# Long Term Dredged Material Management Strategy Maumee River Watershed Toledo Harbor, Ohio

## APPENDIX A

## ECONOMIC JUSTIFICATION FOR CONTINUED MAINTENANCE DREDGING

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# SECTION 1 - INTRODUCTION

## A REPORT PURPOSE

Questions about the economic viability of investing in future dike disposal facilities, as well as their size, location and timing, have arisen in the Toledo Harbor Long Term Dredged Material Management Plan. This appendix addresses what the level of benefits are for continued maintenance of the Toledo Harbor commercial navigation channels.

Approximately 850,000 cubic yards of material is dredged yearly at Toledo Harbor. Due to the contaminated nature of this dredged material, more than fifty percent is placed in confined disposal facilities (CDFs). A number of confined disposal facilities have been built at Toledo over the past 25 years. A new confined disposal facility was completed in 1994 at Toledo Harbor. This facility was built to hold approximately 8million cubic yards of dredged material at the rate of 400,000 cubic yards per year over 20 years.The remaining 450,000 cubic yards would be placed in the open lake. However, all open lake disposal was been discontinued in 1991. Based on the Toledo Harbor Executive Committee's agreement on implementation of the 5-year interim plan, open lake disposal was allowed during the intermediate period. It is therefore estimated that from 1994 to 1998 approximately 600,000 cubic yards will be placed annually in the disposal facility. At the end of the interim period in 1999, all material would be confined, that is, 850,000 cubic yards will be placed in the facility on a yearly basis. Thus the facility is projected to be filled at the end of 2007. In 2008, there will be no additional capacity left in the facility. Since materials dredged beyond the year 2007 will need to be placed in confined disposal facilities if harbor maintenance is to be continued, this may involve construction of new confined disposal facilities.

## B HARBOR LOCATION AND TRIBUTARY AREA

Toledo Harbor is located on the south west shore of Lake Erie, at the mouth of the Maumee River, which flows into Maumee Bay. The port area consists of the lower seven miles of the Maumee River, and a dredged channel extending about 18 miles from the mouth of the River through Maumee Bay to deep water in Lake Erie. The harbor is approximately 96 statute miles west of Cleveland, Ohio, and about 237 miles south west of Port Colborne, Ontario, the Lake Erie terminus of the Welland Canal (see *Figure 1*).

The Maumee River, formed by the confluence of the St. Marys and St. Josephs Rivers at Fort Wayne Indiana, flows in a generally northeasterly direction, and empties into Lake Erie through Maumee Bay. The Maumee River drainage basin covers approximately 6,586 square miles, much of which is intensively farmed, and as a result carries a considerable sediment load. The average discharge of the Maumee River is about 4,800 cfs. The Maumee Rivers outlet into Lake Erie is via Maumee Bay, which is quite shallow. The limited depth in the Bay necessitates dredging of a long lake approach channel to Toledo Harbor.

## C PROJECT DIMENSIONS

The Army Corps of Engineers currently maintains the following navigation channel depths (see *Figure 2*) at Toledo Harbor, Ohio:

1. A lake approach channel approximately 18 miles long, 28 feet deep, and 500 feet wide from deep water in Lake Erie to the mouth of the Maumee River;
2. A river channel 27 feet deep and 400 feet wide from River Mile 0 (the River's mouth) to River Mile 3, a channel 400 feet wide to river mile 6.5 with depths 27 feet over at least a width of 200 feet, and 25 feet deep over remainder of the 400 foot channel width;
3. A river channel 25 feet deep and 200 feet wide from River Mile 6.5 to the upper limit of the project, River Mile 7, and
4. Turning basins of various widths, lengths and depths at River Mile 2.7 (750 feet wide, 800 feet long and 20 feet deep), 6.5 (Semicircular in shape with a radius of 730 feet and 27 feet deep), and 7 (18 feet deep and 8.25 acres in area).

**Figure 1. General Location of Toledo Harbor**

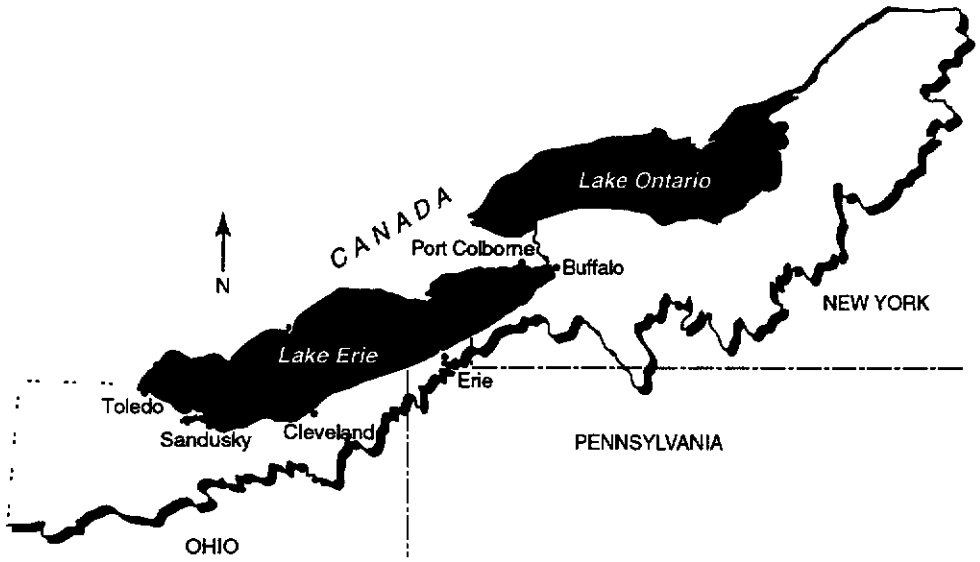
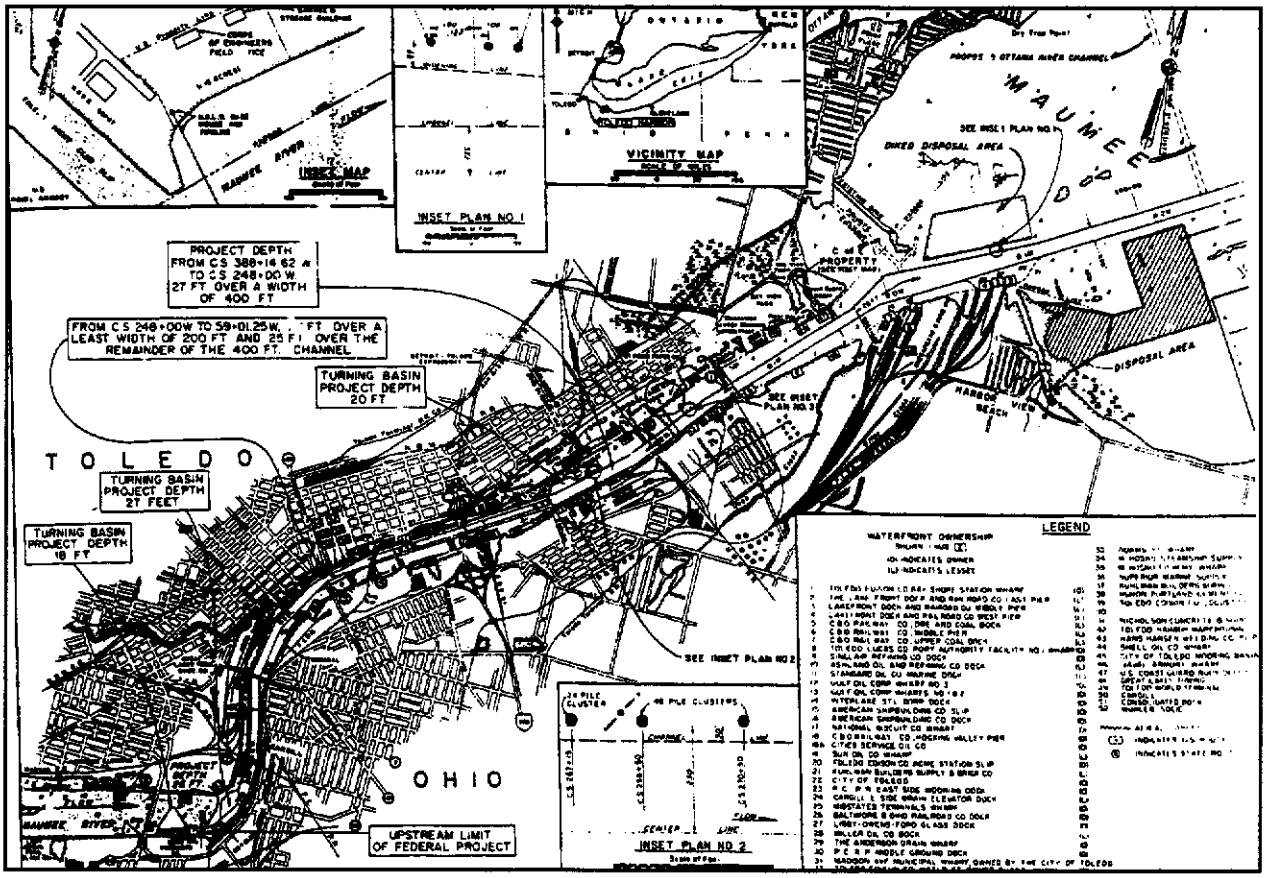



**Figure 2- Map of Toledo Harbor**



# D Basis of Economic Analysis - Benefits

The Federal Government, in determining whether it should undertake a specific construction project, predicates its involvement in that project on economic efficiency. Thus every federal dollar spent on construction and operation costs needs to generate at least one dollar in benefits. Costs and benefits are identified over the project evaluation period (PEP), say 20 years. Costs and benefits are discounted and amortized over the PEP. Average annual costs are subtracted from average annual benefits to determine net benefits for all plans evaluated. Plans with positive net benefits (average annual benefits exceed average annual costs) are candidates for investment.

Toledo Harbor is a major transhipment point for bulk commodities. Iron ore is received at Toledo Harbor from Lake Superior ports. The iron ore is loaded onto railroad cars in Toledo and transported to inland steel mills in Ohio and Kentucky. Coal railed from West Virginia is loaded onto Great Lakes vessels and shipped to electrical generating stations and other consumers in the United States and Canada. Also Toledo is a major exporter of grain to Canada. This report estimates the likely change in commercial navigation transportation costs for these major harbor users if the Corps of Engineers no longer maintains Toledo's commercial navigation channels.

This reports analysis is based on the 1996 commercial navigation season. Commodities, tonnages, and vessel origin/destination patterns that took place in 1996 are assumed to be representative of the traffic patterns occurring over the Project Evaluation Period under the "Without Project" and "With Project" conditions. The Toledo Harbor Study Group placed the Project Evaluation Period at 20 years. The evaluation period used is from 2002 to the year 2021. The Federal Discount rate of 7.125 percent was used in the evaluation. All project benefits reflect September 1998 price levels. A general description of the methodology used to develop average annual benefits follows.

## 1. Plan Benefits

Plan benefits can be defined as the difference in average annual transportation costs between the "Without Project" condition and each "With Project" condition. Benefits theoretically equal the transportation cost savings realized due to plan implementation. The transportation cost savings equals the non incurrance of *increased* transportation costs under the "Without Project" condition.

In the case of Toledo Harbor, the benefit for any one alternative plan is the difference in average annual commercial navigation transportation costs between the "Without Project" and "With Project" condition. The *increase* in commercial navigation transportation costs under "Without Project" conditions, as compared to "With Project" conditions, are the transportation cost savings that would accrue due to the construction of various types of dike disposal facilities (Plans) and continued operation of the Port at existing navigation channel depths.

### 1a. "Without Project" Condition Transportation Costs

Average annual benefits associated with any plan are evaluated in the context of the "Without Project" condition and the "With Project" condition.

In general the "Without Project" condition is what would likely occur in the absence of a Federal project over the PEP. At Toledo, the "Without Project" condition is that no new diked confined disposal facilities will be built over the 20-year evaluation period. The existing Confined Disposal Facility (CDF) was built in 1994 with a capacity of approximately 8.1m cubic yards. The existing confined disposal facility 3 would reach capacity by 2003. There after, CDF management tachniques would be implemented that would allow material to be confined until the year 2007. Therefore after 2007, Toledo Harbor channels would begin to fill up and bulk commodity shippers would begin to incur increased water transportation costs.

No navigation channel maintenance dredging will take place at Toledo harbor from the year 2008 to 2021 in the "Without Project" condition (no disposal facilities in place.) The Harbor channels will be allowed to shoal naturally from the year 2008 to the end of the evaluation period 2021. Eventually the harbor channels will silt up to the natural river bottom depth of 17 feet. The response of shippers under the "Without Project" condition could range from continued usage of the harbor over the 20-year evaluation period to shifting their commodity movements to alternative ports once Toledo Harbors navigation channel depths reach a critical available water column.

Transportation costs associated with the "Without Project" condition were developed for each origin/destination pair for iron ore, coal, and grain. A time stream of transportation costs was developed for each year of the 20-year evaluation period for each origin/destination pair. The analysis evaluated five origin/destination pairs for iron ore movements, twenty-nine (29) origin/destination pairs for coal movements, and one origin/destination pair for grain movements.

In order to capture all of the changes in transportation costs under the "Without Project" condition, "Without Project" condition water and *rail* transportation costs must be calculated for each year in the 20-year evaluation period. These transportation costs may vary from year to year, as shoaling continues at Toledo Harbor, or if commodity movements use alternate ports. Harbor users will continue to use Toledo Harbor as long as the combined water and rail costs associated with using Toledo Harbor are less than the combined water and rail costs associated with using an alternate port.

Total transportation costs (water and rail) were developed for each origin-destination pair by commodity, for different Toledo Harbor channel depths. These Toledo Harbor transportation costs were compared to alternative harbor water and rail transportation costs. If Toledo Harbor transportation costs for a given Toledo Harbor channel depth were lower than total transportation costs at an alternative harbor, the harbor user would continue to use Toledo Harbor. If the alternate port total transportation costs were less than Toledo Harbor total transportation costs, the harbor user would shift to the alternate port and stay there for the remainder of the project evaluation period. Yearly shoaling rates were used to develop channel depths for each year of the project evaluation period. Given these channel depths, total transportation costs were developed for each year of the 20-year project evaluation period for all origin/destination pairs.

The resulting time streams of "Without Project" condition transportation costs for the origin/destination pairs were then converted to average annual dollar values. These calculations used a 7.125 percent annual interest rate and a 20-year evaluation period. The actual calculation of "Without Project" condition transportation costs, the origin/destination pairs evaluated, and the alternative ports are presented in Section 2, Benefit Evaluation.

### 1b. "With Project" Condition Transportation Costs

A "With Project" condition transportation cost was developed based on currently maintained harbor depths being available for each year in the 20-year evaluation period (2002 to 2021). The new CDF recently built at Toledo (1994) will hold all of the material dredged at the harbor between the years 1998 and 2007. All potential Dredged Material Management Plans would provide disposal facilities for all of the channel material being dredged during the remaining portion of the PEP (2008 to 2021). The various plans differ on how they provide enough disposal facility capacity to contain the amount of material dredged over the remaining planning evaluation period.

Therefore, under "With Project" conditions, all of the plans provide currently maintained navigation channel depths over the PEP. Shippers will have the same water column depths currently available during each year of the 20-year evaluation period. Therefore shippers would continue to use Toledo Harbor over the 20-year evaluation period under the "With Project" condition.

