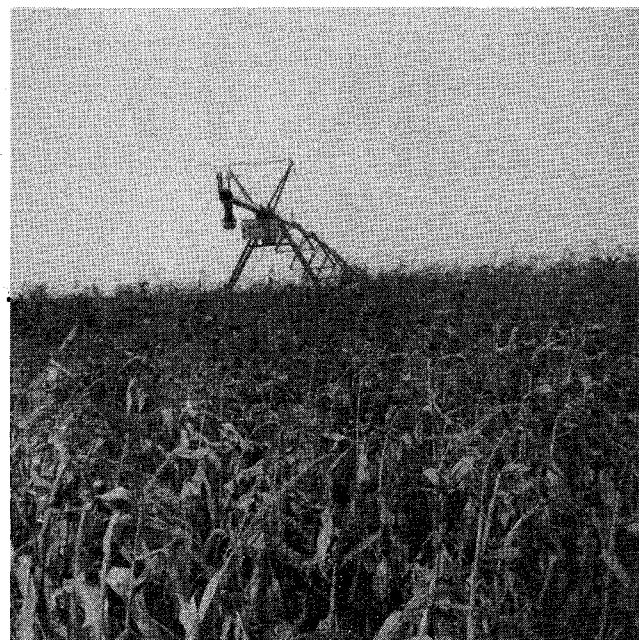
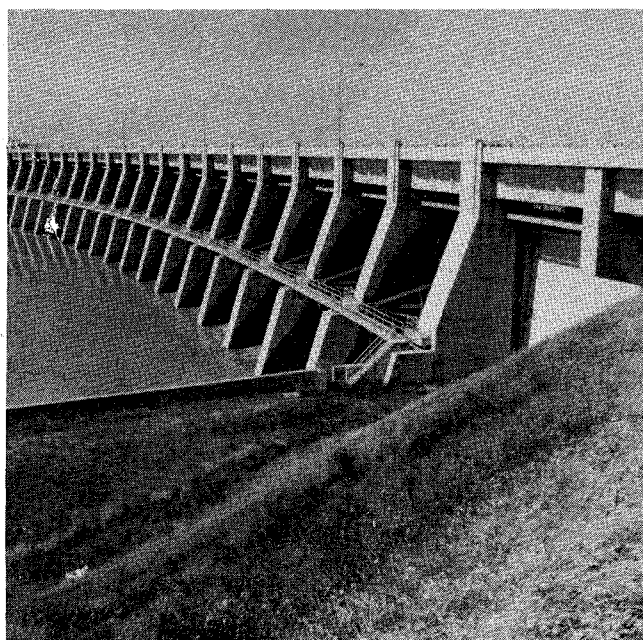


IMPACT OF INUNDATION AND CHANGES IN GARRISON DIVERSION PROJECT PLANS ON THE NORTH DAKOTA ECONOMY

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FOREWORD

This report attempts to identify the economic consequences of the Garrison Diversion Unit and North Dakota's Missouri River impoundments from the state's perspective. The authors hope it will assist individuals and groups making decisions affecting the future development of North Dakota's water resources.

The authors extend their appreciation to the following persons for their assistance in preparing this report:

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Highlights

This report estimates the gains and losses experienced by North Dakotans resulting from inundation of over 500 thousand acres of land by two Missouri River reservoirs and the potential economic effect of diverting Missouri River waters for irrigation. Value estimates were made from a statewide perspective and should not be construed to have any relationship to nationwide benefit-cost accounting.

It was estimated that North Dakota had annual agricultural losses of \$93 million in gross business volume (GBV) and \$34 million in personal income (PI) due to inundation from Garrison and Oahe reservoirs. In addition, annual losses due to bank erosion in 1977 were estimated at \$319,000 in GBV and \$119,000 in PI. Almost \$2.5 million worth of cottonwood stumpage sales were lost, which would have produced over \$15 million worth of lumber sales from sawmills.

Some compensation was made to North Dakota in the form of payments to landowners, electric power generation, flood control, and recreation benefits.

Differential income flows were estimated for irrigated and dry cropland. Using input-output analysis, it was estimated that the increase in agricultural production brought about by the authorized 250,000-acre irrigation project would increase annual GBV by \$135 million and annual PI by \$51 million. A 124,000-acre project would increase annual GBV by \$71 million and annual PI by \$27 million, and the recommended 96,000-acre plan would increase annual GBV by \$49 million and annual PI by \$19 million.

It was estimated that a one-year delay in project completion from the year 1977 would result in \$81 million in GBV and \$30 million in PI foregone in North Dakota.

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by

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Background

The Corps of Engineers Pick Plan¹ provided for a series of dams on the Missouri River that would alleviate flood problems in downstream states. The Bureau of Reclamation's Sloan Plan² called for diversion of water from Fort Peck Reservoir in Montana to North Dakota for irrigation. Political necessity brought these two plans together into the Pick-Sloan Plan³ for development of the Missouri River Basin's water resources (Ridgeway). It was under the authorization of this joint plan that the Garrison Dam in North Dakota and the Oahe Dam in South Dakota were built.

North Dakota was to receive irrigation water from the Missouri reservoir system in return for giving up land inundated³ by the reservoirs. An early Corps of Engineers report (Garrison Dam and Reservoir Project, North Dakota, p. 6) promised: "Though the Garrison Dam and Reservoir Project is being conceived primarily to capture flood waters of the Upper Missouri River, the Project likewise, will bring immeasurable wealth to North Dakota." This report discusses the foregone agricultural production due to inundation and the potential agricultural production that could be gained from diversion of Missouri water for irrigation.

Method of Estimating Influence

One method of measuring the influence of changes in economic activity is input-output analysis. Sand and Bartch constructed

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¹House document 475, 78th Congress, Second session, March 2, 1944.

²Senate document 191, "The Missouri River, Conservation, Control, and Use of Water Resources of the Missouri River Basin in Montana, Wyoming, Colorado, North Dakota, South Dakota, Nebraska, Kansas, Iowa, and Missouri." The Report of the Secretary of the Interior on the Bureau of Reclamation's Plan for Basin Development, 78th Congress, Second session, May 5, 1944.

³Flood Control Act of 1944 (57 Stat. 877).

and tested input-output models of the North Dakota economy. The models can be used to estimate gross business volume and personal income resulting from changes in economic activity. Further, employment changes can be estimated using the ratio of gross business volume to employment since the number of employees in selected sectors⁴ of the state's economy is related to the sales volume of that sector.

Input-output analysis is a technique for describing the linkages that exist between sectors in an economy. Three types of tables are involved in input-output analysis. They are (1) a transactions table, (2) a technical input-output coefficients table, and (3) an interdependence coefficients (multipliers) table.

The transactions table shows the payments of each sector to (from) each other sector. The columns indicate expenditures to the rows, and the rows indicate receipts from the columns.

The technical input-output coefficients table is derived from the transactions table. This table is the transactions table expressed as decimal fractions of column totals.

The interdependence coefficients (multipliers) table is derived from the technical input-output coefficients table (Appendix Table A1). It shows the total input requirements that must be obtained from the row sector per dollar of output for final demand⁵ by the column sector. The column totals of this table are the total output requirements of all row sectors in the economy per dollar of output for final demand by the column sector. For example, to produce a bushel of wheat requires certain inputs, such as gasoline, fertilizer, machinery, and labor, which must be purchased from firms in other sectors of the economy. In order for firms to supply those inputs, they in turn must also purchase inputs as part of their operation. Input-output analysis traces these linkages and can be used to estimate the effect of such expenditures on a region's gross business volume.

⁴A sector is a group of firms that perform similar but not necessarily the same functions. For example, firms engaged in retail trade, such as groceries and hardware items, comprise the retail trade sector.

⁵Final demand is defined as sales that result in a flow of funds into the local economy from outside sources. These sales consist of exports of crops and livestock, exports of mines and manufactured products, expenditures by tourists, and federal government outlays in the area.

Certain sectors of the economy are particularly important when analyzing farm operator expenditures and income. Those sectors are: (1) the retail sector; (2) the finance, insurance, and real estate sector; and (3) the business and personal service sector. In addition, the household sector is important since dollar values in this sector are called personal income which represents wages, salaries, rents, dividends, etc.

Farm operators purchase inputs required for their operation in the retail sector. Examples of items purchased in this sector are seed, fuel, machinery, fertilizer, and hardware.

Insurance and capital needs of farm operators are purchased in the finance, insurance, and real estate sector. The farm operator buys crop insurance and borrows money from firms in this sector.

The business and personal service sector includes firms that service farm equipment and also includes firms that provide custom farming operations.

For every acre of land farmed, the farm operator purchases a certain quantity of goods in the retail trade sector. He may also buy insurance or borrow money from the finance, insurance, and real estate sector. He has repairs made by firms in the business and personal service sector. His net income and the wages he pays hired help pass through the household sector.

Each dollar of goods and services sold in these four sectors has an impact on other sectors of the economy. Part of the money spent in the retail sector ends up in the households sector as personal income. Part also goes to each of the other sectors due to interactions in the economy. The money received by the farmer and his hired help, identified as passing through the households sector, is spent and in turn generates business volume in still other sectors.

Two measures will be used to estimate the economic influence of farmland taken out of production due to inundation and the potentially irrigable land in the Garrison Unit. Personal income estimates will be used to show the total amount of income foregone by North Dakotans. Gross business volume estimates will be used to illustrate the amount of economic activity that is generated as a result of farm production expenditures. Gross business volume can also be used to estimate employment and certain tax revenues.

Prices Used in Analysis

The average prices paid and received by farmers occurring over the ten years, 1963-72, were used as a basis for determining product price relationships (MIP Report No. 1). Average prices occurring over this period represent general price relationships that can be expected to prevail in the future. The base period selected is long enough not to be influenced unduly by cyclical price patterns, and yet it reflects long-term trends in relative prices. This period also represents a time of rather stable agricultural price relationships. All prices were indexed to 1977 values so as to relate to current (1977) income losses.

Crop budgets were developed using "MIP" crop budgets adjusted for area yields and soil types. The "MIP" budgets are expressed in 1974 dollars and they were inflated to 1977 values⁶ using the prices paid index⁷ (1974 dollars x 1.29 = 1977 dollars).

Crop Rotations

Eight crop rotations were developed for analysis for three Garrison Diversion Unit (GDU) areas and the Missouri bottomlands (Figure 1). They were:⁸ (1) dryland inundated by Garrison and Oahe, (2) irrigated land inundated, (3) southern GDU area dryland, (4) southern GDU area irrigated, (5) central GDU area dryland, (6) central GDU area irrigated, (7) northern GDU area dryland, and (8) northern GDU area irrigated.

The rotations were developed using information from several sources. A survey of irrigators was conducted to gather information on rotations and yields in the three Garrison Diversion Unit areas and the Missouri River bottomlands. An Extension Service survey of irrigators was also used.⁹ Several published sources were also used for background information, including the North Dakota Crop and Livestock Statistics, "MIP" reports, and the Knife River Plan (State Water Commission).

⁶See pages 32-33 of "MIP" Report No. 1, June, 1974, for an explanation of indexing.

⁷Unpublished data of "MIP" Interdisciplinary Research Team, North Dakota State University.

⁸Crop rotations and budgets are presented in Appendix Tables.

⁹Annual survey of irrigation by Darnell Lundstrom, North Dakota State University, Extension irrigation specialist.

