A MULTI-PERIOD ANALYSIS OF CAPITAL ACCUMULATION AND FINANCING OF BEGINNING IRRIGATION FARMS IN THE PEMBINA RIVER BASIN

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ABSTRACT

The main purpose of this study was to determine the economic nature of the transition from dryland to irrigation farming. A farm, representative of the proposed Winkler irrigation project, was developed and specified in a multi-period linear programming model. By developing a number of hypothetical farm plans some factors affecting development were identified. The availability of credit for the area as a whole was considered as an important resource.

The factors taken into consideration in constructing the farm plans were:

1. The availability of short term credit.
2. The price of irrigation water.
3. The method of financing irrigation development.
4. The amounts of labor that could be hired.
5. The availability of markets for crops.

The effects of these factors on irrigation development were assessed by developing twenty year income maximizing solutions. Some of the important results were:

1. The amount of short term capital that could be borrowed affected the rate at which irrigation development would take place. Larger amounts of short term borrowing had the effect of raising the level of net returns and shortening the transition period.
2. Within a given framework, the amount of short term capital did not affect the stabilized net returns.
3. When a single price for water of $4.40 per acre foot was used, all the irrigable land was developed. How-

ever, raising the price to $10.00 in years ten to twenty discouraged irrigation for all crops except potatoes.

4. All the irrigable land was developed when costs were amortized over a thirty year period, but when repayment was on a cash basis, a small amount of land was not developed.

5. When labor hiring was restricted, only a portion of the total irrigable acreage was developed.

6. Incomes were higher and development more rapid when larger market possibilities were assumed.

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CHAPTER I

INTRODUCTION

Plans are presently being considered for the construction of a multi-purpose dam on the Pembina River. The project is to be a joint effort between Canada and the United States. An International Joint Commission has investigated the feasibility of such a venture and favors a plan which would service both Manitoba and North Dakota. The project is intended to provide water and facilities for industrial purposes, community development, irrigation, flood control, recreation, and wildlife. Of the above mentioned areas of potential benefit, this study considers irrigation.

Water would be provided for 13,000 irrigable acres in each country if the plan is adopted. The costs of the initial project would be shared jointly and subsequent projects would be financed by the country concerned.

I. THE PROBLEM

If irrigation water is made available, farm operators will have the opportunity to convert their dryland farm units into irrigation farms. The International Joint Commission set up a study group, The International Pembina River Engineering Board, to examine the irrigation potential of the area (11). The evidence gathered by this board indicates that a mature irrigation project would increase the production

of crops presently being grown in the area and would make it possible to grow a greater variety of crops (11, p. 312).

Studies of new irrigation projects show that economic progress of beginning irrigation farmers is greatly affected by the rate at which the land is developed for irrigation. In the past it was customary for farmers to level their own land and develop it slowly. It often took fifteen years to complete development. Prolonging the transition period was an attempt to provide the family with an adequate living income and to allow capital accumulation. Neither of these goals were achieved satisfactorily by this method of development.

In more recent years it has been found that rapid development has encouraged greater progress in both accumulated net worth and annual income (22, p. 1). Rapid development is achieved by making use of large scale equipment and government technical assistance; therefore, the potential productivity of land and water resources is realized more quickly.

Many projects in the United States have been predeveloped by government agencies in an attempt to alleviate the financial hardships of the development period. Land was purchased, fully developed, and resold to irrigation settlers. Little or no down payment was required and repayment was spread over a long period of time. Wherever predevelopment is not possible, it has been suggested that similar results

can be achieved by using government sponsored credit programs (25, p.9).

In this study, it was assumed that irrigation development would take place in the context of private ownership. An attempt was made to determine conditions that would encourage rapid irrigation development without lowering the farmers' standard of living. It is hoped that the many pitfalls and difficulties encountered by irrigation settlers on previous projects can be avoided on the Pembina River Project.

II. OBJECTIVES AND METHOD OF ANALYSIS

The overall objective of this study was to examine the transition from dryland farming to irrigation farming under various assumptions. This has been done by developing a farm which is representative of the project area (Winkler).

The first objective of this study was to review the experiences of some previous irrigation projects and to discuss some related studies. This indicated the types of problems that have existed on older projects.

The second objective was to determine the extent to which credit would be available to beginning irrigation farmers. The nature and sources of agricultural credit are discussed in Chapter III. Agricultural credit statistics were reviewed in order to identify the major sources. Representatives of these sources were contacted to determine the amount of various types of credit that could be available

for irrigation farmers.

The representative farm used in this study formed the basis of the empirical analysis. A number of different hypothetical farms were constructed. Each plan represented different assumptions with respect to financing development, market conditions and labor availability. The analysis of these plans enabled identification of the factors affecting the rate and extent of irrigation development. The determination of these two sets of factors represents the third and fourth objectives of this study.

III. SCOPE OF THE STUDY

This research report is concerned only with the microeconomic aspects of irrigation development. Such an approach is appropriate because all adjustments in resource use necessitated by irrigation must ultimately be made at the individual farm level. By examining a representative farm and analyzing the production possibilities in the area, it will be possible to provide useful information for the development of the area.

In attempting this sort of analysis, the development of the representative farm unit is extremely important. The farm used in this study is one which was developed from a survey of the farms in the area. The farm is of average size, has average levels of resources and reflects the dryland structure and organization of the area. The basic data

for the farm are similar to that used by the Pembina River Engineering Board in their report on the area.

The results from this study and studies relating to it[1] could apply to various stages of the project development. The construction of the dam and related structures would require a large fixed investment. In order to reduce the fixed cost per irrigated acre, it is important that as many irrigable acres as possible be developed. If some of the factors influencing the extent of irrigation development can be identified, then project planners would be better equipped to provide proper direction for this and/or future projects.

This study could also be used as a guide for potential irrigation farmers. The analysis of the farm plans attempts to indicate some factors which should be taken into account while planning irrigation farming. These factors could aid the farmer in realizing full irrigation potential more quickly. However, it must be remembered that the results of this study are nothing more than guides. They were derived by using a particular set of assumptions regarding prices, costs and productivity. It cannot be determined whether or not, or for how long a period of time, an individual farmer would be faced with this particular set of assumptions.

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[1] A colleague, M. Iga, is presently studying this same project area in an attempt to determine the economic value of irrigation water.

CHAPTER II

AN EXAMINATION OF SEVERAL NORTH AMERICAN IRRIGATION PROJECTS

Irrigation experience in other areas, notably the United States and Alberta, has shown that there are many problems involved in the transition from dryland to irrigation farming. This chapter will briefly discuss the manner in which some of the older irrigation projects were developed. Of particular interest will be the methods of financing development; also, the financial progress of the farmers on these projects.

I. ALBERTA

Irrigation farming in Alberta has a history dating back to 1879. The North West Irrigation Act of 1894, the forerunner of the Irrigation Districts Act, sparked the Canadian Government to implement extensive surveys on the existing projects at that time. These early surveys served as a basis for the development of future irrigation projects. The height of irrigation development in Alberta came in the late 1930's and early 1940's (21, p. 8-11).

Project Development

Without the aid of irrigation, successful agriculture would have been impossible in many areas of Alberta. Thus

colonization was closely associated with the development of most irrigation projects. Some projects were undertaken to establish new settlements, while other projects were an attempt to save existing colonies. In many instances, the cost of such projects was borne by private corporations.

The Eastern Irrigation District. This district is estimated to contain 250,000 acres of irrigable land and is the largest project in Alberta (21, p. 8). The project was constructed and managed by the Canadian Pacific Railway Company until 1935 at which time the Company transferred the project to the people of the area. Since 1935, most projects have been financed under the Irrigation Districts Act. Capital is raised by the sale of bonds issued with the irrigable lands as security, in most cases with the bonds guaranteed by the Alberta Government. A few small projects have been financed without the use of bonds but the cost of such projects was provided for fully or partially under the provisions of the Prairie Farm Rehabilitation Act.

Farmer progress. The progress of farmers on Alberta projects has varied from success and survival to disappointment and bankruptcy. Early projects were hampered mostly by the lack of proper equipment to prepare the land. This greatly slowed the rate of development and efficiency of the farms. Farms engaged in specialty cropping activities were generally most successful in that they generated more surplus

income (income for retiring debts or for farm expansion). Livestock farms also showed favorable returns while mixed farms and grain farms as a group exhibited low returns. For grain farms the "farm surplus" was a negative quantity--a deficit (21, p. 37).

In 1962, Veeman reviewed the problems of irrigation farming in Alberta. He cites five main reasons for financial difficulties (24, p. 27):

> (1) general economic conditions (trying to repay a heavy burden of capital costs during depression years); (2) limited market for crops (growing too much wheat, a highly competitive crop); (3) inefficient equipment available for grading land for irrigation; (4) inexperience in irrigation farming and management; and (5) the charging of the total cost of irrigation against the lands irrigated.

Veeman felt that the amount charged to any farmer should be within his capacity to pay. While the annual operation and maintenance costs of a project should be charged against irrigated land, a substantial part of the capital cost quite often cannot be borne by the irrigated land.

More recent problems (1950's) centered on the availability of development capital. Alberta irrigation farmers have demonstrated that they can successfully develop their farms but not on a cash basis. During the past five years, more liberal provincial and federal credit legislation has at least partially removed this last barrier to irrigation farming in Alberta.

II. SASKATCHEWAN

The South Saskatchewan River Irrigation Project is presently in its second year. Settlers are now in the crucial development stage. As progress reports are not yet available, the Saskatchewan project will not be examined in this thesis.

III. NORTH DAKOTA

There are two North Dakota projects which warrant discussion in relation to this thesis. They are: The Lewis & Clarke Project, and The Buford-Trenton Project. Voelker surveyed the farms on these projects after ten years of development (25). His findings are summarized below.

The Lewis & Clarke Project. This project was begun in 1940 (25, p. 5). By 1950, nearly all of the 4,800 acres of irrigable land had been developed. The land was purchased and developed by the North Dakota Rural Rehabilitation Corporation. The land was then subdivided into farm units which were leased to selected operators and later sold to the operators at prewar prices. A small down payment was required with the balance being amortized over thirty-nine years at three per cent interest.

The Buford-Trenton Project. This project contains 10,500 irrigable acres, 71 per cent of which were under

irrigation in 1950. Through the Bureau of Reclamation and the Department of Agriculture 88 per cent of the irrigable land was purchased, developed, subdivided, and eventually resold to selected operators. The method of sale and repayment was similar in nature to The Lewis & Clarke Project (25, p. 5).

Farm operators on both projects were categorized into two groups as follows: full irrigation farmers who farmed project land only and those who operated dry cropland in addition to irrigated land (part irrigation farmers). Full irrigators as a group had a net worth of less than $2,000 at date of settlement while the part irrigators had a net worth of over $5,000. Eight years later the situation was as follows (25, p. 7):

	Part irrigators	Full irrigators
Net worth (average)	$22,500	$9,200
Increases in net worth (average)	$ 2,900/yr.	$1,100/yr.

Most farmers did not feel that their debt load was burdensome. The land debt was spread over a long repayment period; and five year loans, sharing of machinery, and custom hiring provided machinery and livestock capital. In general, the larger the amount of starting resources, the faster the net worth grew. It should be noted that settlement took place in a period of rising prices so that about one-third of the increase in working capital was due to inflation.

These two projects have demonstrated that farmers with few resources can become established on a new irrigation project if sufficient credit and certain advantages are available (and if prices are favorable). Government predevelopment and resale of the irrigable land provided a convenient mechanism for extending real estate credit, for efficient subdivision of land, and served as a check against land speculation. However, this method had the disadvantage of tending to discourage the use of private capital in the development of the projects.

Voelker pointed out that it was not necessary to have a government land acquisition and resale program. The same effect may be achieved through a government sponsored credit program with a capable engineering service available to the operator. The main concern of the credit program should be that sufficient resources for a properly equipped production unit be available to the operator.

IV. MONTANA

A further United States example is the Lower Marias Federal Reclamation Project in north-central Montana. The project farms were privately owned and had been used successfully for the production of dryland crops in previous years. At its initiation in 1950, the project had 70,000 acres of potential irrigable land. The original plan for the project called for the irrigation of a block of 10,000 acres per

year starting in 1959.

The construction of the dam and distribution system was provided by the Bureau of Reclamation. For projects of this nature a maximum development period of ten years is allowed before repayment of construction costs begins. However, operation and maintenance charges are levied during the development period.

Of particular interest for the purpose of this thesis, are studies conducted in the Lower Marias area by Stewart (22) and his colleagues. Their investigation dealt with the first ten years after water became available to the farms. Using a farm representative of the area they attempted to estimate capital requirements and credit needs, and to derive expected incomes under different theoretical conditions of development. They outlined the development process step by step for five different plans over a ten year period. The objective of their budgetary analysis was to outline plans for efficient and profitable irrigation farms.

Four owner-operated plans were considered (22, p. 24).

1. Development Plan I. Owner-operated. Cash crop-livestock. No basic restrictions on capital for land development and farm operation. This plan assumes accelerated development. The total acreage will be irrigated the first year.

2. Development Plan II. Owner-operated. Cash crop-livestock. Restricted capital supply for land and building development. Under this plan the farm family will do much of the development work. Seven years will elapse before all the land is cropped under irrigation.

3. Development Plan III. Owner-operated. Cash crop-livestock. Restricted supply of operating capital. Under this plan, the land will be developed rapidly. Capital limitations will delay the time when the farm is fully equipped and has a livestock unit as large as that under Plan I.

4. Development Plan IV. Owner-operated. Cash crop. No basic restriction on capital for land development and farm operation. The distinctive feature of this plan is emphasis on cash crops and ommission of a livestock enterprise.

Stewart concluded that for the ten year period net income would be largest under Plan I. Net cash incomes for the four plans would average $3,892, $2,869, $2,413 and $3,480 respectively. Incomes under Plan IV would exceed those under Plan I in the early years. It would not be until the later years that the livestock enterprise would have developed and be more profitable than the cash crops.

TABLE II-1

PROJECTED (TEN YEAR) OWNER-OPERATED PLANS OF QUARTER SECTION IRRIGATION FARMS ON THE LOWER MARIAS PROJECT, MONTANA

Plan	Average yearly net cash income	Average yearly management and labor income	Hourly returns	Ten year gains in net worth	Total assets	Return to capital	Average residual return on new farm capital
1	$3,892	$2,612	61¢	$18,950	$32,911	$1,515	4.6%
2	2,869	2,036	51¢	14,796	32,185	927	2.8%
3	2,413	1,530	40¢	6,202	25,738	244	0.9%
4	3,480	2,414	96¢	15,548	21,866	1,900	8.7%

Farmers operating under Plans II and III would probably have difficulty in surviving during the first three or four years. Using Plans I and IV would provide higher income and

lower development cost. Under these plans the operator could make greater use of technical knowledge and large-scale equipment. Thus, more managerial resources could be directed towards farm production.

The critical resource required for accelerated development was capital. Stewart suggested that most Lower Marias farmers would be unable to obtain sufficient credit to provide the necessary capital. Many previous irrigation projects have failed as a result of poor organization. Thus many lenders hesitate to deal with irrigation projects until they have become fully developed. Stewart felt that accelerated development shows sufficient merit to warrant an attack on such credit obstacles.

V. IMPLICATIONS FOR THIS STUDY

The above review provided many useful guides for this study. In many areas of Alberta, the arid climatic conditions made dryland farming virtually impossible. However, irrigation farming was hampered by the lack of proper equipment and development capital to prepare the land.

Stewart (22) suggested that in Montana, large scale equipment was available to the irrigators, but not the necessary capital. He pointed out that rapid development was possible only if the farmers could borrow a sufficient amount of capital.

The success of the two projects in North Dakota

indicates the type of development period that is possible if sufficient resources and proper conditions are present. The farms were predeveloped and subdivided into efficient irrigation units. The long debt repayment period helped to relieve the farmers' yearly debt burden.

The availability of borrowed capital appears to be the most important factor affecting development. If sufficient capital is available, then development can take place at a faster rate. Thus, the potential productivity of land and water resources can be realized more quickly.

CHAPTER III

A REVIEW OF AGRICULTURAL CREDIT IN CANADA

The use of agricultural credit has been steadily increasing over the years. This chapter will discuss some of the terms, uses, and sources of credit with special reference to irrigation in the Winkler area.

I. THE IMPORTANCE OF CREDIT

The technology of modern day agriculture has made credit an essential instrument. To the extent that credit facilitates capital accumulation, it also controls economic activity. It may be used to purchase productive land and livestock, labor-saving equipment, high utility buildings, and essential farm supplies. To be effective, credit must be coupled with proper management. This will ensure proper direction and timing of the appropriate type of credit.

Credit use is often governed by two restrictions: internal rationing and external rationing. The latter implies that lenders prefer to restrict the amount of credit they wish to extend. Internal rationing rests with the borrower and implies that he will not borrow to the extent that the market allows. The borrower may prefer to use only internal funds which may or may not be sufficient. For the purpose of this study it was assumed that there was no internal

rationing, or that internal rationing allowed the use of more credit than was available. This does not preclude the possibility that the available credit is sufficient.

