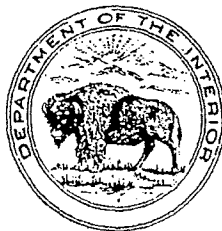


# FARM IMPROVEMENT

## COLUMBIA BASIN JOINT INVESTIGATIONS

### *Problem 9*

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UNITED STATES DEPARTMENT OF THE INTERIOR  
BUREAU OF RECLAMATION, WASHINGTON, D. C., 1945

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UNITED STATES  
DEPARTMENT OF THE INTERIOR  
BUREAU OF RECLAMATION

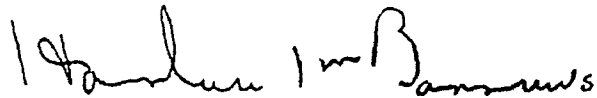
MAY 5, 1944.

Commissioner H. W. BASHORE,  
*Bureau of Reclamation,*  
*Washington, D. C.*

DEAR MR. BASHORE: I transmit herewith the report of the committee which studied Problem No. 9 of the Columbia Basin Joint Investigations and recommend that it be published.

The committee has rendered an important service. It has indicated many practicable means of keeping down the cost of suitable and essential farm improvements on the Columbia Basin Project.

Sincerely yours,



HARLAN H. BARROWS,  
*Planning Consultant.*

## JOINT INVESTIGATIONS COLUMBIA BASIN PROJECT

The Columbia Basin Joint Investigations were sponsored by the United States Bureau of Reclamation to assure successful settlement and development of the more than 1,000,000 project acres that will be irrigated as soon as war conditions permit. These acres, below Grand Coulee Dam in the State of Washington, are expected to strengthen immeasurably the agricultural and related economy of the Pacific Northwest.

This is the report on Problem 9, which discusses farm improvement with the object of helping the project settler obtain the most for his money. Recommendations made herein will aid in the formulation of policies best suited to the veterans and war workers who will seek greater opportunities by settling in the project area. Detailed suggestions are given on expenditures ranging from land leveling and fencing to house furnishings and landscaping of the farmstead.

The committee for Problem 9 urges, for example, that the Bureau of Reclamation level the publicly owned lands, adding the cost of the work to the appraised values of the separate tracts. Land can be prepared for irrigation at a lower initial cost if the work is handled by large-scale methods, the committee states. It also recommends that engineering assistance be made available to the settler "in order that his work may produce maximum benefits at the lowest possible cost."

The reports on problems of the Columbia Basin Joint Investigations are aiding the Bureau of Reclamation greatly in formulating plans and programs for the settlement and operation of the Columbia Basin Project. The Bureau deeply appreciates the assistance rendered by all who participated in the investigations.

The publication of the reports is not intended to indicate, of course, that suggestions and recommendations contained in them necessarily will be approved and carried out by the Bureau.

Similarly, other agencies and organizations that designated representatives to help in the work of the investigations are not bound in any way by the report of that work.



H. W. BASHORE,  
*Commissioner.*

JUNE 15, 1945.

## STATEMENT OF PROBLEM 9

What feasible means could be adopted or created (*a*) to help insure an adequate level of living, and (*b*) to minimize the financial commitments of needy settlers in providing suitable and essential improvements?

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## ACKNOWLEDGMENTS

The major portion of the report consists of a series of papers on subproblems into which the problem as a whole was divided. Each subproblem is concerned with a type of farm improvement and means by which financial commitments for it may be minimized.

The committee is indebted particularly to the Washington State Planning Council for organizing and promoting the subinvestigations and to the subcommittees for preparing the subproblem reports. This indebtedness is acknowledged in the following indication of those contributions.

Subproblem:

1. Land Clearing, Leveling, and Ditching: H. A. Parker, U. S. Bureau of Reclamation.
2. Farm Fencing: Richard Wakefield, Jacques Crampon, and J. M. Berkey, Washington State Planning Council.
3. Livestock and Poultry: E. V. Ellington, M. E. Ensminger, and J. S. Carver, State College of Washington.
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## SCOPE OF THE PROBLEM AND THE REPORT

Problem No. 9 of the Joint Investigations, Columbia Basin Project, poses the question: "What feasible means could be adopted or created (a) to help insure an adequate level of living, and (b) to minimize the financial commitments of needy settlers in providing suitable and essential improvements?" Of these two parts, the investigators have placed considerably more emphasis upon the second. Minimizing the costs for farm improvements clearly is one specific means to achieve the broader objective cited in the first part of this problem. There are obviously many other specific ways of contributing to the establishment of an adequate level of living, both by lowering expenses which farmers must meet for items other than farm improvements, and by increasing farm income. As suggested below, however, means other than minimizing the costs of improvements are subjects of other studies of the Joint Investigations.

Before considering the two phases of Problem 9 an answer to the question of what constitutes an adequate level of living was sought. It was found in a special report<sup>1</sup> which provides an objective method for determining the adequacy of a given level of living by establishing: (1) the minimum level of living which farm families are willing to accept; (2) the standard of living to which farm families aspire and at which the wants of the average family are satisfied; and (3) the reasonable farm income objective somewhere between these two limits.

The customary distinction made between level of living and standard of living is employed. Level of living refers to the actual consumption of food, clothing, housing, and all other elements of family living. It is readily measured and susceptible of expression in terms of units of quantity of goods or services, or customarily in terms of units of value. Standard of living, on the other hand, is a psychological phenomenon, subject to serious difficulties of measurements. It seeks to establish what additional food, clothing, housing, or medical care, if any, is vital to, in our case, the settler's satisfaction. Thus, its function is to measure, in terms of human welfare, the success or failure of a program.

Based upon a study of farm families in the Pacific Northwest and supported by a study of farm families in the Great Plains, typical of areas from which settlers may come, a minimum adequate farm income was established.<sup>2</sup> The relationship between income and expenditures was analyzed by income groups. For each income group the total earned income—net cash family income from farming, plus or minus the net change in farm inventory, plus the value of farm furnished goods, plus income from non-farm sources—was compared

<sup>1</sup> Fisher, Lloyd H. *Standards and Levels of Living for Settlers on New Irrigation Projects*, a report made by the Bureau of Agricultural Economics, United States Department of Agriculture, for the Columbia Basin Joint Investigations, Washington, D. C., February 1943 (preliminary).

<sup>2</sup> Data obtained from the Consumer Purchase Study of the Bureau of Home Economics, conducted in 1935-36.

with the value of the family living. In the lower income groups, the value of family living exceeded the income and a net deficit resulted. In the higher income groups the reverse was true, resulting in a net saving of one form or another. Thus, the extent of the deficit decreased with each increment of income until at about \$1,100 deficits disappeared and savings began. This income, \$1,100, appears necessary to provide an acceptable level of living. (In the Plains States it is slightly higher.) All figures are given in terms of 1935-36 price level and thus will necessitate adjustments to prices existing at the time of settlement.<sup>3</sup>

A further examination of these data reveals the entire amounts of the increments above \$1,100 are not "saved." Expenditures for family living increase with each increase in income until an income of about \$2,500 is reached, at which point expenditures level off. Consequently it is difficult to argue that expenditures made by persons with incomes of only \$1,100 yield a level of living which the family considers adequate. But beginning at about \$2,500, the greater portion of any addition is saved rather than spent. It can be said that current wants for goods and services seem to be approximately satisfied when the family income reaches this point, and thus \$2,500 can be defined as the desired standard of living.

It is interesting, however, to note two exceptions to these general conclusions. As a short run proposition, the settlers on the Vale and Owyhee Projects in southeastern Oregon<sup>4</sup> have indicated a willingness to accept a level of living slightly below the \$1,100 point. Deficits end and net savings begin at the \$750-\$1,000 group, showing that these settlers did lower their level of living for a few years with a reasonable prospect of improved conditions in the not-too-far distant future.

The second exception to the rule is in the case of the part-time farmers.<sup>5</sup> Their tastes and standards are probably more like those of townspeople. No point is found beyond which living expenses remain constant corresponding to the \$2,500 income in farm families. For part-time farmers, outlays increase proportionately with income, to and including the highest income group included in the study—\$4,000.

