Agricultural Economics Report 24 April 1962

NEGATIVE IMPACTS OF GARRISON AND OAHE RESERVOIRS ON THE NORTH DAKOTA ECONOMY

DEPARTMENT OF AGRICULTURAL ECONOMICS
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SAVE

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North Dakota State University
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and

NDSU Extension Service

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TABLE OF CONTENTS

NORTH DAKOTA STATE UNIVERSITY
OF AGRICULTURE AND APPLIED SCIENCE
Fargo, North Dakota

Agricultural Economics

April 16, 1962

Mr. Milo Hoisveen, State Engineer
North Dakota Water Conservation Commission
Bismarck, North Dakota

Dear Mr. Hoisveen:

I am transmitting herewith a copy of our study "Negative Impacts of Garrison and Oahe Reservoirs on the North Dakota Economy" by Jerome E. Johnson, Assistant Agricultural Economist and Richard J. Goodman, Extension Public Policy Specialist.

This study was completed in response to the request of the North Dakota Water Conservation Commission for you to negotiate costs with the Department of Agricultural Economics, North Dakota State University for such a study.

This study has been completed using our regular staff under existing station projects with no out-of-pocket costs to your agency. Due to the urgency of the situation and the need to have the study completed by April 1, 1962, the study is necessarily survey in nature and includes little primary data from our own surveys. Most of the data have been provided by cooperating agencies to whom we are grateful. I feel the authors are to be congratulated upon the excellent job they have done in such a short time on an area relatively new to both of them.

It is a pleasure to make this available to your agency.

Sincerely yours,

/s/ Fred R. Taylor

Fred R. Taylor
Chairman

FRT:c

Enclosure

NEGATIVE IMPACTS OF GARRISON AND OAHE RESERVOIRS ON THE NORTH DAKOTA ECONOMY

by
Jerome E. Johnson[1] and Richard J. Goodman[2]

INTRODUCTION

This report considers some of the negative economic impacts of the Garrison and Oahe Reservoirs to the North Dakota economy. Their positive impacts or benefits are also discussed in this report.

The negative impacts were determined in terms of incomes foregone from agricultural lands taken for the Garrison and Oahe Reservoirs in North Dakota. In addition, uncontrolled stream bank erosion is occurring as a result of the Garrison Reservoir. Fish and wildlife, and mineral losses are shown. Impacts to the community and economy are considered, with the over-all economic impacts indicated by use of a multiplier. The long-term impacts of the income losses are indicated by applying a compound interest accumulator to the total annual income loss to measure just one year's loss over time.

The Garrison Reservoir yields most of its current benefits to the over-all--downstream--Missouri River Basin. But some of its benefits currently accure to North Dakotans. Estimates are reported for the amounts that these benefits contribute to the North Dakota economy in the year 1962. Irrigation is one of the potential benefits, yet undeveloped. To put the case for irrigation development in a few words, we quote:

1 Assistant Agricultural Economist, North Dakota Agricultural Experiment Station
2 Public Affairs Economist, Agricultural Extension Service.

> "The state has lost 566,000 acres to main stem Missouri basin reservoirs. These include 207,000 acres of fertile bottomlands and 238,000 acres of high quality grazing lands. Net gains in production from irrigation on the Garrison Diversion Unit will more than replace this lost agricultural resource. The North Dakota State government, since construction began on Garrison Reservoir, has counted on the benefit from new irrigation to justify the large sacrifice in agricultural land which the reservoir required."[3]

The North Dakota state economy has suffered the severance of thousands of acres of bottom and bench lands and additional bottomland acres are currently being lost through stream bank erosion directly attributable to the Garrison Dam. This study attempts an economic evaluation of these incomes forever foregone.

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[3]U. S. Department of The Interior, Bureau of Reclamation, Region 6, "Report on Garrison Diversion Unit, " Missouri-Souris Projects Office, Bismarck, North Dakota, January 1957, page 15.

AGRICULTURAL LAND LOSSES

Acreages Acquired for Reservoirs

The federal government acquired 462,500 acres of agricultural land in Dunn, McLean, McKenzie, Mercer, Mountrail and Williams counties, North Dakota, for the Garrison Reservoir. A classification of the land taken for the Garrison Reservoir in North Dakota by general type of use at the time of taking is presented in Table 1.

TABLE 1. ACREAGES ACQUIRED IN NORTH DAKOTA BY GENERAL TYPE OF LAND-USE AT TIME OF TAKING FOR THE GARRISON DAM AND RESERVOIR

Previous Use	Total	Fort Berthold Indian Reservation	Irrigation Projects		Other Rural Uses
			Lewis & Clark	Buford-Trenton	
			Acres		
Urban Total	500[a]				
Rural Total	462,500	152,360	8,169	8,718	293,253
Woodlands	88,001	41,358	1,678	2,323	42,642
Pasture	196,914	90,293	1,220	1,044	104,357
Agriculture	177,585	20,709	5,271[b]	5,351[c]	146,254

[a]Villages of Sanish, Van Hook and Elbowoods.
[b]About 94 percent of the cultivated acres were irrigated.
[c]About 57 percent of the cultivated acres were irrigated.

SOURCE: U. S. Corps of Engineers.

The agricultural land acquired for the Garrison Reservoir included 7,966 acres that were previously irrigated in the Buford-Trenton and Lewis and Clark irrigation projects. The remaining agricultural land under cultivation was cropland under dry farming practices.

Similarly, a total of 106,389 acres of agricultural land in Burleigh, Emmons, Morton and Sioux counties, North Dakota will be acquired for the upper reaches or backwater section of the Oahe Reservoir. Table 2 is a classification

of land being taken for the Oahe Reservoir in North Dakota, also by general type of use at the time of taking.

TABLE 2. ACREAGES ACQUIRED IN NORTH DAKOTA BY GENERAL TYPE OF LAND USE AT TIME OF TAKING FOR THE OAHE DAM AND RESERVOIR

Previous Use	Totals	Standing Rock Reservation	Other Rural Uses
		acres	
Woodlands	15,037	9,030	6,007
Pasture	62,256	45,585	16,671
Agricultural	29,096	1,379	27,717
TOTALS	106,389	55,994	50,395

SOURCE: U. S. Corps of Engineers and USDI, Bureau of Indian Affairs, "Damage to Indians of Five Reservations from Three Missouri River Reservoirs in North Dakota and South Dakota." Report No. 138, April, 1954.

All of the agricultural land being taken for the Oahe Reservoir in North Dakota was dry farming cropland.

Estimating the Irrigation Potential Lost

The irrigation potential of the Missouri River bottomlands in North Dakota was estimated to evaluate the potential but now foregone, land-use pattern. This estimate assumes that if the Garrison Dam had not been built, portions of the bottomlands would have been irrigated by individual operators or in organized projects by utilizing pumps along the stream bank.

The major data on the irrigation potential of Missouri River bottomlands in North Dakota was compiled and put into preliminary report form by the U. S. Bureau of Reclamation in 1940. The U. S. Corps of Engineers and the North Dakota State Water Conservation Commission also furnished data for the summary report.

The 1940 Bureau report indicated 27 projects of suitable size and considered at the time economically feasible for development in North Dakota, utilizing pumping plants on the banks of the Missouri River. Two other irrigation projects--Lewis and Clark and Buford-Trenton--were already under construction at the time. Table 3 indicates the gross and tillable acres in these projects, with the projects arranged according to the factor now affecting them. Other small acreages have been intermittently irrigated by wells located near the river banks by individual farm operators.

