DEVELOPMENT, FINANCING AND REHABILITATION OF SMALL INDEPENDENT IRRIGATION SYSTEMS

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This paper is an attempt to deal with some of the more important problems of small- to medium-sized irrigation enterprises. The word "independent" is used in the title to distinguish these projects from the federal Reclamation Bureau projects and larger irrigation districts organized under state laws, which are under state supervision and control.

The enterprises discussed here generally serve from a few hundred to a few thousand acres of land. They are almost entirely farmer owned and managed. Whether legally organized, partnership, or the larger individual developments, they have these problems in common: land, water supply, climatic conditions, management, need for technical assistance, operation, and financing. Due to the magnitude of the subject and the importance of the nontechnical phases, this paper considers only a few of the "high lights." It is not a technical paper in the ordinary sense.

1. Some Requirements for a Sound Irrigation Enterprise

   The basic requirements for new developments are equally pertinent in rehabilitating and refinancing existing projects. You are all familiar with them, but it may be worth while to consider some of them briefly.

   a. Water Supply. Water supply is so basic as to make or break any project; it will be considered more fully later.

   b. Land. Great progress has been made in soil surveys in the past twenty years. The information we can obtain from them obviates a large part of the uncertainties in land selection. When the soil survey information is correlated with field irrigation tests or laboratory work, or both, we have a very comprehensive picture. It gives pretty definite
information on the kind of soil, its permeability, water intake rate, drainability and moisture-holding capacity, and the percent of the soil moisture that is readily available to growing plants. This gives a basis for the determination of the most suitable crops, probable yields, and water and fertility requirements with a degree of accuracy that was not possible in the past. Such information is still not developed, or its use is neglected, on much of our irrigated land. This is particularly the case on the smaller enterprises. In soil conservation districts, it can usually be obtained even on large tracts within a year.

Special soil conditions, including trace elements, which may favor the production of specialty crops are factors that are frequently overlooked. Where choice exists, irrigation of the best land available is axiomatic. Unless the control of and increase in precipitation by the rainmakers becomes an actual fact, the supply of good land in the semi-arid West is much greater than the potential water supply. Water value is increasing very rapidly. The need to use it where it will produce the most is vital to both the farmer and the nation.

c. The Farmer. The farmer's background, education, experience, and financial ability are all-important. After land and water, the farmer is the most important factor in the success or failure of an enterprise. I think many of you would put him first. Individuals unfitted for this important role are no doubt the prime reason for the initial failure of many projects in the past.

On an old project where no change in crops is contemplated, the farmer on the job is the one who will largely determine its future. If the past record of the enterprise has been unsatisfactory, although the
land is good and the water supply adequate, the farmer should be carefully studied by those responsible for planning and financing proposed improvements.

The question is often asked, "What are the qualifications of a successful farmer?" After working with them most of the time for forty years, I have no answer other than that I believe most successful farmers and ranchers are men who would have made their mark in any line of human endeavor they chose to follow. Management is just as important in agriculture as it is in industry. With all due respect to our own profession, I feel they are truly the backbone of America.

d. Satisfactory Climate. Proper adaptation to climatic conditions would supposedly have been determined fully in existing developments, but this is not always true. Unusual conditions, favorable or unfavorable, may not have been given sufficient consideration in the past. This is particularly important where specialty crops are, or could be, grown. In the same valley, lands with southern or western exposure may provide a condition for crop maturity two to three weeks earlier than on lands with northern or eastern exposure. Where snowfall is fairly heavy on northern or eastern exposures, the moisture available from snowmelt may reduce the irrigation-water requirements. Frequently the velocity of winds may vary markedly within narrow boundaries, due to mountain ranges and other conditions. Local storm patterns and annual precipitation may be quite different at locations only a few miles apart. Frost conditions are extremely important and may be influenced by unusual and surprising factors. A project which has had a poor record may be changed to a successful and prosperous development by changing the cropping pattern to take advantage of special, very localized climatic conditions.
c. **Drainage Problems.** Drainage will be ably handled in other sessions of this meeting so it will not be discussed here, but it should never be overlooked.

2. **Water**

Good land, if it had water, is still plentiful in the western United States. But water is scarce west of the 100 meridian. Development is very expensive, which means that new, small irrigation enterprises will be few except in areas where extensive underground water supplies are yet to be developed. Water is the limiting factor, and its availability is the acid test of the feasibility of any proposed new irrigation development. In numerous cases, it is the key question as to the justification for rehabilitation and betterment of an existing system.

Direct diversions from streams, withdrawal from surface reservoirs, and pumping from subsurface reservoirs are the principal sources of water supply.

The big uncertainty in all cases is the dependability of supply; but timeliness and quality are almost as important as quantity. Rain, snowfall, and runoff vary widely, not only annually but for long periods, and runoff may even vary for the same precipitation on the same watershed. We cannot predict these for any future year. We can only say approximately what to expect. Unfortunately, records show the variation in annual precipitation is far greater where the average is less than 20 inches than where it is 40 inches or more, and most of our irrigation is near the 20-inch rainfall belt. In general, periods of low rainfall and runoff on a source watershed coincide with low precipitation on the irrigated areas which the watershed supplies. This means that a low water
supply usually coincides with high irrigation demand.

We strive to correct this by building storage reservoirs which provide late season water when streamflow is usually deficient. Storage in surface reservoirs is not an efficient operation, particularly when it is necessary to store for long periods. Evaporation and seepage take a heavy toll. Underground reservoirs, usually natural but sometimes partly artificial due to the spreading of floodwaters or other recharge measures, are no doubt the most efficient way in which water can be retained from the time precipitation occurs until it is applied to crops.

To make use of underground water as a principal or supplementary source of irrigation requires pumping, except where artesian pressure exists. There has been a tendency to look upon pumped water as very expensive. Now the widespread availability of electric power at relatively low cost, more efficient gas and diesel engines, and improved pumps have greatly increased the areas where pump irrigation is economical.

At the same time, underground water investigations by federal, state, and private agencies have increased our knowledge of the areas where underground water is available and the yield dependable. Underground storage is difficult to evaluate as to the amount of storage space available, the recharge rate, and the decrease in this rate during periods of subnormal rainfall. Some progress toward answering these questions is being made through the jointly financed underground-water studies by the U.S. Geological Survey and the state governments.

Laws intended to prevent overdrafts on underground basins are generally ineffective or nonexistent. New Mexico law, which has been fairly effective, provides for declaring and defining of boundaries of
underground basins by the State Engineer. Permits to drill additional wells in these basins may be denied if it appears that the rate of recharge is inadequate for more wells. Several states now require that permits be obtained before a well is drilled. Well logs and all pertinent data must be filed with the state upon completion of the well.

a. Pumping as Supplementary Water Supply. Where the lift is not too great, this is probably the best and often the cheapest method of providing supplementary water. Some advantages are:

1) It promotes water conservation as no more is pumped than is needed.

2) It encourages efficient use of water. Both enterprise management and water users are very mindful of pumping costs.

3) In some cases it gives water table control under the irrigated land and may eliminate the need for extensive drainage works.

Where electric power is used, and to some degree where internal combustion engines are used, economy requires the maximum power use per horsepower of connected load. A well delivering 1000 gallons per minute on a 24-hour basis is cheaper in first cost, power bills, extra lift due to drawdown, and depreciation, than one delivering 2000 gallons per minute on a 12-hour basis. The use of the farm tractor as a source of power is usually not efficient unless the pumping period is very short. If canal losses are not large, it is probable that enterprise handling of the pumping will be cheaper in a well-managed project than farmer operation, where maintenance is all too often neglected. Continuous operation of the pumping plant is desirable but night irrigation is usually inefficient and inconvenient.
Therefore, overnight or temporary storage is often desirable and usually it is not prohibitive in cost.

b. **Additional Storage.** In the small-project field, including single-farm developments, probably 50 percent of the enterprises have serious water shortages. Times of shortage range all the way from 1 to 7 years out of 10. What can we do to reduce water shortages? This question is a challenge to all users of water. There is no complete answer but much can be done at present at reasonable cost, and we will learn how to do more.

We must, however, grasp the whole picture of water use and its probable increase in the immediate future. In the West, the growth of our cities is very rapid and industrial demands are increasing at a rate not dreamed of at the beginning of the century. Per capita urban use has increased 300 percent in 50 years. All the competing needs must be met to the greatest degree possible.

Three methods can be used for increasing the water supplies to irrigation developments. They are building additional storage reservoirs, providing a supplementary supply by pumping, and transferring water from other areas. Each method has physical and legal limitations, which may prevent its use by specific companies.

Some storage development is still possible on many streams. There are cases where reservoirs of 50 to 500 acre-feet capacity could be built on intermittent streams and filled 7 years out of 10, but in only 1 year out of the 10 would water they store reach the large existing reservoirs farther down the basin. From the water conservation angle, should their construction be permitted even though they now may be illegal under
existing filings? Another question is whether reservoirs at high elevations (above 7500 feet) should be built, even though the water under present rights is decreed to large downstream developments. Most large reservoirs are at elevations below 4000 feet, and evaporation from them ranges from 4 to 7 feet annually. The effective evaporation at high elevations may be around 2 feet, due to low winter temperatures and frequent summer rains.

There are of course other considerations in reservoir development which cannot be covered in this short paper. Live streams provide cheap transportation with little water loss from high elevation reservoirs to irrigated areas 3000 to 6000 feet lower. To provide otherwise unavailable late-season water, dependable storage is frequently justified at high cost per acre-foot.

c. Purchase and Transfer of Water Rights. This may not be possible in the majority of projects, as no water rights will be available for purchase at a price a project can afford to pay. According to the census, 1,600,000 acres of irrigated wild hay were harvested in the 8 western mountain states in 1949. I believe it is conservative to say that 75 percent of this area is high mountain meadows. These areas are on the headwaters of our western rivers and in general have high priority water rights available throughout the growing season. Applications of 7 to 12 acre-feet per acre, and even more, are very common. It is true that a considerable portion of this water finds its way back into the streams, but the losses are still very high. Few figures are available to date, but the indications are that streamflow from this area could be increased by decreasing the use of water on these wild meadows without decreasing the
forage produced. Some research is now being done on this type of irrigation. Evidence already available indicates that both the volume and quality of hay could be increased by using less water. Many ranchers are becoming aware of the value of their water rights and the losses they are incurring from over-irrigation. Downriver neighbors frequently need this water very badly. Sales could be made on an annual basis of so much per acre-foot, or a permanent sale and transfer of rights at so much per second foot.

3. Water Conveyance and Use

A large percentage of our small- to medium-sized projects with insufficient water supplies cannot increase those supplies by the methods already discussed, but all can do something about reducing loss and waste.

a. Conveyance. Studies of many systems show startling differences between the water diverted from streams or withdrawn from reservoirs and the amounts delivered to the farms. Present water values fully justify expenditures for reducing losses that would have seemed fantastic in the past. A careful study to determine how they can be reduced should be the major consideration in any rehabilitation and betterment program.