There exists a wide range between the \$1,100 level at which balance between income and expenditure is achieved and the \$2,500 level at which spending for family ceases to increase. Somewhere in this range the income objective lies. A further analysis of the farm families in the Pacific Northwest makes it possible to predict the effect of any income on the "solvency" of the group, using the term "solvency" here in a somewhat figurative sense to mean an excess of income over expenditure. Thus if the annual income is less than \$500, it may be anticipated that more than 90 percent of all farm families will fail to live within their income or become insolvent. If income rises to the next level, the percent of casualties drops. The proportion of casualties or insolvencies declines steadily as income rises. From other parts of the Joint Investigations we may obtain an estimate of income available from farms of various sizes.<sup>6</sup> As the size of the farm in-

<sup>3</sup> Lloyd Fisher points out the importance of this adjustment when he writes: "If these refinements were introduced they might dictate a slightly different choice of income objective or farm sizes. Before any final choice is made for the Columbia Basin, the requisite modifications will be made." (B. A. E. report cited above, p. 40.)

<sup>4</sup> *New Farms on New Land*, by Carl P. Heising and Marion Clawson. Bureau of Agricultural Economics, United States Department of Agriculture. January 1941. Migration and Settlement Report No. 4.

<sup>5</sup> Data obtained from Consumer Purchase Study, Bureau of Home Economics, U. S. D. A.

<sup>6</sup> See *Types of Farming*, Problem 2. Columbia Basin Joint Investigations.

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## Chapter VI

### RURAL DOMESTIC WATER SUPPLY <sup>69</sup>

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#### Findings and Recommendations

1. The average per unit cost of the well and the pumping equipment required to supply domestic water to settlers of the Columbia Basin Project will be at least \$1,000 and may exceed \$2,500.

*It is recommended* that special attention be given to the water table maps and other aids in order to minimize the cost of the well and pumping equipment.

*It is further recommended* that distribution systems and storage equipment be used to permit utilization of the full capacity of each well, so as to divide the cost among an optimum group of users.

2. The total purchases of equipment during the development period will very probably exceed \$4,000,000.

*It is recommended* that equipment be procured through centralized agencies in order to obtain maximum savings from quantity purchase.

3. A proper selection of materials and equipment will reduce the cost per farm served.

*It is recommended* that particular attention be given to specific requirements in order that the systems may be designed to avoid waste.

*It is further recommended* that the relative length of life of various materials be considered along with price quotations, in order to obtain a minimum cost per year.

*It is further recommended* that the cost of maintenance and operation of various equipment be examined and weighed along with initial outlays.

4. Certain machine labor, such as is used in trenching, pipe laying, and backfilling, is less expensive than hand labor.

*It is recommended* that machine labor be used for these operations in preference to hand labor.

5. The relatively rapid rate of development permits the construction of water systems on a wholesale basis.

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<sup>69</sup> This is the report on subproblem 6, concerned with means to minimize the financial commitments of rural settlers in obtaining domestic water. The study has been made in the report written by Jacques Crampon with the assistance of Richard Wakefield and James M. Berkey, Washington State Planning Council.

*It is recommended* that, all things being equal, contracts for large units of work be given to private companies, but

*It is further recommended* that, if greater savings accrue to the individual settlers, the installation be performed by governmental or cooperative agencies.

**6. The cost of distributing water per farm served increases with an increase in the distance over which the water must be carried.**

*It is recommended* that, unless other factors make such settlement undesirable, the farmsteads be separated from the farms and located in hamlets or communities near the well.

*It is further recommended* that, if group settlement be deemed not desirable, the farmstead be located on the part of the farm nearest the well.

*It is further recommended* that, other factors permitting, e. g., irrigation requirements, the farm plats be arranged and shaped in such fashion as to provide the shortest practicable distance between well and farmstead.

**7. The lowest possible cost per service is obtained by combining and equalizing distribution systems so that each will serve those farmsteads to which it can deliver water at the lowest cost.**

*It is recommended* that the distribution systems be equalized between the wells.

**8. With an increase in the number of farms served, the cost per farm of the well and the pumping equipment will decrease whereas the cost of distributing the water will increase.**

*It is recommended* that adequate studies and tests be made in the field to discover the optimum number of farms that can be economically supplied by any given well and that the systems be constructed in light of such findings.

*It is further recommended* that such studies and tests be modified by the actual experiences of early settlers in drilling wells in the districts.

**9. The administrative and bookkeeping expenses of the agency operating the systems can be reduced by combining these functions with those of other agencies supplying similar public needs.**

*It is recommended* that these functions be combined with those of another agency, e. g., the agency supplying irrigation water.

**10. Economies result from the reduction of unnecessary use and waste of water.**

*It is recommended* that water meters be installed at each service to reduce such wastes.

## INTRODUCTION

One improvement needed by every rural settler is a domestic water supply. The problem posed by the study is to develop certain prin-

ciples that will enable settlers to obtain water at minimum costs. The report is not an attempt to state exactly the cost of a specific domestic system. Any definite prices included are only for the purpose of supporting or explaining various suggestions.

#### Demand for domestic water

The supply of water should be sufficient (1) to satisfy the personal demands of the settlers, including the operation of plumbing facilities; (2) to water livestock; (3) to sprinkle lawns and small gardens occasionally; (4) to process farm products; and (5) to provide some fire protection. Although the total daily requirement of the average farm may be only 200 gallons during the early years, it will expand to perhaps 1,500 gallons during the mature development.<sup>70</sup> Table 15 presents an estimate of the amount that will be required to satisfy these needs. In the table, the consumption of dairy cattle, for example, includes water used in the milk house. To supply the peak demands the essential minimum should be 5 gallons per minute.<sup>71</sup> A pressure of approximately 30 pounds per square inch should be maintained.

#### Supply of domestic water

Irrigation ditches and canals, rivers and creeks, rain catchments, and underground strata are possible sources of water. Ditches and canals could furnish water probably only during the irrigation seasons, and, in common with supplies from rivers and creeks, would require careful filtration and treatment to guard against pollution. Except for areas adjacent to the Columbia River, Rocky Ford Creek, and Moses Lake, the topography limits the use of these sources. Rain catchments are excluded by the low annual precipitation, the long-

TABLE 15.—Ultimate daily rural water consumption (in gallons)

Consumers	Average number <sup>a</sup>	Consumption per head <sup>b</sup>		Total consumption	
		Low	High	Low	High
Human.....	4	40	85	160	340
Livestock:					
Dairy cattle.....	24	20	25	480	600
Other cattle.....	33	6	10	198	330
Hogs and pigs.....	26	2	3	52	78
Horses.....	5	7	10	35	50
Sheep.....	45	1	1.5	45	68
Chickens.....	150	0.025	0.025	4	4
Total.....				974	1,470

<sup>a</sup> This is the mean of the numbers estimated to be on the farms for which land use maps have been prepared by the Soil Conservation Service in conjunction with the Bureau of Agricultural Economics.

<sup>b</sup> Consumption per head has been estimated based upon the following sources: Taylor, George C., Jr., Summary of Ground Water Conditions in Parts of the Columbia Basin Project Area with Respect to Development of Domestic and Livestock Water Supplies, p. 1. Pittsburgh Steel Co., Fence Guide, p. 14. Fairbanks, Morse & Co., 1933, *Shallow and Deep Well Equipment Catalogue*, p. 83.

<sup>70</sup> Taylor, George C., Jr., Summary of Ground Water Conditions in Parts of the Columbia Basin Project Area with Respect to Development of Domestic and Livestock Water Supplies, p. 1. NOTE.—He suggests 1,000 gallons as the ultimate maximum. Walter A. Duffy, Farm Security Administration, in a letter to P. Hetherton, May 20, 1942, states: "During the summer months, the garden and lawn will require substantial amounts of water, probably 5 gallons per minute for an average of 6 hours per day. Some provision should also be made for processing farm products. If a dairy enterprise is engaged in, provisions must be made for more water than is shown."

