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OPERATING COSTS FOR IRRIGATION EQUIPMENT

Western New York, 1956

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INTRODUCTION

Supplemental irrigation is now accepted as a necessary practice on many commercial farms in the Northeast. No longer can irrigation be dismissed as an experimental procedure confined to university or industrial experiment stations. More than 1500 New York farmers have committed themselves to sizable investments in specialized irrigation equipment and many more are considering the possibility.

Growth of Irrigation in New York

The increases in irrigated cropland in New York since the turn of the century are striking. The census taken in 1900 was the only one which obtained information about acreages of crops under irrigation in the Eastern States until 1940. Since that time these data have been obtained regularly every five years. Increasing from a little more than 100 acres irrigated in 1899 to nearly 6,000 in 1939 was an important change in 40 years. However, these 6,000 acres were still only a small part of the state's cropland.

TABLE 1. ACRES IRRIGATED IN NEW YORK
(U. S. Census Reports, 1900-1955)

Year	Farms reporting	Total acres
1899	*	123
1936	*	1,825**
1939	567	5,948
1944	646	10,316
1949	888	19,248
1954	1,675	59,024

* Not available
** Estimated by B. B. Robb, Dept. of Agricultural Engineering, Cornell University, in special study of irrigation in the East

The tenfold increase in acreage during the next 15 years can not be overlooked. Of the 28 Eastern States not included in the regular ten year Census of Irrigation, New York ranked second behind Mississippi in acres irrigated in 1954 with New Jersey a close third. The dry growing season in 1955 provided a special stimulus for producers of high value crops to buy irrigation equipment so that the rate of growth demonstrated in Table 1 has undoubtedly continued.

A variety of reasons can be offered to explain the upsurge of interest in the sub-humid East. Perhaps most important has been the development of acceptable, portable sprinkler systems which can be moved relatively easily without large investments in permanent field installations. The combination of a rising

TABLE 2. ACREAGES OF VARIOUS CROPS IRRIGATED IN NEW YORK, 1955
(U. S. Special Census Report)

Crop	Total acres	
Field Crops:		
Corn	754	
Small grain	121	
Hay	783	
Alfalfa for seed	389	
Pasture	1,915	
Dry beans	92	
Potatoes	26,882	
Hops	60	
		30,996
Vegetables:		
Lima beans	627	
Snap beans	4,374	
Beets	296	
Broccoli	440	
Brussel sprouts	184	
Cabbage	1,191	
Cantaloup and muskmelons	103	
Carrots	228	
Cauliflower	3,369	
Celery	1,114	
Sweet Corn	2,374	
Cucumbers	526	
Endive and escarole	49	
Lettuce	594	
Onions	422	
Peas	529	
Peppers	169	
Radishes	185	
Spinach	298	
Squash	164	
Tomatoes	2,329	
Watermelons	53	
Other vegetables	2,794	
		22,412
Fruit:		
Raspberries	284	
Strawberries	1,409	
Apples	1,133	
Cherries	68	
Peaches	265	
Other fruit	355	
		3,514
Nursery and flower crops		1,151
All other		137
TOTAL ACREAGE REPORTED		58,210

Source:-"Irrigation in Humid Areas," Volume 3, part 6, 1954 Census of Agriculture, U. S. Departments of Commerce and Agriculture, Washington, 1956

price level and the ability to obtain larger amounts of capital that goes with increased farm size has helped a number of farmers to take advantage of this new type of equipment. The series of years in the early 50's, when dry weather generally reduced crop yields, helped to expand interest. Of some importance has been the increasing competition of small fruit and vegetables grown under irrigation elsewhere which are reaching Eastern markets. To obtain equivalent quality of produce and compete with the production efficiency of Western or Southern producers, irrigation has become necessary for a number of important specialty crops in New York. Strawberries, celery, radishes, and brussel sprouts are among the more important.

Crops Irrigated in New York

Many different crops are irrigated in New York. However, potatoes and commercial vegetables make up about 85 percent of the total. In Table 2 are listed the more important crops irrigated in the state in 1955 based on data obtained by the Bureau of the Census in a special survey of irrigation in the East. This survey was not a true census enumeration. About 90 percent of all the irrigated acreage was included in the survey. Many of the small operators and a few larger producers did not cooperate in the study. Hence the data in Table 2 do not indicate all of the acreage irrigated in 1955 and probably underestimate the total acres of some of the smaller crops such as radishes more than the major ones like potatoes. It does, however, give the best picture we have of the way irrigation equipment is being used.