"With Project" condition transportation costs also involve calculating transportation costs associated with the water portion of the commodity movement and the rail portion of the commodity movement for each of the origin/destination pairs evaluated.

Transportation costs associated with the "With Project" condition were developed for each origin/destination pair for iron ore, coal, and grain. A time stream of transportation costs (water and rail) was developed for each year of the 20-year evaluation period for each origin/destination pair. The analysis evaluated five origin/destination pairs for iron ore movements, twenty-nine (29) origin/destination pairs for coal movements, and one origin/destination pair for grain movements.

The time streams of "With Project" condition transportation costs for the origin/destination pairs were then converted to average annual dollar values. These time streams were developed for the water portion of the commodity movement and the rail portion of the commodity movement. These calculations used a 7.125 percent annual interest rate and a 20-year evaluation period. The actual calculation of "With Project" condition transportation costs, and the origin/destination pairs evaluated are presented in Section 2, Benefit Evaluation.

# SECTION 2 - BENEFIT EVALUATION

## A INTRODUCTION

### 1. Benefit Definition

The Port of Toledo receives and ships millions of tons of cargo each year. Commodities are shipped to, as well as received from, the Port of Toledo, other Great Lakes ports and overseas. The port is heavily reliant on the Lake Erie and Maumee River navigation channels maintained by the Federal Government, specifically the Corps of Engineers. Most of the commodity tonnage is transshipped to/from Toledo. For example, coal is received in Toledo by rail from inland mining regions, transferred to lake boats, and transported to ultimate destinations by water.

If the Corps' federal navigation channel maintenance practices change dramatically at Toledo, perhaps even cease, what would be the economic impact on the transportation industry? Assuming that maintenance of navigation channels is not carried out by another state or local governmental agency, how would the transportation industry react and what would be the impact on total transportation costs for commodity tonnage currently moving through Toledo?

The general conditions evident in this situation are referred to by the Corps as the "Without Project" condition. That is, what conditions would exist over time, in the absence of the Corps' maintenance program, if the Toledo Harbor navigation channels were not maintained on the Maumee River and port approach channels in Lake Erie.

Similarly, if the Corps continued to maintain Toledo Harbors navigation channels, this is referred to as the "With Project" condition. The "With Project" condition reflects the pattern of activities that would occur at Toledo, over time, with a Corps' project in place.

This report provides a response to the questions concerning the Port of Toledo's economic impacts on transportation costs. If dredging ceases, the navigation channels will silt up over time and return to natural conditions and bottom elevations. Great Lakes carriers, operators of large commercial freighters, would likely continue to use the Port of Toledo as long as sufficient water depth is available to bring in large boats efficiently, compared to other ports located on the Great Lakes or other modes of transportation. Once Toledo Harbor channel depths become economically inefficient, shippers would consider using alternate Great Lakes ports and cease their Toledo operations. The transportation costs associated with using the alternate ports could be higher than using Toledo Harbor at its currently maintained depths. Use of alternate harbors could increase the vessel distance and rail distance commodities travel when moving from their origins to their destinations. The increased cost of transportation could be avoided by continued Toledo Harbor navigation channel maintenance. The increase is calculated by measuring transportation costs, both vessel and rail components, under "Without Project" and "With Project" conditions. The difference between transportation costs under the "Without Project" and the "With Project" condition are transportation costs that would not be incurred if Toledo Harbor was continued to be maintained. These transportation costs avoided reflect the economic benefit to continued channel maintenance of Toledo navigation channels.

### 2. General Description Of The Benefit Evaluation Process

Transportation costs associated with the "With Project" condition and "Without Project" condition need to be generated for each year of the evaluation period in order to calculate average annual benefits. There are two components to transportation costs under "With Project" and "Without Project" conditions: the water component, and the rail component.

Changes in transportation costs were calculated for iron ore, coal, and grain movements through Toledo Harbor. The 1996 commercial navigation season was taken as being representative of traffic levels that would take place at Toledo Harbor over the 20-year evaluation period. The harbor's 1996 iron ore, coal, and grain traffic patterns, origin/destination pairs, tons moved, and vessel sizes used to move the commodities, were used in developing "With Project" and "Without Project" condition transportation costs associated with the water portion of the commodity movement.

Rail costs per ton were developed for current sourcing patterns, as well as for the Lake Erie ports identified as alternate ports in the "Without Project" condition. A more detailed description of the components of the transportation cost evaluation under "With Project" and "Without Project" conditions follows.

# B WITH PROJECT CONDITION TRANSPORTATION COSTS

"With Project" condition transportation costs are fairly straightforward. Calculate the transportation costs for iron ore, coal, and grain associated with the water portion and the rail portion of the commodity movement. Since these costs will be the same for each year of the 20-year evaluation period, these costs are average annual costs. These annual costs become the "With Project" condition average annual transportation costs. The actual derivation of "With Project" condition water and rail transportation costs follows.

## 1. "With Project" Condition Transportation Costs-Water Leg

A number of pieces of data need to be generated in order to calculate "With Project" condition water costs. One needs to know the commodities affected, their origin/destination routes, the tons moved by route, the vessels used by route, vessel operating characteristics, vessel operating costs, origin/destination harbor loading/unloading rates, and lake/channel levels throughout the origin/destination route.

### 1a. Origin/Destination Of Commodities Evaluated

Waterborne Commerce Statistics Dock To Dock data for 1996 was used to develop the origin/destination routes for iron ore, coal, and grain. This database also supplied the names of the vessels used to move the commodities, the tons carried by each vessel and the vessel sizes. A summary of the 1996 dock to dock data, is provided in *Table 1.*

**Table1. Summary of 1996 Dock to Dock Data for Iron Ore, Coal, and Grain-Toledo Harbor, Ohio**

| Origin Port | Vessel Size | Tons Moved | Distance to Toledo |
|---|---|---|---|
| **IRON ORE** | | | |
| Sept Isles, Quebec | 7 | 476,515 | 611 |
| Presque Isle, Mi. | 6 | 71,098 | 545 |
| | 7 | 26,980 | 545 |
| | 8 | 160,220 | 545 |
| | | 258,298 | |
| Duluth, Mn. | 6 | 158,888 | 779 |
| | 7 | 30,873 | 779 |
| | 8 | 581,968 | 779 |
| | 10 | 466,342 | 779 |
| | | 1,238,071 | |
| Silver Bay, Mn. | 5 | 50,037 | 737 |
| | 6 | 743,233 | 737 |
| | 7 | 77,389 | 737 |
| | 8 | 1,267,478 | 737 |
| | 10 | 66,470 | 737 |
| | | 2,204,607 | |
| Two Harbors, Mn. | 5 | 20,364 | 719 |
| | 6 | 7,861 | 719 |
| | 8 | 56,963 | 719 |
| | 10 | 18,206 | 719 |
| | | 103,394 | |
| Total Iron Ore Receipts | | 4,280,885 | |

## Table1. Continued

| Origin Port | Vessel Size | Tons Moved | Distance to Toledo |
|---|---|---|---|
| **COAL** | | | |
| Alpena, Mi. | 5 | 14,104 | 273 |
| | 8 | 26,613 | 273 |
| | | 40,717 | |
| Ashland, Wi. | 7 | 29,024 | 734 |
| | 8 | 16,043 | 734 |
| | | 45,067 | |
| Cleveland, Oh. | 5 | 11,788 | 96 |
| Dearborn, Mi. | 5 | 15,094 | 50 |
| | 6 | 20,730 | 50 |
| | 8 | 368,645 | 50 |
| | | 404,469 | |
| Detroit, Mi. | 8 | 552,337 | 54 |
| Duluth, Mn. | 8 | 41,986 | 779 |
| Escanaba, Mi. | 7 | 16,197 | 492 |
| | 8 | 221,002 | 492 |
| | | 237,199 | |
| Gladstone, Mi. | 8 | 17,704 | 499 |
| Green Bay, Wi. | 5 | 213,337 | 561 |
| | 8 | 100,545 | 561 |
| | | 313,882 | |
| Hamilton, Ont. | 7 | 858,543 | 294 |
| Harbor Beach, Mi. | 5 | 20,909 | 179 |
| Holland Harbor, Mi. | 5 | 140,946 | 620 |
| Manistee Harbor, Mi. | 5 | 150,145 | 513 |
| | 6 | 13,980 | 513 |
| | | 164,125 | |
| Manitowoc, Mi. | 8 | 16,940 | 554 |
| Marinette, Wi. | 5 | 15,863 | 518 |
| Marysville, Mi. | 5 | 18,798 | 110 |
| | 6 | 17,413 | 110 |
| | 7 | 15,585 | 110 |
| | 8 | 10,820 | 110 |
| | | 62,616 | |
| Milwaukee, Wi. | 8 | 50,904 | 622 |
| Munising, Mi. | 5 | 14,675 | 516 |
| | 6 | 12,405 | 516 |
| | 7 | 15,180 | 516 |
| | | 42,260 | |
| Muskegon, Mi. | 7 | 27,737 | 587 |
| Nanticoke, Ont. | 7 | 235,352 | 190 |
| Ontonagon, Mi. | 8 | 135,073 | 659 |
| Presque Isle, Mi. | 8 | 8,956 | 546 |
| Saginaw, Mi. | 7 | 21,851 | 291 |
| St. Catherines, Ont. | 7 | 33,592 | 259 |
| St. Clair, Mi. | 5 | 32,164 | 105 |
| | 8 | 18,313 | 105 |
| | | 50,477 | |
| St. Lawrence River (Montreal) | 7 | 34,600 | 629 |
| Sault St. Marie, Ont. | 7 | 1,083,031 | 385 |
| Thunderbay, Ont. | 7 | 17,141 | 658 |
| Wyandotte, Mi. | 5 | 45,194 | 45 |
| Total Coal Shipments | | 4,731,259 | |
| **GRAIN** | | | |
| St. Lawrence River (Montreal) | 7 | 1,699,729 | 629 |

### 1b.Vessel Class Operating Characteristics

Vessel class operating characteristics, such as vessel speed, unloading rates, time in locks, etc, are presented in *Table 2.* This data will be used by a computer model to develop total round trip times for various origin/ destination commodity pairings. These round trip times will then be used with vessel operating costs to develop the transportation costs associated with the water leg of the bulk commodity movement.

## Table 2. Vessel Operating Characteristics

| | TRANSIT TIMES | | | UNLOADING RATES SELF UNLOADERS | |
|---|---|---|---|---|---|
| Vessel Class | Soo Lock (MIN) | St. Welland Canal (MIN) | Lawrence River (MIN) | Iron Ore Limestone (S.T./HOUR) | Coal Grain (S.T./HOUR) |
| 5 | 67 | 840 | 217 | 7,400 | 3,700 |
| 6 | 72 | 840 | 252 | 6,700 | 3,000 |
| 7 | 70 | 1,080 | 259 | 7,400 | 3,70 |
| 8 | 72 | | | 7,200 | 7,000 |
| 9 | 100 | | | 7,200 | 7,000 |
| 10 | 104 | | | 11,200 | 10,000 |

### 1c. Vessel Class Operating Costs

Transportation costs are related to daily vessel operating cost and vessel operating characteristics. Daily vessel operating costs for the range of vessel sizes that use the Great Lakes were obtained from the Maritime Administration, U.S. Department of Commerce. Operating costs for the range of vessel classes used in transporting Toledos bulk commodities are shown in *Table 3.* These vessel operating costs included fixed and variable costs. Variable costs included such costs as wages, subsistence, stores and supplies, insurance, maintenance and repair, fuel and other. These variable costs are costs per day.

### 1d Yearly Water Transportation Costs By Channel Depth.

Shipping transportation costs were developed for Toledo Harbor based on 1996 dock-to-dock Waterborne Commerce Statistics. *Table 4* lists the shipping costs associated with Toledo Harbor channel depths ranging from 28 feet through 17 feet. The analysis focused on three commodities: iron ore, coal, and grain.

## Table 3. Vessel Operating Costs

| Vessel Class | 5 | 6 | 7 | 8 | 10 |
|---|---|---|---|---|---|
| **Variable Operating Costs** | | | | | |
| Wages | $8,600 | $9,600 | $9,700 | $9,800 | $10,900 |
| Subsistence | $300 | $400 | $400 | $380 | $360 |
| Stores, Supplies & EQ | $600 | $600 | $500 | $500 | $1,000 |
| Insurance | $2,500 | $3,100 | $2,500 | $3,900 | $4,900 |
| Maintenance & Repairs | $1,000 | $780 | $1,500 | $1,600 | $1,700 |
| Fuel | $2,400 | $1,554 | $1,743 | $2,352 | $3,173 |
| Other | $1,480 | $500 | $1,000 | $950 | $1,000 |
| Total Variable Costs | $16,880 | $16,534 | $17,343 | $19,482 | $23,033 |
| **Construction Costs** | $66.0m | $71.5m | $77.0m | $93.5m | $121.0m |

The shipping transportation costs presented in *Table 4* were developed using two computer based transportation cost programs: Comnav1 and Comnav2. These transportation costs by channel depth are based on September 1998 price levels. These two Transportation cost programs utilize origin-destination routes by commodity; information on the size, physical operating characteristics and financial characteristics of the vessels typically used in transporting goods over a specific origin-destination route; the physical characteristics of the origin harbors, intermediate connecting channels and destination harbors channel depths; vessel underkeel clearances; and variable water levels in estimating total water transportation costs.

A range of physical vessel operating characteristics and vessel financial costs are used in determining cost per ton transportation costs by vessel class by channel depth, on a monthly basis, for individual trade routes. This cost is used in conjunction with monthly commodity tonnage movements to estimate monthly transportation costs. Total annual transportation costs presented in *Table 4* represent the summation of all individual months (April- December) of the navigation season for a range of potential channel depths at Toledo Harbor. The inputs and outputs of each computer model will now be discussed.

**i. Comnav 1**

Comnav 1 computes the transportation cost in dollars per ton for a range of operating drafts for a number of prototype vessels carrying a specific commodity on a specific trade route. The Comnav 1 program first calculates the tonnage capacity of the prototype vessels for various operating drafts. Input needed for the program includes maximum mid-summer operating draft, maximum load at mid-summer operating draft, and the immersion factor of the vessel. The immersion factor reflects the number of short tons the vessel can accommodate given one inch of water. The program calculates each individual ship's unique carrying capacity given the vessel's draft. Next the program calculates the hourly vessel operating cost using the financial characteristics of the prototype vessels. The fixed cost is based on the construction cost, season length, amortization rate, and profit factor. The variable cost is based on wages, supplies, fuel etc., plus an overhead factor.

Comnav 1 then calculates the total transit time by using physical characteristics of the vessel plus the sailing distance between the origin/destination harbors. The total transit time at a given operating draft is multiplied by the hourly vessel operating cost to yield the transportation cost. This cost is divided by the number of tons carried at a given operating draft to arrive at the transportation cost per ton.

**ii.Comnav 2**

The second program, Comnav 2, uses information on channel depths, vessel drafts, and vessel underkeel clearances for the origin harbor, destination harbor, and connecting channels. It also incorporates stage-duration-frequency curves to derive a monthly vessel operating draft. The unit-cost per ton associated with these drafts are determined from the cost per ton-draft matrix developed in Comnav1. These costs per ton are then multiplied by the tonnage allocation for that month, to calculate monthly transportation costs. Comnav 2 uses historical lake level elevations and stage frequencies for a variety of nodes on a given trade route, to establish draft frequencies for that trade route. For example, say the delivery of iron ore from Duluth Superior, to Toledo Harbor was to be modeled. The nodes that would be used in establishing the monthly draft frequencies for this route might include: Duluth Harbor, Vidal Shoals, Lake Huron, Livingstone Channel, Lake Erie, and Toledo Harbor. Each point within the trade route is uniquely represented within the transportation cost model. Stage-duration frequency curves are transformed, after identification of an average channel bottom elevation and a representative underkeel clearance, into draft-frequency relationships.