<sup>71</sup> Farm Security Administration, Region XI, Analysis of Plans and Costs for Domestic Water Supplies and Farm Buildings, Plans of Joint Investigations, Columbia Basin Project, Problem 9 (preliminary report), p. 4.

term average for seven stations in or near the basin being only 8 inches per annum.<sup>72</sup>

The remaining choice is to tap the underground supplies. The occurrence, movements, quantities, and qualities of these waters have been assigned for special study to investigators of Problem 22. They report that residents of the Quincy Basin and the Wahluke and Pasco slopes have stated that the ground waters are pleasing to taste and satisfactory for all purposes, including human consumption. They also report that the underlying strata are capable of yielding sufficient capacities to sustain community water systems.<sup>73</sup>

The existing 8-inch wells<sup>74</sup> vary from 50 to more than 80 gallons per minute in capacity and from 50 to 587 feet in depth. The water level is between 30 and 400 feet below the surface.<sup>75</sup> Though depth is an important factor, the cost of a well also depends upon the difficulty of drilling, the amount of casing required, the necessary transportation of equipment, and the availability and wages of skilled labor. These factors are usually combined in a unit cost per foot of finished well which has varied from \$5 to \$7.<sup>76</sup> To this must be added the cost of the pump unit which increases directly with the depth to water and the rate at which the water is lifted. Estimates of costs of pump units for wells of varying capacities and water levels are presented in table 16. This pump unit includes the pump, pump motor, drop pipe, cylinder, rod, pressure tank, and connecting piping.

If the water is to be carried from the well to the farm, the cost of the pipe and labor must be added. The cost of 1½-inch galvanized pipe is approximately \$0.15 a foot.<sup>76</sup> To dig the trench, lay the pipe, and fill the trench by machine will cost \$0.05 a foot.<sup>77</sup> If distributing to more than one farm, larger pipe may be required.

This report concerns itself with the means to reduce financial commitments. The selection or suggestion of the agency or agencies that will promote adoption of the recommendations and will insure economic maintenance and operation of the systems is the subject of a subproblem of Problem 28.

<sup>72</sup> Parker, H. A., irrigation engineer, Bureau of Reclamation, in a letter to P. Hetherton, dated May 14, 1942, in which he quoted the study made in connection with Problem 4 of the Joint Investigations. Washington, "The Evergreen State," published by the Secretary of State, Olympia, 1938, nine stations in the Basin at which the mean average precipitation varied from 4.64 inches at Pasco to 9.22 inches at Hatton.

<sup>73</sup> Taylor, *op. cit.*, pp. 3-7. NOTE.—Jannsen, N. C. *Ground Water Conditions in the State of Washington*, 1937, asserted that in certain areas, as the uplands that form the east margin of the Quincy Basin, the unconsolidated materials are above the regional zone of saturation and are not water-bearing.

<sup>74</sup> The necessity of reducing the size of the casing as the depth of the well increases makes an 8-inch diameter at the surface the minimum size that will insure a diameter at the water level sufficient to receive the drop pipe and cylinder.

<sup>75</sup> Taylor, *op. cit.*, pp. 4-6. NOTE.—Although artesian flows have been found in the Cold Creek district of Benton County, they are not expected in the Basin. N. C. Jannsen has stated that some wells may be as deep as 1,000 feet, but A. M. Piper believes that this is probably excessive for the greater part of the area for wells yielding no more than 50 gallons per minute.

<sup>76</sup> Taylor, *op. cit.*, p. 7, and Farm Security Administration, *op. cit.*, p. 5. NOTE.—Parker, H. A., irrigation engineer, Bureau of Reclamation, in a letter to P. Hetherton, September 18, 1941, and Langloe, Lars, hydraulics engineer, Washington State Department of Conservation and Development, suggest a graduated scale inferring that the cost of drilling the first 100 feet is less than the last. For example, the cost of drilling the first 100 feet might be \$300; the second 100 feet \$400; the third 100 feet, \$500, etc. A. M. Piper in a letter to P. Hetherton, May 9, 1942, basing his suggestion on the fact that certain of the costs of drilling are relatively fixed, such as cost of moving in, erecting and striking, and that the basalt found in the Basin includes zones that drill rapidly and zones that drill very slowly, stated: "A 100-foot well can encounter a high percentage of dense rock and cost the driller more per foot than a 300-foot well that encounters a high percentage of less resistant rock."

<sup>77</sup> Farm Security Administration, *op. cit.*, p. 8, estimates that the cost of machine trenching would be 2 cents per foot. Parker, H. A., *op. cit.*, estimated that the cost for backfilling should be about one-half that amount, or 1 cent per foot. The estimate of 2 cents for laying pipe is his but he states in a letter to P. Hetherton, May 14, 1942, "This would apply only to steel pipe and not to transite or cast iron which would be considerably higher."

TABLE 16.—Estimated costs of pump units

Well capacity (gallons per minute)	Depth to water			Well capacity (gallons per minute)	Depth of water		
	100 feet	200 feet	300 feet		100 feet	200 feet	300 feet
5.....	\$342	\$385	\$431	25.....	740	843	918
10.....	508	586	628	30.....	771	874	947
15.....	556	660	774	35.....	871	911	986
20.....	603	768	853	40.....	897	937	1,012

Source: Cost data obtained from pump manufacturers.

### Reducing Commitments by Economic Selection of Materials

Economies are available through the selection of the materials that will cost least per year of service. The prices quoted by manufacturers and distributors for pipe made of various materials and the relative length of service of each are presented in table 17. Simultaneously with the consideration of these factors, the cost of laying various types of pipe should be weighed.<sup>78</sup> It is conceivable that even though the cost of cast iron pipe and the cost of laying the same are much higher than the inclusive cost of either steel or wood pipe, the fact that cast iron will last longer might result in a lower cost per year of service. However, the additional fact that an appreciable fraction of the installations will probably become obsolete before the long-life pipe is physically depreciated, which might be especially true during the developmental periods, suggests further economies for steel or wood pipe.<sup>79</sup>

Likewise, maintenance and operation cost should be considered. The equipment that will most economically serve the needs of the settlers is that which will not only cost a minimum but also will require a minimum expenditure for operations. For example, the pipe used in the estimates herein presented might be replaced by smaller pipe. However, if this is done, the cost of operating the system will be increased, since the greater friction loss experienced with smaller pipe necessitates more pressure to maintain the flow at the farmstead. This is merely an addition to the costs of operation. If the capitalized value of this addition exceeds the reduction in initial commitments, the larger pipe is more economical.

Further savings can be obtained through specific selection of equipment to meet exact requirements, e. g., all pumps need not have a 12-inch stroke, a 5-horsepower motor, and a 4½-inch cylinder. The equipment need only be large enough to perform satisfactorily the required job.

A detailed study of comparative economies of alternative materials and equipment, including maintenance and operation costs, should be made. However, present prices under wartime inflation afford little help in determining what might be expected at the time of settlement. New equipment and materials may be developed that will greatly alter the suggested systems.

<sup>78</sup> Parker, H. A., *op. cit.*, and Piper, A. M., *op. cit.*, suggest that the cost of laying some pipe, as transite or cast iron, is somewhat higher.

<sup>79</sup> Hall, G. D., in a letter to P. Hetherton, June 13, 1942, wrote regarding this statement: "This has proven true in a great many cases during the irrigation development of this (Yakima) area, which is probably the nearest basis of comparison to the Basin problem." Nevertheless, he does not believe that short-life materials should be used. The relatively great salvage value of some pipe, as cast iron, and the low cost of removing it, make economies possibly obtainable through use of long-life material.