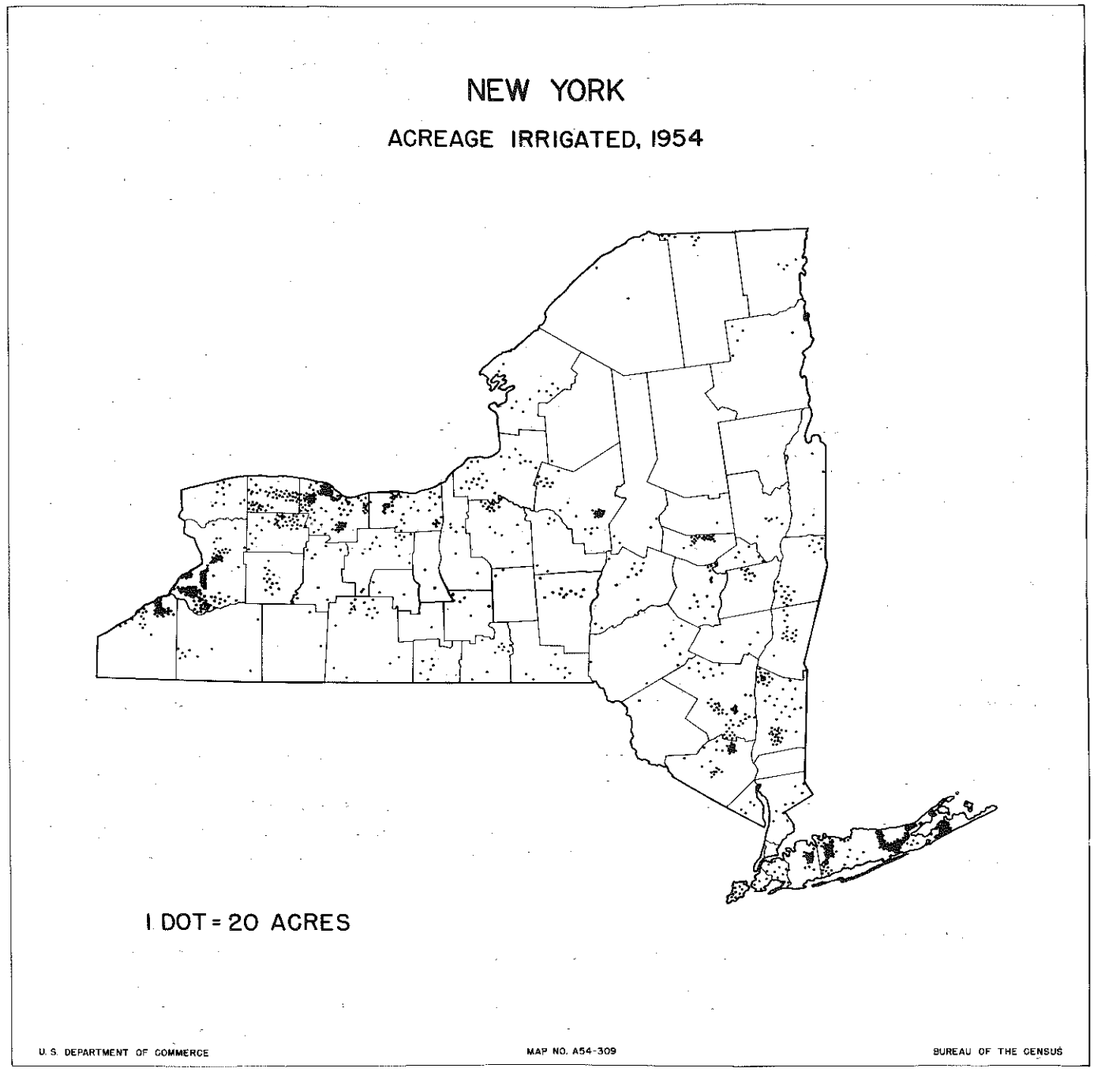
Nearly half of all the acres irrigated in 1955 were used for potatoes. The bulk of them were grown on Long Island. About one-third of total potato acreage is irrigated and it produces more than one-third of the state's crop.

Among the vegetables, snap beans, cauliflower, tomatoes, sweet corn, celery, and cabbage all have sizable acreages under irrigation. In the case of both cauliflower and celery more than half of all the acreage grown is irrigated. From 10 to 15 percent of the snap beans and tomatoes were irrigated in 1955, while only 5 to 10 percent of the cabbage and sweet corn acreage received supplemental water.

Pomologists now generally agree that most commercial strawberry producers should be able to irrigate whenever necessary. About 40 percent of the total acreage was reported as irrigated in 1955, and it seems likely that a higher proportion of the acreage was located on farms with irrigation equipment. Over 1100 acres of apples were irrigated, but this is less than one percent of the total apple acreage.

Location of Irrigated Acreage

Every agricultural county in New York reported some cropland under irrigation in the 1954 census. However, 60 percent of the total was concentrated in Suffolk County on Long Island. There were six other counties with more than 100 irrigated acres, all located in the fruit and vegetable producing sections of Western New York and the Hudson Valley. These in order of size were: Erie, Monroe, Orange, Nassau, Dutchess, and Ulster Counties. Chautauqua, Orleans, and Wayne Counties had between 800 and 1,000 acres under irrigation in 1954. With recent increases in the amount of irrigation equipment sold in these areas more than 1,000 acres can or will be under irrigation in each of these counties.



While there is someone using irrigation in all parts of the state, the acreage is concentrated on relatively large farms producing high value crops. Nearly 80 percent of the irrigated cropland is operated by men with 50 or more acres under irrigation and the greatest potential increases in acreage are on similar farms. Despite this fact, nearly 60 percent of the men who currently use irrigation equipment are smaller operators or have only a small part of their cropland under irrigation. Of the 1231 men reporting in 1955, 755 had never irrigated as many as 50 acres in any year.

TABLE 3. DISTRIBUTION OF IRRIGATED ACREAGE IN NEW YORK, 1955
(U. S. Special Census Report)

Largest acreage irrigated in any year	Farms reporting	Total acreage	Percent of total acreage
1-9	294	1,062	2
10-19	144	1,812	3
20-29	122	2,617	4
30-49	195	7,030	12
50-99	286	18,434	32
100-199	128	15,117	26
200-499	42	10,577	18
500-999	2	1,160	2
Unclassified	18	665	1
New York	1231	58,474	100

Source: "Irrigation in Humid Areas," Volume 3, part 6, 1954 Census of Agriculture, U. S. Departments of Commerce and Agriculture, Washington, 1956

Organization of Study

While the number of acres of cropland under irrigation in New York has increased very rapidly in the past 10 years, they make up only a fraction of the total which might be irrrigated. On Long Island the problem of deciding whether or not to irrigate some of the major crops has pretty well been determined. Nearly all of the larger potato and vegetable farms have irrigation equipment and a source of water developed.

Upstate this is not the case. A wide variety of crops have been irrigated under all sorts of conditions. Only a few of the important questions have been answered satisfactorily in terms of which crops will pay for irrigation, how to handle different kinds of soils when irrigated, how to tell when to irrigate, and how much water to apply. Progress is being made. The Conservation Irrigation Guide for New York prepared jointly by the New York State Extension Service, New York State Experiment Station, Soil Conservation Service, and U. S. D. A's Agricultural Research Service provides technical standards for use in the design of an efficient sprinkler irrigation system. A limited number of controlled experiments on the more important vegetable crops, small fruits, potatoes, and pasture provide some indication of increases in yield resulting from supplemental irrigation.

This study was organized in 1956 to provide some basic data on the cost of operating various sizes of sprinkler irrigation systems. During the summer and fall months names of farmers and others owning and using irrigation equipment were obtained from county agricultural agents, farm equipment dealers, and produce buyers in the six Western New York Counties bordering Lakes Erie

and Ontario. These are the areas where supplemental irrigation is most widely used upstate and where the greatest potential increase in irrigated acreage seems likely. The population identified included 607 operators. From these lists a random sample, stratified by size and counties, of 80 operators was chosen for study. Records were obtained from 61 men who had irrigated from 10 to 75 acres at least one year and from 20 operators who had had more than 75 acres under irrigation at some time. Information on the capital investment in special irrigation equipment, operating costs, labor used in setting up the system and moving pipe, and general information about the farm organization, sources of water, and practices followed were obtained.

