ft.	-891	-6134	-5848	-5546	-6296	-9107	-27328	-39667	-5024	11708	10856	-15195	-98772
11,000 ac.ft.	-891	-6134	-5848	-5546	-6296	-9107	-27328	-39667	-5024	11708	10856	-15195	-98772
Potential North Utah Valley Water Transfer*													
Jordanelle Capacity													
150,000 ac.ft.	0	0	0	0	0	0	0	0	0	0	0	270	0
225,000 ac.ft.	0	0	0	0	0	0	0	0	0	0	0	270	0
325,000 ac.ft.	0	0	0	0	0	0	0	0	0	0	0	270	0
1,000,000 ac.ft.	0	0	0	0	0	0	0	0	0	0	0	270	0
Potential South Utah Valley Water Transfer*													
Wasatch Ag. Capacity													
9,000 ac.ft.	1613	0	0	0	0	0	0	842	7010	0	0	0	27046
10,000 ac.ft.	1613	0	0	0	0	0	0	842	7010	0	0	0	27046
11,000 ac.ft.	1613	0	0	0	0	0	0	842	7010	0	0	0	27046

*Assuming 50 percent shrinkage rate.

TABLE 6-13. Average Monthly Irrigation Water Shortages(+) and Surpluses(-), Utah Valley Water Districts, 2000 Estimates

Area	Oct.	Nov.	Dec.	Jan.	Febr.	Mar.	Apr.	May	June	July	Aug.	Sept.	Average Annual
Lehi-American Fork District	2290	- 765	- 636	- 486	- 394	- 911	-6075	-2565	13691	23852	23363	- 878	50486
Provo District													
Jordanelle Capacity													
150,000 ac.ft.	1382	6	0	0	0	0	0	537	1922	2466	4605	492	11410
225,000 ac.ft.	1007	6	0	0	0	0	0	537	1922	2466	3924	489	10351
325,000 ac.ft.	754	6	0	0	0	0	0	537	1922	2544	3626	415	9804
1,000,000 ac.ft.	525	0	0	0	0	0	0	0	1909	1677	2300	312	6723
Total North Utah Valley													
150,000 ac.ft.	3672	- 759	- 636	- 486	- 394	- 911	-6075	-2028	15613	26318	27968	- 386	61896
225,000 ac.ft.	3297	- 759	- 636	- 486	- 394	- 911	-6075	-2028	15613	26318	27287	- 389	60837
325,000 ac.ft.	3044	- 759	- 636	- 486	- 394	- 911	-6075	-2028	15613	26396	26989	- 463	60290
1,000,000 ac.ft.	2815	- 765	- 636	- 486	- 394	- 911	-6075	-2565	15600	25529	25663	- 566	57209
Spanish Fork District													
Wasatch Ag. Capacity													
9,000 ac.ft.	-2816	-4905	-4753	-4708	-5206	-7788	-24090	-40541	-14421	- 138	0	-11344	-120710
10,000 ac.ft.	-2816	-4905	-4753	-4708	-5206	-7788	-24090	-40541	-14421	- 138	0	-11344	-120710
11,000 ac.ft.	-2816	-4905	-4753	-4708	-5206	-7788	-24090	-40541	-14421	- 138	0	-11344	-120710
Northern Juab Valley District													
Wasatch Ag. Capacity													
9,000 ac.ft.	0	- 347	- 213	- 256	- 208	- 437	-1615	- 413	230	2528	4682	0	3951
10,000 ac.ft.	0	- 347	- 213	- 256	- 208	- 437	-1615	- 413	230	2528	4682	0	3951
11,000 ac.ft.	0	- 347	- 213	- 256	- 208	- 437	-1615	- 413	80	911	1722	0	- 776
Elberta-Goshen District													
Wasatch Ag. Capacity													
9,000 ac.ft.	4	0	0	0	0	0	0	0	0	0	594	0	598
10,000 ac.ft.	4	0	0	0	0	0	0	0	0	0	594	0	598
11,000 ac.ft.	4	0	0	0	0	0	0	0	0	0	107	0	111
Total South Utah Valley													
Wasatch Ag. Capacity													
9,000 ac.ft.	-2812	-5252	-4966	-4964	-5414	-8225	-25705	-40954	-14191	2390	5276	-11344	-116161
10,000 ac.ft.	-2812	-5252	-4966	-4964	-5414	-8225	-25705	-40954	-14191	2390	5276	-11344	-116161
11,000 ac.ft.	-2812	-5252	-4966	-4964	-5414	-8225	-25705	-40954	-14341	773	1829	-11344	-120045
Potential North Utah Valley Water Transfer*													
Jordanelle Capacity													
150,000 ac.ft.	0	6	0	0	0	0	0	537	0	0	0	439	0
225,000 ac.ft.	0	6	0	0	0	0	0	537	0	0	0	439	0
325,000 ac.ft.	0	6	0	0	0	0	0	537	0	0	0	415	0
1,000,000 ac.ft.	0	0	0	0	0	0	0	0	0	0	0	312	0
Potential South Utah Valley Water Transfer*													
Wasatch Ag. Capacity													
9,000 ac.ft.	4	0	0	0	0	0	0	0	230	69	0	0	4549
10,000 ac.ft.	4	0	0	0	0	0	0	0	230	69	0	0	4549
11,000 ac.ft.	4	0	0	0	0	0	0	0	80	69	0	0	111

*Assuming 50 percent shrinkage rate.

TABLE 6-14. Average Monthly Irrigation Water Shortages(+) and Surpluses (-), Utah Valley Water Districts, 1010 Estimates

Area	Oct.	Nov.	Dec.	Jan.	Febr.	Mar.	Apr.	May	June	July	Aug.	Sept.	Average Annual
Lehi-American Fork District	1917	- 390	- 361	- 115	- 19	- 536	-5950	-4802	8121	18158	18687	- 387	34423
Provo District													
Jordanelle Capacity													
150,000 ac.ft.	1813	116	103	151	169	0	0	345	1692	2810	5143	1242	13584
225,000 ac.ft.	1371	116	103	151	169	0	0	345	1692	2810	4585	1052	12394
325,000 ac.ft.	1371	116	103	151	169	0	0	345	1692	2810	3825	1052	11634
1,000,000 ac.ft.	1065	116	103	151	169	0	0	345	1692	1544	3419	790	9394
Total North Utah Valley													
150,000 ac.ft.	3720	- 274	- 158	36	150	- 536	-5950	-4457	9813	20968	23830	855	48007
225,000 ac.ft.	3288	- 274	- 158	36	150	- 536	-5950	-4457	9813	20968	23272	665	46817
325,000 ac.ft.	3288	- 274	- 158	36	150	- 536	-5950	-4457	9813	20968	22512	665	46057
1,000,000 ac.ft.	2982	- 274	- 158	36	150	- 536	-5950	-4457	9813	19702	22106	403	43817
Spanish Fork District													
Wasatch Ag. Capacity													
9,000 ac.ft.	-3252	-4905	-4753	-4708	-5206	-7788	-24339	-42371	-17036	-1183	- 72	-11344	-126957
10,000 ac.ft.	-3252	-4905	-4753	-4708	-5206	-7788	-24339	-42371	-17036	-1183	- 72	-11344	-126957
11,000 ac.ft.	-3252	-4905	-4753	-4708	-5206	-7788	-24339	-42371	-17036	-1183	- 72	-11344	-126957
Northern Juab Valley District													
Wasatch Ag. Capacity													
9,000 ac.ft.	0	- 347	- 213	- 256	- 208	- 437	-1663	- 522	3	493	2026	0	- 1124
10,000 ac.ft.	0	- 347	- 213	- 256	- 208	- 437	-1663	- 522	3	493	2026	0	- 1124
11,000 ac.ft.	0	- 347	- 213	- 256	- 208	- 437	-1663	- 522	0	99	523	0	- 3024
Elberta-Goshen District													
Wasatch Ag. Capacity													
9,000 ac.ft.	0	0	0	0	0	0	0	0	0	0	356	0	356
10,000 ac.ft.	0	0	0	0	0	0	0	0	0	0	356	0	356
11,000 ac.ft.	0	0	0	0	0	0	0	0	0	0	177	0	177
Total South Utah Valley													
Wasatch Ag. Capacity													
9,000 ac.ft.	-3252	-5252	-4966	-4964	-5414	-8225	-26002	-42893	-17033	- 690	1954	-11344	-127725
10,000 ac.ft.	-3252	-5252	-4966	-4964	-5414	-8225	-26002	-42893	-17033	- 690	1954	-11344	-127725
11,000 ac.ft.	-3252	-5252	-4966	-4964	-5414	-8225	-26002	-42892	-17036	-1084	628	-11344	-129804
Potential North Utah Valley Water Transfer*													
Jordanelle Capacity													
150,000 ac.ft.	0	116	103	57	9	0	0	345	0	0	0	193	0
225,000 ac.ft.	0	116	103	57	9	0	0	345	0	0	0	193	0
325,000 ac.ft.	0	116	103	57	9	0	0	345	0	0	0	193	0
1,000,000 ac.ft.	0	116	103	57	9	0	0	345	0	0	0	193	0
Potential South Utah Valley Water Transfers*													
Wasatch Ag. Capacity													
9,000 ac.ft.	0	0	0	0	0	0	0	0	3	493	36	0	356
10,000 ac.ft.	0	0	0	0	0	0	0	0	3	493	36	0	356
11,000 ac.ft.	0	0	0	0	0	0	0	0	0	99	36	0	177

*Assuming 50 percent shrinkage rate.

Within the north Utah Valley, the Lehi-American Fork District tends to be water poor compared with the Provo District, though surpluses do occur at some times, which could be stored for municipal uses in north Utah Valley. Based upon projections of water supply and demand, the Lehi-American Fork District could transfer water to the Provo District during September for year 1980 estimates, during May and September for year 2000 estimates, and during November, December, January, May and September for year 2020 estimates. That is, during these months there exists, on average, a coincidence of shortages in Provo and surpluses in Lehi-American. The amount of the total transfer depends upon the size of the shortage compared with an assumed loss rate for transporting the surplus water.

In the south Utah Valley, the Spanish Fork District tends to have the largest and most frequent water surpluses. The Northern Juab Valley District also has periodic surpluses, though these are relatively small and more than offset by shortages. Elberta-Goshen District is estimated to either have adequate water supplies or small shortages.

Potential water transfers within the south Utah Valley could occur during October, May and June for 1960 and 1980 estimates; June and July for 2000 estimates; and July and August for 2020 estimates. Potential transfers in the years 2000 and 2020 tend not to be large and are probably not significant.

Assuming that water deficits will be satisfied by transfers within either the north or south first and only secondly by transfers from the north to the south, the analysis indicates that no north-south transfers are feasible.

The values of transfers can be calculated by multiplying the monthly marginal value of water times the quantity transferred. Marginal values of irrigation water calculated by Whittlesey[44] are used for this purpose and are shown in Table 6-15. Tables 6-16 to 6-19 summarize the calculated average monthly values of water transfers within the north and south Utah Valley.

The largest payoffs from such transfers appear to be within the south valley, though these benefits decrease rapidly beyond 1980. Conversely, transfers within the north valley tend to become economically more valuable after 1980, though the dollar benefits remain comparatively small. On balance, the dollar benefits of water transfers in Utah Valley are not relatively large.

6.4.2 Cashe la Poudre Valley

A map of the existing Cache la Poudre Valley irrigation system is shown in Figure 6-7. The Rocky Mountains rise to the west of the system and the elevation decreases from west to east within the system.

Table 6-15. Estimated Marginal Value of Irrigation Water

Month	Marginal Value
October-March	$ 2.00
April	7.00
May	10.00
June	13.00
July	26.00
August	92.00
September	31.00

TABLE 6-16. Value of Potential Average Monthly Water Transfers, Utah Valley Water Districts, 1960 Estimates. ($)

Area	Oct.	Nov.	Dec.	Jan.	Febr.	Mar.	Apr.	May	June	July	Aug.	Sept.	Average Annual
North Utah Valley													
Jordanelle Capacity													
150,000 ac.ft.	0	0	0	0	0	0	0	0	0	0	0	0	0
225,000 ac.ft.	0	0	0	0	0	0	0	0	0	0	0	0	0
325,000 ac.ft.	0	0	0	0	0	0	0	0	0	0	0	0	0
1,000,000 ac.ft.	0	0	0	0	0	0	0	0	0	0	0	0	0
South Utah Valley													
Wasatch Ag. Capacity													
9,000 ac.ft.	3426	0	0	0	0	0	0	7020	92690	0	0	0	103136
10,000 ac.ft.	3426	0	0	0	0	0	0	7020	92690	0	0	0	103136
11,000 ac.ft.	3426	0	0	0	0	0	0	7020	92690	0	0	0	103136

TABLE 6-17. Value of Potential Average Monthly Water Transfers, Utah Valley Water Districts, 1980 Estimates. ($)

Area	Oct.	Nov.	Dec.	Jan.	Febr.	Mar.	Apr.	May	June	July	Aug.	Sept.	Average Annual
North Utah Valley													
Jordanelle Capacity													
150,000 ac.ft.	0	0	0	0	0	0	0	0	0	0	0	8370	8370
225,000 ac.ft.	0	0	0	0	0	0	0	0	0	0	0	8370	8370
325,000 ac.ft.	0	0	0	0	0	0	0	0	0	0	0	8370	8370
1,000,000 ac.ft.	0	0	0	0	0	0	0	0	0	0	0	8370	8370
South Utah Valley													
Wasatch Ag. Capacity													
9,000 ac.ft.	3226	0	0	0	0	0	0	8420	91130	0	0	0	102776
10,000 ac.ft.	3226	0	0	0	0	0	0	8420	91130	0	0	0	120776
11,000 ac.ft.	3226	0	0	0	0	0	0	8420	91130	0	0	0	102776

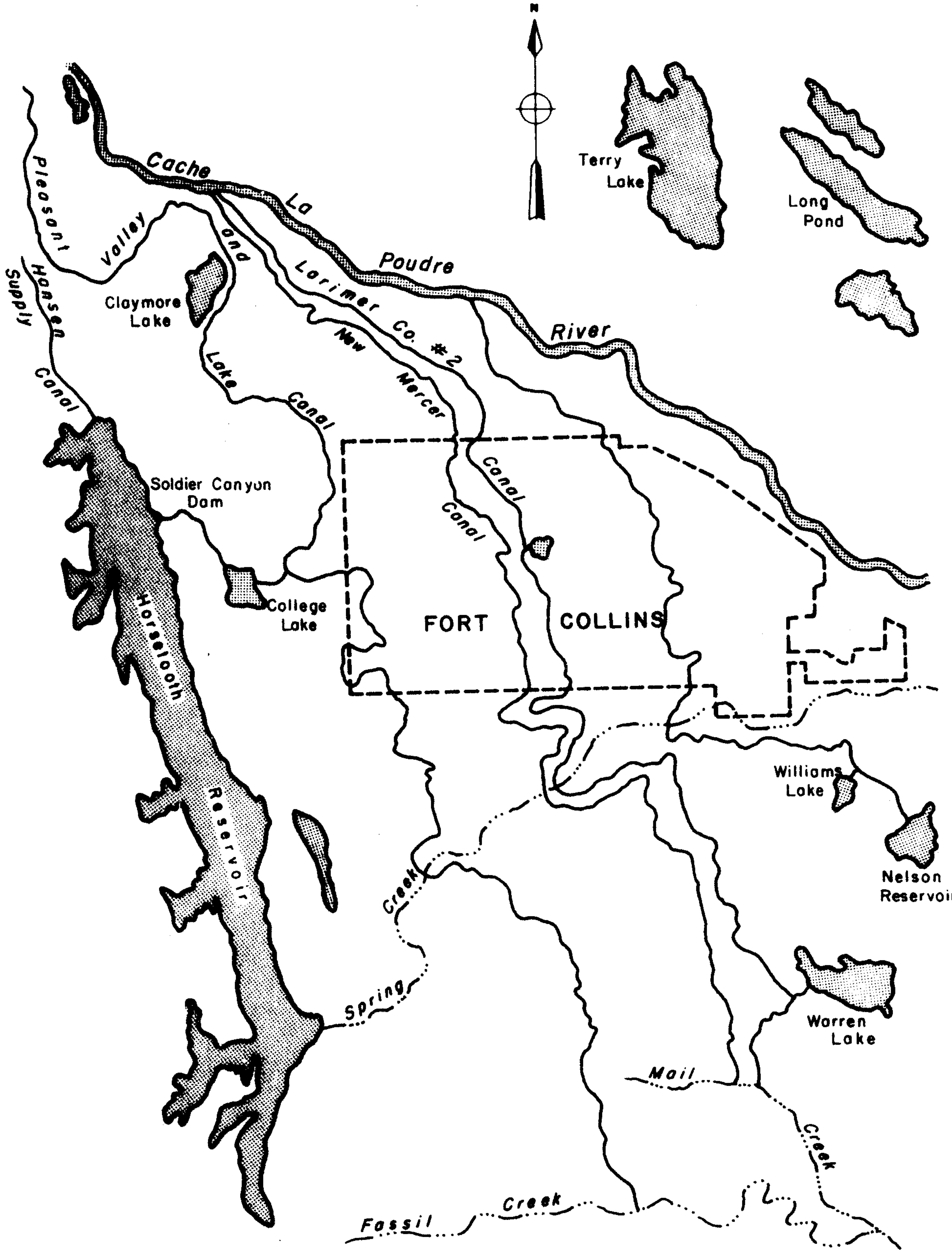
TABLE 6-18. Value of Potential Average Monthly Water Transfers, Utah Valley Water Districts, 2000 Estimates. ($)

Area	Oct.	Nov.	Dec.	Jan.	Febr.	Mar.	Apr.	May	June	July	Aug.	Sept.	Average Annual
North Utah Valley													
Jordanelle Capacity													
150,000 ac.ft.	0	12	0	0	0	0	0	5370	0	0	0	13609	18991
225,000 ac.ft.	0	12	0	0	0	0	0	5370	0	0	0	13609	18991
325,000 ac.ft.	0	12	0	0	0	0	0	5370	0	0	0	12865	18991
1,000,000 ac.ft.	0	0	0	0	0	0	0	0	0	0	0	9672	9672
South Utah Valley													
Wasatch Ag. Capacity													
9,000 ac.ft.	8	0	0	0	0	0	0	0	2990	1794	0	0	4792
10,000 ac.ft.	8	0	0	0	0	0	0	0	2990	1794	0	0	4792
11,000 ac.ft.	8	0	0	0	0	0	0	0	1040	1794	0	0	2842

TABLE 6-19. Value of Potential Average Monthly Water Transfers, Utah Valley Water Districts, 2020 Estimates. ($)

Area	Oct.	Nov.	Dec.	Jan.	Febr.	Mar.	Apr.	May	June	July	Aug.	Sept.	Average Annual
North Utah Valley													
Jordanelle Capacity													
150,000 ac.ft.	0	232	206	114	18	0	0	3450	0	0	0	5983	10003
225,000 ac.ft.	0	232	206	114	18	0	0	3450	0	0	0	5983	10003
325,000 ac.ft.	0	232	206	114	18	0	0	3450	0	0	0	5983	10003
1,000,000 ac.ft.	0	232	206	114	18	0	0	3450	0	0	0	5983	10003
South Utah Valley													
Wasatch Ag. Capacity													
9,000 ac.ft.	0	0	0	0	0	0	0	0	39	12818	3312	0	16169
10,000 ac.ft.	0	0	0	0	0	0	0	0	39	12818	3312	0	16169
11,000 ac.ft.	0	0	0	0	0	0	0	0	0	2574	3312	0	5886

FIGURE 6-7. Map of Existing System in Cache la Poudre System



Water in the system can be divided into the three categories of river water, Colorado-Big Thompson water, and river-to-storage water. River water is water diverted from the Cache la Poudre River. The amounts diverted are determined by the size of the decree held. Table 6-20 lists the water rights held by the ditch companies. These decrees are filled when the river reaches the required level. The Arthur Canal, for example, receives its first decree of 0.72 cubic-feet of water per second when the river flow is 4.22 cubic-feet per second.

Colorado-Big Thompson Project water is water obtained from the Colorado River Basin to supply supplemental water to the Eastern Slope of Colorado. Colorado-Big Thompson water received by this system is stored in Horsetooth Reservoir and is released to its users by way of the Hansen Supply Canal and the Cache la Poudre River or through College Lake.

River-to-storage water is water carried by the ditches to small plains storage reservoirs. Some of these reservoirs are owned by the ditches, while others are owned by separate companies. This water is not directly turned out onto the crops, but it does contribute to seepage losses, but does facilitate more efficient water use.

The climate of the study area is characterized by a low relative humidity, an annual precipitation of less than 15 inches, cold winters, and warm summers. Most of the precipitation occurs between April and September. The distribution of the precipitation during this period is often erratic, and long dry periods often occur during the growing season. The mean annual temperature of the study area is 48°F., though temperatures have been recorded above 100°F. and below -40°F.

The irrigated farming is located primarily in the uplands and valleys. Crops raised on these farms include sugar beets, corn, alfalfa, and small grains. The world's largest cattle feedlot is contained in the study area.

The geology of the study area is not described in this report. The interested reader may refer to the Geological Survey Water Supply Paper 1669-X for a detailed discussion.[45] Wells in the study area are reported to yield an average of only 15 gallons per minute from the sediment deposits. The sediment deposits are recharged by seepage from canals and by percolation from city water applied to lawns and small gardens.

The existing irrigation system is an intricate organization of closely paralleling ditches and laterals. The development of the existing system was shaped by the random course of events. In contrast to this haphazard system, three consolidation plans have been proposed that supposedly would maximize efficiency while minimizing costs.[46]

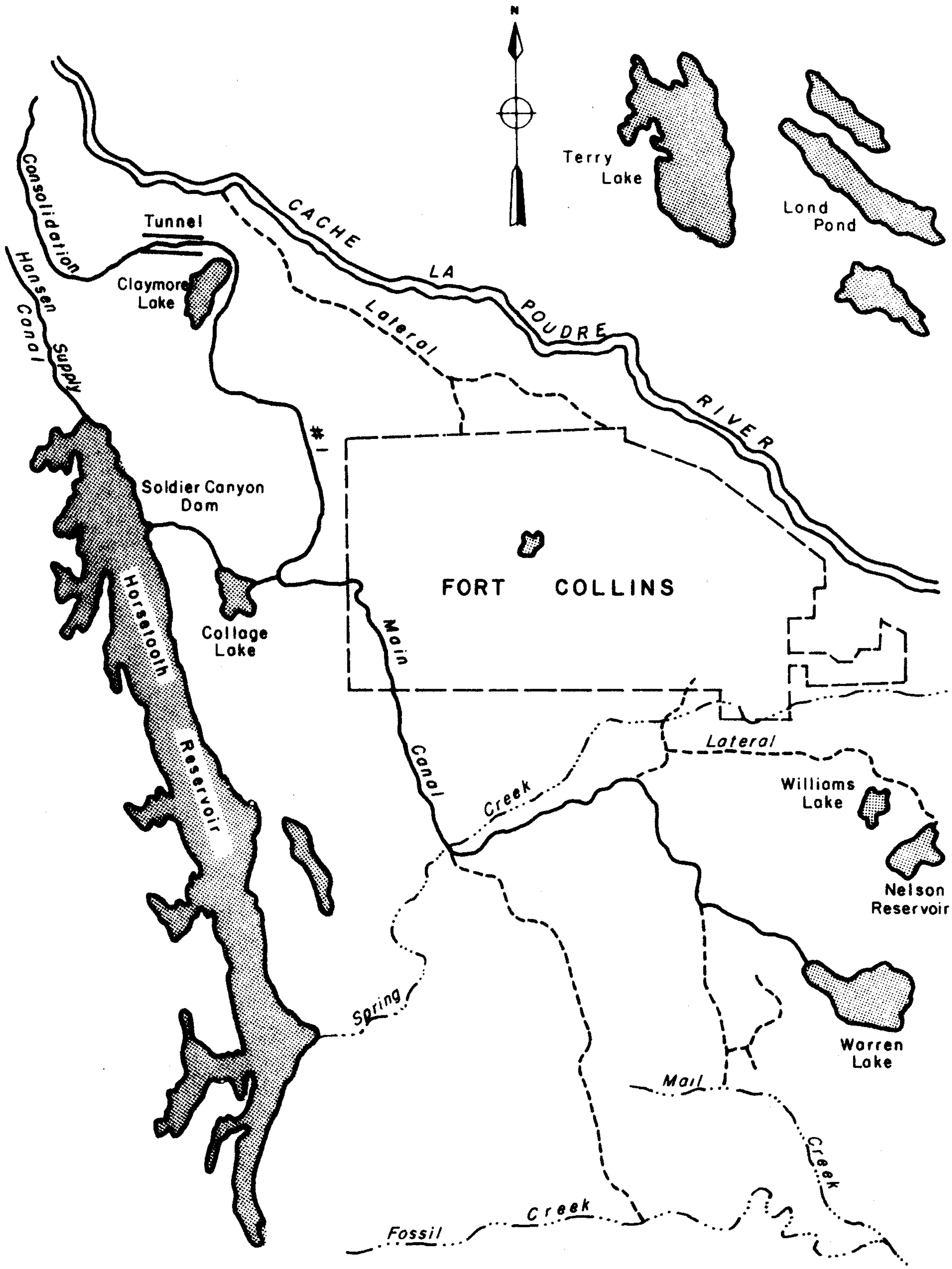
The first consolidation plan is to consolidate four ditches into one. Figure 6-8 shows the proposed layout of the plan. Since the land now served by the four existing ditches is essentially that south of Fort Collins, water would be carried in an enlarged Pleasant Valley and Lake Canal to the south side of the city. It would then turn eastward and connect with the existing New Mercer Canal and the Larimer County #2 Canal. A lateral would be extended to the Arthur Canal. The lower portions of the existing ditches would be used as laterals.

TABLE 6-20. Water Rights on the Cache la Poudre River

Company	Priority Number	Date	Decree (CFS)	Required River Flow to Fill Decree (CFS)
Arthur	2	6-1-1861	0.72	4.22
P.V. & L.C.	4	9-1-1861	10.97	27.58
P.V. & L.C. 1st Enl.	11	6-10-1864	29.63	224.01
Larimer Co. #2	14	5-1-1865	4.00	300.00
Arthur	19	7-1-1866	2.16	335.13
New Mercer	25	10-1-1867	7.03	391.89
Arthur	29	6-1-1868	2.16	403.41
Arthur	32	6-1-1869	1.67	481.25
New Mercer	33	9-1-1869	4.17	485.42
Arthur 1st. Enl.	38	4-1-1871	31.67	693.51
New Mercer 1st. Enl.	47	10-10-1871	8.33	1047.84
New Mercer 2nd. Enl.	49	7-1-1872	15.00	1085.22
P.V. & L.C. 2nd. Enl.	51	7-10-1872	16.50	1164.85
Arthur 2nd Enl.	52	7-20-1872	18.33	1183.18
Larimer Co. #2	57	4-1-1873	175.00	1573.31
Arthur 3rd. Enl.	66	9-1-1873	52.28	1682.77
P.V. & L.C. 3rd. Enl.	92	8-18-1879	80.83	2867.41
New Mercer 3rd. Enl.	99	2-15-1880	136.00	3340.36

Source: Michael Wayne Biggs, Irrigation System Consolidation Research Report (Fort Collins, Colorado: Colorado State University, 1968), p. 12.

FIGURE 6-8. Map of Consolidation Plan No. 1



Claymore Lake would be used as a regulating reservoir. A 1,850 foot tunnel would be required through Bingham Hill in order to raise the level of the lake. This would also eliminate two and one-half miles of ditch around the hill and an area of high seepage losses.

During the past years, the Pleasant Valley and Lake Canal has used the Soldier Canyon Dam outlet from Horsetooth Reservoir to obtain its Colorado-Big Thompson water. Presently, the Colorado State University Hydraulics Laboratory uses the Soldier Canyon outlet to obtain water for its research work. The water is then passed on to College Lake. Under the first consolidation plan, all the Colorado-Big Thompson water would be conveyed through this system. Colorado-Big Thompson water would no longer have to travel by way of the Hansen Supply Canal and the Cache la Poudre River. Approximately twelve miles of conveyance would be eliminated. The hydraulics laboratory would also have additional water available for non-consumptive use. College Lake would be raised to furnish an additional 500 acre-feet storage.

The second consolidation plan differs from the first only in that it does not include the Arthur Canal. Figure 6-9 displays the proposed plan. The reason for this plan is that the Arthur Canal's Board of Directors has not shown a willingness to participate in a consolidation of their ditch with any or all of the other ditches.

The Board of Directors of the Arthur Canal does not want to partici-page in a consolidation because the costs involved would be greater than the benefits received. The ditch already receives more water than it needs. Its seepage and evapotranspiration losses are more than made up by the drainage water it receives from Fort Collins. Since much of the land in the city is covered with buildings and asphalt streets, water that would normally soak into the ground drains off and flows into the ditch.

Another reason is that much of the land served by the Arthur Canal is rapidly changing from agricultural use to urban use as the city expands. As this occurs, the ditch serves less land and therefore has more excess water. If the city's growth continues at its present rate and in the same southeasterly direction, the Arthur Canal will not have any farms to serve in the near future and the ditch will be abandoned. Since the future life expectancy of the ditch is relatively short, the Board of Directors does not want to incur a debt for the construction of a consolidated ditch for which future revenues may not be available to repay.

The third consolidation plan is to consolidate the New Mercer Canal and the Larimer County #2 Canal. The parallel and duplicate operation of these two ditches represents the most conspicuous inefficiency of the existing system. As shown in Figure 6-10, the consolidated ditch would use essentially the same right-of-way as the existing two ditches. The total ditch length would be reduced from the present 26.1 miles to 11.3 miles.