The discussion in Chapter II indicated the importance of credit for beginning irrigation farmers. In preparation for surface irrigation, it is usually necessary to level the land. If this is to be done efficiently, large scale equipment must be hired. Structures such as culverts and control gates must be purchased and installed. To prepare the fields for cropping, certain irrigation machines such as a ditcher, a leveler, and a two way plow must be used. Also, crop production becomes more expensive with irrigation. In order to reap the benefits of irrigation it is necessary to increase such variable inputs as fertilizer, chemicals and labor. It is quite unlikely that many beginning irrigation farmers would be able to meet such costs on a cash basis.

II. THE NATURE AND SOURCES OF AGRICULTURAL CREDIT

It has been estimated that the amounts of various types of credit extended to Canadian farmers have more than doubled during the past seven years (19, p. 14). Table III-1 contains an estimated breakdown of farm credit according to its source and term for the years 1960 to 1967 inclusive.

Short term credit. This name is applied to loans which mature in eighteen months or less. Such loans are used

TABLE III-1

ESTIMATED FARM CREDIT EXTENDED IN CANADA, 1960 to 1967

Source and term of credit	Estimated farm credit extended								Per cent of credit extended 1967
	1960	1961	1962	1963	1964	1965	1966	1967	
	millions of dollars								per cent
Long term (over 10 years)									
Farm Credit Corporation	52.3	68.9	78.4	96.3	139.8	201.7	234.4	251.2	11.5
Veterans' Land Act	19.4	15.2	15.7	18.2	15.9	21.1	33.6	31.3	1.4
Provincial government agencies	37.0	38.1	39.0	40.4	49.4	47.8	51.4	63.6	2.9
Private individuals	7.0	8.0	8.0	9.0	10.0	11.0	12.0	16.0	0.7
Insurance, trust and loan companies	3.0	4.0	5.0	6.0	7.0	8.0	10.0	13.0	0.6
Treasury Branches (Alberta)	1.6	1.6	1.4	1.2	0.3	0.6	0.8	0.8	0.0
Railway and land companies	0.4	0.4	0.2						
Total long term	120.7	136.2	147.7	171.1	222.4	290.2	342.2	375.9	17.1
Intermediate term (18 months to 10 years)									
Banks (FILA)	101.9	108.1	118.1	136.0	150.8	202.7	212.8	203.7	9.3
Private individuals	75.0	78.0	79.0	85.0	95.0	108.0	120.0	134.0	6.1
Supply company finance	29.0	27.0	28.0	30.0	32.0	34.0	38.0	43.0	1.9
Insurance, trust and loan companies	0.5	1.0	2.0	2.0	3.0	3.0	4.0	4.0	0.2
Industrial Development Bank		0.2	0.4	4.8	5.9	7.1	6.9	6.1	0.3
Credit Unions	4.0	7.0	20.0	37.0	51.0	61.0	74.0	90.0	4.1
Municipal (Ontario T.D.A.)	1.3	1.3	1.4	1.6	1.9	1.8	2.2	2.5	0.1
Finance companies (cars and trucks)	8.0	9.0	11.0	12.0	14.0	15.0	15.0	16.0	0.7
Treasury Branches (Alberta)	0.3	0.3	0.4	0.2	0.3				
Sodco (Saskatchewan)					0.1	0.4	0.5	1.0	0.0
Total intermediate term	220.0	231.9	260.3	308.6	354.0	433.0	473.4	500.3	23.0
Short term (up to 18 months)									
Banks (non FILA)	302.0	363.0	428.0	491.0	541.0	574.0	618.0	733.0	33.6
Supply company finance	237.0	245.0	256.0	271.0	267.0	307.0	311.0	348.0	16.0
Credit Unions	51.0	63.0	72.0	75.0	75.0	72.0	70.0	69.0	3.2
Finance companies (household and personal)	6.0	8.0	9.0	10.0	12.0	13.0	14.0	15.0	0.7
Dealers, stores, etc.	25.0	24.0	22.5	21.0	19.5	18.0	19.5	15.0	0.7
Private individuals	55.0	62.0	71.0	77.0	85.0	90.0	95.0	110.0	5.0
Treasury Branches (Alberta)	8.0	9.5	12.0	14.2	12.5	13.5	12.7	13.1	0.6
Total short term	684.0	774.5	870.5	959.2	1,032.0	1,087.5	1,140.2	1,303.1	59.8
Total all credit	1,024.7	1,142.6	1,278.5	1,438.9	1,608.4	1,810.7	1,955.8	2,179.3	99.9

Source: R.S. Rust, Canadian Farm Economics, Vol. 3, No. 4, October 1968.

to pay the operating costs incurred during production (fertilizer, fuel, repairs, etc.) and are repaid when the products have been marketed.

The major suppliers of short term credit have been the banks (Non-Farm Improvement Loan Act) and supply company finance. The maturity dates on bank loans vary from simple ninety-day notes to one-year notes. The funds are transferred to the use of the borrower when the note is approved; the note requires a lump sum repayment at maturity.

Intermediate term credit. Bank credit is also important in the intermediate term credit area (eighteen months to ten years). Most of the intermediate term bank loans are granted under the provision of the Farm Improvement Loan Act (FILA) passed in 1944. Under this Act the total outstanding loan at any time cannot exceed $15,000 or, if it is a loan to purchase land, $25,000. The interest rate on FILA loans is presently seven and one-half per cent. This rate is periodically revised in accordance with the bank rate. When an operator wishes to borrow an amount greater than $15,000 (non-land loan) it may be necessary for him to apply for a non-FILA loan. In this latter case the operator would have to submit a farm budget to the bank's agricultural credit department. Non-FILA loans are often granted at a slightly higher rate of interest, but they make it possible to obtain larger amounts of credit and more complete financing. Many

banks presently offer package-deal loans. Such loans provide short and intermediate term financing as required by the borrower.[1]

Long term credit. This type of credit is usually designated as a loan secured by a real estate mortgage with repayment extending up to twenty-five years or longer. Payments are usually annual and include payment of interest and a portion of the principal.

The major source of long term farm credit is the Farm Credit Corporation (FCC, Table III-1). Recently the Canadian Government passed legislation that has revamped some of the regulations guiding FCC. As it is not known what the effect of this legislation will be, this study will proceed on the basis of previous regulations.

FCC has two types of loans (5): Part II or standard loans and Part III or package-deal loans. Loans under Part II of the Act are first mortgage loans of up to $40,000 or 75 per cent of the appraised value of the farm lands, whichever is less.

The maximum amount of the loan under Part III is $55,000 or 75 per cent of the appraised value of land, livestock and equipment. At least 60 per cent of the necessary

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[1]The author is deeply indebted to Mr. Don Gibb of the Agricultural Department of the Royal Bank of Canada for information regarding banking activities.

security must be in land and not more than 25 per cent may be in equipment. The interest rates on these two types of loans vary in accordance with the bank rate. The repayment period cannot exceed 30 years. Loans from FCC may be used for many purposes: buying land, erecting buildings, purchasing basic-herd livestock, and making improvements on the land.

III. CREDIT FOR IRRIGATION FARMS

Credit availability for irrigation farms has been a problem in the past. This has been especially true for United States projects. The experience of irrigation farmers in Alberta has indicated that a similar problem has existed in Canada. However, the agricultural credit field has changed considerably during the last five years.

Representatives from a bank and FCC were interviewed in order to determine the views of these two lending agencies with respect to credit for irrigation farmers. Irrigation development is one of the purposes for which FCC can lend money. A rule of thumb for estimating the upper limits of FCC loans is given in Table A-7 of Appendix A. FCC loans would have to be secured by a first mortgage on the land. The maximum repayment period for such a loan would be thirty years.

It was indicated by the bank representative that his bank would lend money to a beginning irrigation farmer just as readily as to a dryland farmer. The amount of credit

extended would be guaged by the estimated potential of the farmer and the farm. On this basis a line of credit could be established.

Both representatives pointed out that credit would be an effective tool on a beginning irrigation farm only if coupled with proper management. A farmer that was unfamiliar with irrigation would probably require technical assistance. The representatives expected that irrigation information would be available from various government agencies.

CHAPTER IV

SOME THEORETICAL CONSIDERATIONS

In this study a representative farm firm was analyzed for the purpose of describing the economic nature of irrigation development. Capital accumulation in the form of irrigation development is the essence of the analysis. This chapter will present a brief discussion of the conceptual framework on which this study rests. The discussion centers on capital and economic activity in relation to time. It will be shown that the multi-period programming technique can be used to help describe economic activity over time.

I. CAPITAL AND TIME

Capital may be thought of as an asset capable of producing income or as a fixed factor of production. Capital goods (such as land and machinery) can be combined with variable inputs (such as labor and seed) to produce other economic goods (for example, wheat). These goods can be sold to provide income.

Capital consists of capital goods and capital value. The latter is simply discounted future income, while the former consists of the asset or property. The value of capital depends on its potential productivity or the future net income it can produce. The link between income and

capital is the rate of interest (6, p. 13). The interest rate is used in computing from present to future values (compounding) and from future to present values (discounting).

Keynes relates the rate of interest to capital through his marginal efficiency of capital schedule (13, p. 135). The marginal efficiency of a particular asset is the rate at which the anticipated yield from an additional unit of that asset must be discounted if it is to equal the cost of the asset.

The process of discounting future income is of importance to the analysis of this study. By discounting expected future income, the value of capital over time can be estimated.

II. ECONOMIC ACTIVITY AND TIME

Economic analysis often employs conceptual models to explain economic activity. Samuelson classified economic models into two major categories with respect to time: (1) static models and (2) dynamic models.[1] The former are timeless and assume instantaneous adjustment to changes in the economy (or firm) during the period of observation. They define an equilibrium position but do not indicate how such a position is achieved. On the other hand, dynamic models

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[1]A more detailed discussion on classification of economic models is given by P.A. Samuelson in (20, p. 315-317).

consider the way in which forces produce change in an economic system and the path that the system follows.

The static theory of the firm has been useful in dealing with many microeconomic problems. In studying growth and capital accumulation, static theory is insufficient. With respect to static and dynamic models, Plaxico states (18, p. 12):

> By omitting time as a variable, one may greatly simplify conceptual and empirical models. At the same time, one tends to ignore (assume away) certain practical important problems of production timing, capital acquisition and accumulation, transitory resource efficiency, and the impact of a decision in one time period on production opportunities and choices during subsequent periods.

Basically, this study employs the Hicksian concept of economic dynamics (10, p. 5). Hicks suggests that in a dynamic context, the quantity to be maximized by a firm is the present value of the stream of expected future returns. Baumol classifies the Hicksian approach as statics involving time rather than dynamics. Baumol's concept of dynamics identifies a cause-effect idea which relates preceding and succeeding events (1, p. 4).

In this study, Baumol's concept of dynamics will be added to the Hicksian approach. A more realistic representation of the dynamics of a farm firm is obtained by considering its operation over a number of production periods. In such a situation, production in any given period is often closely interrelated with past years; each of these years may be part

of an overall objective (for example, maximizing discounted future returns).

Capital Accumulation

Economic activity can produce goods for consumption and/or investment (capital goods). In any given production period a choice must be made. How much is to be consumed now and how much is to be reinvested in economic activity? Reinvestment (capital accumulation) may lead to higher consumption in the future thus providing a reward for postponement of consumption.

The accumulated capital of a firm represents economic activity and decisions from the past. As mentioned previously, capital may be described as a stock or fund. This fund which is handed down to succeeding production periods is the most important link that is available to relate production periods over time.

The ability of a firm to generate net income depends on the capital already accumulated (the resource base). The rate of capital accumulation depends on the allocation of this net income between consumption and investment. Figure 4:1 depicts choices and growth over time. Let Xa on the horizontal axis represent capital accumulation and Xc on the vertical axis represent present consumption. PP_1 is an iso-resource curve representing the possible combinations of production for present consumption and capital accumulation.

II_1 is an indifference curve indicating the firm's choices with respect to Xa and Xc. The point of tangency, E_1, specifies the optimum allocation of resources between present consumption (Oc_1) and capital accumulation (Oa_1) for period one.

PP_2 is an iso-resource curve representing the possible combinations of production for present consumption and capital accumulation in year two if Oa_1 production for capital accumulation and Oc_1 for present consumption were produced in year one. Similarly, II_2 is an indifference curve expressing the firm's desire with respect to present consumption and capital accumulation during year two given the above allocation in year one. The optimum allocation in year two is then at E_2.

If we have T years, there are T optimum production possibilities curves, T indifference curves, and a series of T tangency points between them. The line joining these points, OG, represents a growth path over time for a given technology and appropriate indifference curves. At each equilibrium point on the growth path we have the condition $\frac{dXc}{dXa} = \frac{dX^1c}{dX^1a}$ where $\frac{dXc}{dXa}$ is the slope of the production possibilities curve PP_t, and $\frac{dX^1c}{dX^1a}$ is the slope of the indifference curve II_1.

It should be noted that in a dynamic system a decision made during one time period becomes a legacy for subsequent time periods. Thus there is only one optimum growth path available to a particular economic firm. There are, however,

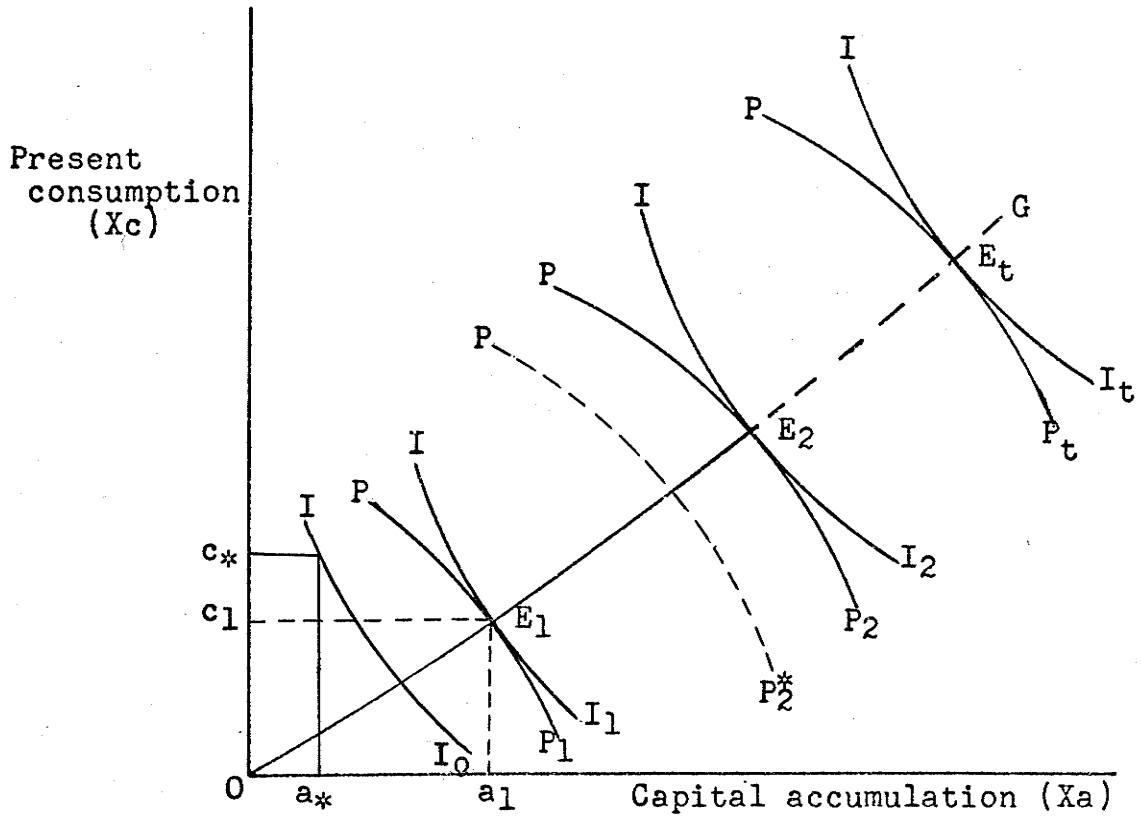

FIGURE 4:1

OPTIMUM GROWTH OVER TIME

an infinitely large number of possible growth paths which do not represent optimal resource allocation over time (18, p. 14).

It is possible to have an indifference curve II_o which lies below II_1 but this will result in a lower satisfaction in year one and a lower production possibilities curve in year two. For example, a combination such as Oc_* for present consumption and Oa_* for capital accumulation would be possible but would result in a lower level of satisfaction. Also, the resulting production possibilities curve in year two, PP_2^*, would lie below PP_2. Thus the choice made in year one would affect the alternatives in year two. Such a conclusion could be generalized over T years.

The above discussion is a brief presentation of the conceptual basis for this study. Irrigation development is used to represent capital accumulation. Land that is developed for irrigation in any given year, is available for growing irrigated crops in each future year. The greater the amount of land that is developed in year t, the higher the level of the production possibilities curves will be in the years to follow. The objective of the model in this study is to maximize the present value of future net income for twenty years with consumption at a fixed level.