The growing season during 1956 in Western New York was comparatively warm and dry in June and then cool and damp during July, August, and much of September. As a result the need for supplemental irrigation on a number of farms was much less acute than it had been in the immediately preceding years. Some with large investments in irrigation equipment never used their system or else set up for only a few acres.

Description of Farms Studied

The sample of farms, from which information on costs and practices was obtained, was originally drawn from two groups based on the maximum number of acres irrigated in any one year. After collecting these data, a more significant classification of size of system appeared to be one based on the original capital investment in specialized irrigation equipment:-pump, power unit, pipe and fittings. Costs of developing a source of water were not included in the total. Such costs could not be expected to be as closely related to the potential acreage under irrigation as would the original costs of pipe and special equipment. In this report, therefore basic data are presented for four different groups of farms:-those with original investments in special irrigation equipment of:

$ 1,000 -- 2,499
2,500 -- 4,999
5,000 -- 9,999
10,000 -- 20,000

Nearly all of the 81 farms from which records were obtained were specialized crop farms. Only four used more labor on livestock enterprises than on crops. None could be considered a specialized dairy or livestock farm on which the cropland was used almost exclusively for producing feed for the herd.

In general, farmers with $10,000 or more dollars originally invested in specialized irrigation equipment operated the largest farms. The smallest of these 11 farms had 154 crop acres of which 100 were irrigable. All but three in this group indicated that 200 or more acres of their present farms could be irrigated with present equipment and water sources if they desired. Vegetables and fruit were the most important crops on all but one farm. Eight of the eleven grew snap beans and seven had tomatoes. Strawberries, raspberries and grapes were important crops on four farms.

TABLE 4. USE OF CROPLAND
(81 Western New York Farms, 1956)

Crop	Your farm	Original investment in irrigation equipment: $1,000-2,499	$2,500-4,999	$5,000-9,999	$10,000 20,000
Number of farms		17	32	21	11
Field crops:		(Average acreage in crops)			
Corn	_____	2	6	3	23
Small grain	_____	6	13	18	43
Cover crops	_____	0	2	26	35
Hay, till. pasture	_____	12	25	27	40
Vegetables:					
Snap beans	_____	7	40	85	124
Tomatoes	_____	2	15	22	33
Potatoes	_____	6	1	2	18
Other	_____	26	24	65	40
Small fruit:					
Strawberries	_____	3	7	16	15
Raspberries	_____	1	8	16	17
Non-bearing berries	_____	1	3	11	15
Grapes	_____	1	6	9	23
Other	_____	0	0	0	2
Tree fruit	_____	5	8	22	5
Idle cropland	_____	3	20	16	57
Total acres in crops	_____	75	178	338	490

Most of the men with original investments of $5,000 to $9,000 in irrigation equipment were farming large acreages as well. However, two had less than 100 acres in crops all of which could be irrigated. More than half of the 21 farmers had between 50 and 175 acres which could be used for irrigation while the rest had from 200 to 400 acres that could be so used. Vegetables and fruit were the principal crops on all these farms. None had an important livestock enterprise. Snap beans and tomatoes were important crops on more than half of the farms. Sweet corn and cauliflower were the next most important vegetable crops. Strawberries were grown on ten farms and raspberries on seven.

The group with $2,500 to $4,999 invested in irrigation equipment operated fewer crop acres than the previous two groups but could not be considered small farms. They had an average of 158 acres in crops and 1465 work units per farm. Only one of the 32 was a part-time farm. Over two-thirds of these farms had from 25-100 acres that could be irrigated with present equipment and water sources. The rest made estimates up to 260 acres. However, none of the group had ever applied irrigation water to as many as 100 acres in one growing season. Three of the 32 farms had large livestock enterprises and had irrigated corn for grain or forage crops. The rest were primarily fruit and vegetable farms.

The operators with the smaller irrigation units, $1,000 to 2,499 originally invested, were the most diversified group. Of the 17 farms, five were large commercial units with over 1,000 work units indicating enough productive work for three to four men during the year. Four were part-time farms operated primarily with family labor and piece work help during the summer and fall months. The other eight were essentially one man businesses employing additional help as needed during the summer and fall. While two of the 17 felt they could irrigate as many as 100 acres with their present systems most indicated 25 to 75 acres as the maximum they could cover in any one season. There were no important livestock enterprises on these farms. Cash income was provided largely by the sale of vegetables and small fruit.

Crops Irrigated on These Farms

As is true for the state as a whole, a wide variety of crops were irrigated on the farms included in this study. Tomatoes and strawberries were the most important crops both in terms of acres and number of farmers irrigating. Celery, snap beans, and sweet corn were next most important with more than 10 farmers irrigating these crops and over 100 acres involved in each in 1956.

TABLE 5. CROPS IRRIGATED
(81 Western New York Farms, 1956)

Crop	Number of farms	Total acres
Tomatoes	31	360
Strawberries	30	369
Celery	13	240
Cabbage	13	78
Lettuce	11	76
Snap beans	10	191
Sweet corn	10	131
Cauliflower	9	53
Raspberries	9	66
Beets	8	25
Potatoes	7	43
Cucumbers	7	22
Squash	5	9
Peppers	5	14

Other crops irrigated on these farms include:-(less than five cases)
Field Crops: corn for grain, corn for silage, sudan grass, rye, alfalfa, permanent pasture, dry beans
Vegetables: green onions, radishes, melons, lima beans, fava beans, broccoli, spinach, parsnips, pumpkins, peas, carrots
Fruit: apples, cherries, peaches, pears
Other: nursery stock, pansies

The list of crops shown in Table 5 when compared with the list for the state as a whole in Table 3 is quite similar. No large specialized potato farms using irrigation were included in the study. Otherwise, most of the important irrigated crops in the state are represented on a reasonable number of these farms.

A total of 4,926 acres were irrigated on these 81 farms in 1955. In 1956 the acreage under irrigation dropped to 1962, about two-fifths of the previous year. While only 81 of the 601 men with irrigation equipment in the lake counties were included in this study, they represent a much higher proportion of the total irrigated acreage than the number might suggest. Those men who had never irrigated as many as 12 acres of crops or who had less than $1,000 invested in irrigation equipment were eliminated from the original population. This reduced those eligible for study by more than one-third. Then to insure sufficient numbers with larger irrigation systems a higher proportion of these men were chosen than those with smaller acreages. The 1954 census indicated a little less than 10,000 acres under irrigation in these six counties. The supplementary census study in 1955 indicated a modest increase in acreage over 1954 of from 10 to possibly 20 percent at maximum. Hence it is reasonable to assume that these 81 farms include from 30 to 40 percent of the acreage presently irrigated in these counties.