For example, all locations below Lake Superior are combined into a composite draft-frequency curve and each point of the origin harbor draft-frequency curve is related to a range of points (ie. drafts) along the composite draft frequency curve. The program then uses the draft-frequencies and the Coast Guard load line limits to establish the effective draft by determining the constraining points on the system by month. The program then uses the effective draft to read the tonnage capacity off the draft tonnage capacity curve. It also uses the effective draft to read the cost per ton off the draft/cost per ton matrix table developed by Comnav1. The cost per ton is then multiplied by the monthly tonnage allocated by vessel size, and aggregated by month to arrive at total annual transportation costs.

## Table 4. Yearly Shipping Costs by Channel Depth - Toledo Harbor

### 1. Toledo Water Transportation Costs By Channel Depth- Iron Ore

| Toledo Harbor Channel Depth | Duluth Minnesota | Presque Isle | Silver Bay | Two Harbors | Sept Isles | Total Water Costs |
|---|---|---|---|---|---|---|
| 28 | $10,326,000 | $1,773,000 | $18,620,000 | $895,000 | $5,240,000 | $36,854,000 |
| 27 | $10,326,000 | $1,773,000 | $18,620,000 | $895,000 | $5,241,000 | $36,855,000 |
| 26 | $10,347,000 | $1,776,000 | $18,658,000 | $897,000 | $5,262,000 | $36,940,000 |
| 25 | $10,471,000 | $1,797,000 | $18,894,000 | $906,000 | $5,350,000 | $37,418,000 |
| 24 | $10,793,000 | $1,853,000 | $19,523,000 | $933,000 | $5,552,000 | $38,654,000 |
| 23 | $11,305,000 | $1,943,000 | $20,529,000 | $977,000 | $5,850,000 | $40,604,000 |
| 22 | $11,949,000 | $2,055,000 | $21,797,000 | $1,034,000 | $6,207,000 | $43,042,000 |
| 21 | $12,698,000 | $2,187,000 | $23,280,000 | $1,101,000 | $6,615,000 | $45,881,000 |
| 20 | $13,562,000 | $2,338,000 | $25,002,000 | $1,178,000 | $7,087,000 | $49,167,000 |
| 19 | $14,566,000 | $2,515,000 | $27,015,000 | $1,268,000 | $7,634,000 | $52,998,000 |
| 18 | $15,750,000 | $2,726,000 | $29,403,000 | $1,375,000 | $8,276,000 | $57,530,000 |
| 17 | $17,168,000 | $2,980,000 | $32,285,000 | $1,503,000 | $9,041,000 | $62,977,000 |

### 2. Toledo Water Transportation Costs By Channel Depth- Coal- Canadian

| Toledo Harbor Channel Depth | Hamilton Ontario | Montreal Quebec | Nantcoke Ontario | Saint Catharines Ontario | Sault St.Marie Ontario | Thunder Bay Ontario | Total Water Costs |
|---|---|---|---|---|---|---|---|
| 28 | $4,388,000 | $288,000 | $727,000 | $162,000 | $6,799,000 | $125,000 | $12,489,000 |
| 27 | $4,388,000 | $288,000 | $727,000 | $162,000 | $6,799,000 | $125,000 | $12,489,000 |
| 26 | $4,392,000 | $288,000 | $728,000 | $162,000 | $6,799,000 | $125,000 | $12,494,000 |
| 25 | $4,421,000 | $290,000 | $731,000 | $163,000 | $6,799,000 | $126,000 | $12,530,000 |
| 24 | $4,503,000 | $296,000 | $741,000 | $165,000 | $6,799,000 | $128,000 | $12,632,000 |
| 23 | $4,663,000 | $308,000 | $762,000 | $171,000 | $6,799,000 | $133,000 | $12,836,000 |
| 22 | $4,880,000 | $325,000 | $790,000 | $179,000 | $6,800,000 | $140,000 | $13,114,000 |
| 21 | $5,141,000 | $344,000 | $824,000 | $189,000 | $6,812,000 | $148,000 | $13,458,000 |
| 20 | $5,439,000 | $366,000 | $862,000 | $199,000 | $6,879,000 | $158,000 | $13,903,000 |
| 19 | $5,787,000 | $392,000 | $907,000 | $212,000 | $7,077,000 | $169,000 | $14,544,000 |
| 18 | $6,191,000 | $422,000 | $959,000 | $226,000 | $7,460,000 | $181,000 | $15,439,000 |
| 17 | $6,679,000 | $458,000 | $1,023,000 | $244,000 | $8,009,000 | $197,000 | $16,610,000 |

## Table 4.Continued

**2. Toledo Water Transportation Costs By Channel Depth- Coal- U.S.**

| Toledo Harbor Channel Depth | Alpena Michigan | Ashland Wisconsin | Cleveland Ohio | Dearborn Michigan | Detroit Michigan | Duluth Minnesota | Escanaba Michigan | Gladstone Michigan |
|---|---|---|---|---|---|---|---|---|
| 28 | $221,000 | $565,000 | $30,000 | $910,000 | $1,287,000 | $582,000 | $2,207,000 | $167,000 |
| 27 | $221,000 | $565,000 | $30,000 | $910,000 | $1,287,000 | $582,000 | $2,207,000 | $167,000 |
| 26 | $221,000 | $565,000 | $30,000 | $910,000 | $1,287,000 | $582,000 | $2,207,000 | $167,000 |
| 25 | $221,000 | $565,000 | $30,000 | $910,000 | $1,287,000 | $582,000 | $2,207,000 | $167,000 |
| 24 | $221,000 | $565,000 | $30,000 | $910,000 | $1,287,000 | $582,000 | $2,208,000 | $167,000 |
| 23 | $221,000 | $565,000 | $30,000 | $910,000 | $1,287,000 | $582,000 | $2,213,000 | $167,000 |
| 22 | $221,000 | $565,000 | $30,000 | $910,000 | $1,287,000 | $582,000 | $2,241,000 | $167,000 |
| 21 | $221,000 | $566,000 | $30,000 | $910,000 | $1,287,000 | $582,000 | $2,322,000 | $167,000 |
| 20 | $224,000 | $574,000 | $31,000 | $911,000 | $1,288,000 | $588,000 | $2,475,000 | $168,000 |
| 19 | $231,000 | $598,000 | $31,000 | $915,000 | $1,294,000 | $609,000 | $2,689,000 | $173,000 |
| 18 | $244,000 | $641,000 | $33,000 | $928,000 | $1,315,000 | $650,000 | $2,964,000 | $184,000 |
| 17 | $263,000 | $700,000 | $34,000 | $959,000 | $1,361,000 | $709,000 | $3,316,000 | $199,000 |

**2. Toledo Water Transportation Costs By Channel Depth- Coal- U.S.**

| Toledo Harbor Channel Depth | Green Bay Wisconsin | Holland Harbor Michigan | Harbor Beach Michigan | Manistee Michigan | Manitowoc Wisconsin | Marinette Wisconsin | Milwaukee Wisconsin | Marysville Michigan |
|---|---|---|---|---|---|---|---|---|
| 28 | $2,732,000 | $1,553,000 | $77,000 | $1,531,000 | $172,000 | $125,000 | $575,000 | $168,000 |
| 27 | $2,732,000 | $1,553,000 | $77,000 | $1,531,000 | $172,000 | $125,000 | $575,000 | $168,000 |
| 26 | $2,732,000 | $1,553,000 | $77,000 | $1,531,000 | $172,000 | $125,000 | $575,000 | $168,000 |
| 25 | $2,732,000 | $1,553,000 | $77,000 | $1,531,000 | $172,000 | $125,000 | $575,000 | $168,000 |
| 24 | $2,732,000 | $1,553,000 | $77,000 | $1,531,000 | $172,000 | $125,000 | $575,000 | $168,000 |
| 23 | $2,734,000 | $1,553,000 | $77,000 | $1,531,000 | $172,000 | $125,000 | $575,000 | $169,000 |
| 22 | $2,746,000 | $1,553,000 | $77,000 | $1,531,000 | $172,000 | $125,000 | $575,000 | $169,000 |
| 21 | $2,785,000 | $1,554,000 | $77,000 | $1,532,000 | $173,000 | $125,000 | $575,000 | $171,000 |
| 20 | $2,871,000 | $1,558,000 | $78,000 | $1,538,000 | $173,000 | $128,000 | $578,000 | $174,000 |
| 19 | $3,024,000 | $1,584,000 | $80,000 | $1,568,000 | $177,000 | $133,000 | $590,000 | $181,000 |
| 18 | $3,242,000 | $1,657,000 | $84,000 | $1,647,000 | $186,000 | $141,000 | $620,000 | $189,000 |
| 17 | $3,515,000 | $1,782,000 | $89,000 | $1,776,000 | $201,000 | $152,000 | $669,000 | $199,000 |

## Table 4.Continued

### 2. Toledo Water Transportation Costs By Channel Depth- Coal- U.S.

| Toledo Harbor Channel Depth | Ontonagon Michigan | Presque Isle Michigan | Saginaw Michigan | St Clair Michigan | Wyondotte Michigan | Total Water Costs |
|---|---|---|---|---|---|---|
| 28 | $1,832,000 | $91,000 | $92,000 | $131,000 | $87,000 | $15,730,000 |
| 27 | $1,832,000 | $91,000 | $92,000 | $131,000 | $87,000 | $15,730,000 |
| 26 | $1,832,000 | $91,000 | $92,000 | $131,000 | $87,000 | $15,730,000 |
| 25 | $1,832,000 | $91,000 | $92,000 | $131,000 | $87,000 | $15,730,000 |
| 24 | $1,832,000 | $91,000 | $92,000 | $131,000 | $87,000 | $15,731,000 |
| 23 | $1,832,000 | $91,000 | $92,000 | $131,000 | $87,000 | $15,739,000 |
| 22 | $1,832,000 | $91,000 | $92,000 | $131,000 | $87,000 | $15,780,000 |
| 21 | $1,833,000 | $91,000 | $94,000 | $132,000 | $87,000 | $15,914,000 |
| 20 | $1,837,000 | $92,000 | $97,000 | $134,000 | $88,000 | $16,214,000 |
| 19 | $1,861,000 | $95,000 | $101,000 | $137,000 | $90,000 | $16,786,000 |
| 18 | $1,935,000 | $102,000 | $106,000 | $143,000 | $92,000 | $17,756,000 |
| 17 | $2,080,000 | $110,000 | $113,000 | $150,000 | $96,000 | $19,172,000 |

### 3. Toledo Water Transportation Costs By Channel Depth- Grain

| Toledo Harbor Channel Depth | Water Costs To Montreal |
|---|---|
| 28 | $13,887,000 |
| 27 | $13,890,000 |
| 26 | $13,929,000 |
| 25 | $14,094,000 |
| 24 | $14,479,000 |
| 23 | $15,031,000 |
| 22 | $15,684,000 |
| 21 | $16,435,000 |
| 20 | $17,284,000 |
| 19 | $18,246,000 |
| 18 | $19,353,000 |
| 17 | $20,638,000 |

## Table 4.Continued

**4. Toledo Harbor Total Water Transportation Costs By Channel Depth**

| Toledo Harbor Channel Depth | Iron Ore | Coal Canadian | Coal Us | Total Coal | Grain | Total Water Costs |
|---|---|---|---|---|---|---|
| 28 | $36,854,000 | $12,489,000 | $15,730,000 | $28,219,000 | $13,887,000 | $ 78,960,000 |
| 27 | $36,855,000 | $12,489,000 | $15,730,000 | $28,219,000 | $13,890,000 | $ 78,964,000 |
| 26 | $36,940,000 | $12,494,000 | $15,730,000 | $28,224,000 | $13,929,000 | $ 79,093,000 |
| 25 | $37,418,000 | $12,530,000 | $15,730,000 | $28,260,000 | $14,094,000 | $ 79,772,000 |
| 24 | $38,654,000 | $12,632,000 | $15,731,000 | $28,363,000 | $14,479,000 | $ 81,496,000 |
| 23 | $40,604,000 | $12,836,000 | $15,739,000 | $28,575,000 | $15,031,000 | $ 84,210,000 |
| 22 | $43,042,000 | $13,114,000 | $15,780,000 | $28,894,000 | $15,684,000 | $ 87,620,000 |
| 21 | $45,881,000 | $13,458,000 | $15,914,000 | $29,372,000 | $16,435,000 | $ 91,688,000 |
| 20 | $49,167,000 | $13,903,000 | $16,214,000 | $30,117,000 | $17,284,000 | $ 96,568,000 |
| 19 | $52,998,000 | $14,544,000 | $16,786,000 | $31,330,000 | $18,246,000 | $102,574,000 |
| 18 | $57,530,000 | $15,439,000 | $17,756,000 | $33,195,000 | $19,353,000 | $110,078,000 |
| 17 | $62,977,000 | $16,610,000 | $19,172,000 | $35,782,000 | $20,638,000 | $119,397,000 |

### 1e. Average Annual "With Project" Condition Water Transportation Costs

*Table 4* contains water transportation costs for iron ore, coal, and grain for all origin-destination pairs involved. Iron ore water transportation costs for a 28-foot Toledo Harbor channel depth, represents "With Project" condition water transportation costs. Since this is a cost that would be incurred each year during the 20-year evaluation period, these are average annual costs. Average annual "With Project" condition water costs for iron ore came to $ 36,854,000. Similarly, average annual "With Project" condition water costs for coal and grain can be found under the column labeled "CHANNEL DEPTH 28 FEET", in the coal and grain transportation cost section of *Table 4*. Average annual "With Project" condition water costs for coal and grain came to $28,219,000, and $13,887,000, respectively. The total "With Project" condition average annual water leg costs came to $78,960,000.

## 2. "With Project" Condition Transportation Costs-Rail Leg

A number of pieces of data need to be generated in order to calculate "With Project" condition rail costs. One needs to know the commodities affected (iron ore, coal, grain), the location of the final users of iron ore that is received at Toledo Harbor, the location of the coal mines that feed Toledo's coal shipments, the location of grain collection points that feed grain to Toledo Harbor, the railroads used in moving the commodities affected (iron ore, coal, and grain), and a current cost per ton for the various rail routes, by commodity. These various inputs will now be discussed.

### 2a. Rail Route Origin/Destination Of Commodities Evaluated

Iron ore is a major commodity received at the Port Of Toledo. Iron ore receipts account for approximately 33 percent of the 1996 tonnage moving through the harbor. The iron ore received at Toledo Harbor is bound for steel plants located in Middletown, Ohio, and Ashland, Kentucky. Approximately 50 percent of the iron ore goes to Ohio and 50 percent to Kentucky.

Coal is the largest commodity moving through the Port Of Toledo. Coal shipments account for approximately 36 percent of the 1996 tonnage moving through the harbor. The coal bound by rail for Toledo is primarily from mines in southern West Virginia. The coal mine districts in southern West Virginia include the Coal River District, Logan River District, and the New River District.

Grain shipments accounted for approximately 13 percent of the 1996 tonnage moving through the harbor. The grain bound by rail for Toledo is primarily from Terra Haute and Fort Wayne, Indiana.