TABLE 3. POTENTIAL IRRIGATION AREAS ALONG THE MISSOURI RIVER IN NORTH DAKOTA AFFECTED BY RESERVOIRS AND STREAM BANK EROSION

Irrigation Project	Gross Acres	Tillable Acres	Acres Recently Irrigated
A. Projects affected by Garrison Reservoir			
*Buford-Trenton	8,322	5,351	7,655
*Lewis and Clark	8,169	4,935	4,765
1. Williston	13,725	8,602	
2. Birdshead	7,756	2,898	
3. Seneschal	2,965	1,820	
4. Nesson	22,735	14,581	
5. Goodall	5,588	3,803	
6. Shell Creek	12,157	4,830	
7. Independence	8,355	4,131	
8. Fort Berthold	13,867	8,851	
9. Old Agency-1st Stage	8,266	6,428	
2nd Stage	4,884	2,700	
10. Fort Stevenson	12,270	6,828	
11. Mannhaven	2,992	1,552	
Subtotal * through 11	132,051	77,310	
B. Areas affected by Stream Bank Erosion Problems			
12. Hancock Flats	9,874	5,027	
13. Stanton	5,522	3,448	2,039
14. Fort Clark	4,822	2,750	
15. Oliver-Sanger	13,309	6,884	
16. Painted Woods	6,320	3,674	
17. Manley	3,188	2,160	
18. Wogansport	3,191	2,400	
19. Square Butte	3,925	2,750	
20. Burnt Creek	3,892	1,940	
21. Mandan	5,000	3,070	
22. Bismarck	6,696	4,876	
23. Little Heart	7,878	3,925	
Subtotal 12-23	73,617	42,904	
C. Areas affected by Cahe Reservoir			
24. Long Lake-Kyes	3,341	2,021	
25. Horsehead	28,420	17,629	
26. Winona	8,595	5,941	
27. Fort Yates	13,740	7,646	
Subtotal 24-27	54,096	33,237	

SOURCE: Data on Projects 1-27 from: Bureau of Reclamation, Missouri-River Pumping Investigation, Draft 1940 by CTH, the source table was titled "Potential Irrigation Projects Along the Missouri River in North Dakota." The book is on file at the Missouri-Souris Project Office of the Bureau of Reclamation in Bismarck.

The Bureau of Reclamation studied 132,000 bottomland acres now affected by the Garrison Reservoir. Approximately 165,000 bottomland acres were acquired for the reservoir. The ratio of studied to acquired land is about 80 percent.

The total acreages affected by the Garrison and Oahe Reservoirs and by stream bank erosion, and the proportion considered tillable are shown in Table 4.

TABLE 4. TOTAL ACREAGES OF MISSOURI RIVER BOTTOMLANDS AFFECTED BY INUNDATION AND STREAM BANK EROSION, NORTH DAKOTA

Area Affected By:	Gross Acres	Tillable Acres	Percent Tillable
Garrison Reservoir Inundation	132,051	77,310	58.1
Stream Bank Erosion	73,617	42,904	58.3
Oahe Reservoir Inundation	54,096	33,237	61.3
TOTALS	259,764	153,451	59.1

The total gross acres presented in Table 4 is about 260,000 acres. Applying the same ratio of studied acres with irrigation potentials to acquired acres gives an estimated 325 thousand gross acres of Missouri River bottomlands in North Dakota. About 60 percent of the gross acres are irrigable. Sixty percent of 325 thousand gross acres gives an estimated 195 thousand bottomland acres with irrigation potentials. An additional 10 percent of the gross acreage could have been developed with sprinkler irrigation, for a total of 227,500 irrigable bottomland acres.

However, some of the irrigable acres would have been utilized for pumping stations, canals, and drains. At the Fort Clark Unit, this amounted to about 4.75%. Thus, about 11,000 acres of irrigable bottomland acres would have been used for irrigation facilities, leaving a potential of 217,000 net irrigable acres along the Missouri River in North Dakota.

Applying the figures for tillable acres from Table 4, the Garrison Reservoir inundated about one-half or 109,000 potential irrigable acres. The Oahe Reservoir affects 22 percent or 47,000 acres with good irrigation potential along the Missouri River in North Dakota. Currently, an additional 28 percent or 60,000 acres along

the Missouri River bottoms, between the Cahe Reservoir and the Garrison Dam in North Dakota, are affected by stream bank erosion.

An estimated 101,206 acres of bottomland taken for the Garrison Reservoir were considered as having good physical and economic irrigation potentials. This is in addition to the 7,966 acres already under irrigation in the Buford-Trenton and Lewis and Clark projects. There were no organized irrigation projects within the North Dakota portion of the Oahe Reservoir takings. However, 46,935 acres to be taken in North Dakota for the Oahe Reservoir have good physical and economic irrigation potentials.

The productive uses of land taken for the Garrison and Oahe Reservoirs at the time of takings, and what the potential use of that land was according to irrigation qualities are presented in Table 5.

TABLE 5. USE CLASSIFICATION OF LAND INUNDATED BY THE GARRISON AND OAHE RESERVOIRS AT TIME OF TAKING AND ACCORDING TO IRRIGATION POTENTIALS

Use Classification	Garrison Reservoir	Oahe Reservoir
	acres	
	Land-Use at Time of Taking	
Irrigated Cropland	7,966	-
Dry Cropland	163,198	28,079
Pasture & Grazing Land	189,460	60,081
Wood & Forest Land	88,001	15,037
Other[a]	13,875	3,192
TOTALS	462,500	106,389
	Potential Land-Use	
Irrigated Cropland	109,172	46,935
Dry Cropland	140,487	-
Pasture & Grazing Land	180,466	52,007
Other[b]	32,375	7,447
TOTALS	462,500	106,389

[a] Farm sites, roads, service, and waste land.
[b] Farm sites, roads, services; pumping stations, canals and drains for irrigation; and waste land.

For both the Garrison and Oahe Reservoirs, all of the land that had commercial forestry value was bottomland adjacent to the river and of irrigable quality when cleared. The remaining irrigable land was bottomland under cultivation in dry farming practices. In the case of the Oahe Reservoir, some of the land with irrigation potential was used for grazing.

The potential use of land taken for the Garrison Reservoir was about 109,000 acres of potential irrigable cropland, over 140,000 acres of dry cropland, and over 180,000 acres of pasture and grazing land. In the case of the land taken for the Oahe Reservoir, the potentials were for nearly 47,000 acres of irrigable cropland and about 52,000 acres of pasture and grazing lands.

Acreage Losses from Stream Bank Erosion

A serious and continuing loss of a valuable resource, the Missouri River bottomlands in North Dakota, is occurring due to uncontrolled stream bank erosion. This problem affects about 80 river-miles of bottomlands between the Garrison Dam and the backwaters of the Oahe Reservoir. The factors are unprotected river banks and clear de-silted water emerging from the Garrison Dam in irregular flows. These irregular flows vary in volume, height of crest wave and in length of sustained flow. The flows of water fluctuate due to varying basin demands for water, but the destruction is entirely that of bottomlands located in North Dakota.