CAPITAL INVESTED IN IRRIGATION

One of the important concerns of any farmer who is considering supplemental irrigation is the amount of additional capital that will be required for a distribution system and an adequate supply of water. There are many variable factors which finally determine the amount of capital which must be invested. Some of the more important include:

(1) the number of acres to be irrigated

(2) the type of crops and frequency of irrigations required

(3) the type of soils on which the crops are grown

(4) existing sources of water:-their capacity, distance from fields, and lift required

(5) the possibility of providing additional sources of water and their expected cost

Every farm has slightly different needs and resources with which to work. Designing an efficient irrigation system and planning for water needs must be done on an individual basis. The Conservation Irrigation Guide for New York mentioned earlier and the company or agency from which irrigation equipment is purchased will provide useful information in this respect. However some rough indications of capital requirements can be determined from observing practicing farmers who are using various types and kinds of systems under a variety of conditions. The following sections will describe some of their experiences.

Original Investment in Equipment and Water Supply

Pipe and fittings to distribute water are the most important items of capital investment on nearly all farms using supplemental irrigation. In four cases the original cost of a pump and motor was greater than the investment in pipe and fittings. All of these cases occurred when the total original investment in an irrigation system was less than $5,000. Under most conditions farmers had from 2 1/2 to 4 times as much money invested in pipe and fittings as in the pump and power to supply water to the crops.

TABLE 6. INVESTMENT IN IRRIGATION EQUIPMENT AND WATER SUPPLY
(81 Western New York Farms, 1956)

	Your farm	Original investment in irrigation equipment $1,000-2,499	$2,500-4,999	$5,000-9,999	$10,000-20,000
Number of farms		17	32	21	11
Original investment:					
Power and pump	_____	$ 470	$1036	$1723	$ 3,260
Pipe and fittings	_____	1334	2543	5279	11,682
Water supply	_____	677	657	847	1,289
Total	_____	$2481	$4236	$7849	$16,231
Present Value:					
Equipment	_____	$1256	$2502	$4756	$10,845
Water Supply	_____	638	603	806	1,118
Total	_____	$1894	$3105	$5562	$11,963

There was some variation within each of the size groups in the amount invested in pipe and fittings. However the primary source of variability was the investment in a power unit and pump. A wide variety of types and makes of both are available on the market. Differences in the amount of lift and in the distance water is pumped account for much of this variability.

Water Supply

Developing a water supply for irrigation on most of these farms has required relatively little capital. Only two of the 81 operators had invested more than $5,000 in obtaining water, one on a relatively small farm irrigating 20 acres, the other on a larger farm where 70 acres were considered irrigable. One-fourth of the men had spent nothing to develop their source of water. They use existing streams, ponds,lakes and the like with no development problems. Most of the group, however, had spent from $500 to $1,500 in developing some of their current sources of water. Ponds and springs were most common. Other capital outlays were for wells, reservoirs, dams, and siphons from creeks or the Barge Canal

TABLE 7. SOURCES OF WATER USED FOR IRRIGATION
(81 Western New York Farms, 1956)

	Your farm	Original investment in irrigation equipment $1,000-2,499	$2,500-4,999	$5,000-9,999	$10,000-20,000	All farms
Number of farms		17	32	21	11	81
Water source:						
Ponds and springs	_____	8	17	13	6	44
Creek or stream	_____	2	14	7	7	30
Barge Canal	_____	1	4	4	3	12
Wells	_____	5	2	0	0	7
Stream and reservoir	_____	1	2	2	1	6
Lakes	_____	0	2	1	1	4
Municipal water supply	_____	2	2	0	0	4
Other	_____	2	2	3	0	7

The different sources of water used on these Western New York farms are shown in Table 7. Three-fifths of the group were using more than one source of water during the season. In some cases they might use two or more ponds, in others a well and a stream, or any number of other similar combinations.

Natural ponds or spring-fed ponds with small drainage areas, constructed with the help of the Soil Conservation Service, were the most commonly used water source. Creeks and streams were next. A number of men farming north of the Barge Canal were using siphons to bring water from the Canal into streams which flow north from the Canal to Lake Ontario. These farms are listed in Table 7 as using the Barge Canal as a water source even though they are not pumping directly from this waterway. Most of the men using a water source described as "other" were pumping from drainage ditches or non-permanent pools of water adjacent to muck land.

Since irrigation is relatively new to Western New York, water rights have not been a serious problem as yet for most of these farmers. They all recognize the importance of securing a stable supply of water on their farm which will not be subject to restriction by other potential users. Those pumping water from major streams, lakes, or creeks flowing north from the Barge Canal, where more than one farmer or business uses a common supply of water, may eventually have to obtain more formal options on the supply they use. At present, a number using water from the Canal are seeking to clarify their present and long-run positions.

OPERATING COSTS

What does it cost to irrigate an acre of tomatoes or strawberries? Perhaps the best answer is a simple one, "It depends." But this is no answer at all for one who wants some idea of what he will spend annually if he decides to irrigate part of his crops. The experiences of the 81 farmers studied in Western New York give some indication of operating costs that should be useful to other farmers with somewhat similar conditions.

Annual Operating Costs

The size of the irrigation system and the amount of water applied during the growing season determine in large part how great will be the cost of irrigation. Because of the differences in costs due to size, annual operating costs for the farms studied were grouped according to the amount originally invested in irrigation equipment. Of the 81 farms studied, nine applied less than 10 acre-inches of water in 1956. Because these systems were used so little they were not included in the averages presented for the groups.

Fixed Costs - Regardless of the amount of water pumped through an irrigation system, there are some costs which occur automatically. These are generally termed fixed costs. Interest on the money invested in the system is one of the most important. A charge of five percent was made on the 1956 depreciated value of the power unit, pump, pipe and fittings. This is slightly less than it would cost to borrow an equivalent amount from most lending agencies, but slightly more than a farmer would receive for the use of this money if placed in a savings bank or in government bonds. Storage and insurance are other fixed costs, but have relatively little importance in the structure of irrigation costs in most cases.