The debate over the proposed consolidation plans has been a heated one, and in many instances more heat than light has been generated on the subject. Those in favor of the project are essentially the farmers

FIGURE 6-9. Map of Consolidation Plan No. 2

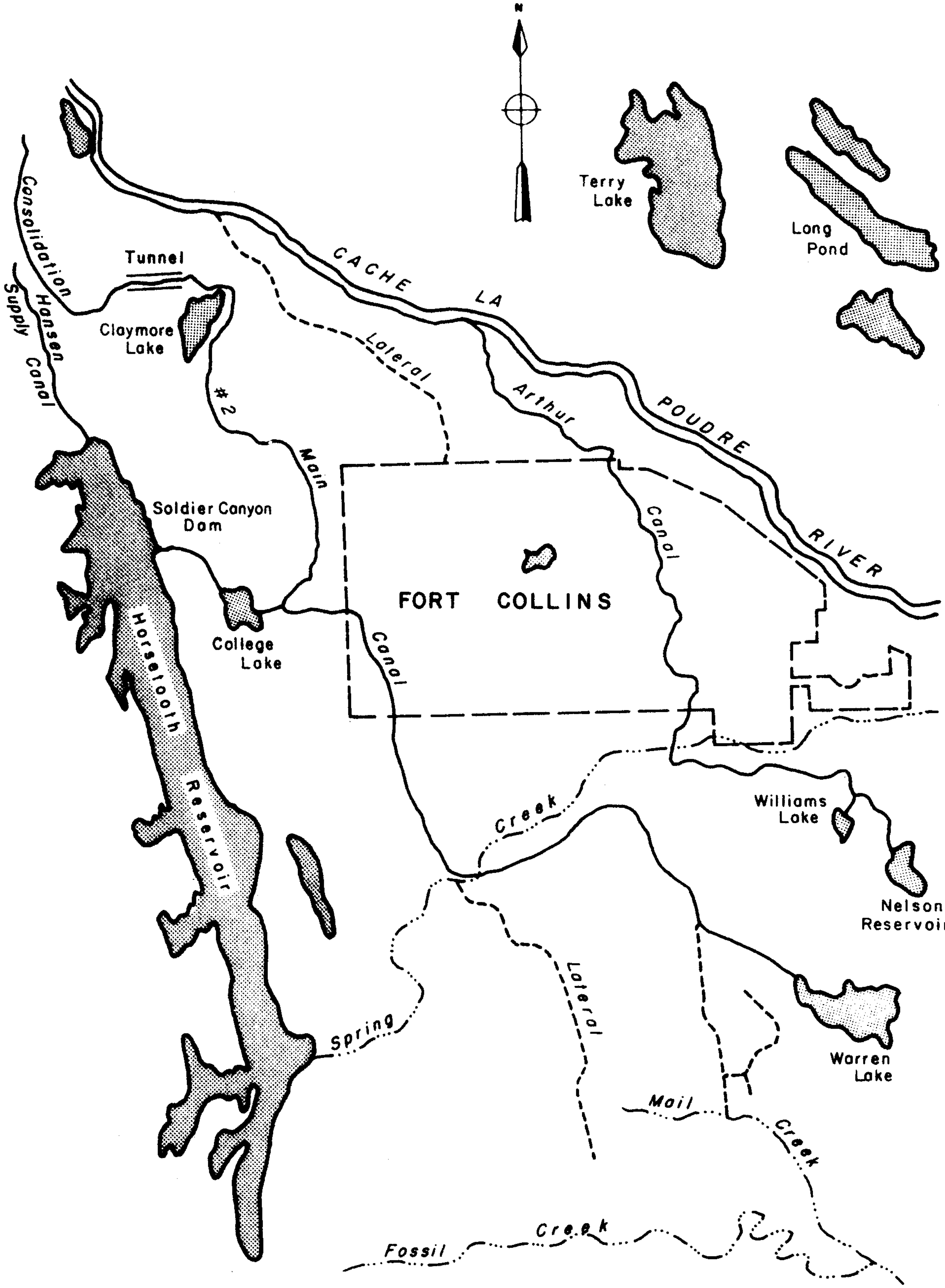
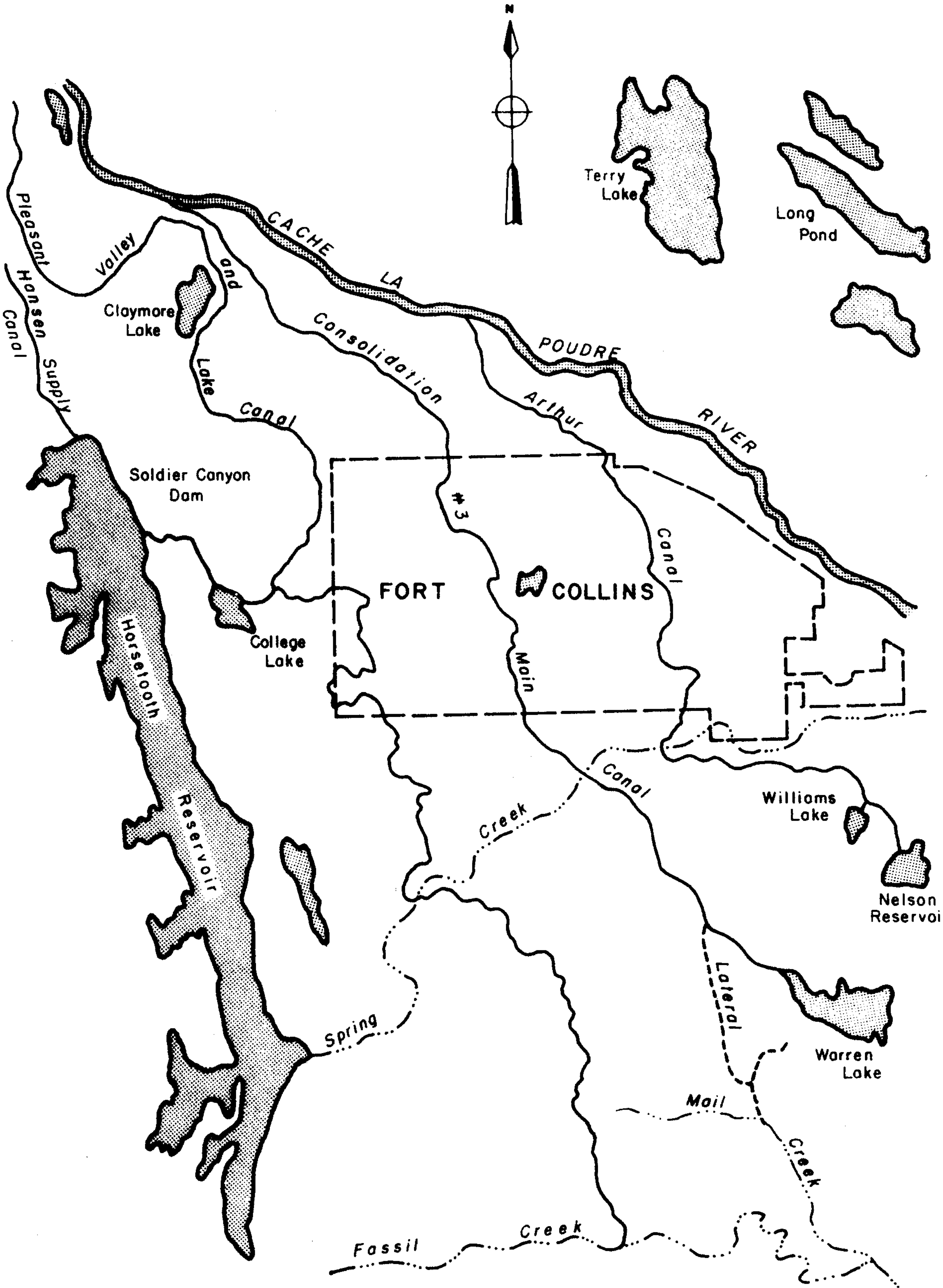


FIGURE 6-10. Map of Consolidation Plan No. 3



who presently receive an inadequate supply of water and who hope to get more water through a consolidation. Also many of the Fort Collins residents are in favor of the consolidation plans in the hope of eliminating the ditches that now pass through the city.

The ditch companies of the existing system are opposed to the consolidation plans. All the ditch companies, except the Arthur Canal, feel they would benefit from a consolidation which included their ditch, but they do not feel that the benefits received would be greater than the cost.

There is also the problem of obtaining the necessary right-of-way. When the original ditches were constructed, farmers permitted the ditch companies to construct the ditches through their land without charge, even if they were not served by the ditch. The situation is different now. Landowners would demand high prices for right-of-ways through their land and court proceedings to determine right-of-ways might be drawn out for years.

The biggest problem, however, seems to be the unwillingness to change. This and the lack of information available on the proposed projects have resulted in nothing being done. The existing system works, though it appears to do so at the price of inefficiency. The consolidation plans appear desirable, but with no data on their actual operation, their desirability is easily questioned.

An earlier study by Huszar[47] evaluated the economic effects of these three consolidation plans both in terms of the entire Poudre water system and in terms of just the four ditches to be consolidated. The four ditches proposed for consolidation are considered to be the upper system, while other ditches affected by the operation of this system through return flow and seepage is called the lower system.

The benefits and costs of the three consolidation plans are summarized in Table 6-21. The benefits are in terms of the value of the increased irrigation water to the upper system. The costs are the sum of the construction costs to the upper system and the value of the decreased return flow water to the lower system. The net benefits are the differences between the benefits and the costs. Values are presented in terms of 80 per cent simultaneous confidence intervals.

The net benefit of the third consolidation plan statistically is zero at the six per cent discount rate. That is, the net benefit interval at the six per cent discount rate contains zero and, therefore, there is no significant difference between the benefits and the costs. However, since the interval tends toward the positive side of zero, it appears that the benefits are greater than the costs.

The net benefits for the first and second consolidation plans are negative. The dollar limits of the net benefit intervals for the second consolidation plan, however, are larger than those for the first consolidation plan.

Note that the benefits and costs are in terms of the differences between the existing system and one of the consolidation plans. If no change occurs, then the benefits and costs are zero. That is, the net benefits of the existing system are zero.

TABLE 6-21. Summary of Discounted Benefits and Costs

Plan	Benefits	Costs	Net Benefits
Consolidation No. 1	$2,597,373 : $2,944,821	$5,191,217 : $5,838,515	-$2,893,694 : -$2,593,844
Consolidation No. 2	1,401,617 : 1,749,065	2,525,589 : 3,172,888	- 1,423,823 : - 1,123,972
Consolidation No. 3	1,338,713 : 1,686,162	1,103,929 : 1,751,227	- 65,065 : 234,784

In terms of the entire system, the third consolidation plan is the most preferred, with the existing system, the second consolidation plan and the first consolidation plan following in that order. The net benefits of the third consolidation plan are positive; the net benefits of the existing system are zero; and the net benefits of the second and first consolidation plans are both negative, with the second consolidation plan having the larger net benefits. The preference ordering of the entire system is summarized in Table 6-22.

The third consolidation plan also appears to have the most desirable benefit-cost ratio. Both the first and second consolidation plans have benefit-cost ratios of less than one. If the corresponding lower and upper limits of the benefits and costs of the third consolidation plan are compared, however, it is questionable if the benefit-cost ratio exceeds one.

Since the actual value of the benefits and the costs may lie anywhere in the confidence intervals, it is possible that the actual amount of the benefits will be equal to the lower limit of the benefit interval and that the actual amount of the costs will be equal to the upper limit of the cost interval. If this is the case, then the third consolidation plan is not financially feasible.

The conclusions to this point have been based on the welfare criterion. However, if only the upper system is considered, the preference ordering of the three consolidation plans and the existing system would be different. The preference ordering for the upper system based on net benefits is given in Table 6-23.

In addition, there are three major limitations associated with the analysis: 1) only two interest groups are considered; 2) only the water value is measured; and 3) non-monetary benefits and costs are not considered.

The analysis only takes account of the upper and the lower irrigation systems. A potentially important third interest group is the city of Fort Collins. Fort Collins has several things to gain by the consolidation of some or all of the ditches.

In recent years the city has studied the possibility of coordinating the city's storm water drainage with one of the consolidation plans. It has been suggested that the Larimer County #2 Canal might be used in such a drainage system.

Another potential benefit to the city is the additional land made available by abandoned ditches. Both the actual right-of-way and the land not used due to the disruptive effect of the ditches could be reclaimed. A considerable amount of land is involved. The cost of building and maintaining the bridges and culverts necessitated by the ditches could also be greatly decreased by consolidation.

The city of Fort Collins has not shown a willingness to participate in any of the consolidation plans. Though the city stands to gain by a consolidation, it will not lend its financial support. Under a more progressive city management, however, the city of Fort Collins might carry

TABLE 6-22. Preference Ordering for the Entire System Based on Net Benefits Discounted at 6 Per Cent

Preference	System
First	Consolidation No. 3
Second	Existing System
Third	Consolidation No. 2
Fourth	Consolidation No. 1

TABLE 6-23. Preference Ordering for the Upper System Based on Net Benefits Discounted at Both 3½ Per Cent and 6 Per Cent

Preference	System
First	Consolidation No. 3
Second	Consolidation No. 1
Third	Existing System
Fourth	Consolidation No. 2

part of the burden of cost to adopt one of the consolidation plans. This occurrence would, of course, alter the previous analysis.

By dealing only in terms of the value of the water, the analysis ignores the effects of a change in the operation, maintenance and management of the ditches with respect to the employment of resources. Unemployment of resources (including labor) is a cost to the resource and a savings to the employer. The net effect may be capable of influencing the analysis.

The non-monetary benefits and costs of any reorganization are the most difficult to ascertain. The danger to life and property due to open ditches flowing through residential areas would be reduced by a consolidation. On the other hand, the risk and uncertainty which accompany change are non-monetary costs. Non-monetary considerations have not been included in the analysis, but they must be weighed in the final analysis.

There is also the possibility that none of the consolidation plans will be adopted. Much of the land served by the Arthur Canal is being developed as residential housing and the other ditch companies may feel that this general trend applies to them too. The future life of their ditch would, therefore, be limited and the feasibility of a major construction plan would be poor.

Another difficulty in constructing a consolidation plan is obtaining the necessary right-of-way. The third consolidation plan would probably not have this problem, since it only calls for the consolidation of two ditches that flow side by side already. In the cases of the other consolidation plans this could be a lengthy and costly problem. Lengthy in that it might require years of bargaining and court proceedings to obtain the right-of-ways. Costly in that each landowner would try to get the highest price for the right-of-way through his land. Legal expenses could also be a major cost.

Notes

1. Little, I. M. D. <u>A Critique of Welfare Economics</u> (London: Oxford University Press, 1965), p. 52.

2. <u>Ibid</u>., p. 52.

3. <u>Ibid</u>., p. 15.

4. Reder, Melvin Warren. <u>Studies in the Theory of Welfare Economics</u> (New York: Columbia University Press, 1951), p. 14.

5. Little, <u>op cit</u>., p. 84.

6. Reder, <u>op cit</u>., p. 16.

7. <u>Ibid</u>., pp. 16-17.

8. <u>Ibid</u>., pp. 94-95.

9. Baumol, William J. <u>Business Behavior, Value and Growth</u> (New York: The Macmillan Company, 1959.

10. Huntzinger, Thomas L. <u>Future Water Use in the Utah Valley</u> (Fort Collins, Colorado: Colorado State University, 1971).

11. Hartman, L. M. and Don Seastone. <u>Water Transfers: Economic Efficiency and Alternative Institutions</u> (Baltimore: The Johns Hopkins University Press, 1970), p. 27.

12. Keith, John. <u>The Economic Efficiency of Inter-Basin Transfers of Agricultural Water in Utah: A Mathematical Programming Approach</u> (Logan, Utah: Utah State University, 1973), p. 19.

13. Dewsnup, Richard L. and Dollin W. Jensen, editors. <u>National Water Commission: A Summary-Digest of State Water Laws</u> (Arlington, Virginia: National Water Commission, 1973), pp. 715, 726.

14. Huntzinger, <u>op cit</u>.

15. Huntzinger, <u>ibid</u>., pp. 62-70.

16. Keith, <u>op cit</u>., pp. 39-40.

17. <u>Ibid</u>., p. 62.

18. Anderson, Thomas C. <u>Water Resources Planning to Satisfy Growing Demand in an Urbanizing Agricultural Region</u>. (Logan, Utah: Utah Water Research Laboratory, College of Engineering, Utah State University, 1972), p. 25.

19. Huntzinger, <u>op cit</u>., p. 62.

20. Hyatt, M. Leon, et al. Hydrologic Inventory of the Utah Lake Drainage Area (Logan, Utah: Utah Water Research Laboratory and Utah Division of Water Resources cooperating, Utah State University, 1969), pp. 90, 129.

21. Thorne, James P., and D. W. Thorne. Irrigation Waters of Utah (Logan, Utah: Division of Agricultural Sciences, Utah State Agricultural College and U.S. Department of Agriculture cooperating, 1951), p. 20.

22. Jeppson, Roland W., et al. Hydrologic Atlas of Utah (Logan, Utah: Utah Water Research Laboraotry, Utah Agricultural Experiment Station, Utah State University, 1968), p. 59.

23. Hyatt, op cit., p. 126.

24. U.S. Bureau of Reclamation. Central Utah Project Initial Phase. Bonneville Unit. Definite Plan Report. Appendix C. Project Lands. Region 4, Salt Lake City, Utah, 1964. p. 8.

25. Anderson, Mark H. An Economic Analysis of Supply and Demand for Irrigation Water in Utah: A Linear Programming Approach. Logan, Utah: Utah State University, 1973., p. 54.

26. Huntzinger, op cit., p. 76.

27. Hyatt, op cit., p. 101.

28. Anderson, Thomas C., op cit., p. 17.

29. Hyatt, op cit., pp. 107-128.

30. Anderson, Mark H., op cit.

31. Ibid., p. 24.

32. Hyatt, op cit., p. 12.

33. Snedecor, George W. and William G. Cochran. Statistical Methods. Ames, Iowa: The Iowa State University Press, 1967.

34. James, L. Douglas and Robert R. Lee. Economics of Water Resources Planning. New York: McGraw-Hill Book Company, 1971.

35. Biggs, Michael Wayne. Irrigation System Consolidation Research Report. Fort Collins, Colorado: Colorado State University, 1968.

36. Huszar, Paul C., David W. Seckler and Donald D. Rohdy. Economics of Irrigation System Consolidation. Experiment Station Bulletin No. 105, p. 36. Fort Collins, Colorado: Colorado State University, 1969.

37. U. S. Bureau of Reclamation. Series 150. Estimating Reclamation Instructions. Appendix A. Denver, 1969.

38. Stevens, George and Charles P. Merrick. *Cost of Irrigation Systems*. College Park, Maryland: University of Maryland, 1970, p. 93.

39. *Ibid*., p. 181.

40. Bagley, Jay M. and Wayne D. Criddle, *Evaluation of Sprinkler Irrigation Systems in Northern Utah*. Utah Agricultural Experiment Station Bulletin 387, Division of Agricultural Sciences, Utah State Agricultural College and U.S. Department of Agriculture cooperating, p. 28.

41. Hudson, James. *Irrigation Water Use in the Utah Valley, Utah*. Chicago: The University of Chicago, 1963, p. 192.

42. Haws, Frank W. *A Study of Water Institutions in Utah and Their Influence on the Planning, Developing, and Managing of Water Resources*. Logan, Utah: Utah Water Research Laboratory, College of Engineering, Utah State University, 1973, p. 50.

43. Huntzinger, *op cit*.

44. Whittlesey, Norman K. "Valuing Irrigation Water in the Uncompaghre Project." Fort Collins, Colorado: Colorado State University, 1960. Unpublished master's thesis.

45. Hershey, Lloyd A. and Paul A. Schneider, Jr., "Ground-Water Investigations in the Lower Cache la Poudre River Basin, Colorado." *Geological Survey Water-Supply* Paper 1669-X (Washington: U.S. Government Printing Office, 1964), p. X6.

46. Biggs, *op cit*.

47. Huszar, *op cit*.

7.1 Preliminary considerations

Previous chapters have already discussed in a general manner some requisites for building the basis for implementation. Having discussed the generation of alternatives in Chapter 5 and the evaluation of water management plans in Chapter 6, we need some more specific remarks as to concrete steps for proceeding with concrete steps in implementing appropriate solutions. Two immediate concerns must be brought forward at this poing: first the importance of the physical situation; and, second, pre-merger negotiation.

7.1.1 Physical situation

When attempting to decide whether to form a company or to federate several companies that already exist or to consolidate and merge some companies or whether to go public, the first thing that must be considered is the physical situation faced by the individuals. Clearly, when two individuals want to form a company, they should be in fairly close physical proximity to each other. It must be remembered that the physical situation is directly related to the economic situation because an expenditure is going to be needed to overcome certain physical problems, such as a mountain range. Even a hill between two individuals could provide an insurmountable barrier to individuals trying to form a company. A matter of even ten miles across flat prairie may prove to be too much to surmount for a couple of individuals who want to form a company. They may simply not have the capital to join facilities across even this small stretch of land. When attempting to recommend to companies as far as their physical situation goes, the choice of a federation has to be looked at.

A federation, it will be remembered, is simply several companies joining together for one purpose and then disbanding that federation after that purpose is accomplished. Clearly, then, physical situation must be taken into account for, if it is too expensive to surmount physical problems, the federation will be impossible, as they are simply coming together for a short term venture. It is strongly advisable to not get them in too deep financially. If they are joined in a federation in a financial venture which will require them to stay a very long period of time to finance the project, the requirements of the project may frustrate their intent. They may be forced to stay together longer than they want to. Similarly, when deciding whether to recommend consolidation or merger of companies that exist, the physical constraints must be considered in a similar light to the constraints seen in deciding whether to federate or not. It is obvious that two companies which would be separated by a geological distance would not want to consolidate because the first thing they would have to do is expend considerable sums of money to join their facilities together--sums of money which they may not be able to raise. Additionally, the existing facilities of each company would have to be taken a look at to insure that those companies were contributing something to the consolidation or merger and that not too much rennovation was going to have to be undertaken on the part of the remaining company or the new company in order to use the facilities of one of the contributing institutes.

The geographic constraint may lead to a recommendation of the public status. For example, if there were several companies separated by large geographic areas from each other, but it appears that a basinwide approach seems far more efficient, then a public entity might be on the proper solution. In such a case it is possible to have a very large reservoir supplying a large area and the public funding would make it possible to merge the existing physical facilities into a workable unit--something that would not be possible on a small private basis. And for that reason, the social and political considerations may be outweighed by the practical consideration of not being able to do anything unless public status is undertaken.

7.1.2 Pre-merger Considerations

One major aspect of merger and consolidation takes place much before the actual events of merger or consolidation, namely the pre-merger negotiations. From these negotiations it will be determined whether there will in fact, be a merger or consolidation at all. While we do not intend to enter into any great detail or to discuss in a technical manner each area, we want simply to list some major areas of concern in preliminary negotiations.

With irrigation companies, as with all companies, statutory authority must be consulted, keeping in mind that some states still do not allow merger or consolidation of a domestic corporation with a foreign corporation. Without statutory authority, the transaction is impossible. Where it is possible, it is provided in some cases, that the surviving corporation must be a domestic corporation. Where public entities are involved, mergers or consolidations are prohibited except with corporations of the same stature or in the same business. Where a corporation has a large number of stockholders a stock acquisition is difficult to handle and a deal whereby the assets of the corporation are simply taken over with no liabilities. (After all liabilities are paid off) or a merger or consolidation is normally indicated (although the stock acquisition is not impossible and can be undertaken if it is desired by the parties).

There is a right of appraisal in all mergers and consolidations and sometimes in an asset sale, dissenting shareholders are granted the right to have their shares purchased by the corporation. If these dissenting shareholders are numerous, the drain on the corporations cash may be so severe that it cannot continue operations. The time involved in valuing the shares of the dissenting shareholders may prevent the deal from being consumated at all.

Additionally, when considering a purchase of stock there may be unwanted assets which are represented by the stock, such as contracts, sales agreements, pension plans or leases which are not wanted at all by the buyer. If these exist, then the buyers will prefer an assets deal whereby all liabilities are paid and strictly the assets are taken. It is important to remember to find out whether the contracts are assignable as many are not. When these contracts are important to the transaction, stock acquisition, merger or consolidation is required.

When non-assignable contracts are present and the buyer must nevertheless have a contract and it is not renegotiable, the only option left is to purchase the stock of the corporation. There may be outstanding loans which call for consolidation of payments when the party is involved in a merger or consolidation. If these are outstanding they will have to be paid off as the collateral for the loan will be impaired by virtue of a consolidation.

The corporate name is not a problem. When a corporation ceases to exist, it may, because of merger or consolidation, be desirable to perpetuate the name in the state where it is doing business. As has been pointed out earlier in this report, it is sometimes more palatable to the selling corporation to remain alive, even though momentarily, rather than to be absorbed by another corporation. For this reason, consolidation may be preferred to merger. The expenses incurred, such as the federal stamp tax, payable on newly issued stock, if the transaction is to be large, can be fairly substantial expenses. A sale at least in an asset transaction, calls for payment of a sales tax. Also, personal state income taxes may be levied on the sale or exchange of stock by the stockholders. Franchise taxes may be increased if they are paid on the actual value of the corporation and the sale price is greater than the value shown on the books. Such things as registered motor vehicle licenses, state licenses, that have to be paid a second time if they are to be under new entities. An experience rating under unemployment conpensation and workmen's compensation is lost in asset transaction and perhaps in a consolidation, whereas a stock transaction will not affect this rating. With a favorable experience rating there is a lower tax than with an unfavorable rating and the acquisition of a company with a bad experience rating occurs, this may increase the tax of the buyer. Moreover, there are problems after acquiring property if the buyer has a mortgage outstanding. He may want to purchase the new organization under a subsidiary and even then some restrictions may be imposed under the terms of the mortgage. It must be remembered, too, that an assets transaction of substantially all the property of the seller, merger or consolidation, will call for the approval of not only the board of directors but also the shareholders of both corporations. The percentage frequently prescribed by statue is two-thirds. It may be difficult to obtain this percentage.

For convenience and flexibility in strictly mechanical terms, a stock transaction is usually the most convenient when the shareholders number is small. When the number is large an assets deal is generally a simpler process. Consolidation is a complicated matter but, for the seller, it may be preferable since the assets and the stock are transferred to one operation. On the other hand, an assets deal involves bills of sale, deeds, and assignments and can lead to as much paperwork as with a merger or consolidation.

The flexibility attending a merger provides a framework which is lacking in the other options. For example, different classes of stock with securities can be given different groups (with a control group normally receiving somewhat less an advantageous exchange than the public stockholders).

In order to meet these requirements and in order to be able to rationally respond, several options have to be examined. First, the letter of intent which is frequently drawn up as a memorandum of substantive points which have been agreed upon. If it exists, it is only the first document to be examined and normally only covers major points. Additionally, the state's corporation act must be read from literally cover to cover as it will be the law governing basic corporation existence. And the charter and the by-laws of the corporation need to be examined for such problems as how directors meet with stockholders or the corporation having the right of the first refusal of sale of any securities and the rights of certain stockholders to elect certain numbers of directors. Any contracts which are outstanding will have to be carefully read and it will have to be determined whether they are assignable. With employment contracts, it must be found whether the employment contracts are with key personnel to see whether their duties may be changed and whether there is deferred compensation arrangement which will have to be met. With non-key personnel there may be union contracts to be dealt with severance pay provisions, trust funds, trust fund provision, medical payments to be made to a certain corporation which are going to have to be dealt with. When these contracts expire is important as well and the general climate for a raise in wages for a new contract should also be examined, as well as the history of union shutdowns, slowdowns, grieveances or arbitrations involved over this particular company. The buyer does not want to be buying problems.

This discussion on negotiations assumes that the corporations involved are small enough so that they are exempted from Securities and Exchange Commission Laws and that they have not issued any securities or offered any securities which will bring them under the provisions of the Securities and Exchange Commission or state Blue Sky laws.

In summary, the question which always must be asked is what in reality is being purchased? With water rights, water companies, and the consolidation, the major concern is the water rights because a company which has a set of rights owned by stockholders is going to be merged with another company who has stockholders with a different set of rights. It is important to note the dates of all the rights, the locations of the rights, the volumes of the rights and to insure that everyone will get the water that they are now getting. If there are no adequate storage facilities available to insure that no one will be cheated or will not get his rights of waters that he is presently getting, it is a certainty that there will be a severe backlash from the stockholders after the consolidation and much agitation for dissolving the consolidated company.

If the water rights are represented by shares, the priority of these rights, the location and the volume are still going to have to be ascertained because it is on these things that the value of the share representing the water rights will be determined. If the deal is going to be one involving transfer of shares where one company will give its shares to the buying company in exchange for shares of that buying company, the value of both shares are going to have to be determined in order to find out how much stock is going to have to be given to the seller to adequately compensate them for what they are giving up.