### 2b. "With Project" Rail Route Transportation Costs Per Ton.

"With Project" condition rail route transportation costs per ton were obtained for a number of rail routes originating from/leading to Toledo. The rail costs per ton were obtained from the Tennessee Valley Authority (TVA.) The TVA maintains a rail cost model data base. The TVA can generate rail costs for a wide range of commodities and transportation routes.

A summary of rail costs obtained from the TVA for "With Project" condition rail transportation costs per ton are presented in *Table 5.* The railroad bill included such truck costs as moving the coal from the mine to the coal prepping plant and then another handling cost for getting the coal from the prep plant to the railroad cars.

### 2c. "With Project" Condition Annual Rail Route Transportation Costs

Given total tons moved by rail by commodity, and a cost per ton to move the commodity, total yearly rail costs can be developed for the "With Project" condition. The derivation of "With Project" condition yearly rail transportation costs, by commodity, is presented in *Table 6.* Yearly iron ore rail costs came to $36,323,300. Yearly coal rail costs came to $65,244,100. Yearly grain rail costs came to $16,453,400. Total yearly rail costs for iron ore, coal and grain came to $118,020,800.

## Table 5. "With Project" Condition Rail Costs Per Ton by Rail Route

| | Rail Carrier | $/Ton |
|---|---|---|
| **1. IRON ORE** | | |
| Rail Costs From Toledo Harbor, Ohio, To: | | |
| Middletown, Ohio | CSX | $8.00 |
| Ashland, Kentucky | CSX | $8.97 |
| **2. COAL** | | |
| Rail Costs To Toledo Harbor Ohio, From: | | |
| Cane Fork, West Virginia | CSX | $13.79 |
| **3. GRAIN** | | |
| Rail Costs to Toledo Harbor Ohio, From: | | |
| Terra Haute, Indiana | CSX-NS | $10.90 |
| Fort Wayne, Indiana | NS | $ 8.46 |

### 2d. Average Annual "With Project" Condition Rail Transportation Costs

The annual rail transportation costs in *Table 6* are rail costs that would be incurred each year during the 20-year evaluation period. Since these rail costs are the same for every year in the 20-year evaluation period, these are average annual costs. These average annual rail costs were allocated among the various origin/destination pairs. The allocation was based on the percent of total tonnage each origin/destination pair carried (See *Table 7*). Average annual "With Project" condition rail costs for iron ore came to $ 36,323,300. Average annual "With Project" condition rail costs for coal came to $ 65,244,100. Average annual "With Project" condition rail costs for grain came to $ 16,453,400. The total "With Project" condition average annual rail leg costs came to $118,020,800.

## Table 6. Yearly "With Project" Condition Rail Costs for Iron Ore, Coal, and Grain

| Destination | Total Tons | Percent Of Total Tons By Destination | Tons By Destination | Rail $/Ton | Rail Costs By Destination |
|---|---|---|---|---|---|
| 1. IRON ORE | | | | | |
| Middletown, Ohio | 4,280,885 | 50% | 2,140,443 | $8.00 | $17,123,540 |
| Ashland, Kentucky | 4,280,885 | 50% | 2,140,443 | $8.97 | $19,199,769 |
| | | | | | $36,323,309 |
| | | | | Rounded | $36,323,300 |

| Origin | Total Tons | Percent Of Total Tons By Origin | Tons By Origin | Rail $/Ton | Rail Costs By Origin |
|---|---|---|---|---|---|
| 2. COAL | | | | | |
| Logan Cnty., W. VA. | | | | | |
| Total Canadian Coal | 2,262,259 | 100% | 2,262,359 | $13.79 | $31,196,552 |
| Total U.S. Coal | 2,469,000 | 100% | 2,469,000 | $13.79 | $34,047,510 |
| | 4, 731,259 | | | | $65,244,062 |
| | | | | Rounded | $65,244,100 |

| Origin | Commodity | Weight | Rate | Weighted Rate | Rail Costs |
|---|---|---|---|---|---|
| 3. GRAIN | | | | | |
| Terra Haute, Indiana | Wheat | 50% | $10.90 | $5.45 | |
| Total U.S. Coal | Corn | 50% | $8.46 | $4.23 | |
| | | | | $9.68 | |
| | | | Tons Of Grain Moved | 1,699,729 | $16,453,377 |
| | | | | Rounded | $16,453,400 |
| 4. TOTAL YEARLY RAIL COSTS | | | | | **$118,020,800** |

## Table 7. Allocation of Yearly "With Project" Condition Rail Costs for Iron Ore, Coal, and Grain among Origin/Destination Ports

### 1.Allocation Of Iron Ore Rail Transportation Costs From Toledo Among Origin Ports

| Origin Ports | Tons Moved | Percent Of Total Tons Moved | Total Rail Transport Cost | Allocated Rail Transport Cost |
|---|---|---|---|---|
| Duluth, Mn. | 1,238,071 | 28.92% | $36,323,309 | $10,505,032 |
| Presque Isle, Mi. | 258,298 | 6.03% | $36,323,309 | $2,191,659 |
| Silver Bay, Mn. | 2,204,607 | 51.50% | $36,323,309 | $18,706,090 |
| Two Harbors,Mn.. | 103,394 | 2.42% | $36,323,309 | $877,298 |
| Sept Isles, Quebec | 476,515 | 11.13% | $36,323,309 | $4,043,230 |
| | 4,280,885 | | | $36,323,309 |

### 2.Allocation Of Coal Rail Transportation Costs From Toledo Among Destination Ports

### A.-Allocation Of Coal Rail Transportation Costs From Toledo Among Canadian Destination Ports

| Origin Ports | Tons Moved | Total Percent Of Total Tons Moved | Allocated Rail Transport Cost | Rail Transport Cost |
|---|---|---|---|---|
| Hamilton, Ont. | 858,543 | 37.95% | $31,196,552 | $11,839,308 |
| St. Lawrence (Montreal) | 34,600 | 1.53% | $31,196,552 | $477,134 |
| Nanticoke, Ont. | 235,352 | 10.40% | $31,196,552 | $3,245,504 |
| St. Catharines, Ont. | 33,592 | 1.48% | $31,196,552 | $463,234 |
| Sault St. Marie, Ont. | 1,083,031 | 47.87% | $31,196,552 | $14,934,997 |
| ThunderBay, Ont. | 17,141 | 0.76% | $31,196,552 | $236,374 |
| | 2,262,259 | 100.00% | | $31,196,552 |

## Table 7-Continued

**2.Allocation Of Coal Rail Transportation Costs From Toledo Among Destination Ports**
**B.-Allocation Of Coal Rail Transportation Costs From Toledo Among U.S. Destination Ports**

| Origin Ports | Tons Moved | Percent Of Total Tons Moved | Total Rail Transport Cost | Allocated Rail Transport Cost |
|---|---|---|---|---|
| Alpena, Mi. | 40,717 | 1.65% | $34,047,510 | $561,487 |
| Ashland, Wi. | 45,067 | 1.83% | $34,047,510 | $621,474 |
| Cleveland, Oh. | 11,788 | 0.48% | $34,047,510 | $162,557 |
| Dearborn, Mi. | 404,469 | 16.38% | $34,047,510 | $5,577,628 |
| Detroit, Mi. | 552,337 | 22.37% | $34,047,510 | $7,616,727 |
| Duluth, Mn. | 41,986 | 1.70% | $34,047,510 | $578,987 |
| Escanaba, Mi. | 237,199 | 9.61% | $34,047,510 | $3,270,974 |
| Gladstone, Mi. | 17,704 | 0.72% | $34,047,510 | $244,138 |
| Green Bay, Wi. | 313,882 | 12.71% | $34,047,510 | $4,328,433 |
| Holland, Mi. | 140,946 | 5.71% | $34,047,510 | $1,943,645 |
| Harbor Beach, Mi. | 20,909 | 0.85% | $34,047,510 | $288,335 |
| Manistee, Mi. | 164,125 | 6.65% | $34,047,510 | $2,263,284 |
| Manitowoc, Wi. | 16,940 | 0.69% | $34,047,510 | $233,603 |
| Marinette, Wi. | 15,863 | 0.64% | $34,047,510 | $218,751 |
| Milwaukee, Wi. | 50,904 | 2.06% | $34,047,510 | $701,966 |
| Marysville, Mi. | 62,616 | 2.54% | $34,047,510 | $863,475 |
| Munising, Mi. | 42,260 | 1.71% | $34,047,510 | $582,765 |
| Muskegon, Mi. | 27,737 | 1.12% | $34,047,510 | $382,493 |
| Ontonagon, Mi. | 135,073 | 5.47% | $34,047,510 | $1,862,657 |
| Presque Isle, Mi. | 8,956 | 0.36% | $34,047,510 | $123,503 |
| Saginaw, Mi. | 21,851 | 0.89% | $34,047,510 | $301,325 |
| St. Clair, Mi. | 50,477 | 2.04% | $34,047,510 | $696,078 |
| Wyandotte, Mi. | 45,194 | 1.83% | $34,047,510 | $623,225 |
| | 2,469,000 | 100.00% | | $34,047,510 |

**3.Allocation Of Grain Rail Transportation Costs From Toledo Among Destination Ports**

| | | | | |
|---|---|---|---|---|
| Terra Haute and Fort Wayne, In. | 1,699,729 | 100.00% | $16,453,377 | $16,453,377 |

**4.Total "With Project" Condition Rail Costs** **$118,020,800**

### 3.Total "With Project" Condition Transportation Costs

*Table 8* summarizes total "With Project" condition average annual transportation costs. These transportation costs have two components: a water leg portion and a rail leg portion. Average annual "With Project" condition water transportation costs came to $ 78,960,000. Average annual "With Project" condition rail transportation costs came to $ 118,020,800. Total "With Project" condition average annual transportation costs for iron ore, coal, and grain came to $ 196,980,800. *Table 9* presents these costs by commodity and origin/destination pairs.

**Table 8. Total "With Project" Condition Average Annual Transportation Costs: Iron Ore, Coal, and Grain**

| | |
|---|---|
| Average Annual Water Transportation Costs | $78,960,000 |
| Average Annual Rail Transportation Costs | $118,020,800 |
| "With Project" Condition Average Annual Costs | $196,980,800 |

## C WITHOUT PROJECT CONDITION TRANSPORTATION COSTS

Assume the evaluation period has a 20-year time frame: from 2002 to the year 2021. Assume the "Without Project" condition (no action plan) maintenance scenario for that time frame is as follows:

> All harbor dredging from 1998 till the year 2007, will be placed in the dike disposal facility constructed in 1994. It is estimated a total of 600,000 cubic yards will be placed annually in the disposal facility from 1994 to 2004. There will be 2.1 m cubic yards of capacity left in 2004. From 2005 on, it is estimated that approximately 800,000 cubic yards will need to be dredged annually. Given this rate of annual dredging, the new dike disposal facility completed in 1994 will become full in the year 2007. Currently maintained channel depths will be available to shippers from 1998 to the year 2007.
>
> No annual maintenance dredging will be performed from the year 2008 to the year 2021. Consequently, after the year 2007, the channels in the harbor will begin to shoal up. The channels in the harbor will be allowed to silt up to their equilibrium level of 17 feet.

"Without Project" condition average annual transportation costs need to be developed, based upon the shipping companies anticipated responses to the "Without Project" condition maintenance scenario. Bulk commodity users have two choices: (1)- continue to use Toledo Harbor throughout the 20-year evaluation period or, (2)- use Toledo Harbor to move their commodities for some portion of the 20-year evaluation period and then use some alternate port or transportation mode for the remaining portion of the 20-year evaluation period.

For example, under "Without Project" conditions, currently maintained harbor depths will be available to shippers from 1998 to the year 2007. However, the available channel water column depth would begin to decrease in the year 2008. No channel maintenance will take place from 2008 to the year 2021. Consequently, the channel would begin to shoal up in the year 2008. Shippers would have to bring their vessels into Toledo Harbor light loaded. This means they will carry less tonnage per trip than under "With Project" conditions. This is because available Toledo Harbor channel depths decrease under "Without Project" conditions due to shoaling as compared to "With Project" conditions. Thus the total number of round trips needed to bring the same amount of annual tonnage would increase.

Eventually, shippers would shift their commodity movements to alternative lake Erie ports once the water column of Toledo Harbor's access channels reach a critical economic point compared to currently maintained channel depths. The Toledo Harbor water column depth at which this shift would take place, would vary by origin-destination pair among the various commodities evaluated. Shippers would shift their commodity movements to alternate ports when the water and rail transportation cost for using Toledo Harbor was greater than the water and rail transportation cost for using an alternate port. Consequently, water and rail transportation costs are needed for a range of channel depths at Toledo Harbor and water and rail transportation costs for each of the alternate ports being used. Once the move to usage of the alternate port has been made, the shippers would deliver their commodities to alternate ports and use railroads to complete the inland movement of their product to their end users.

## Table 9. Total "With Project" Condition Average Annual Iron Ore, Coal, and Grain Transportation Costs: by Origin/Destination Pair

| Origin/Destination | Average Annual With Project Water Transportation Costs | Average Annual With Project Rail Transportation Costs | Total Average Annual With Project Transportation Costs |
|---|---|---|---|
| **Average Annual Iron Ore Transportation Costs** | | | |
| Duluth, Minnesota | $10,326,000 | $10,505,000 | $20,831,000 |
| Presque Isle, Mi. | $1,773,000 | $2,191,700 | $3,964,700 |
| Silver Bay, Mn. | $18,620,000 | $18,706,100 | $37,326,100 |
| Two Harbors, Mn. | $895,000 | $877,300 | $1,772,300 |
| Sept Isles, Quebec | $5,240,000 | $4,043,200 | $9,283,200 |
| | $36,854,000 | $36,323,300 | $73,177,300 |
| **Average Annual Coal Transportation Costs** | | | |
| **Canadian** | | | |
| Hamilton, Ont. | $4,388,000 | $11,839,300 | $16,227,300 |
| Montreal, Ont. | $288,000 | $477,100 | $765,100 |
| Nanticoke, Ont. | $727,000 | $3,245,500 | $3,972,500 |
| St. Catharines, Ont. | $162,000 | $463,200 | $625,200 |
| Sault St. Marie, Ont. | $6,799,000 | $14,935,000 | $21,734,000 |
| ThunderBay, Ont. | $125,000 | $236,400 | $361,400 |
| | $12,489,000 | $31,196,500 | $43,685,500 |
| **United States** | | | |
| Alpena Mi. | $221,000 | $561,500 | $782,500 |
| Ashland, Wi. | $565,000 | $621,500 | $1,186,500 |
| Cleveland, Oh. | $30,000 | $162,600 | $192,600 |
| Dearborn, Mi. | $910,000 | $5,577,600 | $6,487,600 |
| Detroit, Mi. | $1,287,000 | $7,616,700 | $8,903,700 |
| Duluth, Mn. | $582,000 | $579,000 | $1,161,000 |
| Escanaba, Mi. | $2,207,000 | $3,271,000 | $5,478,000 |
| Gladstone, Mi. | $167,000 | $244,100 | $411,100 |
| Green Bay, Wi. | $2,732,000 | $4,328,400 | $7,060,400 |
| Holland, Mi. | $1,553,000 | $1,943,600 | $3,496,600 |
| Harbor Beach, Mi. | $77,000 | $288,300 | $365,300 |
| Manistee, Mi. | $1,531,000 | $2,263,300 | $3,794,300 |
| Manitowoc, Wi. | $172,000 | $233,600 | $405,600 |
| Marinette, Wi. | $125,000 | $218,800 | $343,800 |
| Milwaukee, Wi. | $575,000 | $702,000 | $1,277,000 |
| Marysville, Mi. | $168,000 | $863,500 | $1,031,500 |
| Munising, Mi. | $408,000 | $582,800 | $990,800 |
| Muskegon, Mi. | $187,000 | $382,500 | $569,500 |
| Ontonagon, Mi. | $1,832,000 | $1,862,700 | $3,694,700 |
| Presque Isle, Mi. | $91,000 | $123,500 | $214,500 |
| Saginaw, Mi. | $92,000 | $301,300 | $393,300 |
| St. Clair, Mi. | $131,000 | $696,100 | $827,100 |
| Wyandotte, Mi. | $87,000 | $623,200 | $710,20 |
| | $15,730,000 | $34,047,600 | $49,777,600 |