Depreciation makes up about two-thirds of fixed costs for most systems regardless of size. Some might argue that depreciation is not a fixed cost but one which depends primarily on the amount of use given equipment. This is at least partially true. Nevertheless most farmers charge depreciation on equipment at a constant annual rate as the most realistic way of determining this cost. It is very difficult to determine the amount of wear occurring in any one year. For this reason, depreciation was considered a fixed cost and charged annually using the straight line method.

TABLE 8. ESTIMATED LIFE OF PORTABLE IRRIGATION PIPE
(81 Western New York Farms, 1956)

Years of life	Number of farms
8-12	7
13-17	13
18-22	48
23-27	9
28-32	4

Portable pipe, including mains and laterals, makes up at least half of the total investment in irrigation equipment on nearly all farms. However, few farmers have used aluminum or light-weight, steel pipe long enough to know how rapidly it will need to be replaced or repaired. In setting up a depreciation schedule, this lack of information was evident in the variability shown in farmers' estimates of how long their irrigation pipe would last. Over half indicated about 20 years. However, about 25 percent gave estimates of 10, 12, or 15 years.

Depreciation rates on pumps and power units were given with considerably greater confidence. Most of the pumps were expected to last less than 10 years depending on the type and expected rates of use. Power units were more variable. More than 75 percent used gasoline or diesel oil for fuel. These engines of various sizes were depreciated over a five to ten year period in most cases. The electric motors were expected to last from 20 to 25 years.

Because depreciation and interest make up such a large part of fixed costs, this total is quite closely related to the amount originally invested in irrigation equipment. About two-third of the irrigation systems, regardless of size, had fixed costs which equaled from 9 to 13 percent of the original investment made in equipment. This relationship can also be observed in Table 9 by comparing average fixed costs in each of the four groups to original investment.

TABLE 9. ANNUAL OPERATING COSTS FOR IRRIGATION SYSTEMS
(72 Western New York Farms, 1956)

	Your farm	Original investment in irrigation equipment: $1,000-2,499	$2,500-4,999	$5,000-9,999	$10,000-20,000
Number of farms		14	29	18	11
Acres irrigated	_____	15	22	55	50
Acre-inches applied	_____	49	72	108	109
Fixed Costs:					
Depreciation	_____	$131	$237	$ 531	$1,075
Interest	_____	94	147	271	575
Storage, insurance	_____	0	1	1	4
Total fixed costs	_____	$225	$385	$ 803	$1,654
Variable Costs:					
Labor	_____	$141	$183	$ 449	$ 251
Repairs and maintenance	_____	13	45	49	103
Fuel or electricity	_____	27	52	158	89
Water	_____	40	16	74	12
Truck and tractor	_____	11	12	26	20
Other equipment expense	_____	5	8	23	33
Total variable costs	_____	$237	$316	$ 779	$ 508
Average operating costs	_____	$462	$701	$1,582	$2,162

Variable Costs - The amount of irrigation water applied during a year should in large part determine the size of variable costs. After a certain minimum amount of water has been pumped, variable costs normally will increase almost proportionally with the number of acre-inches of water applied if methods of appli-

cation are not changed considerably. Labor used in servicing equipment and moving pipe, repairs and maintenance, and fuel are the three major items of variable costs on most farms.

Labor made up from 40 to 60 percent of variable costs on the majority of farms. Where the percentage was higher, relatively little water was applied. A few farmers who used their irrigation system at or near capacity in 1956 or who applied as much as two acre-inches of water per setting had labor costs which were less than 40 percent of the total. However nearly all of the men using irrigation would agree that labor was their most important variable cost and primary concern if they had plenty of water.

Basic data were obtained on labor used during the season by enumerating amounts of time spent in (1) setting up the system originally in the summer and then returning it to storage in the fall, (2) servicing the pump and motor, (3) moving pipe and equipment between fields and/or farms, (4) moving pipe within fields, and (5) general supervision. On the larger farms, one of the operators usually provided a good share of the labor in setting up the system, servicing the pump and motor and providing general supervision. Hired labor, including migrants paid by the day or hour, did much of the moving of pipe within fields and often between them. On the smaller farms the operator and his family or regular hired labor did most of the work from setting up the system originally to making moves within a field.

Repairs and maintenance were quite variable from farm to farm in each of the size classifications. Farmers were asked to estimate repairs over a three year period. However recent experience undoubtedly affected these estimates. A little over 10 percent of the group had spent nothing for repairs on their systems as yet. Expenditures for oil, filters, grease, and the like were estimated and included under the heading of repairs and maintenance.

Fuel or electricity amounted to about 20 percent of variable costs. There was a direct relationship between these costs and the amount of water applied on nearly all farms. Gasoline was the chief type of fuel used. On the 29 farms with $5,000 or more invested in irrigation equipment over two-thirds were using Chrysler motors powered by gasoline. There was much greater variability among the smaller systems.

The cost of water was also quite variable. The four men who relied on municipal water supplies had relatively high water bills compared to the rest. This especially affected the average cost of water shown for the group with original investments of $5,000 - 9,999 in irrigation equipment. Special fees, costs of maintaining ponds or springs, and the like were included under this heading.

The remaining items listed under variable costs were for the use of trucks, tractors, and the other special equipment including trailers employed in moving pipe and equipment.

The averages shown in Table 9 seem quite reasonable except for the cost of labor and fuel in the two larger size groups. Since about the same number of acres were involved and the same amount of water was applied one might expect similar average costs. After examining individual records for reasonableness in each of the two groups, no good explanation for this difference was evident.

It may be that the larger systems were located on farms which were unusually efficient in the use of labor. However, one must conclude that this difference resulted from random factors and that in another year when more of the systems are used to capacity the amount of difference observed should be much smaller or disappear.

Average Costs per Acre Irrigated

More rain fell during the growing season in Western New York in 1956 than in any of the previous three years. This cut down on the amount of use obtained from irrigation systems and increased the cost per acre irrigated because fixed costs were distributed over a smaller number of acres. Minimum use also affected some variable expenses such as labor and maintenance where greater efficiency is obtained as the system is used at or near capacity.