TABLE 17.—Comparative cost and life of various kinds of pipe (cost of laying not included)

Pipe size	Estimating price per 100 feet—100-foot head				
	Wood	Galvanized	Steel	Transite	Cast iron
1½ inches		\$15.00			
2 inches	\$23.00	20.00		\$30.00	\$33.00
2½ inches		30.00		37.00	
3 inches	28.00	45.00	\$20.70	44.00	50.00
4 inches	35.00		30.68	58.00	65.00
5 inches	41.00			80.00	
6 inches	50.00		51.33	91.00	105.00
Estimated life (years)	25	25	20	50	75

Sources: Estimating prices are for large quantities as quoted by large distributors and manufacturers. Life of pipe estimated by G. D. Hall, engineer, Yakima.

### Reducing Commitments by Quantity Purchases

The total purchases of equipment during the development period probably will exceed \$4,000,000, which, if controlled by centralized agencies, will make possible economies through large scale operations. Several unique factors permit additional savings not generally available. Similar requirements make possible a further standardization of types and sizes. Concentration of consumers reduces selling, distribution, and installation expenses. Government credit, if available, will permit a saving in collection costs. At a saving ranging from 25 to 50 percent of catalog list prices, several pump units were recently cooperatively purchased for farms at the Farm Security Administration Project at Bonners Ferry, Idaho.<sup>80</sup>

### Reducing Commitments by Construction Economies

#### Economies in construction methods

Savings can be obtained in the employment of special methods of construction. For example, machine labor permits a considerable saving over hand labor in laying pipe. The hand labor estimated cost per foot for digging a trench 4 feet deep is 20 cents and for laying the pipe and backfilling is 10 cents. The combined per foot estimate using machine labor is 5 cents, resulting in a saving of 25 cents.<sup>81</sup>

#### Economies in placing responsibility for construction

Savings can be obtained through the proper placing of the responsibility for construction. The relatively rapid rate of development during the first 20 years or so will permit the employment of governmentally or cooperatively owned and operated well-drilling equipment or the negotiation of favorable contracts by a central authority for large units of work with private companies.<sup>82</sup> If 1,000 new farms are developed annually and if one well is needed to serve eight farms, 125 wells must be drilled each year.<sup>83</sup>

<sup>80</sup> Farm Security Administration, *op. cit.*, p. 7.

<sup>81</sup> Farm Security Administration, *op. cit.*, p. 8 and Parker, H. A., *op. cit.*, p. 2. (See also note 77, p. 55.)

<sup>82</sup> The power to perform such services has been granted to the irrigation districts.

<sup>83</sup> Farm Security Administration, *op. cit.*, p. 5. NOTE.—Parker, H. A., *op. cit.*, estimates that only 833 units averaging 60 acres each will be developed annually. He further suggests that the wells now existing will reduce the requirement.

Although an increase in the number of farm units served by each well will decrease the number of wells needed, the annual drilling requirement will be large. The fact that it takes at least three weeks to set up, drill, develop, and case a well, allowing for repairs and possible failures, permits one outfit to drill up to 15 or 17 wells annually.<sup>84</sup> Thus the fulltime operation of several outfits can be maintained. The relative permanency of the employment due to continual development over a period of years will attract the required skilled labor.

With a limited supply of private equipment and a great demand for immediate drilling, the prices charged by such operators might be considerably advanced to secure high profits. This danger could be avoided by governmental or community drilling, or by a positive threat of the same. If reasonable prices can be obtained from private operators, they might be employed. Otherwise, governmental agencies might assume this responsibility.<sup>85</sup>

#### Reduction in Commitments Through Serving the Optimum Number of Farms

If a single well and pump can be made to serve several farm units, the cost per farm will be less than the cost of individual units. Assuming that a well costs \$1,200 and each farm requires a separate well, the cost per farm would be \$1,200. But if four farms could be served, the cost would be \$300 each. Likewise a saving in the cost of the pump unit can be obtained, although the cost of the unit increases with an increase in the capacity needed to serve an increasing number of farms. For example, if the water level is 100 feet below the surface, the cost of a pump that could serve one farm would be \$342 and of one that could serve four, \$373; but the cost per farm would be \$342 and \$93.25 respectively.

The cost of distributing the water increases as more farms are served. If the farms have an 80-rod frontage and the farmsteads are located at random along a lateral highway extending in two directions from the well (see table 18, Random Line-Settlement Pattern), the total cost of distributing water to four farms would be \$429 and to eight farms \$1,247.40; or the cost per farm served would be \$107.24 and \$155.93, respectively. If the frontage had been 120 rods, the total cost of serving four and eight farms would have been \$643.50 and \$1,871.10, and the cost per farm \$160.87 and \$233.89, respectively. The number of farms served varies inversely with the cost per service for well and pump, but directly with the cost per service of the distribution system.

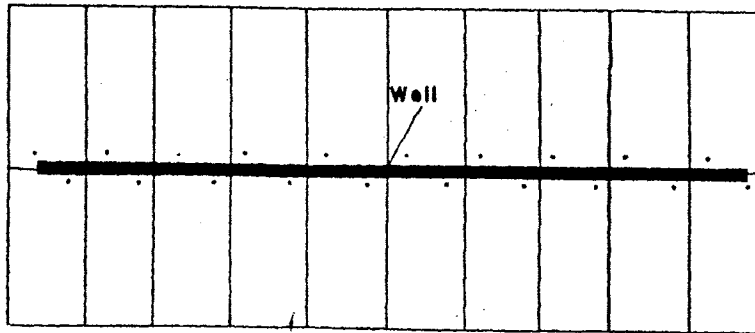
<sup>84</sup> Farm Security Administration, *op cit.*, p. 5, quoting information supplied by A. A. Durand & Son, well drillers. Note.—Arthur M. Piper in a letter to P. Hetherton, June 12, 1942, wrote: "A very large proportion of the footage drilling in the Columbia Basin areas will be in basalt, in which the over-all average rate of progress probably would be in the order of 5 to 10 feet an 8-hour shift. Thus, about 3 weeks might be utilized to construct the shallowest wells and several months probably would be required to construct a well in those parts of the project area where the water-bearing zones are 500 feet or more beneath the land surface."

<sup>85</sup> Wadsworth, Stanley E., in a letter to P. Hetherton, July 15, concurs with the suggestion of governmental drilling, but states that "the cost of the equipment should not be borne by the Government." However, Parker, H. A., *op cit.*, states: "The competition afforded by large volume of drilling to be done, if offered on competitive bids, would tend to hold down contract prices. Therefore the concern expressed . . . seems unwarranted."

TABLE 18.

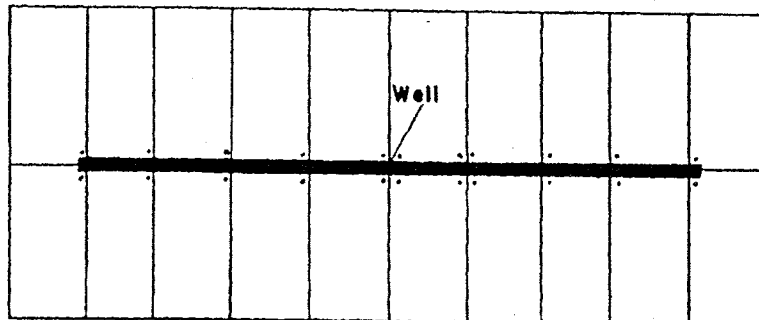
COMPARATIVE INVESTMENT COSTS  
OF DISTRIBUTING WATER  
USING SEVERAL SYSTEMS

80 Acre Farms, 160 Rods Deep



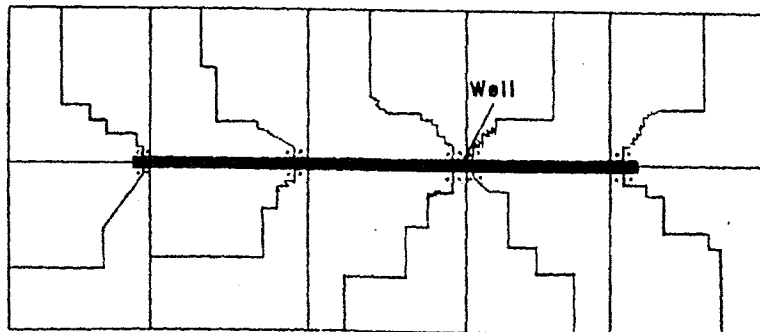
Random Line-Settlement Pattern

No. Farms Served	4	8	12	16	20
Total Cost	\$ 429.00	\$1247.40	\$ 2257.20	\$ 3313.20	\$4408.80



Clustered Line-Settlement Pattern

No. Farms Served	4	8	12	16	20
Total Cost	\$ 41.25	\$ 714.45	\$1597.20	\$ 2 653.20	\$ 3719.10



Extended "F" Cluster Pattern

No. Farms Served	4	8	12	16	20
Total Cost	\$ 41.25	\$ 136.95	\$ 998.25	\$1672.75	\$ 2984.85

The restriction to the number served may be (1) the physical capacity of the well limiting the amount of water available, or (2) the economic consideration requiring that the last farm served contribute at least as much as the cost of extending the system to serve that farm. If the farms have a 160-rod frontage, as shown in table 19, the minimum cost per service is obtained by serving six farms.