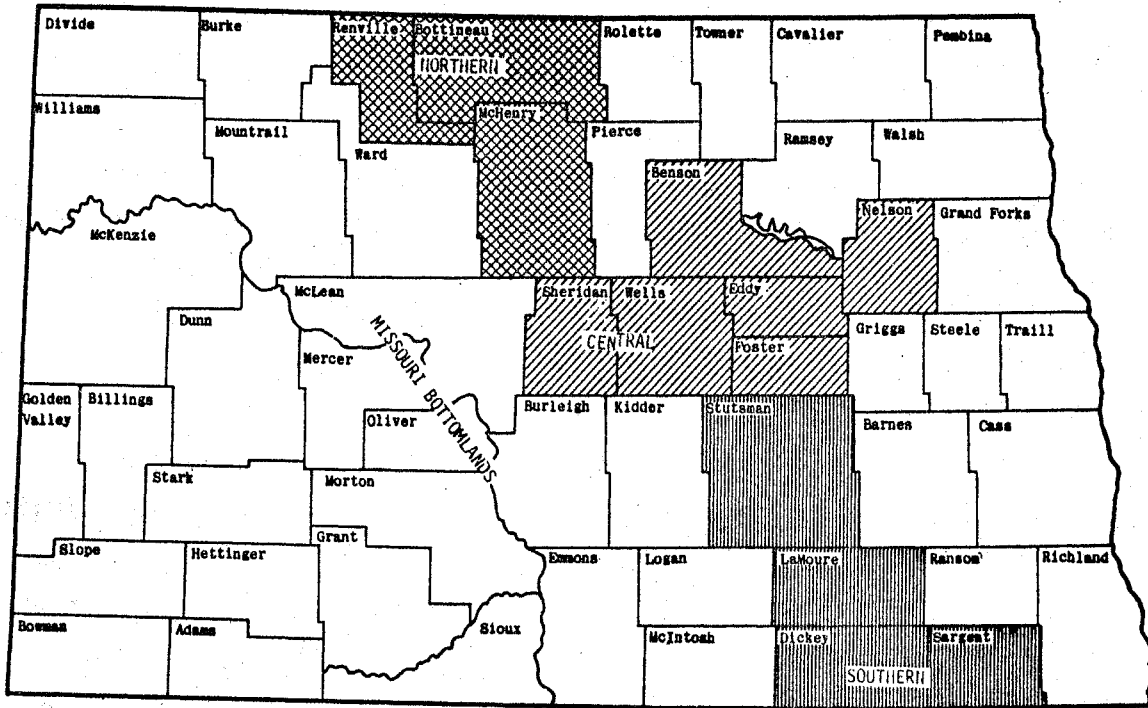


Figure 1. Crop Rotation Areas/Study Areas

Inundation Losses

Large-scale public works projects generally result in some person(s) giving up something so that society, as a whole, will be better off. The state of North Dakota gave up over 500,000 acres of choice river bottom-land so that residents of downstream states would be spared from frequent flooding and to provide electrical power for the multi-state region.

Two reservoirs were created on the Missouri River in North Dakota. Lake Sakakawea, formed as a result of Garrison Dam, took over 460,000 acres of land in six counties. Lake Oahe, formed as a result of Oahe Dam in South Dakota, took over 100,000 acres of land in North Dakota.

The negative impacts of Garrison and Oahe reservoirs were discussed by Johnson and Goodman in their 1962 report. Since that time, circumstances warrant a new examination of the impacts brought about by the two reservoirs. New technologies in irrigation have been developed. Farming technologies in general have improved and land use patterns have changed in North Dakota's agriculture.

Garrison Reservoir Losses

Garrison Dam is located approximately 75 river miles north of Bismarck. The dam is rolled earth filled, 210 feet high, and 11,000 feet long. The reservoir--Lake Sakakawea--is approximately 200 miles long at maximum normal operating pool with a surface area of about 390,000 acres, and extends to within a few miles of the Montana border (U.S. Corps of Engineers, 1947).

Agricultural Losses

Over 462,000 acres of land were required for Garrison Reservoir (Table 1). One-third of that land was located in the Fort Berthold Indian Reservation. The remaining two-thirds was owned primarily by individual farm operators. The river bottomlands, which made up a large portion of land that was taken, were integral parts of farming operations. The wooded areas provided shelter for cattle, as well as income from lumber. The river bottom cropland was rich alluvial soil. Sometimes, it was naturally irrigated by spring flooding and almost always provided better crops, both in terms of yield and reliability, than the adjacent upland areas. River bottom pasture was generally lush with high regrowth potential.

Dry Cropland

There were approximately 169,580 acres of cropland being farmed under dryland conditions in the area taken for Garrison reservoir at the time it was purchased. It was estimated that if the land had remained in operation (not flooded by the reservoir), there would have been 128,536 acres of dry cropland in 1977 (Table 2). The land use estimates reflected in Table 2 show 36,222 acres would have been irrigated, 8,479 acres would have been devoted to other uses, and 124,861 acres would have remained as dry cropland. It was also estimated that about 3,657 acres of woodland would have been cleared to be used as dry cropland in the 25-year period prior to 1977.

TABLE 1. USE OF LAND TAKEN FOR GARRISON RESERVOIR AT THE TIME OF TAKING

Land Use	Land Area		Percent of All Land Taken
	Fort Berthold <i>acres</i>	Reservation <i>percent</i>	
Urban	500 ^a	0.3	0.1
Woodland	41,358	27.1	8.9
Pasture	90,293	59.1	19.5
Cropland: Dry	20,709	13.5	4.5
Irrigated	0 ^b	0	0
	<u>152,860</u>	<u>100.0</u>	<u>33.0</u>
<u>Ongoing Irrigation Projects^c</u>			
	<i>acres</i>	<i>percent</i>	
Urban	0	0	0
Woodland	4,001	23.8	0.9
Pasture	2,264	13.4	0.5
Cropland: Dry	2,617	15.5	0.6
Irrigated	7,966	47.3	1.7
	<u>16,848</u>	<u>100.0</u>	<u>3.7</u>
<u>All Other Land Area^d</u>			
	<i>acres</i>	<i>percent</i>	
Urban	0	0	0
Woodland	42,642	14.5	9.2
Pasture	104,357	35.6	22.5
Cropland: Dry	146,254	49.9	31.6
Irrigated	0 ^b	0	0
	<u>293,253</u>	<u>100.0</u>	<u>63.3</u>
----- T O T A L -----			
	<i>acres</i>		
Urban	500		0.1
Woodland	88,001		19.0
Pasture	196,914		42.5
Cropland: Dry	169,580		36.7
Irrigated	7,966		1.7
	<u>462,961</u>		<u>100.0</u>

^aVillages of Sanish, VanHook, and Elbowoods.
^bThere were some small plots, primarily gardens, that were irrigated.
^cBuford-Trenton and Lewis and Clark irrigation projects.
^dIncludes all land taken that was not either a part of the Fort Berthold Indian Reservation or an ongoing irrigation district.

SOURCE: Johnson and Goodman, Negative Impacts of Garrison and Oahe Reservoirs on the North Dakota Economy.

TABLE 2. LAND USE AT TIME OF TAKING AND PRESENT POTENTIAL LAND USE,^a GARRISON RESERVOIR

From \ To	Total at Time of Taking	Woodland	Pasture	Dry Cropland	Irrigated Cropland	Other ^b
Woodland	88,001	68,545	3,657	3,657	7,742	4,400
Pasture	196,914	0	159,898	0	27,170	9,846
Cropland: Dry	169,580	0	0	124,879	36,222	8,479
Irrigated	7,966	0	0	0	7,966	0
Urban	500	0	0	0	0	500
Potential 1978 Totals	462,962	68,545	163,556	128,536	79,101	23,224

^aPotential 1977 land use was estimated assuming: government owned woodland would remain woodland; woodland within irrigation projects would be converted to irrigated cropland; 80 percent of nonirrigable woodland on private land would remain woodland, 10 percent would be converted to pasture, and 10 percent to dry cropland; woodland on Indian land would remain woodland (except that which was irrigable) due to cultural reasons; all dry cropland and pasture included in irrigation projects would be converted to irrigated cropland; and 5 percent of all land uses would be devoted to other uses.

^bOther category includes: farm sites, roads, services, urban, irrigation works, and nonagricultural land.

SOURCES: Bureau of Reclamation Report No. 66, 1942. Bureau of Reclamation Reappraisal Report, 1965.

An estimate of the crops that might have been grown on dry cropland in the area inundated by Garrison Reservoir in 1977 is shown in Table 3. This mix of crops is somewhat different from that grown on upland areas in the same part of the state because the river bottom soils are generally better, the land in the river bottoms is nearly level, and some natural irrigation is provided by spring floods.¹⁰

A composite acre¹¹ representing the crop mix as shown in Table 3 would have resulted in the following expenditure flows in 1977 from agriculture as estimated by the input-output technique:¹²

¹⁰A portion of the dry cropland inundated was upland; however, this portion was small relative to the amount of river bottom cropland.

¹¹A composite acre is a representation of agricultural land use in a region. It shows what proportion of the cropland is seeded to the various crops and the proportion of land in pasture and summer fallow. A composite acre can also be used to represent the mix of crops grown over time, and may be used to represent the mix of crops that would be planted during a specific period in the planting season.

¹²A budget for the dry cropland inundated is presented in Appendix Table B1.

TABLE 3. ESTIMATED 1977 CROP ROTATIONS AND YIELDS ON DRY CROPLAND INUNDATED BY GARRISON RESERVOIR

Crop	Percent of Cropland	Average Yield
Wheat	42	28 bu.
Oats	12	50 bu.
Barley	5	40 bu.
Flax	4	11 bu.
Corn	14	45 bu. or 5.5 tons
Tame Hay/Alfalfa	11	2.0 tons
Tame Pasture	2	9 aum
Summer Fallow	10	-
	<u>100</u>	

SOURCES: The West River Study. L. W. Schaffner, Present Farm Economy in Three Proposed Irrigation Areas of North Dakota. Feasibility Report on Horsehead Flats and Winona Units. North Dakota Crop and Livestock Statistics, annual. The Plan of Water and Related Land Resources Development for the Knife River Basin.

Retail trade:	\$33.04
Finance, Insurance, and Real Estate:	\$ 8.35
Business and Personal Service:	\$ 3.56
Household:	\$38.35

This per acre expenditure would result in \$227.38 in gross business volume in the state, a part of which (\$85.44) would be personal income to individuals. This income would accrue to the farm operator, as well as those people in the economy who are affected by his business transactions.

The overall effect of 128,536 acres of dryland crop production in the state in 1977 would be \$29,226,500 in gross business volume, including \$10,554,900 of personal income to the household sector. This, of course, was lost by the inundation of the Garrison Reservoir.

Pasture

There were 196,914 acres of pasture taken out of production due to inundation created by the Garrison Reservoir (Table 1). If the land had not been inundated, it was estimated that by 1977 there would have been 163,556 acres of pasture remaining (Table 2). Some of the former pasture (27,710 acres) would have been irrigated, some used for other uses (9,846 acres) and some former woodland (3,657 acres) would have been converted to pasture.

Estimated expenditures associated with each acre of pasture are:

Retail trade:	\$ 3.83
Business and Personal Service:	\$.14
Household:	\$12.96

These expenditures would result in \$48.30 in gross business volume per acre, including \$21.78 of income to households.

The gross business volume that would result from the entire 163,556 acres of pasture is \$7.9 million with \$3,562,200 of income to households. This too was lost.

Irrigated Cropland

A potential existed for irrigation along the Missouri River in areas now under water. There was an available water supply and some soils were suitable for irrigation. The Bureau of Reclamation's Sloan plan had investigated the potential of irrigation along the Missouri in North Dakota. Eleven potential irrigation projects were identified along the Missouri, in addition to two that had been initiated (Bureau of Reclamation Report 66, 1942) (Table 4).

