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Evaluation of the Garrison Diversion
Benefit-Cost Ratio

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The Garrison Diversion Unit is a Bureau of Reclamation development providing water for the irrigation of 250,000 acres. Water will also be provided for municipal and industrial, supplies, fish and wildlife conservation and enhancement, recreation, flood control, and other project purposes [2]. Construction of the project was authorized in accordance with the Bureau of Reclamation report dated November, 1962.

Irrigation water will be pumped from Lake Sakakawea by the Snake Creek Pumping Plant into Lake Audubon, maintaining that lake at a constant elevation of 1,850 feet permitting the gravity diversion of water eastward through the McClusky Canal to the principal regulating reservoir, the Lonetree Reservoir. It will then be diverted to the irrigation areas by other supply canals and regulating reservoirs.

The development also includes Jamestown Dam and Reservoir, constructed in 1952-54 by the Bureau of Reclamation for flood control, and the restoration of Devils Lake and Stump Lake. Power for pumping irrigation water will be supplied from the Missouri River Basin facilities.

The focal point of this author's evaluation will be on the benefit-cost ratio calculations. Benefit-cost ratios permit an evaluation and ranking of expenditures for public properties. They introduce a time dimension into the analysis via the present value into public expenditures. An evaluation is made on the effect of varying discount rates on the benefit-cost ratio and on selection of benefits and cost to be included in a benefit-cost analysis. The results were obtained by using Bureau figures published in

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Appendix K of Definite Plan Report on Garrison Diversion Unit and used identical procedures to those of the Bureau report [1]. Both studies include both direct and indirect benefits.

The author of this analysis selected discount rates of 6 and 10 percent to evaluate the effects on the benefit-cost ratio. The Bureau of Reclamation reported a benefit-cost ratio of 251:1 based on a present value discount rate of 2.875 percent to the United States Congress.

The Bureau utilized a 2.875 percent interest rate, reflecting the interest bearing marketable securities of the United States having terms of 15 or more years remaining to maturity at the time of the Bureau's analysis. Although it will be difficult to estimate the interest rates to exist 25, 50, or 75 years in the future, it is commonly held that the opportunity cost of capital is an appropriate discount rate to use. The Associated Press release dated January 10, 1972, reported the President's Office of Management and Budget (OMB) and the Federal Water Resources Council pressed for at least a 7 percent discount rate and recommended a 10 percent rate. The officials of OMB indicated that earlier discount rates were unrealistically low, inflating the apparent benefit of a project.

Water Supply

The water supply for the diversion unit will be obtained from Lake Audubon of the Garrison Reservoir located on the Missouri River. Annual river flows into Lake Sakakawea - Lake Audubon have averaged 17.6 million acre-feet per year, but have ranged from 9.15 million to 28.8 million acre feet per year (an acre-foot is one foot depth on one acre). The quality of water stored is rated as good.

The initial phase of the Garrison Diversion Unit, which will irrigate 250,000 acres, will require 1,865 miles of canals and laterals and three regulating reservoirs. In addition, 2,813 miles of drains and 141 pumping plants and electrical facilities for pumping plants will be needed. The capacities of the three major regulating reservoirs that will be required by the Garrison Diversion irrigation unit follows in Table 1.

TABLE 1. CAPACITIES OF REGULATING RESERVOIRS

Reservoir	Capacity (acre-feet)		
	Inactive	Active	Exclusive Flood Control
Lonetree	144,000	280,000	0
Jamestown	10,000	18,088	185,435
Taayer	0	28,500	6,500

The inactive capacity of each reservoir is the minimum amount of water that will be maintained in the nonirrigation season. The reservoirs will be filled to active levels in preparation for irrigation with a specified amount left in reserve for flood control.

The capacity in cubic feet per second and length in miles of the major canals used to transport the water follows in Table 2.

TABLE 2. CAPACITY AND LENGTH OF MAJOR CANALS

Canal	Initial Capacity	Length
McClusky	1,950	75
Velva	2,000	85
New Rockford	1,600	52.5
Warwick	770	55
James River Feeder	450	10
Oakes	320	11

The McClusky Canal, the principal canal for the Garrison Diversion Unit, will convey water from Lake Audubon to Lonetree Reservoir. All major canals will convey water by gravity flow only which will require excavation to range from 0 feet to 114 feet.