If the farms have 120-rod frontages, 10 services may be approaching this limit. However, the smaller farms, probably more typical of the Basin, give no evidence of reaching the optimum point at or near 10 services. Many of the wells in the Basin will produce less than 50 gallons per minute<sup>86</sup> whereas more than this amount could be economically distributed. The use of a deeper well and larger pump would tend to increase the optimum number. (See charts 2 and 3, appendix.) The economic optimum will often exceed the physical limit.

TABLE 19.—Comparative investment cost per service

[Cost of well, \$600; depth to water, 100 feet; farm frontage, 60 rods, 80 rods, 120 rods, 160 rods]  
[See chart 1, appendix, p. 66]

Capacity of well (gallons per minute)	Number of services	Total cost per service—farms located in a random line-settlement pattern			
		Rod frontage			
		60 rods	80 rods	120 rods	160 rods
5.....	1	\$642.00	\$642.00	\$642.00	\$642.00
10.....	2	587.50	608.00	641.00	672.00
15.....	3	451.33	473.33	517.33	561.33
20.....	4	381.44	408.00	461.62	515.25
25.....	5	357.30	386.80	446.20	505.60
30.....	6	330.13	365.12	431.44	499.09
35.....	7	320.60	357.23	430.77	504.31
40.....	8	304.20	338.06	421.02	510.53
45.....	9	294.32	334.91	416.31	518.24
50.....	10	281.83	328.40	414.88	519.82

Source: Cost data obtained from manufacturers and distributors.

The total daily requirement of a farm unit has been estimated to be 1,500 gallons, with a maximum of 300 gallons for a single hour (5 gallons per minute).<sup>87</sup> A well producing the maximum could produce 7,200 gallons per day, whereas a well producing only 1.25 gallons per minute could supply the 1,500 demanded in 20 hours. If a storage reservoir with a minimum capacity of 400 gallons per farm were provided in which water could be accumulated in hours of small demand, the peak requirement could be met.

Since the maximum number of farms that could be served by a given well and pump unit can be increased by the addition of a storage system, the cost per farm of the well and pump unit can be decreased. However, to obtain a water pressure of 30 pounds per square inch, a second addition must be made. This pressure may be maintained by elevating the storage tank upon a 90-foot tower or hill,<sup>88</sup> or by

<sup>86</sup> The same results can be obtained as follows: The total cost of serving 5 farms 80 rods apart is \$2,528.00; 6 farms, \$2,944.54; 7 farms \$3,530.17; and 8 farms, \$4,084.24. The added cost of serving the sixth farm is \$466.54, whereas the contribution of the sixth farm is \$499.09. But the added costs of serving the seventh and eighth farms are \$535.63 and \$554.07, respectively, and their contributions are only \$504.31 and \$510.53.

<sup>87</sup> See page 54.

<sup>88</sup> The pressure equivalent of 90-foot head is 38.98 pounds per square inch, which would be required at the well to maintain a 30-pound pressure at the service.

installing an impeller or centrifugal pump to force the water from the storage tank into the pressure tank. Hills of sufficient height exist in parts of the Basin. But the cost of erecting a 90-foot tower would be prohibitive.<sup>89</sup> The centrifugal pump is economically feasible and has been used in preparing the estimates. Table 20 presents estimates of the total cost per farm served, including well, pump unit, and storage equipment. In these cost computations, wood storage tanks and metal pressure tanks have been used.<sup>90</sup> (See chart 1, appendix.)

The optimum number of farms that can be served by a single storage-distribution system (See table 20) if the farms have an average frontage of 60 rods, if the cost of the well is \$1,200 or \$1,800, and if the depth to water is 200 or 300 feet probably is more than 30; but if the cost of the well is \$600 and the depth to water 100 feet, it is approximately 20. Assuming that the average frontage is 80 rods and that the cost of the well is \$600, \$1,200, or \$1,800, the optimum number is approximately 20, 25, or 30, respectively. The larger farms show a similar trend. A more complete analysis can be obtained from the charts in the appendix, which verify the statement that the greater the cost of the well, the greater the depth to water, and the closer the farms are together, the greater will be the number of farms that can be served most economically.

TABLE 20.—Total investment cost per farm served, including storage provisions, for selected well costs, water depth, and rod frontages

[See chart 1, appendix, p. 66]

Number of services	Cost of well	Depth to water	Cost per service for farms			
			60-rod frontage	80-rod frontage	100-rod frontage	160-rod frontage
		(in feet)				
1	\$600	100	\$1,063.00	\$1,063.00	\$1,063.00	\$1,063.00
5	600	100	341.10	370.60	430.00	489.40
10	600	100	282.53	329.10	415.58	520.52
15	600	100	259.65	315.02	416.66	541.18
20	600	100	253.68	313.69	435.79	567.13
25	600	100	255.30	319.67	447.71	592.65
30	600	100	260.46	326.79	473.61	624.64
1	1,200	200	1,689.00	1,689.00	1,689.00	1,689.00
5	1,200	200	491.70	521.20	580.60	640.00
10	1,200	200	349.73	396.30	482.78	587.72
15	1,200	200	305.31	360.68	462.32	586.84
20	1,200	200	288.83	348.84	470.94	602.28
25	1,200	200	282.62	346.99	475.03	619.97
30	1,200	200	282.49	348.82	495.64	646.67
1	1,800	300	2,338.00	2,338.00	2,338.00	2,338.00
5	1,800	300	620.30	649.80	709.20	768.60
10	1,800	300	417.53	464.10	550.58	655.52
15	1,800	300	356.31	411.68	513.32	637.84
20	1,800	300	322.58	383.59	504.54	636.03
25	1,800	300	309.62	373.99	502.03	646.97
30	1,800	300	304.99	371.32	518.14	669.17

Source: Cost data obtained from manufacturers and distributors.

<sup>89</sup>The total cost of erection and material of 70-foot towers that would hold the various wood tanks has been estimated by John R. McCracken, Federal Pipe and Tank Company, Seattle, as follows:

Tank capacity, less than:	Cost
5,000 gallons	\$650
8,000 gallons	1,150
10,000 gallons	1,350
15,000 gallons	1,575
20,000 gallons	1,795

<sup>90</sup>NOTE: This tower is 20 feet lower than would be required. No provision has been made for the pump required to lift the water to the tank. An underground concrete storage tank that could be built at an increase in cost might offer additional advantages, such as longer life, ease of cleaning, freedom from freezing.

## Reducing Commitments by Planning

### Planning the individual system

Layouts that decrease the distance between the farmsteads and the well will lessen the amount of pipe needed and thus reduce the total cost. For example, if farmsteads, having an 80-rod frontage, are located in a random line-settlement pattern (see table 18) the total cost of distributing water to four farms would be \$429.00. But if the four farmsteads are clustered in the adjacent corners of the farms, so that no farmstead is more than 5 rods from the well, the total cost would be \$41.25. Like economies are obtainable for larger numbers of farms. Under the original random line-settlement pattern, the total cost for 20 farms would be \$4,408.80, but under the clustered pattern in which the farmsteads are brought as close to the well as possible without changing the shapes of the farms, the total cost would be \$3,719.10.