TABLE 10. AVERAGE OPERATING COST PER ACRE IRRIGATED
(72 Western New York Farms, 1956)

		Original investment in irrigation equipment			
	Your farm	$1,000-2,499	$2,500-4,999	$5,000-9,999	$10,000-20,000
Number of farms		14	29	18	11
Acres irrigated	_____	15	22	55	50
Average Costs per Acre:					
Fixed	$_____	$15.00	$17.50	$14.60	$33.08
Labor	_____	9.40	8.32	8.16	5.02
Other variable	_____	6.40	6.04	6.00	5.14
Total cost per acre	$_____	$30.80	$31.86	$28.76	$43.24

Average operating costs per acre were quite similar when comparing the four different size groups (Table 10). However, there was considerable variation within each of these groups. The amount of labor and water applied per acre varied depending on the crop and type of operation. Average costs per acre irrigated are presented, nevertheless, because accurate measures of the acre-inches of water actually applied are difficult to obtain.

There was a wide range in operating costs per acre irrigated in each of the size groups. The largest number of growers in the first three groups had costs of $10 to $40 per acre irrigated. Those with higher costs per acre in most cases irrigated only a small acreage during the 1956 growing season. A high proportion of the men with the largest irrigation systems had very high costs per acre irrigated. This reflects their high fixed costs which spread over a limited number of acres.

TABLE 11. DISTRIBUTION OF OPERATING COSTS PER ACRE IRRIGATED BY SIZE OF SYSTEM
(72 Western New York Farms, 1956)

Operating cost per acre	Original investment in irrigation equipment: $1,000-2,499	$2,500-4,999	$5,000-9,999	$10,000-20,000
	(Number of farms)			
$ 0-19	3	7	4	1
20-39	6	9	9	2
40-59	4	6	1	2
60-79	0	3	1	1
80-99	1	1	2	1
100 and over	0	3	1	4

Average Cost per Acre-Inch Applied

Efforts were made to determine the number of acre-inches of water applied to each crop irrigated on each of the farms. A variety of procedures were used to obtain this information. Most of the growers knew how much water they intended to apply at each setting. Some had made definite efforts to check how much water was being applied by placing pans and other receptacles in the field at different points while their sprinklers were operating. Others relied on what their equipment dealers had told them or how the soil looked after a certain amount of water had been applied. There was a considerable margin for error in the estimates of total acre-inches applied as a consequence.

TABLE 12. AVERAGE OPERATING COSTS PER ACRE-INCH APPLIED
(72 Western New York Farms, 1956)

	Your farm	Original investment in irrigation equipment: $1,000-2,499	$2,500-4,999	$5,000-9,999	$10,000-20,000
Number of farms		14	29	18	11
Acre-inches applied	_____	49	72	108	109
Average Costs per Acre-Inch:					
Fixed	$_____	$4.59	$5.35	$ 7.44	$15.17
Labor	_____	2.88	2.54	4.16	2.30
Other variable	_____	1.96	1.85	3.05	2.36
Total operating costs	$_____	$9.43	$9.74	$14.65	$19.83

Costs per acre-inch applied were calculated on all of the farms. While there may have been some over-estimates in the number of acre-inches applied because more careful measurements were not made, these cost figures at least give an indication of the expense per acre-inch in a year when needs for supplemental irrigation were not very great.

Average costs per acre-inch applied were greater for the larger irrigation systems than the smaller ones. Most of these differences resulted from higher fixed costs per acre-inch applied. Variable costs were less divergent. Labor costs per acre-inch were quite similar for the four size groups although there was considerable variation from farm to farm. Fuel, repairs, and other costs of maintenance were more uniform within and between size classifications.

TABLE 13. DISTRIBUTION OF OPERATING COSTS PER ACRE-INCH APPLIED BY SIZE OF SYSTEM
(72 Western New York Farms, 1956)

Operating cost per acre-inch	Original investment in irrigation equipment: $1,000-2,499	$2,500-4,999	$5,000-9,999	$10,000-20,000
	(Number of farms)			
$ 0-4	2	3	1	1
5-9	4	8	2	0
10-14	3	4	2	1
15-19	0	5	5	1
20-29	4	6	3	1
30-39	1	2	1	2
40-49	0	0	1	1
50 and over	0	1	3	4

The variation in operating costs per acre-inch applied within each of the size groups was greater than differences between them. Most of these differences were dirctly related to the amount of water applied. However, labor costs were an important factor in a number of cases. There were seven men whose total costs per acre-inch applied were less than $5.00. All used their systems at or near capacity in terms of acreage of water available. However, an important number in each of the size classifications had operating costs of $20.00 or more per acre-inch applied. The majority of those with large systems were faced with this kind of cost picture.

GENERAL CONCLUSIONS

Cost data for one year from a relatively small number of farms do not provide a satisfactory basis for drawing final conclusions about costs and benefits for irrigation. They do provide a means for making better informed estimates about the nature of irrigation costs and for finding possible areas where efficiency in the operation of irrigation systems can be increased. A few of the more important economic questions to which these data are applicable will now be considered.

Operating Costs When Systems are Used More Fully

What is a reasonable level to expect for operating costs per acre-inch when an irrigation system is used at or near capacity? Needs for supplemental irrigation in Western New York during 1956 were more limited than many years. What might operating costs be in a drier year? If the basic data obtained on total operating costs from these farmers are reasonably representative, then some good estimates can be made.

Variable costs per acre-inch applied, other than labor, were not widely different from farm to farm or between different sizes of systems. Given average or better management of equipment, variable costs other than labor should equal $2.00 per acre-inch or possibly less. Labor costs are more variable. Much depends on the acreage covered per setting and the amount of water applied. Using 1956 experiences as a guide and assuming that there will be some efficiencies in the use of labor associated with the larger systems, an expense of from $2.00 to $2.50 for labor per acre-inch applied may be reasonable. Compared with the averages presented in Table 12, estimated variable costs of $4.00 to $4.50 per acre-inch seem to be consistent for irrigation systems used at or near capacity.

TABLE 14. ESTIMATED OPERATING COSTS PER ACRE-INCH WHEN SYSTEMS ARE USED AT OR NEAR CAPACITY (Budget Data, Western New York, 1956-57)

	Original investment in irrigation equipment			
	$1,000-2,499	$2,500-4,999	$5,000-9,999	$10,000-20,000
Estimated acre-inches applied	100	200	400	800
Average cost per acre-inch:				
Fixed	$2.00	$2.00	$2.00	$2.00
Labor	2.50	2.50	2.25	2.00
Other variable	2.00	2.00	2.00	2.00
Total operating cost	$6.50	$6.50	$6.25	$6.00

Fixed costs per acre-inch decrease as more and more water is applied. If the average of total fixed costs for each of the four size classifications is used as the basis for estimating fixed costs in the future, an estimate of fixed cost per acre-inch can be determined for any number of acre-inches applied. How much water can be applied during a "representative" year with different sizes of systems? What constitutes full use of irrigation equipment? From an engineering point of view the power unit and pump can handle a very sizable quantity of water during a complete growing season. But clearly water will not be needed at all times. In many cases it would not be available from present sources.