III. MULTI-PERIOD LINEAR PROGRAMMING

The analytical model used in this study is multi-period

linear programming. This technique is a subspecies of linear programming and has often been called dynamic linear programming. Because of the restricted sense given to the word "dynamic", in this study, the expression "multi-period" will be used instead.

The relationship of multi-period linear programming to conventional linear programming is similar to that of Hicksian dynamics to pure economic statics. Static linear programming specifies an optimum organization of resources but does not specify the path required to attain this organization. Multi-period programming provides for a static analysis embedded in a framework where time is considered as an additional factor. Furthermore, this technique does not ignore the structure of the system. In the model for this study, capital is generated and/or accumulated to be made available in future years. A decision made in earlier periods is binding on alternatives in the later time periods.

From the programming point of view, the two models are the same. The assumptions and mathematical formulation are similar.[2] Both involve the maximization of a linear objective function subject to certain linear inequalities.

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[2]For further details regarding the assumptions and algebraic bases underlying both multi-period programming and the conventional technique, the reader is referred to the following references listed in the bibliography: (8), (9), and (14).

Although it is a relatively new concept, multi-period programming has been applied in numerous ways. In 1955 Swanson (23) published his model which he described as an attempt to deal with planning over time. He developed a model with crop rotations and livestock enterprises represented over a five year period. Year two was a transition year in that certain fixed assets could be purchased in that year. While some activities extended over the entire five year period, others were represented only in the transition year, and still others extended over the years following the transition year.

Loftsgard and Heady demonstrated a more detailed version of the same technique (14). They introduced the firm-household interrelationship in a model allowing annual expansion of hog production on a farm with a fixed acreage.[3]

Formulation of the Model

As the name implies, multi-period programming takes the time dimension into consideration. Restrictions and activities are distinguished for each of the periods considered. In a plan with T years, the objective is optimized by specifying the plan for each individual year that is most profitable in terms of the entire planning horizon T.

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[3]Numerous other studies have been carried out in the United States, and at least one in Canada. A partial list of such studies includes: (2), (12), (14), (16), and (23).

In a generalized form a multi-period model may be specified as follows:

$$\text{maximize} \quad PV = \sum_{t=1}^{T} \sum_{j=1}^{n} \bar{c}_j^t \; x_j^t \quad \text{(Eq. 4.1)}$$

$$\text{subject to} \quad \sum_{t=1}^{T} \sum_{j=1}^{n} a_{ij}^t \; x_j^t \leqslant b_i^t \text{ for } i=1,\ldots mT \quad \text{(Eq. 4.2)}$$

$$\text{and} \quad x_j^t \geqslant 0 \quad \text{where there are m resources and n activities in each of T years.} \quad \text{(Eq. 4.3)}$$

Equation (4.1) is the linear objective function with PV representing the summation of the discounted net returns produced by n activities over each of T years. Equation (4.2) represents the linear restraint for m resources in each of T years; equation (4.3) is an assumption specifying that the activity levels cannot be negative.

In year t, the level of activity j is x_j^t; $\bar{c}_j^t$ is the discounted net return in the objective function for each such activity; b_i^t represents the level of the i-th resource available in the t-th year; and finally, a_{ij}^t is the amount of the i-th resource required for one unit of the j-th activity in year t.

Table IV-1 illustrates the multi-period linear programming model in the conventional tableau form. The programming activities and restrictions are listed separately for each year. The sub-matrices along the main diagonal (for example, $_2A^2$), represent the input-output coefficients of

individual years. The dynamic feature of this model is facilitated by the coefficients in the lower left hand area. For example, $_1A^2$ is the sub-matrix of coefficients that results from production in year one and affects the resource levels of year two. The objective function to be maximized over T years is shown at the top of the table.

TABLE IV-1

DIAGRAMATIC REPRESENTATION OF MULTI-PERIOD MODEL

Period (year)	Restraint level (b_i^t)	x_j^t : Period	Activities: year 1	year 2	year T	: x_j^t : Period
		PV	: $c_1^1 \ldots c_j^1 \ldots c_n^1$	$\bar{c}_j^2$	$\bar{c}_j^T$	: PV
1	1 ⋮ m		$a_{11}^1 \ldots a_{1n}^1$ ⋮ ⋮ $a_{m1}^1 \ldots a_{mn}^1$			
2	m+1 ⋮ 2m		${}_1A^2$	${}_2A^2$		
T	(T-1) m+1 ⋮ MT		${}_1A^T$	${}_2A^T$	${}_TA^T$	

CHAPTER V

MODEL FORMULATION

The theoretical considerations of Chapter IV can now be coupled with the empirical problem of this study. This chapter will describe the representative farm that was used to depict the project area. The manner in which the empirical model was specified and the situations analyzed will also be described.

I. SOURCE AND DEVELOPMENT OF DATA

The basic data necessary for this study were taken from the report to The International Joint Commission by The International Pembina River Engineering Board. This three-volume report covers the entire scope of the proposed project. Included in this is an analysis of the area's anticipated economy, with and without irrigation (11).

Description of the Area

The proposed Morden-Winkler Irrigation Project is in the Pembina River Basin, approximately seventy miles south-west of Winnipeg. A reservoir on the Pembina River near Walhalla, North Dakota would be the source of water for both Manitoba and North Dakota. The Manitoba area lies east of the Manitoba escarpment in Townships One and Two, Ranges Three, Four and part of Five, west of the Principal Meridian.

Geographically, by virtue of its lacustrine origin, the area is a region of subdued landscape. The flatness of the area is interrupted only by narrow wooded channels extending from the escarpment. The soils of the area are quite fertile. Six soils, namely: Reinland, Neuenburg, Hochfeld, Gnadenthal sand substrate phase, and Deadhorse sand substrate phase and alluvium, occupy more than seventy per cent of the total area. Classification of the land for irrigation showed that fifty-five to sixty per cent of the land was type I. For surface irrigation this would imply that less than 200 cubic yards of soil per acre would have to be moved during leveling. Type II land would require that 200 to 450 cubic yards of soil be moved.

The climatic conditions permit a large variety of crops to be grown. In 1962, twenty-five different crops were produced. The major crops of the area include wheat, oats, barley, flax, rapeseed, field peas, corn, sunflowers, potatoes and sugar beets.

Agricultural Surveys

Data on the present agricultural economy as outlined in the report to The International Joint Commission came from the following sources:

1. Municipal records which gave information on land ownership, assessment, and occupancy.
2. A reconnaissance study in the project area in which every farm with its headquarters within the area was visited. This gave information on

farm size, tenure, land use, and livestock enterprises.

3. A farm business study of a sample of the 368 farms visited in the reconnaissance survey. This study obtained details on farm inventories, income, costs, labor supply and use, crop yields, and many other items.

4. Census of Canada reports and statistics from the Manitoba Department of Agriculture and Conservation.

On the basis of the results from the reconnaissance study the farms were stratified according to size. This is shown in Table V-1.

TABLE V-1

STRATIFICATION OF FARMS ACCORDING TO SIZE

Size-Group (Total acres)	Reconnaissance study (number of records)	Farm business study (number of records)
Less than 10	32	not sampled
10-69	77	19
70-149	54	22
150-239	87	20
240-399	71	29
400-759	40	22
More than 759	7	not sampled
Total records	368	112

One significant feature of the present farm economy is the small average size of farms. The reconnaissance study showed the average size of the 368 farms in the project area was only 218 acres, compared with 419 acres for the Province of Manitoba in 1961. Farms with 239 acres and less accounted for 67.8 per cent of all farms in the area. These farms, although small, are strong and viable.

Present Organization of the Farms

Land use. The land in the project area is quite arable and generally about 90 per cent of it is improved and under cultivation. Allowing for variations that occur from year to year (resulting from operator adjustments for climatological conditions, markets, and other factors) there are several significant points with regard to land use:

1. The amount of summerfallow in this area is low in comparison to other prairie areas. Historically it has been at a level of ten to fifteen per cent and is decreasing.

2. Grain crops and flax use the largest amount of land. Only a small amount of these crops are used as feed.

3. Fodder crops and improved pasture account for about ten per cent of the land use.

4. The cropping pattern includes a significant proportion of specialty cash crops such as sunflowers, sugar beets, potatoes and field peas.

Livestock organization. The high proportion of arable land and lack of low cost pasture has restricted grazing livestock. The cattle operations in the area are generally for domestic use. Most of the farms have a small hog enterprise.

Crop yields. A number of sources were used in estimating dryland crop yields. These sources included a field survey, Manitoba Department of Agriculture statistics, and records from the Manitoba Crop Insurance Corporation.

Irrigated crop yields were estimated by soils and crops specialists by reference to the area and existing irrigation projects. These data and other data pertaining to the area are contained in Appendix A.

II. THE EMPIRICAL PROBLEM

The above section attempted to depict the area as a whole. For the purpose of this analysis it was necessary to determine a single farm unit with which to work. Accordingly, a farm was structured on the basis of the area. Wherever the survey data were not detailed enough to enable the mathematical specification of the representative farm, outside sources of information were used.

A number of terms associated with multi-period programming are used in describing the model formulation. For those who are unfamiliar with this technique, some of the important terms are explained below.

The term activity refers to a particular set of assumptions regarding an enterprise. For example, growing wheat using two different levels of fertilization represents only one crop enterprise (growing wheat). However, in order to program this enterprise, two activities must be used (one for each rate of fertilizer application).

The terms restriction, restraint and resource are used interchangeably. Each farm resource represents a

programming restriction or restraint. Input-output coefficients specify the amounts of the various resources that are required for one unit of an activity. Finally, the net income from each unit of activity represents the amount that activity adds to the objective (directly or indirectly).

To facilitate analysis, a model, which represents the farm to be analyzed, must be constructed. To specify such a model mathematically implies that the quantities of resources, the input-output coefficients of each enterprise, and the amount which each enterprise contributes to the objective must be stated in absolute terms. Assumptions regarding technology and market conditions must be fully identified.

The Objective

The objective for all programs used in this study was to maximize the sum of the present value of net revenues from all production over a twenty year period using a six per cent discount rate. While fixed costs are accounted for in the model, they are not deducted from the objective. The analysis in Chapter VI treats these costs separately.

Resource Restrictions

The resource base of the study farm represents the starting situation before irrigation. This base includes all the fixed and variable resources that make up the dryland unit. A list of these resources is found in Table

TABLE V-2

RESOURCE RESTRICTIONS

Item	Unit	Level
LAND		
Cultivated acres owned	ac.	230
Available to rent	ac.	230
Type I for irrigation	ac.	128
Type II for irrigation	ac.	44
Beginning fallow level	ac.	30
LABOR		
Operator and family		
Spring (April, May)	hr.	862
Summer (June 1-Aug. 15)	hr.	1,217
Fall (Aug. 16-Sept. 30)	hr.	570
October	hr.	358
November and December	hr.	376
Winter (Jan. 1-Mar. 31)	hr.	560
CAPITAL		
Beginning short term	$	2,000
Short term borrowing	$	20,000
Long term borrowing	$	20,000
MARKETING QUOTAS		
Specified acreage	bu./ac.	9

V-2. Their importance to this study is described in the following paragraphs.

Land. In accordance with the small farms of the project area, a 240 acre farm was used. Allowing 10 acres for a farmstead and waste left 230 acres of cultivated land. In order to establish a basis from which to start, it was assumed that there were 30 acres of summerfallow and 200 acres of stubble land in the first year. In certain of the programming situations, additional dryland could be rented.

It was assumed that there were 128 acres of type I irrigable land and 44 acres of type II irrigable land. When land is developed, approximately ten per cent of its area is taken up by irrigation structures and ditches. Thus, for each acre of land developed, ninety per cent of it is available for growing crops.

Labor. The labor supply for this farm was comprised chiefly of operator and family labor. Additional labor could be hired throughout the summer and fall season as necessary. Labor was classified according to season and, in addition, there was an operator labor restraint. Supervision of activities and certain overhead tasks requiring the attention of the farm operator made use of this resource. October labor is distinguished from the harvest period. Land development and the tillage of stubble land took place during this period.

Capital. Two capital restrictions were used, namely, long term and short term. Long term capital provided funds for the development of land and for the purchase of irrigation machines. The short term restriction represents the operating capital necessary to finance production. It was assumed that if short term borrowing was possible, the operator would have $2,000 of his own in year one. If borrowing was not allowed, the operator would have $4,000 of his own operating capital in year one. The maximum amount of long term credit available for this farm was estimated to be approximately $20,000. The calculations used to estimate this maximum are given in Table A-7 of Appendix A.

Grain quota. For some of the plans, the grain quota was nine bushels per specified acre while for others it was made unlimited. Specified acreage includes the total number of farm acres devoted to wheat, oats, barley, summerfallow and forages. It excludes all cash crops such as sugar beets, potatoes, sunflowers, flax and field peas. Maximums were placed on the acreages of the cash crops to reflect crop rotation and market limitations. These maximums are described in later sections.

Machinery. Although there is no machinery restriction in the model, there is a limit to the amount of machine time available. The machinery complement on this farm was

depicted as being sufficient to accommodate a land base of up to 460 acres. The description of this complement is in Appendix B. Irrigation equipment is not initially present on the unit.

There are still some restraints that have not been mentioned. These will be discussed below in relation to the activities with which they are associated.

Programming Activities

The second step in the specification of a model is to select the various possible relevant enterprises. The specification of these enterprises will provide the programming activities of the model.

Crop activities. Crop enterprises were treated on an individual crop basis rather than by the use of rotations. This method allowed more flexibility in the land use pattern and avoided the problem of dealing with a solution that changed from one rotation in one year to another rotation in the following year.

Both irrigated and dryland activities were considered for each crop. The crops considered were: wheat, oats, barley, flax, sugar beets, potatoes, sunflowers and field peas.

A typical activity would be of the following nature. Assume the crop is wheat grown on dry stubble land. It

would require one acre of stubble land, various types of labor (spring, summer, fall, operator's overhead labor) and some operating capital. It would add wheat to the wheat supply and add an acre to the stubble land supply for the following year. The activity for growing irrigated wheat would be similar except that it would require irrigated land and water.

Since activities for growing certain crops on summerfallow were considered, a summerfallowing activity was included. This activity required that land remain idle for one year and become available the following year via the summerfallow supply.

Forage activities. As it is rather impractical to allow forage production for single years only, it was necessary to use a different approach for these crops. A three year production cycle was adopted; one year old forage fields had to be distinguished from two and three year old fields. One year old forage in year n would become two year in year n+1. In year n+2 it would produce only one cut of forage and be made into sod fallow for the rest of the year. In year n+3 this land would be treated as summerfallow ready for crop production.

Corn silage was treated on a single year basis and also contributed to the hay supply. On the basis of total

digestible nutrients per pound, its yield was converted to a hay (alfalfa-brome) equivalent. Silage yields were 4.5 and 6 tons for dry and irrigated land respectively. When converted to a hay equivalent these yields were 5.4 and 7.2 tons respectively.

Livestock production. Four livestock activities were developed: (a) one hog activity based on two litters a year per sow and (b) three feeder cattle activities. The lengths of the feeding periods for the cattle were 260 days, 210 days and 142 days. These activities are described more fully in Appendix B, Tables B-10 and B-11.

Marketing activities. Each of the crop activities contributed to its respective supply of produce and contributed negative amounts to the objective (equal to the variable costs). In order to facilitate the sale of these products, marketing activities were necessary. These activities added positive amounts to the objective and to the supply of generated capital. Employing this method allows the possibility of selling a given crop through more than one marketing channel.

Miscellaneous activities. Activities were also necessary to provide for the purchase of irrigation water if and when development took place. Four labor hiring activities corresponding to spring, summer, fall and October labor were

included. The amount of hiring allowed was varied for some of the plans.

The purchase and repayment of short term capital required two separate activities. The interest rate on short term capital was assumed to be eight and one-half per cent per annum.

A land proportionality activity was used to designate cash crop maximums. These maximums were necessary for two reasons. Crops such as potatoes and sugar beets cannot follow each other in the rotation. Thus, maximums were used to ensure a more appropriate land pattern. Furthermore, the cash crops are sold in a limited market. Potatoes and sugar beets are usually grown under contract.

Special activities. In order to provide the dynamic features of the multi-period program, an inter-year income transfer activity was introduced for every year. After fixed costs and loan repayment were met, the balance of the income could be transferred to the following year. It was assumed in this study that all income remaining after payment of fixed costs (depreciation, taxes, family living expenses) was available to be re-invested into the farm business. Off-farm investments were not considered.

One important objective in this study was the determination of the rate at which land would be developed for the purpose of irrigation. Thus, two development

activities were used; one developed type I land and the other developed type II land. Each contributed to the supply of irrigated land and thence the two types of land were treated in the same manner. In some plans the cost of development was amortized over thirty years at six per cent interest while in others, land was developed on a cash basis.

Coefficients

After having determined the restraints and activities, it was necessary to develop a set of input-output coefficients for each enterprise and resource. This involved specifying the amount of each resource required by one unit of each enterprise.

These coefficients are developed in Appendix B, and the first year of the programming matrix is summerized in Appendix C. The coefficients were designed to reflect average management and are single valued (known with certainty).