Prior to the closure of the Garrison Dam, the Missouri River water was in a state of equilibrium or near-saturation for erosion, silt carrying capacity and sedimentation. Soils eroded in one place were carried to and deposited upon

another part of the bottomlands in North Dakota. What one landowner gained in accreted land was lost by another landowner. The over-all width of the river has been fairly stable in recent years. Annual spring floods replenished moisture of the sandy bottomlands, to enhance their agricultural productivity.

The closure of the Garrison Dam suddenly altered this internal equilibrium. The Garrison Reservoir serves as a vast de-silting chamber, and the resulting clear, de-silted water flowing from the Dam has an enormous capacity to pick up and carry silt until it attains another silt equilibrium or saturation level. The fluctuations in the releases increases the destructive powers of the water. Crest waves are often five feet high as they leave the Garrison area. Rises in the water level, as well as the longer sustained flows, readily weakens the stream banks. This leads to bank slides, increased erosion, and the destruction of existing pumping sites along the river bank.

The acreage loss per year due to bank erosion was determined by studying aerial photographs, interviews with affected landowners, and information presented at a public hearing at Bismarck on February 26, 1960.

A 39 river-mile area from the Burleigh-McLean county line to the Oahe Reservoir take-line was studied by means of 1950 and 1957 aerial photos. Three years elapsed between the 1954 closure and the 1957 photo flights. The actual acreage loss for the three years was determined by means of photo tracings, and a recent annual loss of 3.6 acres per river-mile was determined for the 39 river-miles studied. This indicates a loss of 288 acres per year in the recent years of sub-normal river flows.

Insufficient aerial photo data prevented a similar determination of the acreage losses for the upper portion of the river to the Garrison Dam. This upper portion may be expected to have a higher loss rate because the water is most clear and de-silted as it leaves the Dam.

A survey of 72 owners of river bottomlands indicated that approximately 440 acres of bottomland were lost annually from bank erosion. The loss rate was highest during high and fluctuating water flows. These high, sustained flows occur almost daily whereas previously there were only two annual spring floods.

Releases of water in recent years from the Garrison Dam have been about 10 million acre-feet per year. Average or normal flow of the Missouri River is about 17.6 million acre-feet per year. Thus, any losses from and measures of recent bank erosion would seriously understate the amounts of devastation likely in the near future. With normal river flows, erosion may occur at a rate of 900 to 1,000 acres per year.

Owners of potentially irrigable bottomlands are now discouraged from preparing their lands for irrigation and installing pumps at suitable bank sites because of the rapid destruction of pumping sites and potential irrigable fields. The benefits of stream bank protective works not only accrue to owners of bottomlands but also to downstream areas. The silt load gathered by the water is deposited in the sedimentation sections of the Oahe Reservoir.

ANNUAL INCOME LOSSES

From Lands Lost to Reservoirs

Direct per acre gross incomes were estimated for irrigated cropland, dry cropland, pasture and grazing land, and for wood and forest lands. These per acre gross incomes were used to determine the total direct gross income lost by farmers from taking these lands out of productive cultivation, grazing and forestry uses.

The gross income per acre estimated of land under irrigation was determined from the average value of crops per irrigated acre in the Buford-Trenton project during 1958, 1959 and 1960.[4] The gross returns per irrigated acre in the Buford-Trenton project were: $83.37 in 1958, $66.28 in 1959, and $77.21 in 1960. The three year average is approximately $75.00.

The gross income per acre of dry cropland was determined on the basis of average yields of wheat and barley. For wheat the average yield was 15 bushels per acre and for barley 26 bushels per acre. The current support prices of $2.00 per bushel of wheat and 97 cents for barley were applied to these yields. The typical cropping pattern for the area was wheat on summer fallow, followed by barley, followed by summer fallow. Gross returns were $30 per acre of wheat plus about $24 per acre of barley, or a total of $54 for the crops grown. This total of $54 is divided by three to account for one year of summer fallow every third year. The resulting average gross returns is $18 per acre from dry croplands taken in the Missouri River Valley for the Garrison and Oahe Reservoirs.

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[4] SOURCE: U. S. Department of the Interior, Bureau of Reclamation, Division of Irrigation and Land Use, "Statistical Appendix to Crop Report and Related Data", for the years cited.

The gross return per acre of pasture and grazing land was determined according to the carrying capacity of a combination of native and tame grasses. An average carrying capacity of 1.2 acres per month per cow-calf unit, as reported by the Great Plains Experiment Station at Mandan for land in the Missouri River Valley, was used with a five month grazing season. This would result in a 375 pound stocker calf worth $24.00 per hundredweight, or a total of $90.00. The $90 is divided by six (for the six acre months necessary) to yield a return of $15.00 per acre. The $15 per acre must be adjusted downward by 58 percent to account for the pregnant cow being kept seven months of the year on feed from other sources. The adjusted gross return for grazing and pasture land was thus determined to be $6.30 per acre.

The average annual gross return per acre of commercial forest land was determined from data supplied by the Deputy State Forester.[5] Approximately 103,000 acres were affected inundation by the two reservoirs. The average annual gross return to forestry products operators was about $195 thousand per year. The per acre average annual gross return thus is about $1.90 per acre. Appendix 2 indicates another means of measuring the total forestry losses.

The direct annual gross income losses from land taken for the Garrison Reservoir are presented in Table 6, both for the land-use at the time of taking and for the potential land-use that could be expected by exploiting the feasible irrigation possibilities of the bottomlands.

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[5] Letter from Mr. Duane L. Green, Deputy State Forester, North Dakota Forest Service, March 1, 1962.

TABLE 6. GROSS ANNUAL INCOME ESTIMATES FROM LAND TAKEN FOR THE GARRISON RESERVOIR

Use Classification	Acres	Gross Annual Income Per Acre	Total Gross Annual Income
		dollars	dollars
	Land-Use at Time of Taking		
Irrigated Cropland	7,966	$75.00	$ 597,450
Dry Cropland	163,198	18.00	2,937,564
Pasture & Grazing Land	189,460	6.30	1,193,598
Wood & Forest Land	88,001	1.90	167,202
Other[a]	13,875	-	-
TOTAL	462,500		4,895,814
	Potential Land-Use		
Irrigable Cropland	109,172	75.00	8,187,900
Dry Cropland	140,487	18.00	2,528,766
Pasture & Grazing Land	180,466	6.30	1,136,936
Other[b]	32,375	-	-
TOTAL	462,500		11,853,602

[a] Farm sites, roads, services and waste land.
[b] Farm sites, roads, services; pumping stations, canals, and drains for irrigation; and waste land.

By applying the estimated direct gross returns per acre for the various types of land-uses, the land taken for the Garrison Reservoir would have currently returned a total of nearly $5 million annually under the land-use pattern that prevailed at the time of taking. Under the potentially more intensive irrigation land-use pattern, the total direct gross annual income returned could have been nearly $12 million per year.

For the North Dakota bottomland being taken by the Oahe Reservoir, the total direct gross income loss is slightly over $900 thousand annually, as shown in Table 7. Under the potential irrigation possibilities, the total current direct gross income loss amounts close to $4 million annually.