In Table 14 operating costs are estimated for each of the four general classes of systems studied when the number of acre-inches applied are sufficient to make fixed costs equal $2.00 per acre-inch. Such rates of application are intended to approximate the use of an irrigation system at a rate approaching its capacity under Northeastern conditions. Under these assumptions operating costs equal $6.00 to $6.50 per acre-inch applied, the costs increasing somewhat as size of system decreased.

These figures are clearly estimates. Some farmers might have operating costs of $5.00 or less some years. There were nearly 10 percent of the group providing basic information for this study who had costs of this order in 1956. However, unless the estimates of variable costs are very poor, few should expect to irrigate, even under the best conditions, for less than $4.00 per acre-inch applied. Moreover, few men with $10,000 or more invested in specialized irrigation equipment had applied as many as 400 or 800 acre-inches with their respective systems even in a dry year such as 1955. Hence, a fixed cost of $2.00 per acre-inch for these larger systems may be too low a minimum to set for practical conditions.

In general, when water is readily available at nominal cost, one would expect that irrigation costs will amount to at least $6.00 per acre-inch applied for nearly any portable system. When rainfall provides most plant needs these costs will be higher (as much as $20) depending on the crops grown and their sensitivity to water--for example, strawberries contrasted with alfalfa. If the system is not used at all, fixed costs will go on regardless.

Increases in Yields or Quality Necessary to Pay Costs

Under what circumstances does it pay to have an irrigation system? What crops will make the best use of supplemental irrigation? A simple study of costs will not answer these questions adequately. Yet it does provide some benchmarks against which one can examine experimental evidence of yield response and practical experience on farms already using irrigation.

It has been fairyly well established for some crops like radishes and strawberries that large commercial producers can improve the quality of their crops in at least half of the years by having water available to apply whenever needed. An increasing proportion of these crops placed on the market have been irrigated. Competition is forcing those who do not irrigate to consider adopting this practice in the immediate future or else produce some other crops.

For most crops in Western New York the need for and economic feasibility of supplemental irrigation has not been finally determined. A number of progressive farmers in the area are convinced that irrigation will pay for itself over time when used for a wide variety of crops. However, they have limited amounts of evidence from which to draw such conclusions.

One way to examine the economic possibilities of irrigation is to determine what kind of increase in yield or addition to net value of the crop is necessary to pay irrigation costs. It has been estimated that most farmers can not expect to irrigate for less than $6.00 per acre-inch under current levels of efficiency when their systems are used at or near capacity. This would be the situation in a dry year. When there is a relatively ample supply of rainfall during the growing season, irrigation costs rise per acre-inch applied because of the high fixed costs involved. Hence over time a farmer cannot expect to average as little as $6.00 per acre-inch applied. Establishing a representative cost of irrigation per acre is further complicated by differences between crops in the amounts of water and frequency of applications per acre required during the growing season. However, some calculations are presented showing the increases in yields at average prices necessary to pay for irrigation costs of $30 per acre (Table 15). This $30 would probably pay for four to five acre-inches of water in a dry year or two to three acre-inches in a more humid one.

TABLE 15. INCREASES IN YIELD NECESSARY TO PAY IRRIGATION COSTS OF $30 PER ACRE FOR SELECTED CROPS (Budget Data, Western New York, 1956-57)

	Unit	Average price per unit 1955-56	Harvest and sales cost per unit	Net value per unit	Increase in yield necessary to pay irrigation costs of $30 per acre
Processing crops:					
Cabbage	ton	$ 15	$ 5	$10	3.0 tons
Snap beans	ton	120	65	55	0.5 tons
Sweet corn	net ton*	33	9	24	1.2 tons
Tomatoes	ton	32	11	21	1.4 tons
Fresh market crops:					
Cabbage	ton	$ 34.00	$ 9.00	$25.00	1.2 tons
Celery	60 lb. crates	2.40	1.20	1.20	25 crates
Lettuce	2 doz. boxes	1.50	.70	.80	38 boxes
Strawberries	24 qt. crates	7.50	3.00	4.50	7 crates
Tomatoes	bushel	2.50	.90	1.60	19 bushels
Field crops:					
Corn for grain	bushel	$ 1.40	$ .20	$ 1.20	25 bushels
Alfalfa hay	ton	25.00	8.00	17.00	1.8 tons

* Tons without the husks

The value of increases in yields resulting from irrigation should not be fully charged against irrigation costs. The additional quantity produced must be picked or harvested, and then graded, packaged, and delivered to a buyer. These harvesting and selling costs must be deducted from the value of the increase in yield before determining how great an increase is necessary to pay for irrigation costs. The data on harvesting costs presented in Table 15 for processing crops are based on recent enterprise studies in New York and represent average conditions reasonably well. Information on harvesting and selling costs for fresh market crops is much more limited. The estimates presented are not necessarily typical of average farm conditions in Western New York but are the best estimates available and must be interpreted accordingly. If the basic prices, harvesting and selling costs, or costs of irrigation per acre are not appropriate for a particular farm situation, more appropriate figures should be substituted in Table 15. The basic method of comparing irrigation costs with yield increases should be useful even though the data presented in this table may not be representative for individual situations.

Conclusions drawn from the information presented in Table 15 must be tentative. However, some points are reasonably clear. Intensive, high value crops are more likely to pay for irrigation costs over time than field crops. Shallow rooted plants such as strawberries will need water more often than deep rooted plants like alfalfa. Hence the likelihood of obtaining the increased yields necessary to pay for the costs of applying irrigation water seems much greater for a number of small fruit and vegetables than for most field crops.

Increases in the value of a crop resulting from higher quality are more difficult to measure than increases in yields. The benefits of such increases in quality may or may not be reflected directly in prices received. If, for example, the percentage of a crop grading U. S. #1 or better is increased by 10 percent, this will be reflected directly in the price received for all of the crop. No deduction needs to be made for added harvesting or selling costs. In some cases the results of higher quality packs of fresh vegetables or small fruit are not reflected in grades as much as in premium prices in the market or by the added certainty of selling what is offered at regular market prices. Some processors and chain store buyers are providing direct price incentives or more direct buying guarantees to irrigators primarily because of the higher quality produce they receive from these growers. Such market preferences must be considered as well in deciding how much irrigation may be worth over time on an individual farm.