1) Permanent and adequate headworks insure a project's obtaining the water to which it is entitled under all conditions of stream flow.

2) Tight canals and laterals make more water available on the land.

3) Good canal and ditch structures reduce both water losses and operation costs.
Concrete canal lining is effective and lasting, if properly constructed. Few systems can afford to line all their ditches with it, but if a loss study has been made, the worst stretches will probably justify the use of concrete. Where losses are less, asphalt membrane, fiber glass, soil-cement mixtures, bentonite (if it can be protected from frost), and other treatments, including heavy clay soils, can be tried on short canal sections and the results studied.

If nothing else is presently possible, the earth section can be well maintained, and weeds, willows, cottonwoods and other water-loving vegetation eliminated.

Careless operation accounts for a lot of water loss. Where water is delivered on a rotation basis, turnouts not in use often leak badly. Leaky flumes and siphons also take their toll. Sluice gates, wasteways, and tail sluices are provided to dispose of excess canal flow and water unused at the moment. Conservation of water and neighborly cooperation between companies demand that waste and sluice channels be reasonably maintained and that the water in them be conducted back to the river or to a lower-lying canal without excessive loss.

An organization of mutual water companies and private developments, discussed later, would in numerous instances be justified in studying the stretches of the river in the portion of the valley where its projects are located, with the objective of effecting water savings. Measures which are frequently possible at moderate cost are a reduction in the amount of water-loving vegetation, minor straightening, and removal of snags to reduce meandering in low-water channels. Studies of losses from these causes in California and Arizona have shown that they are
frequently very large. Where additional drainage is needed, use of the water developed by the drains, either by gravity or pumping, should be considered. Intelligent and efficient ditch tenders can reduce losses, particularly if they have good equipment to operate.

b. **Efficient Use of Water.** The greatest source of loss of water in most irrigation systems and, therefore, the greatest probable source of increased supply is on the farm itself. Fortunately, it can be greatly reduced at low cost by improving irrigation practices. To irrigate effectively requires good land preparation. This is not cheap, but it can be properly considered a capital investment. Good water handling and well prepared land are two requirements for good irrigation, but water use is often inefficient even where land preparation is satisfactory.

Good land preparation means that irrigation grades are the best obtainable, and that the right length of run and volume of water to wet the soil uniformly to the desired depth are used. It involves, in addition to land leveling or grading, the proper location and use of ditches, pipe lines, and appurtenant structures of the right capacity.

Good water application means irrigating only when needed. That is usually when roughly two-thirds of the readily available moisture which the soil will hold to the bottom of the root zone has been used. Only the water necessary to raise the soil moisture to field capacity to the same depth should be applied. Water that percolates below the root zone is lost to the plants on the field where it is applied, and it may create a seeped or waterlogged condition on land down slope. Good irrigation also means that surface runoff or waste irrigation water from the field is held to a minimum.
Water should be available in sufficient volume to keep the irrigator busy. If his normal irrigation head is insufficient, it may be increased by rotation with his neighbors or by providing overnight storage. Surface waste water, when it cannot be effectively used on the farm, should be conveyed to another ditch or live stream.

4. Organization

The most common form of enterprise organization is the mutual stock company, a non-profit corporation. The shares represent water, and there is usually a relation between a share of stock and the amount of water required to irrigate an acre of land. A share per acre is a common rule, but there are many exceptions. In some companies the stock is designated as representing water pertinent to a specific tract of land. This is required by law in some states. Water rights are a form of property. Their legal status must be protected and maintained, but it is important that the transfer of water from one tract of land to another be a simple matter. Otherwise, the best use of both land and water often will be prevented.

Funds for operation and maintenance are obtained by assessments on the stock. If assessments are not paid, water is not delivered. A majority vote of all stockholders is usually required before the board of directors can create an indebtedness against the corporation.

There are still a few water companies, organized for profit, which sell water to the farmers. They are not farmer owned.

Partnership or nonincorporated mutual enterprises are common but by far the greatest number of these serve only one farm or ranch. Some of these individual developments, however, are of such size and complexity
that they have many of the problems commonly associated with the incorporated enterprises.

According to the 1950 census, single farm irrigation developments in the 17 western states numbered 101,770 and served 11,817,000 acres. Mutual enterprises, incorporated and unincorporated, served 7,749,000 acres. These farmer owned and operated types of development account for approximately 78 percent of the irrigated area. The mutual type of organization has much to recommend it. It is democratic, locally controlled, and flexible as to management and policy.

5. Operation and Management

The greatest weakness of the small mutual system is the lack of engineering and management service. This is largely due to the small size of the average enterprise which, according to the last census, was 1950 acres. The stockholders generally elect the ablest of their members as officers and directors. However, they usually serve without pay, are reimbursed for actual expenses only, and are busy with their own affairs. In many cases a part-time ditch tender is the only employee. Usually, these enterprises are much more conscious of their legal requirements than the frequently more pressing need of able engineering assistance.

The need for general rehabilitation of the great majority of these systems is very great at the present time. The national prosperity was at a high level during the 1920's, but agriculture did not share in it to the same degree as most segments of the economy. Following this came the depression and the drought over large portions of the irrigated areas. In the late 30's, there was some improvement in agricultural prosperity and construction costs were low. Before more than a good start could be made
on the huge backlog of needed replacements and betterments, however, the war stopped all such work, except for a few very urgent jobs where agricultural production would be severely curtailed if they were not done at once. Since 1945, considerable progress has been made. But during this latter period, many of the more conservative enterprises have delayed projected work expecting that construction costs would decline.

During the past 18 years, the Soil Conservation Service has given technical assistance to many projects, mostly through soil conservation districts. The Farmers Home Administration, through its Water Facilities Program, has given considerable assistance in this field. Financial assistance and a limited amount of technical assistance has been available through the Agricultural Conservation Program activities of the Production and Marketing Administration. These agencies have been able to provide only a small fraction of the technical assistance needed. The Soil Conservation Service has a considerable staff of well-trained engineers, soils men, and agronomists. However, the principal job of this Service is to help on the farm or ranch. Assistance to irrigation enterprises has been a secondary responsibility, and the manpower assigned to this work very limited.

a. Field of the Private Irrigation Engineer. The major portion of the assistance to irrigation enterprises is the field of the private engineer. How can he do it at a price that mutual enterprises can afford to pay? I believe the irrigation companies have already laid the foundation for the solution of this problem. In numerous instances where they feared proposed transmountain diversions, major flood control plans, etc. might affect their interests, groups of enterprises have formed local
organizations. Usually, but not always, they have legal status to represent them effectively. These organized groups have employed legal talent of the highest type. Along similar lines, a group of enterprises with a combined acreage of 5,000 to 40,000 acres, depending upon the volume and complexity of their problems, can profitably justify the cost of a competent, full-time engineer. He should be employed on an annual basis and his salary and expenses prorated to the member enterprises in proportion to his services to them. Some of the needed services he could render are:

1) Work out for each enterprise a program and time schedule of needed replacements and betterments.

2) Design standard structures, such as turnouts, drops, checks, division boxes, measuring devices, etc., which would be applicable in most cases for all member enterprises.

3) Prepare adequate plans and specifications for all work.

4) With the assistance of enterprise attorneys, prepare contract forms.

5) Assist boards of directors in the best use, scheduling, and maintenance of equipment.

6) Study the need for, and types of, new equipment in cases where joint purchase and use may be desirable.

7) Keep the member enterprises informed on latest developments in water-measuring devices, sprinkler equipment, etc.

8) Keep in touch with soil conservation districts, the Soil Conservation Service, Extension people, and others on the latest thinking on water requirements, irrigation methods, land leveling, and lengths of runs for the different soils, slopes, and crops of the area.
9) With enterprise directors and attorneys, represent the member organizations at water, irrigation and river basin conferences.

10) Advise on competent contractors, and on bids obtained for work to be done by contract, and insure that all work is adequately supervised and inspected.

The most important thing that the right type of engineer could do for small, neighboring enterprises would be to make them aware of the ways in which they can help each other. Unfortunately, in many instances, even when their officers and shareholders are literally close neighbors, the relations between water companies are anything but cooperative.

A frequent reason for lack of cooperation is the desire to be independent. Independence is too costly under conditions such as those illustrated in the following example, which are all too common. Several expensive diversion dams and miles of parallel canals are built and maintained where one dam and canal would suffice and would result in large savings in construction costs, maintenance, operation and, most important of all, water losses. The large number of diversion dams on some of our rivers have so reduced river grades that stream beds are aggrading, streams meander in flood time, and formerly productive land along river bottoms is waterlogged and cannot be drained except by pumping. To correct this situation, which is more human and social than technical in many instances, is, I believe, one of the greatest opportunities for real progress in enterprise operation and water management. The engineers serving our irrigation enterprises are in a position to spearhead cooperation.

It is vital that the good engineer have able and farsighted directors to work with if he is to do a real job.
What of the future of the engineer who, after a few years with an established engineering firm, public utility, or government agency, decides to go into this type of work? He must be versatile, to some degree a student of psychology, have initiative and resourcefulness, and be willing to live in a small town. He will get broad experience, have an opportunity to use his own ideas, and will have more than an average chance to make a worthwhile place for himself in the field of irrigation engineering and management. In the past few years some of the larger mutual enterprises and irrigation districts have come to realize that good salaries to such men are excellent investments.

6. Financing

Financing has always been, and continues to be, one of the most serious difficulties of the small- to medium-sized irrigation development. There are numerous reasons for this. Among them are:

1) Many loan organizations do not have the technical staffs available to determine and evaluate such assets as water rights, land capability, and management. The industry, thrift, and enterprise of the farmers who own and operate a project are hard to evaluate.

2) Many loan companies seem fearful when they do not have a first lien or mortgage on the land even though water rights have a value many times that of the land without water.

3) The Federal Reserve policy, and the small percentage of their deposits which banks are able to devote to long-term loans, prevent them from handling much of this type of financing.
4) Prior to 1929, irrigation financing was largely by bond issues. The national depression started in 1929. It was accompanied by drought in many irrigated areas and nationally by over-production and ruinous prices for farm products. Many irrigation enterprises defaulted on their bonds. They were refinanced largely by the Reconstruction Finance Corporation but on a basis which caused severe loss to most bondholders. This and the fact that farming since that time has been a subsidized industry have made irrigation bonds unattractive to the investor. Until the Reconstruction Finance Corporation was abolished recently, it remained one of the principal sources of credit for the financing of replacements and betterments of mutual irrigation enterprises.