Prices and Budgets

To complete the specification of the model, it was necessary to make assumptions regarding prices and costs. It is difficult to choose appropriate prices when dealing with plans for the future. There are three factors that must be taken into account in such plans. Two important

factors are the movements of prices paid and prices received. The third factor is farm productivity. The assumption made in this study is that over time these factors will move in such a manner that the choices between activities will remain unchanged. Furthermore, this study does not attempt to estimate exact future income. It is intended to serve as a guide; it indicates some factors that affect irrigation development. On the basis of the above assumptions, average current prices for factors and products were used. Prices and enterprise budgets are presented in Appendices A and B.

III ANALYTICAL PLANS CONSIDERED

In order to examine the objectives stated in the first chapter, an appropriate framework is required. The representative farm described above, as specified in the form of a multi-period model, provides such a framework. By varying the assumptions regarding certain restraints and activities a series of analytical situations can be developed. The optimal solutions for each situation can be compared to identify the effects of the different assumptions.

Thirteen situations or plans were developed in this study. Each plan was extended over a period of twenty years. Assumptions with respect to short term credit borrowing, the price of water, the hiring of labor, availability of markets, and development costs repayment were varied. The specific

plans are described below. For all plans, except 11 and 12, the major activities are crops and hogs. In plans 11 and 12, the hog activities were replaced by feeder cattle activities.

1. Plan 1. For this plan it was assumed that the maximum amount of short term borrowing was $8,000. Two prices for irrigation water were assumed. A charge equivalent to the annual project operation and maintenance cost per acre was used for water during the first ten years. This charge was estimated to be $4.40 per acre foot. For the remaining ten years a charge of $10.00 per acre foot was used. This rate reflected operation and maintenance costs plus capital repayment. The amounts of fall and October labor that could be hired were unlimited, but summer labor hiring was limited to 1,200 hours. The grain quota was nine bushels per specified acre and the allotment for cash crops was at a high level in this plan. The two levels for cash crops are explained at the end of this chapter.

2. Plan 2. This plan was the same as plan 1 except that the amount of summer labor that could be hired was increased to 2,000 hours.

3. Plan 3. This plan was the same as plan 2 except that a single water price ($4.40) was used for the entire twenty year period and the allotment for cash crops was lowered.

4. Plan 4. This plan assumed a $4,000 limit on short term borrowing. Otherwise, the assumptions are as in plan 3.

5. Plan 5. No short term borrowing was possible in this plan. The grain quota was unlimited.

6. Plan 6. For plans 1 to 5, it was assumed that irrigation development was amortized over a thirty year period. It was assumed to be on a cash basis for plans 6 to 10. In plan 6, $4,000 of short term borrowing was allowed, a single water price was used and labor hiring was as in plan 2. The grain quota was restricted.

7. Plan 7. This plan was the same as 6 except that $10,000 of short term borrowing was allowed.

8. Plan 8. The same as plan 6 with $20,000 of short term borrowing.

9. Plan 9. This plan was the same as plan 8 except that the grain quota was unrestricted.

10. Plan 10. This plan was the same as plan 9 except that additional dryland could be rented at a cost of $10 per acre.

11. Plan 11. For this plan it was assumed that development repayment was amortized, $20,000 of short term borrowing was possible and that the cattle activities were included instead of the hog activity. Grain quotas were unlimited.

12. Plan 12. This plan was the same as 11 except that the grain quota was restricted.

13. Plan 13. For this plan two prices of water were used as in plan 1, $20,000 of short term borrowing was allowed and the hiring of all labor was restricted. The amount of hired labor could not exceed the amount of family labor already available on the farm.

As mentioned above, cash crops were limited to specified percentages of the total land base. Two alternative upper limits were used. In plans 1, 2 and 13, the maximums in terms of proportion of total acreage for these crops were .50 for sugar beets on fallow, .65 for sugar beets on stubble, .33 for flax, and .25 for field peas, potatoes and sunflowers. For the remaining plans the maximums were .50 for flax and .15 for all sugar beets, sunflowers, potatoes and field peas. It should be noted that some of the above maximums are mutually exclusive.

The assumptions in the thirteen plans by no means exhaust the total possible number of assumptions. As it was not practical to consider all such assumptions, only

those that appeared to be more important were chosen. The optimal solutions for the plans are presented in the following chapter.

CHAPTER VI

RESULTS AND ANALYSIS OF FARM PLANS

The optimum or most profitable solutions for the hypothetical farm plans are present in this chapter. These results are based on the assumptions outlined for each plan in the preceding chapter. The solutions are discussed with the aid of Tables VI-1 to VI-14 which are found at the end of the chapter.

Before analyzing these results it should be noted that their validity is dependent upon the following factors: (1) the selection and proper specification of the resource base and production alternatives, (2) the accuracy of the assumed input-output relationships, and (3) the validity of the prices and costs used for each of the enterprises. The interpretation of the results may not apply to a specific set of prices and resources in a specific year. Rather, these results provide a guide and indicate the direction which should be taken by the beginning irrigation farmer if he is to optimize production on his farm.

I. ORGANIZATION OF RESULTS

The results for each of the plans are presented in Tables VI-2 to VI-14. The acreages of the various dryland and irrigated crops, and the number of head of livestock are indicated. The amounts of type I and type II irrigation

land developed are also shown. They are listed in acres for the year in which development took place. The row, 'irrigated land supply' contains the cumulative total of developed land. Since development takes place in October, the land is not available for production until the following year.

The last section of each table is entitled 'financial summary'. Incomes, costs and capital borrowing are described in this section. Gross income represents the income received from the sale of the farm products for the particular year. The term, operating expense, refers to the total variable costs of production and marketing including the cost of hired labor. The 'fixed withdrawal' item has two main components: farm fixed costs such as depreciation and taxes, and a minimum amount for family living expenses. The latter may be regarded as the returns to family labor and is fixed at $4,757.00 for all years.

'Debt repayment' represents the repayment of amortized loans. Such debts are incurred when irrigation machines are purchased and when land development costs are amortized. Any short term capital that is borrowed is repaid in the year in which it is borrowed.

Gross income minus variable and fixed costs represents net income. Since an amount for family labor has already been withdrawn, this net income figure would be the return

to management and investment. In the analysis in Tables VI-2 to VI-14, this amount is designated as net returns and excludes debt repayment which is part of the return on investment. The net returns are available to be used for financing farm operations in the following year. When the farm production pattern and income levels have stabilized it is possible that only some of the net returns from one year are required for financing production in the following year. The remaining net returns then become surplus capital. This occurs only when there is no short term borrowing. The exact amount of surplus capital could not be calculated for certain years of some plans. In these instances the surplus capital represents an accumulation over a number of year(s) and the exact amount accruing in a single year cannot be estimated. For the years in which there is surplus capital, the total amount of surplus capital is less than or equal to the total net returns for these same years.

The multi-period linear programming model used to obtain the results for the plans maximized the present value of future income (discounted net income). The incomes or net returns used in summarizing the results are undiscounted. This procedure was used in order that year to year incomes could be more easily compared.

II. ANALYSIS OF RESULTS

The results of the hypothetical plans are analyzed with respect to the assumptions that were varied. Three main terms will be used in discussing the results. These may be explained as follows:

1. The transition period. This refers to the years during which development takes place. It is the period between year one and the first period during which income reaches a stable level.

2. The net returns during the transition period. The figures in Table VI-1 representing net returns during the transition period are the average net return for the particular plan.

3. The stabilized net returns. After the transition period of a particular plan, the solutions for each year were identical. Thus net returns would be the same for each year and are referred to as the stabilized net returns for the plan.

These three terms will aid in providing a more meaningful comparison of the plans.

The Effects of Variations in Short Term Borrowing

The solutions for the plans indicate that short term capital is very important during the transition period. It facilitated higher net returns during the transition period and shortened the length of this period. A comparison of the results for plans 3, 4 and 5 as shown in Table VI-1, indicates some important points. The more short term capital that was available during the transition period, the higher was the average net return. The levels of the

stabilized net returns were the same for each plan. The relationship between the borrowing limit and length of the transition period can be observed by comparing plans 6 and 10. In plan 10 ($20,000 capital) the transition period was four years while in plan 6 ($4,000 capital) the transition period was eight years.

It should be noted that increasing the amount of the fixed withdrawal would have approximately the same effect on the transition period as decreasing the short term borrowing limit. For this reason the fixed withdrawal was left constant for all years of all plans.

Effects of Variation in Grain Quotas

Two different assumptions were made with respect to grain quotas. In the one case the quota was nine bushels per specified acre and in the other case the quota was unlimited.

Quotas affect such crops as wheat, oats and barley. These crops and flax were most important during the first few years for plans in which operating capital was limited. For example in plan 4 these crops were grown without fertilizer so that capital could be rationed. Unlimited quotas supplemented the accumulation of operating capital during the transition period by facilitating the sale of these less capital intensive crops.

A comparison of the results from plans 5 and 6

suggests the effects of quotas. In plan 5 the quota was unlimited and in plan 6 it was not. Even though there was no borrowing in plan 5, the transition period was six years as in plan 4 which included $4,000 of short term borrowing. The stabilized net returns are the same in each plan.

The level of the grain quota has important effects on plans which include a beef feedlot enterprise rather than a hog enterprise. In each of plans 3, 4, and 5, the hog enterprise was part of the stabilized solution (20 sows in each case). This implies that the oats and barley crops were used to feed hogs regardless of the quota level. A comparison of plans 11 and 12 shows that this is not the case when hogs are replaced by beef feeding enterprises. In plan 11 (unlimited quota) only three beef feeders were included in the solution. On the other hand, in plan 12 (restricted quota) forty-one beef feeders were included as an outlet for barley, oats and corn silage. The difference in the stabilized net returns was $986 per year.

Effects of Changing the Cash Crop Allotment

Cash crops such as sugar beets, potatoes, sunflowers and field peas are generally more profitable than small grains and flax. They also require more labor and capital per acre. In plans 1 and 13, the levels of the cash crops were restricted by the supply of summer and fall labor. In plan 2, after the third year the only crops produced were

sugar beets, sunflowers and potatoes. With sugar beets and potatoes at levels of 136 and 60 acres respectively, the crop rotation would be undesirable due to problems of disease. The remaining plans have lower allotments for these crops in an attempt to alleviate the rotation problem.

The problem of a limited cash crop market must also be taken into account. As an example, the market for table potatoes is limited and therefore sensitive to over production. In terms of the market faced by the area as a whole, it may be necessary to reduce the allotment for potatoes. For sugar beets and sunflowers the problem is similar. These crops are usually grown under contract.

In general, cash crops were a substantial part of the cropping pattern in each plan. They were absent only when operating capital was scarce. Net returns were generally higher in the plans for which the allotment for these crops was higher.

Effects of Changes in the Price of Irrigation Water

In the plans that included a higher price for irrigation water during years ten to twenty, less land was developed for irrigation. The only irrigation in plan 2 (two water prices) was sixty acres of potatoes while in plan 3 (single water price) the entire amount of irrigable land was developed. A charge of $4.40 per acre foot for

water did not restrict the extent of irrigation.

Effects of Different Development Repayment Schemes

The two schemes for financing development that are considered in this study represent two extremes. In plans 6 to 10, land is developed on a cash basis while in the remaining plans the costs are amortized over a thirty year period. In terms of the type of commercial credit available to the farmers in the project area, thirty years is the longest repayment scheme which is available. For the plans in which the costs were amortized, the development activities decreased the objective by an amount equal to the sum of the interest charges incurred during the duration of the plan. When land was developed on a cash basis, the entire cost of development was charged in the year in which development took place. In plans 3, 4, 5, 10, 11, and 12, costs were amortized and the entire amount of irrigated land was developed. In plans 6 to 9, thirty acres of type II land remained undeveloped.

On the basis of this comparison, it is evident that the repayment scheme affects the extent to which land is developed for irrigation. Various schemes between these two extremes are possible: for example part cash and part credit. These alternative schemes may or may not facilitate the development of the entire amount of land.

Effects of Renting Land and Restricted Labor

Plans 10 and 13 require special attention. In plan 10, land renting was allowed to take place. In chapter V, it was mentioned that the maximum land base that could be accommodated by the machinery complement was 460 acres. However, in plan 10, since there was no restraint placed on the amount of land that could be rented, the total farm acreage increased to 1,023 acres. For this reason alone, plan 10 becomes unrealistic. In addition to having exceeded the available supply of machinery, the possibility for each farmer in the area to rent this amount of land does not exist. This plan was included to indicate the direction which would be taken by the farm, given the opportunity to rent additional land. When land was rented, the only irrigated crop was potatoes. The most profitable dryland crops are wheat, flax and sunflowers.

In plan 13, since labor hiring is restricted, forty-one acres of non-irrigated land remains idle for nineteen of the twenty years of the plan. This is unrealistic in terms of the practice that is generally followed by farmers.

The significance of this plan is that it indicates the importance of an adequate labor supply on an irrigation farm. On the basis of the thirteen plans analyzed, this is especially true for fall labor. The average amount of fall labor hired per year in all plans excluding plans 10 and 13,

is 880 hours. If fall labor costs $1.75 per hour, then the total cost for labor is $1,540. Thus, it would appear that the possibility of increased mechanization of harvesting should be investigated.

TABLE VI-1

SUMMARY OF ANALYSIS

Item	Unit	Plan 1	Plan 2	Plan 3	Plan 4	Plan 5	Plan 6	Plan 7
Short term borrowing limit	$/yr.	8000	8000	8000	4000	0	4000	10000
Capital borrowed	$	23053	24000	24281	17317	0	28000	36467
Quota	bu./sp. ac.	9	9	9	9	unlim.	9	9
Cash crop allotment	level	high	high	low	low	low	low	low
Water price	$/ac. ft.	4.4/10*	4.4/10*	4.40	4.40	4.40	4.40	4.40
Repayment scheme	type	amort.	amort.	amort.	amort.	amort.	cash	cash
Length of transition period	yr.	3	6	3	6	6	8	6
Acres developed	ac.	67	67	172	172	172	142	142
Transition period net return	$	7186	8981	5086	4592	2990	3030	4592
Stabilized net return	$	8804	10806	6610	6610	6610	7466	7465

*$4.40 per acre foot in years one to ten and $10.00 per acre foot in years eleven to twenty.

TABLE VI-1 (continued)

Item	Unit	Plan 8	Plan 9	Plan 10	Plan 11	Plan 12	Plan 13
Short term borrowing limit	$/yr.	20000	20000	20000	20000	20000	20000
Capital borrowed	$	55830	55830	97758	22504	23441	24241
Quota	bu./sp. ac.	9	unlim.	unlim.	unlim.	9	9
Cash crop allotment	level	low	low	low	low	low	high
Water price	$/ac. ft.	4.40	4.40	4.40	4.40	4.40	4.4/10*
Repayment scheme	type	cash	cash	cash	amort.	amort.	amort.
Length of transition period	yr.	6	6	4	6	6	6
Acres developed	ac.	142	142	172	172	172	80
Transition period net return	$	4920	4875	9963	4495	3619	3759
Stabilized net return	$	7465	7465	24954	5437	4451	4345

*$4.40 per acre foot in years one to ten and $10.00 per acre foot in years eleven to twenty.

TABLE VI-2

OPTIMUM MULTI-PERIOD SOLUTION--PLAN ONE

Activities	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Years 7-20[1]
Dryland crops (ac.)							
Sugar beets	51	39	13	77	77	77	77
Sugar beets-fallow	30	-	78	-	-	-	-
Wheat	29	50	-	1	1	1	1
Oats	-	-	-	12	12	12	12
Oats- no fert.	15	-	7	-	-	-	-
Barley	-	-	11	20	20	20	20
Barley- no fert.	26	-	-	-	-	-	-
Flax	79	2	-	-	-	-	-
Sunflowers	-	-	60	60	60	60	60
Fallow	-	78	-	-	-	-	-
Irrigated crops (ac.)							
Potatoes	-	60	60	60	60	60	60
Livestock (sows)							
Hogs	5	-	2	4	4	4	4
Development (ac.)							
Type I land	67	-	-	-	-	-	-
Irrigated land supply	60	60	60	60	60	60	60
Financial summary ($)							
Gross income	$20104.	$29293.	$38797.	$38068.	$38067.	$38068.	$38068.
Operating expense	10000.	12454.	20160.	21079.	21080.	21078.	21078.
Fixed withdrawal	7650.	7650.	7650.	7650.	7650.	7650.	7650.
Cash transferred	4454.	13107.	21079.	29882.	12276.	29882.	29882.
Debt repayment	-	536.	536.	536.	536.	536.	536.
Short term borrowing	8000.	8000.	7053.	-	-	-	-
Surplus capital	-	-	2479.	-	17605.*	-	-
Net returns	2454.	8653.	10451.	8803.	8801.	8804.	8804.

[1]Years 7 to 20 have identical solutions.

*The starred numbers in Plans One to Thirteen represent an accumulation of surplus capital from previous year(s).