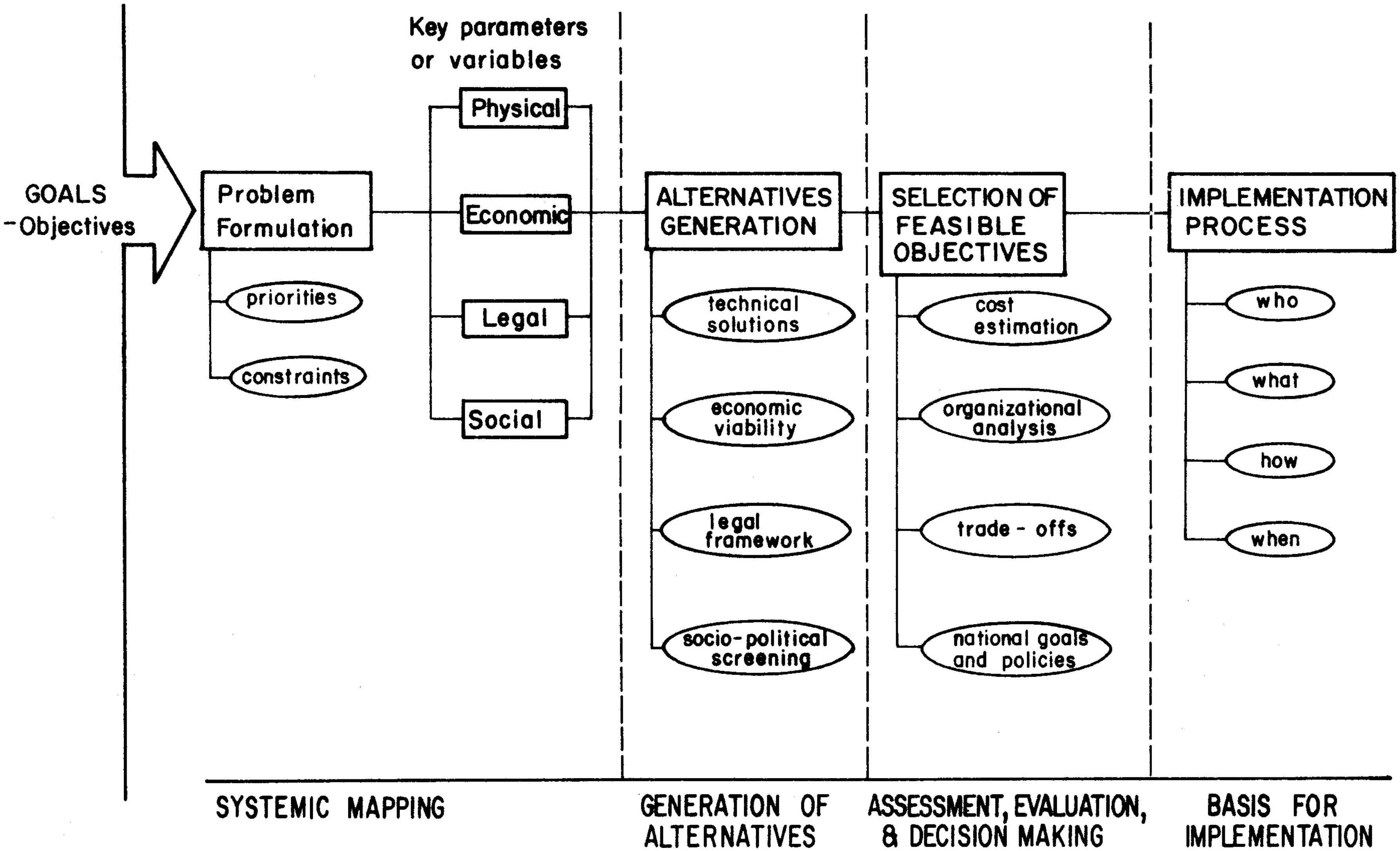
7.1.3 Ownership of Water in the Companies

Percentage ownership may be described as a right to a part of a reservoir owned by a company, the right to that percentage of the reservoir by the customer of the company which owns the reservoir. A volume ownership is a claim to a certain amount of water at a certain time and looks much like a basic appropriation. Finally, renting is simply a contract between the company and the user to get a certain amount of water usually on a yearly basis for the period of the rent.

Disscussion of the relationship of the consumer to the carrier ditch company involves problems in semantics.[1] An appreciation of legal problems which can arise between the water user and the company or between the company and third person is not notably aided by a discussion of the appropriation right and the ownership of water under the appropriations doctrine. The real problem which the courts face is giving some protection to the ocnsumer when a company discontinues its water for one reason or another.[2] The problem is to find out what the consumer's relationship is to the company; that is, may he receive water only at the whim of that company or is his relationship to the company so close that he cannot sell the water right or how easily may the company raise the rates for water?

When looking at these questions, it is clear that simply saying that he has a property right or right of service is not the answer to the question. Despite the fact that the consumer merely has the "right of service" the California State courts have resisted giving substantial protection in relationship to the carrier. For example, he is entitled to have the water supply continued unless there is a shortage for which the company is not responsible, and it has been suggested that when there is a shortage the water must be fairly apportioned among all consumers.[3] Moreover, the rates are regulated by the public utilities commission[4] which offers additional protection to the user in that he has the opportunity to publicly object. The courts have apparently reached the conclusion that, when a joint appropriation is involved, it is the carrier who makes the diversion and the irrigation applies the water to beneficial use.[5] The conclusion to be drawn from all of these is that there is a bifurcated situation in most states: that is, between the external relationship between the project and other claimants to the water the distributing agency is regarded as the proprietor of the appropriation. But internally between the distributor and the consumer, the consumer has property rights that the court will protect from arbitrary action by the distributor.[6]

FIGURE 7-1. Building the Basis for Implementation



7.2 Levels of Autonomy and Organizational Integration

All previous remarks in section 7.1 provided an example of the myraids of legal details that accompany a decision to merge or consolidate. Similarly there is a vast number of remarks that can be made for developing proper organizational schemes and working procedures in any alternative water management effort. While there are many ways of developing actual organizational charts and managerial schemes, it is safe to conclude that all of these revolve around three critical requirements:

1. the creation of support through the hiring of appropriate <u>personnel</u>;
2. the rallying of resources through appropriate <u>facilities</u> and the creation of infrastructure;
3. the establishment of organizational <u>procedures</u> or rules of operation.

Rather than expanding on organizational theory and its connection to efforts for consolidation, we may highlight a few items of the type of concern in this area:

a) The need to maintain decision-making at the lowest level possible, an effort which accentuates granroots involvement.
b) The expansion of leadership and the establishment of new lines of command.
c) Expansion and improvement of personnel.
d) Flexibility in rearrangements and the extent to which the organization is capable of alternative organizational arrangements, reassigning of priorities, regrouping of personnel, etc.
e) Resolution of questions of spatial separation and betterment of facilities.
f) Perfecting procedures and rules of operation, recluding specific organization roles.
g) The distribution of functional tasks and the allocation of responsibilities.
h) Steps for incorporating feedback mechanisms and "attention" management in monitoring performance.

All the above are but indicative of the attention that must be paid to an organizational preparedness for meeting the challenge of consolidation. As related in Section 5.3, the underlying concept is one of a transitional process and of an evolutionary scheme involving problem definition (or systemic mapping); generation of alternatives; assessment of alternatives; decision making; and, implementation. Another way of recapitulating here the process of building the basis for implementation is through the help of Figure 7-1.

Assuming that such a process is based on an adequate understanding of all aspects of the problem, on the generation and evaluation of alternatives, and on a proper clarification of institutional arrangements there are some key questions that underline the requirements for an effective implementation process and involve such concerns as:

1. Who implements, or the discovery of the appropriate units and authorities as well as persons for successfully bringing about implementation.
2. How do we implement, or the dymanic process of bringing about social change through exposure, awareness, persuasion, trial, adoption, and confirmation.
3. What do we implement, or the selection of an appropriate mix and strategy of organizational solutions in the context of the socio-economic environment of the particular area.
4. When do we implement, or the strategic timing for bringing about change, the stages and phases of implementation, and the combination of effective social policy in the context of available manpower and economic resources and appropriateness of measures for the minimization of social costs involved in any transformation.

These are, indeed, fundamental questions and raise concern as to a broader commitment ot integrated water resources planning. A few remarks on this last topic may allow us to conclude this brief chapter on setting the stage for efforts of implementation.

7.3 Integrated Water Resources Planning

To be done properly, planning for water development obviously cannot be isolated from the planning of other resources, both natural and human. The use of the term "comprehensive planning" as applied to water resources is not a recent invention but goes back to the turn of the century when in many countries including the United States the term "multi-functional" planning was first introduced.

The comprehensiveness of water resource planning has been the subject of controversy and debate in the literature. It has been recognized, however, that in order to be able to maximize the benefits from any water resource project a much larger systemic analysis of the surrounding environment is needed, a broadening of the horizons of traditionally narrow planning efforts, and increased sensitivity to decision-making problems associated with multi-objective and multi-dimensional interventions.

The beginning and end of comprehensive planning is goal setting. The definition of long-term goals produces medium-term objectives from which quantifiable short-term or immediate targets may be derived. At every level, however, goal setting, the determination of trade-offs, and the establishment of priorities depend primarily on political value judgments.

What we are trying to say above is that in considering, planning and managing a water project we are guided at the same time by an awareness of what indeed such a proposed technical project can do for the larger society. This implies also a striving to adapt to natural conditions; designing facilities relevant to the area; and the respect of local culture and historical continuity.

Given current trends and developments water management, an integrated system of water resources involves the following broader points of concern:

a. Successful development and management of water resources requires much larger institutional and organizational arrangements, quite succinct from the presently prevailing highly segmentalized and individualized approaches in various parts of the world.
b. Norms and cultural values concerning water use must be coordinated within a larger social planning domain, especially with regard to water rights.
c. Each proposed water resource system, independent of its level of analysis, must develop unique patterns much more responsive to the specific people and cultural conditions found in a given region, rather than a simple transferrence of generalized information from other nations.
d. The larger the scope of the water system and the greater the scale of analysis, the more complicated the organizational arrangements and, therefore, the more the need for coordinating powers and comprehensive planning.

By now, we have moved away from our question of consolidation a much more general discussion of holistic water management. But it is important to reiterate that consolidation of irrigation systems is but a facet of a more general preoccupation with efficient, effective and efficacious management of a precious natural resource. Such a general management scheme would involve a balanced approach that would combine in some innovative "social calculus" what is technically sound, economically viable, legally pertinent, socially acceptable, and last, but not least, what is politically feasible. At the end, present and future water management schemes sould require: a) strong incentives for efficent water use ; b) significant structural changes, such as new organizational arrangements; c) "regulatory counter-incentives", such as stricter enforcement and pricing policies; d) fundamental changes in "water intensive" cultural practices.

Notes

1. Trelease, Cases on Water Law, p. 263 (1967)

2. R. E. Clark (ed.), Waters and Water Rights (Vol. 4), §343.1 at 405 (1970).

3. Leavitt v. Lassen Irrig. Co. 157 Cal. 82, 106 P. 404 (1902).

4. Henrici v. South Feather Land and Water Co., 177 Cal. 442, 170 P. 1135 (1918).

5. See Board of County Commissioners of Jefferson County v. Rocky Mountain Water Co., 102 Colo. 351, 79 P. 2d 373 (1938).

6. Trelease, Cases on Water Law, p. 264 (1967).

8.1 Consolidation in Perspective

This study has been a continuation of an earlier phase attempting to provide a general framework of crucial engineering, legal, and sociological factors (constraints and/or facilitators) involved in any effort of consolidating irrigation systems. This general thrust has been combined during Phase II with a consideration of economic criteria in the "interdisciplinary" effort of delineating the consolidation challenge not only as a simple task of merging adjoining irrigation systems into a single unit, but also as a necessary means for meeting the larger quest for efficient and effective utilization of water resources in the rapidly changing arid West.

Investigations conducted in eight areas of varied socio-economic, legal, physical, and irrigation conditions (Poudre and Grand Valleys, Colorado; Ashley and Utah Valleys, Utah; Eden and Riverton Valleys, Wyoming; the Truckee-Carson Irrigation District in Nevada; and the Salt River Valley in Arizona) have provided a comparative scheme of similar and dissimilar conditions for already consolidated and potential cases for consolidation. Factors of successful operation and management have been isolated and attitudes toward change have been delineated in areas of potential future action leading towards consolidation.

In addition to bringing together in a cogent scheme the great variety of physical and non-physical factors affecting the degree of successful consolidation and efficient management, the study has been concentrating in explicating; (a) the overall desirability of consolidation; (b) the feasibility of probable change; and (c) the basis for implementation, including organizational principles, priorities of action, and certain specific steps that may enhance any efforts for directed action.

While there was some obvious overlap between the two phases, Phase II was characterized by the following key concerns:

a) determination and evaluation of the physical characteristics of the selected valleys;
b) identification and measurement of the economic benefits and costs of alternative physical and operational systems;
c) analysis of legal conditions for a range of institutional alternatives and outlining of important differentiations between merger and consolidation; and
d) explication of social conditions and users' knowledge and attitudes towards present as well as alternative organizational arrangements.

The discussion in all previous chapters was permeated by some broader concensus with both the historical development of irrigation in the West and with the balancing of three important dimensions in natural resources questions namely:

a. efficiency or growth in material development so that a solid basis of economic sufficiency may be maintained;
b. equality, or fair access of resources and consumption to different segments of the population; and

c. <u>effectiveness</u> or the overall significance of any policy vis-a-vis the pursuing of certain larger social goals.

Furthermore, the concern with the consolidation of irrigation companies, forced early the need for an integrated approach in the management of water (and other natural) resources as a result of a number of major transformations in the world around us, such as:

a. increasing societal complexity, leading to interdependence and vulnerability;
b. the magnitude or intensity of effects which test the tolerance or resiliency of surrounding environments;
c. the rapidity of change("future shock") and the shortening of the span for effective decision-making;
d. the uneven distribution of effects (equity); and
e. the demand to cope and the search for a proactive (rather than reactive) approach to the problems and opportunities.

At the same time, it is not only that technical problems proliferate faster than social solutions can be found to meet them, but also the very quantity of problems changes their qualitative character. Irrigated agriculture is also caught in a spiral of a successive set of new or residue problems stemming from a series of conditions which include:

- the dynamics of technology
- expanding populations
- urbanization and industrialization
- increased costs
- decreasing resources
- growth and expansion which demand large investments and long planning periods
- inertia of existing social institutions

The end result of all such remarks and apprehensions for the argument at hand is that the creation or perpetuation of appropriate organizations for managing natural resources require a much more complex approach, analytical capabilities and organizational units. Indeed, in the literature of environmental management there is agreement that there must be continuous coordination between such conflicting and complementary purposes as:

- resource planning for substantial economic output
- regional planning for successful coordination
- facility planning for technical efficiency
- ecological planning for biotic fitness
- social planning for community integration
- institutionalization for policy implementation

Turning now to the problem at hand, it was particularly emphasized in the Preface that the successful development of water resources management alternatives require a combination of institutional arrangements and successful implementation of physical measures. Thus, the approach of the present research considered a series of basic propositions for increasing efficiency and effectiveness of alternative water management schemes. In a truncated form they can be summarized as follows:

(1) Changing life situations require reconsideration of traditional irrigation conditions. One of them is the question of consolidation that involves both physical and organizational alternatives.
(2) Organizational rearrangements are most important because they involve not only the larger human community, but also successful implementation of technological innovations.
(3) As a result of the above, improvement of water management requires above all administrative and larger organizational rearrangements.
(4) In trying to implement change there are, however, serious constraints (and facilitators), as a result of cultural practices, historical factors, and ecological limitations in any given area.
(5) The knowledge and proper consideration of constraints/facilitators makes it easier to proceed with the introduction of alternatives to water systems.
(6) The implementation of new water management technologies entails two things: a) delineation of technologies; and b) some specific process of successful implementation.
(7) In implementing alternative water management systems specific strategies and tactics must be considered for making the transition to "new states" and for recognizing both physical and non-physical interdependencies.

It has already been emphasized, that in order to meet ever-changing societal goals, water resources planning, development and management must be a dynamic process. With new demands continually being placed on existing water resources, this challenge will require continued improvements in irrigation water management. Thus, the implementation of improved water management practices today must not become the problems of tomorrow, but rather be a part of the evolutionary process of achieving higher and higher levels of water use efficiency. Therefore, an irrigation system must retain flexibility in order to be responsive to public needs. Part of such a commitment implies that our effort shall also preserve as much as possible the status and importance of irrigation in the arid West and recognize its value in the economy and life of the nation. The program that one can design in order to improve water management should allow potential beneficiaries to decide which option or combination of alternatives is most suitable to their ideals, conditions, and capabilities.

The purpose of the study was to delineate the characteristics of an effective process for implementing technical and institutional considerations involved in any potential effort of consolidating irrigation companies. The process involved around attempts to:

a. define the problem in terms of its legal, physical, economic, and social parameters;
b. identify alternatives in relation to the parameters of the problem;
c. assess the range of alternatives for diverse situations;
d. build the basis for implementation by considering specific steps in any consolidation effort.

The obvious premise here is that the consolidation of irrigation companies for the intermountain region where perennial scarcity coupled with strong trends of population growth and new demanding economic activities provide both the impetus and the needed urgency for a prudent policy of water management under effective organizational structures and processes. The literature on the topic, as well as general discussions of irrigation operations, seem to support the general notion that consolidation of small irrigation systems and the subsequent expansion of the organizational span can contribute to the solution of many vexing irrigation problems in the arid West. These problems may be divided into four types:

a. problems concerned with the physical situation involving parallel canals, duplicate structures, multiple diversions, and costly operation and management;
b. legal problems concerning the right of the use of water involving complex combinations of priority, period of use, and water supply;
c. human problems involving the attitude of water users toward the development and use of water; and
d. economic problems connected with the physical development and value of the water supply.

At the end, at least on a theoretical basis, where consolidation can be achieved, existing water supplies can be more effectively and efficiently used by eliminating duplicate systems and organizational management can be improved through centralization of functions and reduction of enterprise personnel, while at the same time permitting employment of technically trained assistants. The resulting institution will enjoy less legal expenses per unit acre, greater visibility, voice and influence on political and lobbying issues of interest, taking full tax and insurance advantages and improved morale and safety by modernizing and improving company facilities and equipment.

Consolidation becomes particularly pertinent when one contrasts the historical piecemeal systems (whose evolution was described in Chapter 2) with the modern distribution systems which are planned comprehensively in advance of construction. It is exactly the combination of the old piecemeal systems, of physical problems, and of changing socio-economic circumstances that constitutes the challenge of consolidation (or at least reorganization or renovation). The challenge facing us is twofold: On one hand there is an established legal and institutional system consisting of many water users satisfied and unwilling to change. On the other hand, water is a scarce resource. Water requirements have multiplied rapidly in recent years and the political and social structure of our society is undergoing significant change. Physical development of the canal system and pertinent works, the legal development of the right to use water, the organizational entities which have been formed to operate and maintain irrigation systems, and various social and economic problems have created the present predicament which exists in many of our Western irrigated valleys.

In the context of the present analysis is also important to remember the evolutionary prespective described previously. Users will change whenever they can perceive that there is a need of doing so and demonstrable advantages for altering present practices. After all, such water practices have evolved, changed, and reshaped over time. What is rather different today is the dramatic, rapid change engulfing the West, the result of population influx, transformations in the social character of the region, strains from ecological spill-overs, all within a very short time span. To put it otherwise, while change, constant change, has been and is part of everyday life, many areas of the region face both a "culture" and a "future" shock, as their traditional way of arranging their affairs is severely tested.

To conclude this section: if we are to enlarge our perspective on consolidation, we must also see the larger context within which water developments are taking place in the West. A number of critical issues are associated with this broader perspective and with the effort of orderly development of scarce resources. Such issues include:

a) Re-examination of present assumptions about agricultural growth and of the role of agriculture in the West.
b) The rational use of a precious resource which makes possible a broader consideration of the types of growth envisaged in fragile areas of the region.
c) Strong legislative control over the allocation of water among competing and conflicting demands which will enable state or local authorities to regulate development through the licensing of appropriate water uses.
d) Environmental policies which encourage water development in terms of scale economies through community-wide or region-wide management systems.
e) Monitoring mechanisms for early detection signals of impending changes and feedback loops that permit timely re-adjustments.

Although these sound like lofty ideals, they provide a framework and a state of mind within which water systems, valleys, or local communities can find the motivation, the vision, and part of the legal clout for promoting specific requirements for comprehensive water management.

8.2 Study Findings and the Range of Alternatives

Results of this research are scattered throughout the previous pages. The broadest statement that can be made here is that, generally, the findings point out that even though efficiency may be desirable from an engineering and economic point of view, question of equity (fair access of resources to all segments of population) may lead to decisions of non-consolidation.

It may be useful to look back at the thrust of the argument as a combination of existing conditions, envisaged "change" variables, and the consequences thereof (perceived in methodological terms as the "dependent" variable). Figure 8-1, summarizes in a different form the context of the study both as an expression of its methodological emphasis and as an expression of variables central in questions of consolidation. Again, we must see the improvement in water management not only in terms of typical technical solutions, such as modification of delivery schedule, and modernization of project facilities; equally important are also the non-technical considerations which exemplify our concern with the socio-economic environment of any water system. Here we may begin with management improvements in operational practices, such as streamlining of companies, innovative administrative procedures, trained personnel, etc. The consolidation of irrigation companies and districts will contribute to achievement of lower operating costs per unit area and more efficient regulation and control of the water supply, as well as avoidance of duplication and increased capital waste. Other institutional changes such as the interpretation of the legal doctrine are also crucial efforts for improving water management. At the same time, comprehensive planning and concerted social policies are part of the larger complex scene of resource utilization. Finally, education programs are all important as informational inputs attempting to reach all those responsible for the operation of a given irrigation system and the ultimate use of water on the farm.

The overall findings of the study, reinforce a number or previous points and other remarks made in the general literature concerning successful irrigation projects. In the shortest form possible, conditions for effective management of irrigation projects include:

1. Maintenance and protection of all water rights.
2. Delivery of an adequate water supply to the water users when water is needed.
3. Improvements to keep the physical structures and properties in working order, guaranteeing optimum use of water and of water facilities.
4. Keeping records of water deliveries and project costs needed in order to insure equitable water distribution and evidence of beneficial use.
5. Educating water users in the means of obtaining high water use efficiency.
6. Developing sound budgets for covering costs of operation and maintenance and obtaining necessary funds by assessments, loans, bonds, etc., for continuous financing.

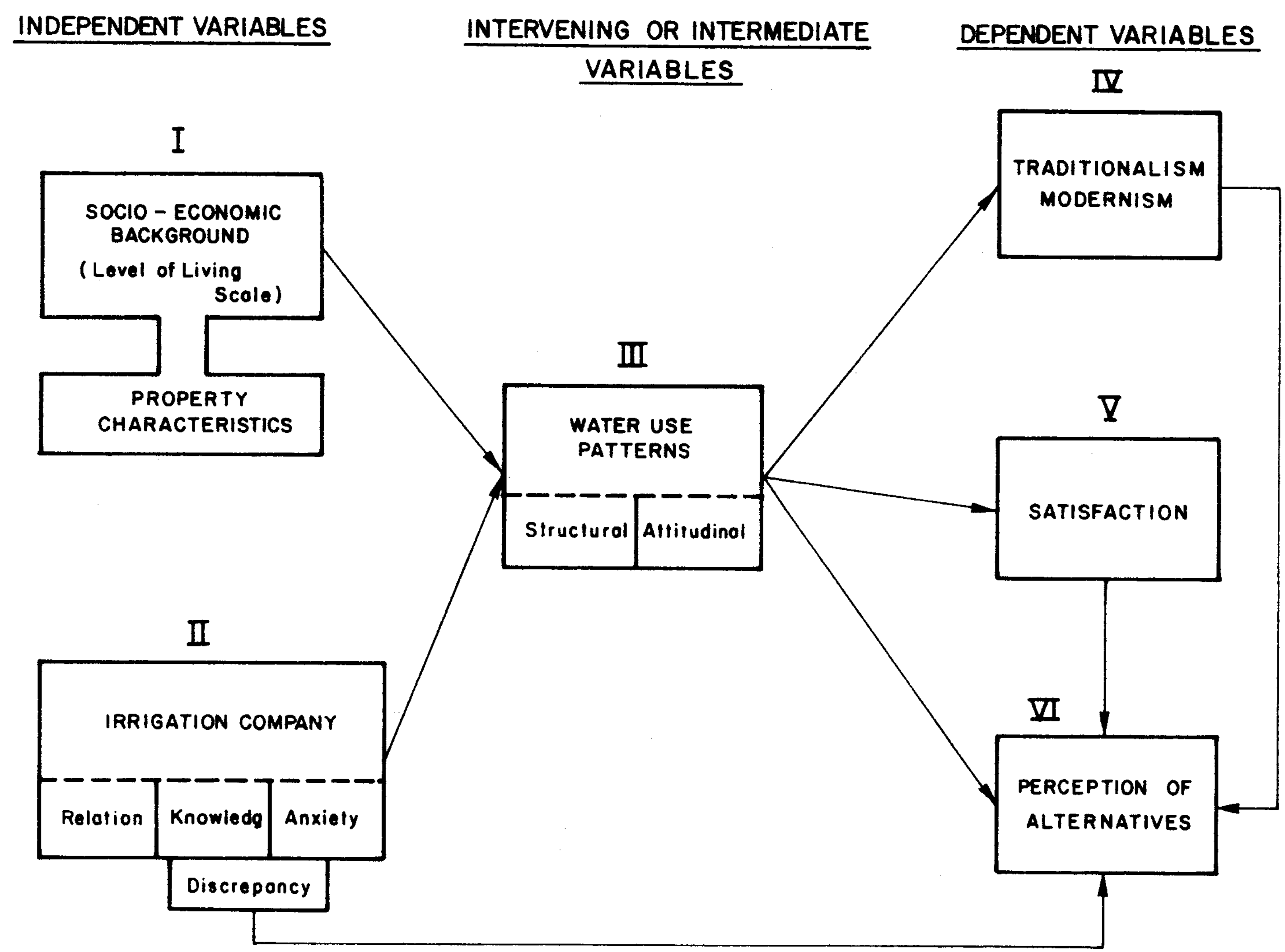


FIGURE 8-1. The Design of the Study Relating Background Variables, Water Use Patterns and Individual's Satisfaction and Predisposition to Change

7. Streamlining of operations and integration of physical and non-physical structures, especially in the form of a consolidated organization.

The basic task of such an organization is to operate and maintain the irrigation system efficiently so that planned water management can be made effective. Efficient operation implies not only a well-maintained irrigation and drainage system, but also trained personnel familiar with the operational procedures covering an entire range of well-integrated systems of irrigation. What should be emphasized is that such procedures need to be up-dated periodically, and, therefore, the organization should also incorporate a system of feedback of information concerning its adequacies of operation for continuous review and improvement. Feedback mechanisms must exist and continuous monitoring of the performance of the system must be maintained in order to meet present inadequacies, as well as forecast future bottlenecks in the system.

The general conclusions of the study, as well as many introductory comments in previous parts, have underscored the importance of what we may summarily describe as the "evolutionary perspective." Such an approach simply underlines the notion that an understanding of present challenges and the delineation of alternatives are largely influenced by a host of pre-existing environmental, historical, socio-cultural, etc., conditions. Central in such an approach is the assumption that natural resources need always to be understood within the context and in relation to a surrounding social-cultural milieu. Water has meaning and importance where socially used for the achievement of certain objectives. Its physical availability and natural characteristics are certainly constraining factors, but its eventual social use is what makes it a valuable resource.

While the study provided a cursory review of the complex topic of the organizational evolution of irrigation, no attempt was made to describe the perculiarities of the myraids of specific irrigation systems all over the world. The point was made throughout, though, was that concerning the importance of an increasing division of labor and complexity over time. Contrasted to the basic physical similarities between earlier historical times and today, the exigencies of modernization, increasing populations, new and expanding demands, all have contributed to an increased scale of organizational arrangements. Yet, one should not belittle the advantages of decentralization (as contrasted to the emphasis here on consolidation and organizational efficiency of centralized systems). The distribution of control and activities tends also to increase the adaptability, resilience, tolerance, even survivability of a system. In addition, the symbolic power of decentralization can be seen as an integral part of historical continuity, accepted cultural practices and of a societal commitment to participatory democracy. In essence, the question of consolidation brought forward a broader discussion of the relative merits and costs between concentration and decentralization. In such a discussion, there must be an accounting of what are the needed transformations as irrigation systems must respond to changing local and national conditions; as they move from simpler to more complex arrangements; and, finally, as they relate local economy and independence to regional or even national systems of interdependence and of economies of scale.

The arguments made above have set the stage for potential solutions concerning changing (or desired) irrigation circumstances. The various alternatives or potential solutions must take into account both individual attitudes and the organizational structure that provide the rules and mechanisms which influence individual behavior--for the individual potential solutions must involve an awareness of the importance of alternative organizational arrangement. In turn the organizational structure solutions revolve around the creation of mechanisms and practices which can facilitate the adoption of new form and administrative practices.

Improved irrigation water management practices will almost invariably result in reduced demand for water diversion. Where irrigation districts and other water users' organizations join forces, it is also possible to realize other types of water savings. A real difficulty in gaining water user acceptance lies in solving the problem of who benefits from the saved water. At the present time, the irrigator cannot benefit from the water saved by improved irrigation water management practices. Consequently, little progress can be expected until the water right issue is addressed. Thus, a central constraint to improving water management in the West is the present system of water law administration. Water is allocated, distributed and administered under a body of law which grants to the user a water right synonymous to the property right interest one can acquire to land. The water right is not one of absolute ownership, but rather one for the use of water only and subject to specific conditions and concepts which theoretically are prescribed to protect the public and other users.

Irrigated agriculture is a collective enterprise involving all of the users and improving existing water management practices, whether to alleviate water quality degradation or more effectively utilize existing water supplies to increase crop production, certainly requires collective action. There exist a number of organizational entities that administer irrigation, but generally, there is a lack of communication and coordination between agencies and districts, and the farmers with regard to how the water should be managed.

Generally, the specific solutions associated with consolidation and considered in this study, ranged from those which were wholly technical (e.g., rehabilitation of distribution systems), to those which were purely institutional (e.g., creation of water markets). Some can be combinations of technical and institutional measures which would cause improvements in water management (e.g., cost-sharing arrangements for improved irrigation facilities). For the sake of summary, they can be tenatively grouped as:

a. those concerned with the influent, i.e., the water diverted to agriculture;
b. those associated with the management of land and water on farms; and,
c. those directed to sources of water, i.e., generally those which would increase supply.