Among the present sources of credit is the Farmers Home Administration which, under its Water Facilities Program makes loans to mutual water companies and other non-profit irrigation enterprises and to individuals with water rights and physical irrigation works as security. The maximum of any loan is now $250,000 to organizations and $25,000 to individuals, and the program now covers the entire United States. The interest rate is 3 percent and the repayment period is the physical life of the works financed or 20 years. Under special conditions, the repayment period to organized groups may be extended to 40 years. Loans are made under this program only where other sources of credit at reasonable interest rates are not available.

The Small Business Act of 1953, administered by the Small Business Administration, would seem to be applicable to irrigation enterprises.
Its interest rates are 6 percent for direct loans and not less than 5 percent where they participate with a bank or other institution on a loan. Maximum size of loan is $150,000 and the repayment period not over 10 years. This agency also does not make loans except where private credit is not available to the borrower. It makes loans both to organizations and to individuals.

Bond issues are not entirely out of the credit picture, and with the present sound financial condition of many irrigation developments they should increase in favor with investors.

The State of Utah has created a revolving fund, administered by the Utah Water and Power Board, of $1,750,000 (which I understand is being increased to $2,750,000) which is used for interest-free loans to non-profit irrigation organizations for improvements to their systems. The engineering is done by the Board's technical staff or approved by them. If they do the technical work, the cost of it is repaid to the state by the borrowers along with the principal of the loan. There is no fixed time for repayments. The justification for the program is the development of the land and water resources of the State and to insure good engineering, adequate design, and well-constructed irrigation works.

I understand that a few other states have similar funds, but I am not familiar with them. Such a plan is certainly a boon to mutual irrigation enterprises.

Many of the smaller loans are made by local individuals and loan companies when they are personally familiar with the enterprise, its assets, and management.
It is imperative that sound irrigation enterprises have credit facilities equal to those of other types of business where security to the investor is comparable.

Closing

Census figures show the number of incorporated enterprises increased by over 200 between 1940 and 1950. If their stockholders will make the best use of soil- and water-use information now available, it should add greatly to their prosperity. Sound management, cooperation, and good engineering will give them a better financial status. This should enable them to provide, under favorable financing, the needed rehabilitation and additional water supplies required. The continued success of this type of project is vital to the nation.
Irrigation Engineering—Where is it going? What is the future? What is the need? What work is to be done? Relationship to Agrie. Can Irrig. Engg. be replaced by some other training? How about Agric. Science? What is the place of Engineering in this training? Relationship to Irrig. water supply & its state of development. Inc. ground water. Heavy construction, design, vs. water management and soil- water- plant relationship

Discussion

Criticism. Basin Case—Cely—see W. Heller paper. New Basin—self-policing plan. When depletion is known a standing fund is set, after which an algebraic formula the recharge and runoff from various areas is used for development.

Tetra. Local economy for future basis is provided for
CONSOLIDATION OF IRRIGATION COMPANIES

By

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Introduction

Modern irrigation requires an adequate knowledge of the water needs of the crops, the portion of those needs that will be met from rainfall or other natural sources, methods of applying that water to the land safely and efficiently, and ways of removing the excess water from the land. It also requires facilities for getting the water from the source of supply to the land to be irrigated and some type of an enterprise for controlling and managing the business affairs of the irrigators.

Definition of Irrigation

Irrigation is defined as being the artificial application of waters to the soil to meet moisture needs of crops not supplied by rainfall or natural ground water conditions. Thus, irrigation is the mechanical act of applying water to the land.

Basic Concepts of Irrigation

There are a few basic concepts of irrigation that must be understood before good irrigation can be practiced. First, there must be a water supply. This supply, which may come from surface or subsurface sources, must be available when and as needed. It must be of such quality that it will not be harmful to the crops and it must be sufficiently cheap that it can be used for the type of crops grown.

Supply of Water: Unfortunately, most surface streams of the West being snowfed, flow heavily during the spring and early summer months but decrease rapidly after mid-summer when the water requirements of the plants are highest. To make the water supply coincide with the demand, the streamflow must be controlled in the spring and stored for use later in the season. Since streamflow varies throughout the season and from year to year, for full development, it is necessary to store during years of heavy runoff for use in the drier years.

Supplies from lakes and ground water are not usually subject to the same wide seasonal variation as are uncontrolled surface streams. However, many of our underground water basins are experiencing a continuous lowering of the water table because the use of water is exceeding the recharge. Artificial recharge is being resorted to in some areas to prevent the lowering of the ground

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water level to a point from which water can no longer be pumped economically.

Moisture Requirements

Moisture requirements of plants must be met when and as needed for maximum growth or production. Water should be applied when the total soil moisture in the root zone is reduced to about sixty percent of the total water that the soil in the root zone of the crop will hold between point and field capacity. If the soil is allowed to become too dry, growth slows down and with many vegetables, fruits and certain other crops, quality as well as yield, is lowered. Some crops are very sensitive to the moisture supply and if the soil is allowed to become too dry for only a day or so during an entire season, the yield and quality are greatly reduced.

Different crops have different water requirements both as to the total seasonal amount of water needed and time of application. Spring grain crops on irrigated lands are frequently planted early and take advantage of low temperatures and spring rainfall to postpone the first irrigation of the season. Wheat is then ready for harvest early in the summer, and requires only a limited amount of irrigation water. However, alfalfa will, on an average, consume about an inch of water for every six days of the frost free period. Such use is not constant throughout the season but varies with temperature, length of daytime hours and other factors, but for continued growth, water must be available when needed throughout the season.

Land Preparation

To apply water efficiently and uniformly requires that the land be properly prepared for the method of irrigation to be used. With sprinkler irrigation, this means only nominal land leveling. To properly use surface methods require much better land preparation than is needed for sprinklers but the degree varies widely between methods.

Regardless of the irrigation method used, the rate and period of application is dependent upon the soil characteristics including intake rates, water holding capacities, and erodability. Thus, the various influencing factors must be taken into consideration and a proper balance established between the size of stream, length of run, intake rate and water holding capacity of the soil in the root zone of the crop.

Soil as a Storage Reservoir

The soil plays an important role in irrigation. It is both a conveyance medium and a storage reservoir. Water flows over, into and through it to all portions of the root zone. Once the water is properly distributed, within the crop root zone throughout the field, the soil stores it for use as needed by the crops. Soils vary widely in their ability to absorb, convey and store water. For example, certain sandy soil may absorb water at the rate of five inches per hour but only hold 0.5 inches of usable water per foot depth of soil. On the other extreme, a clay loam soil may absorb water at a rate of 0.1 inch per hour but be capable of storing 2.5 inches of water per foot depth of soil.
Thus the sandy soil would absorb water fifty times as fast as the clay soil but be able to store only one-fifth as much water. This affects the size of the irrigation stream and the frequency of irrigation needed.

Removal of Excess Water

With any good irrigation, there is always a certain amount of excess water to be removed, either by natural or artificial means. Water cannot be applied entirely uniformly by any practical method of irrigation now used. Thus, in order to adequately irrigate all parts of the field, excess water will be applied to parts.

In addition to the excess water that percolates into the soil and must be removed, there is also the problem of removing excess surface water safely. In areas of high intensity rainfall and sloping land, this becomes a major problem.

There are many factors which are basic to good irrigation and which greatly influence the operation and management of the irrigation system. The physical system, the water supply and the management practices of any irrigation company must be geared to take into consideration all of these factors.

History of Irrigation Development in Utah (Cooperative Enterprises)

On July 23, 1847 the waters from City Creek here in Salt Lake City were first diverted and thus began modern irrigation in America. Other diversions were soon made from this Creek and other streams flowing from the mountains to the east.

On August 22, 1847, less than a month after the entry of the Pioneers into the Valley, the first water master was appointed.

In 1853, following the organization of a city government, a general water master was appointed by Salt Lake City to supervise the distribution and use of water in the Valley. Small area, or ward water masters, reported to the general supervisor.

Although formal organization of mutual irrigation companies did not come until irrigation systems and practices were rather well established, informal water associations set up in the first year of irrigation were, in reality, the early mutual companies. The first incorporation of companies was based on an act of the Territorial Legislature of 1865. Within the next decade, a great many of the existing companies were formally organized under corporate charter. Many of the informal associations found it necessary to incorporate in order to protect their water rights and to have a legal basis for taxing and raising needed revenues. In other areas where competition for water has not developed, informal associations of water users still exist and perform all the necessary services to its members.

Establishment of Water Rights

Since the first users of water for irrigation had no place to turn to obtain any legal rights to the use of water, it was generally recognized that
an established use constituted a right and that first in time is first in right and that beneficial use is the basis, the measure and the limit of the right. Eventually, provision was made by law for the recording of water rights claimed. The law was changed a number of times, defining the steps for water appropriation.

During the 1903 session of the Utah Legislature, substantial advancement was made in laws concerning rights to the use of water. Responsibility for administering the laws concerning rights to the use of water and procedures for acquiring water rights and making proof of appropriations was included in the Utah Water Code as passed in 1903. The State Engineer was given the responsibility of administration of the water laws. The present law requires that a water right may be initiated only by a filing in the State Engineer's Office. Specific steps are required to appropriate the water and put it to beneficial use. Upon satisfying the conditions governing application to appropriate and put water to beneficial use, a certificate of appropriation and application to beneficial use is issued by the State Engineer which is the evidence of the water right. The date of priority of the right is the date of filing with the State Engineer, provided all the requirements of the statute have been complied with.

Development of Irrigated Areas

Early development of irrigation in Utah was all by private enterprise. It was not until after the Reclamation Act was passed in 1902 that Federal funds were made available for any major development of irrigated lands in Utah. Prior to that, about a million acres of land had been developed. Since that date, only about 200,000 acres have been developed with a considerable portion still being developed by private capital.

Because of the way irrigation has developed in Utah and other areas of the West, many problems have arisen which are causing difficulty at the present time. It was only natural that the first diversions from a stream would be at the point where it could be done most easily and cheaply. Usually, this was along the lower reaches of the stream where the channels were not so deep and diversions were easy. These diversions were usually adjacent to flat irrigable lands not requiring long conveyance canals and not subject to heavy land development costs. The earliest water rights were established on the lower portions of the streams. As the pressure increased for more irrigated land, and as our engineering knowledge and ability to divert the waters and develop the land increased, diversions moved progressively upstream. More or less parallel conveyance canals ran out from the streams to serve strips of land which lay progressively higher up the rim of the valley floors. The junior rights to the use of water are at the higher diversion which are usually the most expensive. The lands to be served are generally the roughest and most difficult to reach. Such lands frequently have inadequate water, the water being available only during the period of highest stream flow.

This type of development is usually not only expensive, in the total cost, but is also inefficient in the use of water and man power. Each diversion usually meant a separate organization. If a stream basin could be fully planned and developed under one organization, the costs of such development and operation
would be greatly reduced. Often a single diversion structure would serve all the lands. Fewer canals and structures would be needed. A single company adequately staffed with technical men could operate and maintain the necessary facilities to efficiently and effectively deliver the water to the users.