TABLE VI-3

OPTIMUM MULTI-PERIOD SOLUTION--PLAN TWO

Activities	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Years 7-20[1]
Dryland crops (ac.)							
Sugar beets	38	33	130	111	136	136	136
Sugar beets-fallow	30	-	-	25	-	-	-
Wheat	67	24	16	-	-	-	-
Oats- no fert.	35	12	-	-	-	-	-
Barley- no fert.	60	22	-	-	-	-	-
Flax	-	57	-	-	-	-	-
Flax- no fert.	-	22	-	-	-	-	-
Sunflowers	-	-	-	34	34	34	34
Fallow	-	-	25	-	-	-	-
Irrigated crops (ac.)							
Potatoes	-	60	60	60	60	60	60
Livestock (sows)							
Hogs	11	4	-	-	-	-	-
Development (ac.)							
Type I land	67	-	-	-	-	-	-
Irrigated land supply	60	60	60	60	60	60	60
Financial summary ($)							
Gross income	$30320.	$31824.	$42784.	$44795.	$44427.	$44428.	$44428.
Operating expense	10000.	12670.	23638.	25264.	25435.	25435.	25436.
Fixed withdrawal	7650.	7650.	7650.	7650.	7650.	7650.	7650.
Cash transferred	4670.	15638.	26598.	25435.	25435.	36242.	36242.
Debt repayment	-	536.	536.	536.	536.	536.	536.
Short term borrowing	8000.	8000.	8000.	-	-	-	-
Surplus capital	-	-	-	12508.*	10806.	10806.	10806.
Net returns	2670.	10968.	10960.	11345.	10806.	10807.	10806.

[1]Years 7 to 20 have identical solutions.

*This number represents surplus capital accumulated from the previous year.

TABLE VI-4

OPTIMUM MULTI-PERIOD SOLUTION--PLAN THREE

Activities	Year 1	Year 2	Year 3	Year 4	Year 5	Years 6-20[1]
Dryland crops (ac.)						
Sugar beets	6	31	-	-	-	-
Sugar beets-fallow	30	-	34	-	-	-
Wheat	7	64	68	36	36	36
Oats	10	-	-	-	-	-
Oats- no fert.	63	22	-	3	3	3
Barley	114	-	-	-	-	-
Barley- no fert.	-	38	-	-	-	-
Sunflowers	-	-	2	36	36	36
Fallow	-	34	-	-	-	-
Irrigated crops (ac.)						
Sugar beets	-	5	2	36	36	36
Potatoes	-	36	36	36	36	36
Oats	-	-	33	30	30	30
Barley	-	-	56	53	53	53
Livestock (sows)						
Hogs	24	7	22	20	20	20
Development (ac.)						
Type I land	46	82	-	-	-	-
Type II land	-	13	31	-	-	-
Irrigated land supply	41	127	155	155	155	155
Financial summary ($)						
Gross income	$19960.	$24975.	$33443.	$33901.	$33901.	$33901.
Operating expense	10000.	12310.	16335.	18163.	18163.	18163.
Fixed withdrawal	7650.	7650.	7650.	7650.	7650.	7650.
Cash transferred	4310.	8959.	17258.	23868.	24012.	24773.
Debt repayment	-	366.	1159.	1478.	1478.	1478.
Short term borrowing	8000.	8000.	7376.	905.	-	-
Surplus capital	-	-	-	-	6465.	5849.
Net returns	2310.	4649.	8299.	6610.	6610.	6610.

[1]Years 6 to 20 have identical solutions.

TABLE VI-5

OPTIMUM MULTI-PERIOD SOLUTION--PLAN FOUR

Activities	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Years 7-20[1]
Dryland crops (ac.)							
Sugar beets	6	3	-	-	-	-	-
Sugar beets-fallow	30	-	36	36	-	-	-
Wheat	37	-	-	40	6	6	36
Wheat-fallow	-	-	-	22	-	-	-
Wheat- no fert.	-	36	58	-	-	-	-
Oats- no fert.	19	-	-	41	-	-	3
Barley	-	-	-	42	60	60	-
Barley- no fert.	33	-	-	-	-	-	-
Flax	104	-	42	-	-	-	-
Flax- no fert.	-	114	-	-	-	-	-
Sunflowers	-	-	-	-	36	36	36
Fallow	-	36	58	-	-	-	-
Irrigated crops (ac.)							
Sugar beets	-	-	-	-	36	36	36
Potatoes	-	35	35	36	36	36	36
Oats	-	-	-	-	33	33	30
Barley	-	-	-	11	23	23	53
Flax	-	6	-	-	-	-	-
Livestock (sows)							
Hogs	6	-	-	13	21	21	20
Development (ac.)							
Type I land	39	6	8	75	-	-	-
Type II land	-	-	-	14	-	30	-
Irrigated land supply	35	41	48	128	128	155	155

TABLE VI-5 (continued)

Activities	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Years 7-20[1]
Financial summary ($)							
Gross income	$14577.	$17089.	$21668.	$28827.	$33424.	$33424.	$33901.
Operating expense	6000.	6927.	9124.	13657.	18070.	18332.	18163.
Fixed withdrawal	7650.	7650.	7650.	7650.	7650.	7650.	7650.
Cash transferred	2927.	5124.	9657.	16753.	23284.	18163.	24773.
Debt repayment	-	315.	361.	424.	1173.	1173.	1478.
Short term borrowing	4000.	4000.	4000.	4000.	1317.	-	-
Surplus capital	-	-	-	-	-	5780.	6610.
Net returns	927.	2197.	4533.	7096.	6531.	6269.	6610.

[1]Years 7 to 20 have identical solutions.

TABLE VI-6

OPTIMUM MULTI-PERIOD SOLUTION--PLAN FIVE

Activities	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Years 7-20[1]
Dryland crops (ac.)							
Sugar beets	-	9	1	7	24	-	-
Sugar beets-fallow	30	-	1	-	12	34	-
Wheat	128	210	209	184	123	9	36
Wheat- no fert.	72	-	-	-	-	-	-
Oats- no fert.	-	-	-	-	-	59	3
Barley	-	-	-	-	-	90	-
Sunflowers	-	-	-	-	-	-	36
Fallow	-	1	-	12	34	-	-
Irrigated crops (ac.)							
Sugar beets	-	-	-	-	-	2	36
Potatoes	-	11	19	29	36	36	36
Oats	-	-	-	-	-	-	30
Barley	-	-	-	-	-	-	53
Livestock (sows)							
Hogs	-	-	-	-	-	19	20
Development (ac.)							
Type I land	12	10	11	7	2	86	-
Type II land	-	-	-	-	-	44	-
Irrigated land supply	11	19	29	36	38	155	155
Financial summary ($)							
Gross income	$12209.	$13004.	$14727.	$17804.	$23211.	$29927.	$33894.
Operating expense	4000.	4559.	5260.	6905.	9891.	15240.	18163.
Fixed withdrawal	7650.	7650.	7650.	7650.	7650.	7650.	7650.
Cash transferred	4559.	5260.	6905.	9891.	15240.	18163.	18163.
Debt repayment	-	94.	172.	263.	321.	335.	1471.
Short term borrowing	-	-	-	-	-	-	-
Surplus capital	-	-	-	-	-	3779.	6610.
Net returns	559.	701.	1645.	2986.	5349.	6702.	6610.

[1]Years 7 to 20 have identical solutions.

TABLE VI-7

OPTIMUM MULTI-PERIOD SOLUTION--PLAN SIX

Activities	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Yr. 9-20[1]
Dryland crops (ac.)									
Sugar beets	6	36	16	-	-	-	36	-	-
Sugar beets-fal.	30	-	20	36	36	36	-	-	-
Wheat	47	20	35	23	46	6	7	7	7
Oats	-	-	-	-	-	56	35	-	-
Oats- no fert.	24	4	6	-	12	-	-	-	-
Barley	-	-	-	-	-	96	103	64	60
Barley- no fert.	42	7	11	-	21	-	-	-	-
Flax	80	120	70	98	43	-	-	-	-
Potatoes	-	24	36	36	5	-	-	-	-
Sunflowers	-	-	-	-	-	-	-	34	36
Fallow	-	20	36	36	36	-	-	-	-
Irrigated crops (ac)									
Sugar beets	-	-	-	-	-	-	-	36	36
Potatoes	-	-	-	-	31	36	36	36	36
Oats	-	-	-	-	-	-	13	33	33
Barley	-	-	-	-	-	-	-	21	23
Livestock (sows)									
Hogs	8	1	2	-	4	20	22	22	22
Development (ac.)									
Type I land	-	-	-	34	6	15	73	-	-
Type II land	-	-	-	-	-	-	12	2	-
Ir. land supply	-	-	-	31	36	50	126	128	128
Financial summary-$									
Gross income	$15092.	$16396.	$18718.	$18357.	$23543.	$30501.	$30729.	$33391.	$33425.
Op. expense	6000.	7442.	8746.	11068.	10707.	15837.	22784.	18256.	18071.
Fixed withdrawal	7650.	7650.	7650.	7650.	7650.	7650.	7650.	7650.	7650.
Cash transferred	3442.	4746.	7068.	6707.	11837.	18784.	18256.	18071.	18071.
Debt repayment	-	-	-	-	56.	67.	92.	234.	238.
S.T. borrowing	4000.	4000.	4000.	4000.	4000.	4000.	4000.	-	-
Surplus capital	-	-	-	-	-	-	-	7436.*	7466.
Net returns	1442.	1304.	2322.	-361.	5130.	6947.	203.	7251.	7466.

[1]Years 9 to 20 have identical solutions.

*This number represents surplus capital accumulated from the previous year.

TABLE VI-8

OPTIMUM MULTI-PERIOD SOLUTION--PLAN SEVEN

Activities	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Years 7-20[1]
Dryland crops (ac.)							
Sugar beets	6	36	-	36	10	10	-
Sugar beets-fallow	30	-	36	-	-	-	-
Wheat	41	57	6	7	7	7	7
Oats	-	-	56	23	-	-	-
Oats- no fert.	60	18	-	-	-	-	-
Barley	92	-	96	106	107	107	60
Barley- no fert.	-	31	-	-	-	-	-
Flax	-	16	-	-	-	-	-
Sunflowers	-	-	-	-	9	9	36
Fallow	-	36	-	-	-	-	-
Irrigated crops (ac.)							
Sugar beets	-	-	-	-	26	26	36
Potatoes	-	36	36	36	36	36	36
Oats	-	-	-	21	35	35	33
Barley	-	-	-	-	-	-	23
Livestock (sows)							
Hogs	20	6	20	23	23	23	22
Development (ac.)							
Type I land	40	-	24	43	-	21	-
Type II land	-	-	-	-	-	14	-
Irrigated land supply	36	36	57	96	96	128	128
Financial summary ($)							
Gross income	$18726.	$24296.	$30501.	$31181.	$32751.	$32751.	$33424.
Operating expense	12000.	11076.	16579.	19251.	16958.	20289.	18071.
Fixed withdrawal	7650.	7650.	7650.	7650.	7650.	7650.	7650.
Cash transferred	1076.	6579.	12784.	16958.	20289.	24922.	11219.
Debt repayment	-	67.	67.	106.	179.	179.	238.
Short term borrowing	10000.	10000.	10000.	6467.	-	-	-
Surplus capital	-	-	-	-	4633.	-	7465.
Net returns	-924.	5503.	6205.	4174.	7964.	4633.	7465.

[1]Years 7 to 20 have identical solutions.

TABLE VI-9

OPTIMUM MULTI-PERIOD SOLUTION--PLAN EIGHT

Activities	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Years 7-20[1]
Dryland crops (ac.)							
Sugar beets	6	36	-	-	-	-	-
Sugar beets-fallow	30	-	-	-	-	-	-
Wheat	8	7	7	7	7	7	7
Oats	68	33	-	-	-	-	-
Oats- no fert.	-	-	15	-	-	-	-
Barley	118	103	108	87	86	86	60
Sunflowers	-	-	-	22	22	22	36
Irrigated crops (ac.)							
Sugar beets	-	-	36	36	36	36	36
Potatoes	-	36	36	36	36	36	36
Oats	-	15	28	34	34	34	33
Barley	-	-	-	9	10	10	23
Livestock (sows)							
Hogs	25	22	23	22	22	22	22
Development (ac.)							
Type I land	57	54	17	-	-	-	-
Type II land	-	-	-	-	-	14	-
Irrigated land supply	51	100	115	115	115	128	128
Financial summary ($)							
Gross income	$20506.	$30821.	$33032.	$33217.	$33222.	$33222.	$33424.
Operating expense	14856.	19958.	18403.	17643.	17622.	19193.	18071.
Fixed withdrawal	7650.	7650.	7650.	7650.	7650.	7650.	7650.
Cash transferred	-	3118.	9912.	17622.	19193.	25358.	10783.
Debt repayment	-	95.	185.	214.	214.	214.	238.
Short term borrowing	12856.	19958.	15285.	7731	-	-	-
Surplus capital	-	-	-	-	6165.	7284.*	7465.
Net returns	-2000.	3118.	6794.	7710.	7736.	6165.	7465.

[1]Years 7 to 20 have identical solutions.

*This number represents surplus capital accumulated from previous years.

TABLE VI-10

OPTIMUM MULTI-PERIOD SOLUTION--PLAN NINE

Activities	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Years 7-20[1]
Dryland crops (ac.)							
Sugar beets	6	36	-	-	-	-	-
Sugar beets-fallow	30	-	-	-	-	-	-
Wheat	8	7	7	7	7	7	7
Oats	68	33	-	-	-	-	-
Oats- no fert.	-	-	15	-	-	-	-
Barley	118	103	108	87	86	86	60
Sunflowers	-	-	-	22	22	22	36
Irrigated crops (ac.)							
Sugar beets	-	-	36	36	36	36	36
Potatoes	-	36	36	36	36	36	36
Oats	-	15	28	34	33	33	33
Barley	-	-	-	9	10	10	23
Livestock (sows)							
Hogs	25	22	23	22	22	22	22
Development (ac.)							
Type I land	57	54	17	-	-	-	-
Type II land	-	-	-	-	-	14	-
Irrigated land supply	51	100	115	115	115	128	128
Financial summary ($)							
Gross income	$20506.	$30821.	$33032.	$33216.	$33221.	$33221.	$33424.
Operating expense	14856.	19958.	18403.	17643.	17622.	19193.	18071.
Fixed withdrawal	7650.	7650.	7650.	7650.	7650.	7650.	7650.
Cash transferred	-	3118.	9912.	17622.	19193.	25358.	10783.
Debt repayment	-	95.	185.	213.	213.	213.	238.
Short term borrowing	12856.	19958.	15285.	7731.	-	-	-
Surplus capital	-	-	-	-	6165.	7465.*	7465.
Net returns	-2000.	3118.	6794.	7710.	7736.	6165.	7465.

[1]Years 7 to 20 have identical solutions.

*This number represents surplus capital accumulated from previous years.

TABLE VI-11

OPTIMUM MULTI-PERIOD SOLUTION--PLAN TEN

Activities	Year 1	Year 2	Year 3	Year 4	Year 5	Years 6-20[1]
Dryland crops (ac.)						
Sugar beets	40	30	82	103	-	-
Sugar beets-fallow	30	-	-	-	77	77
Wheat	282	209	209	259	259	259
Oats- no fert.	66	-	-	-	-	-
Barley- no fert.	38	-	-	-	-	-
Flax	-	135	162	166	299	299
Sunflowers	-	-	-	-	155	155
Fallow	-	-	-	77	77	77
Irrigated crops (ac.)						
Potatoes	-	68	82	108	155	154
Livestock (sows)						
Hogs	12	-	-	-	-	-
Development (ac.)						
Type I land	75	15	30	8	-	-
Type II land	-	-	-	44	-	-
Irrigated land supply	68	81	108	155	-	-
Rent dryland	225	211	304	484	793	793
Financial summary ($)						
Gross income	$29135.	$40635.	$54881.	$69704.	$92502.	$92502.
Operating expense	22000.	21485.	32859.	47079.	59610.	59610.
Fixed withdrawal	7650.	7650.	7650.	7650.	7650.	7650.
Cash transferred	1485.	12859.	27079.	41852.	59610.	59610.
Debt repayment	-	126.	152.	202.	288.	288.
Short term borrowing	20000.	20000.	20000.	20000.	17758.	-
Surplus capital	-	-	-	-	7196.	24954.
Net returns	-515.	11374.	14220.	14773.	24954.	24954.

[1]Years 6 to 20 have identical solutions.