Approximately 7,966 acres were being irrigated prior to filling of the reservoir (Copper) (Table 1). Had the land not been inundated, the potential existed for irrigation of another 71,135 acres by 1977 assuming a moderate rate of development (Table 2). If North Dakota had not allowed inundation to occur, an estimated 79,000 acres of irrigated cropland along the Missouri River would have been in production in 1977 (Table 2).

TABLE 4. LAND USE AT TIME OF TAKING ON POTENTIAL IRRIGATION PROJECT AREAS, GARRISON RESERVOIR

Land Use	Acres	Percent of Total
<u>Area Studied^a</u>		
Urban	0	0
Woodland	10,360	19
Pasture and Cropland	44,780	81
	55,140	100
<u>All Land Inundated^b</u>		
Urban	0	0
Woodland	13,595	19
Pasture and Cropland	58,757	81
	72,352	100

^aThe area studied by the Bureau in Report 66 and the Reappraisal Report was approximately 80 percent of the total area to be inundated.

^bThe area studied was increased by 25 percent to account for having studied only 80 percent of the area inundated. It was further increased by 10 percent to allow for improved technologies in sprinkler irrigation (Johnson and Goodman, p. 7). The area was then reduced by 4.75 percent to allow for area taken up by irrigation infrastructure (Johnson and Goodman, p. 7; and The Plan for the Knife River Basin, p. 95).

SOURCES: Johnson and Goodman, Negative Impacts of Garrison and Oahe Reservoirs on the North Dakota Economy. Bureau of Reclamation Report No. 66, 1942. Bureau of Reclamation Reappraisal Report, 1965.

Each acre of irrigated cropland would generate \$502.87 in gross business volume and \$179.07 in personal income in 1977 from the following annual expenditure and income flows:

Retail:	\$84.64
Finance, Insurance, and Real Estate:	\$21.78
Business and Personal Service:	\$ 7.48
Household:	\$73.23

All 79,101 acres of irrigable land would have generated \$14,159,000 of personal income to North Dakotans and \$39,787,000 of gross business volume.

Mineral Losses

The Garrison Reservoir inundated areas of the Fort Union coal formation, and the Oahe Reservoir inundated areas of the Hell Creek and Fox Hills coal formation in North Dakota (Brant). An estimated 5,850 million tons of lignite were inundated by Garrison Reservoir (Johnson and Goodman and Laird).

In addition to lignite, there are 29 potential 80-acre petroleum locations within the 1,850-foot contour limits of Garrison Reservoir in Williams and McKenzie counties that were not drilled. If all proved to be productive, they would yield an estimated 5 million barrels of oil (Johnson and Goodman).

Whether these mineral resources would have been developed and to what extent is academic, the point is that their use was lost to the North Dakota economy.

Forestry Losses

The losses sustained by the state due to inundation of woodland are primarily intangible. Woodland in the river bottom and coulees provides valuable shelter for cattle. The dollar value for this use is difficult to measure. "The timber lands, usually present in these areas, are a source of shelter to the cattle during periods of inclement weather during the winter months, which adds to the value of the bottomland. Upland severed from access to the bottomland is greatly deflated in value and the carrying capacity of the entire area is adversely influenced." (Statement of Congressman Don L. Short at the Public Hearing on Bank Stabilization on Missouri River from Garrison Dam, North Dakota to the Oahe Reservoir, February 26, 1960). Woodland and brushland also provide habitat for a variety of wildlife.

Green estimated the total net merchant volume of timber lying below the taking elevations to be 508 million board feet. This timber was primarily cottonwood. The 1977 average price of rough green cottonwood lumber was \$120 per thousand board feet, while the stumpage value was \$20 per thousand board feet.¹³

If the river would have remained in its natural state, however, not much of the timber would have been harvested. Of the 88,001 acres of woodland at the time of taking (Table 1), it is estimated that 68,545 would have remained in woodland in 1977 (Table 2). The Corps of Engineers (1977a, pp. 6-52) reported that in 1977 "Much of the remaining forest in the river bottoms is as yet uncleared land adjacent to the river banks."

The woodland cleared would have been converted to dry cropland, pasture, or irrigated cropland. The economic value of timber to the owner from 19,456 acres or 112 million board feet of cottonwood would be approximately \$2,240,000, while the value of lumber produced at a sawmill would be \$13,440,000.

There are several reasons for assuming only about 20 percent of the woodland would have been cleared. First, clearing woodland requires a considerable amount of capital. Second, almost 20 percent of the woodland was government owned and likely would not have been harvested. Third, the woodland provided valuable shelter for livestock. Fourth, North Dakota has the least amount of woodland of any state in the United States, and as the amount decreases, each remaining acre becomes more valuable. Finally, the woodland provided excellent habitat for wildlife, and wildlife interests would probably have attempted to ensure maintenance of woodland habitat.

The foregone income flows from woodland that would have been present in 1977 are difficult to estimate since they are made up of a number of components. The value of woodland in relation to the rest of the farming unit in terms of cattle production must be considered. No

¹³Lewis Hendricks, Extension Forester, University of Minnesota, telephone conversation February 8, 1978. Rough green lumber is the end product of the mill. Stumpage value is what the landowner would be paid for his standing timber.

universally acceptable method of measuring the value of woodland as wildlife habitat has been found. Finally, the value of native woodland in terms of aesthetics cannot be measured with the more common techniques of economic analysis. The income flows foregone from woodland not harvested as timber are greater than zero, but will not be given dollar values in this report. Again, it is important to note that the potential to use this resource was sacrificed by the filling of Garrison Reservoir.

Bank Erosion Losses¹⁴

The remaining natural reach of Missouri River in North Dakota-- approximately 83 miles between Garrison Dam and Oahe Reservoir--has been subject to bank erosion since closure of Garrison Dam. Bank erosion was a natural occurrence under pre-dam conditions, but what is different under post-dam conditions is that erosion losses of valley lands are no longer replaced. The process of bank erosion and land building are not in balance. With the natural river there was balance over the years between erosion of valley lands and building of new lands by sediment deposition during floods. Operation of the reservoir system has eliminated both the floods and sediment deposition that were essential for the flood plain land building process, and the erosion continues.

From the individual landowner's viewpoint, bank erosion is a real threat since he may suffer major losses of valuable bottomland which may have been developed for irrigation. With the elimination of the annual threat of flooding, private investment in such improvements as sprinkler irrigation is occurring. Individuals cannot afford to have their investments washed away by the river.

The Corps of Engineers has recognized this problem and has ongoing bank stabilization projects at seven sites between Garrison and Oahe, with 21 additional sites authorized. The loss of land due to bank erosion has been estimated by the Corps to be 0.9 acres/river mile/year (Corps of Engineers, 1977a). The total loss of acreage due to bank erosion since

¹⁴Much of this discussion on bank erosion is from Review Report for Water Resources Development, Missouri River, South Dakota, Nebraska, North Dakota, Montana, Omaha: Corps of Engineers, pp. C-50 - C-75, 1977.

closure of Garrison Dam through 1975 was approximately 1,772 acres. Assuming another 75 acres were lost in 1976 and 1977 (83 miles x 0.9 acres/mile = 74.7 acres/year), the total acreage lost through 1977 would be approximately 1,922 acres.

If land use of eroded river banks is the same as in the rest of the river basin, losses of business volume and personal income would occur. The estimated total annual loss in 1977 for 1,922 acres of bank erosion is \$319,000 in foregone gross business volume and \$119,000 in foregone personal income (Table 5).

TABLE 5. ANNUAL GROSS BUSINESS VOLUME AND PERSONAL INCOME FOREGONE FROM LAND LOST TO BANK EROSION, 1977

Land Use	Percent	Acres	GBV Foregone	Personal Income Foregone
Woodland	15	288	a	a
Pasture	35	673	\$ 32,506	\$ 14,658
Cropland: Dry	28	538	122,330	45,967
Irrigated	17	327	164,481	58,556
Other	5	96	b	b
	<u>100</u>	<u>1,922</u>	<u>\$319,317</u>	<u>\$119,181</u>

^aIncome flows foregone on woodland subject to bank erosion are difficult to measure, but certainly are greater than zero.

^bIncome flows on "other" land are essentially equal to zero.

Oahe Reservoir Losses

Oahe Dam, on the Missouri River near Pierre, South Dakota, impounds 376,000 surface acres of water at full pool, and required 440,000 acres of land to be taken out of production. Approximately 106,400 acres of land in North Dakota was taken for Oahe Reservoir (Table 6).

Agricultural Losses

At the time of taking, 58 percent of the land was pasture, 27 percent was dry cropland, and 14 percent was woodland. Had the land not been inundated, there would have been some woodland cleared, pasture and dry cropland converted to irrigated, and some land taken out of production for "other" uses (Table 7).

TABLE 6. USE OF LAND TAKEN FOR OAHE RESERVOIR (IN NORTH DAKOTA) AT TIME OF TAKING

Land Use	Land Area		Percent of Total
	acres	percent	
<u>Standing Rock Reservation</u>			
Woodland	9,030	16.1	8.5
Pasture	45,585	81.4	42.8
Cropland: Dry	1,379	2.5	1.3
Irrigated	0 ^a	0	0
	<u>55,994</u>	<u>100.0</u>	<u>52.6</u>
<u>All Other Land Area^b</u>			
	acres	percent	
Woodland	6,007	11.9	5.6
Pasture	16,671	33.1	15.7
Cropland: Dry	27,717	55.0	26.1
Irrigated	0 ^a	0	0
	<u>50,395</u>	<u>100.0</u>	<u>47.4</u>
----- T O T A L -----			
	acres		
Woodland	15,037		14.1
Pasture	62,256		58.5
Cropland: Dry	29,096		27.4
Irrigated	0		0
	<u>106,389</u>		<u>100.0</u>

^aThere were some small plots, primarily gardens, that were irrigated.
^bIncludes all land area taken that was not a part of the Standing Rock Indian Reservation.

SOURCE: Johnson and Goodman, Negative Impacts of Garrison and Oahe Reservoirs on the North Dakota Economy.

TABLE 7. LAND USE AT TIME OF TAKING AND PRESENT POTENTIAL LAND USE,^a OAHE RESERVOIR

From \ To	Total at Time of Taking	Woodland	Pasture	Dry Cropland	Irrigated Cropland	Other ^b
Woodland	106,389	12,190	451	451	1,193	752
Pasture	62,256	0	47,710	0	11,433	3,113
Cropland: Dry	29,096	0	0	24,925	2,716	1,455
Irrigated	0	0	0	0	0	0
Urban	0	0	0	0	0	0
Potential 1977 Totals	106,389	12,190	48,161	25,376	15,342	5,320

^aPotential 1977 land use was estimated assuming: government owned woodland would remain woodland; woodland within irrigation projects would be converted to irrigated cropland; 80 percent of nonirrigable woodland on private land would remain woodland, 10 percent would be converted to pasture, and 10 percent to dry cropland; woodland on Indian land would remain woodland (except that which was irrigable) due to cultural reasons; all dry cropland and pasture included in irrigation projects would be converted to irrigated cropland; and 5 percent of all land uses would be devoted to other uses.

^bOther category includes: farm sites, roads, services, urban, irrigation works, and nonagricultural land.

SOURCES: Bureau of Reclamation Report No. 66, 1942. Bureau of Reclamation Reappraisal Report, 1965.