In areas developed by the Bureau of Reclamation, much greater consideration has been given to an overall development plan. This is especially true of projects now being planned in the Upper Colorado River Basin. These plans not only take into account all of the water and irrigable land in each state but include the entire stream basin. This allows for the most economical and efficient development of all the potential irrigated lands.

Irrigation Companies in Utah

Because most of the water for irrigation in Utah comes from small streams draining the high Wasatch and Uintah Mountain fronts, many small irrigation companies have developed.

According to the 1950 census, Utah has 3,165 enterprises of which 2,107 are single farm enterprises, 406 are mutual unincorporated companies, 634 are incorporated, 2 are commercial, 5 are irrigation districts, one is a Bureau of Reclamation operated project (other U. S. Bureau of Reclamation projects in Utah are operated by water user associations), 3 Bureau of Indian Affairs, and 7 by cities. These enterprises irrigate 21,126 farms containing 1,166,972 acres, with a total capital investment of nearly $57 million.

There are no legal restrictions as to the size of irrigation companies. The largest company in Utah irrigates approximately 50,000 acres, the smallest less than 100 acres.

Examples of irrigation company set up: In Utah there are numerous examples of irrigation companies that divert and use water from a common source. Ten separate irrigation companies use water from the Logan River. In some cases, canals in this area run so close together that silt and debris cleaned from one can be thrown directly into the other for considerable stretches. The Utah Agricultural College has estimated that all of these companies on the river could be consolidated, assuring large savings annually. The Logan River companies now have ten times as many presidents and secretaries as are needed and probably not less than five times as many company directors as would be necessary if the water were handled by one company. In this same general area being irrigated by Logan River's water, is a large wet meadow area underlain by artesian pressure. This area offers a potential water supply for irrigation. Some of the irrigated land lying above these wet lands contribute water to them. Thus, it would seem only reasonable that such lands should be included within a single consolidated company. Increased efficiency in use of water on the higher lands might well alleviate the drainage problems in the lower lands.

Another example is the Ashley Valley Area in Eastern Utah. Recently, two of the canals diverting highest on the creek found it necessary to replace their diversion structures. Instead of consolidating and constructing a single diversion at a cost of some $30,000.00, they each constructed one with combined costs nearly double what a single joint structure would have cost even though the points of diversion are within some 500 feet of each other.
As the need for culinary and irrigation water supplies increased in the Salt Lake City metropolitan area, many changes were necessary in handling the available waters. While the city was small, culinary requirements were likewise small. Irrigation companies developed rights to the waters from the small streams flowing into the valley from the east. As the city grew and as culinary water uses increased, city officials began looking for new sources of good potable water. It was apparent that Utah Lake offered about the only source of unappropriated water. Therefore, the city filed on Utah Lake water and through negotiation and exchange, traded the brackish Lake water, which was entirely satisfactory for irrigation purposes, to the farmers of the area for their clear mountain water. Such exchanges required the bringing together of small irrigation companies and the development of a plan of operation which would not penalize any owner of water in the Valley. It required a complete analysis of the natural flow of the streams, the rights of the various appropriators and the combining of the natural stream flows with storage.

Problems Involved in Consolidation

Unless physical conditions are such that common facilities may be used to serve the entire area, there may be justifiable reasons for having separate irrigation companies. Where duplicating and overlapping facilities exist, some method should be worked out to prevent such duplication and increase efficiency. Major obstacles, which must be overcome before consolidation can take place, include a determination and evaluation of water rights, debt obligations, adequacy of distribution system, methods of water distribution, and most difficult of all — the human element.

Water Rights: The right to use water in any given area may have been obtained simply by use as were practically all of the early rights, or by statute which specified the procedure which must be followed to obtain a right to use water. In the western states, beneficial use is declared to be the basis and the measure of the right and first in time is first in right. Each state has its own code of water law. Utah, Colorado, Wyoming, Idaho, Nevada, Arizona and New Mexico adhere strictly to the basic doctrine of appropriation while all the rest of the seventeen western states follow a modified doctrine of riparian rights which recognize beneficial consumptive use of water.

Every stream is essentially a law unto itself when it comes to the character and distribution of the rights to its use. The early users have the best rights to the natural flow. Later users have junior rights. Still later storage rights may be developed and owned by both the prior and junior users. Some canal companies have several classifications of rights and as many different kinds of stock as there are classes of rights. When a consolidation involves several canals, each with one or more classes of rights, the problem becomes involved.

The solution to this problem lies in defining each right in terms of quantity and time of availability to the satisfaction of each claimant. Such determination must be based on water measurement which usually should be made by disinterested parties. The relationship of the quantity of water and the time of its availability to the shares of stock in the respective companies must then be evaluated.
After agreement is reached between all claimants as to the water supply owned by each and its relationship to the stock held by the respective claimants, all stock must be pooled in the new company and stock in the new company issued to each claimant in lieu of the stock which each said claimant put into the pool. Securing agreement among the several companies and the individual stockholders in each company is not easy but in many cases, it can be secured. Frequent round table discussions between all participants under the direction of a disinterested moderator, assisted by competent technicians to present facts backed up by measurements, will yield results. Avoid, whenever possible, the raising of legal questions during these discussions. When agreement on the principles is reached, then bring in the attorneys to prepare the language of the agreement.

Debt Obligations: Debt obligations of each company must be evaluated and liquidated by the respective companies or adjusted upon entry into the new company so that said obligations are not passed on into the new company without compensation.

Adequacy of Distribution System: The distribution system required to serve all users in the new company must be established and agreed to by all parties. A detailed plan of changes in the distribution system that will be necessary and a plan of operation and maintenance must be worked out before a consolidation can be consummated.

Methods of Water Distribution: Different irrigation companies have different methods of water distribution. Some provide continuous delivery, some rotation and some deliver water on demand. Where storage is available, delivery on demand may be possible. Usually continuous flow is undesirable, especially where the streams are small. Type of crops grown and the temperature will usually govern the frequency of irrigation. A method or methods of water distribution must be agreed to in advance of consolidation and such methods must be geared to the physical distribution systems, the availability of water and the crops grown. A knowledge of the water requirements of the crops to be grown and the character of the water supply make it possible to design an adequate distribution system and establish a method or methods of distribution to adequately serve all users.

The Human Element: In the arid west, water is the life blood of the agricultural economy. The early pioneers fought the elements to establish the means of division and the right to use water. They guarded this right jealously. It is said a man will fight quicker over his water right than over any other property he owns. For this reason, the average water user is suspicious of any proposal that involves his water right. He considers possession paramount and hesitates to accept promises of rights under any other system than that which he developed.

Water measurement has not been widely practiced. As a result, it is difficult in most cases to evaluate a water right in terms of quantity and time of availability. Until such measurements are available and accepted by the owners of water rights, consolidation of small irrigation companies will be slow and difficult.

The older generation who developed most of the water supplies, are particularly hard to convince. The younger generation, who recognize the validity of measurements and the need for increased efficiency, are more likely to con-
sider favorably proposals for consolidation. Public agencies should become more actively engaged in getting information that will form a basis for consolidation of small irrigation companies using water from a common source and having common problems of distribution.

Practical Approach to Solution of Consolidation Problems

Consolidation of irrigation companies, like most other worthwhile enterprises requires a lot of good hard work evaluating the influencing factors, acquainting all of the people affected of the true situation and then developing a legal basis on which to operate.

Get the Facts: Before consolidation of irrigation companies is attempted, all of the engineering, economic, human and legal facts for each company must be obtained. Engineering assistance is essential in compiling the information on water supplies, management and the use of the supplies and the adequacy of the existing physical systems and how they can be adapted to meet the needs after consolidation.

Legal information is needed relative to water rights held by the various companies and a plan worked out jointly by the companies concerned with the assistance of disinterested technicians as to how such water rights, distribution system and operation and maintenance procedures can be integrated into the single new company.

The economic facts should not be overlooked. The present economic condition of the various companies and the effect consolidation will have on the economy of the area should be thoroughly investigated.

Informing all the People Concerned: Once all the facts are known, the people directly affected by the proposed consolidation should be called together and the facts and proposals explained to them. Each water user should be allowed to take part in a round table discussion to iron out differences in opinion and to thoroughly familiarize himself with the various features of the consolidation and the affect such consolidation will have on his particular rights. This is a job requiring a great amount of tact, patience and perservance on the part of those preparing the consolidation, the moderators and the technicians.

Establishing a Single Legal Organization

After all water users have become fully acquainted with the proposal and understand each others views and problems, the legal details should be completed by competent council and the new company formed.

A three-step program -- finding the facts, informing the parties concerned and setting up new organization -- as outlined above will require time and cost money but such time and costs will be fully justified if increased efficiency and reduced cost of acquiring and distributing water to the users is achieved.
Summary

Consolidation of small irrigation companies having a common source of water or common problems of operation and maintenance and replacement, is absolutely essential to a full and complete and efficient utilization of the available water and land resources. Its consummation will not be easy. An evaluation of all factors involved is the first essential. This means a determination of the water supplies and their characteristics by measurement. It means relating these water supplies to the land areas to be served. It means a determination of existing water rights and their conversion to quantities and times of availability. Engineering technicians are necessary at this stage.

After the factors involved have been evaluated, these evaluations must be explained to the owners of water rights and applied to the respective land areas. Agreement must be reached voluntarily. This is the difficult job because of the human problems involved. The chairman of the meetings or the moderator must be a diplomat.

Once agreement is reached around the council table, the findings must be reduced to written form for the record. Here great care must be exercised so that double meanings do not creep in to give rise to later litigation. Legal council at this stage is essential.

Consolidation of small irrigation companies properly affected will:

1. Reduce conveyance and administrative water losses inherent 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 ground water supplies.

7. Provide a more effective organization to participate in basinwide development and to contract with Federal government or other agencies for additional water supplies or to improve the distribution systems.

Consolidation of small irrigation companies offers great opportunities to increase the net usable water supply available for irrigation and presents a challenge to the ingenuity and ability of the engineers, the corporation and progressiveness of the water users and the ability of the legal profession.
CONSOLIDATION OF SMALL IRRIGATION COMPANIES

By L. M. Winsor

NOTE: This brief outline covers the actual experience of the author in bringing about the consolidation of four undertakings of various types. This occurred under the immediate supervision of the author during the years 1921 to 1928, while he was Irrigation Specialist in the Extension Service, and while directing local operations in the Division of Irrigation Investigations, United States Department of Agriculture.