TABLE VI-12

OPTIMUM MULTI-PERIOD SOLUTION--PLAN ELEVEN

Activities	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Years 7-20[1]
Dryland crops (ac.)							
Sugar beets	6	-	-	-	-	-	-
Sugar beets-fallow	30	-	-	-	-	-	-
Wheat	178	50	50	50	50	50	39
Sunflowers	16	36	36	36	36	36	36
Corn silage	-	-	-	-	-	-	.25
Irrigated crops (ac.)							
Sugar beets	-	36	36	36	36	36	36
Potatoes	-	36	36	36	36	36	36
Wheat	-	72	72	72	72	72	78
Oats	-	-	-	-	-	-	2
Barley	-	-	-	-	-	-	2
Livestock (head)							
Beef feeders (210 days)	-	-	-	-	-	-	3
Development (ac.)							
Type I land	128	-	-	-	-	-	-
Type II land	32	-	-	-	-	12	-
Irrigated land supply	144	144	144	144	144	155	155
Financial summary ($)							
Gross income	$13520.	$27800.	$27800.	$27800.	$27801.	$27801.	$28438.
Operating expense	6139.	13326.	13326.	13326.	13327.	13433.	13873.
Fixed withdrawal	7650.	7650.	7650.	7650.	7650.	7650.	7650.
Cash transferred	1731.	7206.	12676.	13327.	13433.	18797.	13873.
Debt repayment	-	1354.	1354.	1354.	1354.	1354.	1470.
Short term borrowing	4139.	11595.	6120.	650.	-	-	-
Surplus capital	-	-	-	4819.	5364.	4924.	5437.
Net returns	-269.	5470.	5470.	5470.	5470.	5364.	5437.

[1]Years 7 to 20 have identical solutions.

TABLE VI-13

OPTIMUM MULTI-PERIOD SOLUTION--PLAN TWELVE

Activities	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Years 7-20[1]
Dryland crops (ac.)							
Sugar beets	6	-	-	-	-	-	-
Sugar beets-fallow	30	-	-	-	-	-	-
Wheat	15	2	2	2	46	48	36
Oats- no fert.	13	-	-	-	40	41	-
Barley	9	-	-	-	31	32	-
Flax	120	120	120	120	4	-	-
Sunflowers	36	36	36	36	36	36	36
Corn silage	.5	-	-	-	1.5	1.5	3
Irrigated crops (ac.)							
Sugar beets	-	36	36	36	36	36	36
Wheat	-	-	-	-	-	-	7
Potatoes	-	36	36	36	36	36	36
Oats	-	-	-	-	-	-	41
Barley	-	-	-	-	-	-	35
Livestock (head)							
Beef feeders (210 days)	6	-	-	-	19	20	41
Development (ac.)							
Type I land	80	-	-	-	-	48	-
Type II land	-	-	-	-	-	44	-
Irrigated land supply	72	72	72	72	72	155	-
Financial summary ($)							
Gross income	$13720.	$25322.	$25321.	$25322.	$28296.	$28394.	$33765.
Operating expense	6666.	12363.	12328.	12328.	15471.	16375.	20186.
Fixed withdrawal	7650.	7650.	7650.	7650.	7650.	7650.	7650.
Cash transferred	1404.	6070.	10770.	15471.	20003.	16558.	20186.
Debt repayment	-	643.	643.	643.	643.	643.	1478.
Short term borrowing	4666.	10959.	6258.	1558.	-	-	-
Surplus capital	-	-	-	-	-	3543.	4451.
Net returns	-596.	4656.	4700.	4701.	4530.	3726.	4451.

[1]Years 7 to 20 have identical solutions.

TABLE VI-14

OPTIMUM MULTI-PERIOD SOLUTION--PLAN THIRTEEN

Activities	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Years 7-20[1]
Dryland crops (ac.)							
Sugar beets	71	-	-	-	-	-	-
Sugar beets-fallow	30	37	-	-	-	-	-
Wheat	27	27	34	35	33	33	31
Flax	-	27	23	-	-	-	-
Peas-fallow	-	-	-	11	13	12	13
Fallow	37	-	11	13	12	13	13
Sunflowers	60	60	60	60	60	60	60
Irrigated crops (ac.)							
Sugar beets	-	-	-	21	24	22	24
Wheat	-	-	-	-	-	2	2
Potatoes	-	38	60	49	48	48	48
Development (ac.)							
Type I land	42	25	11	2	-	2	-
Irrigated land supply	38	60	70	72	72	74	74
Financial summary ($)							
Gross income	$20089.	$23546.	$24976.	$25228.	$25276.	$25254.	$25289.
Operating expense	11367.	11564.	12355.	12604.	12643.	12631.	12642.
Fixed withdrawal	7650.	7650.	7650.	7650.	7650.	7650.	7650.
Cash transferred	3072.	7071.	11506.	15858.	16992.	16970.	738.
Debt repayment	-	333.	536.	622.	634.	634.	652.
Short term borrowing	9367.	8492.	5284.	1098.	-	-	-
Surplus capital	-	-	-	-	3215.	4361.*	4328.
Net returns	1072.	3999.	4435.	4352.	4349.	4339.	4345.

[1]Years 7 to 20 have identical solutions.
*This number represents surplus capital accumulated from the previous year.

CHAPTER VII

SUMMARY AND CONCLUSIONS

The history of irrigation projects suggests that there can be many factors affecting farmers' progress on a new project. The most important period on an irrigation project is the one in which development takes place. The development stage represents the transition from dryland to irrigation farming and often determines the success or failure of the beginning irrigation farmer.

The data necessary for this study were taken from surveys and reports by the Pembina River Engineering Board. With the aid of appropriate government agencies, this group was able to gather detailed information about the area which is intended for irrigation development. A farm which is representative of this area was constructed from the information. Thirteen hypothetical farm plans were formulated using various different assumptions with respect to operating capital, development repayment, irrigation water costs and markets for the crops. Some sources of farm credit were investigated to determine the nature of credit that could be available to beginning irrigation farmers. From the analysis of the farm plans, some factors affecting irrigation development were identified.

I. CONCLUSIONS

The overall objective of this study was to examine the nature of the transition from dryland to irrigation farming. The specific objectives were as follows:

1. To review the experiences of some previous irrigation projects.
2. To determine the extent to which credit could be available to beginning irrigation farmers.
3. To identify factors that affect the rate of irrigation development.
4. To identify factors that affect the extent of irrigation development.

Winkler Project in Relation to Other Projects

Several previous irrigation projects were briefly discussed in Chapter II of this study. On some projects, the land was predeveloped by government agencies while on others it was developed in the context of private ownership. All researchers dealing with these beginning irrigation projects stressed the importance of sufficient resource availability.

Under the assumptions of this study it appears that development of irrigation farms by private owners is feasible. In areas where the existing dryland farms are strong and viable, private development would be especially favorable. Important resources such as land and machinery would be already available and possibly wholly paid for. In such an event, only the cost of irrigation development must be met.

If a project is predeveloped and sold, the beginning farmer must finance the cost of land and field machinery in addition to the cost of development.

Credit Availability for Irrigation Farmers

Credit availability is very important for a beginning irrigation farmer. It is unlikely that many farmers would be in a position to convert from dryland to irrigation farming without the use of credit.

Commercial banks and the Farm Credit Corporation were identified as two possible sources of credit. FCC loans could be used to develop land. In this study, the long term credit limit used was probably the maximum that a 230 acre farm in the Winkler area could secure. This limit was calculated on the assumption that the entire farm acreage could be used for security. Under such circumstances it would appear that sufficient long term credit could be obtained to facilitate land development and the purchase of irrigation machines.

Bank loans could be used for operating capital and for irrigation machines as well. This assumes that the operators applying for loans are credit worthy and have a set of records to familiarize the bank with the farm. It was indicated by a bank representative that line of credit financing could be used.

The only concern expressed by the representatives was

with respect to technical assistance for the farmers. If farmers are unfamiliar with irrigation farming techniques they will require outside information during the initial years of irrigation. The lenders expected that the agricultural extension workers in the area would soon be in a position to provide such information.

The Rate and Extent of Irrigation Development

Extent. The interrelationship of rate and extent of development is quite important. The term 'extent of development' refers to the amount of irrigable land that is developed as a proportion of the total amount that is suitable for development. In order to attain low overhead costs for the project, it is essential that as much of the area as possible be developed. Low overhead costs would be reflected in the price of irrigation water.

The analysis of the optimal solutions for the farm plans indicated some of the factors that could affect the extent of irrigation development. The price of irrigation water is one such factor. This follows quite readily since the cost of water affects the profitability of growing irrigated crops. Under the assumptions of this study, when the cost of water was $10.00 per acre foot during the last ten years of the plan, potatoes were the only profitable irrigated crop. This study did not attempt to determine the economic value of water for the various irrigated crops.

A second factor affecting the extent of development is the type of scheme available for financing development. When it was assumed that repayment of development could be spread over thirty years, the full amount of irrigable land was developed. Under the assumptions of cash payment for development, thirty acres of type II land were not developed.

Since irrigated crops are more labor intensive, labor availability also affects the extent of development. In this study, only part of the land was developed when labor hiring was limited. All irrigable land was developed when it was assumed that unlimited labor could be hired. Certain aspects of irrigated cropping can be mechanized, but the profitability of such plans was not examined in this study. Also, the amount of labor available to be hired by irrigators as a group is not known. However, if an insufficient amount of labor is available, the extent to which irrigation development takes place could be affected.

Rate. The rate at which irrigation development takes place would be important to the individual farmers on the project. The sooner the farm is fully developed, then the sooner the benefits from irrigation can be realized. The results of the farm plans analyzed in this study indicate that rapid development (a short transition period) is more desirable than slow development (in terms of total net returns). For plans in which there was sufficient short term

borrowing to facilitate rapid development, the net return stabilized more quickly. Thus the total net return at the end of twenty years would be greater for these plans in comparison to those in which insufficient capital was available. The amount of operating capital that could be borrowed affected the length of the transition period, but not the level of the stabilized net return. For plans in which the borrowing limit was higher, net returns during the transition period were higher and more capital was borrowed. This suggests that it would be advantageous to both the farmer and the credit agency to consider loans that are sufficient for the farmers' needs. Loans that are too small would needlessly extend the transition period by preventing proper utilization of existing resources.

The markets that are available for the products of the area can affect both the rate and extent of development. If operating capital is limited then it can be generated by the production of such crops as wheat and flax. If these crops can be readily sold then the operating capital can be generated more quickly. Similarly, if the production of crops which are profitable under irrigation is limited by market conditions, then less land may be irrigated. Market availability is an exogenous variable in so far as an individual farmer is concerned. However, the farmer can attempt to cope with this problem by adjusting his cropping pattern

appropriately. It is probable that such adjustments could be made over a wider range of crops when irrigation is possible. This cannot be fully determined until more is known about the potential of irrigation in the area.

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APPENDIX A

TABLE A-1

DISTRIBUTION OF FARMS BY TOTAL ACRES FOR WINKLER AREA
IN COMPARISON TO CENSUS DIVISION 2
AND PROVINCE OF MANITOBA

Size of farm	Census Division 2, 1961[a]		Province of Manitoba, 1961[a]		Project area[b]	
Total acres	Number	Per cent	Number	Per cent	Number	Per cent
Under 3	38	0.9	209	0.5	9	2.4
3-9	99	2.5	553	1.3	23	6.2
10-69	311	7.7	1,909	4.4	77	20.9
70-239	1,173	29.1	10,460	24.1	141	38.3
240-399	1,346	33.4	12,562	29.0	71	19.3
400-559	591	14.7	7,628	17.6	28	7.6
560-759	336	8.3	5,065	11.7	12	3.3
760-1,119	108	2.7	3,284	7.6	4	1.1
1,120-1,599	22	0.5	1,133	2.6	1	0.3
1,600-2,239	7	0.2	503	1.2	2	0.6
2,240 and more	-	-	-	-	-	-
All farms	4,031	100.0	43,306	100.0	368	100.0
Average size (ac.)	306		419		218	

a/ Census of Canada 1961
b/ Reconnaissance study, June 1962

TABLE A-2

USE OF IMPROVED LAND ACCORDING TO SIZE OF FARM, WINKLER AREA, 1962

Size of farm (ac.)	70-149		150-239		240-399		400-759	
	Acres per farm	Percent of crop-land	Acres per farm	Percent of crop-land	Acres per farm	Percent of crop-land	Acres per farm	Percent of crop-land
Wheat: fallow	4	4.21	14	8.24	29	10.47	60	13.30
stubble	4	4.21	4	2.35	10	3.61	6	1.33
Oats: fallow	4	4.21	18	10.59	3	1.08	12	2.66
stubble	30	31.58	32	18.82	61	22.02	68	15.08
Barley: fallow	-	-	-	-	-	-	3	0.67
stubble	1	1.05	2	1.18	1	0.36	3	0.67
Flax: fallow	2	2.11	7	4.12	-	-	4	0.89
stubble	18	18.95	46	27.06	89	32.13	111	24.61
Rye	1	1.05	2	1.18	1	0.36	12	2.66
Buckwheat	3	3.16	10	5.88	6	2.17	2	0.44
Grass seed	-	-	-	-	1	0.36	1	0.22
Corn: grain	4	4.21	-	-	4	1.44	6	1.33
fodder	3	3.16	2	1.18	6	2.17	8	1.77
sweet	1	1.05	2	1.18	1	0.36	4	0.89
Grass and Legume Hay	6	6.32	7	4.12	9	3.25	28	6.21
Mixed grain	1	1.05	-	-	1	0.36	9	2.00
Sunflowers	3	3.16	11	6.47	15	5.42	27	5.99
Peas: canning	-	-	-	-	2	0.72	3	0.66
field	-	-	-	-	2	0.72	1	3.32
Potatoes	-	-	1	0.58	-	-	15	3.32
Beans: canning	1	1.05	-	-	1	0.36	-	-
Improved pasture	4	4.21	2	1.18	5	1.81	4	0.89
Fallow	4	4.21	9	5.29	28	10.11	51	11.31
Sugar beets	1	1.05	1	0.58	2	0.72	13	2.88
Total cropland	95	100.00	170	100.00	277	100.00	451	100.00

TABLE A-3

DRYLAND AND IRRIGATED (ESTIMATED) CROP YIELDS[a] AND EXPENDITURE ON FERTILIZER FOR WINKLER PROJECT AREA

Crop	Dryland unfertilized	Dryland yield fertilized	Dryland fertilizer cost	Irrigation yields fertilized	Irrigation fertilizer cost
	Per acre	Per acre	Per acre	Per acre	Per acre
Wheat -fallow	23 bu.	27 bu.	$ 3.26	[b]	[b]
-stubble	20 bu.	23 bu.	3.26	40 bu.	$ 5.43
Barley-stubble	22 bu.	25 bu.	3.00	45 bu.	5.00
Oats -stubble	37 bu.	42 bu.	4.00	75 bu.	5.00
Sugar beets					
-fallow	[b]	12 ton	4.00	[b]	[b]
-stubble	[b]	11 ton	5.00	15 ton	8.43
Field peas-stub.	[b]	22 bu.	2.00	33 bu.	2.05
Sunflowers-stub.	[b]	700 lb.	1.00	1,000 lb.	2.00
Potatoes-stub.	[b]	150 bu.	10.50	240 bu.	15.00
Corn silage-stub.	[b]	4.5 ton	1.35	6 ton	1.50
Forage-stub.	[b]	2.5 ton	3.00	4 ton	7.50
Flax-stub.	[b]	11 bu.	3.00	17 bu.	3.50

[a] Estimates made by Manitoba Department of Agriculture for report to International Joint Commission on Pembina River Basin.

[b] Not required.

TABLE A-4

SUMMARY OF PRODUCT PRICES

Product	Unit	Price
Wheat	bu.	$ 1.61
Oats	bu.	.63
Barley	bu.	1.00
Flax	bu.	2.95
Sugar beets	ton	14.96
Potatoes	bu.	1.45
Field peas	bu.	2.06
Sunflowers	cwt.	4.89
Feeder cattle	cwt.	23.00
Hogs	cwt.	25.00

TABLE A-5

SUMMARY OF PRINCIPAL FACTOR PRICES

Item	Unit	Price
Seed		
Wheat	bu.	$ 2.15
Oats	bu.	1.40
Barley	bu.	1.85
Flax	bu.	5.50
Sunflowers	ac.	1.50
Field peas	bu.	1.65
Potatoes	ac.	36.00
Fertilizer		
Nitrogen (N)	lb.	0.12
Phosphate (P_2O_5)	lb.	.085
Chemicals		
Cereals	ac.	0.45
Sugar beets	ac.	4.00
Potatoes	ac.	5.00
Commerial feeds		
Pig starter	cwt.	5.60
Hog supplement	cwt.	6.20
Cattle supplement	cwt.	5.36
Labor		
Spring	hr.	1.75
Summer	hr.	1.50
Fall	hr.	1.75
October	hr.	1.50

TABLE A-6

MACHINERY COMPLEMENT FOR 240 ACRE FARM

Machine	Size	Replacement value[a]	Deprec. rate	Depreciation
		Dollars	Per cent	Dollars/year
Tractor	3-4 pl.	$ 4,630.	7.0	$ 324.10
Cultivator	10 ft.	530.	6.0	31.80
Harrow	30 ft.	420.	5.0	21.00
Seed drill	12 ft.	1,530.	5.5	84.15
Discer	12 ft.	1,760.	5.0	88.00
Sprayer	30 ft.	260.	5.0	13.00
Swather	10 ft.	1,185.	8.5	100.73
Combine (AM)	10 ft.	5,250.	8.0	420.00
Plow	3-14 in.	925.	5.0	46.25
Double disc	10 ft.	560.	5.0	28.00
Mower	6 ft.	550.	5.0	27.50
Rake		660.	5.0	33.00
Baler (½ share)		1,070.	8.0	171.20
Planter (½ share)	4 row	600.	6.0	36.00
Potato harvester (1/3 share)		1,800.	8.0	144.00
Beet harvester (1/3 share)		1,800.	8.0	144.00
Auger		175.	6.0	10.50
Truck	1 ton	3,815.	6.5	247.98
Tools and misc.		300.	5.0	15.00
		$28,290.		$1,950.21

Irrigation Machines Required

Machine	Value
Two-way plow	$1,050.
Ditcher	300.
Leveler	1,200.
Float	250.
	$2,800.

a/ 1965 prices

TABLE A-7

CALCULATION OF LONG TERM BORROWING LIMIT

Item	Amount
Market value of land per acre	$ 200.
FCC appraised value per acre (60%)	120.
Maximum FCC loan per acre (75% of appraised value)	90.
Total for 230 acre farm	20,700.
Maximum allowed in this study	20,000.