**Table 9. Continued**

| Origin/Destination | Average Annual With Project Water Transportation Costs | Average Annual With Project Rail Transportation Costs | Total Average Annual With Project Transportation Costs |
|---|---|---|---|
| **Total Average Annual Coal Transportation Costs** | | | |
| Canadian | $12,489,000 | $31,196,500 | $43,685,500 |
| United States | $15,730,000 | $34,047,600 | $49,777,600 |
| | $28,219,000 | $65,244,100 | $93,463,100 |
| **Total Average Annual Grain Transportation Costs** | | | |
| Montreal | $13,887,000 | $16,453,400 | $30,340,400 |
| **Total Average Annual "With Project" Condition Transportation Costs** | | | |
| | $78,960,000 | $118,020,800 | $196,980,800 |

"Without Project" condition transportation costs involve calculating transportation costs for the water portion of the commodity movement and the rail portion of the commodity movement for each year of the 20-year evaluation period. Water and rail transportation costs would be associated with Toledo Harbor up to the time the switch to an alternate port is made. The switch to an alternate port will occur at the Toledo Harbor channel depth at which the water and rail transportation cost is more costly to continue using Toledo Harbor as opposed to using an alternate port. Once the switch to an alternate port is made, water and rail costs are those costs associated with using the alternate port. Alternatively, the commodity may continue to use Toledo Harbor over the whole 20-year evaluation period. It may be cheaper to deliver commodities to Toledo Harbor, even when its channel depths have decreased to 17 feet, than to use an alternate port as the transshipment location. The number of miles the commodity travels by water or by rail may increase/decrease, based upon the location of the alternate ports with respect to Toledo Harbor and the various origins and destinations of the commodities evaluated.

These annual time streams of "Without Project" condition transportation costs (water and rail) must then be converted to average annual dollar values. This would be done using a 20-year evaluation period and a 7.125 percent annual discount rate.

Again, "Without Project" condition transportation costs have a water leg and a rail leg component. To compute total "Without Project" condition transportation costs, one must have the following information: what alternate port(s) will be used by commodity, how many tons will go through the alternate port(s), shoaling rates for Toledo Harbor in order to determine available Toledo Harbor channel depths over time, water transportation costs at Toledo Harbor under varying channel depths, water transportation costs for using the alternate port(s), rail rates per ton by commodity associated with using Toledo Harbor and the alternate port(s), total transportation costs (water and rail) at Toledo Harbor under varying channels depths, total transportation costs (water and rail) for using an alternate port(s) and Toledo's channel depths at which a switch is made to usage of an alternate port. Derivation of "Without Project" condition transportation costs for water and rail will now be discussed.

## 1. Alternate Ports Evaluated

There were two potential alternate ports for the iron ore evaluation: Ashtabula, and Conneaut. There were three potential alternate ports for the coal evaluation: Sandusky, Ashtabula and Conneaut. There was only one alternate port for the grain evaluation: Chicago. These ports have existing dock infrastructure/capacity that can accommodate additional iron ore receipts and coal and grain shipments. The annual through-put capacities by port are listed in *Table 10.* Actual tonnage handled at the alternate ports during the 1996 commercial navigation season is also presented in *Table 10.* The difference between the alternate ports maximum capacity and the 1996 actual tonnages is the excess tonnage capacity each alternate port would be capable of handling on an annual basis, for purposes of this report.

### 1a. Excess Port Capacity

Each alternate port has excess capacity which can be used to handle tonnage coming from Toledo Harbor under the "Without Project" condition. The alternate ports would have to be able to handle additional receipts of 4,280,885 tons of iron ore and additional shipments of 4,731,259 tons of coal and 1,699,729 tons of grain.

## 2. Alternate Ports Chosen

Both Ashtabula and Conneaut have enough excess capacity to handle all of Toledo's iron ore. The alternate port for iron ore chosen for this evaluation is Ashtabula Harbor. Ashtabula has existing dock infrastructure capacity that can accommodate all of Toledos iron ore. It also has the rail connections needed to deliver the iron ore to its inland destinations. Iron ore rail costs were lower for Ashtabula than those associated with using Conneaut, therefore Ashtabula was chosen as the alternate port for iron ore.

As for coal, only Conneaut has enough excess capacity to handle all of Toledo's coal. However, again, Ashtabula had the lowest rail costs of the three alternate ports evaluated. Therefore coal was allowed to divert to Ashtabula until its excess capacity was used up. The next port with the lowest rail cost was Sandusky, followed by Conneaut. Coal would divert to these ports only after Ashtabula's excess capacity was used up.

Chicago is the only alternative port for grain shipments, since it is the nearest port that has rail connections, grain handling facilities, and shipping capabilities.

### Table 10. Alternate Port Capacities and Excess Capacity, by Commodity

| PORT | AVAILABLE IRON ORE CAPACITY | 1996 (1) RECEIPTS | AVAILABLE EXCESS ORE CAPACITY |
|---|---|---|---|
| **IRON ORE** | | | |
| Ashtabula, Oh. | 15,000,000 | 3,299,000 | 11,701,000 |
| Conneaut, Oh. | 8,000,000 | 1,769,000 | 6,231,000 |

| PORT | AVAILABLE COAL CAPACITY | 1996 (1) SHIPMENTS | AVAILABLE EXCESS COAL CAPACITY |
|---|---|---|---|
| **COAL** | | | |
| Sandusky, Oh. | 6,000,000 | 3,169,000 | 2,831,000 |
| Ashtabula, Oh. | 7,000,000 | 5,152,000 | 1,848,000 |
| Conneaut, Oh. | 10,000,000 | 2,753,000 | 7,247,000 |

| PORT | AVAILABLE GRAIN CAPACITY | 1996 (1) SHIPMENTS | AVAILABLE EXCESS GRAIN CAPACITY |
|---|---|---|---|
| **GRAIN** | | | |
| Chicago, Il. | | 3,000,000 | 682,000 |
| 2,318,000 | | | |

(1) SOURCE: WATERBORNE COMMERCE STATISTICS OF THE UNITED STATES, 1996.

## 3. Toledo Harbor Shoaling Rates

Under the "Without Project" condition, harbor channel dredging will continue until the CDF addition built in 1994 reaches capacity. Given the estimates of cubic yards dredged annually presented in Section 1, the CDF is projected to reach capacity in the year 2007. After the year 2007, for the purposes of this analysis, it will be assumed annual channel maintenance will no longer be performed. Channels will be allowed to silt to their equilibrium level of 17 feet LWD. The channel shoaling rates for Toledo Harbor, by project evaluation year, are presented in *Table 11*. It is expected channel equilibrium will be reached in the year 2020. Available channel depths under the "Without Project" condition are 28 feet LWD from 1998 to the year 2007. After the year 2007, the channel depth will begin to diminish until the navigation channel depth stabilizes at 17 feet LWD. *Table 11* presents annual shoaling rates at Toledo Harbor, over the 20-year evaluation period, and the resulting Toledo Harbor channel depths.

**Table 11. "Without Project" Condition Toledo Harbor Shoaling Rates, and Channel Depths by Project Evaluation Year.**

| CALENDAR YEAR | EVALUATION YEAR | SHOALING RATE | DREDGING PERFORMED | CHANNEL DEPTH |
|---|---|---|---|---|
| 2002 | 1 | 1.5 | YES | 28.0 |
| 2003 | 2 | 1.5 | YES | 28.0 |
| 2004 | 3 | 1.5 | YES | 28.0 |
| 2005 | 4 | 1.5 | YES | 28.0 |
| 2006 | 5 | 1.5 | YES | 28.0 |
| 2007 | 6 | 1.5 | YES | 28.0 |
| 2008 | 7 | 1.5 | NO | 26.5 |
| 2009 | 8 | 1.5 | NO | 25.0 |
| 2010 | 9 | 1.5 | NO | 23.5 |
| 2011 | 10 | 1.5 | NO | 22.0 |
| 2012 | 11 | 1.4 | NO | 20.6 |
| 2013 | 12 | 0.6 | NO | 20.0 |
| 2014 | 13 | 0.6 | NO | 19.4 |
| 2015 | 14 | 0.5 | NO | 18.9 |
| 2016 | 15 | 0.5 | NO | 18.4 |
| 2017 | 16 | 0.4 | NO | 18.0 |
| 2018 | 17 | 0.4 | NO | 17.6 |
| 2019 | 18 | 0.4 | NO | 17.2 |
| 2020 | 19 | 0.4 | NO | 17.0 |
| 2031 | 20 | 0.0 | NO | 17.0 |

## 4. Total Yearly Transportation Costs At Toledo Harbor Under Varying Channel Depths

Total "Without Project" condition transportation costs were calculated for a range of channel depths at Toledo Harbor for iron ore, coal, and grain. These calculations assumed all tonnages stayed at Toledo Harbor throughout the 20-year evaluation period. These "Without Project" condition transportation costs consist of water costs and rail costs associated with using Toledo Harbor. Iron ore, coal, and grain had a water component and a rail component. Total yearly transportation costs for iron ore, coal, and grain, for a range of Toledo Harbor channel depths, were developed for each commodity origin/destination pair shown in *Table 1*. *Table 4* presented annual water transportation costs at Toledo Harbor for the three commodities for channel depths ranging from 28 feet to 17 feet measured from Low Water Datum.

Weighted rail costs per ton were developed for iron ore, coal, and grain movements through Toledo Harbor, in *Table 6*. These weighted rail costs per ton were then multiplied by the number of tons moved on a given origin/destination. This resulted in annual rail costs associated with moving iron ore, coal, and grain through Toledo Harbor. *Table 7* presents rail costs associated with using Toledo Harbor for each of the origin/destination routes evaluated.

These fixed rail costs were then added to the water costs by channel depth presented in *Table 4*, to arrive at total transportation costs associated with using Toledo Harbor over the 20-year evaluation period, given "Without Project" conditions. Total annual "Without Project" condition transportation costs for iron ore, coal, and grain were calculated for all Toledo Harbor channel depths from 28 feet to 17 feet.

*Table 12* presents a summary of the range of these "Without Project" condition transportation costs by providing

total transportation costs for a 28-foot Toledo Harbor channel and a 17-foot Toledo Harbor channel. Total Toledo Harbor transportation costs for a 28-foot channel depth came directly from *Tables 4 and 6.* The water cost by origin destination pair came from *Table 4*, 28-foot channel depth. Rail costs associated with using Toledo Harbor, by origin/destination route, came from *Table 7.*

Total transportation costs for a 17-foot channel depth came from *Tables 4 and 7.* Water costs for a 17-foot Toledo Harbor channel depth came from *Table 4*, from the row labeled "Toledo Harbor Channel Depth", 17. This was added to the rail costs by origin/destination presented in *Table 7* to arrive at total transportation costs associated with a 17-foot channel depth at Toledo Harbor.

## 5. Total Yearly Transportation Costs Associated With Using An Alternate Port

Yearly total transportation costs were recomputed for each origin/destination commodity pair, by commodity, assuming the commodities would be sourced through an alternate port. The alternate port for iron ore and coal was Ashtabula, Ohio and the alternate port for grain was Chicago, Illinois.

Total transportation costs associated with using an alternate port would have a water component and a rail component. *Table 12* summarizes total yearly transportation costs associated with using the alternate ports. The derivation of these various water and rail costs follows.

### 5a. Water Costs Associated With Using An Alternate Port

The two water transportation cost models were rerun using *Ashtabula* as the transshipment port for iron ore and coal and *Chicago* as the transshipment port for grain. Distances between the origin/destination pairs were recalculated. This added essentially 192 miles to each round trip water route for iron ore and coal. For grain, the round trip distance was increased by 1,376 miles.

The tonnages, vessels used, tons moved by origin/destination pair, and vessel operating costs were the same as used in calculating "With Project" condition transportation costs. Harbor depths at Ashtabula and Chicago were assumed to be 27 feet and 20 feet respectively, measured from Low Water Datum. These water transportation costs associated with using Ashtabula Harbor and Chicago Harbor, are presented in *Table 12.*

### 5b. Rail Costs Associated With Using An Alternate Port

Total rail costs were calculated for iron ore, coal, and grain using Ashtabula, and Chicago Harbor, respectively, as the transshipment port. It was assumed the iron ore destination areas (Middletown, Ohio and Ashland, Kentucky), the coal origin area (Cane Fork, West Virginia) and grain origin area (Terra Haute and Fort Wayne, Indiana) would remain the same even though the commodities now moved through Ashtabula, and Chicago Harbor; respectively.

Rail costs per ton associated with using the alternate ports were obtained from the TVA and are summarized in *Table 13.* Given total tons moved by rail by commodity, and a cost per ton to move the commodity, total yearly rail costs can be developed for the "Without Project" alternate port condition. The derivation of "Without Project" condition alternate port yearly rail transportation costs, by commodity, is presented in *Table 14.* Yearly alternate port iron ore rail costs came to $49,679,700. Yearly alternate port coal rail costs came to $101,201,600. Yearly alternate port grain rail costs came to $13,427,900. Total yearly alternate port rail costs for iron ore, coal, and grain came to $164,309,200.

The alternate port rail costs associated with the various origin/destination routes can now be calculated for using Ashtabula Harbor and Chicago Harbor as the transshipment port. These rail costs are simply the percent of total tons associated with each origin/destination route during the 1996 commercial navigation season times the total rail cost per commodity associated with using Ashtabula Harbor and Chicago Harbor as the transshipment port. This procedure is presented in *Table 15.* This data was then used to provide the alternate port rail costs presented in *Table 12* for the various origin/destination pairs.