In the process of development throughout the arid and the semi-arid parts of the West, the lands most easily reached were covered first by irrigation ditches and canals. In due time these lands were allotted prior rights to the available primary water supply. As time went on the more difficult canals were dug and the lands that lie higher up the slopes were covered. This has continued through the years until there have been developed two, three, even four independent ditch or canal systems running more or less parallel to each other, that serve adjacent lands.

As a rule, the canal that has the best water right serves the lower lands. In many cases, these low-lands are already burdened with too much water, through seepage from the irrigation of lands at higher levels.

Handled independently, these small units present a major problem; first, to obtain a satisfactory and dependable water right; second, to administer the rights covered equitably and in a manner such as to avoid complications.

Collectively or under systems of consolidation these major difficulties disappear. Canals and ditches that serve the same or adjacent lands may usually be united to the advantage, often the very great advantage, of all concerned without sustaining loss in any way. For this reason it is usually advisable for secondary and all later systems developed, to unite with other irrigation units, both early and late, in order that the entire system may be handled as one unit under a single, unified management.

In bringing about a consolidation there are obstacles to overcome, chief of which is the question of values in water rights. There is no fixed rule for evaluating water rights; but there is a way to determine relative values; and as a rule there is a market value that is pretty well established by practice.
As early as 1921 this problem came up for consideration and action in Utah. One small community was served by a stream that had an abundant flow while late snows were melting in early spring; but the water-master was faced with the problem of dividing the stream between the different users who held rights classed consecutively from "A" to "H". When the stream was at maximum flow then all users could be served; but when it began to fall off then it was necessary to cut off part or all of the water from "H" then "G" then "F", etc., and on down. This gave rise to much trouble and many serious arguments.

The problem was settled by placing a value on Class "A" water. It was easy to calculate, with this as a unit, the value of each of the other classes. Then the entire lot was pooled and new rights were issued, each one receiving stock in proportion to what he turned in. The system was divided into districts and the water was taken in rotation by the users, each one receiving in proportion to his shares in the new corporation. This gave the late comers a little even of the primary stream, enough for a few rows of truck crop or garden.

As a special measure the new company went over or around the mountain and diverted water from the other side into their own canyon to build up a better supply and make their primary stream hold up longer.

The consolidation marked a definite step forward for the community served.

The following year, 1923, another Utah community decided to try consolidation. This community had three mutual canal companies and one partnership ditch, running more or less parallel. Some of the users owned stock in two or more of these organizations, and were frequently faced with the necessity of handling two or more streams of irrigation water at the same time.

The oldest of these companies had the first rights. To arrive at a unit value, the boards of directors were called together. It required a full day and part of a night of deliberation. But a decision was reached and a plan was made that passed the stockholders unanimously, when they were called together for a vote.
As a result, new stock was issued in proportion to values turned in. Then, the entire community turned out and built a small reservoir on the other side of the mountain, and provided additional late season water. (They had previously constructed a tunnel through the divide for carrying high water.) The following summer the entire community turned out again and built a second small reservoir to provide more late-season water.

The water supply was distributed by rotation through a series of lateral systems.

The water users estimated that the consolidation and the attendant improvements gave them an increase of more than double in returns. It is also important to observe that along with the increased returns for water came other important improvements. First and probably of greatest value (1) A water system with pure water from a nearby mountain spring was installed, and water was carried to each home. (2) Electric lights were made available to each home by building a line two miles to connect with the main lines of the power company. (3) A new meeting house (a church chapel) was built. (4) A new school house was built. (5) Sidewalks were built leading to the business center.

This community began to move forward when it made the decision to consolidate its scattered irrigation interests.

Another type of condition where parallel ditches lead from a common water supply to serve adjacent lands is found at East Helena, Montana. In this case each ranch has its independent ditch except in one case where, about 1918, two parallel ditches were consolidated. There are more than fifteen additional ditches where combinations could be worked out that would improve conditions very markedly for the mid and late season water. When the warm weather comes and the stream flow falls off there is seldom enough water to do more than wet the long, independent ditches after the supply is divided between the many users.

If a consolidation were effected, and if portions of several of these long ditches were eliminated from use, and the limited water supply were held together
and taken in rotation, it would be effective in carrying through many acres of late season crop.

Based on these examples, it is evident that each case must be studied individually; but that there is usually a way, and that consolidation is feasible in one form or another where there is more than one ditch serving adjacent lands.
CONSOLIDATION AND REHABILITATION

I. PATTERN OF IRRIGATION DEVELOPMENT

A. Poudre River typical:
   1. Union colony about 1870 brought rapid development in irrigation.
   2. Ditches were built in random fashion, serving first the lands near
      the river and later those farther away.
   3. Frequently, two ditches parallel for considerable distances.
   4. Best water rights, hence, are held by people in lower reaches of rivers.
   5. Diversions moved upstream as engineering ability and machinery for
      ditches construction improved.
   6. The later diversions are most expensive, serve the rougher lands, require
      more conveyance and have poorer water supply.

B. The existing development is inefficient in water use, as well as unduly costly.
   1. Each diversion is costly.
   2. A separate organization for each is required.
   3. Single diversion would serve all at less cost, fewer canals, fewer struc-
      tures, less water loss.

II. Examples of the problem
   A. In Utah, two companies replaced diversion works within 500 ft. at cost of
      $300,000 each where one would have served.
   B. On Poudre River in Colorado, Larimer-Weld County constructed diversion in
      1956 at $30,000 while other companies with nearby diversions are constantly
      building new diversions or repairing old ones. These could have been consoli-
      dated.

III. Problems involved in consolidation
   A. Water right
      1. Every stream a law unto itself when considering the character of its
         rights,
         a. Early and late rights,
         b. Storage rights owned by various users,
         c. Certain companies have rights classed according to kind of stock owned.
      2. Solution:
         a. Define each right in terms of quantity and time of availability to free
            satisfaction of each owner,
         b. Relations of quantity, time available, and share of stock should be
            evaluated,
         c. All stock must be pooled and new stock issued,
         d. Disinterested moderator, technical facts will make possible an agree-
            ment to consolidate,
         e. Seek legal action last, following agreement,
   B. Debt Obligation: must be evaluated and liquidated by each company or adjusted
      on entry to new company so new company is not unjustly obligated.
   C. Adequacy of Distribution System: A distribution system agreed upon by all is
      necessary. It must have the capacity to handle the needs of the new organi-
      zation.
   D. Method of water distribution must be agreed upon.
   E. Human Element: Careful handling of the personality conflicts is essential.
IV. SUMMARY: Consolidation, where possible, will:

A. Reduce conveyance and administrative water losses inherent in a multitude of duplicating ditches.
B. Decrease cost of water distribution by reducing the number of directors and water masters.
C. Increase flexibility and efficiency of available water supplies.
D. Make it possible to employ trained men to operate and maintain the system.
E. Strengthen the financial structure so that adequate financing for O, & M, replacements, and betterments may be secured.
F. Make possible the effective integration and use of natural flow, surface storage and ground water supplies.
G. Provide a more effective organization to participate in basin-wide development, and to participate in local and state affairs affecting irrigation, and water supply development. (This latter point assumes considerable importance in the political arena.)
Meeting 22 August
Foller President.
Goodwin Secr.

Will ask 4 companies
to appoint 2 members
each to a steering committee.
Also city one, county
commissioners one, &
Welkern, Evans, Brown.
October 21, 1966

Mr. Norman A. Evans
Department Head
Agricultural Extension Service
Colorado State University
Fort Collins, Colorado 80521

Dear Mr. Evans:

In answer to your letter inquiring about consolidation of ditch companies in Utah, I am sending a copy of Utah Science dated March 1966. On page 18 is an article describing the overall water development in Ashley Valley which is located in eastern Utah. This article was written around the benefits and the efforts made on a community basis to develop water in this area.

On page 20 is a description of Steinaker Dam which was without a doubt a factor in the establishment of the Central Irrigation Office.

This Central Irrigation Office takes care of the actual water delivery, collection of money and all the operating procedures for irrigation companies and the one reservoir company mentioned. While these companies have not consolidated legally, they have for most other respects.

At the present time, they are struggling with the decision of whether to complete the consolidation and disband their present canal and irrigation companies which, by the way, do very little if anything. The President of each of these companies form the committee for the Central Office which carries out all the functions except ratification which is necessary now and then. One other system similar to this is in operation near Ogden, Utah. I will try and get some specific details on this for you.

In the meantime, I hope this will be of help to you.

Sincerely,

Richard E. Griffin
Water Resource Specialist

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Water Resources Archive
Colorado State University Libraries
August 16, 1966

Mr. E. E. Zoller
Route 4, Box 274
Ft. Collins, Colo.

Dear Mr. Zoller:

This is in reply to your request for a proposed program for the meeting to be held on August 22nd.

I believe Steve Goodwin kept the minutes of the meeting held on June 22nd. If possible these minutes should be read at the start of the meeting. If the minutes are not available I suggest you briefly report on the meeting held on June 22nd. This then might be followed by giving the purpose or reasons for the meeting being held (August 22).

I will then present the information I have compiled on the diversions records for each of the 4 canals along with some remarks regarding these records.

It then might be possible that Dugan Wilkinson could discuss the kind of procedure that might be required of the Water Commissioners in the event the 4 canals were consolidated. At this time the kind of procedure followed should be only considered as tentative and subject to change when more information is available.

Mayor Harvey Johnson might be asked for his general comments including the potential use of the water now owned by the city and how this potential use would affect the amount of water flow in each canal.

Other topics that might be discussed in round table discussion are:
(a) Selection of steering committee. How? Who?
(b) Canal seepage losses—How much? How can they be determined.
(c) Water measuring devices.
(d) Superintendents and ditch rider records.
(e) Other topics you might think of or others might think of.

Sincerely,

Floyd E. Brown
Extension Irrigation Specialist

FEB/djk

cc: Norman A. Evans
Department of Civil Engineering
Colorado State University

"Irrigation System Consolidation in the Fort Collins Area"
PRELIMINARY REPORT

By
Michael W. Biggs
June 2, 1967
TABLE OF CONTENTS

Purpose ............................. 1

Introduction .......................... 1

Water Rights .......................... 3

Water Supply .......................... 7

Land Uses ............................. 10

Alternate Consolidation Plans ........ 12

Conclusions ........................... 13

References ............................ 15

Appendix
PURPOSE

This paper presents some of the problems involved in the consolidation of irrigation systems in the Cache la Poudre Valley, near Fort Collins, Colorado. At the present time, four separate irrigation canals pass through the city limits. An economic and engineering feasibility considering consolidation of these canals is currently being sponsored by the Agricultural Experiment Station and the Department of Civil Engineering of Colorado State University.

Basic data has been collected concerning the water diversions for the four canals and precipitation data has been collected for the Fort Collins area. Using this basic data, alternate consolidation proposals and cost estimates are presented. The basic proposals are shown on the USGS quadrangle display maps.