TABLE 7. GROSS ANNUAL INCOME ESTIMATES FROM LAND TAKEN IN NORTH DAKOTA FOR THE OAHE RESERVOIR

Use Classification	Acres	Gross Annual Income Per Acre	Total Gross Annual Income
		dollars	dollars
	Land-Use at Time of Taking		
Dry Cropland	28,079	18.00	505,422
Pasture & Grazing Land	60,081	6.30	378,510
Wood & Forest Land	15,037	1.90	28,570
Other[a]	3,192	-	-
TOTAL	106,389		912,502
	Potential Land-Use		
Irrigable Cropland	46,935	75.00	3,520,125
Pasture & Grazing Land	52,007	6.30	327,644
Other[b]	7,447	-	-
TOTAL	106,389		3,847,769

[a]Farm sites, roads, services, and waste land.
[b]Farm sites, roads, services; pumping stations, canals, and drains for irrigation; and waste land.

The combined current direct gross income loss by the takings for both reservoirs amounts to about $5.8 million annually under the land-use pattern existing at the time of taking. The potential irrigation land-use pattern would have yielded a combined direct gross annual income loss of nearly $15.7 million per year.

Severance Damages

An analysis of severance or indirect damages considers several interrelated losses. The initial direct loss was the bottomlands taken for the two reservoirs. The loss of bottomlands results in a smaller farm or ranch remaining, and this smaller acreage means that fewer units of crops and animals may be raised and hence a loss in incomes. The loss of bottomlands is of peculiar importance to livestock ranchers, because the bottomlands provided the bulk of the winter feed to support the cow herds that grazed during the summer on uplands not taken for the reservoir. The farms were left with only uplands, and had to either acquire additional upland acres to support the same herd size, reduce herd sizes, or purchase the winter feed necessary. The result was the same--a reduction in net incomes.

A second loss is a reduction in efficiency of production of temporarily fixed inputs. With no alternative uses and the same labor supply, the same labor supply was spread over fewer units, with a consequent reduction in labor efficiency. Other fixed assets--buildings and equipment--also had lower utilization and hence less efficient use after the severance of the bottomlands.

The first severance loss is a reduction in scale of operation and the second loss is a reduction in the efficiency of production. A third loss arises from attempts of the landowner to readjust to the new smaller size of unit. During this adjustment phase he experiences a reduced income. He may face additional and/or increased costs in attempting to purchase additional land in an inflated seller's market where other similarly affected owners are attempting to purchase additional acres, the same or increased per unit costs for marketing a smaller output, less

opportunity to secure credit because his unit now has a high risk since his income is now less stable than before and of a smaller size. The farmer may have to build additional new fences, move or build new buildings, maintain buildings now too large for the units housed, relocate farm service lanes, and so forth. The farmer is faced with increased money costs and reduced income.

Most of the affected landowners were not willing sellers, though their bottomlands were priced in the "arm's length, willing buyer-willing seller"context. The landowner after the taking was in a considerably weakened income earning position. The compensation given for his bottomlands did not leave him as well off after, as he was before, the taking.

But these indirect damages are difficult to measure. For the Fort Berthold Indian land takings, the Bureau of Indian Affairs estimated that the indirect damages were 3.42 times larger than the direct damages.[6] However, our severance or indirect damage definition is somewhat different, so that their figure is not directly applicable to this problem.

A recent farm budgetary approach to direct and indirect or severance damages for the North Dakota reservoir takings indicated that indirect damages were about 2/3 those of the direct damages. Thus multiplying direct damages by 1.66 yields approximately the total direct and indirect or severance damages determined by the farm budget analysis. However, we include part of the indirect damages by use of a multiplier in our analysis below. We must separate the severance damages by subtracting the multiplier, as developed below, from the total indirect factor of 1.66 to derive a severance damage estimate. The severance factor thus is equal to about 37 percent of the total direct damages or $2,231,628 to the bottomland owners.

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6 See Appendix 1

Monetary Losses from Bank Erosion

Three types of annual monetary losses from stream bank erosion are considered: the value of land physically eroded away, the land value increase that would have occurredbut are now foregone because the land was lost, and the gross crop income loss from the land eroded away.

The aerial photograph study indicated that 288 acres were lost per year. The landowners estimated 440 acres were being lost per year. Considering that after the reservoir has filled and normal river flows occur, an estimate of 440 acres lost per year is apt to understate the actual losses. The estimate of 440 acres being lost per year from the stream bank erosion is used in this section.

The value of irrigated Missouri River bottomlands in North Dakota is at least $250 per acre. Even non-irrigated bottomlands have a high value to livestock ranchers, for these acres provide the winter feed necessary to support the beef herd through the winters. The direct loss due to bank erosion, 440 acres, would be $110 thousand per year for each year an equal amount of land is eroded away.

The altered situation created by the closing of the Garrison Dam must also be considered. The river will continue to destroy land over an ever-widening plain until it establishes a new meander belt. This new meander belt may be about a mile wide. The deposits of sand bars and new land are worthless for agricultural purposes until leveled and drained. It will require a large investment to prepare these accreted lands for agricultural uses. For a moment, let us consider the future, when the river has established a new meander belt. The land losses may be estimated by considering the middle year of a 50-year period. By the 25th year,

losing land at a rate of 440 acres per year, a total of 11,000 acres at $250 per acre, or $2,750,000 worth of agricultural land would have been destroyed.

In the next 50 years, land values may be expected to rise in North Dakota, especially irrigable bottomlands. Land values have nearly doubled in North Dakota in the past decade. Bottomland values may increase $80 per acre in the next five decades. Though this increase does not accrue at regular intervals, it averages out to about $1.60 per acre per year. For 440 acres it is about $704 per year. This increased value would accrue to landowners and also would be available for taxation purposes.

The gross agricultural returns of developed bottomlands are high, besides being vital to the livestock enterprises. Four tons per acre of alfalfa, at $20 per ton, is not atypical. The loss in gross crop income for the year in which the land is lost is about $80 per acre. Thus, $35,200 of important forage is lost each and every subsequent year from these 440 acres of destroyed bottomlands.

The total economic loss for the first year due to stream bank erosion of 440 acres is the summation of the three values foregone. Each year that 440 acres of irrigable bottomlands are lost, landowners are losing approximately $145,904 for the three losses of crops that could not be grown, land physically eroded away and the increased valuation foregone. At the end of the 25th year, the total of these losses would be at least $3,652,000 due to the loss of 11,000 acres. With higher erosion rates, this loss may be achieved in fewer years.

Fish, Game and Wildlife Losses

In 1946 the U. S. Fish and Wildlife Service, in cooperation with the North Dakota Game and Fish Department, studied the impacts from the major water impoundments in North Dakota. Table 8 presents their data on the fish, game and wildlife losses or gains due to the Garrison Reservoir.

TABLE 8. ANNUAL FISH AND WILDLIFE LOSSES OR GAINS FROM WATERS IMPOUNDED IN NORTH DAKOTA BY THE GARRISON RESERVOIR, 1946 PRICES

Summary Item	Annual Loss	Annual Gain
	dollars	dollars
Loss of stream fishing	$ 29,700	
Loss of wildlife habitat	336,800	
Loss of waterfowl habitat	138,900	
Value of reservoir for fishing		150,750
Improvement of river below dam		19,360
Value of waterfowl resting area created		119,250
TOTAL	$ 505,400	$ 289,360
TOTAL Net Annual Losses	216,040	

SOURCE: Letter from Mr. Russell W. Stuart, Commissioner of North Dakota Game and Fish Department, January 26, 1962.

The loss in stream fishing is more than offset by the potential value of the reservoir for fishing. However, the loss in wildlife and waterfowl habitat has not been as yet offset.