Dry Cropland

Losses from dry cropland inundated for Oahe Reservoir were assumed to be similar to those for Garrison, only the acreages affected were different. The loss of a potential acre of dry cropland based on land use patterns similar to those for Garrison in 1977 represents an estimated \$227.38 in gross business volume, including \$85.44 in personal income. The loss of 25,376 acres of dry cropland to inundation represents a total loss of \$5,770,000 in gross business volume and \$2,168,000 in personal income in 1977.

Pasture

It was estimated that there would have been 48,161 acres of pasture in the area inundated by Oahe Reservoir in 1977 if it had not been dammed (Table 6). The gross business volume resulting from an acre of pasture is \$48.30, with \$21.78 being personal income. Total dollar values for the 48,161 acres are \$2,326,000 of gross business volume and \$1,049,000 of personal income.

Irrigated Cropland

Rotations and budgets used for Garrison inundated land were also used for irrigated land inundated by Oahe. The inundation of 15,342 acres of cropland that were irrigable, and may have been irrigated by 1977, results in a loss of \$7,717,000 in gross business volume and \$2,746,000 in personal income foregone in North Dakota in 1977.

Mineral Losses

No significant mineral reserves were identified on the land inundated by Oahe Reservoir in North Dakota, so this loss is believed to be negligible.

Forestry Losses

Nearly four-fifths, or 12,190 acres, of the 15,000 acres of woodland existing at the time of taking would have remained woodland in 1977 (Table 6). The timber production from cleared woodland would have been approximately 16 and one-half million board feet of cottonwood. At 1977 market values, that represents foregone stumpage income to the woodland owner of \$330,000, and \$1,980,000 worth of sales of rough green lumber to the sawmill.

The annual income flows generated from unharvested woodland were not estimated, but are probably significant.

Recreation Losses

The inundation of 295 miles of the Missouri River in North Dakota by Garrison and Oahe reservoirs dealt a severe blow to the wildlife dependent upon river bottom habitat. Seventeen percent of the state's woodlands were flooded behind the Garrison Dam alone. Nearly all of the land permanently flooded was considered to be high-quality wildlife habitat (Enyeart). Pheasants, which were the state's number one game bird at the time of inundation, were affected in an area of 2 and one-fourth million acres around the reservoir as a result of the loss of suitable winter habitat.

Resource based recreationists; namely, hunters, depended on the river bottom habitat and woodland to provide them with huntable populations of deer, pheasant, and grouse, to mention but a few species. The area encompassing the reservoirs previously accommodated 23 percent of North Dakota's hunters and produced 25 percent of the state's annual deer harvest (1952 figures). In 1971, the same area accommodated 9 percent of the state's deer hunters and provided 9 percent of the annual harvest (Enyeart, p. 17),

The loss in wildlife numbers due to Garrison Reservoir provided recreation for 616 deer hunters and 2,453 small game hunters. However, deer numbers were increasing in this area and would have provided a potential harvest of almost 4,500 deer or recreation for about twice that many hunters by the late 1960's (Enyeart).

The loss in recreation opportunity is difficult to evaluate because of the nature of recreation provided by the reservoir. The loss of wildlife resulted in a decline in the amount of hunting recreation available in the state. In addition, the loss of 295 miles of free flowing river, which is desired by some recreationists (i.e., canoeists, stream fishermen), was replaced by 386,000 acres of reservoir which other recreationists use (i.e., powerboaters, sailboaters, fishermen). The slack water recreation can be provided elsewhere, but the free flowing river environment favored by many outdoor enthusiasts does not have any substitutes and cannot be duplicated. North Dakota (and nonresident) recreationists traded off one set of recreation possibilities based primarily on wildlife and a river in its natural state for another set of recreation possibilities based on a reservoir for the most part and fish to some degree. The corresponding change in overall social well-being is at best difficult to assess and no attempt was made herein to do so.

Tax and Severance Losses

Approximately 50 percent of the land taken for Garrison and Oahe reservoirs was not taxed since it was either government owned or part of an Indian Reservation. The ten counties where land was taken each lost a portion of their tax base. McLean County's tax base suffered the greatest percentage loss--6.5 percent. The other counties affected by Garrison

Reservoir were Williams (3.1 percent), McKenzie (3.0 percent), Mountrail (4.8 percent), Dunn (0.6 percent), and Mercer (3.8 percent). The counties affected by Oahe Reservoir were Emmons (2.7 percent), Burleigh (0.7 percent), Morton (0.6 percent), and Sioux (0.5 percent).

The effect of losing part of the tax base is either to increase tax rates on the remaining taxable property or to bring about reductions in tax revenues.

Severance damages can occur as a result of large-scale projects and may not have occurred if the same activity (such as land sales) had occurred over a reasonable length of time; or they may be damages that cannot be compensated for, such as the loss inflicted by forcing someone to leave his home. Zieman discusses some of these problems in relation to individuals of the Fort Berthold Indian Reservation. The Garrison Reservoir had a tremendous social and cultural impact on members of the Fort Berthold Reservation and all individuals directly involved, the value of which cannot be measured in monetary terms.

Summary of Inundation Losses

Inundation losses due to Garrison and Oahe dams, measured in terms of gross business volume and personal income foregone, were estimated for both dry and irrigated cropland and pasture. Estimated potential 1977 revenues foregone for these three land uses totaled \$92,748,000 in gross business volume and \$34,239,000 in personal income for land inundated by both reservoirs (Table 8).

In addition to the losses of foregone agricultural production, other types of income flows and amenities were given up. A potential for mineral exploitation was lost. Almost \$2.5 million worth of cottonwood stumpage sales were lost, which would have produced over \$15 million worth of lumber sales from sawmills. Approximately 2,000 acres of bottomland were eroded away by the river since closure of the dam. Under natural conditions this bank erosion would replace as much land through deposition as it took, but due to the unique conditions between Garrison Dam and Oahe Reservoir no land was built up for that taken. The income flows possible on land lost due to bank erosion would have added \$319,000 to the state's gross business volume and \$119,000 to personal income in 1977. The recreation setting was changed from 295 miles of free flowing river to two large reservoirs.

TABLE 8. SUMMARY OF REVENUES FOREGONE DUE TO INUNDATION OF CROPLAND AND PASTURE BY GARRISON AND OAHE RESERVOIRS, ANNUAL LOSSES

Land Use	Garrison	Oahe	Total
<u>Gross Business Volume</u>			
Dry Cropland	\$29,226,500	\$ 5,770,000	\$34,996,500
Irrigated Cropland	39,787,800	7,717,026	47,504,829
Pasture	7,900,000	2,326,176	10,226,176
	<u>\$76,914,300</u>	<u>\$15,813,202</u>	<u>\$92,747,505</u>
<u>Personal Income</u>			
Dry Cropland	\$10,554,900	\$ 2,168,000	\$12,722,900
Irrigated Cropland	14,159,079	2,746,218	16,905,297
Pasture	3,562,000	1,048,946	4,610,946
	<u>\$28,275,979</u>	<u>\$ 5,963,164</u>	<u>\$34,239,143</u>

Governmental bodies who formerly taxed inundated lands lost a portion of their tax base, increasing the tax burden on those lands remaining. Finally, severance damages were experienced by all individuals involved in the reservoir projects, many of which could not be compensated financially.

Compensation to North Dakota

The federal government compensated landowners for the 570,000 acres of land taken. Also, North Dakota expected to benefit from the two reservoirs and the operation of the power plant at Garrison Dam. Electrical power, flood control, and recreation were all part of the benefits the state expected to receive in addition to payments made to landowners. Most importantly, North Dakota expected to get the Garrison Diversion Unit, an irrigation project for up to 1,000,000 acres of arid cropland that would bring new wealth and stability to the state's agricultural economy.

Payment to Landowners

Adequate compensation cannot always be determined or made when large-scale development forces hundreds of landowners to sell all or part of their farming operation. The purpose of this report is not to discuss

the adequacy of the payments made for land acquisition for Garrison and Oahe reservoirs,¹⁵ but rather to point out some problems inherent in such large scale undertakings and report the transactions that took place.

There are several problems that confront an individual landowner when he sells all or a large portion of his farm. First, it may leave him with a less than economical unit to operate. This may occur because the farm is simply too small, or the bottomland which made up an important part of his operation is gone. Second, appraisal procedures usually depend on recent sales information involving willing sellers. Many of the landowners displaced by the reservoirs may not have been willing to sell their property under normal circumstances. Also, prices may have reflected the price farm operators who were getting out of the business were willing to accept, not the price active farmers would sell for.

A third problem is disruption in the lives of those forced to relocate. Families must be moved to new locations and start farming anew. Often there were delays in payments made to landowners (South Dakota State University Agricultural Economics Pamphlet 46).

Income tax considerations are another important factor. Landowners received large sums of money for their property which usually had appreciated considerably; therefore, they had to pay capital gains taxes if they did not reinvest within a certain time.

A cursory review of payments made for land taken for Garrison and Oahe reservoirs shows that payments of \$21 million were made for Garrison Reservoir and \$7.7 million for Oahe Reservoir in North Dakota (Table 9).

If the average payment of \$46.27 for Garrison and \$96.57 for Oahe were adjusted at a 7 percent rate of appreciation to 1977, the resulting values would be \$251.25 and \$249.15, respectively. The average value for farmland and buildings in Oliver, Morton, McLean, Burleigh, Emmons, and McKenzie counties on November 1, 1977, was \$246.50.¹⁶ In other words, with a land value appreciation rate of 7 percent, payments to landowners for land taken for the reservoirs were close to 1977 land values in those

¹⁵ Some Local Impacts of Reservoirs in South Dakota, South Dakota State University Agricultural Economics Pamphlet No. 46, June, 1953, presents a more detailed discussion of land acquisition procedures of the Corps of Engineers and the implications.

¹⁶ Based on 1974 U.S. Census of Agriculture using U.S. Department of Agriculture, November 1, 1977, index of change.

TABLE 9. PAYMENTS MADE FOR LAND ACQUIRED FOR GARRISON AND OAAHE RESERVOIRS

County	Acreage	Payment	Average Payment Per Acre
<u>Garrison^a</u>			
Dunn	61,677	\$ 1,982,979	\$ 32.15
McKenzie	70,792	4,634,007	65.46
McLean	161,602	5,122,061	31.70
Mercer	51,651	1,577,222	30.54
Mountrail	66,016	3,806,303	57.66
Williams	51,134	4,292,511	83.94
Totals	462,870	\$21,415,079	\$ 46.27 ^b
<u>Oahe^c</u>			
Burleigh	9,154	1,146,818	125.28
Emmons	31,500	2,601,852	82.60
Morton	13,846	1,503,623	108.59
Sioux	25,253	2,449,348	96.99
Totals	79,753	7,701,641	96.57 ^b

^a Acquisition occurred in the early 1950's.

^b Average for all land acquired, regardless of year acquired.

^c Acquisition occurred between 1961 and 1965.

SOURCES: Letter from Mr. H. F. Josephson, Chief, Real Estate Office, Corps of Engineers, Riverdale, North Dakota, January 5, 1978. Letter from Mr. R. J. Andrews, Chief, Planning & Control Branch, Real Estate Division, Corps of Engineers, Omaha, Nebraska, January 31, 1978.

areas inundated. These payments do not entirely make up for the loss in business volumes generated as a result of operating the farmland inundated, as much of these proceeds were probably reinvested out of state.