But rather than continuously referring to "solutions", "alternatives", or to the relative general advantages of consolidation, we should now summarize the specific points made with regard to the potential merging or consolidating or irrigation systems. In a telegraphic form the following range of specific "solution" exemplify physical (technical), legal, organizational, and economic alternatives in the consolidation of irrigation systems:

A. Physical and technical

(1) lining of canals
(2) converting canals to pipelines
(3) use of improved irrigation methods (e.g. sprinkler or trickle irrigation)
(4) employment of irrigation scheduling, or better timing of delivery of water quantities at the farm
(5) use of more flow measuring devices, so that the farmer knows what he is trying to manage
(6) rehabilitation of irrigation systems (renovation of the water distribution system)
(7) conjuctive use of surface and groundwater

B. Legal

(1) trading of water right shares
(2) sharing of conveyance losses
(3) redistribution of assessments
(4) allowing for alternate points of diversion
(5) re-examination of the obligation to the public and to the water users
(6) strict enforcement of state water laws (beneficial use and duty of water)
(7) provision for incentive programs that allow user to capitalize on resale or reallocation of water
(8) conversion to partnership vs corporation in order to enable tax write-offs but with protection through liability insurance
(9) release company liability for public use of water.

C. Organizational

(1) technical assistance for providing the basis for implementation
(2) hiring of better personnel
(3) creation of federation of interest along lines beyond narrow interests
(4) streamlining of organizational procedures, distribution of functional tasks and "attention" management
(5) dissemination of information and public participation
(6) enlargement of the area of administrative responsibility
(7) acceptability of exchanged water
(8) creation of a "Congress" of water users (parallel structures) with state administrative offices

(9) collaborative relations between various authorities and programs
(10) flexibility in rearrangements, reassignment of priorities, regrouping of personnel and reallocation of funds in order to meet a wider spectrum of problems.

D. Economic

(1) continuous evaluation within a socio-economic framework
(2) development of better measurements for cost-effectiveness and of cost-sharing for capital improvement
(3) incorporation of externaties in costs and non-monetary considerations
(4) incentive payments for improved water management programs.

Needless to say, one should not see any one of the above in isolation. It is their combination that makes consolidation work. At the end, a consolidated system and an organizational preparedness make possible and feasible the typical technical solutions which ultimately characterize improved water management.

The above, despite their elegance in principle, do not lead to a blanket endorsement of consolidation. There is a great variability of specific circumstances, clusters of alternatives, and capacities for transformation in new schemes. Furthermore, the impetus for consolidation does not emanate only from localized desire for more efficient administrative and technical systems; it is also pushed forward by other broader changes such as political rearrangements, socio-demographic changes, economic demands, new taxation schemes, etc.

Even when larger, general studies have been made on the technical feasibility, economic desirability, and organizational preparedness for consolidation, there still remains the very central problem of individual receptivity to change, and of the effort of harmonizing conflicting interests involved in a unified purpose. Despite technical, economic and organizational evidence favoring consolidation, little progress has been achieved and public sentiment has not provided the momentum for an incorporation of such changes. Attempts toward consolidation depend also on the individual's knowledge and attitude toward water use patterns, on the nature and extent of his relation with the particular irrigation company, his socio-economic background and property characteristics, and on a cluster of predispositions toward change and modernity, level of satisfaction and perception of alternatives. In essence, then, we are talking about three major categories of social factors which may operate as either facilitators or constraints to a proposed consolidation scheme: community environment and culture, organizational structure and networks, and general perception of change and of organizational alternatives by individual users.

The findings of a special survey in four valleys in the West point out also that while a number of irrigation company members (especially in non-consolidated cases) have particular complaints about aspects of present arrangements, no overwhelming support has been exhibited for consolidation. This should not surprise us. Administrative efficiency and organizational effectiveness are not synonymous with further survival of the present agricultural systems. Holding on to existing rights in the face of encroaching urbanization and avoiding the impersonality of larger organizations, is an understable reaction to the forces of change.

Thus, an important point to be made in the conclusions is the understanding of the factors which contribute to a resistance to innovation. Such factors in the context of consolidation are particularly important because they exemplify threats to the established social structure. The resistance to innovation is proportional to the amount of change required in the social structure as well as proportional to the strengths of social values challenged. In other words, changes associated with consolidation provide us with an important case of resistance to innovation by threatening vested interest, individual lifestyles and existing networks of long-established social values and practices.

The challenge for change (result of both internal and external forces) must be, then, seen as a difficult combination of maintenance of identity, concerted action, flexibility in organizational response, equitable cost sharing and benefit distribution, and of an appropriate mix of incentives for physical consolidation. Assuming that we have approached the problem correctly, that we have adopted an appropriate organizational approach, and that we are sensitive to local conditions, then implementation efforts become more feasible. And they are so, because we have also created a general climate of trust and cooperation as the necessary ingredient for meeting competing and conflicting water demands in the West.

8.3 Some General Recommendations

As a culminating point to our discussion and given the complex arrangement of the interrelated parts of any system of irrigated agriculture, it is important to re-emphasize some major points of concern:

(1) Successful development and management of water resources requires much larger institutional and organizational arrangements, quite succinct from the presently prevailing highly segmentalized and individualized approaches in agriculture in various parts of the world.
(2) Norms and cultural values concerning water use must be coordinated within a larger social planning domain, especially with regard to water rights and physical constraints.
(3) Each proposed irrigation system, independent of its level of operation, must develop unique patterns much more responsive to the specific people and cultural conditions found in a given region, rather than simply blindly accepting generalized findings and principles from other areas.
(4) The larger the scope of the irrigation system and the greater the scale of analysis, the more complicated the planning effort and, therefore, the more the need for coordinating powers and interdisciplinary integration.
(5) Laws should be enforced to limit water use to beneficial need and, thus, prevent wasteful application of water and unreasonable transmission losses.
(6) Conservation rather than further development of water supplies becomes an immediate attack to problems of adequacy. Similarly irrigation water rate structures should be designed to encourage efficient, rather than excessive, water use.

Out of these broad concerns and points of conveyance, we may deduce, with the help of all previous material, a series of more specific recommendations for alternative water management schemes, notably consolidation. Indicative of such specific recommendations (with relevence to each case study) the peculariaties involve the following points:

(1) A first measure of efficiency is the discontinuation of excessive irrigation uses and the bringing up to a reasonable standard of current inefficient diversion works and transmission facilities through the utilization of the best available assistance and technology.
(2) Following also the suggestions of the National Water Commission (1973) where irrigation rights on streams prevent efficient application of water in periods of low flow (or where the rights call for smaller quantities than needed for efficient application) schedules of "rotation" can be implemented by irrigators operating in concert.
(3) In the same spirit (and following the recommendation of NWC), a higher degree of efficiency can be realized through storage facilities, so that the irrigator receives the amount of water to which he is entitled at the time needed.

(4) Solutions to problems of irrigation efficiency should deal with causes and not symptoms. This means the tracking of the conditions needed for effective management must be done through a careful analysis of the provisions of the legal system and the creation of a market and other institutional mechanisms that could reach the roots of the problem rather than the manifestations of it.

(5) A water management improvement program should be implemented to include the following components:

   a. system rehabilitation to allow timely and accurate delivery of water so that existing constraints to better on-farm water management may be removed;
   b. an irrigation scheduling service to farmers to allow optimal quantities of water for crop production to be applied with a minimum of waste;
   c. measurement of irrigation water to the farm to allow the application of the desired quantity of irrigation water; and
   d. a change in irrigation methods in some cases (e.g., trickle irrigation for orchards, sprinkler irrigation for field crops) to reduce consumptive use and waste due to nonuniformity of water application.

(6) Assurances must be promoted that a more frugal use of water will entitle the irrigator to use of the water he saves.

(7) In terms of implementability, the most acceptable methods are those which ensure the most local control. Thus, local solutions are needed which maximize implementability and are sensitive to the problem at hand, and which may also require the creation of new institutions.

(8) There must be greater participation by the farmers and users in order to enhance the feeling of joint action, grass roots mobilization, involvement, and attitudes of democratic decision-making. This implies that the implementation efforts are part of a community-wide basis of total involvement rather than part of a handed-down solution.

(9) Personnel and leadership must be organized along new lines, including perfection of operational procedures and streamlining of organizational roles.

(10) The beneficial uses of water and the amount of water that is required to carry on that use should be more precisely defined in the law of each state.

(11) The transfer of water from one use to another should consider not only the economic value but also the impact on other resource uses.

The inescapable conclusion of this study is that water projects and planning in the West are facing underlying significant changes. The transformation of the region, the new demands, and the requirements for coping with the effects of change all point out that a greater emphasis must be placed on much broader objectives altered to meeting a wide variety of human needs.

In this broader context what is obviously needed for efforts of consolidation or alternative water management schemes is innovative thinking; combinations of feasible, credible and believable solutions; consideration of pragmantic impediments especially in the context of specific areas; and an understanding of the process of change in order to be able to stop, modify, or adapt proposed solutions or alternatives. Consolidation requires a skillful combination of physical methods, implementation measures, and institutional arrangements. A new "calculus" must be developed that would balance what is: technically sound, ecologically appropriate, economically viable, legally pertinent, socially acceptable, and last, but not least, politically feasible. In other words, the range of choices to be made will be limited by such crucial factors as the physical availability of resources, the costs of alternatives, institutional constraints, and long-established cultural factors and practices.

Once again, at the end, we come to the three key questions which summarize the search for an appropriate process of reorganization and meaningful assessment:

a. How do we balance in an equitable manner costs and benefits involved in any alteration of the surrounding physical and social environments;
b. How do we make appropriate changes and transitions to new states without unacceptable disruption to all systems; and
c. How do we measure in a valid, reliable and refined way changes and effects and then provide guidance to the previous two questions.

For consolidation, the answering of such questions and the skillful synthesis of physical methods, organizational arrangements, and specific implementation steps should be based on a gradual testing of alternative management schemes; on knowledge of and sensitivity to local conditions; and, on an open process of involvment and communication linking appropriate authorities with individual users.

A.1 Research Areas

In order to evaluate the engineering, economic, legal and sociological factors affecting the consolidation of irrigation systems, a number of irrigated valleys located throughout the Intermountain West were selected for study. The general location of these systems is shown in Figure O-1. The areas chosen for this research effort are:

1. Poudre Valley, Colorado
2. Grand Valley, Colorado
3. Ashley Valley, Utah
4. Utah Valley, Utah
5. Eden Valley, Wyoming
6. Riverton Valley, Wyoming
7. Truckee-Carson Irrigation District, Nevada
8. Salt River Valley, Arizona

There are a number of reasons for selecting the above research areas. In each case, considerable data collection and/or research has taken place, or is presently underway, thus providing adequate background information for most of the systems.

The research areas were chosen to include irrigation systems which are already essentially consolidated in addition to systems which would appear to benefit considerably by consolidating. Thus, each area has not been studied with the same intensity, but the amount of effort for any one study area was dependent upon whether or not the area operates as a consolidated system or contains some unique characteristic which provides leads toward an understanding of the consolidation process.

In addition, areas were chosen that would include some similar and some dissimilar characteristics. For example, in some cases, the area operates the irrigation water supply essentially as a consolidated system, while in others, there is considerable fragmentation among quite a number of communities.

Poudre Valley, Colorado was chosen because of interest within the valley to consolidate the irrigation systems, along with incorporating rapidly increasing municipal and industrial water demands. This system is unique in that it represents a high degree of cooperation among the major irrigation companies to meet the seasonal requirements for water. By trading or renting water within the system to take advantage of geographic conditions in the valley, these water entities have been able to circumvent certain rigid, complex and costly legal procedures with respect to changing points of diversion and time of use.

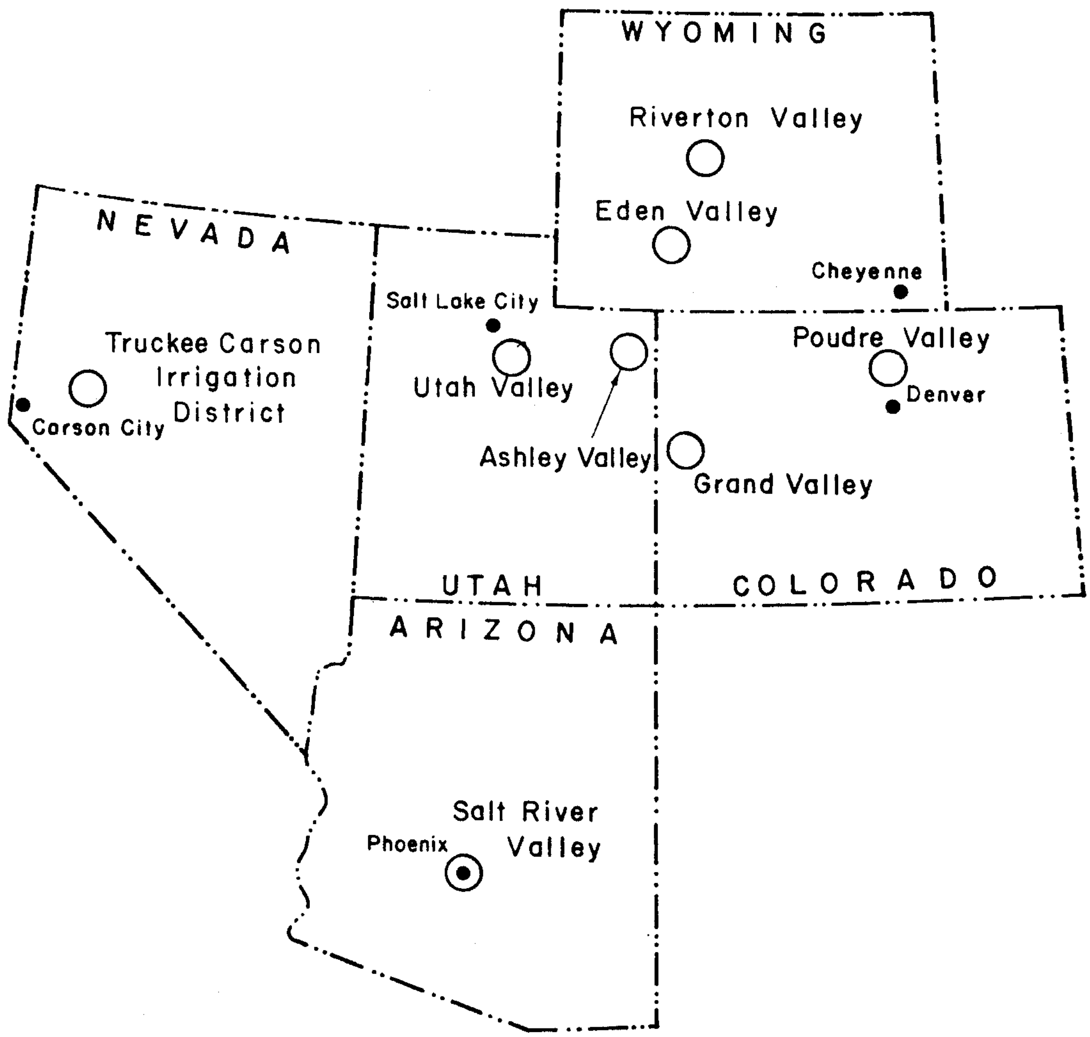


FIGURE O-1. Consolidation of Irrigation Systems Study Areas

Grand Valley, Colorado was chosen partly because of physical similarities with the Truckee-Carson Irrigation District in Nevada. Institutionally important in Grand Valley is the presence of both mutual and commercial irrigation companies, presenting additional possibilities in seeking more efficient water allocation and utilization. On the other hand, the Nevada system is essentially operated as an integrated system, but considerable improvements in the management of the water supply are still needed. The Nevada system is attractive as a research area because of a confrontation involving conflicting demands upon the system for irrigation, recreation, and wildlife, which will probably necessitate improved management of the available water supply. Nevada has a unique statutory provision allowing the State Engineer to determine the duty of water throughout the state to prevent waste and encourage efficient and optimum use of this scarce resource.

Ashley Valley, Utah is an area which has recently gone through the consolidation process with apparent success. The Vernal Unit of the Central Utah Project was constructed by the United States Bureau of Reclamation during the early 1960's to supply supplemental water to irrigated lands in the valley. Following completion of construction, joint efforts by local irrigation company officials and Extension Service personnel resulted in the consolidation of the irrigation companies into a central office for operation and management of the surface water supplies.

Utah Valley, Utah contains a complex irrigation system involving approximately 50 irrigation companies. The water rights of the various companies vary considerably. Some irrigation companies are typically short of water during the late season, while some companies will rarely ever be short of water. The northern part of Utah Valley is rapidly changing from a rural to an urban society. The urban growth rate in this area is among the highest in the Intermountain West.

The two areas in Wyoming were chosen to reflect two separate situations. The irrigation systems in Eden Valley operate essentially on a call basis, which has become possible because of a recently completed U.S. Bureau of Reclamation (USBR) project. The project was recently taken over by a locally formed irrigation district, and presents an opportunity to observe the social reaction and ability to cope with physical and legal problems that are on the horizon. For example, the repayment of project construction costs begin in 1972, a fact which will increase the total annual charges beyond the farmers' ability to pay. The area also provides an interesting manipulation of Wyoming water law which ties direct flow rights to the land but permits transfer of direct flow to storage rights. Riverton Valley has also had the benefits of a recently constructed USBR project, but has some problems due to conflicting water demands. Here, also, in addition to the three irrigation districts that encompass the area, the bordering Shoshone-Arapahoe Indian Reservation gives rise to possible water claims under the "reservation doctrine."

The Salt River Valley, Arizona was studied primarily as a success area in that the irrigation water supply is operated essentially as an integrated system. Also, the area is relatively progressive in seeking solutions to water management problems and at the same time it offers the special challenge of meeting water demands in the rapidly expanding metropolitan area of Phoenix.

Three of the areas selected for study (Poudre Valley, Utah Valley, and Salt River Valley) are undergoing rapid urban growth, with consequent decreases in agricultural lands. Of the three areas, only Salt River Valley is operated as an integrated irrigation system, whereas water users in Poudre Valley are studying the consolidation process, and Utah Valley remains a complicated maze of irrigation systems. Urban planning is being conducted in each area, but little thought is given to the effects of urban and general population growth on the irrigation system. Not only are there changes in land and water use, but water transfers are continually occurring in these areas.

In summary, the selection of these eight areas has been guided by an implicit understanding of a "continuum" of characteristics of irrigation systems. Such a continuum involves dimensions of population and organizational size, urban-rural differentiation, aspects of socio-demographic characteristics, political, legal and administrative variability, and diversified forms of organizational structures and processes.

Thus, these areas afford two-thrust comparative studies. On the one hand, they offer the opportunity for a comparative synthesis of engineering, economic, legal and social facilitators and constraints in a number of similar irrigation systems; and, on the other, they permit comparative analysis of similarities or dissimilarities of characteristics in each substantive area (engineering, economic, legal, or social) for each geographical area or for the total number of systems under examination.

A detailed description of each study was presented in the final report for Phase I of this project (Skogerboe, Radosevich, and Vlachos, 1973). In order to illustrate the merger mechanism described in the previous chapters of this report, three of the study areas--namely, Utah Valley, Grand Valley, and Poudre Valley--have been selected as case studies. Interestingly, each of these three areas present quite different situations for implementing the principles of merger.

A.2 Utah Valley

A.2.1 Location and physiography

The Utah Lake drainage area lies in the north central part of the state of Utah. The area is part of the drainage system of the Great Salt Lake, which in turn is a part of the Great Basin. The boundaries of the Utah Lake drainage fall within five counties (Utah, Sanpete, Juab, Wasatch and Summit), the major part being in Utah County. The Utah Lake drainage area is divided into several subunits which are separated by hydrologic divides. The largest subunit in the drainage area is Utah Valley. Utah Valley is bounded on the east by the Wasatch Mountains and on the west by Utah Lake and the Lake Mountains. The valley opens to the south over a low ridge into Northern Juab Valley and is bounded on the north by the Traverse Range.

For the present study, Utah Valley can be divided into four districts, each being supplied from a separate river system. These are the Lehi-American Fork district, Provo district, Spanish Fork district and Elberta-Goshen district. These districts are supplied by the American Fork River, Provo River, Spanish Fork River and Currant Creek, respectively; Currant Creek is supplied by Northern Juab Valley return flows stored in Mona Reservoir. The Elberta-Goshen District consists of the western part of Goshen Valley not supplied by the Spanish Fork River system. These districts are served by water distributing canals or irrigation companies, as shown in Figures A-1 and A-2.

All waters from the Utah Valley eventually drain into Utah Lake. Utah Lake is shallow, averaging eight feet in depth with a maximum of about twenty feet. The lake has gently sloping shores causing large changes in surface area with fluctuations in surface elevation. The lake is located in the valley center, the main body being about 19 miles long in the north-south direction and 10 miles wide. A swampy area called Provo Bay is connected to it on the east side by a narrow channel. The outlet for Utah Lake is the Jordan River, which runs in a northerly direction through Salt Lake County and eventually empties into Great Salt Lake.

The 219,658 acres of agricultural land in the Utah Lake drainage area is the largest user of water. There is 162,150 acres, or 74 percent, of the agricultural land that is irrigated. The rest is dry land farming. The total irrigated land in Utah Valley is 117,760 acres (Table A-1). Alfalfa, pasture, grain, corn, sugar beets and orchards are representative irrigated crops, with the largest amount of irrigated land being used for alfalfa and pasture.

A.2.2 Human community

Salt Lake Valley was settled by the Mormons in 1847 and shortly thereafter Utah Valley was explored. The first people to arrive and divert water, came in 1848. They were a relatively transient group that remained

FIGURE A-1. Irrigation Districts in Northern Utah Valley

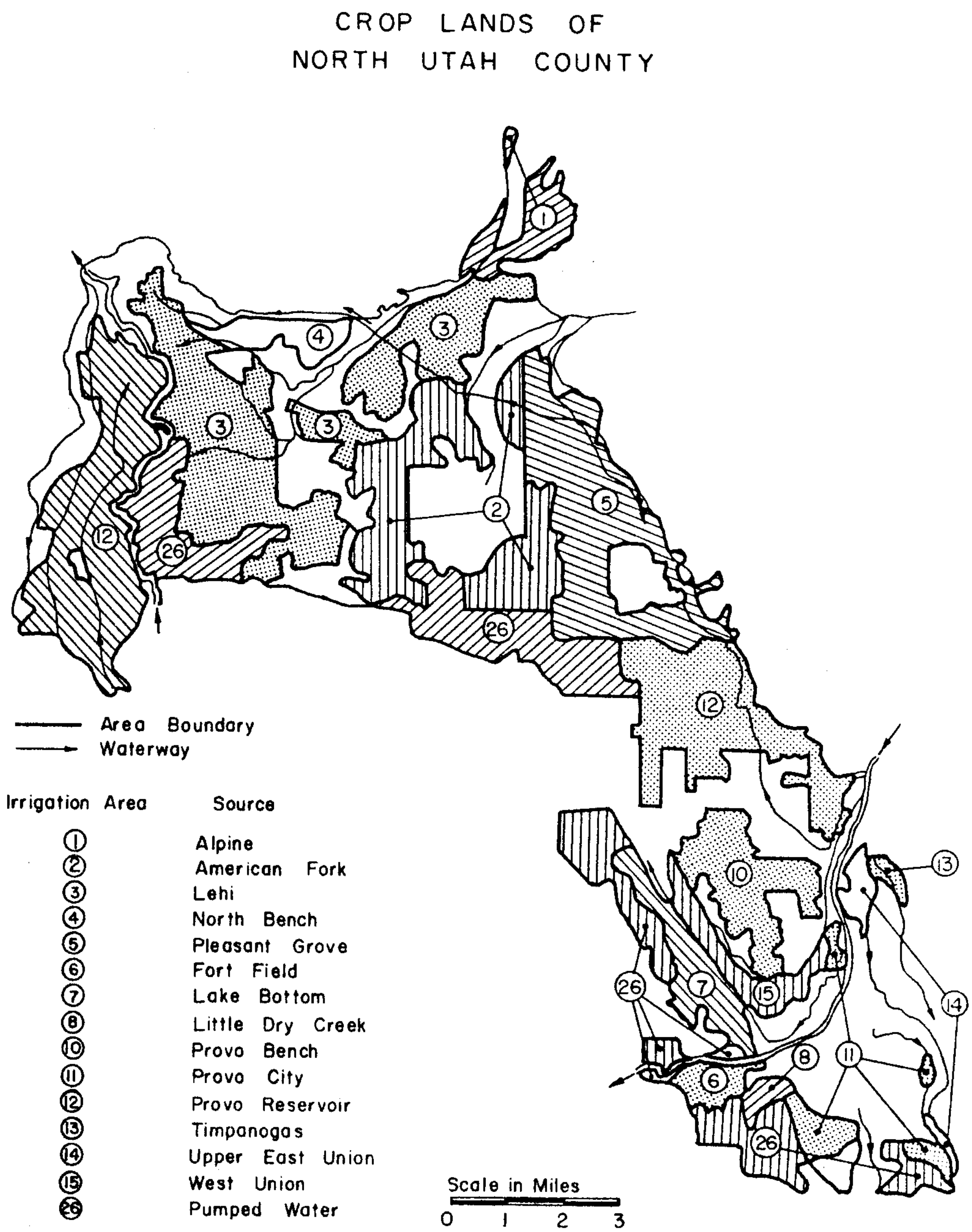
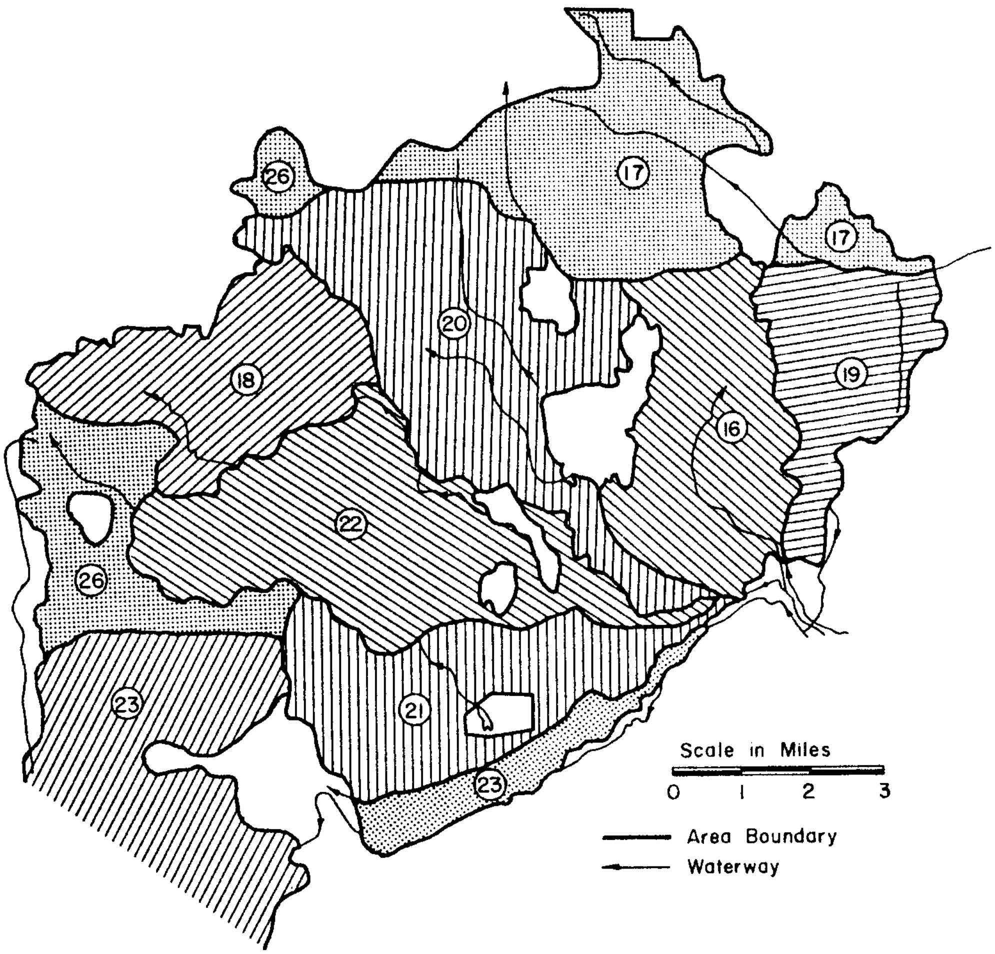


Fig. 4. Irrigation districts in Northern Utah Valley.

FIGURE A-2. Irrigation Districts in Southern Utah Valley

CROP LANDS OF
SOUTH UTAH COUNTY



Irrigation Area	Source	Irrigation Area	Source
16	East Bench	21	Salem Canel
17	Hobble Creek	22	Spanish Fork South
18	Lake Shore	23	Strawberry Highline
19	Mapleton	26	Pumped
20	Mill Race		

Fig. 5. Irrigation districts in Southern Utah Valley.

Table A-1. Agricultural lands in Utah Valley.

Hydrologic Area	Crop Area, acres	Phreatophytes and Native Vegetation, acres
(Utah Valley)	117,760	40,500
(Lehi-Am. Fork)	20,492	1,937
(Provo)	23,495	8,080
(Spanish Fork)	73,773	17,554
Goshen Valley	15,785	12,929

in the Valley for a short time. In fact, in the spring of 1849 a stockade was built and log houses were erected for pioneer settlers in the Utah Valley. From this point on irrigation rapidly developed.

The population of Utah Valley is essentially concentrated in Utah County. The 1970 census showed the population for the county as being 137,776 inhabitants. The major city in the area is Provo which taken together with the Orem Division account for almost 80,000 inhabitants in the county. To these, if we add other larger communities in the area such as American Fork, Pleasant Grove, and Springville, it can be seen that by 1970 over 110,000 of the total population of the county lived in urbanizing areas. At the same time 20,642 persons were classified as rural.

The pattern of population growth in Utah Valley, as well as in the whole Wasatch front, bears striking similarity to parallel population and spatial developments along the Colorado eastern front. An emerging strip city with high rates of growth, more recently in the suburban fringe, and an increasing attraction for industrial concerns. Thus, while the rate of growth for Utah County between 1960-1970 was 28.8 percent, that of Provo city was almost double, 47.3 percent. The pattern of population growth and distribution in the Valley have remained more or less constant over the years, with the Provo-Orem area having the lion's share of the total population.