The Garrison Reservoir took 165 thousand bottomland acres in North Dakota. The net annual loss attributable to the Garrison Reservoir for fish, game and wildlife is estimated at $216,040. This averages $1.31 per acre for the affected bottomland acres acquired for the Garrison Dam and Reservoir.

In the Oahe Reservoir taking area, the losses on an acre basis of river bottomland actually lost in North Dakota is apt to be higher because these lands previously provided good wildlife conditions. A larger proportion of these bottomlands tended to be in wooded-pastures, brush or woodlands.

ECONOMIC IMPACTS TO THE COMMUNITY

The total impacts of inundation and erosion of river bottomlands extend beyond the losses in income to the landowners directly affected. The community in which they reside and participate is also involved. Also, there are indirect effects throughout the economy caused by a chain of reactions resulting from reduced agricultural production in affected areas. On the one hand, farmers buy fewer inputs in the form of seed, fertilizer, fuel, repairs and so forth. On the other hand, a smaller output marketed requires less marketing facilities and means a reduction in income from marketing margins. These reductions affect such factors as transportation, wholesalers, manufacturers, credit agencies and so forth. These latter impacts are not included in this study.

The emphasis in this report is to show actual measurements of income changes and their impacts on affected farmers and their community. As indicated above, in income impacts on the community involves more than the immediate direct losses in income to farmers. There are additional, cumulative losses to the economy. These additional losses can be referred to as second, third, fourth round effects of the initial income losses. The sum of these effects is approximated by use of a "multiplier."

Understanding the Multiplier Concept

The multiplier concept is deceptively easy to understand. Just imagine that your regular income after taxes this year was reduced by $1,000. Let's also assume that you would have immediately spent all of this income for needed goods and services. We can assume that, on the average, each person from whom you would have bought goods and services will withhold 15 percent for his risk and profit margin. But the $1,000 was not available for spending, so all the "second" persons

(from whom you would have bought) had their net incomes reduced by 15 percent of the $1,000 or $150. This is the second round effect of the initial $1,000 decrease in net income. Likewise, there are third, fourth, fifth round effects, as the initial reduction in income is felt throughout the economy.

If, on the average, the risk and profit margin is 15 percent throughout the system, and we were able to watch the effects of the initial $1,000 decrease in income work itself out, throughout the system, the effects would look pretty much like this:

Initial loss or first round effect			$1,000.00
Second round effect =	$1,000.00 X 15%	or	150.00
Third round effect =	150.00 X 15%	or	22.50
Fourth round effect =	22.50 X 15%	or	3.37
Fifth round effect =	3.37 X 15%	or	.51
Sixth round effect =	.51 X 15%	or	.07
Seventh round effect=	.07 X 15%	or	.01
Total decrease in demand			$1,176.45

The total decrease in the demand for goods and services, after the loss in income has worked itself out throughout the system, is $176.45 greater than the initial $1,000 loss in income. The initial income loss is about 85 percent of the total decrease in the demand for goods and services.

The process of determining the total decrease in the demand for goods and services can be simplified by use of a multiplier. The formula for the multiplier is ONE divided by ONE minus the sales margin, 1/(1-margin). For this example, the multiplier is equal to 1/(1-.15) or 1.176. By multiplying the multiplier value times the initial $1,000 loss, we get $1,176; which corresponds to the total decrease determined by the longer method. With this understanding of the multiplier concept, we can now apply it to the figures at hand.

Application of the Multiplier

The multiplier can be used to indicate the total negative impacts on landowners and the economy of the communities involved. The multiplier used in this application is 1.17645, as previously derived. The total income losses to which the multiplier is applied is shown in Table 9.

TABLE 9. ANNUAL INCOME LOSSES IN NORTH DAKOTA FROM GARRISON AND OAHE RESERVOIRS

Type of Loss	After Takings	Foregone Potentials
	dollars	dollars
Direct Income Loss: Reservoirs	5,808,316	15,701,371
Indirect Income Loss: Reservoirs	2,231,628	
Stream Bank Erosion Loss, 1st Year	145,904	
Fish, Game and Wildlife Losses	216,040	
TOTAL Direct and Indirect Losses	8,401,888	15,701,371
TOTAL Community Economic Impact	9,884,401	18,471,878

The total economic impact to farmers and the community is about 9.9 million dollars annually under the types of land-use followed at the times of taking. But this loss is the loss for the first year only, because if this income had been available for spending, some of it would have been invested in buildings, furniture, machinery and so on. These long-term cumulative losses are indicated below by use of compound interest accumulator. The 9.9 million dollar loss occurred in 1959, 1960, 1961 and so forth for each year since the takings and is not reported here as a cumulative loss, but as an annual loss to the North Dakota economy.

If the lands for these reservoirs had not been taken, farmers would have gradually irrigated these bottomlands, either individually or in small irrigation projects. The incentives are increased returns and insurance against drouth that results from the undependable and erratic rainfall of the area. For the expected land-use pattern, with substantial irrigation, the potential direct annual income loss is approximately 15.7 million dollars. The potential total annual economic impact to farmers and their community would have been $18,471,878.

INCOME LOSSES THROUGH TIME

It is only proper to consider what the loss of this income would mean to its recipients over the longer period of time for which the effects are experienced.

If the income had been received, it would have been either spent or invested. If it was spent, the things bought have a value to the buyer at least equal in value to what it would have returned if it was invested. Otherwise it would have been invested instead of immediately spent. That is, if we spend our money for things we now want, it must mean that we value our current consumption at least as much as if we had deferred our consumption to a future date.

One way of valuing the deferred consumption is to use a compound interest accumulator. This accumulator reflects how much our money would have increased or accumulated over time. At a $2\frac{1}{2}$ percent compound interest rate, our investment would have grown by $2\frac{1}{2}$ percent for each period that the investment earns interest.

In this report we are taking just one year's loss into consideration. Our total period for compound interest is 50 years. This means that the initial year's loss is accumulated annually at $2\frac{1}{2}$ percent interest for 50 years. Notice that the initial year's loss may be for the year 1961, but the loss of land means that we have also lost its incomes for the years 1962, 1963 and so forth, which are not considered herein. This report considers only the loss for one year and the foregone investment and satisfaction returns for this one year's loss, which is accumulated at $2\frac{1}{2}$ percent interest annually for 50 years.

Understanding the Accumulator Concept

The concept of a compound interest accumulator is readily explained with a simple example. At compound interest, the principal is increased at the end of each period by the interest earned in that period. For the first period, the amount at compound interest is the same as the amount at simple interest. However, the effect of compounding is cumulative, and after the first period the amount or principal at compound interest becomes progressively larger. In this simple example let us develop both the compound interest accumulator formula and its application. For the application let us imagine we loan the government $100 for 50 years at $2\frac{1}{2}$ percent interest, compounded annually (the old Savings Bonds were for ten years at this rate).