## Table 12. Summary of Channel Depth at Which Tonnages Would Shift to an Alternate Port by Origin/Destination Route

| Origin/Destination | Alternate Port | Water Costs Alternate Port | Rail Costs Alternate Port | Total Transport Costs Alternate Port | Lowest Total Transport Cost (28 ft) Toledo Harbor | Highest Total Transport Cost (17 ft) Toledo Harbor | Toledo Harbor Channel Dpth At Which Switch Is Made |
|---|---|---|---|---|---|---|---|
| **Iron Ore** | | | | | | | |
| Duluth, Minnesota | Ashtabula | $11,428,000 | $14,367,814 | $25,795,814 | $20,831,032 | $27,673,032 | 18.39 |
| Presque Isle, Mi. | Ashtabula | $2,041,000 | $2,997,548 | $5,038,548 | $3,964,659 | $5,171,659 | 17.52 |
| Silver Bay, Mn. | Ashtabula | $20,830,000 | $25,584,464 | $46,414,464 | $37,326,090 | $50,991,090 | 18.71 |
| Two Harbors, Mn. | Ashtabula | $996,000 | $1,199,887 | $2,195,887 | $1,772,298 | $2,380,298 | 18.53 |
| Sept Isles, Quebec | Ashtabula | $4,703,000 | $5,529,957 | $10,232,957 | $9,283,230 | $13,084,230 | 22.05 |
| **Coal- Canadian** | | | | | | | |
| Hamilton, Ont. | Ashtabula | $2,955,184 | $18,364,235 | $21,319,418 | $16,227,308 | $18,518,308 | Never |
| Montreal, Ontario | Ashtabula | $244,045 | $740,094 | $984,139 | $765,134 | $935,134 | Never |
| Nanticoke, Ont. | Ashtabula | $359,674 | $5,034,179 | $5,393,853 | $3,972,504 | $4,268,504 | Never |
| St. Catherines, Ont. | Ashtabula | $101,954 | $718,533 | $820,487 | $625,234 | $707,234 | Never |
| Sault St. Marie, Ont | Ashtabula | $8,494,335 | $23,166,033 | $31,660,368 | $21,733,997 | $22,943,997 | Never |
| ThunderBay, Ont. | Ashtabula | $143,237 | $366,646 | $509,883 | $361,374 | $433,374 | Never |
| **Coal -United States** | | | | | | | |
| Alpena Mi. | Ashtabula | $298,714 | $870,937 | $1,169,651 | $782,487 | $824,487 | Never |
| Ashland, Wi. | Ashtabula | $638,896 | $963,983 | $1,602,880 | $1,186,474 | $1,321,474 | Never |
| Cleveland, Oh. | Ashtabula | $60,000 | $252,145 | $312,145 | $192,557 | $196,557 | Never |
| Dearborne, Mi. | Ashtabula | $2,657,200 | $8,651,592 | $11,308,792 | $6,487,628 | $6,536,628 | Never |
| Detroit, Mi. | Ashtabula | $3,575,000 | $11,814,488 | $15,389,488 | $8,903,727 | $8,977,727 | Never |
| Duluth, Mn. | Ashtabula | $653,723 | $898,081 | $1,551,803 | $1,160,987 | $1,287,987 | Never |
| Escanaba, Mi. | Ashtabula | $2,637,634 | $5,073,687 | $7,711,321 | $5,477,974 | $6,586,974 | Never |
| Gladstone, Mi. | Ashtabula | $199,128 | $378,689 | $577,817 | $411,138 | $443,138 | Never |
| Green Bay, Wi. | Ashtabula | $3,199,508 | $6,713,936 | $9,913,444 | $7,060,433 | $7,843,433 | Never |
| Holland, Mi. | Ashtabula | $1,793,465 | $3,014,835 | $4,808,299 | $3,496,645 | $3,725,645 | Never |
| Harbor Beach, Mi. | Ashtabula | $118,296 | $447,244 | $565,540 | $365,335 | $377,335 | Never |
| Manistee, Mi. | Ashtabula | $1,817,503 | $3,510,634 | $5,328,137 | $3,794,284 | $4,039,284 | Never |
| Manitowoc, Wi. | Ashtabula | $201,805 | $362,347 | $564,152 | $405,603 | $434,603 | Never |
| Marinette, Wi. | Ashtabula | $148,166 | $339,310 | $487,476 | $343,751 | $370,751 | Never |
| Milwaukee, Wi. | Ashtabula | $663,746 | $1,088,837 | $1,752,583 | $1,276,966 | $1,370,966 | Never |
| Marysville, Mi. | Ashtabula | $314,618 | $1,339,356 | $1,653,974 | $1,031,475 | $1,062,475 | Never |
| Munising, Mi. | Ashtabula | $483,907 | $903,941 | $1,387,848 | $990,765 | $1,040,765 | Never |
| Muskegon, Mi. | Ashtabula | $217,583 | $593,294 | $810,877 | $569,493 | $623,493 | Never |
| Ontonagon, Mi. | Ashtabula | $2,098,877 | $2,889,211 | $4,988,089 | $3,694,657 | $3,942,657 | Never |
| Presque Isle, Mi. | Ashtabula | $107,000 | $191,569 | $298,569 | $214,503 | $233,503 | Never |
| Saginaw, Mi. | Ashtabula | $122,351 | $467,393 | $589,743 | $393,325 | $414,325 | Never |
| St. Clair, Mi. | Ashtabula | $250,771 | $1,079,703 | $1,330,474 | $827,078 | $846,078 | Never |
| Wyandotte, Mi. | Ashtabula | $272,600 | $966,700 | $1,239,300 | $710,225 | $719,225 | Never |
| **Grain** | | | | | | | |
| Montreal | Chicago | $21,728,000 | $13,427,900 | $35,155,900 | $30,340,377 | $37,091,377 | 18.59 |

## Table 13. "Without Project" Condition Rail Costs Per Ton by Rail Route

| | Rail Carrier | $/Ton |
|---|---|---|
| **1. IRON ORE** | | |
| Rail Costs From Ashtabula Harbor, Ohio, To: | | |
| Middletown, Ohio | CSX | $11.39 |
| Ashland, Kentucky | CSX | $11.82 |
| **2. COAL** | | |
| Rail Costs To Ashtabula Harbor, Ohio, From: | | |
| Cane Fork, West Virginia | CSX | $21.39 |
| **3. GRAIN** | | |
| Rail Costs to Chicago Harbor, Illinois, From: | | |
| Terra Haute, Indiana | CSX-NS | $ 8.11 |
| Fort Wayne, Indiana | NS | $ 7.69 |

## Table 14. Yearly "Without Project" Condition Alternative Port Rail Costs for Iron Ore, Coal, and Grain

| Destination | Total Tons | Percent Of Total Tons By Destin | Tons By Destination | Rail $/Ton | Rail Costs By Destination |
|---|---|---|---|---|---|
| **1. IRON ORE-Alternate Port Is Ashtabula, Ohio** | | | | | |
| Middletown, Ohio | 4,280,885 | 50% | 2,140,443 | $11.39 | $24,379,640 |
| Ashland, Kentucky | 4,280,885 | 50% | 2,140,443 | $11.82 | $25,300,030 |
| | | | | | $49,679,670 |
| | | | | Rounded | $49,679,700 |

| Origin | Total Tons | Percent Of Total Tons By Origin | Tons By Origin | Rail $/Ton | Rail Costs By Origin |
|---|---|---|---|---|---|
| **2. COAL-Alternate Port Is Ashtabula, Ohio** | | | | | |
| Cane Fork, West VA. | | | | | |
| Total Canadian Coal | 2,262,259 | 100% | 2,262,359 | $21.39 | $48,389,720 |
| Total U.S. Coal | 2,469,000 | 100% | 2,469,000 | $21.39 | $52,811,910 |
| | 4, 731,259 | | | | $101,201,630 |
| | | | | Rounded | $101,201,600 |

| Origin | Commodity | Weight | Rate | Weighted Rate | Rail Costs |
|---|---|---|---|---|---|
| **3. GRAIN-Alternate Port Is Chicago, Illinois** | | | | | |
| Terra Haute, Indiana | Wheat | 50% | $8.11 | $4.06 | |
| Fort Wayne, Indiana | Corn | 50% | $7.69 | $3.85 | |
| | | | | $7.90 | |
| | | Tons Of Grain Moved | | 1,699,729 | $13,427,859 |
| | | | | Rounded | $13,427,900 |
| **4. TOTAL YEARLY ALTERNATE PORT RAIL COSTS** | | | | | **$164,309,159** |
| | | | | Rounded | $164,309,200 |

## 6. Determination Of Whether A Switch Would Be Made To An Alternate Port

*Table 12* now contains all the ingredients needed to determine whether a switch would be made to an alternate port over the 20-year evaluation period. *Table 12* has total annual transportation costs (water and rail costs) associated with staying at Toledo Harbor over a range of channel depths for iron ore, coal, and grain. *Table 12* has total annual transportation costs associated with staying at Toledo Harbor for a 28-foot channel and a 17-foot channel. Assuming channel equilibrium is 17 feet, measured from LWD, the total transportation costs associated with the 17-foot channel depth is the maximum annual transportation cost that would be incurred if bulk commodity users continued to source their bulk commodities through Toledo Harbor throughout the 20-year evaluation period.

*Table 12* also has total transportation costs (water and rail costs) associated with using the alternate ports: Ashtabula for iron ore and coal and Chicago for grain. These yearly total alternate port transportation costs can now be compared to the range of yearly total transportation costs associated with using Toledo Harbor at various channel depths. If the yearly total transportation cost associated with using the alternate port fell within the range of yearly total transportation costs for various Toledo Harbor channel depths (28-foot channel depth to a 17-foot channel depth, LWD), then the commodity would switch to using the alternate port. If a switch is made, *Table 12* provides Toledo Harbors channel depth at which the switch is made. If the total transportation costs associated with using Toledo Harbor, regardless of channel depth at Toledo, were always less than the yearly transportation cost associated with using an alternate port (Ashtabula for iron ore and coal and Chicago for grain), then the commodity would be sourced through Toledo Harbor throughout the 20-year evaluation period.

With respect to iron ore, it was always cheaper to switch to the alternate port, Ashtabula. Channel switch depths ranged from 22.0 feet for Sept Isles Canada to 17.52 for Presque Isle, Michigan. However, this was not true for coal shipments. Usage of Toledo Harbor for every year in the 20-year evaluation period was less expensive for all coal origin/destination routes, on a total water and rail transportation cost basis, than switching to Ashtabula Harbor. Consequently, all origin/destination routings for coal continued to use Toledo Harbor throughout the complete 20-year evaluation period under "Without Project" conditions. With respect to grain shipments, when Toledo Harbor's channel depths reached 18.59 feet, all grain shipments would switch to Chicago, Illinois.

## Table 15. Allocation of Yearly Alternate Port Rail Costs for Iron Ore, Coal, and Grain Among Origin/Destination Ports

| Origin Ports | Tons Moved | Percent Of Total Tons Moved | Total Rail Transport Cost | Allocated Rail Transport Cost |
|---|---|---|---|---|
| **1. Allocation Of Iron Ore Rail Transportation Costs From Ashtabula Among Origin Ports** | | | | |
| Duluth, Mn. | 1,238,071 | 28.92% | $49,679,670 | $14,367,814 |
| Presque Isle, Mi. | 258,298 | 6.03% | $49,679,670 | $2,997,548 |
| Silver Bay, Mn. | 2,204,607 | 51.50% | $49,679,670 | $25,584,464 |
| Two Harbors,Mn. | 103,394 | 2.42% | $49,679,670 | $1,199,887 |
| Sept Isles, Quebec | 476,515 | 11.13% | $49,679,670 | $5,529,957 |
| | 4,280,885 | 100.00% | | $49,679,670 |
| **2a.Allocation Of Coal Rail Transportation Costs From Ashtabula Among Canadian Destination Ports** | | | | |
| Hamilton, Ont. | 858,543 | 37.95% | $48,389,720 | $18,364,235 |
| Montreal, Canada | 34,600 | 1.53% | $48,389,720 | $740,094 |
| Nanticoke, Ont. | 235,352 | 10.40% | $48,389,720 | $5,034,179 |
| St. Catherines, Ont. | 33,592 | 1.48% | $48,389,720 | $718,533 |
| Sault St. Marie, Ont. | 1,083,031 | 47.87% | $48,389,720 | $23,166,033 |
| ThunderBay, Ont. | 17,141 | 0.76% | $48,389,720 | $366,646 |
| | 2,262,259 | 100.00% | | $48,389,720 |
| **2b.Allocation Of Coal Rail Transportation Costs From Ashtabula Among U.S. Destination Ports** | | | | |
| Alpena Mi. | 40,717 | 1.65% | $52,811,910 | $870,937 |
| Ashland, Wi. | 45,067 | 1.83% | $52,811,910 | $963,983 |
| Cleveland, Oh. | 11,788 | 0.48% | $52,811,910 | $252,145 |
| Dearborne, Mi. | 404,469 | 16.38% | $52,811,910 | $8,651,592 |
| Detroit, Mi. | 552,337 | 22.37% | $52,811,910 | $11,814,488 |
| Duluth, Mn. | 41,986 | 1.70% | $52,811,910 | $898,081 |
| Escanaba, Mi. | 237,199 | 9.61% | $52,811,910 | $5,073,687 |
| Gladstone, Mi. | 17,704 | 0.72% | $52,811,910 | $378,689 |
| Green Bay, Wi. | 313,882 | 2.71% | $52,811,910 | $6,713,936 |
| Holland, Mi. | 140,946 | 5.71% | $52,811,910 | $3,014,835 |
| Harbor Beach, Mi. | 20,909 | 0.85% | $52,811,910 | $447,244 |
| Manistee, Mi. | 164,125 | 6.65% | $52,811,910 | $3,510,634 |
| Manitowoc, Wi. | 16,940 | 0.69% | $52,811,910 | $362,347 |
| Marinette, Wi. | 15,863 | 0.64% | $52,811,910 | $339,310 |
| Milwaukee, Wi. | 50,904 | 2.06% | $52,811,910 | $1,088,837 |
| Marysville, Mi. | 62,616 | 2.54% | $52,811,910 | $1,339,356 |
| Munising, Mi. | 42,260 | 1.71% | $52,811,910 | $903,941 |
| Muskegon, Mi. | 27,737 | 1.12% | $52,811,910 | $593,294 |
| Ontonagon, Mi. | 135,073 | 5.47% | $52,811,910 | $2,889,211 |
| Presque Isle, Mi. | 8,956 | 0.36% | $52,811,910 | $191,569 |
| Saginaw, Mi. | 21,851 | 0.89% | $52,811,910 | $467,393 |
| St. Clair, Mi. | 50,477 | 2.04% | $52,811,910 | $1,079,703 |
| Wyandotte, Mi. | 45,194 | 1.83% | $52,811,910 | $966,700 |
| | 2,469,000 | 100.00% | | $52,811,910 |
| **3. Allocation Of Grain Rail Transportation Costs From Chicago Among Destination Ports** | | | | |
| Terra Haute and Fort Wayne, In. | 1,699,729 | 100.00% | $13,427,859 | $13,427,859 |

## 7.Derivation Of "Without Project" Condition Average Annual Total Transportation Costs

Calculating "Without Project" condition average annual total transportation costs involves developing a time stream of "Without Project" condition total transportation costs for each commodity by origin/ destination route for the 20-year evaluation period. The development of the time stream of "Without Project" condition total transportation costs uses "Without Project" condition channel depths by project year (*Table 11*), corresponding "Without Project" condition total transportation costs (derived from *Tables 4 and 12* for the water portion and *Tables 7 and 15* for the rail component) and information about whether this commodity switches to an alternate port for the origin/destination pair being evaluated.

These time streams of "Without Project" condition total transportation costs can then be converted to an average annual dollar equivalent based on a 7.125 percent annual interest rate and a 20-year project life. The development of these transportation cost time streams, for iron ore, coal, and grain, follows.

### 7a. "Without Project" Condition Average Annual Total Transportation Costs-Iron Ore

The hardest part about developing the time stream of "Without Project" condition total transportation costs is determining whether the commodity will shift to an alternate port, and if it does, at what Toledo Harbor channel depth does this takes place at. *Table 12* showed that for iron ore, all origin/destination pair tonnages will eventually shift to the alternate port: Ashtabula. *Table 12* also presented the Toledo Harbor channel depth at which this switch would take place. Consequently the time stream of iron ore total "Without Project" condition transportation costs uses water and rail costs associated with Toledo Harbor up to the time of the switch and then uses alternate port (Ashtabula Harbor) water and rail costs for all years remaining in the project evaluation period.