INTRODUCTION

Irrigated agriculture has been practiced in Eastern Colorado since 1852. Typically, the pioneer settlers placed their diversion structures and canals low in the valleys and irrigated the adjacent land. As the development of the river basins progressed, later settlers were forced to make their diversions higher on the streams. These later canals usually served land which was more distant from the stream and passed through rougher terrain. As a result these later canals were much more expensive.

Because the basins were developed without a comprehensive development plan, three or four canals often exist where only one is required.

The complete reconstruction of canal and lateral systems in most areas would be impractical and probably financially infeasible. However, in some areas, it might be possible to combine the systems by enlarging the highest ditch and either eliminating the lower ditches or using parts of them as lateral systems. The following problems will be found to exist in areas where there are duplicate or parallel systems:

(1) An excessive amount of land is required for the water conveyance system.
Costly river diversion structures are required to serve each canal;

(3) The number of farm turnouts is greatly increased because some farms receive water from more than one canal system;

(4) The number of bridges and culverts is greatly increased;

(5) Seepage and evapotranspiration losses are greater than for a single canal;

(6) The costs of operation, maintenance, and administration are higher than for a single canal system; and

(7) There is excessive hazard to life and property in residential areas.

In an optimum state of conservation, the maximum practicable use of flow resources is the goal of the resource user. In most states of the arid West, the existing water supplies have been appropriated. Yet, in many areas, the water demand is still greater than the dependable supply. The optimum consumptive use requirement for irrigation in the South Platte basin is approximately 2.20 acre feet per acre (Ref.3, pg.4). The direct diversions for irrigation from natural streamflow are not great enough to supply this volume of water, as a result, several transmountain diversions have been constructed to convey water from the western slope of the Rocky Mountains. The most notable example is the Colorado-Big Thompson (C-BT) Project which annually conveys up to 310,000 acre-feet of supplemental irrigation water to the arid north-eastern portion of Colorado.

In recent years, water demand for this region has again exceeded the available supply. This is partly due to the increased demand for municipal and industrial water and partly due to the increased acreages of water-intensive row crops. Reservoir sites on the Cache la Poudre River have been investigated but the development of these sites is not economically justifiable at the present time. It appears that the best way to satisfy the increased demand is to seek a more efficient use of the existing water supply through the elimination of seepage and evaporation losses. The ramifications of this situation are illustrated by
this statement by A. A. Bishop (Ref. 6).

Agriculture, with its widespread irrigation, now consumes more water than all other uses combined and will probably continue to be the largest single consumptive user of water. Along with the use of water, irrigation is probably a major source of waste of the valuable water resources. This is due in large measure to the inefficiency of existing canal and distribution systems with their duplication and obsolescence.

WATER RIGHTS

In regions where the water supply is less than the demand, legal doctrines have been established to control the use of surface waters. In most humid areas, water rights are determined in accordance with the common-law riparian rights doctrine. In the western United States, the riparian doctrine was found to be unsuitable for the unique situations caused by large scale mining and irrigation. The doctrine of appropriation evolved to satisfy the distribution of water for consumptive use.

The Riparian Rights Doctrine. -- Under the riparian rights doctrine, the owner of land adjacent to a natural watercourse is entitled to receive the full natural flow of the stream, undiminished in quantity or quality. Land owners with riparian rights may use all the water necessary for domestic purposes and the watering of livestock. This system does not make the provisions necessary for consumptive uses, such as irrigation and mining.

Riparian rights are limited to riparian land and under most circumstances they cannot be lost through non-use. The riparian doctrine does not specify any fixed point of diversion and dams may be constructed to retain water if no injury is incurred by other property owners.

The Doctrine of Appropriation. -- The economic base of the arid western states is dependent upon the consumptive use of water. The appropriation doctrine was instituted to serve these areas and the special problems introduced by the large scale consumptive use of water.
Under this system, both riparian and non-riparian land owners are allowed to file claims to divert water from streams or other bodies of water as long as their claims do not conflict with previous claims. In this manner, a system of priorities develops under which each appropriator has a recognized exclusive right to divert water from the stream up to the full amount of his decree, providing that there is sufficient water to satisfy all prior appropriators. Barlow (Ref. 5) summarizes the principal features of the appropriation doctrine as follows:

(1) It gives an exclusive right to the first appropriator. Later appropriations are provisional and justified only if all prior decrees are satisfied;

(2) It makes all rights conditional on beneficial use;

(3) Water may be diverted to both riparian and non-riparian lands;

(4) Diversion is permitted regardless of the diminution of the stream; and

(5) Continuation of the right depends on beneficial use. Non-use may result in the cancellation of the right.

Colorado recognizes the appropriation doctrine exclusively. Some states have found it necessary to institute a "modified riparian doctrine" in which the riparian concept has been modified to allow the appropriation of reasonable amounts of water for beneficial use.

In contrast to the riparian concept, the doctrine of appropriation requires administrative procedures. Action of administrative boards and the courts is required in defining and adjudicating water right conflicts, and administrative procedures must be established for the filing and recording of claims. In addition, ditch riders and water masters are required to make certain that appropriators do not exceed the specified amount of their decree.
Data for the irrigation canals included in this study concerning the water rights and water supply is shown in Tables I, II, and III. Table I shows the decreed capacity of the canal, the length of the canal and the number of acres served by each canal. Table II shows the adjudicated decrees held by each canal and the river flow required to fulfill the specified decree. Table III shows the amounts of water carried by each canal (1958-1965 average) from all sources.

<table>
<thead>
<tr>
<th>Company</th>
<th>Decreed Capacity</th>
<th>Length</th>
<th>Area Served</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>in GFS</td>
<td>in Miles</td>
<td>in Acres</td>
</tr>
</tbody>
</table>

| Arthur Canal   | 108.99 | 8.2 | 2,400 |
| Highline       | 137.93 | 19.7 | 6,820 |
| New Mercer     | 170.53 | 12.8 | 7,000 *  |
| Larimer Co., Canal #2 | 179.00 | 13.3 | 6,000 |

**Total** | **596.45** | **54.0** | **22,220 *  |

* Includes 2,600 acres served by Mall Creek Ditch Co.
### TABLE II - Water Rights on the Cache La Poudre River

<table>
<thead>
<tr>
<th>Company</th>
<th>Priority Number</th>
<th>Date</th>
<th>Decree</th>
<th>River Flow Required to Fill the Decree in CFS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arthur</td>
<td>2</td>
<td>6-1-1861</td>
<td>0.72</td>
<td>4.22</td>
</tr>
<tr>
<td>Highline</td>
<td>4</td>
<td>9-1-1861</td>
<td>10.97</td>
<td>27.58</td>
</tr>
<tr>
<td>Highline 1st Enl.</td>
<td>11</td>
<td>6-10-1864</td>
<td>29.63</td>
<td>224.01</td>
</tr>
<tr>
<td>Larimer Co. #2</td>
<td>14</td>
<td>5-1-1865</td>
<td>4.00</td>
<td>300.00 (app)</td>
</tr>
<tr>
<td>Arthur</td>
<td>19</td>
<td>7-1-1866</td>
<td>2.16</td>
<td>355.13</td>
</tr>
<tr>
<td>New Mercer</td>
<td>25</td>
<td>10-1-1867</td>
<td>7.03</td>
<td>391.89</td>
</tr>
<tr>
<td>Arthur</td>
<td>29</td>
<td>6-1-1868</td>
<td>2.16</td>
<td>403.41</td>
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<tr>
<td>New Mercer</td>
<td>32</td>
<td>6-1-1869</td>
<td>1.67</td>
<td>481.25</td>
</tr>
<tr>
<td>Arthur</td>
<td>33</td>
<td>9-1-1869</td>
<td>4.17</td>
<td>485.12</td>
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<tr>
<td>Arthur 1st Enl.</td>
<td>38</td>
<td>4-1-1871</td>
<td>31.67</td>
<td>693.51</td>
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<tr>
<td>New Mercer 1st Enl.</td>
<td>47</td>
<td>10-10-1871</td>
<td>8.33</td>
<td>1,087.84</td>
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<tr>
<td>New Mercer 2nd Enl.</td>
<td>49</td>
<td>7-1-1872</td>
<td>15.00</td>
<td>1,085.22</td>
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<tr>
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<td>51</td>
<td>7-10-1872</td>
<td>16.50</td>
<td>1,164.85</td>
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<td>Arthur 2nd Enl.</td>
<td>52</td>
<td>7-20-1872</td>
<td>18.33</td>
<td>1,183.18</td>
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<td>Larimer Co. #2</td>
<td>57</td>
<td>4-1-1873</td>
<td>175.00</td>
<td>1,573.31</td>
</tr>
<tr>
<td>Arthur 3rd Enl.</td>
<td>66</td>
<td>9-1-1873</td>
<td>52.28</td>
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<td>Highline 3rd Enl.</td>
<td>92</td>
<td>8-18-1879</td>
<td>80.83</td>
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<td>2-15-1880</td>
<td>175.00</td>
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### Annual Average

### TABLE III - Water Supply from Various Sources (1958-1965) - in acre-feet

<table>
<thead>
<tr>
<th>Company</th>
<th>River Diversion</th>
<th>C-BT Project</th>
<th>Exchange or Storage</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arthur</td>
<td>5,464</td>
<td>993</td>
<td>42</td>
<td>6,499</td>
</tr>
<tr>
<td>Highline</td>
<td>16,053</td>
<td>1,094</td>
<td>1,123</td>
<td>16,270</td>
</tr>
<tr>
<td>New Mercer</td>
<td>4,969</td>
<td>2,177</td>
<td>36</td>
<td>6,282</td>
</tr>
<tr>
<td>Larimer Co. #2</td>
<td>6,490</td>
<td>2,366</td>
<td>666</td>
<td>9,522</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>30,976</strong></td>
<td><strong>6,630</strong></td>
<td><strong>1,867</strong></td>
<td><strong>38,573</strong></td>
</tr>
</tbody>
</table>
Water Supply

Since the volume of water available to these four ditches is highly dependent on the flow of the Cache la Poudre River, a wide variation in yearly diversions would be expected. Hydrographs of the river for the irrigation season are shown for 1961 and 1965 in Figure I. The hydrographs show that the peak flow in the river usually occurs about June 10th and then the flow decreases throughout the irrigation season. Due to the nature of the doctrine of appropriation, many of the later decrees are able to receive river water for only short periods of time during the irrigation season and must depend on supplemental water for the balance of the irrigation season. The total water requirement necessary for the irrigation of the lands served by the canals (22,220) using the desirable value of 2.20 acre-feet per acre is approximately 48,880 acre-ft. per year. During the nine year period (1958-1965), this approximate volume of water was supplied only once. The maximum diversion occurred in 1962 when a total of 47,674 acre feet of water were diverted. The minimum diversion during this period was 28,878 acre-feet in 1961. From Table III, the nine year average was 36,573 acre feet or approximately 79% of the desirable volume of water.