	Formula		Application	
Initial amount or principal, P =	1	=	P	= 100.00
Interest earned in 1st period, 1.r	r	=	$2\frac{1}{2}\%$	= 2.50
Amount at end of 1st period	$1+r$	=	$(1.025)P$	= 102.50
Principal at start of 2nd period	$1+r$	=	P	= 102.50
Interest earned in 2nd period	$r(1+r)$	=		2.56
Amount at end of 2nd period	$(1+r)^2$	=	$(1.0506+)P$	= 105.06
Principal at start of 3rd period	$(1+r)^2$	=	P	= 105.06
Interest earned 3rd period	$r(1+r)^2$	=		= 2.62
Amount at end of 3rd period	$(1+r)^3$	=	$(1.0768+)P$	= 107.69
Principal at start of 50th period	$(1+r)^{49}$	=	P	= 335.33
Interest earned in 50th period	$r(1+r)^{49}$	=		8.38
Amount at end of 50th period	$(1+r)^{50}$	=	$(3.43711)P$	= 343.71

The example indicates that if we had loaned or invested $100 at 2½% interest, compounded annually, 50 years ago, we could today receive $343.71. Of this $343.71, $243.71 would be due to the interest earned and $100 of it was our initial investment. To get the amount at the end of each year we multiply the principal by r, and the product is added to the principal, which is equivalent to multiplying the principal by 1+r. Rather than multiply and add the amounts for each year, we refer to a "Table of the Amount of 1 at 2½ percent Compound Interest per Period." The table gives the applicable accumulator values of 1+r to use times the principal.

Application of the Accumulator Concept

The value of the compound interest accumulator (1+r) at 2½ percent interest compounded annually for a 50 year period, is 3.43710872. The total direct and indirect economic impact to the local economy is shown above to be 9.9 million dollars. But this is now foregone. If we had not lost this money, it could have been invested at 2½ percent interest, compounded annually for 50 years, and eventually be worth $33,973.761. This is the value of investments and pleasures foregone in the next five decades if this income had been available for current or deferred consumption.

If the river bottomlands had been developed, in view of their feasible irrigation potentials, the agricultural gross returns would have been over 15.7 million dollars per year. The community would have had over 18.5 million dollars in earnings. If these earnings had been invested, the total would have been worth $63,489,853 in fifty years. The total, equal to $(1+r)^{50}$, includes the initial amount of $18.5 million, which was invested. The initial earnings with the irriga-

tion potential developed of 18.5 million dollars, could have been either consumed immediately or invested. If it was immediately consumed, it means that people value the satisfactions from this spending and the services rendered from the items purchased at least as much as the total sum that could have been earned if invested.

GARRISON PROJECT BENEFITS

The analysis of the Garrison Project benefits is problematical, and depends upon certain value judgments. A review of past discussions of the Garrison only serves to highlight the problems involved.[7]

Flood control was a primary goal of the Garrison and other main stem Missouri River structures. Other functions include navigation, water storage for irrigation, municipal and industrial use, hydroelectric power generation, and pollution abatement.

The $291,000,000 Garrison and $361,000,000 Oahe multi-purpose projects were financed by the federal government with tax money from the entire nation. The total annual charges to the Oahe is $18.5 million and for the Garrison $14.7 millions per year.

In this analysis we are concerned with the Garrison project for the Oahe Reservoir yields few benefits to North Dakota. The Garrison is part of an integrated Missouri River Basin multi-purpose system and most of its short and long-term benefits accrue downstream. The current real and tangible benefits of Garrison to the North Dakota economy are mainly limited to the marginal value of the public power generated. The major projected real and tangible benefits to the North Dakota economy are based on the hopes of a Garrison Diversion irrigation project for central and eastern North Dakota. This diversion unit was initially advocated in 1944 as a part of the Sloan plan.

The functions and total Missouri River Basin benefits of the Garrison project, and the estimated annual benefits of the Garrison to North Dakota are presented in Table 10.

7 See: Missouri Basin Survey Commission, MISSOURI: LAND AND WATER, (Washington, D. C.: US Government Printing Office, 1953), Especially pp. 91-103.

TABLE 10. ANNUAL BENEFITS OF THE GARRISON TO THE MISSOURI RIVER BASIN BY FUNCTION, AND AMOUNTS SHARED BY THE NORTH DAKOTA ECONOMY

Function	Source of Data	Basin Annual Benefits	Estimated Benefits to North Dakota Economy	
		dollars	percent	dollars
Flood Control	1	2,380,000	5	119,000
Navigation	1	2,040,000	none	none
Irrigation	1	5,150,000	a	a
Public Power	1	10,285,000	40	4,114,000[b]
Recreation	2	640,000	100	640,000
Employee Earnings	3	610,000	100	610,000

a This is apt to be zero for the next decade. The benefits will not accrue for 10,15 or more years in the future, so its a potential benefit, but not at all certain to be exploited in the near future.

b Apparent value, but higher than its marginal value to North Dakota economy.

SOURCE: 1. Letter of Brig. General Shuler, U. S. Army, January 8, 1962.
2. Brig. General Shuler's Letter to the Editor, the Bismarck Tribune, Jan. 20, 1962, stating that over 400,000 visitors had visited the project in 1961.
3. Actual current annual payroll.

A primary function of the Garrison project is flood control for the Missouri River Basin. Bismarck and Mandan were the only cities in North Dakota substantially affected, and in most cases waters of the Heart River were the cause of flood damage in Mandan. Offsetting the urban damage from flooding were the agricultural gains--soil accretion and restoring moisture in sandy bottomlands. A generous share of the $2,380,000 flood control benefits of the Garrison would be 5 percent, or $119,000 annually to North Dakota.

Garrison navigation benefits are listed at $2,040,000 annually. A realistic appraisal of the North Dakota economy and alternative transportation available indicates no navigation benefits locally. Current transportation systems run east-

west and this reflects the continuing transportation needs of the state. Duluth is 250 miles away and is the gateway to the Great Lakes and the St. Lawrence Seaway, and is closer than the nearest Missouri River Basin facility, Sioux City, Iowa.

The Garrison irrigation benefit is listed at $5,150,000 annually. At the time of this writing, eight years after the Dam closure and 18 years after the plan was advocated, no Garrison irrigation facility has been constructed in North Dakota. The Garrison Diversion Conservancy District and several irrigation districts have been legally organized to locally prepare the way for the hoped-for project. It would be unrealistic to currently credit the state economy a benefit neither currently produced nor currently assured.

Someday, the agricultural and business economy of the state may feel the impact of irrigation development under the Garrison Diversion Unit. Economists of the Bureau of Business and Economic Research at the University of North Dakota estimate a minimum projection of $26,335,000 for local secondary benefits from developments of 250,000 acres of irrigation of the Garrison Diversion Unit. This value indicates the very importance of secondary benefits of the irrigation project to the state. In addition, the estimated increase in gross farm income would be about $35 million annually. But these benefits do not commence until the project is constructed and utilized.

The apparent major benefit to North Dakota of the Garrison has been and will continue for sometime to be the public power it generates, and which is distributed within this state. Approximately 40 percent of the Garrison power is allocated to North Dakota. Figures for the 1963-64 winter allocation by states of the total

Missouri River Basin firm power are as follows: Montana 2.35%, Iowa 13.82%, North Dakota 15.24%, Nebraska 20.34%, South Dakota 20.16%, and Minnesota 27.64 percent. North Dakota customers are to receive 150,930 of 990,510 kilowatts generated by applicable units of Fort Peck, Garrison, Oahe, Fort Randall, and Gavins Point projects.

The power benefits of Garrison are given as $10,280,000 annually. Approximately 40 percent or $4,114,000 is the North Dakota apparent share of this benefit. However, the marginal value of the public power generated is considerably less. The marginal value of this hydroelectric power to North Dakota customers would be the difference between the value of the Garrison public power locally distributed and the cost of providing alternative power in a given time period. The alternative power may come from lignite burning steam generation plants. The marginal value of the hydroelectric power to North Dakotans may be but a fraction of the $4,114,000 indicated above as the North Dakota apparent share.