The important conclusion from these numbers is the fact that rapid urbanization creates new competing water demands, with associated friction from the urban spillover to the surrounding rural hinterland.

Water in Utah Valley is a rather emotionally laden issue. Although there have not been range wars and shootings to an extent that might be found in other areas outside of Utah, there has been a great deal of conflict concerning water in this area. In the early days of settlement, when there was a dispute concerning the water, this dispute would be taken to Church leaders and the Church leaders would act as judge and jury in bringing this dispute to an equitable solution. The case would be heard by the elders of the Church, the elders would define the party who was at fault, and would determine retribution to the injured individual. The word of the church was the final judgment in the case.

A.2.3 Water supply system

The two major streams draining the Utah Lake area are the Provo River and the Spanish Fork River. The American Fork River, Hobble Creek, Summit Creek, Payson Creek, Salt Creek and Currant Creek are the smaller principal streams.

The Provo River originates in the Uinta Mountains and empties into Utah Lake, flowing through Kamas and Heber valleys and across Northern Utah Valley. Due principally to the Provo River, the Northern Utah Valley (north of Provo City) receives about 70 percent of the total inflow to Utah Valley while having less than 40 percent of the irrigated land. The volume of natural inflow is highly variable with about one-half the annual flow occurring during April through June and one-sixth of the annual flow occurring during July through September. The river is fully appropriated.

The Spanish Fork River heads in the Wasatch Plateau west of Soldier Summit and discharges to Utah Lake, flowing across southern Utah Valley. The natural flow of the river has a high discharge in the months of April through June and a low discharge in the months of July through September, similar to the Provo River. It has two major tributaries, Thistle Creek and the Diamond Fork. The Diamond Fork serves as a conveyance for inter-basin transfers to the Spanish Fork area from Strawberry Reservoir.

Streamflow regulation has occurred along the Spanish Fork and Provo Rivers with little regulation on any other streams. Fifteen small reservoirs have been developed at the headwaters of the Provo River, which contribute about 8,000 acre-feet of irrigation water annually. The Deer Creek Reservoir, located at the lower end of Heber Valley, releases 96,700 acre-feet annually to the Provo River and provides municipal and industrial water in Salt Lake County through the Salt Lake Aqueduct. The Strawberry Reservoir, located in the Uinta Basin, provides interbasin exports through the Strawberry Tunnel into the Diamond Fork River.

Mona Reservoir provides the only significant regulation of a minor stream in the drainage area. It is located on Currant Creek at the northern edge of Northern Juab Valley. It stores return flows from Northern Juab Valley and Currant Creek flows to supply the Elberta-Goshen district of the Southern Utah Valley.

Strawberry Reservoir impounds water from an entirely different watershed and it is brought in through a transmountain diversion. The natural flow of Hobble Creek and American Fork Creek are, for all intents and purposes, unimpeded and there is an adequate supply early in the year but later in July and August the amount of water available tends to rapidly decrease. The return flow of water in Utah Valley is dumped into the Utah Lake drainage. By the time water reaches the Utah Lake it is fairly degraded. The water which finally arrives in Utah Lake is used as irrigation water in Salt Lake Valley through complex trade agreements. Irrigation water is supplied to Salt Lake Valley and potable water is given in return for it. There are wells in Utah Valley; there is a huge underground reservoir underlying the entire Valley and this is a closed basin so the pumping is very carefully controlled by the State Engineer's Office.

The water table is maintained and carefully checked with well permits given very judiciously. The wells range from artesian wells which are many times used as potable water sources, to wells which are very large and used for industrial as well as agricultural purposes. U.S. Steel maintains several deep water wells, with the water used in the cooling process of the steel. The water, once used, is stored in a lagoon and recycled back through the mill. The company does not use Utah Lake water, but it discharges some of its effluents into the lake.

Finally, a number of springs, owned by various municipalities contribute direct water into the pipelines and through the processing plant and into the culinary water. Great efforts have been made by various municipalities to protect the purity and high quality of water from these springs.

A.2.4 Irrigation development and organization

Water was first diverted from Provo River in 1848 and other diversions continued as new settlers came into the Valley. Most of the companies were formed during the middle and late 1800's so that by 1900 no new companies appeared in the area.

Hudson makes an interesting observation that irrigation companies fit their size to the amount of water available. Many do not need to expand, either because their source of water is sufficient for their needs, or because the demands cannot be increased. Others are unable to expand, being unable to afford more water (Hudson, 1962, p. 121).

It is interesting to note the reasons for forming new companies. When either a new source was discovered (as in the case of return flow) or a new demand developed (as in the growth of cities), instead of the established company meeting those needs or acquiring the new source, a different company often came into being. The reason, never stated specifically, is hinted at several times by Hudson - that the existing company was too conservative to make the changes necessary for the new source or use (Hudson, 1962, p. 124).

There are approximately 75 irrigation companies in Utah Valley. The companies are quite similar to one another in composition and organizations. In 1926 the Strawberry Water Users Association was formed as the legal contracting entity with the federal Bureau of Reclamation to develop a large scale storage and diversion works on the Strawberry River. In 1938, the Provo River Water Users Association was formed as the Deer Creek Dam Project was started. Water was first sold in 1942. The old canal systems were used, and in time were rebuilt to handle more water. The Provo River was rechanneled, a project completed as late as 1962. The water from Strawberry and Deer Creek reservoirs is controlled under contracts with the Bureau of Reclamation, with the contractees being the Provo River Water Users Association (PRWUA), also called Deer Creek, and the Strawberry Water Users Association (SWUA). Both Users Associations do not directly supply water to the farmers, but to the irrigation companies which in turn supply the water to the farmers. The irrigation companies must receive their water first due to prior water rights, and the Associations get the last rights so that they in effect are able to save the flood waters which were lost in years prior to the projects.

Presently, the irrigation companies are able to purchase water from the Associations and provide the farmers with water for the latter part of the summer. This late water is extremely valuable, since before the projects Utah Valley farmers found their streams nearly dry by the end of July, and their crops burned.

There is a third component which will be increasingly important in the future, namely the contribution of the Central Utah Project (CUP) and its contractee, the Central Utah Water Conservancy District (CUWCD). When completed it is envisaged as part of a highly complex system of providing municipal, industrial, and irrigation water all along the fast growing strip development along the Wasatch front. Thus, with the creation of the CUWCD in the early 1960's, the pyramid of organizations was completed. The mutual companies form the base foundation, the water user associations serve as federations of local interests within each valley and CUWCD operates at the highest level with their area of jurisdiction not only in the drainage basin but also over the areas from which water is imported.

Urban water presently is supplied through the series of springs mentioned earlier and Deer Creek Reservoir. Deer Creek supplies water to the Utah Valley area as well as to the Salt Lake Valley area. The rural water is derived through the adjudicated rights system of the 1800's. Even with the construction of Strawberry Reservoir and Deer Creek Reservoir, the natural flow rights must be honored first. Thus, the irrigation companies which existed prior to the construction of these two projects receive their water first and then the two projects have the later water rights. This is both a blessing and a curse. During extremely water rich years, the two impoundments are able to catch all of the flood waters and hold them for future use. On the other hand, in a rather water poor year, the reservoirs may not receive any water at all due to their low priority in the adjudicated rights system.

It is interesting to notice that the last project is a very expensive one. Compared to Strawberry Reservoir which cost about $40.00 per acre, CUP water is estimated to reach $500.00 per acre. Also, the number of acre feet vary from season to season, but Deer Creek averages between 3.0 to 3.5 acre feet per acre of land served. In SWUA, the lower land holders have about 3.0 acre feet, while the higher ones have about 2.0 acre feet. The higher land is quite sandy and it could use at least 4.0 acre feet, while the lower land could be farmed with less than the allotted 3.0 acre feet.

The last remark brings forth an interesting observation concerning agricultural water use in the Valley. Because of the benches (the lens of sand and gravel areas left by old Lake Bonneville), there is a need for abundant water to adequately water the crops which are located on those particular slopes. The lower areas, the areas which are located near the river bed are primarily a loamy type soil, highly productive not needing as much water as the upper bench areas. Since the earliest settlers first irrigated the lowlands, the river banks and the river bed areas, one can find also there earlier and larger water rights. Typically the people in the lower areas have 3.0 to 3.5 acre feet of water for every acre of land they own. The people on the benches typically have only two acre feet of water for every acre of land they own. As mentioned above, the sandy soils on the benches could probably use 4 acre feet of water very easily, while the people down in the river bottoms could probably use 2 acre feet and still have adequate water supplies. In terms of water efficiency, the area may be described as somewhat inverted in terms of needs and applications of water, a result of historical circumstances and not a response to actual needs today.

The costs of water in Utah Valley can only be dealt in a very general way because of the diversified conditions of 75 different irrigation companies. Some companies buy their water from the Deer Creek project through the Provo River Water Users Association or from the Strawberry Reservoir through the Strawberry Water Users Association. The water which comes directly from Deer Creek costs $1.25 per year for delivery costs, and $2.85 more in construction costs for each share of water. As this water goes from the river to the various irrigation companies, a delivery cost is added, so that the average cost of water is in the neighborhood of $6.50 to $9.00 for every acre foot of water delivered to the individual. The SWUA has an actual cost per acre foot of water of $10.00 to $12.00; fortunately, the Strawberry project being an older project is now just about paid off and since the contract is nearly retired this has helped to reduce costs because construction costs are no longer being charged. At the same time, the SWUA is generating power and the power revenues are used to pay for part of the high operating costs in terms of delivery water. Thus, in reality, the SWUA charges about $2.50 per acre foot for water delivered to the irrigation company. When water reaches the individual user, the total cost reaches $6.50 to $9.00 for every share of water which is delivered.

A.2.5 Local water entities

The organization and operation of the irrigation water companies are controlled by farmers. Diversified as they are, the various companies in the Valley can be grouped into three major categories: 1) Most of them can be classified as "formal, original companies." 2) A few small companies can be classified as "informal, original companies." 3) A few later large companies and younger associations can be classified as "reservoir companies." Although the degree of formality differs from the loosely organized ones of category 2 to the more structured organization of the reservoir companies, there is generally a great deal of simplicity, informality, and flexibility in the running of all companies.

Essentially a board of directors is charged with the task of providing the leadership and general policy for the company, with the actual day-to-day operation delegated to an individual who is an employee of the company. The last is charged with the primary task of seeing that the agricultural water is delivered to the various groups.

The board of directors receive their position through elections and the voting individuals are the individual shareholders within the irrigation company. The role of the board is one of making policy decisions concerning the irrigation company and to define the general needs of the company in terms of how large the budget should be for the following year's operation. As in so many other instances in the West, the individual board member is the representative of the shareholders with the explicit obligation of carrying forth their interest, needs, and desires concerning water use. Once again, the status of being on the board is viewed with great ambivalence both by the members of the board as well as by individuals who elect them. It is the same thankless job described elsewhere, but at the same time a vital spot for generating policy guidelines. Since the successful farmers are the ones usually interested and/or elected, they are the ones who seem to know best what is going on, or at least have the largest vested interest for water delivered at the cheapest costs. Cost, over and over again, is the main consideration in meeting company objectives, followed closely by the need of fulfilling prescribed water rights.

As the companies become more formal (as in the case of reservoir companies), the requirements for organizational efficiency also increase. The Provo Water Users Association has a 17 man board which serves 16 different water companies (municipal, industrial, and irrigation with thousands of patrons). Of all board members, 8 represent urban water interests, with the remaining 9 agricultural and irrigation interests. The 17 members are elected by shareholdings, with the class "A" share electing 8 members, class "B" share electing 2, all holders over 10,000 getting one more member and the manager being an ex officio member. Contrasted to such formal organizations and to an office staff for PRWUA of 22 full-time employees, other "informal, original companies" have no officers, no records, no assessment with little, if any, work done on the ditches. There are such companies with only five shareholders.

The most critical position throughout every company is that of the water master. He is the one responsible for the actual delivery of the water, the representative of the company with whom the farmers are most in contact. Like all other officers, he is a farmer and a shareholder. His training, as well as the training of all water managers is an informal one. Although water knowledgeable, they typically learn water management within their family, and quite often positions have been handed from one family member to another. This knowledge is mostly one of experience and sensitivity as to the overall system, the idiosyncratic characteristics of the organization, and the specialized needs of the users. The manager is also charged with the task of supervising any office employees. These could be office girls or they could be ditch riders or both in the case of larger companies. The effect of the shareholders on the manager is somewhat varied. Typically, his job is to supply the water to them and to keep them happy. One manager described his job as that of being a crying towel. On the other hand, individual shareholders have little to do with larger policy questions, which are the prerogative of the board of directors. Such a policy is formulated at the annual meeting by the members of the water board and is placed for approval before the group of shareholders. They in turn (and quite often this is only a ritual), vote affirming or denying the particular policy or provision thereof.

Voting is primarily done by proxy rather than through attendance at the annual meetings. Stockholders meetings are usually held during the day, sometime in winter, generally around the first or second month of the year. The large farmers attend the meetings and make their feelings public at this particular time. The smaller farmers, the part-time farmers, and other small land owners typically receive a proxy vote by mail. They sign this vote and return it to the irrigation company and that is usually the extent of their voting or participation. The proxy will simple support or be used as a support for the incumbent of the irrigation company unless there is some very significant reason for wanting to get rid of a particular individual. Changes in management are rather infrequent; very rarely is a manager fired from his position, in fact many managers become so old that they have to quit because they simply are not able to carry forth their task.

All in all, the companies, their organization and management reflect a high conservative atmosphere with diffused responsibility and authority for meeting the increasing demands of centralized planning in an urbanizing, industrializing social environment. One may speculate that despite the early historical centralizing presence of the Church, the jealousies surrounding precious water rights have led to segmentalization of power among competing groups, multiplicity of jurisdictions and organizations, and a pervasive sense of diffusion and decentralization.

The fragmentation outlined above is also accentuated by the changing character of the social life of the communities in the area. Very few full-time farmers still remain in the area, with an estimated 80-90 percent of all farmers in Utah Valley considered as part-time farmers. Thus, bureaucratic diffusion overlaps with the lack of knowledge and/or interest from many users who have other jobs competing with the attention required for full-time farming.

As it is to be expected, attitudes towards water depend on its seasonal availability. During water poor years, people become acutely aware of its scarcity and use judiciously all available supplies. From the reconnaissance interviews, it seems that most people are reasonably well satisfied with the available water, the project, and the management of the two water associations in the Valley. There were some complaints expressed earlier by old timers, people who had been in the Valley as agricultural water users prior to the advent of the Deer Creek project. Such people feel that the Deer Creek project has somehow taken water that they previously had.

A.2.6 Prospects for consolidations

The water right system that currently exists in Utah Valley would not be a great impediment to consolidation. Assuming that one cannot overcome the psychological barriers associated with water ownership, a system of ranking the rights in terms of their adjudication dates would be a simple process to insure the rights of individual irrigation water users within a consolidated system. Perhaps one way of visualizing such change is through a fairly straightforward process of taking the adjudicated water rights and giving them a priority according to their dates; if for any reason the water rights cannot be met for all water right owners, a system of ranking under a consolidated system would be implemented. This means that the senior rights would receive water first and if there was any water left over this would be distributed to the junior rights according to their rank in terms of the water priority system. Yet, such simplistic proposals do not solve the problems of hostility from a voluntary program of centralization and consolidation. However, mergers are resisted by a number of farmers who are afraid of being short changed on water rights or being dominated by outside more powerful groups. Yet, both PRWUA and SRWUA are already providing the experience for working in federations, especially with groups (such as urban interests) which represent new and increasing water demands; but both projects have been met with hesitancy. Many people did not feel that these projects were needed, or that their water supply was short enough to justify the cost of the Deer Creek project. Similar criticisms on increased cost are also now raised by a number of individuals concerning the Central Utah Project. But cost is only one of the considerations for future consolidation. More important is the underlying question of the changing demands and of the ability to meet increased needs in the Valley given the present trends of continuous population growth and economic expansion.

Hudson (1962) best sums up the historical and current reasons why consolidation has not been the overwhelming pattern in Utah Valley:

> The jealous guarding of company water rights, the fear of submergence in larger groups, and personal and institutional inertia have so far blocked all but one or two minor mergers.

So it seems that no one wants to take the first step. Instead of consolidating, splinter companies are formed. The present pattern has existed for so long that people are used to it.

The water demands in Utah Valley, and the supplies which satisfy them, will change significantly in the future. Population of the industrialized sections of Utah Valley will have tripled by the year 2020 and doubled in the present rural areas. This constitutes a necessary reallocation of the existing supplies from agricultural to municipal uses, resulting in a change in the time distribution of demands as well as changes in absolute amounts of water needed.

Anticipation of problems resulting from these changes has prompted the State of Utah to endorse the Central Utah Project, which encompasses the Utah Lake drainage area. The Central Utah Project involves transporting water from the Colorado River Basin into Utah Valley to facilitate changing demands in the area, and also to provide water for transfer north to Salt Lake County and south to the Sevier River Basin.

The Central Utah Project (CUP) will be a primary source of additional water for the Utah Valley and also for the Salt Lake Valley. The major thrust of the Central Utah Project is one of taking water from the relatively unpopulated areas, such as the slopes of the Uintah Mountains, diverting it through a series of reservoirs and power generators to be used in the Utah and Salt Lake Valley areas. The major problem, which will be encountered with CUP, is the high cost of the water estimated to be approximately $500 per acre, a very steep price if water is to be used primarily for agricultural purposes. In addition, given the emerging megalopolitan concentration across the Wasatch front, problems of pollution and effluent discharge will be accentuated.

Coming back to the agricultural demands under the Central Utah Project, the Lehi-American Fork district of Utah Valley will receive no supplemental irrigation water. The Central Utah Project will benefit the Provo District, which will obtain water from construction of Jordanelle Reservoir. The enlargement of Strawberry Reservoir will provide additional irrigation water to the Spanish Fork, Northern Juab Valley, and Elberta-Goshen districts.

Also alterations to the present Utah Lake will be constructed as a part of the Central Utah Project. A dike will be constructed across Goshen Bay to reduce lake evaporation and to provide more opportunity for development of recreation and wildlife on and around the lake.

Limitations of the system can be seen and some possible changes may be suggested in the operation of the Utah Lake drainage area water system. Some changes in transport water in the area may result in less shortage. Also, reservoir and aqueduct sizes may be estimated. All alternatives were not modeled because the added work would make this study prohibitive.

The perpetual shortages in the Lehi-American Fork area could partially be remedied by using water from the Provo area. At present, Deer Creek Reservoir has sufficient water to supply Lehi-American Fork needs, but would not adequately supply both areas by the year 1980. After 1980, water designated as export water to Salt Lake County from the Provo district could be used in the Lehi-American Fork area, utilizing the increased return flows from all areas to supply Salt Lake County demands via Utah Lake. Also, the analysis of possible exports to Salt Lake County in addition to its present demands indicates no water is available for that purpose in any significant amounts directly from Deer Creek Reservoir. Therefore, any water transported to satisfy increasing needs in Salt Lake County must come from Utah Lake.

The rather lengthy discussion of projected future demands were forwarded mostly as an indication of the strong population and other pressures facing the Valley in the years to come. In this fast changing situation and with the competing or multiple uses of water, the consolidation of irrigation systems becomes not only a meaningful organizational alternative, but also a pressing need for future survival.

The prospects for consolidation in Utah Valley continuously increase as the CUP becomes more and more a reality. CUP will incorporate the use of Strawberry as well as the Provo River water associations and in the final analysis, the conservancy district will control nearly all of the water which enters Utah Valley. An organizational structure is, therefore, emerging which could also serve as the springboard for a consolidated organization. Already the Central Utah Water Conservancy District, which is located in Orem, acts as an independent entity contracting with the federal government for the repayment of the CUP and the eventual management of the project when it becomes a reality. The Central Utah Water Conservancy District will not only maintain the water structures, the diversion canals, the impoundments, and other facilities needed, but it will also be charged with the task of maintaining and operating the power generating facilities in the system.

The innovative character of the CUP will facilitate the potential for consolidation and future consolidation attempts will probably meet with most success if they were oriented as a part of the water conservancy district structure rather than as grass-roots mergers. The constant fears of a loss of water rights will have to be allayed, as well as the feelings of a loss of autonomy, primary group identification, and identification with a certain power base.

It seems once again that an external stimulus may act as a catalyst for bringing about consolidation of segmentalized and fragmented irrigation companies. The Central Utah Project provides means for redistributing the existing water supply, along with providing imported water. The elimination of shortages in all areas of the Valley removes also the perennial fear of irrigators concerning potential losses of water rights in any consolidation attempt. However, CUP must be operated as a single management unit, with the proper legal means to control the distribution of the water supply in order to most nearly satisfy the demands. This requires that a consolidation of the existing separate irrigation companies take place to allow the distribution of water from areas of surplus to those areas short of water. The existing management system in the Valley not only prevents maximum utilization of the facilities provided by the Central Utah Project, but it is also thoroughly inadequate to meet the accelerating demands resulting from rapid urbanization and industrialization.

A.3 Grand Valley

A.3.1 Location and physiography

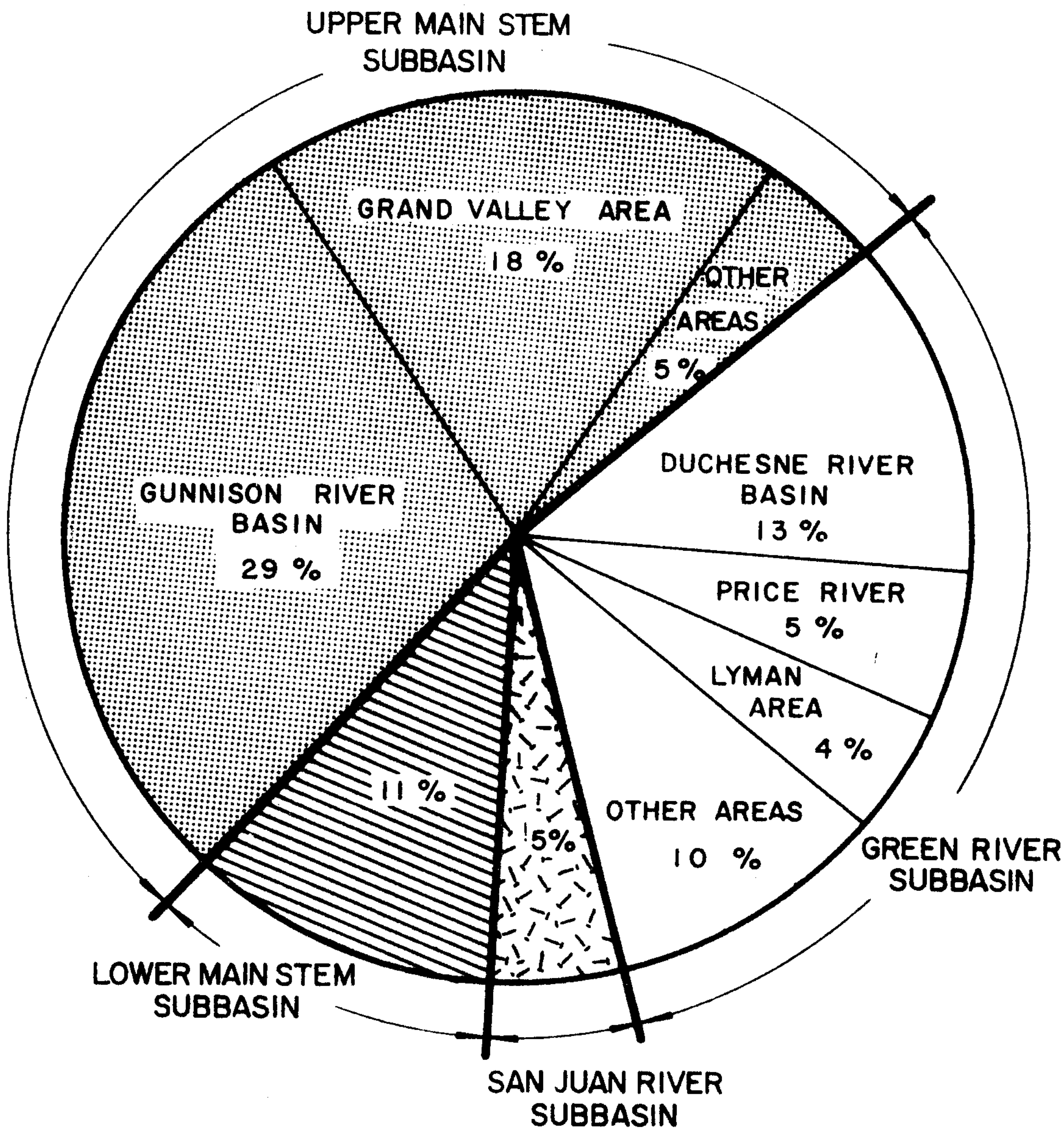
Grand Valley is located in west central Colorado very near the Utah border. The city of Grand Junction, which is a name derived from the junction of the Grand (now the Colorado) and Gunnison rivers very near the city, is the largest community on the West slope (that portion of Colorado west of the Continental Divide). The Colorado River enters the Grand Valley from the East, is joined by the Gunnison River at Grand Junction, Colorado, and then exits to the West. A major characteristic in the area is the high contribution to the total salt flows in the basin as illustrated in Figure A-3. The primary source of salinity is from the extremely saline aquifers overlying the marine deposited Mancos shale formation. The shale is characterized by lenses of salt in the formation which are dissolved by water from excessive irrigation and conveyance seepage losses when it comes in contact with the Mancos shale formation. The introduction of water through these surface sources percolates into the shallow ground water reservoir where the hydraulic gradient it produces displace some water into the river. This displaced water has usually had sufficient time to reach chemical equilibrium with the salt concentrations of the soils and shale. These factors also make the Grand Valley an important study area for the interaction of water quantity and quality, since the conditions encountered in the valley are common to many locations in the basin.

A.3.2 Human community

Numerous hieroglyphics and abandoned ruins testify to occupation of the Colorado River Basin long before agriculture settlement began. The inhabitants of the Grand Valley prior to the settlers were the Ute Indians. The first contact these peoples had with white men was recorded in 1776 when an expedition led by Fathers Dominiquez and Escalante passed north of what was later to be Grand Junction and across the Grand Mesa. The region was subsequently visited by fur trappers, traders and explorers. In 1839 one such trader named Joseph Roubdeau built a trading post just upstream from the present site of Grand Junction.

In 1853, Captain John W. Gunnison led an exploration party into the Grand Valley from up the Gunnison River Valley in search of a feasible transcontinental railroad route. As Captain Gunnison and his party traversed the confluence of the Colorado and Gunnison Rivers, an error was made by the expedition recorder as to the proper naming of the rivers. Beckwith referred to the Gunnison River as the Grand River and the Colorado River as the Blue River or "Nah-un-Kah-rea" as it was known to the Indians. The mistake was later corrected, however, since the Colorado River was known as the Grand River prior to the early 1900's. As a result of the Meeker Massacre of 1879, the Utes were forced to accept a treaty moving them out of Colorado and onto reservations in eastern Utah. After the completion of the Utes' exit in September 1881 the valley was immediately opened up for settlement with the first ranch staked out on September 7, 1881 near Roubdeau's trading post. Later that year on September 26, George A. Crawford

FIGURE A-3. Relative Magnitude of Agricultural Salt Sources in the Colorado River Basin.



founded Grand Junction as a townsite and formed the Grand Junction Town Company, October 10, 1881. On November 21, 1882, the Denver and Rio Grande Railroad narrow-gage line was completed to Grand Junction via the Gunnison River Valley and thus assured the success of the settlement.

Early exploration concluded that the Grand Valley had limited potential for agriculture since the terrain appeared very desolate. A great deal of appreciation for this judgment can be acquired just passing through the area and noting the landscape outside the irrigated agricultural boundaries. In 1853, Beckwith described the valley as, "The Valley, twenty miles in diameter, enclosed by these mountains, is quite level and very barren except scattered fields of greasewood and sage varieties of artemisia - the margins of the Grand (Gunnison) and Blue (Colorado) Rivers affording but a meager supply of grass, cottonwood, and willow." Soon after the settlement began, it was realized that the climate could not support a nonirrigated agriculture. As a result, irrigation companies were organized to divert water from the river for irrigation. In the year 1883, when the county was organized, marks also the beginning of water being diverted in the area. The first canal built (the Pacific Slope Ditch) brought water to the Grand Junction community itself, and was soon followed by a whole series of subsequent canals as depicted in Figure A-4.