Electric Power Generation

The five turbine-generators located in the Garrison Dam powerhouse have a combined capacity of 400,000 kilowatts and are capable of producing over 2 billion kilowatt-hours of electrical energy annually. The first generator was activated in 1956.¹⁷ Through December 1977, the project had produced about 46.3 billion kilowatt-hours of electrical energy.¹⁸

¹⁷ Water Resources Development in North Dakota, Omaha, Nebraska: Department of the Army, Missouri River Division Corps of Engineers, p. 20, 1977b.

¹⁸ Letter from Mr. Searles M. Hornstein, Acting District Manager, U.S. Department of Energy, Bismarck, North Dakota, December 30, 1977.

North Dakota consumers have been receiving from one-third to one-half of the electrical energy produced at Garrison Dam (Hornstein). Electrical energy consumption in North Dakota in 1976 was approximately 4.8 billion kilowatt-hours,¹⁹ with about one-third of that generated at the hydro plant at Garrison Dam. Due to water conditions in 1977, only about 20 percent of the electrical energy consumed in North Dakota was generated at Garrison.

Flood Control

Flood control benefits of Garrison Dam are realized primarily by residents of downstream states. The Corps of Engineers does not disaggregate flood control benefits by state.²⁰ It is assumed that very little is accounted for in North Dakota as there was little development in the river bottoms prior to the dam. The floods that did occur were as much a benefit to farmland as they were a detriment in that they provided valuable soil moisture and deposited rich sediment upon the land.

Recreation

North Dakota traded one form of recreation for another. The recreation provided by 295 miles of free flowing river and several hundred thousand acres of choice river bottom habitat was traded away for over 400,000 acres of slack water; namely, Lakes Sakakawea and Oahe. The creation of Lake Sakakawea tripled the total fishing water in the state. The 1975 State Outdoor Recreation Plan praises the opportunities presented by the two huge reservoirs:

Lake Sakakawea and Oahe in the Missouri River Valley are North Dakota's water playgrounds. These expansive bodies of water provide a recreational outlet for thousands of fishermen, boaters, and others attracted to the enormous lakes. The lake areas are very scenic. The hundreds of miles of shoreline in public ownership offer tremendous potential for further recreation expansion (p. 2.10).

¹⁹ Annual Report of the North Dakota Public Service Commission, 1977.

²⁰ Letter from Mr. John E. Vehehradsky, Chief, Planning Division, Corps of Engineers, Omaha, Nebraska, December 22, 1977.

But, goes on to say:

Lake Sakakawea offers some 385,893 acres of water, but only a small proportion is available to the fisherman since the vast open areas in the middle of the reservoir are undesirable for fishing. The same is true of Lake Oahe. The highest quality sport fishing is often found in lakes and reservoirs of smaller size that can be effectively managed (p. 2.10).

The Corps of Engineers extolls the recreation provided by Garrison Dam, while ignoring the recreation foregone:

An incidental benefit which has resulted from the construction of the Missouri River's system of dams is the remarkable growth of water-based recreation. Lake Sakakawea has a 1,340-mile shoreline which provided excellent opportunities for fishing, swimming, water skiing, boating, camping, and other outdoor activities. There are at present 17 recreation areas which were initially developed by the Corps of Engineers.

In 1975, Garrison Dam and Lake Sakakawea recorded about 965,000 recreation days by people who toured the powerhouse and used the many outdoor recreational facilities available to them. The lake and the downstream tailwater fishing areas are enjoying a growing popularity and are attracting anglers from all parts of the United States and Canada. (U.S. COE, 1977b, p. 20)

While there is no doubt that the development of Lakes Sakakawea and Oahe Reservoir provide substantial recreational opportunities to the state of North Dakota, these opportunities were gained only with the loss of other types of recreational opportunities. Whether the state was a net gainer or loser in terms of recreational opportunities remains an open question.

Income Differentials of Irrigation and Dryland Operations

The influence of irrigation from the proposed Garrison Diversion Unit is examined from the viewpoint of the state's economy. Irrigation brings about a considerable change in farm operator costs and returns, which in turn influence the income and business volume of others in the economy.

Dry Cropland Income Flows

Present dryland crop rotations on three Garrison Diversion Unit (GDU) project areas were estimated (Table 10). "MIP" crop budgets were used to develop composite acre budgets for the southern, central, and northern GDU areas (Appendix Tables C1, D1, and E1).

TABLE 10. ASSUMED DRY CROPLAND ROTATIONS IN GDU PROJECT AREAS, 1977

Crop	GDU Project Area		
	Southern	Central	Northern
	-----percent of cropland-----		
Corn	14	5	5
Barley	8	9	5
Oats	5	7	9
Wheat	25	38	25
Flax	5	4	8
Rye	7	3	3
Alfalfa	6	8	15
Tame Pasture & Native Hay	8	7	10
Sunflower	12	4	0
Fallow	<u>10</u> 100	<u>15</u> 100	<u>20</u> 100

SOURCES: Mark Gullickson, Potential Irrigator Profiles in North Dakota, Fargo: North Dakota State University, M.S. thesis, December, 1974. North Dakota Crop and Livestock Statistics, Fargo: North Dakota State University Agricultural Experiment Station and U.S. Department of Agriculture Statistical Reporting Service, annual.

The initial expenditure and income flows associated with each acre currently under dryland farming were estimated (Table 11). The income flows in the first three sectors shown in Table 11 are direct payments made by farm operators for each acre farmed. For example, in the southern GDU area \$38 worth of goods is purchased in the retail trade sector by farm operators for each acre farmed. The income flows to the households sector consist of two separate components. First, they show the payments farm operators make for hired labor, which is a direct payment to the household sector. Second, they show the payments received by the farm operators over and above their production expenses, which is also a direct payment to the household sector. Dry cropland income flows thus represent the direct expenditures farm operators make for inputs, including hired labor, plus the net return to farm operators.

TABLE 11. EXPENDITURE AND INCOME FLOWS FOR THREE GDU PROJECT AREAS PER ACRE OF DRYLAND CROPLAND FARMED BY SECTOR, 1977

Sector	GDU Project Area		
	Southern	Central	Northern
Retail Trade	\$38.08	\$25.93	\$23.84
Finance, Ins., & Real Estate	4.73	6.94	5.65
Business & Personal Service	3.49	2.35	2.43
Households	12.23	4.72	4.77

SOURCE: Appendix Tables C3, D3, and E3.

Irrigated Cropland Income Flows

Composite irrigated cropland acres were developed for each GDU area (Appendix Tables C2, D2, and E2). "MIP" budgets were used to estimate gross expenditure and income flows as a result of irrigation. The initial flows and the sectors directly affected are presented in Table 12.

The expenditure and income flows estimated for irrigated cropland represent payments farm operators make for inputs and net returns to farm operators. The income flows equal the gross return per acre, but are allocated to the sectors which receive direct payments.

TABLE 12. EXPENDITURE AND INCOME FLOWS FOR THREE GDU PROJECT AREAS PER ACRE OF IRRIGATED CROPLAND FARMED BY SECTOR, 1977

Sector	GDU Project Area		
	Southern	Central	Northern
Retail Trade	\$144.53	\$94.44	\$100.76
Finance, Ins., & Real Estate	16.87	30.37	27.22
Business & Personal Service	16.70	8.24	10.30
Households	142.37	91.73	85.15

SOURCE: Appendix Tables C3, D3, and E3.

Income Differentials: Irrigated
vs. Dry Cropland

The economic influence of irrigated agriculture is the effect the increased levels of spending for production inputs and the increased net returns have on the economy. Net expenditure and income flows by sector for irrigated cropland that replaces dry cropland in the three GDU areas are presented in Table 13. The income flows shown are the net or additional receipts each of the four directly affected sectors receive when one acre of formerly dry cropland is irrigated. For example, if one acre in the southern area was converted from dry cropland to irrigated cropland, an additional \$106 worth of purchases would be made in the retail trade sector. These additional purchases would be for irrigation equipment; farm machinery; or special pesticides, herbicides, and fertilizers required for irrigated crops.

TABLE 13. ADDITIONAL INCOME FLOWS FOR THREE GDU PROJECT AREAS PER ACRE OF DRY CROPLAND BROUGHT UNDER IRRIGATION BY SECTOR, 1977

Sector	GDU Project Area		
	Southern	Central	Northern
Retail Trade	\$106.45	\$68.51	\$76.92
Finance, Ins., & Real Estate	12.14	23.43	21.57
Business & Personal Service	13.21	5.89	7.80
Households	130.14	87.01	80.38

SOURCE: Tables 11 and 12.

The effects of increased agricultural income brought about by irrigation were measured in terms of increases in both gross business volume and personal income in the entire economy. Gross business volume is the total value of sales that occur in the economy for a given amount of sales of final product, such as crops produced under irrigation. Personal income measures the wages and salaries (plus other incomes discussed earlier) received by individuals in all sectors of the economy resulting from business activity. Personal income is a part of gross business volume since a portion of sales income in each sector is paid out as wages and salaries, rent, etc.

Using the North Dakota input-output model, personal income and gross business volume occurring as a result of additional income flows due to irrigation in certain sectors were estimated (Table 14). For example, using the southern GDU area, the additional expenditures and income per acre attributed to irrigation (Table 13) result in additional gross business volume of \$703 and personal income of \$269 (Table 14).

TABLE 14. ADDED GROSS BUSINESS VOLUME AND PERSONAL INCOME GENERATED IN THE REGION PER ACRE OF IRRIGATED CROPLAND

Item	GDU Project Area		
	Southern	Central	Northern
Net Gross Business Volume Per Acre	\$703.37	\$513.36	\$508.60
Net Personal Income Per Acre	\$268.87	\$194.62	\$187.30

Economic Effects of Potential GDU Projects
on the North Dakota Economy

The economic effects of irrigation were estimated using input-output analysis. The effects of the 250,000 acre GDU as authorized by Congress, of "Plan 2 (b),"²¹ and the recommended 96,000 acre project are presented in this section. The effects of irrigating 1,000,000 acres would require more detailed studies of several factors, including soil types and locations for a project that large. Since this detailed information is unavailable, no attempt has been made to evaluate the impacts of a 1,000,000-acre project.

250,000-Acre GDU

The 250,000 acres as identified by "Garrison Diversion Unit Special Project Study"²² was used for this analysis. It includes 116,000 acres in the northern area, 74,670 acres in the central area, and 59,993 acres in the southern area.

²¹Bureau of Reclamation, "Garrison Diversion Unit Special Project Study," Bismarck, North Dakota, September 13, 1977.

²²Bureau of Reclamation, September 13, 1977.

Land would be taken out of production for construction of the project features, such as canals and reservoirs. Lands taken for wildlife mitigation are not analyzed since they have not been identified and land use would probably not change substantially on the majority of them, only ownership would be affected. The project features for 250,000 acres of irrigation would change the land use on approximately 54,325 acres, of which about one-half is currently being cropped (Table 15).

TABLE 15. GDU PROJECT FEATURE LAND USE BEFORE DEVELOPMENT

Land Use	Plan		
	250,000 acres	124,000 acres ^a	96,300 acres ^b
Cropland	30,500 ac. 56%	27,845 ac. 57%	24,396 ac. ^b 56% ^b
Native Range	16,495 ac. 30%	15,750 ac. 32%	13,505 ac. ^b 31% ^b
Woodland	585 ac. 1%	490 ac. 1%	436 ac. ^b 1% ^b
Water & Other	6,895 ac. 13%	4,920 ac. 10%	5,227 ac. ^b 12% ^b
	<u>54,325 ac.</u> 100%	<u>49,015 ac.</u> 100%	<u>43,564 ac.</u> ^c

^aDeleted: Velva Canal, one-half of New Rockford Canal, Warwick Canal, Devils Lake Feeder Canal, and Stump Lake Feeder Canal.