The recreational use of the Garrison Reservoir is still an undeveloped potential. However, this potential is great. One problem will be the varying pool levels due to varying demands for water and a variable supply of water. Recently the U.S.Corps of Engineers reported for 1961 a total of over 400,000 visitor-days at Garrison. Valuing each visitor-day at $1.60, the current National Park Service figure, indicates that someday the Garrison recreational benefits may attain a value of $640,000 per year. Currently, however, the recreational facilities of the Park Service and the Garrison Reservoir differ significantly, and the above value is currently too high.

A current significant benefit of the Garrison project is employee incomes earned in operating and maintaining the structure. The annual payroll for operation, maintenance and administration of the Garrison is currently about $610,000.

The total annual benefits of the Garrison Dam and Reservoir at this time have a maximum possible value of $5.5 million per year to the economy of North Dakota. Its value to the North Dakota economy is currently considerably less than $5.5 million.

One possible additional benefit of the Garrison project to the North Dakota economy was the expenditure of 291 million dollars to build the structure. The over-all permanent effect of this huge expenditure upon the economy is difficult to ascertain, for today there is no evidence in the area indicating any business enhancement as a result of this expenditure.

Why no permanent effects? Can the leakage in the local economy be so high for this type of expenditure? The necessary cement and steel were imported into the state, for they are not manufactured locally. Most of the specialized labor force came from outside the state, not all brought their families along, and most left when their tasks were finished. Specialized equipment came from outside the state. Generators and electrical items were imported. Administration and supervisory personnel mostly came from outside the state. The local community was not greatly involved, for these projects tend to "take care of their own". So the local community participates very little in a construction of this type.

Some money was paid to farmers for their resources taken, but these farmers either bought other land, retired, or moved from the community or the state. Some money was paid the counties to relocate roads. But there were no sustained local investments or spendings to generate more local investments or spendings by the Garrison project, except the current payroll expenditures.

SUMMARY

The negative impacts were developed in terms of annual income foregone due to the takings of Missouri River bottomlands for the Oahe and Garrison Reservoirs in North Dakota.

The several income streams foregone include the gross returns from the lands taken for the reservoir. Gross returns were calculated for lands lost at the time of taking, and also in terms of the economically feasible irrigation potential that existed for these bottomlands. The combined direct gross income lost by the takings for both reservoirs amounted to about $5.8 million annually under the land-use pattern existing at the time of taking, and nearly $15.7 million annually if the irrigation potential had been developed. In addition to direct income losses, landowners experienced indirect, severance damages of about $2.2 million because of the resulting smaller, less efficient units remaining after the takings.

Uncontrolled stream bank erosion is occurring due to clear, de-silted, fluctuations of the Dam controlled waters. Erosion wastes bottomlands, causes owners to lose crops that could have been raised, and discourages development of these bottomlands for irrigation. The annual loss to landowners is approximately $146,000 for each year these losses continue.

Fish, game and wildlife losses and gains were studied. The net loss for fish, game and wildlife is approximately $216,000 per year due to the Garrison Reservoir. Mineral losses were considered, but are discussed in the appendix. It is more difficult to measure mineral losses, which vary with changes in prices and costs, which affect the amounts of mineral feasibly exploited in any given time period.

The total annual direct and indirect income losses to landowners, summarized in Table 9 are approximately $8.4 million per year. The impact of this income loss on the community was studied by use of a multiplier. The total economic impact on the landowner and his community is $9.9 million per year. The direct income loss if the irrigation potential has been developed is about $15.7 million to the landowners affected, and about $18.5 million to landowners and the local economy.

The income losses are considered over time with the use of an accumulator. The accumulator measures the interest the income could have earned if it has been available and invested. If we use it for immediate consumption, rather than investing it, this suggests that we value our current consumption at least as much as if it had been invested. If the $9.9 million had been invested at $2\frac{1}{2}$ percent interest, compounded annually it would have been worth $34 million at the end of fifty years.

The major projected real and tangible benefits of the Garrison Dam and Reservoir to the North Dakota economy are based on the hopes of a Garrison Diversion irrigation project, yet undeveloped. The current benefits consist primarily of the public power generated, which should be measured at its marginal value to the North Dakota economy. A primary function of the Garrison is flood control for the Missouri River Basin. The flood control benefits to the North Dakota economy are small. Navigation benefits are nonexistent to North Dakota economy. The recreation use of the Garrison Reservoir is still an undeveloped potential.

APPENDIX 1

Just Compensation - in Retrospect

In any taking of private lands for public use there are at least two basic approaches that may be followed. One method, demonstrated below in the takings of Indian lands, has the objective of leaving the landowner at least as well off after the taking as before, and to minimize the injury to his community. This is the more enlightened interpretation of just compensation for private lands.

This first approach entails purchase of lands and rights needed at prices which will enable the owners, if they have to move, to relocate and re-establish themselves in new situations which will afford them advantages at least equal to those they now enjoy; or, if they do not have to move, to make these readjustments and replacements as are necessary for the continued use and enjoyment of their properties without impairment of their present economic positions. In other words, the taking agency cooperates with and assists the landowners and does not take advantage of distressed financial conditions or seek to buy lands or rights only at minimum prices.

This enlightened approach recognizes that the farmer affected usually does not want to sell his lands. The loss of his land imposes a burden upon him even if he receives a fair price. The farmer must seek a new place to live, move his household and furnishings, move or dispose of his farming implements and stock and make other substantial adjustments. If he attempts to rebuy in the same general area, he must buy his new farm in an inflated seller's market in which he must compete with other similarly dispossessed farmers. The farmer experiences a reduced income during an adjustment phase in his farming enterprises. He may also experience new costs because of the changes he deems necessary in the new farm.

The second approach also pays the owner "just compensation" as determined by due process of law. In either approach the difficult problem is to determine what constitutes just compensation. In the latter approach it is defined as a "fair market value." The fair market value is interpreted to mean that price a willing buyer would pay a willing seller, neither being under any threat or force to buy or sell. It is hardly likely that the Garrison landowners were largely willing sellers. Also, this does not necessarily mean that the landowners would be in the same pecuniary position before and after the taking, which is the objective of the first approach.

An example of the enlightened approach is the compensation of the Indians in the taking areas in North Dakota as shown in Appendix Table 1.1. The damages were divided into direct and indirect damages. The direct damages were measured by the fair market values of properties taken. The indirect damages covered all other forms of loss or injury to Indian people. The table items are enlightening as to what items were included in the indirect damages. It was determined for the Fort Berthold settlement that the ratio of direct to indirect damages was 1 to 3.42. And this ratio was applied to the other reservations affected. Also, this gives an insight into the magnitudes of the indirect damages suffered by other affected landowners.