Benefit-Cost Analysis

The benefit-cost analysis was conducted by the Bureau of Reclamation to evaluate the economic benefits and costs of the proposed multipurpose Garrison Diversion Unit for the initial phase of 250,000 acres to be irrigated. Irrigation benefits, benefits from drainage, and loss of benefits in the right-of-way areas assumed an index of prices received by farmers of 250 and an index of prices paid by farmers of 265, where $1,910 - 1,914 = 100$.

The procedures used in this analysis to compute the benefit-cost ratio were identical to those used by the Bureau with the exception of the higher discount rates. The life of the overall project was assumed to be 100 years. The higher discount rates provided a more realistic basis for evaluating the opportunity cost of capital.

The computation of the benefit-cost ratio involves annual equivalents of each type of benefit and cost. The amortization factor used by the Bureau was 0.03054; however, in this analysis a 0.002947 factor was used for the 6 percent discount rate and a 0.000072 amortization factor for 100 years at 10 percent interest rate. Table 3 summarizes the annual equivalents for each type of benefit at the three discount rates.

The annual equivalent benefits at a 6 percent discount rate are over \$21 million less or only 4.2 percent of those calculated by the Bureau. At a 10 percent discount rate, annual equivalent benefits were over \$22 million less or only 0.05 percent of the values calculated by the Bureau when they

applied a 2.875 percent discount rate. The reason for these lower values is the increased discount rates.

TABLE 3. ANNUALIZED BENEFITS ON A 100 YEAR ANALYSIS, GARRISON DIVERSION UNIT

Type of Benefit	Annual Equivalent 2.875 Percent	Annual Equivalent 6 Percent	Annual Equivalent 10 Percent
Irrigation	\$20,051,000	\$842,477	\$ 9,907
Municipal	365,000	24,334	185
Industrial	186,000	6,978	100
Fish and Wildlife	1,027,000	37,670	612
Recreation	602,000	29,272	363
Flood Control	141,000	8,535	128
Drainage	541,000	49,361	1,282
Subtotal	\$22,913,000	\$998,627	\$12,577
Agricultural Losses	747,000	71,423	1,071
Total	\$22,166,000	\$927,204	\$11,506

A summary of the annual equivalent cost values for the Garrison Diversion project are as follows (Table 4):

TABLE 4. ANNUALIZED COSTS ON A 100 YEAR ANALYSIS, GARRISON DIVERSION UNIT

Type of Cost	Annual Equivalent 2.875 Percent	Annual Equivalent 6 Percent	Annual Equivalent 10 Percent
Construction	\$6,271,000	\$453,258	\$ 7,276
Jamestown Dam	169,000	28,441	1,302
Assigned	993,000	95,821	2,341
OM and R	1,398,000	81,410	778
Total	\$8,831,000	\$658,930	\$11,697

The annual costs on a 100 year analysis using the Bureau's 2.875 percent figure was \$8.8 million. The annual costs for the 6 percent and 10 percent analysis are substantially less because of the higher discount rates.

The resulting values of Tables 3 and 4 are incorporated into Table 5 where the actual benefit-cost ratios were calculated as shown on the following table.

TABLE 5. COMPARATIVE BENEFIT-COST RATIOS, GARRISON DIVERSION UNIT

Discount Rates	2.875%	6%	10%
Benefit-Cost Ratios	2.51:1	1.41:1	0.97

The computed results of Tables 3 and 4 provide a benefit-cost ratio for the Bureau using 2.875 percent discount ratio of 2.51:1. The 6 percent discount rate yields a benefit-cost ratio of 1.41:1 or a reduction of \$1.10 of benefits per \$1.00 of costs. The 10 percent present value discount rate yielded a benefit-cost ratio of 0.97:1. This additional \$0.44 reduction of benefits would indicate that it no longer would be feasible to make the investment when using a 10 percent discount rate as for every \$1.00 of costs only \$0.97 of benefits will be returned. The results indicate that it is essential that an appropriate rate of interest be chosen.

Additional Concerns

The Garrison Diversion irrigation unit has long been controversial in North Dakota and more recent controversy has concerned environmental, agricultural, and other possible impacts of the project and their benefit-cost analysis. This section presents several impacts which were not considered by the Bureau in their benefit-cost study.