^bEstimated.

^cUSDI Report on the Recommended Plan, Garrison Diversion Unit, Washington, D.C., February, 1978 (draft).

The estimated gross business volume generated on a composite acre of project feature land is \$71 and the estimated personal income is \$22. For lands used as project features in the 250,000-acre project, \$1,195,000 of personal income would be foregone annually as a result of building the project, and \$3,857,000 of annual gross business volume would be foregone as a result of project features.

Assuming the entire 250,000-acre GDU were operational in 1977,²³ a total additional gross business volume of \$135,204,000 would have occurred in North Dakota (Table 16). Increased personal income would have accounted for \$51,016,000 of this amount.

²³The assumption of the entire project having been operational in 1977 is presented merely to show the influence of irrigation relative to current values, as opposed to presenting the influence of the entire project life and discounting to present. By using 1977 as a hypothetical case some of the abstract concepts, such as discounting and project life, can be avoided.

TABLE 16. ANNUAL ADDITIONAL GBV AND PERSONAL INCOME AS A RESULT OF A 250,000 GDU PROJECT, 1977

X Item	GDU Project Area			Totals
	Southern	Central	Northern	
Acres	59,330	74,670	116,000	250,000
Added GBV Per Acre	703.37	513.36	508.60	--
Total GBV	\$41,730,942	\$38,332,306	\$58,997,600	\$139,060,848
Loss Due to Project				
Features	a	a	a	- 3,857,000
Net Change in GBV	a	a	a	<u>\$135,203,848</u>
Added Personal Income				
Per Acre	268.87	194.62	187.30	--
Total Personal Income	\$15,952,057	\$14,532,275	\$21,726,800	\$ 52,211,132
Loss Due to Project				
Features	a	a	a	- 1,195,000
Net Change in Personal Income	a	a	a	<u>\$ 51,016,132</u>

^aCalculated as project totals only.

124,000-Acre GDU

If 124,000 acres of the project area had been irrigated in 1977 (59,330 in southern area and 64,670 in central area), the additional gross business volume in North Dakota would have been \$71,450,000, with \$27,460,000 in additional personal income to North Dakotans (Table 17).

TABLE 17. ANNUAL ADDITIONAL GBV AND PERSONAL INCOME AS A RESULT OF A 124,000-ACRE GDU PROJECT, 1977

X Item	GDU Project Area			Totals
	Southern	Central	Northern	
Acres	59,330	64,670	none	124,000
Added GBV Per Acre	703.37	513.36	--	--
Total Added GBV	\$41,730,942	\$33,198,990	--	\$74,929,942
Loss Due to Project				
Features	a	a	--	-3,480,665
Net Change in GBV	a	a	--	<u>\$71,449,867</u>
Added Personal Income				
Per Acre	268.87	194.62	--	--
Total Added Personal Income	\$15,952,057	\$12,586,075	--	\$28,538,132
Loss Due to Project				
Features	a	a	--	-1,078,330
Net Change in Personal Income	a	a	--	<u>\$27,459,802</u>

^aCalculated as project totals only.

96,000-Acre GDU

If the plan as recommended by the Department of the Interior (February, 1978) had been operational in 1977, North Dakotans would have received \$19 million more personal income that year from the effects of irrigating 96,000 acres (Table 18). Gross business volume would have been increased by approximately \$49 million, the increase brought about due to increased expenditure and income flows of irrigation agriculture.

TABLE 18. ANNUAL ADDITIONAL GBV AND PERSONAL INCOME AS A RESULT OF A 96,000-ACRE GDU PROJECT, 1977

Item	GDU Project Area			Totals
	Southern	Central	Northern	
Acres	13,350	82,950 ^a	none	96,300
Added GBV Per Acre	703.37	513.36	--	--
Total Added GBV	\$9,389,989	\$42,583,212	--	\$51,973,201
Loss Due to Project				
Features	b	b	--	<u>-3,093,044</u>
Net Change in GBV	b	b	--	<u>\$48,880,157</u>
Added Personal Income				
Per Acre	268.87	194.62	--	--
Total Added Personal Income	\$3,589,414	\$16,143,729	--	\$19,733,143
Loss Due to Project				
Features	b	b	--	<u>- 958,408</u>
Net Change in Personal Income	b	b	--	<u>\$18,774,735</u>

^a Approximately 55,000 acres have not been completely surveyed relative to their irrigability at this time.

^b Calculated as project totals only.

Income Foregone Due to Project Delay

The amount of gross business volume and personal income foregone as a result of delays in constructing the Garrison Diversion Unit is equal to the present value of each year of delay less the present value of each additional year of project life.²⁴ For example, the present

²⁴ Each year of delay was assumed to add one year to project life.

value of a dollar to be received 5 years from today discounted at 6 and one-half percent²⁵ is 73 cents. The present value of a dollar to be received 50 years from today is only 4 cents. In other words, 73 cents in the bank at 6 and one-half percent interest would yield a dollar in five years, but to receive a dollar 50 years from now would require an investment of only 4 cents. By foregoing receipt of a dollar in 5 years for a dollar in 50 years a present value loss of 69 cents occurs.

Given the construction schedule in Table 19 and the income differentials in the previous section, the present value of personal income foregone due to one year's project delay is \$30 million. The present value of gross business volume foregone due to a one-year delay would be about \$81 million (Table 20).

TABLE 19. CONSTRUCTION SCHEDULE FOR GDU, 250,000-ACRE PROJECT

Area	Acres Irrigated	Year First Irrigated
Southern	45,980	1982
	13,350	1983
Central	6,515	1984
	20,935	1985
	47,220	1987
Northern	12,200	1988
	103,800	1989

TABLE 20. GROSS BUSINESS VOLUME AND PERSONAL INCOME FOREGONE DUE TO DELAY OF 250,000-ACRE GDU

Years of Delay	Gross Business Volume Foregone	Personal Income Foregone
1	\$ 81,000,000	\$ 30,000,000
2	157,000,000	58,000,000
3	229,000,000	85,000,000
4	297,000,000	110,000,000
5	359,000,000	133,000,000

²⁵Six and one-half percent was used as the discount factor. The current government authorized discount rate is 6 and three-eighths percent. The absolute difference is insignificant.

Municipal and Industrial Use of Garrison Water

Water supply for domestic, municipal, and industrial uses has been a component of multiple use plans for the Missouri since those plans began to take shape in the 1940's. The Bureau's original plan for the Missouri in North Dakota (Senate Document 191) included water supply to 19 municipalities.

The original plan of the Corps of Engineers (House Document 475) also supported diversion for municipal and industrial use:

During excessively dry years the regions in the vicinity of Devils Lake and the James River Basin become so short of water that animals are subjected to great suffering and the people to severe hardship. Droughts almost, if not entirely, destroy animal and plant life in these areas. The best over-all use of the multiple-purpose reservoir would permit a feasible diversion of water from the Missouri River into the Dakotas for domestic use. (House Document 475 p. 28)

One of three conclusions reached by the Corps in House Document 475 supported the provision of water for municipal and industrial purposes:

...a diversion from the vicinity of Garrison Dam into the Dakotas leading to the Devils Lake and the James River regions together with the pumping stations, conduits, and other facilities necessary to supply water during drought seasons for the Devils Lake and James River regions. (p. 31)

Diverted water will assist also in ameliorating pollution problems at nearly a score of cities in North Dakota, South Dakota, and Minnesota. (p. 8)

Provision of municipal and industrial water was a part of the original Corps plan (the Pick Plan, Senate Document 191) and the original Bureau plan (the Sloan Plan, Senate Document 475). And so, with the merging of the two plans--the Pick-Sloan Plan for Missouri River Basin development--providing water for municipal and industrial uses was one of several multiple uses planned.

The development plan, as it was modified in 1960, provided for water to 41 towns and cities throughout the project area. Cost estimates indicated that water supplied from the Missouri River would be more economical to obtain than from local sources, which are mainly ground water (House Document 325, 1960).

Identification of Municipalities

Twenty-nine municipalities would be served with Missouri River water with the full development plan for Garrison Diversion (Table 21). Several other towns and cities may likely request diversion waters when the unit is completed, once they are sure of the supply and have some idea of the cost of GDU water and the cost of water from alternative sources. Nineteen municipalities have requested GDU water under Plan 2, Option B, and fourteen would be provided water with the recommended plan.

Assessment of Water Needs

The 29 municipalities identified in Table 21 need GDU water because their present sources are insufficient or of poor quality. Those towns that rely on surface waters are at the mercy of the weather to provide them with sufficient water throughout the year. While those using ground water often times have quality problems, they may have quantity problems as well.

Water quality problems in North Dakota may be caused by excessive salts in water from shallow wells causing alkaline water. Water from deeper wells may be high in mineral content. Both of these quality problems result in higher treatment costs for municipal users.

All 29 municipalities presently expressing a desire for GDU water would consume approximately 37,000-acre feet of water in the year 2000. Their projected total consumption by the year 2030 is 47,000-acre feet (Table 21). This quantity of water is a small fraction of the total available or the amount used for irrigation.

Summary

North Dakota is located in the semiarid Northern Great Plains Area of the United States. The state's economy is highly dependent on agriculture and agriculturally related industries. Water limits agricultural production severely in most areas of the state because lack of rainfall typically inhibits plant development at some point during the growing season. The importance of water for the intensification of the agricultural economy of the state is easily recognized through the substantial yield increases that are achieved by irrigation of crops in the farming areas of the state. Further, the growth of industry is frequently contingent on

TABLE 21. POTENTIAL MUNICIPAL AND INDUSTRIAL WATER USERS OF GDU WATER

Community ^a	1970 Popula- tion	Alternative		Recom- mended Plan	Consumptive Use		
		Plan 1	Plan 2 (B)		1975	2000	2030
-----acre feet-----							
Casselton	1,485	x	x	no	260	277	302
Cogswell	203	x	x	no	27	22	17
Fargo	53,365	x	x	x	9,419	12,030	14,786
Fessenden	815	x	x	x	101	84	140
Forman	596	x	x	no	107	118	134
Garrison	1,614	x	x	x	223	297	410
Harvey	2,361	x	x	x	368	412	490
Jamestown	15,385	x	x	x	2,576	2,806	3,394
Leeds	626	x	x	no	106	114	118
Mayville	2,554	x	x	x	359	420	521
McClusky	664	x	x	x	129	143	151
Mercer	132	x	x	x	20	15	8
Milnor	645	x	x	no	114	114	118
New Rockford	1,969	x	x	x	308	302	286
Sheyenne	362	x	x	x	57	50	44
Turtle Lake	712	x	x	x	125	151	168
Underwood	781	x	x	x	133	218	252
West Fargo	6,437	x	x	x	1,275	1,848	2,890
Sargent Co. Rural		x	x	no	174	185	202
Plan 2 (B) Totals					15,881	19,606	24,431
Glenburn	381	x	no	no	71	97	118
Granville	282	x	no	no	48	49	59
Gwinner	623	x	no	no	130	168	218
Lakota	964	x	no	no	204	218	252
Lansford	296	x	no	no	63	64	67
Minot	32,290	x	no	no	5,509	16,091	21,740
Surrey	361	x	no	no	156	286	470
Tolna	247	x	no	x	45	50	59
Upham	272	x	no	no	46	47	59
Plan 1 Totals		29	19	14	22,153	36,676	47,473

^aOne community in Minnesota and three in South Dakota are potential M&I users from GDU.