In order to use the available water more effectively, an extensive and complex system of water exchanges has evolved. This system relies more upon the accounting of water rather than upon the strict application of priorities. The basis for this development is the physical availability of plains storage reservoirs interconnected with the canals. In addition to this purpose these reservoirs serve the purpose of storing surplus runoff that would otherwise be wasted and also serve an extremely useful function as flow regulators.

The major disadvantage arising from the use of these shallow plains storage reservoirs is the high evaporation rate (approximately 1.75 acre-feet per acre of surface area). Various proposals for eliminating these reservoirs by providing storage on the Cache la Poudre River have not indicated a favorable benefit-cost ratio.
HYDROGRAPH FOR THE CACHE LA Poudre RIVER
AT FORT COLLINS, COLORADO
APRIL TO SEPTEMBER - 1961
DRAINAGE AREA = 1055 SQ. MI.

HYDROGRAPH FOR THE CACHE LA Poudre RIVER
AT FORT COLLINS, COLORADO
APRIL TO SEPTEMBER - 1965
DRAINAGE AREA = 1055 SQ. MI.
The essential features of water supply for the four canals are shown on Figures II and III. Figure II shows the annual diversion for each of the four canals for the 1958-1966 period. Figure III shows the average monthly distribution of the canal diversions for each canal.

The relation between precipitation and the crop water requirement is highly dependent on the intensity and the duration of the rainfall. High intensity rainstorms are potentially dangerous to crops and long duration rainstorms have a high surface runoff. In an average year, about 3 inches of rain serve as being effective toward meeting cropwater requirements in the Fort Collins area. The precipitation data collected up to this time has mainly been used to correlate precipitation and runoff studies.

In order to estimate the magnitude and occurrence interval for flooding in this area, precipitation data from 1896 to 1966 has been checked and a list of major storms is shown in the Appendix. Maximum rainfall periods have been correlated to flood conditions by checking issues of the Fort Collins Coloradoan.

The construction of Horsetooth Reservoir has considerably reduced the flood threat to Fort Collins by limiting the area of contribution. For this reason, no meaningful relationship can be derived between the present day situation and periods before 1948. For the 1948-1966 period, the major flood was associated with the rainstorm of August 2-3, 1951, when 6.06 inches of rain fell in a 26 hour period. The flood damage to the Bellvue-Fort Collins-Loveland area was estimated at two and one-half million dollars.

At the present time, the city of Fort Collins is engaged in a storm water drainage study (Ref.9). The possibility of co-ordinating the city's storm water drainage and the canal consolidation is being considered to determine whether or not a dual-purpose irrigation-flood control channel would be beneficial to both projects. Since the con-
solidation proposal calls for the abandonment of some of the canals as they pass through the town, the city would be interested in obtaining the vacated canal right-of-way to serve as a conveyance system to dispose of excess storm waters.

In the preliminary report by J. T. Banner and Associates, it is recommended that storm waters from the area south of La Porte Avenue and north of Horsetooth Road should be conveyed to the Spring Creek drainage channel. This channel would have to be improved throughout its entire length to accommodate the expected flood flows. In determining the magnitude of the flood flows, the "rational method" was used. In this method, the magnitude of the predicted flood is given by the formula $Q = C i A$,

where $Q$ = discharge in cubic feet per second,

$C$ = runoff coefficient,

$i$ = rainfall intensity in inches per hour, and

$A$ = the drainage area in acres.

This method has been used extensively for predicting storm flows and has proven to be satisfactory in most cases. The runoff coefficient $C$, is the fraction of runoff which can be expected. $C$ varies with the slope of the area and the perviousness of the terrain. In this study, composite coefficients were computed for various types of surfaces and an average value of $C = 0.50$ was found to be representative of this area under the expected conditions for future development. Plate II-1 from Ref. 9, is included in this study to show the expected rainfall intensities and durations.

The expected flood flow which would have to be carried concurrently with the irrigation water in a consolidated canal is approximately 1500 cfs. This flow is for a rainstorm with a ten-year frequency under the conditions of ultimate development. Due to the magnitude of the storm flow, it would be desirable to have a joint facility from La Porte Avenue to the Spring Creek channel, which would be capable of carrying
a total flow of 2000 cfs (combined irrigation and storm flows). If all four canals were consolidated, the vacated right-of-way could then be developed as additional flood protection to convey storm flows to the Spring Creek Channel.

Land Use

The problems introduced into this study by the expansion of the city of Fort Collins and the growth of Colorado State University are reflected mainly in the changing land use patterns to the south and west of the city. The general tendency for growth is to the south, this fact is evidenced by the large number of subdivisions being constructed in this area. In this expanding process, land is taken out of agricultural production and an increased demand is placed on the water supplies. The amount of land which must remain under agricultural production is highly dependent on the crop yields. Decreasing yields due to past exploitive practices will lead to greater agricultural land requirements, while increasing yields will allow an expansion of the residential areas without the necessity of increasing agricultural land requirements.

The term land use intensity is a measure of the relative amounts of capital and labor which are combined with land in the production process. The intensity of land use reflects the natural characteristics of the land, its location with respect to markets and its general use-capacity. As population increases, the intensity of land use generally increases. Typically, land moves from agricultural production to residential or commercial uses. When studying the intensity of land use, two important concepts are of value. The intensive margin is defined as the point at which the last units of labor and capital used barely pay their cost (marginal cost equals marginal revenue). The extensive margin is usually considered to be the no rent margin at which the land under optimum conditions will yield just enough to cover the costs of production (average cost equals marginal cost).

When the physical supply of land is the limiting factor, operators have a tendency to push their operations to the intensive margin. When a
PRECIPITATION RECORDS FOR FORT COLLINS, COLORADO
1954-1966

AVERAGE PRECIPITATION

Precipitation - Inches

Precipitation in Inches

Average Monthly Precipitation

non-land resource is the limiting factor, it is most profitable for operators to proportion their input factors around the limiting resource. If the supply of the limiting resource is increased, it will have the effect of increasing both the intensive and extensive margins of land.

Through the consolidation of irrigation systems, an additional quantity of water would be made available to the farms. Since irrigation water is a limiting resource in this area, the effect of consolidation will be to remove some of the constraints on production. With increased yields, the amount of agricultural land could be held at the present level and support an increasing population.

At the present time, no extensive seepage measurements have been made on the four canals. Estimates of seepage losses range from 25% to 40% of the water which is diverted. Assume that the present value of seepage losses is 25% and that through consolidation these losses can be reduced to 10%. The net annual savings of water under these conditions would be approximately 5800 acre-feet. As was stated previously, the Colorado-Big Thompson project conveys an average of 6630 acre feet annually to the area served by the four canals. It would seem reasonable that the effect of consolidation would be of the same magnitude as the effects of the introduction of C-BT water.

The general effect of C-BT water on the productive capacity of northeastern Colorado is reported in "Introduction of Supplementary Irrigation Water" (Ref. 3).

Generally, farms were enlarged somewhat and farmers brought more land under irrigation. More land was planted to intensive, high-water requirement, row crops and fewer acres to low-value short-season crops.

Yield increases were reported on all crops grown, particularly row crops and alfalfa.

Twice as many farmers were fertilizing after C-BT water was used than before and they were fertilizing more heavily. One can speculate that this is due partly to the complimentary between water and fertilizer and partly to increasing knowledge of the value of fertilizer.
In order to estimate the value of water per acre-foot, use is made of the data presented in Ref. 4. In this study, the value of water was determined from a regression analysis of farm sales data for Northeastern Colorado. The estimated mean value of company water was $21.53 per acre-foot and the estimate for C-BET water was $25.71 per acre-foot. These values were calculated for 1963 and have increased considerably since that time. In estimating the value of water in this study a price of $40.00 per acre-foot has been used.

**Alternate Consolidation Plans**

The four irrigation canals to be included in this study are the Pleasant Valley and Lake Canal (Highline), the New Mercer Canal, the Larimer County Canal No. 2, and the Arthur Canal. These canals were constructed between 1860 and 1880 and very little additional development has occurred since. The four canal systems are shown on the display maps. The alternate proposals for consolidation are also shown on the display maps.

**Plan "A"** -- This plan is, essentially, to eliminate the lower canals as they pass through Fort Collins, and carry the water in an enlarged Highline canal. Included in the study, is an investigation concerning the feasibility of increasing the capacity of both Claymore Lake and College Lake.

Claymore Lake would serve as a regulating reservoir in the new system. The additional elevation required to enter Claymore Lake would be obtained by eliminating a two and one-half mile reach of canal which follows the contour of Bingham Hill. This section of canal is reported to be a reach with high seepage losses. The construction of a 1850 foot tunnel would be required to bypass this section of canal. The resultant increase in the capacity of Claymore Lake would be approximately 600 acre-feet.

At the present time, College Lake serves as the reservoir for
water used by the Colorado State University Hydraulics Laboratory. Water is released through an outlet in Soldier Canyon Dam, passes through the laboratory facilities and then enters College Lake. For the past two years, the Highline Canal has used the Soldier Canyon outlet to obtain its allotment of C-BT water. Under the proposed consolidation, the C-BT water for all four canals would be conveyed through this system. This would eliminate approximately twelve miles of conveyance of the C-BT water in open channels and make additional water available for the non-consumptive research purposes at the hydraulics laboratory. College Lake could be raised to provide an additional 500 acre feet of storage.

Plan "B". -- This plan is similar to Plan "A" in all respects except that the Arthur Canal has not been included in the design.

Plan "C". -- This plan would combine only the New Mercer Canal and the Larimer Co. Canal No. 2.

The display maps show all three plans and Table IV details the costs and benefits of each project. The benefit-cost ratios were computed considering the direct benefits to irrigation. If the project is financed through the procedures outlined in the U. S. Bureau of Reclamation Small Projects Act, additional benefits to flood control could be included in the study. From this analysis, all three of the alternate plans is economically feasible.

Conclusion.

From the analysis of the limited data which has been presented in this paper, it appears that a favorable benefit-cost ratio can be attained by this project. Additional data concerning seepage losses, sediment transport, and changing land uses will be required before the consolidated system can be designed and a reliable cost estimate prepared.

From an economic standpoint, this project should be undertaken as soon as possible because of the high rate of increase in construction
Costs. Cooperation on this project should involve the board of directors of all the participating companies, the City of Fort Collins, Colorado State University and the county and state governments.