APPENDIX TABLE 1.1. DATA RELATING TO INDIAN PEOPLE AND LAND, AND DIRECT AND INDIRECT DAMAGES TO INDIANS OF TWO RESERVATIONS FROM GARRISON AND OAHE RESERVOIR TAKINGS, NORTH DAKOTA

Item	Unit	Fort Berthold	Standing Rock
PEOPLE AND LAND INVOLVED			
Indian Families Resident			
1. On reservation	Number	370	680
2. On taking area	Number	289	170
3. Percentage in taking area	Percent	78	25
Indian Farms and Ranches			
4. On reservation	Number	160	212
5. To be relocated because of takings	Number	150	50
6. To be relocated because of takings	Percent	94	24
Indian Lands			
7. Before reservoir takings, total area	Acre	584,718	1,026,655
8. Area in reservoir taking	Acre	152,360	55,994
9. Percentage of total Indian land in taking	Percent	26.1	5.5
10. Percentage of irrigable land in taking	Percent	100	26
11. Percent of timberland in taking	Percent	89	75
12. Percent of taking area which is timberland	Percent	13	25
13. After taking, total area	Acre	432,358	970,661
14. After taking, tribal land	Acre	6,324	156,482
15. After taking, tribal land affected by reservoir	Acre	6,124	17,637
DIRECT DAMAGES		Dollars	Dollars
16. Market value of properties taken		3,654,332	1,613,454
INDIRECT DAMAGES			
Cost of Re-establishing Homes, Ranches, and the Economy			
17. Moving and relocating personal properties and persons		197,000	101,500
18. Moving and re-establishing movable improvements		491,300	277,450
19. Extra cost of weatherproofing and equipping dwelling		170,000	50,500
20. Shelter for livestock		150,000	50,000
21. Domestic and livestock water		390,000	131,000
22. Additional fences needed under new ranching conditions		195,000	65,000
23. Reduced net income from ranches in adjustment period		300,000	100,000
24. Cost of repurchasing salvable buildings and improvements		66,227	32,562
25. Cost of rehabilitating tribal		400	2,500
26. Cost of lands to replace land in taking area		3,420,000	1,289,000
27. Total cost of re-establishment		5,379,927	2,099,512

APPENDIX TABLE 1.1. (Continued)

DATA RELATING TO INDIAN PEOPLE AND LAND, AND DIRECT AND INDIRECT DAMAGES TO INDIANS OF TWO RESERVATIONS FROM GARRISON AND OAHE RESERVOIR TAKINGS, NORTH DAKOTA

Item	Unit	Fort Berthold	Standing Rock
28. Less appraised value of land and improvements taken		3,489,000	1,372,966
29. Net additional capital needed for re-establishment		1,896,927	726,546
Timber, Wildlife, and Wild Product Losses			
30. Value to Indians of timber from taking area		1,583,000	1,658,675
31. Value to Indians of wildlife from taking area		1,017,500	680,000
32. Value to Indians of wild products in taking area		296,375	229,500
33. Less appraised value of commercial timber		175,789	205,648
34. Loss in excess of appraised value of commercial timber		2,721,086	2,362,527
35. Potential increase in value of irrigable land		267,810	78,440
36. All other damages, mostly intangibles		3,947,475	737,046
37. Total Indirect Damages (Items 29,34,35 & 36)		8,833,298	3,904,559
38. Total Damages (Items 16 and 37)		12,487,630	5,518,013

SOURCE: United States Department of Interior, Bureau of Indian Affairs, "Damage to Indian of Five Reservations from Three Missouri River Reservoirs in North Dakota and South Dakota," Report No. 138, April 1954 (Footnotes of Table 1 omitted herein. See report for their explanations.)

APPENDIX 2.

A Second View of the Forestry Losses

The report expresses the annual income losses for one year. That is, it considers the annual incomes foregone because of the inundation of agricultural lands.

Another way of measuring the forestry losses is to consider the forestry losses as a "once-for-all" or a "one-shot" loss. This method values the forest just before inundation, and does not consider its annual returns but its total returns as if it were all harvested just before inundation.

Appendix Table 2 indicates the approximate acreages of commercial forest land inundated in North Dakota.

APPENDIX TABLE 2.1. ESTIMATED COMMERCIAL FOREST LAND ACREAGES INUNDATED BY RESERVOIR WATERS IN NORTH DAKOTA*

Garrison Reservoir	88,000 Acres
Oahe Reservoir	15,000 Acres
TOTAL Commercial Forest Land Acres Lost	103,000 Acres

*SOURCE: Letter from Deputy State Forester Mr. Duane L. Green, North Dakota Forest Service, January 19, 1962.

APPENDIX TABLE 2.2. ESTIMATED INCOME EARNINGS LOST FOR COMMERCIAL FOREST LAND ACREAGES INUNDATED IN NORTH DAKOTA BY THE GARRISON AND OAHE RESERVOIRS*

Item	Millions Bd. Ft.	Per 1,000 Bd. Ft.	Total Values Foregone
			dollars
Total Net Merchantable Volume of Timber Lying Below the Taking Elevation	594.6		
Logging Costs (felling, bucking, skidding)		$15.00	4,919,000
Milling Costs (milling, fuels, etc.)		31.00	18,432,600
Profit and Risk Margin (25% of above 2 items)		11.50	6,837,900
Indicated Stumpage Values (to landowners)		7.50	4,459,500
TOTAL Values Foregone		65.00**	$38,649,000

*SOURCE: Letter from Deputy State Forester Mr. Duane L. Green, North Dakota Forest Service, January 19, 1962

** Average selling price of rough green cottonwood lumber at the mill.

Commercial forest landowners have lost nearly $4.5 million dollars of lumber due to inundation. In addition, they lost the incomes they may have earned in logging the timber on their properties. Forest product mill operators have lost incomes they could have earned by milling the logs. In other words, to harvest the estimated 594.6 million board feet of commercial forest inundated by the Garrison Reservoir would have directly earned the affected parties over 38 million dollars.

APPENDIX 3.

Mineral Losses Due to Inundation

The monetary values of mineral losses due to inundation are more difficult to establish. The mineral deposits may or may not be exploited depending on development costs, product prices, market structures, legislative actions, regulatory body rulings and so forth. For these reasons we have chosen not to second-guess the authorities in this field and have not included mineral losses in our annual income loss estimate.

However, the magnitude of the mineral losses have been estimated by Dr. Wilson M. Laird, State Geologist. The State Geologist has completed first-approximations of the impact of the Garrison Reservoir in North Dakota on lignite and petroleum deposits. Appendix Table 3.1. presents the estimated quantities of lignite left in land within the 1,850 foot contour limits of the Garrison Reservoir.

TABLE 3.1. ESTIMATED QUANTITIES OF LIGNITE LEFT IN LAND INUNDATED BY WATERS OF THE GARRISON RESERVOIR, BY COUNTIES, NORTH DAKOTA

County	Millions of Tons of Lignite
Dunn	1,583
McKenzie	1,822
Mercer	1,420
McLean	378
Mountrail	206
Williams	441
TOTAL Estimated Loss of Lignite	5,850 Million Tons

SOURCE: Letter of State Geologist, Dr. Wilson M. Laird, North Dakota Geological Survey, December 27, 1961

These estimates are only first-approximations of the lignite depositions, since there are no detailed topographical maps of the area and the information had

to be based on pits and outcroppings in the area.

Understandably, not all of these lignite deposits would have been developed under current product prices and costs of developing. However, at an average price of $2.30 per ton, the lignite left in the ground within the Garrison Reservoir represents a gross value of 13,455 million dollars.

There are 29 potential 80-acre petroleum locations within the 1,850-foot contour limits in Williams and McKenzie counties that have not been drilled. Speculating that if these all proved to be producers, there may be 5 million barrels of oil in these wells, currently valued at 14.75 million dollars.

There are no important lignite beds and no known oil pools within the taking area of the Oahe Reservoir.