Source: Farm Credit Corporation

TABLE A-8

CALCULATION OF FIXED COSTS

Item	Cost
Machinery depreciation	$1,950.
Depreciation on farm buildings	400.
Real estate taxes[1]	300.
Building insurance	50.
Licences	40.
Electricity	63.
Miscellaneous	90.
Total	$2,893.
Family living expenses	$4,757.
Total fixed cost	$7,650.

[1]It was assumed that the increased value of land for irrigation would eventually be reflected in real estate taxes. This increase was estimated to be 45¢ per acre if and when irrigation development took place.

APPENDIX B

TABLE B-1

CULTURAL PRACTICES

Practice	Frequency in years	Rate/acre	Cost/acre
Weed spraying	1/1	-	$ .45
Seed replacement			
Wheat	1/4	1.6 bu.	2.94
Oats	1/4	2.5 bu.	2.13
Barley	1/4	2.0 bu.	2.48
Flax	1/4	40.0 lb.	2.58
Field peas	1/4	2.5 bu.	5.90
Sugar beets	-	-	2.50
Potatoes	-	-	41.00
Corn silage	-	12.0 lb.	1.60
Hay mixture	1/3	13.0 lb.	2.24
Seed cleaning			
Wheat	1/1	-	.08
Oats	1/1	-	.13
Barley	1/1	-	.10
Flax	1/1	-	.12
Corn	1/1	-	.11
Seed treating			
Barley	1/1	-	.16
Field peas	1/1	-	.18

TABLE B-2

TILLAGE PRACTICES FOR CROPS

Crop	Tillage
Dryland	
Cereal on fallow	Cf-3Hr-Dr-Sp-Sw-C-Ha
Cereal on stubble	Cf-3Hr-Dr-Sp-Sw-C-Ha-P-Ds-2Hr
Flax on stubble	Cf-3Hr-Dr-Sp-Sw-C-Ha-P-Ds-2Hr
Sugar beets on stubble	Cf-Hr-Pa-Dr-4Cr-Sp-Hv-Ha
Sunflowers	Cf-Ds-Hr-Dr-Cr-C-Ha-Ds-Cf
Field peas	Cf-Dr-Hr-Sp-C-Ha-P-Ds
Potatoes	P-Ds-Pl-Hr-3Cr-Hv-Ha-P-Ds
Corn silage	Cf-Hr-Dr-Ds-Cr-Hv-Ha-P-Ds
Forage	M-R-B-Ha
Summerfallow	P-Ds-3Cf-3Hr
Sodfallow	P-Ds-2Cf-3Hr
Irrigated	
All small grains (stubble)	Dt-2Hr-L-2Fl-Dr-Sp-Sw-C-Ha-P-Ds-Hr
Potatoes	Dt-2Hr-L-Fl-Pl-Cr-Sp-D-Hv-Ha-P-Ds-Hr
Sugar beets	2Dt-2Hr-Fl-L-Pl-3Cr-D-Hv-Ha-P Ds-Hr
Corn silage	Dt-2Hr-L-Fl-Pl-3Cr-D-Sp-Hv-P-Ds-Hr
Field peas	Dt-2Hr-2Fl-Dr-Sp-C-Ha-P-Ds-Hr
Sunflowers	Dt-2Hr-2Fl-Dr-D-Cr-C-Ha-Ds-Hr

KEY FOR TABLE B-2

Cf - Field cultivator	Hr - Harrow
Cr - Row cultivator	M - Mow
Dr - Drill	R - Rake
Sp - Sprayer	B - Bale
Sw - Swather	L - Level
C - Combine	Fl - Float
Ha - Haul	D - Ditcher
P - Plow	Pa - Packer
Ds - Discer	Pl - Plant
Hv - Harvester	Dt - Tandem disc
2, 3...n - number times over	

TABLE B-3

TIME AND COST OF MACHINE OPERATIONS TO WORK ONE ACRE, ONCE OVER ON DRYLAND

Operation	Mach. time (hours per acre)	Man time (hours per acre)	Tractor (cost/hour)	Mach. (cost/hour)	Total cost/ac.
Cultivator	.31	.34	$ .90	$ .19	$ .34
Discer	.25	.29	.90	.21	.28
Drill	.25	.32	.80	.25	.26
Harrow	.11	.13	.80	.15	.31
Sprayer	.11	.13	.80	.32	.12
Plow	.94	1.04	.90	.18	1.02
Harvester					
Sugar beet	2.10	3.80	.90	.41	2.75
Potato	2.00	3.80	.90	.35	2.50
Swather	.23	.26	.80	.21	.23
Combine	.46	.60	.90	.35	.57
Haul					
Grain	.44	.50	-	-	.19
Sugar beets	.98	2.50	-	-	.85
Potatoes	1.00	2.50	-	-	.85
Mower	.90	1.00	.80	-	.86
Rake	.85	.88	.80	-	.81
Baler	1.30	1.35	.80	-	1.31
Forage harvester	1.50	1.58	.80	.35	1.73
Overhead labor					
Marketing and supply hauling	-	.75	-	-	-
Seed preparation	-	.22	-	-	-
Repairs	-	.20	-	-	-
Tot. overhead labor	-	1.17	-	-	-

NOTE: The information contained in Tables B-3 and B-4 was adapted from the following sources:

S.W. Garland, and L.M. Johnson, Crop Production Requirements in Manitoba, Economics Division, Canada Department of Agriculture (Ottawa, Dec. 1958).

G. Mackenzie, and J.C. Brown, How Labor is Used on Red River Valley Farms, Publication 923, Economics Division, Canada Department of Agriculture (Ottawa, 1954).

W. McMartin, and R.O. Bergan, Irrigation Practices and Costs in North Dakota, Bulletin 474, Agricultural Experiment Station (Fargo, March 1968).

TABLE B-4

TIME AND COST OF MACHINE OPERATIONS TO WORK ONE ACRE, ONCE OVER ON IRRIGATED LAND

Operation	Mach. time (hours per acre)	Man time (hours per acre)	Tractor (cost/hour)	Mach. (cost/hour)	Total cost/ac.
Cultivator	.55	.62	$ .90	$ .19	$ .60
Discer	.27	.32	.90	.21	.30
Drill	.28	.35	.80	.25	.29
Harrow	.12	.14	.80	.15	.13
Sprayer	.11	.13	.80	.32	.12
Plow	1.10	1.04	.90	.18	1.20
Harvester					
Sugar beet	2.10	3.80	.90	.41	2.75
Potato	2.00	3.80	.90	.35	2.50
Swather	.25	.32	.80	.21	.25
Combine	.62	.75	.90	.35	.80
Leveler	.42	.46	.90	.72	.69
Float	.29	.32	.80	.10	.24
Tandem disc	.41	.51	.90	.20	.44
Ditcher	.44	.47	.90	.15	.47
Haul					
Grain	.49	.60	-	-	.22
Sugar beets	1.03	2.75	-	-	.95
Potatoes	1.10	2.75	-	-	.95
Mower	.90	1.00	.80	-	.86
Rake	.87	.90	.80	-	.86
Baler	1.35	1.40	.80	-	1.38
Forage harvester	1.55	1.62	.80	.35	1.79
Overhead labor					
Marketing and supply hauling	-	.85	-	-	-
Seed preparation	-	.22	-	-	-
Repairs	-	.30	-	-	-
Irrigation overhead labor	-	.27	-	-	-

TABLE B-5

COSTS AND LABOR REQUIREMENTS OF LAND PREPARATION FOR IRRIGATION

Item	Unit	Type I	Type II
Leveling			
Amount	cu. yd./ac.	200.0	320.0
Rate	$/cu. yd.	.23	.23
Cost	$/ac.	46.00	73.50
Planning	$/ac.	5.00	5.00
Farm laterals	$/ac.	2.23	2.23
Farm drains	$/ac.	2.40	2.40
Clearing	$/ac.	1.00	1.00
Structures	$/ac.	6.00	6.00
Fertilizer	$/ac.	7.45	7.45
Other	$/ac.	5.64	5.64
Total cost	$/ac.	75.72	103.22
Total labor	hr./ac.	5.80	5.80

TABLE B-6

IRRIGATION WATER REQUIREMENTS[1] FOR CROPS UNDER CONDITIONS OF AVERAGE RAINFALL

Crops	Amount of Irrigation Water (inches/acre)
Small grains	10.25
Flax	13.23
Corn	12.06
Potatoes	8.99
Sugar beets	10.69
Field peas	5.18
Sunflowers	10.60
Alfalfa	16.42

[1] Estimated from H.F. Blaney, Determining Consumptive Use and Irrigation Water Requirements, Technical Bulletin No. 1275, U.S.D.A.

TABLE B-7

SUMMARY OF COSTS OF PRODUCTION
DRYLAND (DOLLARS PER ACRE)

Crop	Machine cost	Fert. cost	Seed clean and treat	Seed Replace.	Chem.	Total
Wheat						
-stubble	$ 4.34	$ 3.26	$ .08	$ 2.94	$ .45	$11.07
-fallow	2.00	3.26	.08	2.94	.45	8.72
Barley						
-stubble	4.34	3.00	.26	2.48	.45	10.53
Oats						
-stubble	4.34	4.00	.13	2.13	.45	11.05
Sugar beets						
-stubble	10.50	12.00	-	2.50	4.00	29.00
-fallow	7.65	5.50	-	2.50	4.00	19.65
Field peas	3.29	-	3.75[1]	5.90	-	12.94
Sunflowers	4.25	-	-	1.51[2]	-	5.76
Potatoes	7.50	10.50	-	41.00[3]	-	59.00
Corn silage	5.14	1.35	.10	1.60	.50	8.69
Flax	4.34	3.00	.11	2.58	.45	10.48
Forage	1.55	3.00	-	2.24	.45	7.24

1/ Includes cost of chemical, fertilizer and seed treatment.

2/ Includes cost of fertilizer, seed, and chemical.

3/ Includes cost of seed and chemicals.

TABLE B-8

SUMMARY OF COSTS OF PRODUCTION ON IRRIGATED LAND (DOLLARS PER ACRE)

Crop	Machine cost	Fert. cost	Seed clean and treat	Seed Replace.	Chem.	Total
Wheat -stubble	$ 5.04	$ 5.43	$ .08	$ 2.94	$ .45	$13.94
Barley -stubble	5.04	5.00	.26	2.48	.45	13.23
Oats -stubble	5.04	5.00	.13	2.13	.45	12.75
Sugar beets -stubble	14.40	14.50	-	2.50	5.00	36.40
Field peas	4.01	2.05	.60	5.90	.60	13.16
Sunflowers	4.91	2.00	.10	.30	-	7.31
Potatoes	9.88	15.00	-	36.00	5.00	65.88
Corn silage	7.19	1.35	.10	1.60	.50	10.74
Flax	5.04	3.50	.11	2.58	.45	11.68
Forage	4.05	7.50	-	2.24	.45	14.24

TABLE B-9

LABOR REQUIREMENTS FOR IRRIGATING
VARIOUS CROPS

Crop	Man hours per acre
Small grains	2.60
Potatoes	5.60
Sugar beets	7.00
Corn silage	4.27
Forage (per acre per year)	2.00

TABLE B-10

COSTS, RETURNS AND RESOURCE REQUIREMENTS PER HEAD FOR FEEDER CATTLE ENTERPRISES

Item	Unit	Length of feeding period: 260 days	210 days	142 days
Costs				
Cost of feeder	$	108.00	145.00	194.00
Freight and marketing	$	7.00	7.00	8.00
Salts and minerals	$	.50	.50	.50
Veterinary and drugs	$	3.30	3.30	3.00
Bedding	$	2.00	2.00	2.00
Death loss (3%)	$	3.24	2.90	3.88
Feed supplement	$	3.00	2.80	2.50
Total	$	127.04	163.50	213.88
Weights and returns				
Beginning weight	lb.	400	600	800
Selling weight	lb.	1000	1100	1200
Gross return	$	230.00	253.00	276.00
Labor				
Summer	hr./head	3.5	-	-
Fall	hr./head	2.6	1.8	-
Winter	hr./head	6.2	6.2	7.5
Spring	hr./head	2.8	2.8	2.8
Farm grown feed				
Oats	bu.	142.8	74.5	29.7
Barley	bu.	45.7	38.8	58.1
Forage	tons	.5	.38	.38

TABLE B-11

COSTS, RETURNS AND RESOURCE REQUIREMENTS
PER SOW FOR HOG ENTERPRISE

Item	Unit	Two litters per year
Costs		
Feed supplements	$	110.19
Boar and sow costs	$	14.25
Veterinary and drugs	$	6.00
Marketing cost	$	12.60
Bedding	$	8.00
Total	$	151.04
Weights and returns		
Selling weight (dressed/head)	lb.	160
Litter size	hogs	7
Gross returns	$	560.00
Labor		
Spring	hr.	13.1
Summer	hr.	8.3
Fall	hr.	43.8
Winter	hr.	29.5
Farm grown feeds		
Oats	bu.	113.5
Barley	bu.	117.0
Wheat	bu.	7.0

NOTE: The data in Tables B-10 and B-11 were adapted from: Principles and Practices of Commercial Farming, Faculty of Agriculture and Home Economics, University of Manitoba.

APPENDIX C

TABLE C-1

CODING OF RESTRAINTS FOR PROGRAMMING MATRIX

Restraint	Code
Total land	TL
Irrigation water	IRH2O
Type 1 irrigable land (Period 1)	IRL11
Type 2 irrigable land (Period 1)	IRL21
Irrigable land supply (Period 1)	IRLSS1
Total labor	TLA
Total operator labor	TOPLA
January, February, March labor	JFMLA
Spring labor	AMYLA
Summer labor	J-ALA
Fall labor	A-SLA
October labor	OCTLA
November labor	NOVLA
December labor	DECLA
Hire spring labor	HSPLA
Hire summer labor	HSMLA
Hire fall labor	HFLLA
Wheat supply	WHSS
Oats supply	OTSS
Flax supply	FXSS
Sunflower supply	SNSS
Pea supply	PESS
Barley supply	BRSS
Potato supply	POTSS
Irrigation machine supply	IRMACH
Sugar beet supply	SBSS
Hire October labor	HOTLA
Sunflower maximum	SNMX
Grain quota	GRQT
Flax maximum	FXMX
Potato maximum	POMX
Pea maximum	PEMX
Sugar beet maximum	SBMX
Fixed costs (Period 1)	FIXCT1
Short term capital (Period 1)	STCP1
Generated capital	GENCP
Long term capital (Period 1)	LTCP1
Stubble supply (Period 1)	STBSS1
Summerfallow supply (Period 1)	SMFWSS1
Hay supply	HAYSS
Buy short term capital	BYSTCP
Buying limit for short term capital	BLSTCP
Year one forage dryland	FORD1
Year two forage dryland	FORD2
Year three forage dryland	FORD3
Year one forage irrigated	FORI1
Year two forage irrigated	FORI2
Year three forage irrigated	FORI3

TABLE C-2

CODING OF ACTIVITY NAMES FOR
PROGRAMMING MATRIX

Activity name	Code
Sugar beets, stubble, fertilized, dry	SBSFD
Sugar beets, stubble, fertilized, irrigated	SBSFI
Wheat, fallow, fertilized, dry	WFFD
Wheat, stubble, fertilized, dry	WSFD
Wheat, stubble, fertilized, irrigated	WSFI
Oats, stubble, fertilized, dry	OSFD
Oats, stubble, fertilized, irrigated	OSFI
Barley, stubble, fertilized, dry	BSFD
Barley, stubble, fertilized, irrigated	BSFI
Flax, stubble, fertilized, dry	FXSFD
Flax, stubble, fertilized, irrigated	FXSFI
Sunflowers, stubble, fertilized, dry	SNSFD
Sunflowers, stubble, fertilized, irrigated	SNSFI
Peas, fallow, fertilized, dry	PFFD
Peas, stubble, fertilized, irrigated	PSFI
Sugar beets, fallow, fertilized, dry	SBFFD
Potatoes, stubble, fertilized, dry	POSFD
Potatoes, stubble, fertilized, irrigated	POSFI
Work summerfallow	WSMFW
Buy irrigation water	BH2O
Hogs, two litters per year	HOG2L
Hire spring labor	HSPLA
Hire summer labor	HSMLA
Hire fall labor	HFLLA
Hire October labor	HOTLA
Sell wheat on quota	SWQ
Sell oats on quota	SOQ
Sell flax	SFX
Sell sunflowers	SSN
Sell peas	SP
Sell barley on quota	SBQ
Sell potatoes	SPOT
Sell sugar beets	SSB
Land proportionality activity	LDIS
Develop type I irrigation land	DVTA
Develop type II irrigation land	DVTB
Pay fixed costs	PFC
Buy short term capital	BSTC
Repay short term capital	RSTC
Transfer generated capital from year one to year two	1T2G