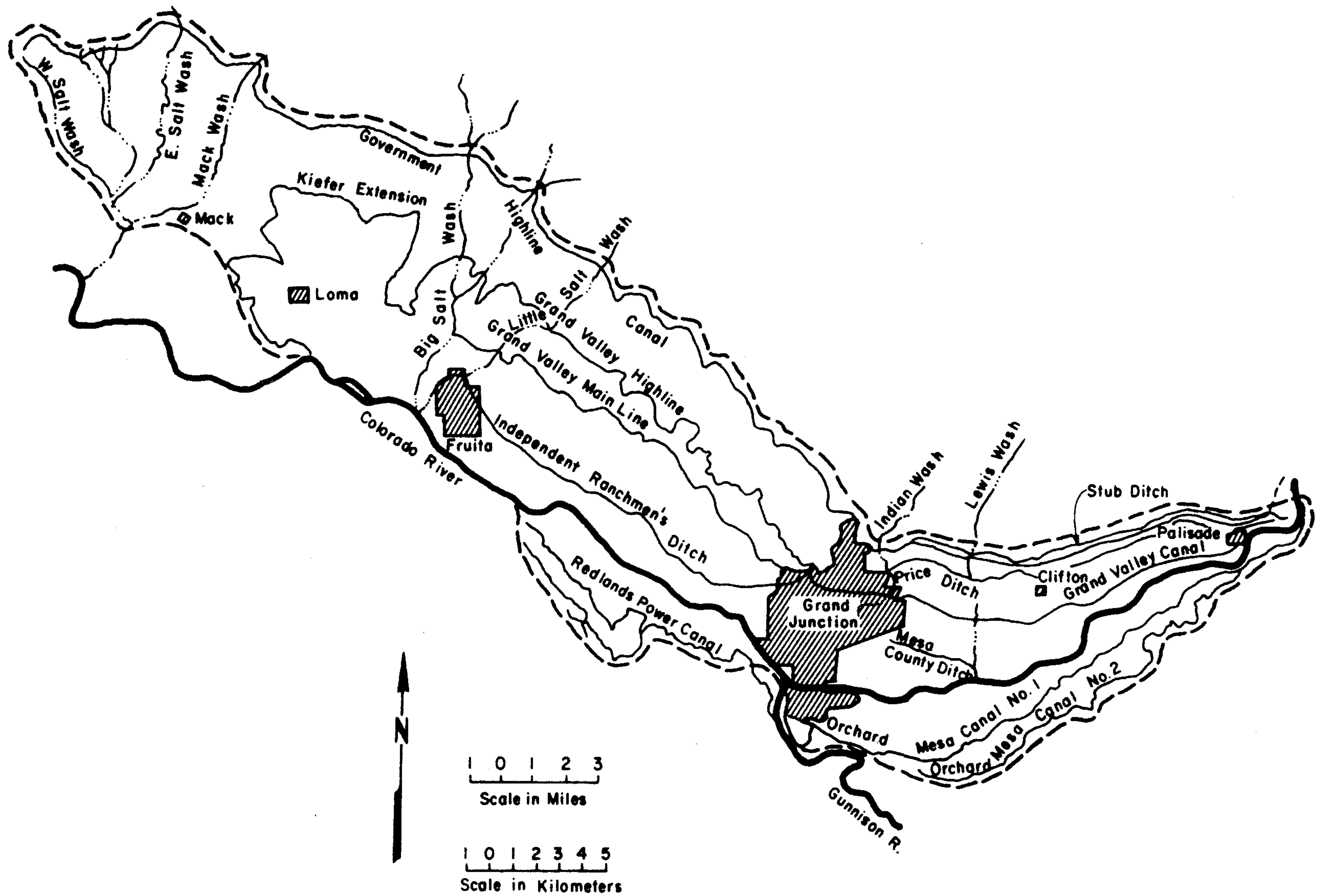
From the time of the initial settlement, the area grew rather slowly primarily due to limitations of water. In 1912, the first Reclamation Project of 62 miles of canal provided water for a 40 mile strip along the river. Its construction provided the impetus for the establishment of rich fruit growing areas and increased significantly the agricultural productivity of the area.

Even with the coming of the Grand Valley project, population remained fairly stable until the early 1950's. During the 1950's, uranium production became an additional source of employment contributing to a significant population increase for that decade.

Grand Valley is only one of the two counties on the Western Slope of Colorado which has shown a population increase. All other counties in the area have shown a net decline (sometimes a dramatic one) between the 1960 and the 1970 censuses. The continued growth of the Grand Valley area can be attributed to a combination of continuous mining and of successful irrigated agriculture.

Although not as pronounced as on the Eastern Slope, there are trends of urbanization around the Grand Junction area. The Grand Junction division, which one may call the "Greater Grand Junction City," area grew at a rate of 52.6 percent over the 1960-1970 census period, with a total population of 28,527. Other settlements in the Valley have grown at a much lower rate. As a matter of fact, two areas in the Grand Valley area have shown a decline in population: the town of Fruita (population 1822 in 1970) and the Palisade division showed a net population decline of -28.8 percent during the same time period with a total of 1964 inhabitants in 1970.

FIGURE A-4. Grand Valley Canal Distribution System



Further growth of the area will depend primarily on further exploitation of natural resources, such as oil shale, natural gas, petroleum, and particularly coal. In addition, a major potential for the area is recreation and tourism. The area has long been known for its aesthetic value and for its fish and game. Deer hunting, elk hunting, and fishing are major magnets of attraction.

It should be noted, however, that large scale development of natural resources, such as in particular oil shale, require large amounts of water for their processing. Thus, given the existing problems of salinity, the interrelationship between irrigation and other water uses becomes a crucial one for the future of the region.

A.3.3 Salinity problem

The system of irrigation most common to the area is surface flooding by furrows. Most farms in the area are small and have short run lengths. The quantity of water delivered to the farmer is plentiful so the usual practice is to allow self-regulated diversions. Although the method of irrigation is quite similar throughout Grand Valley, there is considerable contrast in land use. The lands at the upper (eastern) end of the valley are largely orchards, which is also the case for the Orchard Mesa lands, which are south of the Colorado River. Larger tracts of farm land are located in the western portions of the valley, with many of these lands having good soils, which contribute to the production of high yield crops.

Salinity is the most pressing problem facing the future development of water resources in the Colorado River Basin. Because of the progressive deterioration in mineral quality towards the lower reaches, the detrimental effects of using an increasingly degraded water are first seen in the Lower Basin. As a result of the continual development in the Upper Basin, most of which will be diversions out of the basin to meet large municipal and industrial needs, water ordinarily available to dilute the salt flows will be depleted from the system, causing significant increases in salinity concentrations throughout the basin. The economic penalty resulting from a use of lower quality water will be incurred by those users in the lower system. The U.S. Environmental Protection Agency (1971) has estimated that the present economic losses from salinity are $16 million annually. If water resources development proceeds as proposed without implementing a salinity control program, the average annual economic detriments (1970 dollars) would increase to $28 million in 1980 and $51 million in 2010. These damages do not reflect further costs downstream to Mexico.

The bulk of the salt loads passing into the lower reaches is attributable to the Upper Basin. Salinity management in the Upper Basin must therefore concern itself with the aspect of salt loading in the river system from municipal, industrial, agricultural and natural resources. The other aspect, which is the salt concentrating effects, is related to consumptive use, evaporation, and transbasin diversions. Although several methods of controlling salinity, such as phreatophyte eradication (although controversial from a wildlife standpoint) and evaporation suppression on reservoirs, are desirable, the most feasible solutions are in reducing inflows from mineralized springs and more efficient irrigation practices.

Since the Colorado River Basin is not a rapidly growing municipal and industrial area, the pollution problems are primarily associated with agriculture. Thus, a major aspect of reducing the salt inputs in the Upper Basin must be the effective utilization of the water presently diverted for irrigation by comprehensive programs of conveyance channel lining, increasing irrigation efficiency on the farm, improved irrigation company management practices, and more effective coordination of local objectives between the various institutions in the problem areas. Salinity is no longer a local problem and should be considered regionally. In irrigated areas, it is necessary to maintain an acceptable salt balance in the crop root zone which requires some water for leaching. However, when irrigation efficiency is low and conveyance seepage losses are high, the additional deep percolation losses are subject to the highly saline aquifers and soils common in the basin and result in large quantities of salt being picked up and carried back to the river system. Therefore, a pressing need exists to delineate the high input areas and examine the management alternatives available to establish the most effective salinity control program. In this challenge of efficient agriculture lies the key problem for understanding the operation of the irrigation system in the valley.

A.3.4 Irrigation development

Grand Valley Canal. The present Grand Valley Canal system comprising approximately 110 miles of canals and subcanals is the result of a consolidation of the Grand River Ditch Company, Grand Valley Canal Company, Mesa County Ditch Company, Pioneer Extension Ditch Company, and the Independent Ranchmen's Ditch Association. The construction of what is now the main line Grand Valley Canal probably began in 1882 since the original priority is dated August 22, 1882. However, the early development times were uncertain and the company, like many others, was facing financial trouble so was sold to the Traveler's Insurance Company which also acquired title to the other four companies now making up the system. On January 29, 1894, the Grand Valley Irrigation Company was incorporated when the Certificate of Incorporation was filed with the Secretary of State's Office and the title was acquired from the insurance company.

Upon the organization of the company, an application was made for an adjudication of its water rights from the Colorado River. The application for the Grand Valley Canal was awarded a decree of 520.81 cfs, July 27, 1912, with the priority date of August 22, 1882, which was priority No. 1 on the Colorado River. The hearings which lead to the adjudication established an irrigated acreage of 30-35 thousand acres with a probable 20% system loss rate. On July 25, 1914, the First Enlargement of the Grand Valley Canal was awarded Priority No. 358 and dated July 23, 1914 for 195.33 cfs, of which 75.86 cfs is conditional upon the addition of 4,661.25 acres to the system. Although the original decree was based on an estimated acreage of 30-35,000 acres, later investigation revealed the acreage was slightly less than 40,000 acres, plus the additional 4,661.25 acres not yet developed, for a total of about 44,000 acres. If the usual 200-day irrigation season is experienced, this water right amounts to approximately 5.76 acre-feet per acre, from which an estimated 20% loss rate of 1.05 acre-feet per acre leaves about 4.71 acre-feet per acre for irrigation.

The company is organized in the corporation format. The division of water among irrigators is on the basis of shares of the capital stock of the company comprising a total of 48,000 shares. Thus, an individual holding one share of stock would be entitled to 4.23 acre-feet of water at his turnout. It should be noted that this figure does not include the loss rates of the company. In addition, these figures do not include the 75.86 cfs of conditional water. In 1971, the water assessment was $15.00 for the first share and $2.40 for each additional share. Occasionally, some assessments cannot be paid, in which case a period is given for the irrigator to reclaim the water share, after which grace period the share is sold at auction.

Grand Valley Project. The Grand Valley project which now serves water to four irrigation companies, the Grand Valley Water Users Association, the Orchard Mesa Irrigation District, Palisade Irrigation District (Price Ditch), and the Mesa County Irrigation District (Stub Ditch), is the result of considerable effort and a long series of disappointments.

The Grand Valley Water Users Association was incorporated February 7, 1905 and later renewed the incorporation September 11, 1945. It operates the Government Highline Canal which serves about 44,416 acres of irrigable land. In addition, the Association diverts 800 cfs during the nonirrigation season for power development through a siphon across the Colorado River shortly below the main diversion. During the irrigation season, 400 cfs is used for power development, with the remaining 400 cfs passing through the irrigation pumps. The power generated with this water is sold to the Public Service Company of Colorado to help pay the debt on the original project.

The operation of the Grand Valley Water Users Association is on a corporation basis, and although stock is registered in the County Recorder's Office, none has ever been issued. The Bureau of Reclamation classified the land into one of five categories: Class 1 - good orchard; Class 1A - young orchard; Class 2 - good agricultural lands; Class 3 - fair agricultural lands; and, Class 4 - poor agricultural lands. On the basis of this classification, a farmer can sign up for his irrigable acreage which allows him at the present time four acre-feet per acre, above which (if the supply is available) he is charged for the excess. There are restrictions on the time rate of delivery, however, which are imposed when the supply is limited. This restriction is usually a limit of 1 cfs per 40 acres and sometimes as low as 0.75 cfs per 40 irrigable acres; this practice has, in the past, been necessary only during the peak use months of the summer. During the fall and spring, water is usually delivered on a demand basis. It should be further noted that although a farmer signs up for a fixed area of irrigable acreage, he may apply the water as he wishes on his property. In addition, when the property is sold he is allowed only to sell water for the irrigable acreage being sold, so in effect the water is tied to the land and nonshareholders or outside acreage cannot obtain Association water.

The Orchard Mesa Division of the Grand Valley Project was formed by request of the people of the Orchard Mesa Irrigation District when the prior operation was facing bankruptcy. The District was organized under the 1905 Colorado Statute covering irrigation districts, which was later revised to the 1921 Colorado Law. The operation of the district in many ways is similar to the Association in that the water duty and land classification are the same. The Orchard Mesa Irrigation District is now provided water through a siphon diversion from the Government Highline Canal into the Orchard Mesa Power Canal. During the irrigation season, 1/2 of the 800 cfs in the canal is diverted through the Orchard Mesa Irrigation District pumps which lift 80 cfs 40 feet into the Orchard Mesa #2 Canal and 60 cfs 130 feet into the Orchard Mesa #1 Canal.

The Palisade Irrigation District, with essentially the same organizational format as the Orchard Mesa Irrigation District, operates the Price Ditch. This ditch is supplied 66-68 cfs through a turbine pump just off the Government Highline Canal as it exits through Tunnel No. 3. An additional 22-24 cfs is delivered through turnouts in the Highline Canal.

Both the Palisade Irrigation District and the Mesa County Irrigation District were organized independently of the government projects. Their history is somewhat unknown to the writers, but they consolidated their systems with the Highline Canal when it was built, presumably to streamline their operation.

The Mesa County Irrigation District, which operates the Stub Ditch, has an irrigation water right of 40 cfs. The operation and organization of this district is similar to the previous five districts mentioned. At the turbine pump serving the Price Ditch, 15 cfs is pumped into the Stub Ditch, with the remaining 25 cfs being diverted directly from the Highline Canal to agricultural lands within the boundaries of the Mesa County Irrigation District.

Redlands Water & Power Company. The Redlands Water & Power Company, a mutual ditch company, irrigates about 3,000 acres southwest of Grand Junction and south of the Colorado River. The water supply is diverted from the Gunnison River in a canal carrying 670 cfs. Six cfs is used for irrigation of lands below the power canal, 610 cfs for power generation and 54 cfs is pumped to an initial height of 127 feet for irrigation. Small areas in the project are served by higher lifts, the highest being at about 300 feet. Electricity in excess of pumping needs is sold to project settlers and to the Public Service Company of Colorado.

A.3.5 Conveyance system

Consideration of the water distribution system is an essential part of most water management and salinity control alternatives, which suggests that a broader perspective of system improvement, which includes salinity control, is required. The delivery system in the valley is divided into the canal or ditch subsystem and the lateral subsystem. The division between the two subsystems is based on management responsibility. The canal companies and irrigation districts divert the appropriated water directly from the river, transport the water in the canal subsystem, and control the delivery of water through the canal turnout, but they generally assume little responsibility for the water below this point. The canal and ditch subsystem can, thus, be defined as that part of the delivery network which is controlled by irrigation authorities. The lateral network, extending beyond the turnout from the canal or ditches, is managed by cooperative agreements between the individual users served by the turnout. The transfer of responsibility between the two phases should be the equitable measurement and charge for the water at the turnout, but there is little incentive to make this effort with the abundance of water presently available. The turnouts comprising the Water Users Association under the Government Highline Canal are an exception, where individual measurements are made and recorded.

The canals and ditches in the Grand Valley, shown previously in Figure A-4, are operated and maintained by the respective organizations mentioned earlier. Discharge capacities at the head of the canals range from above 700 cfs in the Government Highline Canal to 30 cfs in the Stub Ditch and diminish along the length of each canal or ditch. The lengths of the respective canal systems are approximately 55 miles for the Government Highline Canal, 12 miles each for the Price, Stub, and Redlands Ditches, 110 miles for the Grand Valley system, and 36 miles for the Orchard Mesa Canals.

The management of the canals and ditches in the area varies between canals, as well as with changes in the water supply. For example, during periods when river flows become small, restrictions are placed on the diversion into the Government Highline Canal. This is possible because the flows are measured and recorded at each individual turnout in that system, and it is required since their water rights are junior to others. On the other hand, in most instances along the other canals measurements are not made because little shortage is experienced. Another practice used extensively in the region is the regulation of canal discharges at points in the system by varying the amounts of spillage into the natural wasteways and washes. Neither of these practices - inadequate flow measurement and canal spillage - are conducive to either good water management or salinity control.

The dilemmas being faced by irrigation officials are numerous, but can be traced to one factor. When the demand for irrigation was realized and the canal alignments located, the expected demand for water was based on the total area of land under the canal. However, when the acreages of roads, homes, phreatophytes, etc., are deducted, the water available for each acre is significantly increased. For example, under the Grand Valley Canal are 44,774 acres of which only 28,407 are irrigable. Consequently, instead of having a water duty (annual volume of water diverted from the river per unit area) of 5.76 acre-feet per acre, there is more than 9 acre-feet per irrigable acre. The result is a two-fold problem:

(1) With the excess of water available to the irrigators, it is more economical to be wasteful, because failure to provide adequate water to crops during critical growing periods can affect yields more than an overirrigation.

(2) The history of development in the Western United States has always shown water to be a valuable commodity to an area and as such, the rights one has are to be protected since the rights not historically diverted are lost. Consequently, the Grand Valley must divert its rights for fear of losing them.

In short, it is not the practice of agriculture to be wasteful, but the laws regulating the use of water dictate that a user either be wasteful or give up a valuable right.

A few remarks are also needed for the lateral system. The term "lateral" refers to the small conveyance channels delivering water from company operated canals to the cropland. When water is turned into the lateral system, it becomes the responsibility of the users entitled to the diversion. Single users served by an individual turnout are not uncommon, but most laterals serve several irrigators who decide among themselves how the lateral will be operated. Most of the multiple-use laterals, which may serve as many as 100 users, are allowed to run continuously with the unused water being diverted into the drainage channels. This practice would be almost completely eliminated if the only water diverted was that quantity appropriated to each acre in the company water rights. The costs that would be passed on to the irrigator for a more regulated canal system would also provide added incentive for more efficient water management practices below the canal turnout. Thus, there would be an indirect economic incentive for better management.

There is a definite need for system rehabilitation in the form of linings and regulating structures prior to placing restrictions on lateral diversions. The reason is simply that little means of water distribution on an equitable basis below the canal turnout exists. Aside from the canal turnouts themselves, which could be rated individually, no observable means of water measurement exists. Without adding control and measurement structures, it would be impossible to either regulate lateral diversions or equitably distribute the water among users.

A.3.6 Water anagement in the Grand Valley

The saline soil conditions associated with inadequate drainage and the basin-wide urgency of rising salinity concentrations make water management in the Grand Valley increasingly important. The inefficiencies apparent in present practices of water use result from a combination of abundant water supply, low water costs, and critical soil and topographic characteristics. These problems would have been dealt with more substantially long ago, if the economic penalties had been more severe. In the Grand Valley, the 30% of the acreage highly affected by poor water management was an insufficient deterrent to offset the belief that use must be made of all water rights in order to protect them. Nevertheless, the time has arrived when the growing salinity problem in the Colorado River Basin, complicated by recent and planned development in the Upper Basin States, has forced areas like the Grand Valley to plan for more efficient management of water.

The Grand Valley Water Purification Project, Inc. (a consortium of local irrigation companies organized to seek improvements in the conveyance system), interested citizens, and state legislators have realized the need to promote investigations that will lead to a feasible salinity control program for the valley. This attitude is extremely farsighted and will prove beneficial to the irrigators in the area by studying all available solutions and providing for increased farm output to offset the costs that will be incurred. More recently, this entity reorganized as the Grand Valley Canal Systems, Inc.

The internal phases of a salinity control program in the valley involve canal system management, on-farm water use improvements, and drainage.

Canal System Management. Although the primary use of water is on the farm, the primary control is not. Therefore, the first step in effecting a sound management scheme is the incorporation of more rigid water company controls. It has been alluded to several times in the preceding sections that the adjudicated water supply under normal water years is especially abundant, on the order of 8-9 acre-feet per irrigated acre. With such a high water duty, waste and inefficient use is encouraged. There are several conditions existing that should be improved. These include the increased control of canal diversions to reduce spillage into natural washes and drains, company control of lateral turnouts to avoid the excessive waste below in the form of dumping water into the drainage system when not used in multiple use systems, and control on the delivery mechanism such as a call period to efficiently meet irrigation demands.

On-Farm Water Management. Excessive application of water to soils in the Grand Valley is undoubtedly the primary cause of salt inputs to the river system. Increased irrigation efficiencies will be the most influential factor affecting improvements in salt contribution, drainage problems, and crop production. It is estimated that the valley-wide farm efficiency ranges between 30 to 40%. In this range of operation, every acre-foot of water consumptively used by crops must be accompanied by about two and one-half acre-feet that flows as deep percolation or field tailwater. If improved canal management measures were present, farm efficiency would be sharply enhanced. The real need in this area is a program to improve irrigation methods and practices.

Drainage. The present open ditch drainage system is largely ineffective in reducing the high water tables and, for the most part, is used mainly as a conveyance for field tailwater. The reason for the general inadequacy of these drains is based on the fact that insufficient attention appears to have been given to the true characteristics of the problem. Piezometric readings and stratum surveys taken throughout the valley indicate that a relatively impermeable layer confines a cobble aquifer commonly producing a vertical gradient. The confining layer has been found to be discontinuous in at least one location, allowing water to move more freely into and out of the cobble, thus increasing the drainage potential. Measurements of hydraulic conductivity and hydraulic gradients show conclusively that most flows into the river, occurring as subsurface flows, are transmitted by the cobble aquifer.

A.3.7 Institutional requirements

When all aspects are considered, the institutional constraints compromising the wishes of local water users and regional salinity planners will be the most difficult and the most important to resolve. Salinity control in the Grand Valley simplifies immediately to the restricted use of water resulting in a quantity that need not be diverted. The question immediately confronted is what happens and who obtains the water saved by salinity control programs in the Grand Valley? The legal constraint here is the possibility of forced abandonment of some of the decreed water right in the valley and then, the successive reapportionment to other uses. Thus, the water use must be changed from irrigation to another desired use if it is to be left in the valley supply.

Ineffective drainage, excessive salt inputs to the Colorado River, and marginal agricultural production from at least 30% of the valley are not three independent problems, just one - poor water management practices by an irrigated agriculture. Grand Valley is not unique in this respect, either. Consequently, the implementation of salinity control measures will require the formation of an administrative body to coordinate the activities of the various entities concerned with irrigation in the valley. These and similar questions suggest a valley authority for coordinating the salinity control program. The basic structure of this institution would allow it to seek salinity control funding, research funding, etc., and to transmit pertinent data and planning efforts between the federal-state entities and the local organizations. It would also stimulate the interest and investigation of economic, social, and legal problems influential in salinity reductions.

The prospect of obtaining federal money for canal and lateral lining as a first step in salinity control in the late 1960's led to the organization of the Grand Valley Water Purification Project, Inc. (GVWPP). The next step is a logical extension of the GVWPP into a regional salinity management coordinating council. Since the present organization is comrpised of local irrigation and drainage officials, it seems justified to broaden the format to include such responsibilities.

The possibility of organizational consolidation at the local level among the existing irrigation companies to facilitate more efficient irrigation operations as well as operating the valley salinity control program should also be considered. Such a consolidation would allow a pooling of personnel, equipment, and finances, thereby providing some savings in operational costs, but more importantly, allowing the entire Grand Valley irrigation enterprise to be operated as a truly integrated system.

In January 1972, a new organization, "Grand Valley Canal Systems, Inc.," was formed. This organization has membership on the Board of Directors from the Grand Valley Irrigation Company, Mesa County Irrigation Districts, Palisade Irrigation District, Redlands Water and Power Company, and Fruita Canal and Land Company. The principal purpose of this entity is:

To promote the efficient and proper use of irrigation water in the Grand Valley area of Mesa County, Colorado; to protect the quality and quantity of water available for irrigation purposes in said Grand Valley; to promote a cooperative effort between companies and districts distributing irrigation water through the said Grand Valley area of Mesa County, Colorado; and to do and perform all things deemed beneficial for the interest of the individual users and distributors of irrigation water in said area.

Noticeably absent in this organization is the Grand Valley Water Users Association and the Orchard Mesa Irrigation District. Although this organization does not completely accomplish the goals of "Consolidation in Irrigation Systems," it does represent a large step forward to the eventual achievement of an integrated Grand Valley irrigation system. Of particular interest is that this organization resulted from the strong emphasis upon salinity control in the Colorado River Basin.

Another highly important organizational feature would be the creation of informed lateral associations. At the present time, the water users on a few laterals have organized under an informal arrangement for improving the operation and maintenance of the lateral. In most cases, the water users on a lateral are not well organized for managing their irrigation supply. At the same time, the irrigation companies avoid becoming involved in water distribution among the water users of a lateral. Thus, in order to effectively rehabilitate these laterals, it becomes highly important that the users on each lateral be organized to provide input to those Federal agencies which will be responsible for implementing a salinity control program in Grand Valley and to obtain the maximum benefits under the program.

To sum up the case of the Grand Valley: this was a case where the physical problem of salinity control is acting as a catalyst for organizational change. Although no in-depth sociological survey of the area was conducted, it has become apparent that, as in many other valleys in the West, coordination and centralized organizational approaches are imperative means for survival and for meeting the changing circumstances of both the physical and the social surrounding environments.

A.4 Poudre Valley

A.4.1 Location and physiography

The drainage area for the Cache la Poudre River lies in north-central Colorado on the eastern side of the Rocky Mountains and is shown in Figure A-5. The eastern side of the Laramie and Medicine Bow Ranges forms the western hydrologic boundary. The Mummy Range forms the southern hydrologic boundary between the Big Thompson River and the Cache la Poudre River. The northern boundary is in the high plateau region of southern Wyoming. The Cache la Poudre discharges into the South Platte River on the eastern boundary near the city of Greeley.

The Cache la Poudre River technically heads at Poudre Lake on the Continental Divide (by Trail Ridge Road), but in actuality it heads at Chambers Lake. The Cache la Poudre River is the last major perennial tributary to the South Platte River before its confluence with the North Platte River in Nebraska. From its headwaters, the Poudre proceeds in a north and east direction to the mouth of Poudre Canyon, where it swings east and south for about 35 miles until it meets with the South Platte River just east of Greeley, Colorado. The agricultural portion of Poudre Valley lies mostly in the Colorado Piedmont section of the Great Plains Province. Basically, the Poudre Valley consists of a series of lowlands lying along the stream separated by gently rolling uplands.

A.4.2 Water supply

The natural water supply is totally supplied from melting snow, and the perennial snow fields in the mountains, and precipitation. However, the transbasin diversions, of which the Colorado-Big Thompson is the largest, provide a very significant contribution to the total flow. These foreign waters are also derived from melting snow sources in other high mountain watersheds.

The natural flow of the Cache la Poudre River and its mountain tributaries contributes about 44 percent of the total water supply to the valley. The Colorado-Big Thompson contributes another 17 percent and the other trans-mountain diversions furnish 6 percent. Pumped water yields another 33 percent (Figure A-6). Intensive reuse of return flows from irrigation and municipal waters, plus the natural flows of the plains tributaries, yield (in effect) an additional 145,400 acre-feet per year.

A.4.3 Agricultural economic conditions

The Cache la Poudre Valley is an area of widely diversified agriculture ranging from native hay to corn and sugar beets to carrots, potatoes and cucumbers. Although many crops grow well in this area, the three major crops are corn, sugar beets, and alfalfa.