Although the shapes of the farms may be determined by factors other than domestic water distribution economies, i. e., irrigation requirements, consideration should be given to the fact that savings may be obtained through careful platting of the farm unit. An "F" cluster settlement pattern has been suggested in which eight farmsteads are located in a group without requiring triangular fields or removal of farmsteads from the farms.<sup>91</sup> Extending this pattern to include 20 farms (see table 18), the total cost of distributing water is \$2,984.85.

A further saving might be obtained by removing the farmsteads from the farms and locating them in small communities or hamlets. A system serving a hamlet of 20 farmsteads, assuming that the average distance between them was 5 rods and that the barns were near the houses, would cost \$265.65.<sup>92</sup> A communal-farm settlement in which water would be pumped to only one joint barn rather than to individual barns offers further economies.

In certain areas, such as the Quincy Basin and the upland district in the northern and eastern sections there are numerous usable wells in existence, many of which can be used by initial settlers.<sup>93</sup> During the initial stage of settlement, economies might be obtained if, so far as feasible, the farm layouts are adapted to utilize these existing wells.

### Planning the systems of the community

The optimum number of farms that can be served by a given number of wells is the sum of the optimum number that can be served by the individual wells, i. e., if the optimum number served by one is 30 and by another is 20, the optimum number that could be served by both would be 50. However, postulating that the rod frontage of all farms served was equal, to pump water from a well to 30 farms would require

<sup>91</sup> Fuhrman, Walter U., Bureau of Agricultural Economics, Memorandum to Lloyd Fisher, (The "F" Cluster), August 12, 1941.

<sup>92</sup> Duffy, Walter A., op. cit., states: "We believe that particular stress should be placed on the absolute necessity of locating the wells and determining the capacity before any buildings are constructed or before water distribution is planned. In spite of all hypothetical planning, the ultimate design of each system will be dependent on capacity and location."

<sup>93</sup> Piper, Arthur M., op. cit., states: "In the central part of the Quincy Basin, there is an existing well to every one or two sections on the average; only about 20 percent of these wells are now in use. In the upland district there is one well to every two or three sections on the average; about 90 percent of these wells are now used . . . To put these wells to use, a fairly large proportion would need be cleaned, perhaps deepened, or otherwise reconditioned."

the use of larger and more expensive pipe than to pump it to 20. The per unit cost of distributing water increases with the number of farms served, as can be seen from chart 2 of the appendix. If the number of farms served by each well could be readjusted so that each, regardless of cost or size of the well, served the 25 nearest to it, further savings could be obtained, since the large and expensive pipe that would have been needed to serve the last five farms on the system serving 30 could be replaced by smaller and less expensive pipe. Thus, still assuming that the distance between the farmsteads were constant, the per unit cost for the group as a whole would be a minimum when each of the two wells served the half of the farms located nearest to it. An equalization of the length of the distribution systems of several wells will produce a minimum cost.

For example,<sup>94</sup> assume a shallow well costing \$600 is near a deep well costing \$1,800.<sup>95</sup> The optimum number served by the \$600 well, if the average farm frontage is 80 rods, would be 20 at \$313.69 each, and by the \$1,800 well, 30 at \$371.32 each. Or, the combined optimum number served by the two wells would be 50. Thus the average cost per service for each, if the total cost of the two wells were combined and spread over the entire community, would be \$348.27. If, however, 25 farms were served by each well so that the cost per service for the \$600 well would be \$319.67 and for the \$1,800 well would be \$373.99, the average cost per service for the 50 would be reduced to \$346.83.

#### Reducing Commitments by Economic Maintenance and Operation

Economic operation and maintenance of the system will reduce the ultimate financial commitments of the settlers. In the case that replacement of pipe or pumping equipment is needed, large quantities purchased through centralized agencies will permit savings for the settlers in the same manner that commitments could be reduced in the purchase of equipment. (See: Reducing Commitments by Quantity Purchases.)

The administrative expense should be held to a minimum. The total clerical and bookkeeping expense of a large agency will be but little more than that of a small one. Thus the per unit cost decreases with the number of services. To obtain a minimum expense per service numerous systems could be combined into one administrative agency. The committee investigating the domestic water supply agency for Problem 28 recommends that the irrigation districts be used for this purpose. They offer the additional advantage of being able to obtain an economy by combining the clerical divisions of irrigation and water supply districts.<sup>96</sup>

The avoidance of unnecessary or extravagant use of water will reduce costs. The installation and use of water meters at every service, in order to determine the exact amount of water consumed by each farm unit, will discourage waste of water and make available an

<sup>94</sup> Data from table 20.

<sup>95</sup> Such conditions may exist. G. D. Hall, *op. cit.*, cited the following example from the Yakima valley: "In one locality a crooked well necessitated the use of an inefficient air-lift. The community decided to drill a straight well permitting the use of a deep well turbine which would retire by reduced operating costs the capital invested in less than 4 years. The new well was located within 15 feet of the old well and although the depth was 30 feet greater than the old well, they had a dry hole."

<sup>96</sup> Washington State Planning Council, Domestic Water Supply Agency, Subproblem 8, Problem No. 28, Joint Investigations, Columbia Basin Project. Note: G. D. Hall, *op. cit.*, stated: "It is very seldom that the actual expense of billing in small city systems is less than 15¢ per statement. With the plan proposed here, I believe, the minimum can be reduced to about 8¢ if there is no expense for postage."

equitable basis upon which the total cost can be prorated among the users.<sup>97</sup>

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#### Appendix

##### APPROXIMATE COSTS PER SERVICE UNDER DIFFERING CONDITIONS

This is not an attempt to state exactly the cost of a domestic water supply for the settlers of the Columbia Basin. Rather, it is an attempt to set forth some principles that will enable these settlers to obtain water at the lowest possible cost. The accompanying charts, therefore, show general trends rather than actual costs.

Estimates of the prices of various parts required for such a system have been made in order to test the various hypotheses and to prove or disprove various theories concerning methods that might result in savings for settlers. Charts 2 and 3, although they are based upon prices furnished by various manufacturers and distributors, picture only general trends. Since the development will take place during a period following the war, when prices cannot be expected to be the same as the estimates obtained today (although attempts have been made to discount for the present inflation), charts showing exact costs would be meaningless. In addition, certain economies might be introduced that will change the cost analysis, e. g., a saving obtained from large-scale purchase of pipe may be found to be non-existent in the large-scale purchase of pumping equipment. Other factors, some unseen at present, may shift the curves considerably.

Nevertheless, there exists a minimum cost and an optimum number of farms that can and should be served from each well. This should be the goal of every system. The following charts illustrate the methods used in attempting to discover these points. They are a graphic presentation of the variation of the costs of obtaining water per farm

<sup>97</sup> The water system as provided by this study does not qualify under the fire-protection standards established by the Washington Surveying and Rating Bureau and, thus, cannot obtain the economies of reduced fire insurance rates for the settlers. Though the system will provide some fire insurance, the additional cost of providing large mains and hydrants capable of meeting the standards seems unwarranted.

with the number of farms served by a given system. An example of the breakdown of two of the total cost curves is presented and indicates the methodology employed in constructing the curves.

The solid line is a graphic summation of the four other curves. In chart 2 these include: (1) The cost per service of a well costing \$600; (2) the cost per service of a pump unit, including pump, tanks, and pit, required to lift the water in the desired quantities from a depth of 100 feet; (3) the cost of the required storage and pressure tanks and provisions; and (4) the cost of distributing the water, including the pipe and labor, to farms having an average frontage of 80 rods and located in a line-settlement pattern along a highway extending in two directions from the well. (See table 18.)