SOURCES: Sam Cunningham, Bureau of Reclamation, Bismarck, North Dakota, November 9, 1977. U.S. Department of the Interior, Garrison Diversion Unit Draft Environmental Statement, Volume 1, Washington, D.C., January, 1978.

the availability of adequate water supplies to sustain both the process and the population water needs of industrial development. The state's economy would improve through increased irrigated agricultural and industrial growth made possible by diversion of Missouri River waters to central and eastern North Dakota.

This study was designed to measure the annual impact of Missouri River development programs on the economy of the state of North Dakota. The study provides estimates of the economic losses due to inundation by the Garrison and Oahe Reservoirs and potential economic gains due to irrigation under the Garrison Diversion Project in the state of North Dakota. The reader should recognize that all expenses and income flows are annualized to 1977 values and that economic gains and losses are viewed from a state perspective only so as to reflect economic impacts on the North Dakota economy. As an example, downstream flood control or income leakages to other states are not considered in the computation of economic impacts of the project. Because of these fundamental characteristics of this analysis, the computations are not comparable or applicable to cost-benefit analysis of the project which takes on a much broader time and geographic perspective of costs and incomes generated by the project.

The losses of rich river bottomland in the Missouri River through inundation by the Garrison and Oahe reservoirs have resulted in agricultural losses, mineral and forestry losses, as well as losses of recreation. It was estimated that North Dakota had annual agricultural losses of \$93 million in gross business volume and \$34 million in personal income due to the inundation from the Garrison and Oahe reservoirs. In addition, annual losses due to bank erosion in 1977 were estimated at \$319,000 in gross business volume and \$119,000 in personal income. There were also unquantified losses of mineral resources, forest production, and wildlife to the state.

Compensation to the state for these losses was minimal in the form of condemnation payments to landowners which likely had substantial leakages outside the state economy. Electrical power, and flood control have been provided but their magnitude has not been sufficient to compensate the state for inundation losses. Recreation gains and losses are difficult to quantify thus leaving it unclear if the net effect has been positive or negative.

A potential boost to the North Dakota economy is the possibility to irrigate the state's farming areas with waters directed from the Garrison Reservoir. It was estimated that irrigation of the proposed 250,000 acres of farmland under the Garrison Project would increase annual gross business volume in North Dakota by \$135 million and increase annual personal income by \$51 million based on 1977 values. This increased economic activity would slightly more than compensate the state for the income flows lost due to inundation.

Additional incomes to the state are foregone each time the project is delayed due to political negotiation. It was estimated that a one-year delay in project completion from the year 1977 would cost the state \$81 million in foregone gross business volume.

It is apparent that if Missouri River water resources are not developed to the benefit of agricultural, municipal, and industrial users, the state of North Dakota will have paid dearly for flood control, power, and water resource benefits that accrue to downstream states. It is fully recognized that this report takes a somewhat provincial view of Missouri Basin development. However, it is the authors' view this perspective should be considered, as policies regarding the allocation of impounded Missouri River waters are formulated. Specifically, the concept of compensation for economic losses imposed on a region or state should weigh heavily in the allocation of a resource, such as water.

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Appendexes

Appendix A
Input-Output Coefficients

APPENDIX TABLE A1. INPUT-OUTPUT INTERDEPENDENCE COEFFICIENTS, BASED ON TECHNICAL COEFFICIENTS FOR 13-SECTOR MODEL

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
	Ag, Livestock	Ag, Crops	Mining	Contract Construction	Transportation	Utilities	Ag Processing and Misc. Mfg. ^a	Retail Trade	Fin., Ins., & Real Estate	Bus. & Pers. Service	Prof. & Soc. Service	Households	Government ^b
(1) Ag, Livestock	1.21	.08	.04	.03	.05	.04	.19	.09	.06	.04	.06	.07	0.00
(2) Ag, Crops	.40	1.09	.03	.01	.02	.02	.66	.03	.04	.02	.02	.03	0.00
(3) Mining	.01	.01	1.00	.03	.01	c	.01	c	c	c	.01	.01	0.00
(4) Contract Construction	.07	.08	.05	1.05	.05	.06	.06	.03	.07	.05	.08	.09	0.00
(5) Trans- portation	.02	.01	.01	.01	1.01	.01	.01	.01	.01	.01	.01	.01	0.00
(6) Utilities	.09	.08	.07	.06	.08	1.10	.08	.05	.13	.11	.12	.11	0.00
(7) Ag Processing and Misc. Mfg. ^a	.58	.16	.06	.02	.03	.02	1.77	.05	.07	.02	.04	.04	0.00
(8) Retail Trade	.71	.81	.40	.41	.55	.43	.62	1.27	.68	.45	.67	.74	0.00
(9) Fin., Ins., & Real Estate	.15	.17	.08	.08	.12	.11	.13	.06	1.14	.11	.14	.17	0.00
(10) Bus. & Pers. Service	.06	.07	.03	.03	.05	.04	.05	.02	.08	1.05	.05	.06	0.00
(11) Prof. & Soc. Service	.07	.06	.05	.04	.05	.05	.05	.03	.08	.05	1.10	.10	0.00
(12) House- holds	1.05	.96	.67	.61	.79	.79	.80	.40	1.20	.72	1.04	1.55	0.00
(13) Govern- ment	.10	.10	.05	.05	.26	.10	.08	.04	.11	.08	.09	.11	1.00
Gross Receipts Multiplier	4.51	3.69	2.57	2.44	3.05	2.79	4.52	2.09	3.68	2.71	3.41	3.08	1.00

^aWholesale trade, although relatively insignificant, is included in Sector 7.
^bDirect and indirect requirements of the local government sector are assumed to be exogenous to the model.
^cLess than 0.005.

SOURCE: Heritsgaard, Thor A., et al., Developing Economic Impact Projection Models for the Fort Union Coal Region, Final Report of Phase I Environmental Protection Agency Contract No. 68-01-3507, Department of Agricultural Economics, North Dakota State University, Fargo, June, 1977.

Appendix, B
Budgets and Differentials for
Land Inundated

APPENDIX TABLE B1. BUDGET FOR A COMPOSITE ACRE OF DRY CROPLAND INUNDATED

Item	Crop								Total 1974	Total 1977	Input- Output Sector
	Wheat	Oats	Barley	Flax	Corn	Tame Hay/ Alfalfa	Pasture	Fallow			
Percent of Acre Yield	42 28 bu.	12 50 bu.	5 40 bu.	4 11 bu.	14 45 bu.	11 2 tons	2	10			
	----- dollars -----										
Seed	1.74	0.43	0.17	0.17	0.73	0.60	0.05	--	3.89	5.02	8
Fert. & Chem.	2.94	0.54	0.64	0.27	2.72	0.17	0.03	--	7.31	9.43	8
Misc.	--	--	--	--	0.69	0.34	0.03	--	1.06	1.37	10
Insurance & Int.	3.51	0.20	0.40	0.08	1.16	--	--	0.18	5.53	7.13	9
Fuel	1.90	0.55	0.26	0.18	0.87	0.48	0.03	0.16	4.43	5.71	8
Repairs	0.73	0.21	0.09	0.07	0.31	0.19	0.01	0.09	1.70	2.19	10
Operating Cap.	0.38	0.09	0.06	0.03	0.24	0.12	0.01	0.01	0.94	1.21	9
Labor	2.25	0.59	0.31	0.19	0.92	0.61	0.05	0.19	5.11	6.59	12
Depreciation	3.56	1.68	0.42	0.54	2.46	0.96	0.06	0.30	9.98	12.87	8
Returns Over Cost	16.34	1.17	0.69	0.72	1.70	4.37	0.56	-0.93	24.62	31.76	12

SOURCE: Crop rotations and yields from Table 3.

APPENDIX TABLE B2. ANNUAL GBV AND PERSONAL INCOME FOREGONE PER ACRE OF DRY CROPLAND INUNDATED, 1977

Sector	Expenditure or Income Flow	
Retail (8)	\$33.04	
Finance, Insurance, and Real Estate (9)	8.35	
Business and Personal Service (10)	3.56	
Households (12)	38.35	
		I-O Model = \$ 85.44 Personal Income \$227.38 GBV

APPENDIX TABLE B3. BUDGET FOR A COMPOSITE ACRE OF IRRIGATED CROPLAND INUNDATED

Item	Crop						Total 1974	Total 1977	Input- Output Sector
	Corn	Alfalfa	Small Grain	Sugarbeets	All Beans	Pasture			
Percent of Acre Yield	37 20 tons	36 4.6 tons	8 53 bu.	12 20 tons	4 22 bu.	3			
	----- dollars -----								
Seed	3.70	--	0.36	1.13	1.82	0.13	7.14	9.21	8
Fert. & Chem.	11.94	1.13	2.22	9.19	0.71	0.31	25.50	32.89	8
Misc.	--	0.69	--	1.09	--	0.04	1.82	2.35	10
Electricity	3.66	1.15	0.36	--	0.33	--	5.50	7.09	8
Insurance & Int.	6.74	1.50	1.70	1.59	1.43	0.03	12.99	16.76	9
Fuel	3.17	0.65	0.44	2.98	0.24	0.39	7.87	10.15	8
Repairs	2.15	0.41	0.21	0.97	0.16	0.08	3.98	5.13	10
Operating Cap.	1.36	0.23	0.25	1.98	0.04	0.03	3.89	5.02	9
Labor	4.64	1.03	0.55	3.29	0.32	0.13	9.96	12.85	12
Depreciation	9.68	2.11	1.87	4.16	0.95	0.84	19.61	25.30	8
Returns Over Cost	9.98	4.19	2.88	24.06	4.31	1.39	46.81	60.38	12

SOURCE: Crop rotations and yields from survey of 200+ irrigators (45,000 acres) in Morton, Mercer, McLean, Oliver, Burleigh, McKenzie, and Emmons counties. Crop budgets from "MIP" team.

APPENDIX TABLE B4. ANNUAL GBV AND PERSONAL INCOME FOREGONE PER ACRE OF IRRIGATED CROPLAND INUNDATED, 1977

Sector	Expenditure or Income Flow	
Retail (8)	\$84.64	
Finance, Insurance, and Real Estate (9)	21.78	
Business and Personal Service (10)	7.48	
Households (12)	73.23	
		I-0 Model = \$179.07 Personal Income \$502.87 GBV

Appendix C
Budgets and Differentials for
Southern GDU Area

APPENDIX TABLE C1. BUDGET FOR A COMPOSITE ACRE OF DRY CROPLAND, SOUTHERN GDU AREA

Item	Crop										Total 1974	Total 1977	Input- Output Sector
	Corn	Barley	Oats	Wheat	Flax	Rye	Alfalfa	Native Hay	Sun- flowers	Fallow			
Percent of Acre	14	8	5	25	5	7	6	8	12	10			
	----- <i>dollars</i> -----												
Seed	0.73	0.28	0.18	1.04	0.21	0.21	0.33	0.19	0.48	--	3.65	4.71	8
Fert. & Chem.	2.76	0.72	0.13	3.93	0.27	0.21	0.48	0.11	1.35	--	9.96	12.85	8
Misc.	0.66	--	--	--	--	--	0.16	0.11	0.15	--	1.08	1.39	10
Insurance & Int.	0.39	0.14	0.05	0.36	0.06	1.34	--	--	0.28	0.18	2.80	3.61	9
Fuel	0.95	0.36	0.22	1.09	0.22	0.28	0.24	0.13	0.49	0.16	4.14	5.34	8
Repairs	0.31	0.14	0.09	0.44	0.09	0.11	0.10	0.06	0.20	0.09	1.63	2.10	10
Operating Cap.	0.24	0.08	0.03	0.22	0.04	0.02	0.07	0.03	0.13	0.01	0.87	1.12	9
Labor	0.91	0.37	0.23	2.14	0.23	0.27	0.30	0.22	0.56	0.19	5.42	6.99	12
Depreciation	2.46	1.10	0.68	3.43	0.67	0.88	0.49	0.24	1.52	0.30	11.77	15.18	8
Returns Over Cost	1.20	-0.57	-0.25	0.12	-0.11	-0.13	1.53	2.43	0.77	-0.93	4.06	5.24	12

SOURCE: Used "MIP" budget for southern area under normal management for 20 percent loam and 80 percent sandy loam. See Table 11 for source for rotations.