FIGURE A-5. Hydrologic Boundary of the Cache la Poudre River

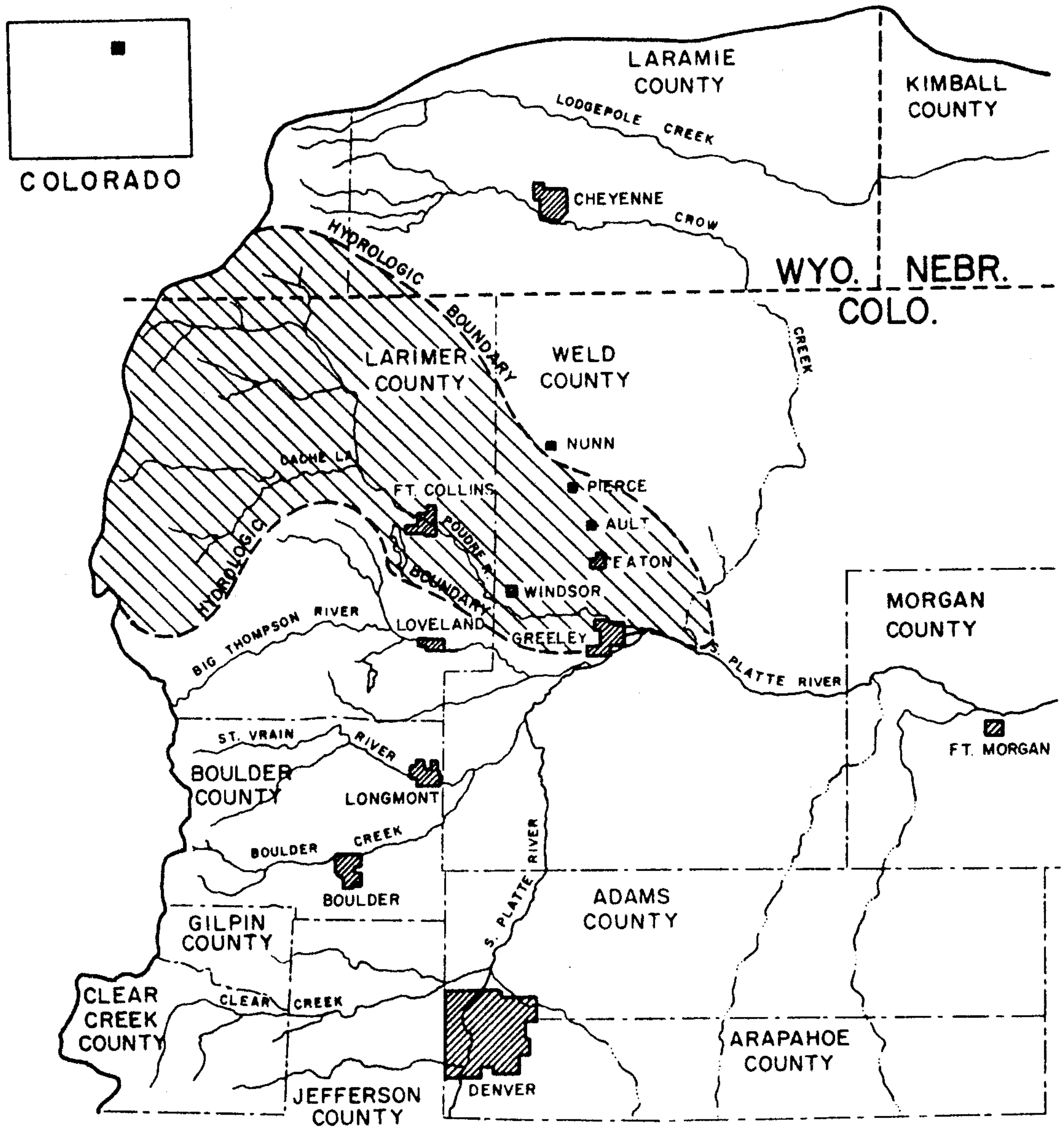
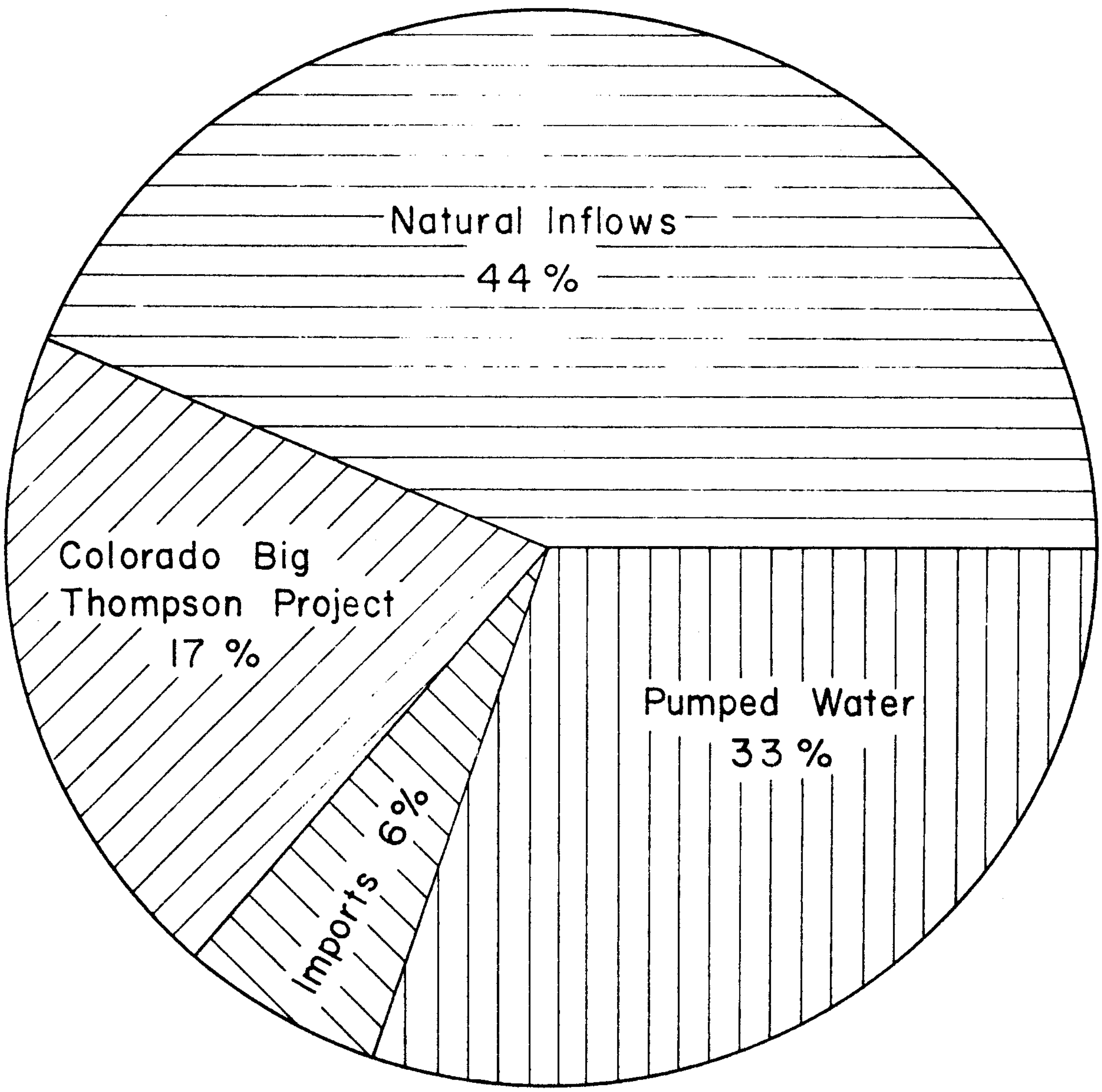


FIGURE A-6. Relative Proportions of Water Supply Sources to the Cache la Poudre Valley



The principal agricultural industries are general farming, livestock feeding and dairying. The alfalfa and corn are usually raised for consumption in the area by the large number of feeder cattle and sheep. Sugar beets are sold to Great Western Sugar Company, and the tops and pulp used to supplement the livestock industry. The small grains such as oats and barley are primarily consumed in the area.

The farming in the area is of two types, one being irrigated, the other being dry farming. The dry farming is found on the hills that are too high or the cost incurred in deliverying the water to these hills would be too great, or the soil was deemed as marginal. These dry farm plots are primarily used for small grains. The irrigated lands, on the other hand, are used for farming and they have been leveled under the direction of the SCS to enhance the production capability. The products which are grown are primarily sugar beets, small grains, corn, alfalfa and some soybeans.

The cash value of agricultural crops during 1967 for Larimer and Weld counties was $9,600,000 and $43,600,000, respectively. Of the total cash value of $53,200,000, the value of crops from irrigated lands was $47,000,000. Thus, the average cash value of crops from irrigated lands was approximately $190 per acre.

A.4.4 Human community

Poudre Valley contains two northern counties of Colorado; namely, Larimer and Weld. Both of these counties are fairly similar in terms of population, size, and composition, but with Larimer County increasingly becoming highly urbanized, as contrasted to Weld County's firmer agricultural basis.

Larimer County, which is located on the west edge of the valley, with a population of 89,000 according to the 1970 census, has shown a high increase of 69 percent over the previous census. The number of the inhabitants of Larimer County classified as urban in 1970 were 59,557, with the remaining 23,644 classified as rural. However, Larimer lists only 2,167 persons as full-time employed in agriculture, a rather small proportion of the 34,094 persons gainfully employed in the county. The largest number of employed persons in any single category is to be found in manufacturing, followed by education and construction. The population of the county is rather young, with high in-migration and high levels of educational attainment. The principal city in Larimer County is Fort Collins. Fort Collins has been growing much more rapidly than the rest of the county showing an increase of 72 percent between 1960 and 1970 for a total population of 43,098 inhabitants in 1970. Fort Collins is the eighth largest city in the state, rapidly becoming the populous pole in the emerging Colorado megolopolis stretching all the way from Fort Collins in the north to Pueblo in the south. As a matter of fact, projections to the year 2000 estimate an approximate population of 200,000 persons in the county with an even higher number of people by the year 2020 (estimated to about 355,000 inhabitants).

The urban growth of the city of Fort Collins is part of a rapidly growing urban hinterland contained between the cities of Fort Collins, Loveland, and Greeley (the last in Weld County) forming an idealized "urban triangle." The population of this triangle which is superimposed on Poudre Valley is expected to increase from about 95,000 to more than 400,000 people by the year 2020.

The rapid urban growth of Poudre Valley represents a situation where a great deal of agricultural land and agricultural water are rapidly being converted into water used for municipal and industrial purposes. Part of the industrial growth in the Poudre Valley has been through the recent influx of new industry such as the new Kodak plant, right across the Larimer County line in the neighboring Weld County. There are also other large manufacturing establishments such as the Hewlett-Packard plant in Loveland, which employs many Fort Collins residents, Woodward Governor which maintains a fairly large facility in the Fort Collins area, and Colorado State University, absorbing for its supporting personnel a significant number of people in the Larimer County region.

The continuous trends of urban and industrial growth and the emergence of an industrial-commercial complex (including development of transporation companies, material supply commerical businesses, and service enterprises) are expected to become the standard features characterizing life in Poudre Valley in the coming years. What should be remembered here, both in the context of changing communities and from new conditions resulting from the conversion of water uses, is that when the location of industrial plants occur and urban growth rapidly takes place, they are often accompanied by sudden, and sometimes traumatic, changes in the lives of surrounding communities. In addition to vast changes brought about with the new and massive capital influx, new values, and conflicting demands for natural resources, the old social structure is also altered and traditional and established patterns of community life and employment are also disrupted.

Against such a background of a rapidly changing and fast-urbanizing valley, we need to see the past developments of irrigation, the present role of agriculture and some prospects concerning water and land use in the valley.

A.4.5 Irrigation development

The first Anglo settlers of the land now known as Colorado came for purposes quite different from religious ones. The men came for excitement, adventure, the thrill of taking risks - but mostly they came for the furs. A good income could be made by following the animals, and some of the mountain men built a sizable trading establishment on major trading routes. These trading posts or forts were well-known to many explorers sent later by the United States government.

Summer is not a good time to trap for furs, so the owner of a post turned his hand to farming. The Mexican traders irrigated successfully, but the Anglos, not being familiar with the method, were not as quick to adopt it. The results of this error probably reinforced the belief among later settlers that farming in Colorado was possible only by using irrigation.

In the 1850's a new wave invaded the territory, seeking a more solid resource. It is no doubt safe to say that most of these men were unsuccessful. Some, deciding to stay, tried farming, especially when confronted with the high cost of food-stuffs brought in from St. Louis. These farmers had no worries about demand for their products, not with so many miners in the territory, and more passing through on the way to the Pacific.

The first settler in the Cache la Poudre River Valley (this river is hereafter referred to as the Poudre) was Antoine Janis, who as a twelve-year-old, had passed through the valley (in 1836) with his father in a trader's caravan on their way from St. Louis to Green River. He returned eight years later to stake a squatter's claim on land in what is now the village of LaPorte. At that time the land was occupied by a group of Arapahoes, with huge herds of buffalo nearby. Janis did not immediately settle on this claim but continued scouting, operating out of Fort Laramie. He noted that the settlers began coming in during the winter of 1858-9.

That following summer small, short ditches were dug by individual farmers in LaPorte to utilize the water from the Poudre for farming. The first diversion decree on the Poudre was later established by a court to date from June 1, 1860, for a canal built by a G.R. Sanderson of Pleasant Valley. His squatter's right was purchased by J.H. Yeager in 1863 and the canal became known as the Yeager Ditch.

McKinnon describes the Poudre Valley as the "first intensively irrigated area in the State". In the 1860's, ditches were small, and only bottom lands were farmed. The chief crop was hay. Later, farmers tried sugar beets, alfalfa, and potatoes, crops which need water over a longer time period than river flow can supply. More sophisticated methods had to be utilized.

Greeley provided the stimulus for agricultural growth and irrigation development. It began as an organized colonial settlement, privately financed by members. This Union Colony planned four ditches, designed to irrigate about 110,000 acres. Planners felt that $20,000 would be enough. By the time they finished, the total had reached $412,000. Many engineering problems had to be overcome, and members had no experience in irrigation to guide them. Nevertheless, they were eventually successful, and irrigation projects were begun all over the state. The trend was toward cooperation in district organization. There was even some demand for state control of the water supply, but this was not universal. Because of various developments, the courts and legislature took steps to safeguard irrigation from corporate monopolies.

Early irrigation (before the Union Colony) had been extremely primitive - dam a stream and flood the adjacent bottom lands or direct the water to the field by means of small channels or ditches. The Union Colony project was more ambitious. Greeley Ditch No. 3 was built to serve the city itself and farmland immediately adjacent to the city. Greeley Ditch No. 2, with its diversion point farther upstream (away from Greeley), was built to irrigate some bottom land and also some higher land, as people began to realize that altitude alone did not determine fertility of the soil. The No. 2

was bigger than No. 3 and longer - 27 miles in length. After it was built by the Colony, ownership was transferred to the farmers who used the water. A third ditch, No. 1, was planned for the north side of the river but never started. The land it would have irrigated was served instead by the Larimer and Wēld Canal.

Encouraged by the success at Greeley and the optimism of rapid growth, and interested in the chance for a high profit, British speculators later built big ditches. This was not popular among the farmers, for the British companies believed that they owned the water in the ditches and therefore charged a royalty for the use of this water. Eventually the issue was brought to court, and after several attempts, the farmers won a victory in the Colorado Supreme Court, in a ruling that the ditches were common carriers, that the companies did not have property rights in the water, and that farmers need not pay the royalty. As a result, prices for water were stabilized and British speculation was ended.

In the 1870's, the Union Colony faced some severe competition that threatened its existence. While the case referred to above was important, the events that occurred in Fort Collins determined the direction of irrigation in the West, when the doctrine of prior appropriation was added to the Colorado Constitution. In 1871, Greeley built its No. 2 Canal, diverting from the Poudre near Fort Collins. The village of Fort Collins had recently been organized as a speculative venture patterned after Greeley. It was just beginning to become established, for the residents had suffered from a flood in 1865 when the village was located at LaPorte. The diversion point for the ditches serving Fort Collins were farther upstream than the headgates for the Greeley No. 2 and No. 3. The summer of 1874 happened to be a dry one. Farmers in the Fort Collins colony diverted as much water as they felt they needed, but with there not being as much water in the Poudre River that summer as usual, very little was left to reach Greeley. Actually, the Greeley No. 3 went dry before its farmers got any water. The Fort Collins diversions were farther upstream; the water of the river reached them first. The Greeley farmers claimed that since theirs was built first, they should get the water first. Fortunately, cool heads prevailed. A meeting of farmers from several areas debated the problem. A few men from Greeley were charged with finding a compromise or mutually acceptable plan. The issue was settled by the doctrine of prior appropriation. Under this doctrine, which became part of Colorado's new Constitution, anyone who diverted water from a stream for a beneficial purpose could file a claim for the right to that water. Provided that he exercised this right regularly, he would be entitled to that amount of water each year and could take it before other irrigators who had built their diversions at a later time. Of course, this meant that if he was junior to another irrigator, he too had to wait until the other had taken his water share. The most senior right (the one who had been there first) was respected before the later ones.

In the early stages, it was assumed that there was enough water for everyone. The dry years of the 1870's, referred to above, pointed out the fallacy of this belief. First, the settlers were from eastern states where water shortages were not part of their experience. It was something they had never known and could not anticipate. Second, the travelers who spread stories of the promise of the West, had passed through in early summer, when the rivers were at their highest flow and would indeed seem to have an adequate supply. The travelers saw the rivers at their peak, for no diversions for agriculture had yet been made. After farmers moved in and claimed the river water for their crops, they must have been surprised to see how the flow dwindled to a trickle in late summer.

The next large canal constructed, which involved the enlargement and lengthening of an existing ditch, was the Larimer and Weld Canal. This canal was constructed during the period 1879-1881, when it was enlarged to 571 cfs. The Larimer and Weld Canal, the largest of the canals drawing water from the Poudre, heads just north of Fort Collins and runs to Crow Creek near Barnesville.

There is an extensive and detailed system of laterals to deliver water from the main canals to the fields. Generally, these laterals follow the tops of the ridges and, therefore, run at the slope of the ridges and require drop structures. Where there are several farms under a lateral, the owners have often formed lateral ditch companies. These small companies operate in the same manner as the large companies and, although they use water from a canal, are often completely independent.

Another ditch constructed above the Larimer County Canal which extends past the end of the North Poudre Canal was the Laramie-Poudre Canal. This canal ran discontinuously for a few years until 1928 when it was abandoned.

The framework of the canals (Figure A-7) conforms approximately to the contour lines and provides a general indication of the character and slope of the country. Most of the irrigated lands lie north of the river; the most notable exceptions are near Fort Collins and a small area near Greeley.

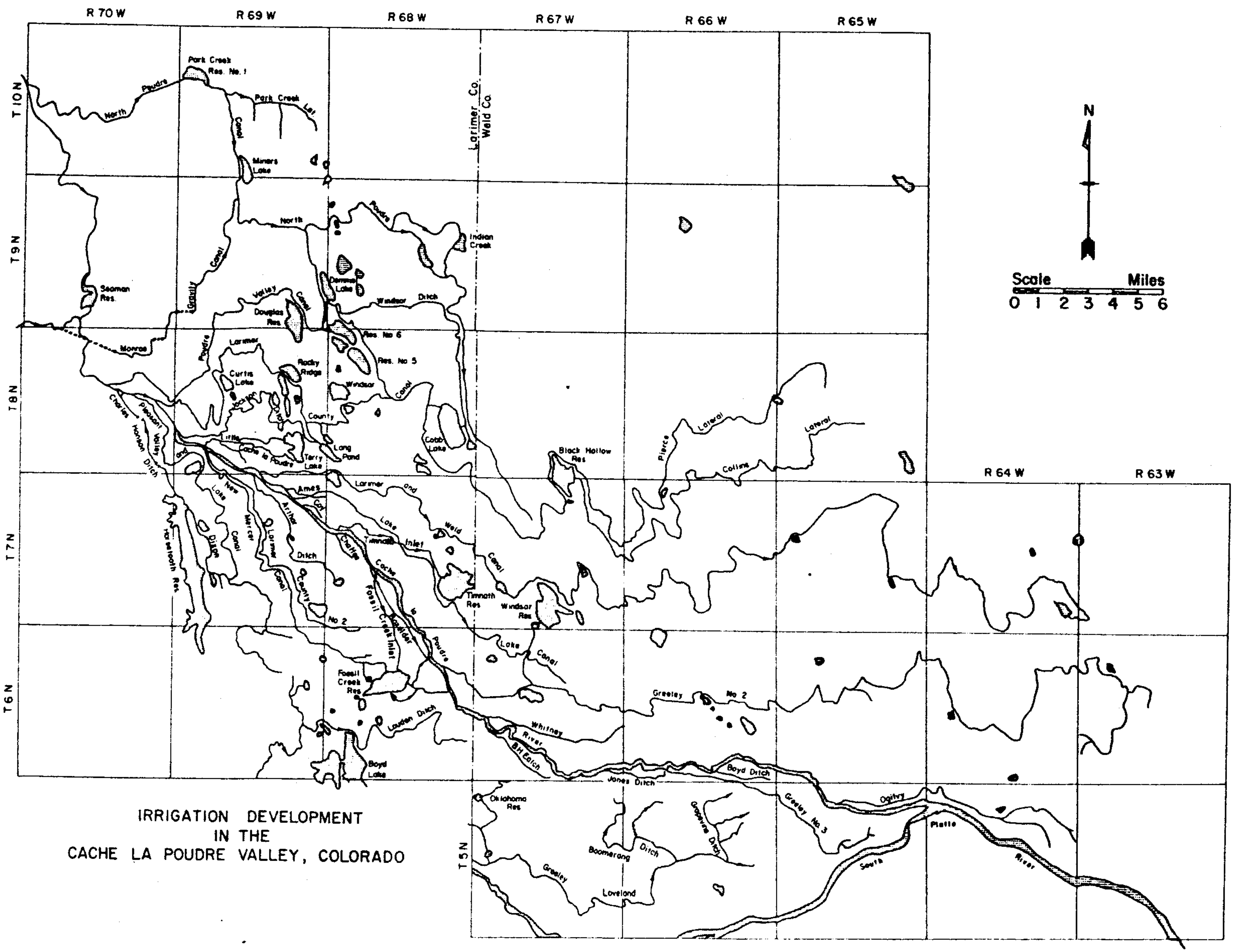
Most of the ditches have been operated and managed on the premise of collecting the return flows from canals lying above and reapplying this water to the land. In fact, many of the canal companies could not operate, would not have enough water to irrigate all of their lands, if it were not for this additional water from return flows. The Bureau of Reclamation has made the observation that the seepage losses of a canal are "reclaimed" by catching the return flows and seepage from the higher canals.

Because the Poudre was one of the first rivers in Colorado to be heavily used for irrigation, it was also one of the first to encounter the associated problems of irrigation. The problems were similar to the difficult questions confronting all heavy water-use areas, but the solutions appear to be unique -- due mostly to the large number of reservoirs and large total storage capacity of the system in the Poudre Valley.

A.4.5 The reservoir system

Water shortages, coupled with the inhibitions imposed by senior appropriations, led later irrigators to seek some other method of supplying water to farms. During low flow of summer, the senior rights took their

FIGURE A-7. Map of Existing Canal and Reservoir Systems in the Cache la Poudre Valley



IRRIGATION DEVELOPMENT
IN THE
CACHE LA POUDRE VALLEY, COLORADO

water and very little was left for the junior appropriators, like the Larimer County Ditch. To solve this, during high flow, they arranged to divert all the water they were entitled to. It was more than enough to supply the needs of the farmers, so the surplus was stored in a reservoir built especially for that purpose. Then in the drier season that followed, when demand for water increased, they could release water from storage without harming the rights of senior appropriators. Other companies followed this practice. The Larimer and Weld, the second largest company in Colorado at that time, owned one-third of all the acreage it supplied with water. To ensure a steady supply of water, the company (owned by the Colorado Mortgage and Investment Company, Ltd., of London) built three reservoirs. Two were started in 1890, with Terry Lake ready for release in 1891 and the Windsor finished in 1896. Greeley Ditch No. 2 put a reservoir (Cache la Poudre Reservoir) near Timnath in 1892, with release of storage water beginning in 1893. Soon other reservoirs dotted the map within that decade (e.g., Long Pond, Rock Ridhe, and Lindenneier).

These reservoirs were needed because of the senior rights and uneven river flow. Another factor was the nature of the crops grown in the valley. Potato cultivation became popular. This crop needs most of the irrigation water late in July, in August, and sometimes in early September - times when river flow is low. The high demand, based on the requirements of the crops, necessitated storage of water for release at more appropriate times.

The profitable cultivation of the Cache la Poudre area became possible by this intricate system of reservoirs and the exchange of water which evolved from necessity. As an example, the North Poudre Irrigation Company has an extensive system of canals, tunnels, syphons, and inter-connected reservoirs. One of the largest groups of natural basins in the state lay below this canal and promised easy development of reservoir sites, which was the main reason for construction of the system. However, the rights of the system are subsequent to almost all the rights on the river. Due to this shortage of water, development of lands tributary to this canal has not been as rapid or as advanced as that of the lands elsewhere in the valley. Ground water mining was the only source of supplemental water. Today, the North Poudre irrigation system is thought by some to be one of the most important factors in the local economy because of playing a larger role in the general exchange system than any other irrigation company in the area.

Reservoirs under the management of the North Poudre Canal include the newly constructed Park Creek Reservoir, Halligan, Fossil Creek, the Boxelder Reservoirs, Clark Lake, Indian Creek Reservoir, Miners Lake, Caverly, Spitzer, Demmel, Wasson, Bee Lake, Hackel, Reservoirs No. 4, No. 6, and No. 15, and some others. Although the North Poudre Canal is the northern-most company, it is of particular significance to note that it is a major stockholder in the Fossil Creek Reservoir which is almost at the southern-most boundary of the entire system.

In addition, there are twenty-six mountain reservoirs having a total decreed capacity of about 48,000 ac-ft. Most of these are owned by irrigation companies, and six are owned by the city of Greeley.

The Plains Storage Rights for approximately 65 reservoirs have decreed storage amounting to about 176,200 ac-ft (without Horsetooth Reservoir). There are approximately 90 or more reservoirs in the plains section. Many of these reservoirs have been operating at less than decreed capacity due to sediment buildups, phreatophytic growth, and deterioration of the facilities.

Historically, the mountain reservoirs are filled during periods of high runoff caused by melting snows. The plains reservoirs are usually filled from April to June with some fall storage, but some are filled during the period of October to May when other uses do not require the water. Most of the reservoirs lie on the northern upstream half of the canal system, and there is little conflict from downstream users to fill the reservoirs, if a call is not being made on the river.

The right to use water for storage purposes during the irrigation season is junior to those rights for direct irrigation. That is, when all the water in the river is needed to satisfy rights for direct application to the land, no water can be diverted to storage.

A.4.7 Reasons for an exchange system

The Cache la Poudre River has more land available for irrigation than there is water to supply it, as is the case in most of the arid West. As was stated earlier, this area was one of the first to develop; it was also one of the first areas to encounter the problems caused by an inadequate water supply. This area was also one of the first to solve the problem.

The flow of the Cache la Poudre River is always highest in June with an average virgin flow of 1769 cfs. The maximum monthly virgin river flow for the last 35 years has been 3590 cfs, and the minimum, 530 cfs.

Using the list of existing appropriations of Cache la Poudre water users, it can be shown that most of the canals have several enlargements over their original decree, each of which has a priority date dependent upon the date of construction of the expansion. For instance, the Greeley No. 2 Canal has an original decree, No. 37, for 110 cfs, with claims prior to theirs for river water for the amount of 759.26 cfs. The Greeley No. 2 Canal secured three more enlargements, the last being No. 83 which credited the canal with an additional 121 cfs, making a total appropriation of 585 cfs. However, the third enlargement is preceded by prior demands on the river for 2574.9 cfs, which must be satisfied before the 121 cfs can be diverted.

The Larimer and Weld Canal has a fourth enlargement, No. 88 for 571 cfs, its main appropriation, which is preceded by claims on the river for 2735.87 cfs. The Larimer County Canal has appropriation No. 100 for 469.80 cfs with senior claims in the amount of 3653.91 cfs. The North Poudre Canal has an initial appropriation for 315 cfs, but has to satisfy prior rights for the amount of 4129.71 cfs.

As can be seen from the above discussion, most of the major canals could not operate even in June, the largest water month of the year. The average river flow at the mouth of Poudre Canyon for June is 1769 cfs, while the last enlargement for the Greeley No. 2 Canal has 2575 cfs in prior claims. The river has had two years in the last 35 which could satisfy these claims, much less the rights of the Larimer and Weld Canals or the North Poudre Canal.

Ignoring the contribution of the Colorado-Big Thompson water which started in 1951, it was the above conditions which caused the evolvement of an intricate exchange system.

The existing exchange system for this area was possible for three major reasons: (1) company ownership of water rights; (2) development of private and corporate storage reservoirs, and (3) the contribution of the Colorado-Big Thompson Project (C-BT).

Company ownership of waters removes the restriction that a water right is appurtenant to a specified tract of land and allows the water to be moved between several parcels of land. The reservoir system made possible a dependable water supply late in the summer. The C-BT, under its charter, can easily transfer water anywhere within the Northern Colorado Water Conservancy District (NCWCD) from any one use to any other use.

There are three basic types of transfers which have evolved along the Cache la Poudre River: (1) exchanges between stockholders in a company; (2) exchanges between companies; and (3) exchanges of C-BT water.

Transfers involving persons belonging to a ditch company are handled by the company office, if the canal is large; or, if it is a small ditch or private reservoir, on an individual agreement-payment basis. The large companies often maintain a service to facilitate the "rentals" by having a list of those who have surpluses and how much water is surplus; and, when any stockholder requests additional water, the company can effect the transfer with a minimum of difficulty. Many companies set a fixed rate of exchange while others leave the price up to the seller. Also, some ditches have elected to have no intraditch exchanges (e.g., the Whitney Ditch). These exchanges amount to about 6 percent of the total diversion. These intro-ditch transfers have a legal basis under Colorado Law as stated below:

> CRS 1963, 148-6-5 It shall be lawful for the owners of ditches and water rights taking water for the same stream, to exchange with, and loan to, each other, for a limited time, the water to which each may be entitled, for the purpose of saving crops or using the water in a more economical manner; provided, that the owners making such loan or exchange shall give notice in writing signed by all the owners participating in said loan or exchange, stating that such loan or exchange has been made, and for what length of time the same shall continue, whereupon said water commissioner shall recognize the same in his distribution of water.

Some people have been able to acquire more water than they can possibly use and rent this excess every season. Since there is no property tax on a water right, renting of water can be a lucrative source of suppplemental income.

Transfers between ditch companies take place only in conjunction with the reservoirs in the valley. From the previous discussion, and a look at the map of the reservoir system, it can be discerned that very few reservoirs can be made to actually serve the lands of their owners. Fortunately, through the Cache la Poudre solution to water shortages, whether a reservoir lies above or below a canal is of little significance as long as it can be utilized, with the capability for exchange being the only criterion for usefulness.

The exchange system was the child of necessity because it had become imperative to move the water from areas where it could not be utilized to where it could be used. The main reason for the exchanges was that the ditches with high priority dates and no reservoirs wished to ensure themselves of a late water supply, while the other junior rights just needed to ensure themselves of a water supply.

The process gained legal acceptance in 1897 when the following law was enacted legalizing the exchange and providing for the measurement of waters:

> CRS 1963, 148-6-4 When the rights of others are not insured thereby, it shall be lawful for the owner of a reservoir to deliver stored water into a ditch entitled to water or into the public stream to supply appropriations from said stream, and take in exchange therefor from the public stream higher up an equal amount of water, less a reasonable deduction for loss, if any there be, to be determined by the state engineer. Provided, that the person or company desiring such exchange shall be required to construct and maintain under direction of the state engineer measuring flumes or weirs and self-registering devices at the point where the water is turned into the stream or ditch taking the same or as near such as is practicable so that the water commissioner may readily determine and secure the just and equitable change of water.

There are some other values of the transfer system besides the more economical use of water. There is the fact that it does not involve lengthy and costly litigation for changes in points of diversion. Also, the use of water on the upper portions of a stream for irrigation will increase the natural flow of the stream by return flows later in the season. In time, the return of seepage flows will ensure the lower portion of the drainage a steady supply and thereby enable larger acreages to be farmed or cultivated.

Municipalities such as Boulder, Loveland, Greeley, Fort Collins, and Longmont have competed for any C-BT water being sold, even if it is not immediately needed, thus raising the price to a point where, if a farmer no longer wants C-BT water it will invariably go to a municipality because agriculture cannot afford to pay for it. Although the municipal and domestic water districts have acquired almost 23 percent of the C-BT water, the loss to agriculture is not as great as it would seem at first glance for three reasons: (1) the cities have expanded and taken over lands previously used for agriculture; (2) there are much larger return flows from cities than from a corresponding agricultural area, even though the same amount is approximately needed on a per acre basis for both uses; and (3) at the present time, the cities have surplus water and are "renting" it to agricultural and industrial users.

A.4.8 The organization of irrigation companies

Parallel to physical developments concerning the supply and distribution of water in Poudre Valley, there have also been organizational changes and the building of institutions aimed at maximizing agricultural production. Thus, before we proceed with a concluding discussion as to the challenge (and opportunity) of consolidation in the Valley, we need briefly to summarize key points of the organization and functioning of irrigation companies.