Environmental Effects

The most controversial current issue concerns the amount of pollution that will occur in the return flow waters. Many feel that this issue alone warrants a moratorium on continued construction. Canadians may be directly affected by the pollutants so the Canadian government has indicated its concern. Specific estimates on the environmental effects are not currently available, but additional research is being conducted by the Bureau.

The Garrison Diversion irrigation project was rated third most ecologically damaging of the 33 largest public works projects in the United States according to the March, 1974, issue of Garrison Diversion Report [3].

Irrigation drains and canals may lower ground water levels of land immediately adjacent to irrigated lands or the water supply canals. In addition, supply to wells and lakes in the area may be depleted.

With full irrigation development, Lonetree and Taayer Reservoirs will undergo draw down of water level exposing beach area. Pollution levels at these lakes could increase substantially. Additional vegetation in other areas due to irrigation could reduce dust pollution in those areas.

Agricultural Effects

The major agricultural benefit expected of the Garrison Diversion irrigation project would be both increased and stabilized income for North Dakota farmers affected by the project. An additional \$21 million could be generated in the economy due to economic spin-offs gained by supplies of fertilizer, seed, labor, and other production inputs. This spin-off is a result of an increase in agricultural income of \$15.7 million due to irrigation [4].

Who will pay for the increased and stabilized incomes? In 1974, the Bureau estimated the total cost of the 250,000 acre initial stage Garrison Project would be \$363 million, but the General Accounting Office estimated that the true total costs may be as much as \$429 million [6]. If 86 percent of total costs are allocated to irrigation as was the case in 1965 then these costs would be \$369 million or a subsidy of nearly \$1,500 an acre by the federal government. The Bureau estimates that 3.1 acre-feet of water

will be needed for each acre of irrigation. If this water is valued at \$5.66 per acre-foot the annual subsidy per acre for water would be \$17.55.

The irrigator's share of the cost of increased and stabilized income will be the additional investment and operating costs resulting from producing specialized crops. Irrigation sprinkler system costs vary widely by type of system, but present costs can be expected to be \$45,000 to \$60,000 for a 160 acre sprinkler system or \$280 to \$375 per irrigable acre.

An impact on farm structure will occur as individual irrigation landowners are required to comply with excess land provisions of reclamation law.¹ About 12 percent of the landowners hold irrigable land in excess of 160 acre limit for individuals (320 acres for joint ownership).

Additional impacts, which are difficult to measure, involve 170,000 acres of private land acquired for the Garrison Diversion Unit. This included 5,000 individual parcels of land. The intangible costs of relocating 47 farm-owners due to right-of-way acquisitions and an additional 40 farmers for other acquisitions were also not accounted for in the costs and benefits of the project. These intangible costs and benefits could lead to a different benefit-cost ratio than was computed by the Bureau.

Power Generation

Water diverted via Lake Audubon will reduce the water supply available from Lake Sakakawea for other uses. This may mean the generation capacity loss of 112.4 million kilowatt-hours of electrical energy at Garrison annually and 306.6 million kilowatt-hours downstream. The pumping unit of the Garrison Diversion irrigation unit will require 57.1 million kilowatt-hours of electrical energy. Increased use of electrical energy by irrigators for on-farm use could increase by 100 million kilowatt-hours annually. This energy may have to be

¹Although the Bureau has a 160 acre limit per individual or 320 acres per joint ownership, evidence in California indicates that it is not being followed.

supplied by other power sources, such as lignite-fired power plants. These costs plus other intangible costs associated with strip mining and pollution have not been taken into account in the benefit-cost analysis conducted by the Bureau.

Wetlands and Recreation

The benefits attributed by the Bureau to additional wetlands has been a source of controversy. The Bureau allocated \$1.027 million of fish and wildlife benefits and \$602,000 of recreation benefits annually. The Bureau of Sports Fisheries and Wildlife has estimated that Garrison Diversion will destroy 40,000 acres of prime wetlands, while replacing 56,000 acres of developed wetlands. The result is a net increase of 16,000 acres. Dr. Glenn Sherwood maintains that some 34,000 acres of the 56,000 to be developed already exist, so that only 22,000 acres will be developed. Dr. Sherwood has concluded that there would be a loss in benefits instead of the gain reported by the Bureau [8].