APPENDIX TABLE C2. BUDGET FOR A COMPOSITE ACRE OF IRRIGATED CROPLAND, SOUTHERN GDU AREA

Item	Crop							Total 1974	Total 1977	Input- Output Sector
	Corn	Alfalfa	Small Grain	Pinto Beans	Soybeans	Sunflowers	Potatoes			
Percent of Acre Yield	50 120 bu.	12 4 tons	8 48 bu.	6 22.4 cwt.	5 40 bu.	9 21.6 cwt.	10 280 cwt.			
----- dollars -----										
Seed	4.21	0.63	0.36	2.73	0.41	0.49	8.20	17.03	21.97	8
Fert. & Chem.	20.93	1.61	1.94	1.09	0.38	2.22	6.25	34.92	45.05	8
Misc.	6.60	0.92	--	--	--	0.39	0.70	8.61	11.11	10
Insurance & Int.	3.87	--	0.38	1.24	0.60	0.74	2.39	9.22	11.89	9
Fuel	9.09	2.34	0.79	0.93	0.81	1.38	2.40	17.74	22.88	8
Repairs	2.16	0.56	0.21	0.25	0.18	0.33	0.64	4.33	5.59	10
Operating Cap.	1.90	0.30	0.17	0.25	0.10	0.21	0.93	3.86	4.98	9
Labor	4.51	1.35	0.49	0.46	0.30	0.57	2.30	9.98	12.87	12
Depreciation	21.32	4.48	2.93	2.28	1.79	3.51	6.04	42.35	54.63	8
Returns Over Cost	26.69	4.97	2.51	7.12	3.66	4.84	50.60	100.39	129.50	12

SOURCE: Crop rotations and yields from survey of 21 irrigators (5,528 acres) in Stutsman, LaMoure, Dickey, and Sargent counties, and North Dakota State University Extension Service unpublished data.

APPENDIX TABLE C3. ANNUAL ADDITIONAL GBV AND PERSONAL INCOME PER ACRE DUE TO IRRIGATION, SOUTHERN GDU AREA, 1977

Sector	1977 Business Volume	1977 Dry	Net	
Retail (8)	\$144.53	\$38.08	\$106.45	
Finance, Insurance, and Real Estate (9)	16.87	4.73	12.14	
Business and Personal Service (10)	16.70	3.49	13.21	
Households (12)	142.37	12.23	130.14	
				I-0 Model = \$268.87 Personal Income \$703.37 GBV

Appendix D
Budgets and Differentials for
Central GDU Area

APPENDIX TABLE D1. BUDGET FOR A COMPOSITE ACRE OF DRY CROPLAND, CENTRAL GDU AREA

Item	Crop										Total 1974	Total 1977	Input- Output Sector
	Corn	Barley	Oats	Wheat	Flax	Rye	Alfalfa	Native Hay	Sun- flowers	Fallow			
Percent of Acre	5	9	7	38	4	3	8	7	4	15			
	----- dollars -----												
Seed	0.42	0.29	0.25	1.58	0.17	0.08	0.44	--	0.14	--	3.37	4.35	8
Fert. & Chem.	0.79	0.68	0.20	2.65	0.22	0.09	0.39	--	0.39	--	5.41	6.98	8
Misc.	--	--	--	--	--	--	0.17	0.05	0.05	--	0.27	0.35	10
Insurance & Int.	0.26	0.64	0.47	2.74	0.26	0.18	--	--	0.08	--	4.71	6.08	9
Fuel	0.28	0.45	0.35	1.84	0.19	0.14	0.36	0.08	0.17	0.24	4.10	5.29	8
Repairs	0.14	0.16	0.12	0.68	0.07	0.04	0.15	0.01	0.05	0.13	1.55	2.00	10
Operating Cap.	0.08	0.08	0.04	0.33	0.03	0.01	0.05	--	0.04	0.01	0.67	0.86	9
Labor	0.38	0.52	0.40	2.13	0.22	0.16	0.47	0.13	0.21	0.28	4.90	6.32	12
Depreciation	0.39	0.76	0.59	3.15	0.32	0.23	1.01	0.05	0.27	0.45	7.22	9.31	8
Returns Over Cost	-0.26	-0.72	-0.61	0.38	-0.10	-0.24	1.08	0.38	0.24	-1.39	-1.24	-1.60	12

SOURCE: Used "MIP" budget for central area under normal management for 23 percent loam and 77 percent sandy loam.
See Table 11 for source for rotations.

APPENDIX TABLE D2. BUDGET FOR A COMPOSITE ACRE OF IRRIGATED CROPLAND, CENTRAL GDU AREA

Item	Crop							Total 1974	Total 1977	Input- Output Sector
	Corn	Alfalfa	Pinto Beans	Flax	Small Grain	Sunflowers	Potatoes			
Percent of Acre Yield	24 15 tons	19 4.6 tons	6 21.6 cwt.	4 23 bu.	22 53 bu.	20 19.2 cwt.	5 280 cwt.			
----- dollars -----										
Seed	2.02	--	2.73	0.18	0.99	0.80	4.10	10.82	13.96	8
Fert. & Chem.	6.31	2.15	1.06	0.11	6.11	3.96	3.12	22.81	29.43	8
Misc.	--	1.31	--	--	--	0.77	0.35	2.43	3.14	10
Electricity	2.37	2.17	0.50	0.18	1.00	1.82	--	7.84	10.11	8
Insurance & Int.	4.14	2.84	2.15	0.77	4.68	2.78	1.20	20.54	26.50	9
Fuel	1.83	1.24	0.36	0.19	1.20	0.94	1.20	6.96	8.98	8
Repairs	1.31	0.78	0.24	0.10	0.59	0.62	0.32	3.95	5.10	10
Operating Cap.	0.75	0.43	0.06	0.06	0.68	0.56	0.46	3.00	3.87	9
Labor	2.70	1.96	0.48	0.23	1.52	1.33	1.15	9.37	12.09	12
Depreciation	5.99	3.99	1.43	0.90	5.15	4.30	3.02	24.78	31.96	8
Returns Over Cost	6.52	7.94	6.47	1.30	7.93	9.38	25.30	61.74	79.64	12

SOURCE: Crop rotations and yields from survey of 30 irrigators (7,817 acres) in Foster, Wells, Benson, Sheridan, Nelson, and Eddy counties, 1977.

APPENDIX TABLE D3. ANNUAL ADDITIONAL GBV AND PERSONAL INCOME PER ACRE DUE TO IRRIGATION, CENTRAL GDU AREA, 1977

Sector	1977 Business Volume	1977 Dry	Net	
Retail (8)	\$94.44	\$25.93	\$68.51	
Finance, Insurance, and Real Estate (9)	30.37	6.94	23.43	
Business and Personal Service (10)	8.24	2.35	5.89	
Households (12)	91.73	4.72	87.01	
				I-0 Model = \$194.62 Personal Income \$513.36 GBV

Appendix E
Budgets and Differentials for
Northern GDU Area

APPENDIX TABLE E1. BUDGET FOR A COMPOSITE ACRE OF DRY CROPLAND, NORTHERN GDU AREA

Item	Crop									Total 1974	Total 1977	Input- Output Sector
	Corn	Barley	Oats	Wheat	Flax	Rye	Alfalfa	Native Hay	Fallow			
Percent of Acre	5	5	9	25	8	3	15	10	20			
	----- dollars -----											
Seed	0.42	0.16	0.32	1.04	0.34	0.08	0.82	--	--	3.18	4.10	8
Fert. & Chem.	0.79	0.38	0.26	1.74	0.44	0.09	0.73	--	--	4.43	5.71	8
Misc.	--	--	--	--	--	--	0.32	0.07	--	0.39	0.50	10
Insurance & Int.	0.26	0.35	0.60	1.73	0.52	0.18	--	--	0.36	4.00	5.16	9
Fuel	0.28	0.25	0.45	1.21	0.38	0.14	0.67	0.11	0.32	3.81	4.91	8
Repairs	0.14	0.09	0.15	0.45	0.14	0.04	0.29	0.02	0.18	1.50	1.93	10
Operating Cap.	0.08	0.04	0.05	0.22	0.06	0.01	0.10	--	0.02	0.38	0.49	9
Labor	0.38	0.29	0.51	1.40	0.44	0.16	0.88	0.18	0.38	4.62	5.96	12
Depreciation	0.39	0.42	0.76	2.07	0.64	0.23	1.89	0.07	0.60	7.07	9.12	8
Returns Over Cost	-0.26	-0.40	-0.78	0.25	-0.20	-0.24	2.02	0.55	-1.86	-0.92	-1.19	12

SOURCE: Used "MIP" budget for central area under normal management for 21 percent loam and 79 percent sandy loam. See Table 11 for source for rotations.

APPENDIX TABLE E2. BUDGET FOR A COMPOSITE ACRE OF IRRIGATED CROPLAND, NORTHERN GDU AREA

Item	Crop					Total 1974	Total 1977	Input- Output Sector
	Corn	Alfalfa	Small Grain	Potatoes	Pinto Beans			
Percent of Acre Yield	34 15 tons	46 4.23 tons	7 44 bu.	7 280 cwt.	6 18 cwt.			
----- dollars -----								
Seed	2.86	--	0.31	5.74	2.73	11.64	15.02	8
Fert. & Chem.	8.62	6.90	2.55	4.37	1.41	23.85	30.77	8
Misc.	--	2.92	--	0.49	--	3.41	4.40	10
Electricity	3.36	5.24	0.32	--	0.50	9.42	12.15	8
Insurance & Int.	5.87	6.73	1.42	1.68	1.96	17.66	22.78	9
Fuel	2.60	2.82	0.37	1.68	0.35	7.82	10.09	8
Repairs	1.85	1.84	0.19	0.45	0.24	4.57	5.90	10
Operating Cap.	1.07	1.15	0.22	0.65	0.35	3.44	4.44	9
Labor	3.82	4.52	0.47	1.61	0.47	10.89	14.05	12
Depreciation	8.48	9.62	1.62	4.23	1.42	25.37	32.73	8
Returns Over Cost	2.30	12.93	0.84	35.42	3.63	55.12	71.10	12

SOURCE: Rotations and yields from survey of 13 irrigators (2,456 acres) in Renville, McHenry, and Bottineau counties, 1977.

APPENDIX TABLE E3. ANNUAL ADDITIONAL GBV AND PERSONAL INCOME PER ACRE DUE TO IRRIGATION, NORTHERN GDU AREA, 1977

Sector	Irrigated Income Flows	Dry Cropland Income Flows	Difference	
Retail (8)	\$100.76	\$23.84	\$76.92	
Finance, Insurance, and Real Estate (9)	27.22	5.65	21.57	I-0 Model = \$187.30 Personal Income \$508.60 GBV
Business and Personal Service (10)	10.30	2.43	7.87	
Households (12)	85.15	4.77	80.38	

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