TABLE C-2 (continued)

Activity name	Code
Transfer short term capital from year one to year two	1T2STC
Buy irrigation machines	BIRMH
Transfer long term capital borrowing limit from year one to year two	1T2LTBL
Wheat, fallow, unfertilized, dry	WFD
Wheat, stubble, unfertilized, dry	WSD
Barley, stubble, unfertilized, dry	BSD
Oats, stubble, unfertilized, dry	OSD
Flax, stubble, unfertilized, dry	FXD
Year one forage, dry	FORD1
Year two forage, dry	FORD2
Year three forage, dry	FORD3
Year one forage, irrigated	FORI1
Year two forage, irrigated	FORI2
Year three forage, irrigated	FORI3
Corn silage, stubble, fertilized, dry	CSFD
Corn silage, stubble, fertilized, irrigated	CSFI
260 day beef feeding activity	FL260
210 day beef feeding activity	FL210
142 day beef feeding activity	FL142

TABLE C-3

ACTIVITIES FOR FIRST YEAR OF PROGRAMMING MATRIX AND ASSOCIATED RESTRAINTS

		Net price	-29.00	-36.40	-8.72	-11.07	-13.94	-11.05	-12.75
						Activity			
Restraint	Unit	Level	SBSFD	SBSFI	WFFD	WSFD	WSFI	OSFD	OSFI
IRH2O	ac. ft.	0	-	10.70	-	-	10.30	-	10.30
IRLSS	ac.	0	-	1.00	-	-	1.00	-	1.00
TLA	hr.	3,940	35.40	46.16	3.55	4.90	11.20	5.15	11.20
TOPLA	hr.	3,086	1.17	1.64	1.17	1.17	1.64	1.17	1.64
AMYLA	hr.	862	2.53	3.91	.92	1.05	2.75	1.13	2.75
J-ALA	hr.	1,217	19.70	26.92	.13	.13	2.70	.17	2.70
A-SLA	hr.	570	9.24	9.24	1.33	1.33	1.88	1.39	1.88
OCTLA	hr.	358	2.76	4.45	-	1.22	2.23	1.30	2.23
WHSS	bu.	0	-	-	-26.25	-23.00	-40.00	-	-
OTSS	bu.	0	-	-	-	-	-	-42.00	-75.00
SBSS	tons	0	-11.00	-14.00	-	-	-	-	-
GRQT	bu.	2,070	9.00	9.00	-	-	-	-	-
SBMX	ac.	0	1.00	1.00	-	-	-	-	-
STCP	$	2,000	29.00	36.40	8.72	11.07	13.94	11.05	12.75
STBSS1	ac.	200	1.00	1.00	-	1.00	1.00	1.00	1.00
SMFWSS	ac.	30	-	-	1.00	-	-	-	-
STBSS2	ac.	0	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00

TABLE C-3 (continued)

		Net price	-10.53	-13.23	-10.48	-11.68	-5.76	-7.30	-12.94
						Activity			
Restraint	Unit	Level	BSFD	BSFI	FXSFD	FXSFI	SNSFD	SNSFI	PFFD
IRH2O	ac. ft.	0	-	10.30	-	13.20	-	10.60	-
IRLSS	ac.	0	-	1.00	-	1.00	-	1.00	-
TLA	hr.	3,940	5.02	11.20	4.96	11.20	3.96	13.38	4.29
TOPLA	hr.	3,086	1.17	1.64	1.17	1.64	1.17	1.64	1.17
AMYLA	hr.	862	1.08	2.75	1.05	2.75	1.28	2.75	1.30
J-ALA	hr.	1,217	.13	2.70	.13	2.70	.55	3.32	.40
A-SLA	hr.	570	1.34	1.88	1.31	1.88	-	-	.70
OCTLA	hr.	358	1.30	2.23	1.30	2.23	1.37	5.67	.72
FXSS	bu.	0	-	-	-11.00	-17.00	-	-	-
SNSS	cwt.	0	-	-	-	-	-710.00	-1,000.00	-
PESS	bu.	0	-	-	-	-	-	-	-21.70
BRSS	bu.	0	-25.00	-45.00	-	-	-	-	-
SNMX	ac.	0	-	-	-	-	1.00	1.00	-
GRQT	bu.	2,070	-	-	9.00	9.00	9.00	9.00	9.00
FXMX	ac.	0	-	-	1.00	1.00	-	-	-
PEMX	ac.	0	-	-	-	-	-	-	1.00
STCP	$	2,000	10.53	13.23	10.48	11.68	5.76	7.30	12.94
STBSS1	ac.	200	1.00	1.00	1.00	1.00	1.00	1.00	-
SMFWSS	ac.	30	-	-	-	-	-	-	1.00
STBSS2	ac.	0	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00

TABLE C-3 (continued)

		Net price	-13.16	-20.16	-59.00	-65.88	-2.90	-4.40	409.00
						Activity			
Restraint	Unit	Level	PSFI	SBFFD	POSFD	POSFI	WSMFW	BH2O	HOG2L
IRH2O	ac. ft.	0	5.20	-	-	9.00	-	-12.00	-
IRLSS	ac.	0	1.00	-	-	1.00	-	-	-
TLA	hr.	3,940	12.32	34.05	28.58	31.71	4.58	-	94.63
TOPLA	hr.	3,086	1.64	1.17	1.17	1.64	.75	-	43.99
JFMLA	hr.	559	-	-	-	-	-	-	16.83
NOVLA	hr.	188	-	-	-	-	-	-	7.01
DECLA	hr.	188	-	-	-	-	-	-	5.61
AMYLA	hr.	862	2.75	2.40	8.63	3.68	-	-	13.13
J-ALA	hr.	1,217	3.10	19.70	2.53	8.68	2.45	-	8.26
A-SLA	hr.	570	3.20	9.24	15.00	15.39	.53	-	29.25
OCTLA	hr.	358	1.63	1.54	1.25	2.32	.85	-	14.54
WHSS	bu.	0	-	-	-	-	-	-	7.00
OTSS	bu.	0	-	-	-	-	-	-	113.50
PESS	bu.	0	-33.00	-	-	-	-	-	-
BRSS	bu.	0	-	-	-	-	-	-	117.00
POTSS	bu.	0	-	-	115.00	200.00	-	-	-
SBSS	tons	0	-	-12.00	-	-	-	-	-
GRQT	bu.	2,070	9.00	9.00	9.00	9.00	-	-	-
POMX	ac.	0	-	-	1.00	1.00	-	-	-
PEMX	ac.	0	1.00	-	-	-	-	-	-
SBMX	ac.	0	-	1.00	-	-	-	-	-
STCP	$	2,000	13.16	20.16	59.00	65.88	2.90	4.40	151.04
GENCP	$	0	-	-	-	-	-	-	-560.00
STBSS1	ac.	200	1.00	-	-	-	1.00	-	-
SMFWSS1	ac.	30	-	1.00	-	-	-	-	-
STBSS2	ac.	0	-1.00	-1.00	-1.00	-1.00	-	-	-
SMFWSS2	ac.	0	-	-	-	-	-1.00	-	-

TABLE C-3 (continued)

		Net price	-1.75	-1.50	-1.75	-1.50	1.61	.63	2.95
						Activity			
Restraint	Unit	Level	HSPLA	HSMLA	HFLLA	HOTLA	SWQ	SOQ	SFX
TLA	hr.	3,940	-1.00	-1.00	-1.00	-1.00	-	-	-
AMYLA	hr.	862	-1.00	-	-	-	-	-	-
J-ALA	hr.	1,217	-	-1.00	-	-	-	-	-
A-SLA	hr.	570	-	-	-1.00	-	-	-	-
OCTLA	hr.	358	-	-	-	-1.00	-	-	-
HSPLA	hr.	680	1.00	-	-	-	-	-	-
HSMLA	hr.	900	-	1.00	-	-	-	-	-
WHSS	bu.	0	-	-	-	-	1.00	-	-
OTSS	bu.	0	-	-	-	-	-	1.00	-
FXSS	bu.	0	-	-	-	-	-	-	1.00
GRQT	bu.	2,070	-	-	-	-	1.00	1.00	-
STCP	$	2,000	1.75	1.50	1.75	1.50	.02	.02	.02
GENCP	$	0	-	-	-	-	-1.61	-.63	-2.95

TABLE C-3 (continued)

		Net price	.049	2.06	1.00	1.45	14.96	0	-43.72
						Activity			
Restraint	Unit	Level	SSN	SP	SBQ	SPOT	SSB	LDIS	DVTA
TL	ac.	240	-	-	-	-	-	1.00	-
IRL11	ac.	128	-	-	-	-	-	-	1.00
TLA	hr.	3,940	-	-	-	-	-	-	5.80
OCTLA	hr.	358	-	-	-	-	-	-	5.80
SNSS	cwt.	0	1.00	-	-	-	-	-	-
PESS	bu.	0	-	1.00	-	-	-	-	-
BRSS	bu.	0	-	-	1.00	-	-	-	-
POTSS	bu.	0	-	-	-	1.00	-	-	-
IRMACH	hr.	0	-	-	-	-	-	-	1.00
SBSS	tons	0	-	-	-	-	1.00	-	-
SNMX	ac.	0	-	-	-	-	-	-.15	-
GRQT	bu.	2,070	-	-	1.00	-	-	-	-
FXMX	ac.	0	-	-	-	-	-	-.50	-
POMX	ac.	0	-	-	-	-	-	-.15	-
PEMX	ac.	0	-	-	-	-	-	-.15	-
SBMX	ac.	0	-	-	-	-	-	-.15	-
STCP	$	2,000	.03	.05	.02	.30	3.70	-	-
GENCP	$	0	-.049	-2.06	-1.00	-1.45	-14.96	-	-
LTCP	$	20,000	-	-	-	-	-	-	75.72
IRL12	ac.	128	-	-	-	-	-	-	1.00*
IRLSS2	ac.	0	-	-	-	-	-	-	-.90*
FIXCT2	$	7,650	-	-	-	-	-	-	-6.37*

*These coefficients for DVTA in year 1 are also necessary in years 3, 4,...20.

TABLE C-3 (continued)

		Net price	-58.21	0	-.085	0	0	0	-4326.00
						Activity			
Restraint	Unit	Level	DVTB	PFC	BSTC	RSTC	1T2G	1T2STC	BIRMH
IRL21	ac.	44	1.00	-	-	-	-	-	-
TLA	hr.	3,940	5.80	-	-	-	-	-	-
OCTLA	hr.	358	5.80	-	-	-	-	-	-
IRMACH	hr.	0	1.00	-	-	-	-	-	-172.00**
FIXCT1	$	7,650	-	1.00	-	-	-	-	-
STCP1	$	2,000	-	-	-1.00	-	-	1.00	-
GENCP	$	0	-	1.00	-	1.00	1.00	-	-
LTCP	$	20,000	103.22	-	-	-	-	-	2,800.00
BYSTCP	$	0	-	-	-1.00	1.00	-	-	-
BLSTCP	$	15,000	-	-	1.00	-	-	-	-
IRL22	ac.	44	1.00*	-	-	-	-	-	-
IRLSS2	ac.	0	-.90*	-	-	-	-	-	-
FIXCT2	$	7,650	-8.52*	-	-	-	-	-	-288.40**
STCP2	$	0	-	-	-	-	-1.00	-1.00	-

*These coefficients for DVTB in year 1 are also necessary in years 3, 4,...20.

**These coefficients for BIRMH in year 1 are also necessary in years 2, 3,...16.

TABLE C-3 (continued)

		Net price	0	-5.46	-7.81	-7.53	-7.05	-7.48	103.00
						Activity			
Restraint	Unit	Level	1T2LTBL	WFD	WSD	BSD	OSD	FXD	FL260
TLA	hr.	3,940	-	3.38	4.73	4.85	3.99	4.79	15.09
TOPLA	hr.	3,086	-	1.00	1.00	1.00	1.00	1.00	7.19
JFMLA	hr.	559	-	-	-	-	-	-	3.51
AMYLA	hr.	862	-	.92	1.05	1.08	1.13	1.05	2.80
J-ALA	hr.	1,217	-	.13	.13	.13	.17	.13	3.50
A-SLA	hr.	570	-	1.33	1.33	1.34	1.39	1.31	1.60
OCTLA	hr.	358	-	-	1.22	1.30	1.30	1.30	1.00
NOVLA	hr.	188	-	-	-	-	-	-	1.51
DECLA	hr.	188	-	-	-	-	-	-	1.17
WHSS	bu.	0	-	-20.00	-18.00	-	-	-	-
OTSS	bu.	0	-	-	-	-	-37.00	-	142.80
FXSS	bu.	0	-	-	-	-	-	-9.00	-
BRSS	bu.	0	-	-	-	-22.00	-	-	45.70
GRQT	bu.	2,070	-	-	-	-	-	9.00	-
FXMX	ac.	0	-	-	-	-	-	1.00	-
STCP	$	2,000	-	5.46	7.81	7.53	7.05	7.48	127.04
GENCP	$	0	-	-	-	-	-	-	-230.00
HAYSS	tons	0	-	-	-	-	-	-	.38
LTCP1	$	20,000	1.00	-	-	-	-	-	-
STBSS1	ac.	200	-	-	1.00	1.00	1.00	1.00	-
SMFWSS	ac.	30	-	1.00	-	-	-	-	-
LTCP2	$	0	-1.00	-	-	-	-	-	-
STBSS2	ac.	0	-	-1.00	-1.00	-1.00	-1.00	-1.00	-

TABLE C-3 (continued)

	Net price	90.00	62.00	-7.24	-7.24	-9.74	-14.24	-14.24
					Activity			
Restraint	Unit	Level	FL210	FL142	F1D	F2D	F3D	F1I	F2I
IRH20	ac. ft.	0	-	-	-	-	-	16.40	16.40
TLA	hr.	3,940	10.82	10.25	5.42	5.42	9.67	12.24	12.24
TOPLA	hr.	3,086	7.19	7.45	1.17	1.17	1.92	1.64	1.64
JFMLA	hr.	559	3.51	3.51	-	-	-	-	-
AMYLA	hr.	862	2.80	2.80	.08	.08	.08	.20	.20
J-ALA	hr.	1,217	-	-	4.17	4.17	6.29	10.40	10.40
A-SLA	hr.	570	.83	-	-	-	.53	-	-
OCTLA	hr.	358	1.00	1.00	-	-	.85	-	-
NOVLA	hr.	188	1.51	1.71	-	-	-	-	-
DECLA	hr.	188	1.17	1.23	-	-	-	-	-
OTSS	bu.	0	74.50	29.76	-	-	-	-	-
BRSS	bu.	0	38.80	58.03	-	-	-	-	-
STCP	$	2,000	163.70	213.88	7.24	7.24	9.74	14.24	14.24
GENCP	$	0	-253.00	-276.00	-	-	-	-	-
SMFWSS2	ac.	0	-	-	-	-	-1.00	-	-
HAYSS	tons	0	.38	.50	-2.50	-2.50	-2.50	-4.00	-4.00
FORI21	ac.	0	-	-	-	-	-	-	1.00
FORI11	ac.	0	-	-	-	-	-	1.00	-
FORD31	ac.	0	-	-	-	-	1.00	-	-
FORD21	ac.	0	-	-	-	1.00	-	-	-
FORD11	ac.	0	-	-	1.00	-	-	-	-
FORI32	ac.	0	-	-	-	-	-	-	-1.00
FORI22	ac.	0	-	-	-	-	-	-1.00	-
FORD32	ac.	0	-	-	-	-1.00	-	-	-
FORD22	ac.	0	-	-	-1.00	-	-	-	-

TABLE C-3 (continued)

		Net price	-16.74	-8.69	-11.49
					Activity
Restraint	Unit	Level	F3I	CSFD	CSFI
IRH2O	ac. ft.	0	16.40	-	12.10
IRLSS	ac.	0	-	-	1.00
TLA	hr.	3,940	16.49	7.10	17.27
TOPLA	hr.	3,086	-	1.17	1.64
AMYLA	hr.	862	.28	1.12	2.97
J-ALA	hr.	1,217	12.52	1.35	6.92
A-SLA	hr.	570	.53	2.59	3.51
OCTLA	hr.	358	.85	.87	2.23
STCP	$	2,000	16.74	8.69	11.49
STBSS1	ac.	200	-	1.00	1.00
STBSS2	ac.	0	-	-1.00	-1.00
IRLSS2	ac.	0	-1.00	-	-
SMFWSS2	ac.	0	-1.00	-	-
HAYSS	tons	0	-4.00	-5.40	-7.20
FORI3	ac.	0	1.00	-	-