The most favorable financing on this type of project would probably be achieved through the U. S. Bureau of Reclamation "Small Reclamation Projects Act." Under this plan, the construction costs are interest free on a 50-year repayment contract. In order to qualify for this loan, the project must be primarily for irrigation but may include benefits to flood control and municipal and industrial water.
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Diversion Dam and Road-</td>
<td>$ 52,000</td>
<td>$ 52,000</td>
<td>$ 10,000</td>
</tr>
<tr>
<td>works on the Cache La</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Foudre</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Tunnel at Blighson Hill</td>
<td>373,000</td>
<td>348,000</td>
<td></td>
</tr>
<tr>
<td>1890 Feet Long</td>
<td></td>
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<tr>
<td>3. 6 Foot Bottom Width</td>
<td>1,023,000</td>
<td>903,000</td>
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<td>Canal</td>
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<td>4. 7 Foot Bottom Width</td>
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<td>5. 1/2 Inch Pipeline</td>
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<td>89,000</td>
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<td>Structures, Fins, Turnouts, and Check Structures</td>
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<td></td>
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<tr>
<td>8. Improvements at College</td>
<td>96,000</td>
<td>96,000</td>
<td></td>
</tr>
<tr>
<td>and Claymore Leases</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Subtotal                  | $2,171,000  | $1,629,000  | $663,000    |
| Engineering Cost @ 7%     | 128,000     | 128,000     | 64,000      |
| Contingencies @ 10%        | 237,000     | 183,000     | 61,000      |

Total Estimated Cost = $2,533,000  $2,040,000  $774,000

Estimated Water Savings
5,750 AF  4,810 AF  2,370 AF

Value of water, $.80.00/AF $232,000 /yr, $192,000 /yr, $95,000 /yr

Cost of 60 Year
Annual Payment @ 3½% int. 2.15  2.11  2.88

Correction Sheet for Preliminary Report
1. Estimate seepage losses - 25%
2. Marginal value of water - $.80/AF
3. Benefits discounted @ 3½%
4. Corrections applied to the above table and corrected B/C ratio is shown.
References


April 25, 1967

Mr. Emanuel Zoller, Chairman
Consolidation Steering Committee
Route 4, Box 274
Fort Collins, Colorado 80521

Dear Mr. Zoller:

Since I was unable to attend the last steering committee meeting concerning the consolidation of ditches, this is to indicate the information I obtained from the Bureau of Reclamation regarding the preliminary engineering study which is needed for a loan application.

Each such study is tailor made to the local situation and project. The objective of the study is to make a reasonable cost estimate and only that information which is needed for this purpose is required. Of course, a route map showing the location of the proposed canals would be required. In general, such a map made from aerial photographs would probably be adequate. Details of structural designs are not required, but "typical" structures should be sketched to provide the basis for material estimates.

No foundation investigation is required for structures, but a general description of the foundation materials in the area would be desirable. In the case of a tunnel, only surface geology would be needed to form the basis of a cost estimate. No drilling would be required.

Earthwork cost estimates can be made from USGS topographic maps supplemented with spot checks in the field.

It would appear to me that once the ditch companies give the green light to the preliminary investigation for the purpose of applying for a loan, the actual investigation could be conducted quite economically and rapidly. It will unquestionably require the services of a professional engineering firm experienced in this kind of work. I am inclined to think concurrence should be sought from the ditch company Boards before such a step is taken, however.
Mr. Emanuel Zoller

April 25, 1967

The University would be willing to contribute toward the cost of such a survey in view of its interest and the benefits to be accrued to the University from relocating ditches. The exact extent of commitment cannot be indicated at this time.

Yours truly,

Norman A. Evans
Head of Department

cc: George Weaver
Donald Kaufman
<table>
<thead>
<tr>
<th>Date</th>
<th>A Arthur</th>
<th>Larimer Co. #2</th>
<th>Mercer</th>
<th>Highline</th>
<th>Total</th>
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<tr>
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<td>64</td>
<td>141</td>
<td>76</td>
<td>104</td>
<td>385</td>
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<td>71</td>
<td>142</td>
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<td>116</td>
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<td>67</td>
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<td>6’ 9</td>
<td>62</td>
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<td>75</td>
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<td>69</td>
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<td>34</td>
<td>108</td>
<td>351</td>
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<tr>
<td>1960 5/21</td>
<td>60</td>
<td>159</td>
<td>40</td>
<td>99</td>
<td>358</td>
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<tr>
<td>1961 6/25</td>
<td>54</td>
<td>149</td>
<td>51</td>
<td>101</td>
<td>355</td>
</tr>
<tr>
<td>1962 5/12</td>
<td>76</td>
<td>142</td>
<td>60</td>
<td>115</td>
<td>393</td>
</tr>
<tr>
<td>5/13</td>
<td>74</td>
<td>137</td>
<td>61</td>
<td>115</td>
<td>387</td>
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<tr>
<td>5/14</td>
<td>72</td>
<td>136</td>
<td>59</td>
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</table>

1963 No days when total exceeded 350 CFS
1964 No days when total exceeded 350 CFS
1965 No days when total exceeded 350 CFS
1966 No days when total exceeded 350 CFS
Yearly Diversion - Acre-feet
(Not Checked for Accuracy)

Arthur Canal

<table>
<thead>
<tr>
<th>Date</th>
<th>River</th>
<th>Big T</th>
<th>Exchange</th>
<th>Total</th>
<th>Days Run</th>
</tr>
</thead>
<tbody>
<tr>
<td>1958</td>
<td>4,150</td>
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<td>30</td>
<td>5,638</td>
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</tr>
<tr>
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<td>.66</td>
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</tr>
<tr>
<td>1962</td>
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<td>856</td>
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<td>964</td>
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<td>5,064</td>
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<td>1966</td>
<td>4,356</td>
<td>1,226</td>
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<td>Total</td>
<td>49,178</td>
<td>8,938</td>
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<td>1,181</td>
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<td>5,464</td>
<td>993</td>
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<td>6,499</td>
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Larimer County #2

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<th>Exchange</th>
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<tbody>
<tr>
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<td>22</td>
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<tr>
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<td>1,604</td>
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<tr>
<td>1966</td>
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<td>4,080</td>
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<tr>
<td>Total</td>
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<td>666</td>
<td>9,522</td>
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</table>

Diversion data for all canals for 1966 does not include diversions made after September 17, 1966

New Mercer

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<tr>
<th>Date</th>
<th>River</th>
<th>Big T</th>
<th>Exchange</th>
<th>Total</th>
<th>Days Run</th>
</tr>
</thead>
<tbody>
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<td>1963</td>
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<td>46</td>
<td>7,226</td>
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<td>4,566</td>
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<tr>
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<td>3,622</td>
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<td>6,748</td>
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<tr>
<td>Total</td>
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<td>2,177</td>
<td>36</td>
<td>6,282</td>
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Highline

<table>
<thead>
<tr>
<th>Date</th>
<th>River</th>
<th>Big T</th>
<th>Exchange</th>
<th>Total</th>
<th>Days Run</th>
</tr>
</thead>
<tbody>
<tr>
<td>1958</td>
<td>13,694</td>
<td>1,090</td>
<td>742</td>
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<td>1961</td>
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<td>414</td>
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<td>132</td>
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<td>1962</td>
<td>17,524</td>
<td>948</td>
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<tr>
<td>1966</td>
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<td>422</td>
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<td>Total</td>
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<tr>
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<td>851</td>
<td>1,123</td>
<td>16,027</td>
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</table>

Big Thompson water for Highline not included for 1965 and 1966.
<table>
<thead>
<tr>
<th>Month</th>
<th>1965</th>
<th>1966</th>
<th>Year Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>April</td>
<td>32</td>
<td>34</td>
<td>33</td>
</tr>
<tr>
<td>May</td>
<td>36</td>
<td>32</td>
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<tr>
<td>June</td>
<td>42</td>
<td>44</td>
<td>43</td>
</tr>
<tr>
<td>July</td>
<td>40</td>
<td>42</td>
<td>41</td>
</tr>
<tr>
<td>August</td>
<td>38</td>
<td>40</td>
<td>39</td>
</tr>
<tr>
<td>September</td>
<td>35</td>
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<td>October</td>
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<tr>
<td>November</td>
<td>32</td>
<td>34</td>
<td>33</td>
</tr>
<tr>
<td>December</td>
<td>30</td>
<td>32</td>
<td>31</td>
</tr>
</tbody>
</table>

**Year Average:**

- April: 33
- May: 34
- June: 43
- July: 41
- August: 39
- September: 36
- October: 35
- November: 33
- December: 31
I  Problems involved in Consolidation
   A. Water Rights
      1. Early and Late rights
      2. Storage Rights
      3. Classes of Stock within a company
      4. Solution
         a. Define each right in terms of quantity and
time of availability to the satisfaction of
each owner.
         b. Relationship of quantity (both rate of flow
and volume), time available, and shares of
stock should be established
         c. All stock must be pooled and new stock issued.
d. Technical facts will make possible agreement
to consolidate. Seek legal action as last
step following agreement.
   B. Debt Obligation--must be evaluated and liquidated
by each company or adjusted on entry to lnew
company so new organization is not unjustly obligated.
   C. Adequacy of Distribution System-- A new distribution
system agreed upon by all is necessary. It must
have the capacity to handle the needs of the new
organization.
   D  Method of water distribution must be agreed upon

II  Suggested information to be collected from each ditch
company.
   A. Water Supply
      1. Direct Flow Rights
         a. priority number
         b. Amount of flow
         c. Dependability--frequency of no delivery or
otherwise show nature of the rights.
      2. NCWCD agreements by stockholders
      3. Amount of surface runoff or seepage pick-up into
ditch system during irrigation season.
   B. Stockholders
      1. Number of farms served
2/ Name and No. shares each stockholder
3. Acreage irrigated each stockholder
4. Meaning of share of stock—in water; in market value; in time available
5. Limitations imposed on stock—ownership; transfer; assessments; penalty for delinquency; classes; etc.

C. Financial condition of company
   1. Outstanding obligations
   2. Assets valuation if possible
   3. Physical facilities and condition (need for rehabilitation or betterment)

D. Adequacy of distribution system
   1. Capacity of system
   2. Maintenance costs and procedures

E. Method of Operation
   1. Water delivery system and procedure
   2. Organizational structure
   3.
1. Value must be placed on present water right-
   
   # and/or volume-time of water.

2. Water measurements serve as factual basis for evaluating rights - Commission to "disinterested" party with reliable data.

3. Each ditch would relate shares of rights to quantity & time of availability of water.

4. Agreement once reached on value of stock - then it can be posted & stock re-issued in new company for stock turned in.
5. Avoid legal questions at first to allow the physical facts to be established.

6. Debt obligations of each Co. must be segregated from arrows made to carry the mill to the mill Co. in a negotiable way.

7. New system distributed works must be agreed by all in advance. A plan for operators & manuals.

8. method of water shafts also detail plan agreed in advance.
9. Get the facts
   ENGLISH
   LEGAL
   ECONOMIC.

10. Inform the people.