As mentioned earlier, the natural flow of water through Poudre Valley is exclusively through the Poudre River. Even impounded water finds its way, one way or another, into the Poudre River and then is diverted out of the Poudre River by the river commissioner. The natural flow of the Poudre River, supplied primarily by the Rocky Mountains west of the Fort Collins area, is augmented by a diversion canal which brings water from the Laramie River, and by water which comes from the Colorado-Big Thompson Project that is stored in Horsetooth Reservoir.

The return flow is also very significant in the Poudre Valley area because such flow is adjudicated and owned by various irrigation companies. This water is impounded generally at the lower end of an irrigation company's area and it is then traded to another company which is located down river from the first irrigation company. This second irrigation company, the lower company, will trade water which is impounded in the mountains to the upper company for the water that they have stored in the Valley. For example, the North Poudre Irrigation Company is located in Wellington; the New Cache la Poudre Irrigation Company is located in Greeley. During the irrigation year the North Poudre Irrigation Company in Wellington irrigates its land and stores the water in the Reservoir adjacent to Windsor. This water is then traded to the New Cache la Poudre Irrigation Co. which runs the water from Windsor Lake into its canal system and irrigates the land around Greeley. To repay this debt the New Cache la Poudre Irrigation Co. gives the North Poudre Irrigation Co. water which is stored in mountain lakes west of Fort Collins.

This complex use of return flow allows the farmers in the Poudre Valley area to, first of all, optimize the water which is potentially available to them; and secondly, and more important, such procedures allow various people in the area to obtain the water to which they are entitled according to their water rights. Without this very complex system of water trades it would be impossible to irrigate the amount of land which is presently being tilled in the Greeley-Fort Collins area. In addition, this water supply has been augmented by water from deep water wells. The water is pumped directly from the ground, dumped into irrigation ditches and used as flood irrigation from that particular point on.

To conclude the introduction setting the stage for the organization of irrigation companies, the Poudre Valley area presently has few prospects of gaining new water from outside areas. All of the water which is available on the western slope is owned by various organizations and cannot be diverted to the eastern slope. All of the water which is available in the Poudre River has been adjudicated and these rights have been so totally exploited that the last rights on the river can only be satisfied if the Poudre River is in a state of virtual flood. The potential of exploiting the underground resources in drilling more wells is also significantly limited by the State Engineer's Office because the State Engineer is now compelling farmers to register their wells. This is nothing more than a preliminary step toward adjudicating water wells in the Fort Collins-Greeley area. The adjudication of wells becomes necessary because so many people have been exploiting the underground water, that the water table began to drop at an alarming rate.

Legally, water is defined as the property of the people of the state of Colorado and this water is to be used in a way which is deemed beneficial to the people of that state. Historically, water has been a very emotionally-laden issue in the Poudre Valley area because this has been an area of very fertile land but chronically water short. Despite the help provided by the Colorado-Big Thompson project, water is still in somewhat of short supply. The water companies in the Fort Collins area are defined by the State in the water laws. All of the irrigation companies in the area, and there are about 40 of them, have 5 men on the board of directors. The larger companies serve as high as 350 members and the smallest companies serve as few as 15 members. Ninety percent of all water in the area is supplied by four irrigation companies. These companies are the Eaton Ditch Co., Eaton, Colorado; the North Poudre Irrigation Co., Wellington; Water Supply and Storage, Fort Collins; and the New Cache la Poudre Irrigation Co., located in Greeley. All of these companies date back into the mid-1800's for their water rights. However, it should be pointed out that these major four companies are in a sense large federations, since all four of them serve several smaller companies as a part of the main company. Such an arrangement is nothing more but an economic means of attempting to maximize the efficiency of the irrigation companies. These companies are organized under provisions of Colorado state law. All of them are mutual companies with no dividends paid to the shareholders, other than those expressed in the form of irrigation water. The general water authority delineation can be seen in the descriptive diagrams of Figure A-8.

The board of directors in the companies of the valley receive their position through election by shares. Every person who owns property is able to vote and help elect the man who he feels should be chosen to represent him on the water board. Because of many part-time farmers in the area, much of the voting is done by proxy vote. The role of the members of the board of directors in Poudre Valley is one of forming policy. Their task is not to say how the company should be run in its day-to-day operation but

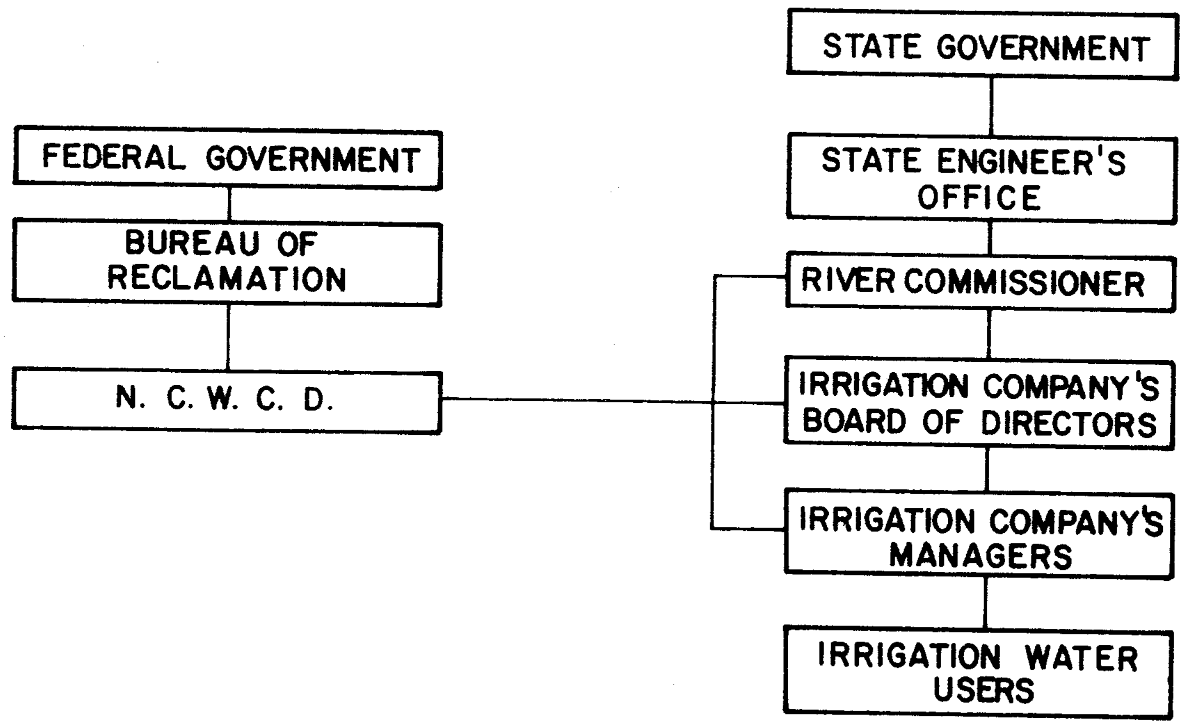


FIGURE A-8. Descriptive Chart of Water Authority in Poudre, Colorado primarily as to what the general policies should be and how such policies should be implemented in the day-to-day operation. All in all, the role of a representative or board member is one of directing the irrigation company in a way that it will be most beneficial for the majority of the water owners in the company. Since board members are considered representatives of various groups, their task of representation is also one of maintaining the best interests of particular groups who own shares in the irrigation company. In interviews conducted in the Valley, no one felt that being on the board of directors was a very prestigious position. All people interviewed felt it was a necessary task which must be done so that water will be delivered, delivered economically, and that the irrigation company will have an administration which will see that the task gets done. It was noted, however, that all board members of the irrigation companies during the field investigation, were relatively successful farmers and for the most part elderly. They had the time to invest in administering the irrigation company because they were semi-retired or in a few cases, totally retired.

The same is also true for the actual management of the irrigation companies, which tends to have older persons. Retirement of ditch riders and water masters is something which most irrigation companies dread because most irrigation management people maintain these positions for many years. Quite often, the board of directors will not permit a man to retire when he reaches retirement age because they feel he is too valuable to be replaced by a beginner. The expertise and training of such people is primarily one of applied knowledge. By working many years on the system, the water master or the ditch rider has an immense understanding of everyday problems and the intricacies of distribution, and he is capable to deal with the problems which are encountered through his applied knowledge. As indicated above, the board of directors dictates only general policy to these men. The day-to-day operation of irrigation companies is something which the managers themselves take care of. Thus, the task of hiring a new water master is a very uncomfortable process for an irrigation company and the members of the board do their best to keep their men as long as possible. On the other hand, the effect of the shareholders on the managers is somewhat distant. Although they receive their instructions in terms of general policy from the board of directors, the water masters and ditch riders still have to maintain a great number of ties with the irrigators themselves as they actually deliver the water to these shareholders. As a result, many of the management people have defined themselves as being someone who has to sympathize with the problems of the various farmers and act as intermediaries offering help for the alleviation of individual problems.

Broadly speaking, the irrigation companies in Poudre Valley are more or less the same as they were 75 to 100 years ago. However, when it is absolutely necessary, certain innovations and changes are undertaken. Changes in the surrounding environment, new conditions of life, and the need to maintain or improve the efficiency of the system, provide a continuous challenge to the survival of a given company.

Before concluding this section on the organization of irrigation companies in the Poudre Valley, a few points need to be emphasized; namely, water rights and practices. Needless to say, the water rights themselves are strictly defined by law and firmly adhered to in the rate and amount of water allocation. On the other hand, water trades, such as those described previously between the North Poudre Irrigation Co., and the New Cache la Poudre Irrigation Co., can vary from day-to-day, week-to-week, and season-to-season depending on agreements which are renewed every year.

Various other norms, traditions, and flexible organizational procedures characterize the actual operation of the various irrigation companies. For example, the norms concerning the election of board members are part of a relatively passive process. Many of the agricultural water users in the area are part-time farmers, working simultaneously in other industries in the Valley. As a result, when the annual water meetings are held, these individuals, for one reason or another, are unable to attend. Therefore, they use the mechanism of voting by proxy. A proxy vote is best described as a vote for the status quo. As a result the election of board members is nothing more than going through the motions of an election on an annual basis. There really is no consequence or significance to such an annual ritual in the eyes of many water owners in the Poudre Valley area.

A.4.9 Prospects for consolidation

Seasonal maldistribution of water would be a very serious problem in the Cache la Poudre Valley if it were not for the highly developed use of return flows, ground water supplies, regulatory surface storage facilities, and the Colorado-Big Thompson Project. All contribute to a very high degree of water use efficiency within the valley.

The advantages of consolidation in the Poudre Valley would be first of all a situation of significant economic benefits. In reality such an <u>ad hoc</u> consolidation has already been implemented in many respects, because Poudre Valley has now four very large irrigation companies which control 90 percent of all water coming into the Valley. These four irrigation companies are in essence a federation of many smaller irrigation companies all housed in the same office. This is done simple because it has been much more efficient to house the various groups in one office, having one main group of managers operating the system and delivering the water to the various companies all through a centralized office. These organizational advantages of the federation (or "consolidation") have already been noticed by the local users. Unfortunately, however, consolidation of canals has not taken place. If the canals were to be consolidated, there would be a drastic reduction in the number of canals in the area. This would lead to additional advantages, such as increased safety for the children in the area, savings from diminished maintenance, abandonment of old canals (to be used for many other social uses, as e.g., long strip type parks, bicycle paths, bridle paths, etc.), and generally water savings resulting from a more tightly organized system.

What should be avoided here is especially compulsory consolidation, which would lack both the support and legitimacy of the water users in the valley. As a result the emerging, consolidated organization would probably meet with a great deal of buffetting, dissention, and marked contention among various people in the area. The perennial fear in the valley is that a consolidated system might take not only water rights away, but eventually the water itself and with it the power to administer the company in a way beneficial to all users.

As things stand now, the probability of consolidation in Poudre Valley is rather small. It would be necessary for some form of external impetus or event to be presented to the people of the valley before consolidation would become a reality. Such outside events seem rather remote, although there is an increasing awareness of larger trends and changing circumstances in the area. The water situation will probably continue under a present decentralized, loosely "consolidated" or federated system.

The major goal as stated by the irrigation companies in the valley is one of supplying to the people the amount of water to which they are entitled to, at the lowest possible cost. Yet, both officers and users in the various irrigation companies are aware of the need for improved methods of water application as evidenced by such efforts as sprinkling, and ditches which are lined with concrete. Typically these lined ditches are found on the individual's property and they are his private ditches rather than being the canal system or the lateral system. Rarely is a canal lined and when it is done it is because the seepage at a particular point was so great that it was nearly prohibitive to carry water through this particular point. On the other hand, increased bureaucracy through consolidation seems to be the stumbling block in the minds of many users. Farmers feel that there would be more levels of bureaucracy for them to have to work with, with a resultant loss of voice and power due to the multi-layers and increased levels of bureaucracy.

An opportunity for consolidation was presented with the establishment of the conservancy district, when the supplemental water is administered through a consolidating organization. The District serves all of the irrigation companies and any of the companies which wish water have to order that water from the district. Thus, the district tends to be an equalizing factor which draws the companies together, particularly when one of the sources of water which is exchanged and traded is the Colorado-Big Thompson Water.

An event which may facilitate consolidation (if not coordination) is the practice of farmers getting together in the spring and walking the ditch. Walking the ditch is going out and cleaning the ditch and preparing the ditch for the year's activities. This process is typically done in the spring prior to letting water into the main ditch and the laterals. This process of walking the ditch serves more than a mechanistic function of simply cleaning the ditch. The process of walking the ditch allows the people along the ditch to get to know one another, to renew friendships, to reinforce frienships, to smooth over previous misunderstandings, and serves as a catalyst for discussing the year's forthcoming irrigation problems and activities. Walking the ditch has been described by some irrigators as "a process of keeping us from killing each other during the year." In this process of walking the ditch the people performing this service are in a position to increase their knowledge of the irrigation company. Such increased knowledge may also help in the alteration of water related attitudes so that users are much more amenable to the needs and overall feelings of the group. A person who has invested some of his time and some of his energy into maintaining the system and helping to rebuild it can be much more satisfied with it and also understand the necessity of coordinated action and centralized organization.

However, as society becomes more complex, and with the encroachment of urbanization, the tendency of all of the water users to walk the ditch diminishes. As a result, many users become isolated members of irrigation companies having little understanding of the demands for efficiency and collective action. They tend to be less satisfied with the irrigation companies simply because they really do not have any knowledge of the functions of the company. They simply pay their water assessment and expect their water to be delivered to them. Their attachment to the company becomes a secondary relationship. This may be proven at the end a truly facilitating factor for consolidation, since quite a number of people have no real attachment for their irrigation company. As long as they get their water they are happy. If it is a consolidated company that is fine with them, provided that water arrives at the time specified.

The future in Poudre Valley points more toward voluntary water consolidation. This is primarily due to the spreading of urbanization upon the agricultural hinterland. The Poudre Valley area is rapidly turning into an urbanized territory within the confines of an urban triangle described above. As this growth continues the irrigation companies will be compelled to look toward one another for support if they are to survive. The irrigation organizations in the area are fully capable of making the transition from independent companies to consolidated systems. Legally, the water rights can be satisfied in a water poor year as well as in a water rich year. And physically the capability exists for such an integration. The major impediment are the water users themselves; many of them are older people who view water as their personal property with water rights not to be tampered with by anyone from the outside. Such users are a vanishing breed, however, because much of the farmland in the area is moving into large agribusiness. Commerical farms are becoming prevalent in the area and many of the smaller farms are simply being taken over or turned into subdivisions by various land development companies. Consolidation in the area, an apparent organizational necessity, may come about as an inevitable evolution to a fast changing and rapidly urbanizing dynamic territory.

References

1. Arrington, Leonard J. _Great Basin Kingdom An Economic History of the Latter-day Saints 1830-1890_ (Lincoln: University of Nebraska Press; 1958).

2. Brough, Charles Hillman. _Irrigation in Utah_ (Baltimore: Johns Hopkins Press; 1898).

3. McKinnon, J.C. "Poudre Valley Contributions to Colorado Irrigation Practice"; _A Hundred Years of Irrigation in Colorado 1852-1952_ (The Colorado Water Conservation Board, Colorado A & M; 1952).

4. Mead, Elwood. _Irrigation Institutions_ (New York: MacMillan; 1903).

5. _The National Atlas of the United States of America_ (Washington: U.S. Department of the Interior Geological Survey; 1970).

6. Smiley, Jerome C. _Semi-Centennial History of the State of Colorado_ (Chicago: Lewis Publishing Company; 1913).

7. Steinel, Alvin T. _History of Agriculture in Colorado 1858-1926_ (Fort Collins: State Agricultural College; 1926).

B.0 APPENDIX B - THE QUESTIONNAIRE OF THE STUDY

To begin with, we would like to ask you a few questions about you and your family.

1. How long have you lived in this area? (please circle)

   1. Less than one year
   2. 1-5 years
   3. 6-10 years
   4. 11-15 years
   5. Over 15 years

2. Please circle the number of the age group containing your age.

   1. Under 20
   2. 21-29
   3. 30-39
   4. 40-49
   5. 50-59
   6. 60-69
   7. 70 and over

3. What was the highest grade of school you have completed? (Circle your choice.)

   Grades: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
   Trade school: 1, 2, 3, 4
   College: 1, 2, 3, 4, 5 or more
   Business school: 1, 2, 3, 4
   Other: ____________________

4. What is your REGULAR occupation? (Please be specific.) (If you have more than one job, give the one with the most income.)

   ____

5. How many acres do you operate?

   1. Acres owned personally ____________________
   2. Acres owned in part ____________________
   3. Acres rented ____________________
   4. Other (please specify) ____________________

   Acres in crops this year ____________________

6. Do you rent part of your land out?

   1. Yes
   2. No

   (If YES) How many acres do you rent out? ____________

7. What is the number of acres left fallow each year? ________

8. What types of crops do you grow?

   1) ____________________
   2) ____________________
   3) ____________________
   4) ____________________

9. What is the approximate production of these crops per acre?

   1) ____________________
   2) ____________________
   3) ____________________
   4) ____________________

10. What was the total value of farm products sold from your farm in:

    1970 ______________

    1969 ______________

11. What is the approximate total value of your farm equipment? (Please circle.)

    1. Less than $25,000
    2. $25,001 to $50,000
    3. $50,001 to $75,000
    4. $75,001 to $100,000
    5. $100,001 to $125,000
    6. $125,001 to $150,000
    7. More than $150,000

12. Do you belong to one or more irrigation companies?

1. One
2. More (Please specify number ________________.)

13. Do you serve presently in any of them in an official capacity?

1. Yes
2. No

14. Have you ever served as an official in an irrigation company before?

1. Yes
2. No

15. How long have you been with your main irrigation company?

1. Less than one year
2. 1-5 years
3. 6-10 years
4. 10-15 years
5. More than 15 years

16. How long have you been served by your Conservancy District?

1. Less than one year
2. 1-5 years
3. 6-10 years
4. 10-15 years
5. More than 15 years

17. Do you use water from any other source than the irrigation company?

1. No
2. Yes (Please check) ___ Private well
   ___ Conservancy District
   ___ Other (please specify) ___________

18. How many shares or water rights do you own? ____________________

19. Approximately how much water does your main irrigation company handle?

____ acre feet

20. How many shares are there in the company? ____________________

21. How many acre feet of water would you estimate the reservoir owned by your company holds?

____________________ acre feet

22. What is the annual average amount of water impounded in your main company's reservoir each year?

____

23. How much water does your main irrigation company distribute each year?

____

24. Could you tell us how many members are in the board of directors of the main irrigation company you belong to?

____

25. When are the directors elected (how often elections are held)?

____

26. From your knowledge of your major irrigation company, how are costs assessed?

27. Is the irrigation company currently paying a repayment contract?

1. Yes
2. No
3. I don't know

(If YES) How much of your total assessed cost goes to the repayment contract?

____

28. How much influence do you feel you have on your main company?

1. Very much
2. Quite a bit
3. Some
4. Very little
5. None at all

29. How much "say" do you feel members should have about how the irrigation company is run?

1. Less say
2. About the same
3. More say

30. Do you feel that you belong or identify with your major irrigation company?

1. Very much
2. Quite a bit
3. Somehow
4. Very little
5. None at all

31. Do you attend the annual stockholders meeting?

1. Regularly (almost every year)
2. Occasionally (on and off, quite a few)
3. Seldom (very few)
4. Never

32. Do you feel the present water assessments of your major company are:

1. far too low
2. somewhat too low
3. don't know
4. about right
5. somewhat too high
6. far too high

33. In your opinion, is the water accurately measured?

1. very well measured
2. fairly well measured
3. not so well measured
4. very badly measured
5. I really don't know

34. Most years, do you feel that you have an adequate water supply late in the summer?

1. Adequate
2. Barely enough
3. Not at all

35. If you don't have adequate water supply what are the alternatives for gaining additional water?

36. Do you use all the water available to you?

1. Yes
2. No
3. I am not sure

37. Do you have a seepage problem?

1. Yes
2. No

38. Is shrink (seepage from your water delivery):

1. taken from your water delivery?
2. taken from the irrigation company's water supply?
3. taken from the district's water supply?
4. taken from another source (state source)

39. How much shrink (carrying charge) occurs in your delivery?

1. 0-10%
2. 11%-20%
3. 21%-30%
4. 31%-40%
5. More than 40%

40. Is there a need for improving the delivery system by lining or new structures?

1. Definitely so
2. I am not sure
3. Not really

41. If there is a need for improvement, is it because of:

1. seepage
2. phreatophytes (water weeds)
3. operating and maintenance costs
4. inadequate canal maintenance
5. erosion

42. Do you feel that you are efficiently irrigating your land?

1. Yes
2. No
3. Not sure

43. Approximately how much of your water is lost due to deep perculation or runoff?

1. 0-10%
2. 11%-20%
3. 21%-30%
4. 31%-40%
5. More than 40%

44. Are there any problems with other people using water out of turn?

1. Yes
2. No
3. Don't know

45. Are there ever any problems in this area with not getting the right amount of water according to your shares?

1. Yes
2. No
3. Don't know

(If YES) What are the causes of this?

46. Do you have any problems around there because of what other people are doing with the water in other areas?

1. Yes
2. No
3. Don't know

(If YES) What are these problems?

47. Have you ever complained or discussed complaints about water conditions with officials (local, district, or state)?

1. No
2. Yes (please check all items that apply)

_____ high assessment
_____ poor service
_____ poor management
_____ unequal treatment of users by the company
_____ measurement troubles
_____ special fees or assessments
_____ (please specify) ______________________________

48. To what extent do you see a pressing need in your main irrigation company for improvement in the following areas?

	Quite a lot of improvement	Some type of improvement	Only a minimal change or improvement	It is adequate as it is	I really don't know
1. Water assessments					
2. Use and maintenance of equipment					
3. Ditch maintenance and repair					
4. Water shrinkage					
5. Delivery methods and measurement					
6. Water schedule and delivery					
7. Personnel of the company					
8. Better office facilities					

49. In evaluating the performance of overall water administration that serves you, could you please tell us by checking the categories below how effective do you consider the administration of the water by:

	Very Effective	Some-What Effective	Undecided	Relatively Ineffective	Absolutely Ineffective	Don't know or Haven't any contact
1. The water master						
2. The ditch-rider						
3. The irrigation company						
4. The conservancy district						
5. The river commissioner						
6. The State Engineer						
7. Bureau of Reclamation						
8. Courts						

50. Generally, compared to other irrigation companies, how would you rate your main irrigation company?

1. Far better than the other irrigation companies
2. Somewhat better than the other irrigation companies
3. Just as good as the other irrigation companies
4. Not quite as good as the other irrigation companies
5. Somewhat worse than the other irrigation companies
6. Far worse than the other irrigation companies

Please give us some of your opinions about each of the following items, just as you feel when you first read each statement. Check the answer most like your own feelings in terms of whether you agree or disagree with the item covered. Please do not leave any item unanswered.

	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
51. Most of the State's water laws should be rewritten.					
52. People who use water are a lot more able to decide how to distribute water than are the water officials.					
53. What we need in this area is a place where we can go and get results on water matters.					
54. Water officials in the company don't care much what people like me think.					
55. There is nothing wrong with the present water distribution.					
56. Generally, the board pays a lot of attention to the average water user in this area.					

	Strongly Agree	Agree	Unde-cided	Dis-agree	Strongly Disagree
57. The prior appropriation doctrine is no longer useful in today's complex society.					
58. It seems to me that water officials don't really care how much I pay for water.					
59. It really doesn't do much good for a person to vote in water company elections.					
60. This irrigation company would probably be in much better shape today if the Conservancy District had never been created.					
61. There should be more restriction upon the sale and transfer of water rights.					
62. As long as I have plenty of water I don't care about what water officials do.					
63. The major responsibility with water development and distribution should be with the individual farmer.					
64. There should be stricter limitations upon the transfer of water between river basins.					
65. If water matters were left up to ourselves there wouldn't be any problem.					

	Strongly Agree	Agree	Unde-cided	Dis-agree	Strongly Disagree
66. The State's urban and industrial growth should be strictly regulated in order to preserve the farmer's water.					

We would like now to have your opinion about some more general items. The following statements have been given to a large number of people in other parts of the country. These are all matters of opinion. Please check how you feel when you first read each statement.

	Strongly Agree	Agree	Unde-cided	Dis-agree	Strongly Disagree
67. You can't really make progress without change.					
68. I would rather be a person who tries to make do with what he has; being dissatis-fied all the time just leads to problems.					
69. Long term progress is more important than immediate benefits.					
70. In whatever one does, the "tried and true" ways are always the best.					
71. The irrigation com-pany policy is best when it maintains the old accepted ways of doing things.					

We would like to ask you now a few questions concerning the future of your area, community, and irrigation company.

72. Generally, are things changing in this area?

1. Yes
2. No
3. Don't know

(If YES) How?

73. Speaking of change and water, has there been any important change in the past 10 years in the use of water in this area?

1. Yes
2. No
3. Don't know

(If YES) In what way?

74. Do you think that the present system of water rights should be changed in any way?

1. Yes
2. No
3. Don't know

(If YES) Could you explain how you would like to see such a change?

75. Do you think there are other alternatives to the present water system?

1. Yes
2. No
3. I have no opinion

76. (If YES) Please rank 1, 2, 3 the following alternatives in terms of how important you consider them for an improved water system. (Put 1 for the most important, 2 for the next and 3 for your third choice in terms of importance.)

___ Turning the system into a private profit making organization.
___ Asking the local water district.
___ Asking the State to run the system.
___ Converting the company into a private water association.
___ Consolidating the smaller companies into a larger one.
___ Other (Please explain).

77. Generally, what in your opinion are the main advantages (if any) for consolidating irrigation companies.

78. Also, can you give us the main disadvantages which would in your opinion occur if irrigation companies consolidate?

79. Which of the following do you consider the most significant future problems for water organizations in this area? (Please rank the three most important by putting 1 for the most significant, 2 for the next and 3 for your third choice in terms of significance.)

_____ maintenance of water quality
_____ maintenance of adequate water supply
_____ efficiency of water delivery systems
_____ protection of present water rights
_____ protection against greater governmental regulation
_____ developing adequate planning programs
_____ maintenance of a fair rate structure
_____ other (please explain)

80. Which of the following do you consider to be the most significant barriers to effective water planning in this area? (Please rank as before - 1 for the most important in your opinion, 2 for the next, etc.)

_____ lack of financial resources
_____ lack of trained personnel and management
_____ lack of public support
_____ lack of technical information
_____ present water law
_____ unavailability of water resources
_____ lack of communication among water officials
_____ rapid population growth
_____ other (Specify)

Finally, we would like to ask you about your home and about some items which you or members of your family may own. Please check the appropriate response.

81. How many rooms do you have in your house (not including unfinished basements, bathrooms, porches, closets, halls, or storage areas)?

(SPECIFY THE NUMBER) _____

82. Is there a specific room used as a "family room"?

YES ____ NO ____

83. Is there a separate room used for recreation?

YES ____ NO ____

84. Do you have a piped in water supply?

YES ____ NO ____

85. How many bathrooms do you have?

(SPECIFY THE NUMBER) _____

86. Is there a central heating system?

YES ____ NO ____

87. Do you have an automatic washing machine?

YES ____ NO ____

88. Do you have a clothes dryer?

YES ____ NO ____

89. Do you have an automatic dishwasher?

YES ____ NO ____

90. How many T.V. sets do you have?

ONE ____ TWO OR MORE ____ NONE ____

91. Do you have a color T.V. set:

YES ____ NO ____

92. Do you have a piano or electric organ?

YES ____ NO ____

93. Does your family have a car?

NO, NONE ____ YES, ONE ____ YES, TWO OR MORE ____

(IF FAMILY OWNS A CAR ANSWER THE NEXT QUESTION: IF NOT, GO TO QUESTION 95.)

94. What year is the newest car?

____ 1968-1970
____ 1965-1967
____ 1962-1964
____ 1959-1961
____ older than 1959

95. Do you take a daily newspaper?

YES ____ NO ____

96. Here is a list showing several family income levels. Family income includes any income of all family members from wages and salaries and net income, from farm or business, and any other income. Please indicate into which of these categories your family income was before taxes during last year:

_____ under $1,000
_____ $2,000 - $2,999
_____ $3,000 - $4,999
_____ $5,000 - $6,999
_____ $7,000 - $9,999
_____ $10,000 - $12,999
_____ $13,000 - $15,999
_____ $16,000 and over

97. Approximately what percent of your net income came from the following sources?

_______ Farming or ranching
_______ Farm labor jobs
_______ Non-farm wages or salaries
_______ Non-farm self-employment
_______ Other (social security, pension, dividends, rental property, etc.)

(TOTAL SHOULD ADD TO 100)

THANKS AGAIN FOR ALL YOUR TIME AND HELP. IS THERE ANYTHING THAT YOU WOULD LIKE TO ADD, CONCERNING THE AREA, OR THE WATER SUPPLY?