The total cost of the well is \$600 regardless of the number served by that well. It is assumed that the physical capacity of this well is greater than the optimum economic capacity of the system. The cost of the well has been estimated at a specific amount. The difficulties of estimating accurately the cost per foot of drilling<sup>98</sup> and of determining the depth to which a well must be drilled seemed to demand a figure that would permit some variation. Thus, the \$600 well might represent a 100-foot well costing \$6.00 a foot, a 120-foot well costing \$5.00 a foot, or a 150-foot well costing \$4.00 a foot. This method further tends to eliminate any assumption as to a direct relationship between the depth of the well and the depth to the water. If we assume a depth to water of 100 feet and \$600 as the cost of the well, this well may vary from 100 feet to 150 feet in depth. This is typical of actual conditions.

The cost of the pump unit is a summation of the cost of the pump complete with cylinder, rod, drop pipe and motor; the cost of the pressure tank and fittings; the cost of the pump pit; and the cost of the storage tank and pressure tank. It is assumed that the water is to be lifted 100 feet to the surface and that a pump producing 1.25 gallons per minute working 20 hours each day, supplemented by an adequate storage system, will be able to supply the daily demand. As the amount of water to be lifted increases, the size and cost of the pump increases. The pumps used have a 6-inch, 9-inch, or 12-inch stroke, and the motor ranges from  $\frac{1}{3}$  horsepower to 5 horsepower. The drop pipe varies from  $1\frac{1}{2}$  inches to 6 inches, whereas the cylinder varies from  $1\frac{3}{8}$  inches to  $5\frac{3}{4}$  inches. The total cost of the pump, estimated from such specifications, varies from \$149 to \$535.

The pressure tank that has been used in connection with this system is a metal tank with a minimum capacity of 40 gallons per farm served. The tank costs from \$28 to 470, varying directly with its size. A centrifugal pressure pump is employed with a capacity of from 5 to 125 gallons per minute and costs between \$73 and \$245. This variation also depends entirely upon the size required.

The storage tank used is a wooden tank with a minimum capacity of 400 gallons per farm served. This capacity has been found to be sufficient to supply the peak hourly demands of the settler, if used with a pump producing 1.25 gallons per minute. The cost of the wooden tank has been estimated by assuming that the tank were shipped to the Basin in a knocked-down condition and erected there.

<sup>98</sup> Authorities and experts differ considerably in their estimations of drilling and casing cost. Figures ranging from \$5 to \$7 per foot with possible reduction for large-scale operations have been estimated. Others, however, suggest that the cost cannot be estimated at a constant rate per foot but must increase with the depth of the well. See page 55.

Labor and freight costs are included in the total cost of the storage tank which ranges from \$62 to \$479.

The cost of the pump pit is estimated at \$150 regardless of the size of the pump or pressure tank. This cost is included with the cost of storage facilities and pressure tank.

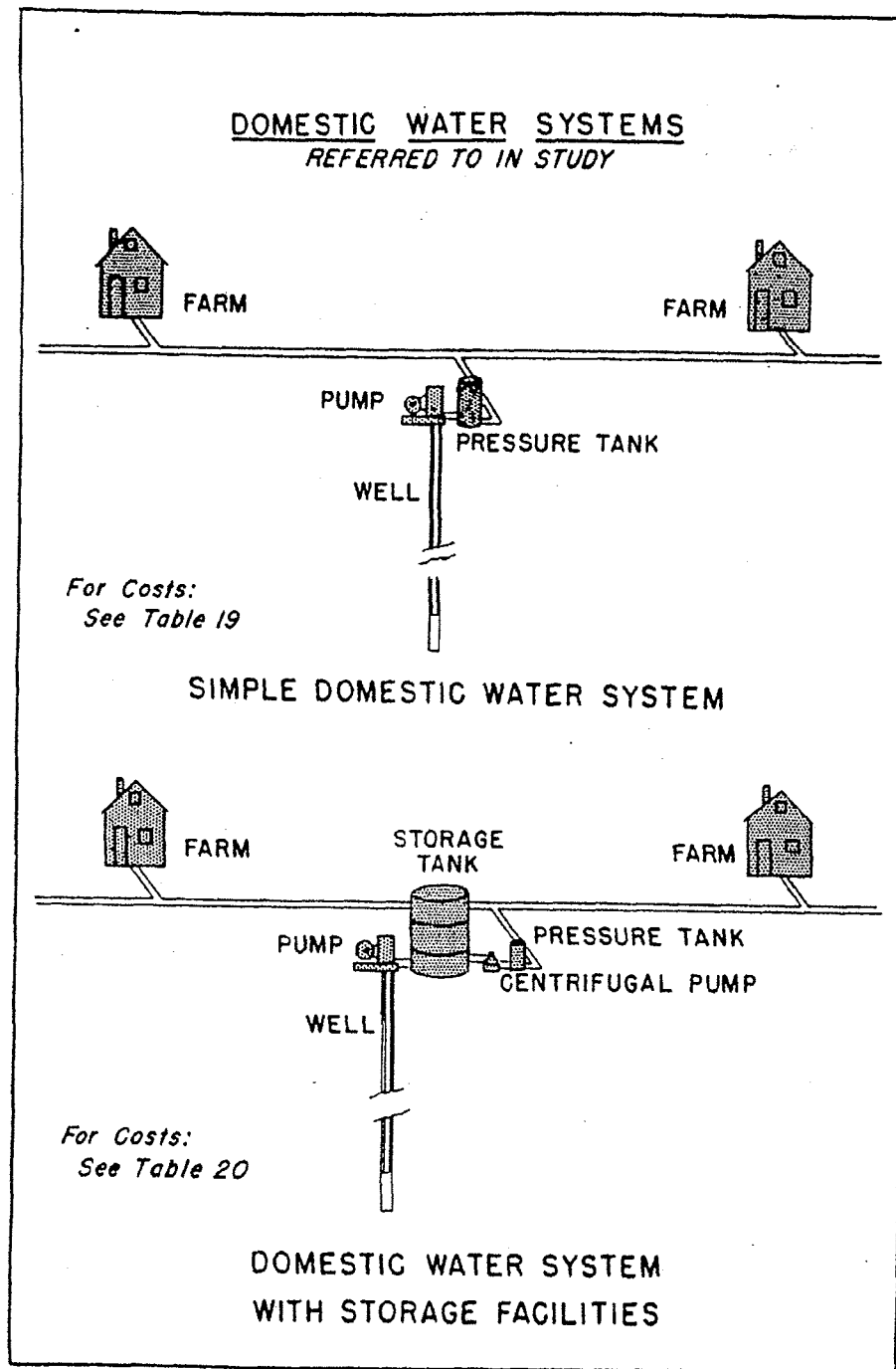


CHART 1.

The cost of distributing the water is based upon the assumption that one farmstead is located at the well and that the others are located at an average of one every 40 rods along both sides of a lateral highway extending in two directions from the well. (Random line-settle-

# APPROXIMATE INVESTMENT PER SERVICE OF DOMESTIC WATER SYSTEM

Theoretical Estimates Based upon \$600 Well,  
100 Foot Lift, and 80-Rod Farm Frontage