Once this time stream of "Without Project" condition total iron ore transportation costs is developed for each year of the 20-year project evaluation period, these costs can then be converted to average annual costs using a 7.125 percent annual interest rate and a 20-year evaluation period. An example of deriving average annual "Without Project" condition total transportation costs is presented using Duluth Minnesota as the trade route being evaluated.

Total "Without Project" condition iron ore transportation costs were developed for a range of channel depths that would be reached over the 20-year project evaluation period. These total "Without Project" condition iron ore transportation costs by channel depth are presented in *Table 16*. These transportation costs by channel depth were then used in conjunction with channel depth achieved in each project evaluation year presented in *Table 11*, to develop "Without Project" condition iron ore transportation costs associated with each evaluation year.

*Table 12* indicates that iron ore tonnages on the Duluth Minnesota trade route will switch to an alternate port (Ashtabula) when Toledo Harbors channel depths equals 18.39 feet. *Table 11* shows that Toledo Harbor's channel depth will equal 18.39 feet in the year 2017, or project evaluation year 16. Consequently, all yearly total transportation costs up to project year 15 will be associated with using Toledo Harbor. However, under "Without Project" conditions, Toledo Harbor channels start shoaling up in project year 7. Thus from project year 1 to project year 6, shippers will have a 28-foot channel depth. Total annual water and rail costs associated with a 28.0 foot Toledo harbor channel depth is $20,831,000 (see *Table 9*). The water cost associated with a 28-foot Toledo Harbor channel is $10,326,000 (*Table 4*) and the rail costs associated with a 28-foot Toledo Harbor channel is $10,505,000 (*Table 7*).

In project year 7, the Toledo Harbor channel depth has shoaled to a 26.5 feet. The water cost associated with continuing to use Toledo Harbor has now risen to $10,336,500. This water transportation cost was interpolated from the 27.0-foot and 26.0-foot water transportation cost provided in *Table 4*. However, the rail cost has remained at $10,505,000. Consequently total "Without Project" condition iron ore transportation costs have risen to $20,841,500 for the Duluth Superior trade route.

**Table 16. "Without Project" Condition Total Iron Ore Transportation Costs By Channel Depth-Duluth Superior Trade Route**

| Toledo Harbor Channel Depth | Water Costs Duluth Minnesota | Rail Costs Duluth Minnesota | Water & Rail Costs Duluth Minnesot |
|---|---|---|---|
| 28.0 | $10,326,000 | $10,505,032 | $20,831,032 |
| 27.0 | $10,326,000 | $10,505,032 | $20,831,032 |
| 26.5 | $10,336,500 | $10,505,032 | $20,841,532 |
| 26.0 | $10,347,000 | $10,505,032 | $20,852,032 |
| 25.0 | $10,471,000 | $10,505,032 | $20,976,032 |
| 24.0 | $10,793,000 | $10,505,032 | $21,298,032 |
| 23.5 | $11,049,000 | $10,505,032 | $21,554,032 |
| 23.0 | $11,305,000 | $10,505,032 | $21,810,032 |
| 22.0 | $11,949,000 | $10,505,032 | $22,454,032 |
| 21.0 | $12,698,000 | $10,505,032 | $23,203,032 |
| 20.6 | $13,043,600 | $10,505,032 | $23,548,632 |
| 20.0 | $13,562,000 | $10,505,032 | $24,067,032 |
| 19.4 | $14,164,400 | $10,505,032 | $24,669,432 |
| 19.0 | $14,566,000 | $10,505,032 | $25,071,032 |
| 18.9 | $14,684,400 | $10,505,032 | $25,189,432 |
| 18.4 | $15,276,400 | $10,505,032 | $25,781,432 |
| 18.0 | $15,750,000 | $10,505,032 | $26,255,032 |
| 17.6 | $16,317,200 | $10,505,032 | $26,822,232 |
| 17.2 | $16,884,400 | $10,505,032 | $27,389,432 |
| 17.0 | $17,168,000 | $10,505,032 | $27,673,032 |

In "Without Project" condition evaluation year 8, *Table 11* indicated Toledo Harbor's channel depths will have shoaled up to 25.0 feet. *Table 16* indicates that Duluth Harbor's total "Without Project" condition iron ore transportation costs for a 25.0-foot channel depth at Toledo Harbor equals $20,976,000. This process of reading total "Without Project" condition iron ore transportation costs off of *Table 16* for channel depths achieved in various project evaluation years continues until the tonnages switches to an alternate port. Duluth Harbor tonnages switch when Toledo Harbor's channel equals 18.39 feet. This takes place in project evaluation year 16. Consequently for project evaluation years 16 through 20, total "Without Project" condition iron ore transportation costs are now water and rail costs associated with using the alternate port: Ashtabula. Water and rail costs associated with using Ashtabula Harbor are $25,795,800 (*Table 12*). If the shipper had continued to use Toledo Harbor, in project year 16 he would have incurred a total "Without Project" condition iron ore transportation cost of $26,255,000. It is cheaper to use the alternate port, consequently the shipper switches to the alternate port.

This time stream of total "Without Project" condition iron ore transportation costs for each project evaluation year in the 20-year evaluation period is presented in *Table 17*. These annual total transportation costs were converted to present worth values using a 7.125 percent annual interest rate. These present worth values were summed and then converted to an average annual value using a 7.125 percent annual interest rate and a 20-year project evaluation. Duluth Harbor's "Without Project" condition total average annual transportation cost came to $22,375,700. This process was repeated for each of the remaining four iron ore trade routes. "Without Project" condition total average annual transportation costs for all the iron ore origin/destination routes are presented in *Table 18*. "Without Project" condition total average annual transportation costs for iron ore came to $78,467,300.

**Table 17. Calculation Of "Without Project" Condition Total Average Annual Iron Ore Transportation Costs- Duluth Superior Trade Route**

| Year | Project Year | Toledo Channel Starting Depth | Toledo Amount Shoaled Per Year | Channel Depth Beginning Of Year | Water & Rail Transport Costs | Present Worth Factor | 30-year Present Worth Total Transport Costs |
|---|---|---|---|---|---|---|---|
| 2002 | 1 | 28.0 | 1.5 | 28.0 | $20,831,032 | 0.933488915 | $19,445,538 |
| 2003 | 2 | 28.0 | 1.5 | 28.0 | $20,831,032 | 0.871401554 | $18,152,194 |
| 2004 | 3 | 28.0 | 1.5 | 28.0 | $20,831,032 | 0.813443691 | $16,944,872 |
| 2005 | 4 | 28.0 | 1.5 | 28.0 | $20,831,032 | 0.759340668 | $15,817,850 |
| 2006 | 5 | 28.0 | 1.5 | 28.0 | $20,831,032 | 0.708836097 | $14,765,788 |
| 2007 | 6 | 28.0 | 1.5 | 28.0 | $20,831,032 | 0.661690639 | $13,783,699 |
| 2008 | 7 | 28.0 | 1.5 | 26.5 | $20,841,532 | 0.617680876 | $12,873,416 |
| 2009 | 8 | 26.5 | 1.5 | 25.0 | $20,976,032 | 0.576598251 | $12,094,744 |
| 2010 | 9 | 25.0 | 1.5 | 23.5 | $21,554,032 | 0.538248075 | $11,601,416 |
| 2011 | 10 | 23.5 | 1.5 | 22.0 | $22,454,032 | 0.502448612 | $11,281,997 |
| 2012 | 11 | 22.0 | 1.4 | 20.6 | $23,548,632 | 0.469030209 | $11,045,020 |
| 2013 | 12 | 20.6 | 0.6 | 20.0 | $24,067,032 | 0.437834501 | $10,537,377 |
| 2014 | 13 | 20.0 | 0.6 | 19.4 | $24,669,432 | 0.408713653 | $10,082,734 |
| 2015 | 14 | 19.4 | 0.5 | 18.9 | $25,189,432 | 0.381529665 | $9,610,516 |
| 2016 | 15 | 18.9 | 0.5 | 18.4 | $25,781,432 | 0.356153713 | $9,182,153 |
| 2017 | 16 | 18.4 | 0.4 | 18.0 | $25,795,814 | 0.332465543 | $8,576,219 |
| 2018 | 17 | 18.0 | 0.4 | 17.6 | $25,795,814 | 0.310352899 | $8,005,806 |
| 2019 | 18 | 17.6 | 0.4 | 17.2 | $25,795,814 | 0.289710991 | $7,473,331 |
| 2020 | 19 | 17.2 | 0.4 | 17.0 | $25,795,814 | 0.270441998 | $6,976,271 |
| 2021 | 20 | 17.0 | 0.0 | 17.0 | $25,795,814 | 0.252454608 | $6,512,272 |
| | | | | | | | $234,763,213 |
| | | | | | Partial Payment Factor For 20-years | | 0.0953119 |
| | | | | | Average Annual Value | | $22,375,737 |
| | | | | | Rounded Average Annual Value | | $22,375,700 |

## Table 18.Total "Without Project" Condition Average Annual Transportation Costs

### A. Total Average Annual Without Project Condition Iron Ore Transportation Costs

| | |
|---|---|
| Duluth, Minnesota | $22,375,700 |
| Presque Isle, Mi. | $4,258,700 |
| Silver Bay, Mn. | $40,250,900 |
| Two Harbors, Mn. | $1,905,300 |
| Sept Isles, Quebec | $9,676,700 |
| | $78,467,300 |

### B. Total Average Annual "Without Project"Condition Coal Transportation Costs

| | |
|---|---|
| **Canadian** | |
| Hamilton, Ont. | $16,793,800 |
| Montreal, Ontario | $807,200 |
| Nanticoke, Ont. | $4,405,400 |
| St. Catherines, Ont. | $645,300 |
| Sault St. Marie, Ont. | $21,913,300 |
| ThunderBay, Ont. | $379,000 |
| | $44,584,000 |
| **United States** | |
| Alpena Mi. | $788,700 |
| Ashland, Wi | $1,206,800 |
| Cleveland, Oh | $193,300 |
| Dearborne, Mi | $6,493,600 |
| Detroit, Mi | $8,912,700 |
| Duluth, Mn | $1,179,300 |
| Escanaba, Mi | $5,689,300 |
| Gladstone, Mi | $415,700 |
| Green Bay, Wi. | $7,199,200 |
| Holland, Mi | $3,526,600 |
| Harbor Beach, Mi | $367,200 |
| Manistee, Mi | $3,827,100 |
| Manitowoc, Wi. | $409,600 |
| Marinette | $348,100 |
| Milwaukee, Wi | $1,289,700 |
| Marysville, Mi | $1,037,200 |
| Munising, Mi | $997,000 |
| Muskegon, Mi | $579,900 |
| Ontonagon, Mi | $3,726,000 |
| Presque Isle, Mi. | $217,300 |
| Saginaw, Mi | $397,200 |
| St. Clair, Mi | $830,300 |
| Wyandotte, Mi. | $711,700 |
| | $50,343,500 |
| Total Average Annual Coal Transportation Costs | |
| | $94,927,500 |

### C. Total Average Annual "Without Project" Condition Grain Transportation Costs

| | |
|---|---|
| Chicago, Ill. | $31,903,300 |
| **Total Average Annual "Without Project" Transportation Costs** | **$205,298,100** |

### 7b. "Without Project" Condition Average Annual Total Transportation Costs-Coal

The procedure used to develop "Without Project" condition average annual total transportation costs for iron ore was used to develop "Without Project" condition average annual total transportation costs for coal. Again, the key piece of information in developing the time stream of "Without Project" condition total transportation costs is determining whether the commodity will shift to an alternate port, and if it does, at what Toledo Harbor channel depth does this takes place at. *Table 12* showed that for coal, all origin/destination pair tonnages will *never* shift to an alternate port. Consequently the time stream of coal total "Without Project" condition transportation costs uses water and rail costs associated with Toledo Harbor over the 20-year project evaluation period.

Once this time stream of "Without Project" condition total transportation costs is developed for each year of the 20-year project evaluation period, these costs can then be converted to average annual costs using a 7.125 percent annual interest rate and a 20-year evaluation period. An example of deriving average annual "Without Project" condition total transportation costs is presented using Ashland Wisconsin as the trade route being evaluated.

Total "Without Project" condition coal transportation costs were developed for a range of channel depths that would be reached over the 20-year project evaluation period. These total "Without Project" condition coal transportation costs by channel depth are presented in *Table 19.* These transportation costs by channel depth were then used in conjunction with channel depth achieved in each project evaluation year presented in *Table 11*, to develop "Without Project" condition coal transportation costs associated with each evaluation year.

*Table 12* indicates that coal tonnages on the Ashland, Wisconsin trade route will not switch to an alternate port. This commodity will remain at Toledo Harbor throughout the 20-year evaluation period. Water transportation costs for this route will increase as Toledo Harbor channels experience shoaling. *Table 11* shows Toledo Harbors channel depths throughout the "Without Project" condition. Toledo Harbor channels start shoaling up in project year 7 under "Without Project" conditions. Thus from project year 1 to project year 6, shippers will have a 28-foot channel depth. Total annual water and rail costs associated with a 28.0-foot Toledo harbor channel depth is $1,186,500 (see *Table 9*). The water cost associated with a 28-foot Toledo Harbor channel is $565,000 (*Table 4*) and the rail costs associated with a 28-foot Toledo Harbor channel is $621,500 (*Table 7*).

In project year 7, the Toledo Harbor channel depth has shoaled to a 26.5 feet. The water cost associated with continuing to use Toledo Harbor has remained at $565,000. In addition, the rail cost has remained at $621,500. Consequently total "Without Project" condition coal transportation costs have remained at $1,186,500 given a 26.5-foot Toledo Harbor channel depth, for the Ashland, Wisconsin, trade route. Water costs do not start to increase until the water column has reached 21 feet. Toledo Harbor channels reach 21 feet in project evaluation year 11. Thus total transportation costs remain the same from project year 1 through project year 10.

This phenomenon is characteristic of all coal trade origin/destination pairs evaluated. There is relatively little increase in coal transportation costs until channels reach the 22 to 21-foot range. This is due to coal's light density. A vessel carrying coal, will become completely filled up before the vessel reaches its mid summer draft. Consequently, even though a vessel may have a mid summer draft of say 26 feet, the vessels holds will be filled by the time the vessel drafts 21 to 22 feet. This is because coal has a lower *density* than say iron ore. The cubic feet of space needed by coal to hold 2,000 pounds (42 cubic feet) is much larger than the cubic feet of space needed by iron ore to hold 2,000 pounds (13 cubic feet).

In "Without Project" condition evaluation year 11, *Table 11* indicates Toledo Harbor channels will have shoaled up resulting in a 20.6-foot channel depth. *Table 19* indicates that Ashland Harbor's total "Without Project" condition coal transportation costs for a 20.6-foot channel depth at Toledo Harbor equals $1,190,700. This process of reading total "Without Project" condition iron ore transportation costs off of *Table 19* for channel depths achieved in various project evaluation years continues until Toledo Harbor channels reach their equilibrium levels of 17 feet. Toledo Harbor channel depths reach 17 feet in project evaluation year 19. Consequently for project evaluation years 19 through 20, total "Without Project" condition coal transportation costs are $1,321,500. (Note: Usage of the alternate port (Ashtabula) would have resulted in a total coal transportation cost of $1,602,900. This is greater than the total transportation cost associated with using a 17-foot channel depth at Toledo Harbor; $1,321,500. Consequently, the shipper continues to use Toledo Harbor throughout the 20-year evaluation period. If the shipper had switched to the alternate port, he would have incurred a higher total "Without Project" condition coal transportation cost. It is cheaper to stay at Toledo Harbor over the 20-year evaluation period than to switch to the alternate port.)