Devils Lake

Some argue the most patently unjustified benefit of the Garrison project is the Bureau's plan to restore the water level of Devils Lake so it can be used for recreation. An estimated \$20 million would be spent to raise the level of the lake to 1,423 feet. Natural rainfall and drainage have already raised the lake's level of 1,421 feet since 1942. The Bureau has planned to spend \$20 million to raise the water level of Devils Lake two feet.

Population Change

The Garrison Diversion Project is expected to reduce and possibly reverse the out-migration of people from the state [2, III-10]. New job

opportunities on farms and in agriculture-oriented businesses will be made possible by expanding crop production, as well as the increase in livestock production in the irrigation area. If population increases are realized, it is not expected to increase the governmental services required.

Impacts of Inflation

An appropriation of \$212 million was authorized for the Garrison Diversion irrigation unit in 1965. In January, 1973, the total cost was estimated at \$309 million and by January, 1974, the total cost was estimated to have risen to \$418.8 million. One needs to remember that, with most of the effects of inflation removed, the Bureau underestimated the cost of its first 34 projects by 214 percent. Ten of the projects, which were built during the depressed 1930's, had an average cost overrun of 51 percent [7].

Costs of the project are indexed annually and the \$418.8 million reflects January, 1974, prices as computed by the Bureau of Reclamation. Benefits were adjusted only slightly until 1974 when a new analysis of benefits and costs was computed [5]. On the basis of these changes, the benefit-cost ratio of the project is 2.82:1. A summary of the revised data is presented in Table 6.

TABLE 6. REVISED ANNUAL EQUIVALENT VALUES, GARRISON DIVERSION UNIT

Item	Annual Equivalents
<u>Benefits</u>	
Irrigation	\$43,882,000
Municipal and Industrial Water	1,108,000
Fish and Wildlife	2,282,000
Recreation	1,554,000
Flood Control	285,000
Total Benefits	\$49,111,000
<u>Costs</u>	
Investment	\$15,934,000
OM and R	1,493,000
Total Cost	\$17,427,000
Benefit-Cost Ratio	2.82:1

All project benefits were indexed from their 1962 level to January, 1974. The most recent Water Resources Council agricultural prices were used in indexing annual equivalent irrigation benefits to reflect projected benefits over the life of the project. Municipal and industrial water, recreation, fish and wildlife, and flood control benefits were indexed to the January, 1974, level on the basis of the relationship of benefits to costs.

The Bureau of Reclamation believes that, while this updated benefit-cost analysis is based only on indexing benefits to January, 1974, price levels, it is a realistic estimate of annual benefits to be expected from development of the Garrison Diversion Unit [5]. It should be pointed out, however, that production potential projected under early studies has already proven to be far below actual production obtained on farms currently growing crops under irrigation.

Conclusion

Despite its limitations, a benefit-cost analysis can be a useful tool in analyzing and ranking public projects. This analysis has shown the importance in selecting the proper discount rate and what impact changing the discount rate will have on the benefit-cost ratio. The author has attempted to point out some of the difficulties in estimating benefits and costs of a specific project, the Garrison Diversion irrigation unit.

References

- [1] Definite Plan Report on Garrison Diversion Unit, Appendix K, U.S. Bureau of Reclamation, Billings, Montana, January, 1962 (revised February, 1965).
- [2] Final Environmental Statement, U.S. Bureau of Reclamation, January 10, 1974.
- [3] "Garrison Diversion Report," Disasters in Water Development, April, 1973.
- [4] "Irrigated Acre's Income \$62.82 More," The Dakota Farmer, April, 1975, p. 50.
- [5] Letter to author from Warren Jamison, U.S. Bureau of Reclamation, Bismarck, April 11, 1975.
- [6] Letter to Representative Henry S. Reuss from U.S. General Accounting Office, May 15, 1974, as quoted in a news release issued by Reuss May 18, 1974.
- [7] Renshaw, Edward F., Toward Responsible Government, An Economic Appraisal of Federal Investment in Water Resource Programs, Idya Press, Chicago, I-1, 1957.
- [8] Sherwood, Dr. Glenn, New Wounds for Old Prairies, 1972, p. 23.