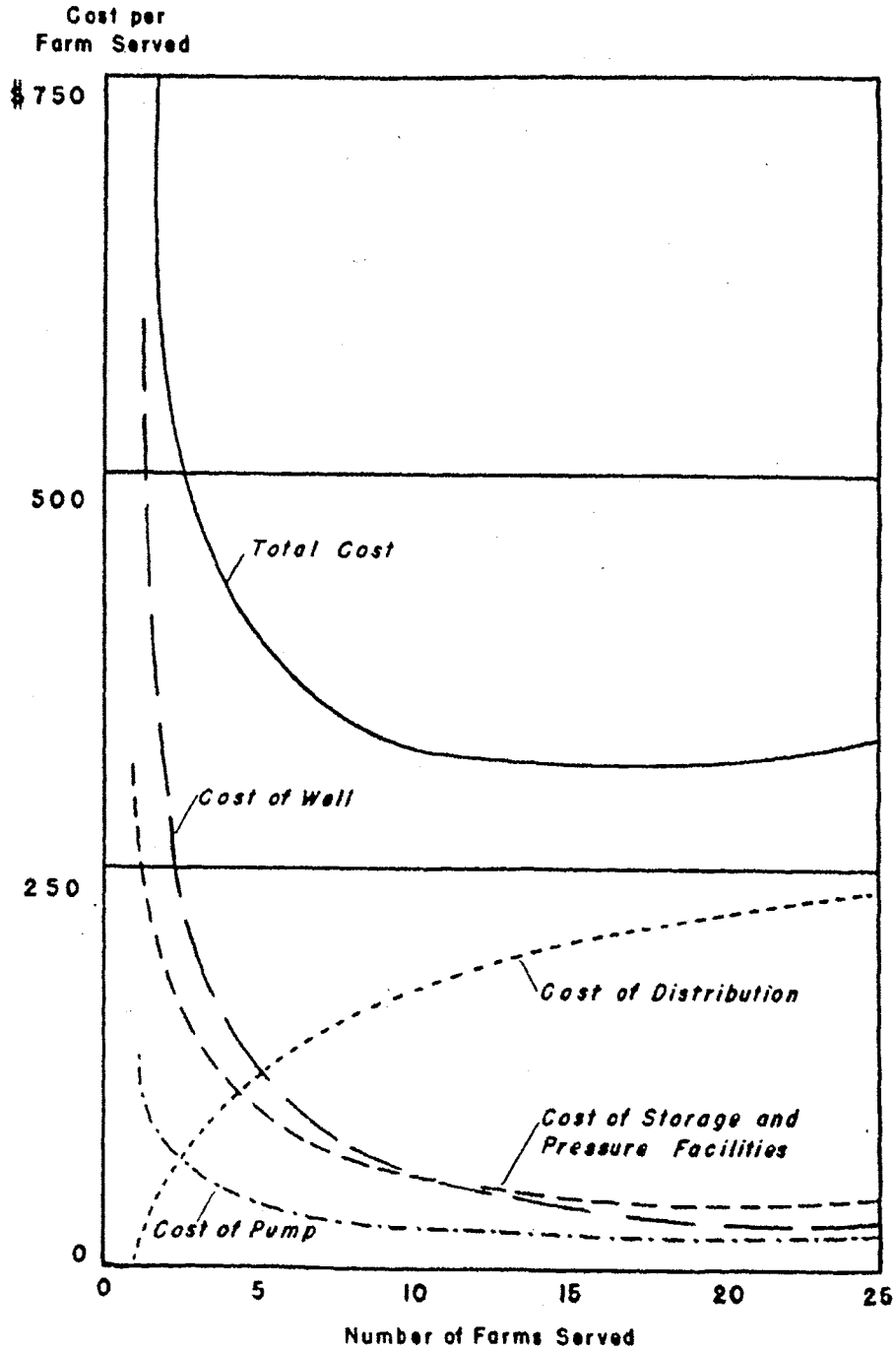


CHART 2.

ment pattern.)<sup>60</sup> This is to say that each farm would have an 80-rod frontage and, if 160 rods deep, would have an area of 80 acres. The pipe used in distributing the water, if less than 2 inches in diameter, is galvanized steel, and if larger is wood. The size of the pipe increases as the number of farms served or the length of pipe increases. In the estimates of the size required, the friction loss has been considered. The price of pipe per foot ranges from \$0.15 for 1½-inch pipe to \$0.50 for 6-inch pipe. Machine labor, used throughout to dig the trench, lay the pipe, and fill the trench, is estimated at \$0.05 per foot. The total cost of distributing the water to one farmstead 40 rods from the well is \$132. If the system were set up to serve 35 farms the total distribution cost would be \$9,200. (The cost of pipe required to connect the main and the farmstead and the cost of water meters have not been included.)

Chart 3 is a graphic summation of costs arising from different conditions. This chart pictures the conditions when the farms have an average frontage of 160 rods, when the depth to water is 200 feet, and when the cost of the well is \$1,200. Other curves representing any expected conditions could be drawn.

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<sup>60</sup> The economies noted on page 62, obtainable through use of the clustered settlement pattern, have not been included in this estimate.

# APPROXIMATE INVESTMENT PER SERVICE OF DOMESTIC WATER SYSTEM

Theoretical Estimates Based upon \$1,200 WELL -  
200 FOOT LIFT AND 160-ROD FARM FRONTAGE

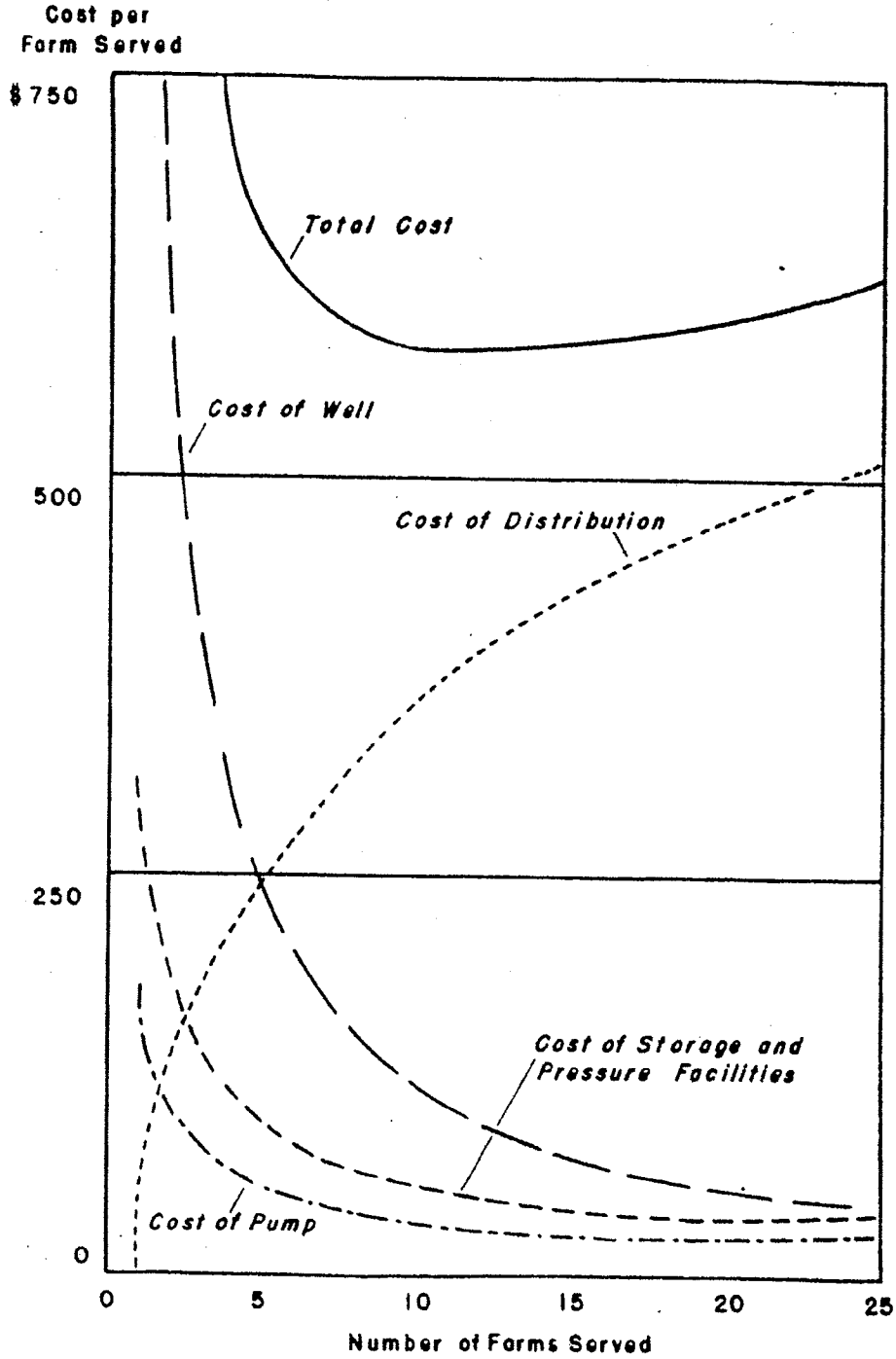


CHART 3.