Size of Irrigation System and Operating Costs

Can a small commercial producer operate an irrigation system for his business as efficiently as a man with a larger operation? Is it reasonable to consider irrigation for a small acreage with a small system? Most economic studies indicate that large units tend to be more efficient than smaller ones - that efficiency is very often associated with size. Despite this fact, the majority of irrigators in the Northeast operate small systems for limited acreages of high value crops.

The evidence presented in this report suggests that the original investment in irrigation equipment is not a very important factor in determining operating efficiency as indicated by low operating costs per acre or per acre-inch of water applied. Average costs presented in Tables 10 and 12 show that

farmers with smaller systems often have lower costs, at least in a wet year, than those with greater investments in such equipment. High fixed costs associated with large investments in irrigation equipment require moderate to heavy use of these systems to obtain relatively low operating costs on a unit basis. Hence, the risks of high operating costs per acre in a wet year are somewhat greater with large systems.

Irrigation systems can be designed for efficient use on small acreages. There are now enough different sizes and types of pumps and motors on the market to allow good individual design for specific needs. Likewise enough such equipment is being purchased so that there is a market for old as well as new equipment. From a cost standpoint, a man planning to irrigate should design a system big enough for his current needs rather than try to project what his needs will be too far into the future. Under humid Northeastern conditions, where irrigation water is supplemental rather than the chief source of supply, small well-designed systems can be operated over time at as low unit costs as larger ones.

APPENDIX A

FREQUENCY AND RATES OF APPLICATION OF IRRIGATION WATER ON IMPORTANT IRRIGATED CROPS

TABLE A. TOMATOES
(32 Western New York Farms, 1956)

Times water was applied	Number of farms	Acre-inches per application	Number of farms
1	17	.25 - .74	4
2	9	.75 - 1.24	17
3	4	1.25 - 1.74	8
4	1	1.75 - 2.24	3
5 or more	1		

TABLE B. STRAWBERRIES
(32 Western New York Farms, 1956)

Times water was applied	Number of farms	Acre-inches per application	Number of farms
1	8	.25 - .74	3
2	7	.75 - 1.24	17
3	10	1.25 - 1.74	3
4	4	1.75 - 2.24	7
5 or more	3	2.25 and over	2

TABLE C. CELERY
(13 Western New York Farms, 1956)

Times water was applied	Number of farms	Acre-inches per application	Number of farms
1	2	.25 - .74	2
2	4	.75 - 1.24	6
3	2	1.25 - 1.74	3
4	4	1.75 - 2.24	1
5 or more	1	2.25 and over	1

TABLE D. CABBAGE
(13 Western New York Farms, 1956)

Times water was applied	Number of farms	Acre-inches per application	Number of farms
1	6	.25 - .74	3
2	4	.75 - 1.24	8
3	3	1.25 - 1.74	1
		1.75 - 2.24	1

TABLE E. LETTUCE
(11 Western New York Farms, 1956)

Times water was applied	Number of farms	Acre-inches per application	Number of farms
1	4	.25 - .74	4
2	2	.75 - 1.24	5
3	4	1.25 - 1.74	0
4	1	1.75 - 2.24	2

TABLE F. SNAP BEANS
(10 Western New York Farms, 1956)

Times water was applied	Number of farms	Acre-inches per application	Number of farms
1	5	.25 - .74	1
2	4	.75 - 1.24	3
3	0	1.25 - 1.74	4
4	0	1.75 - 2.24	2
5 or more	1		

TABLE G. SWEET CORN
(10 Western New York Farms, 1956)

Times water was applied	Number of farms	Acre-inches per application	Number of farms
1	1	.25 - .74	1
2	1	.75 - 1.24	3
3	8	1.25 - 1.74	4
		1.75 - 2.24	1
		2.25 and over	1

APPENDIX B

METHODS OF CALCULATING COSTS

Wherever possible direct or cash costs were provided by the operators of irrigation equipment. The cost of such items as gasoline, hired labor, and municipal water rates were easily obtained. Charges for the use of tractors and trucks and the operator's labor were more difficult. The following methods and rates were used:

Depreciation

The straight line method of figuring depreciation was employed. The original costs of power units, pumps, pipe, fittings, and water sources were determined and divided by the estimated life of each item. Depreciation was charged regardless of the amount of use in any one year.

Interest

Interest was charged on the present value of all capital assets used primarily for irrigation at the rate of 5 percent per year.

Storage and Insurance

Storage charges were made at the rate of $2 per $1,000 for the pump and power unit in all cases and for pipe and fittings when they were stored inside or in a special structure. Fire insurance was carried on the pump and power unit by a number of farmers. In most cases this was charged at $4 per $1,000 insured.

Labor

Rates per hour for each class of labor used were estimated by each irrigator. Farmers indicated either an estimate of the price per hour they would have had to pay to replace themselves or their family on the job, or the price per hour actually paid. These estimates were often obtained by determining monthly wage rates and the number of hours worked per month. Four general classes of labor were designated with a rate for each:-operators, family, regular hired, and day or special labor. The averages of the rates per hour estimated for use in this study by these farms were:

Class of labor	Rate per hour
Operators	$1.58
Family	1.05
Regular hired	1.20
Day or special	.90

Repairs and Maintenance

Cash expenses for repairs and maintenance to any specialized irrigation equipment during the most recent three-year period were enumerated. This total was divided by three to get an estimate of annual repairs. To this were added costs of oil, grease, filters, and the like used during the 1956 season. Labor for maintenance proved by the operator was charged under the heading of labor.

Fuel or Electricity

Farmers indicated average rates of fuel consumption and total hours of use except when they had more accurate records for a given power unit. The farm price of gasoline or diesel fuel was used. Electricity was charged at the rate of one kilowatt per hour per horsepower of the motor used.

Truck and Tractor

Standard rates were applied for all truck and tractor use. These rates were:

Machine	Rate
One plow tractor	$ .80 per hour
Two plow tractor	.95 per hour
Three plow tractor	1.15 per hour
Small truck (1 ton or less)	.10 per mile
Large truck (1 ton or more)	.19 per mile