**Table 19. "Without Project" Condition Total Coal Transportation Costs By Channel Depth-Ashland, Wisconsin, Trade Route**

| Toledo Harbor Channel Depth | Water Costs Ashland, Wisconsin | Rail Costs Ashland, Wisconsin | Water & Rail Costs Ashland, Wisconsin |
|---|---|---|---|
| 28.0 | $565,000 | $621,474 | $1,186,474 |
| 27.0 | $565,000 | $621,474 | $1,186,474 |
| 26.5 | $565,000 | $621,474 | $1,186,474 |
| 26.0 | $565,000 | $621,474 | $1,186,474 |
| 25.0 | $565,000 | $621,474 | $1,186,474 |
| 24.0 | $565,000 | $621,474 | $1,186,474 |
| 23.5 | $565,000 | $621,474 | $1,186,474 |
| 23.0 | $565,000 | $621,474 | $1,186,474 |
| 22.0 | $565,000 | $621,474 | $1,186,474 |
| 21.0 | $566,000 | $621,474 | $1,187,474 |
| 20.6 | $569,200 | $621,474 | $1,190,674 |
| 20.0 | $574,000 | $621,474 | $1,195,474 |
| 19.4 | $588,400 | $621,474 | $1,209,874 |
| 19.0 | $598,000 | $621,474 | $1,219,474 |
| 18.9 | $602,300 | $621,474 | $1,223,774 |
| 18.4 | $623,800 | $621,474 | $1,245,274 |
| 18.0 | $641,000 | $621,474 | $1,262,474 |
| 17.6 | $664,600 | $621,474 | $1,286,074 |
| 17.2 | $688,200 | $621,474 | $1,309,674 |
| 17.0 | $700,000 | $621,474 | $1,321,474 |

A time stream of total "Without Project" condition coal transportation costs, for each project evaluation year in the 20-year evaluation period, is presented in *Table 20*. These annual total transportation costs were converted to present worth values using a 7.125 percent annual interest rate. These present worth values were summed and then converted to an average annual value using a 7.125 percent annual interest rate and a 20-year project evaluation. Ashland Harbor's "Without Project" condition total average annual transportation cost came to $1,223,300. This process was repeated for each of the twenty-eight remaining coal trade routes. "Without Project" condition total average annual transportation costs for all the coal origin/destination routes are presented in *Table 18*. Total "Without Project" condition average annual transportation costs for coal came to $94,927,500.

### 7c. "Without Project" Condition Average Annual Total Transportation Costs-Grain

The procedure described to develop "Without Project" condition average annual total transportation costs for iron ore and coal was used to develop "Without Project" condition average annual total transportation costs for grain. Again, the key piece of information in developing the time stream of "Without Project" condition total transportation costs is determining whether the commodity will shift to an alternate port, and if it does, at what Toledo Harbor channel depth does this take place at.

*Table 12* showed that for grain, this commodity would shift to an alternate port when Toledo Harbor channel depths equaled 18.59 feet. Consequently the time stream of grain total "Without Project" condition transportation costs uses water and rail costs associated with Toledo Harbor up to the time of the switch and then uses alternate port (Chicago Harbor) water and rail costs for all years remaining in the project evaluation period. *Table 21* shows "Without Project" condition total grain transportation costs for various Toledo Harbor channel depths.

Data from *Table 21* was used in conjunction with *Table 11* to develop the time stream of total transportation costs for grain over the 20-year evaluation period. This time stream of "Without Project" condition total transportation costs for grain is presented in *Table 22*. These costs can now be converted to average annual costs using a 7.125 percent annual interest rate and a 20-year evaluation period.

## Table 20. Calculation Of "Without Project" Condition Total Average Annual Coal Transportation Costs- Ashland, Wisconsin, Trade Route

| Year | Project Year | Toledo Channel Starting Depth | Amount Shoaled Per Year | Toledo Channel Depth Beginning Of Year | Water & Rail Transport Costs | Present Worth Factor | Present Worth Total Transport Costs |
|---|---|---|---|---|---|---|---|
| 2002 | 1 | 28.0 | 1.5 | 28.0 | $1,186,474 | 0.93348 | $1,107,560 |
| 2003 | 2 | 28.0 | 1.5 | 28.0 | $1,186,474 | 0.87140 | $1,033,895 |
| 2004 | 3 | 28.0 | 1.5 | 28.0 | $1,186,474 | 0.81344 | $965,130 |
| 2005 | 4 | 28.0 | 1.5 | 28.0 | $1,186,474 | 0.75934 | $900,938 |
| 2006 | 5 | 28.0 | 1.5 | 28.0 | $1,186,474 | 0.70883 | $841,016 |
| 2007 | 6 | 28.0 | 1.5 | 28.0 | $1,186,474 | 0.66169 | $785,079 |
| 2008 | 7 | 28.0 | 1.5 | 26.5 | $1,186,474 | 0.61768 | $732,862 |
| 2009 | 8 | 26.5 | 1.5 | 25.0 | $1,186,474 | 0.57659 | $684,119 |
| 2010 | 9 | 25.0 | 1.5 | 23.5 | $1,186,474 | 0.53824 | $638,617 |
| 2011 | 10 | 23.5 | 1.5 | 22.0 | $1,186,474 | 0.50244 | $596,142 |
| 2012 | 11 | 22.0 | 1.4 | 20.6 | $1,190,674 | 0.46903 | $558,462 |
| 2013 | 12 | 20.6 | 0.6 | 20.0 | $1,195,474 | 0.43783 | $523,420 |
| 2014 | 13 | 20.0 | 0.6 | 19.4 | $1,209,874 | 0.40871 | $494,492 |
| 2015 | 14 | 19.4 | 0.5 | 18.9 | $1,223,774 | 0.38152 | $466,906 |
| 2016 | 15 | 18.9 | 0.5 | 18.4 | $1,245,274 | 0.35615 | $443,509 |
| 2017 | 16 | 18.4 | 0.4 | 18.0 | $1,262,474 | 0.33246 | $419,729 |
| 2018 | 17 | 18.0 | 0.4 | 17.6 | $1,286,074 | 0.31035 | $399,137 |
| 2019 | 18 | 17.6 | 0.4 | 17.2 | $1,309,674 | 0.28971 | $379,427 |
| 2020 | 19 | 17.2 | 0.4 | 17.0 | $1,321,474 | 0.27044 | $357,382 |
| 2021 | 20 | 17.0 | 0.0 | 17.0 | $1,321,474 | 0.25245 | $333,612 |
| | | | | | | | $12,661,434 |
| | | | | | Partial Payment Factor | | 0.0953119 |
| | | | | | Average Annual Value | | $ 1,206,786 |
| | | | | | Rounded Average Annual Value | | $ 1,206,800 |

**Table 21. "Without Project" Condition Total Grain Transportation Costs By Channel Depth-Montreal, Quebec, Trade Route**

| Toledo Harbor Channel Depth | Water Costs To Montreal | Rail Costs To Toledo | Water & Rail Costs For Toledo |
|---|---|---|---|
| 28.0 | $13,887,000 | $16,453,377 | $30,340,377 |
| 27.0 | $13,890,000 | $16,453,377 | $30,343,377 |
| 26.5 | $13,909,500 | $16,453,377 | $30,362,877 |
| 26.0 | $13,929,000 | $16,453,377 | $30,382,377 |
| 25.0 | $14,094,000 | $16,453,377 | $30,547,377 |
| 24.0 | $14,479,000 | $16,453,377 | $30,932,377 |
| 23.5 | $14,755,000 | $16,453,377 | $31,208,377 |
| 23.0 | $15,031,000 | $16,453,377 | $31,484,377 |
| 22.0 | $15,684,000 | $16,453,377 | $32,137,377 |
| 21.0 | $16,435,000 | $16,453,377 | $32,888,377 |
| 20.6 | $16,774,600 | $16,453,377 | $33,227,977 |
| 20.0 | $17,284,000 | $16,453,377 | $33,737,377 |
| 19.4 | $17,861,200 | $16,453,377 | $34,314,577 |
| 19.0 | $18,246,000 | $16,453,377 | $34,699,377 |
| 18.9 | $18,356,700 | $16,453,377 | $34,810,077 |
| 18.4 | $18,910,200 | $16,453,377 | $35,363,577 |
| 18.0 | $19,353,000 | $16,453,377 | $35,806,377 |
| 17.0 | $20,638,000 | $16,453,377 | $37,091,377 |

## Table 22. Calculation Of "Without Project" Condition Total Average Annual Grain Transportation Costs- Montreal, Quebec, Trade Route

| Year | Project Year | Toledo Channel Starting Depth | Amount Shoaled Per Year | Toledo Channel Depth Beginning Of Year | Water & Rail Transport Costs | Present Worth Factor | 30-year Present Worth Total Transport Costs |
|---|---|---|---|---|---|---|---|
| 2002 | 1 | 28.0 | 1.5 | 28.0 | $30,340,377 | 0.93348 | $28,322,405 |
| 2003 | 2 | 28.0 | 1.5 | 28.0 | $30,340,377 | 0.87140 | $26,438,651 |
| 2004 | 3 | 28.0 | 1.5 | 28.0 | $30,340,377 | 0.81344 | $24,680,188 |
| 2005 | 4 | 28.0 | 1.5 | 28.0 | $30,340,377 | 0.75934 | $23,038,682 |
| 2006 | 5 | 28.0 | 1.5 | 28.0 | $30,340,377 | 0.70883 | $21,506,354 |
| 2007 | 6 | 28.0 | 1.5 | 28.0 | $30,340,377 | 0.66169 | $20,075,943 |
| 2008 | 7 | 28.0 | 1.5 | 26.5 | $30,362,877 | 0.61768 | $18,754,568 |
| 2009 | 8 | 26.5 | 1.5 | 25.0 | $30,547,377 | 0.57659 | $17,613,564 |
| 2010 | 9 | 25.0 | 1.5 | 23.5 | $31,208,377 | 0.53824 | $16,797,849 |
| 2011 | 10 | 23.5 | 1.5 | 22.0 | $32,137,377 | 0.50244 | $16,147,380 |
| 2012 | 11 | 22.0 | 1.4 | 20.6 | $33,227,977 | 0.46903 | $15,584,925 |
| 2013 | 12 | 20.6 | 0.6 | 20.0 | $33,737,377 | 0.43783 | $14,771,388 |
| 2014 | 13 | 20.0 | 0.6 | 19.4 | $34,314,577 | 0.40871 | $14,024,836 |
| 2015 | 14 | 19.4 | 0.5 | 18.9 | $34,810,077 | 0.38152 | $13,281,077 |
| 2016 | 15 | 18.9 | 0.5 | 18.4 | $35,155,859 | 0.35615 | $12,520,890 |
| 2017 | 16 | 18.4 | 0.4 | 18.0 | $35,155,859 | 0.33246 | $11,688,112 |
| 2018 | 17 | 18.0 | 0.4 | 17.6 | $35,155,859 | 0.31035 | $10,910,723 |
| 2019 | 18 | 17.6 | 0.4 | 17.2 | $35,155,859 | 0.28971 | $10,185,039 |
| 2020 | 19 | 17.2 | 0.4 | 17.0 | $35,155,859 | 0.27044 | $9,507,621 |
| 2021 | 20 | 17.0 | 0.0 | 17.0 | $35,155,859 | 0.25245 | $8,875,259 |
| | | | | | | | $334,725,453 |
| | | | | | Partial Payment Factor | | 0.0953119 |
| | | | | | Average Annual Value | | $31,903,318 |
| | | | | | Rounded Average Annual Value | | $31,903,300 |

*Table 12* indicates that grain tonnages on the Montreal trade route will switch to an alternate port (Chicago) when Toledo Harbor's channel depths equals 18.59 feet. *Table 11* shows that Toledo Harbor's channel depth will equal 18.59 feet in the year 2016, or project evaluation year 15. Consequently, all yearly total transportation costs up to project year 14 will be associated with using Toledo Harbor. Under "Without Project" conditions, Toledo Harbor channels start shoaling up in project year 7. Thus from project year 1 to project year 6, shippers will have a 28-foot channel depth. Total annual grain water and rail transportation costs associated with a 28.0-foot Toledo Harbor channel depth is $30,340,400 (see *Table 9*). The water cost associated with a 28-foot Toledo Harbor channel is $13,887,000 (*Table 4*) and the rail costs associated with a 28-foot Toledo Harbor channel is $16,453,400 (*Table 7*).

In project year 7, the Toledo Harbor channel depth has shoaled to a 26.5 feet. The grain trade water cost associated with continuing to use Toledo Harbor has now risen to $13,909,500. This water transportation cost was interpolated from the 27.0-foot and 26.0-foot water transportation cost provided in *Table 4*. However, the rail cost has remained at $16,453,400. Consequently total "Without Project" condition grain transportation costs for project year seven has risen to $30,362,900 for the Montreal, Quebec, trade route. This process is continued for each of the remaining years in the 20-year evaluation period until the grain traffic transfers to the alternate port: Chicago. Again, this transfer happens when Toledo Harbors channel depth reaches 18.59 feet. This happens in project year 15. Therefore total "Without Project" condition grain transportation costs, from project year 15 to project year 20, are transportation costs associated with using the alternate port: Chicago. The total "Without Project" condition grain transportation costs associated with using Chicago, Illinois, is $35,155,900. (Note: Total grain transportation costs are less through Chicago ($35,155,900) than continuing to remain at Toledo after project year 15 ($35,363,600 when Toledo Harbor channel depths reach 18.4 feet).)

A time stream of total "Without Project" condition grain transportation costs, for each project evaluation year in the 20-year evaluation period, is presented in *Table 22*. These annual total transportation costs were converted to present worth values using a 7.125 percent annual interest rate. These present worth values were summed and then converted to an average annual value using a 7.125 percent annual interest rate and a 20-year project evaluation. Grains "Without Project" condition total average annual transportation cost came to $31,903,300.

### 7d. "Without Project" Condition Total Average Annual Transportation Costs

*Table 18* provided a summary of total average annual "Without Project" condition transportation costs for iron ore, coal, and grain for each origin/destination pair evaluated. These "Without Project" condition total average annual transportation costs include the water leg and rail leg component costs. Total average annual "Without Project" condition transportation costs for iron ore, coal, and grain came to $205,298,100.

## D Total Average Annual Transportation Benefits Associated With Maintaining Toledo Harbor

Benefits have been defined as the difference in average annual transportation costs between the "Without Project" condition and the "With Project" condition. *Table 18* summarized total "Without Project" condition average annual transportation costs, by origin destination route. Total "Without Project" condition average annual transportation costs came to $205,298,100. *Table 9* summarized total "With Project" condition average annual transportation costs. Total "With Project" condition average annual transportation costs came to $196,980,800. *Table 23* provides a summary of total average annual transportation benefits, by commodity, by origin/destination pairs. Total average annual transportation benefits associated with maintaining Toledo Harbor are $8,317,300. These average annual benefits reflect September 1998 prices, a 7.125 percent annual interest rate, and a 20-year project life.

These average annual benefits would accrue to any Long Term Dredged Material Management Plan that provides a 28-foot channel over the 20-year evaluation period. The average annual transportation benefits generated can be converted to a present worth value by applying the present worth of a dollar per period factor for a 7.125 percent annual interest rate and a 20-year project evaluation period. This factor is 10.49187. Consequently, transportation benefits alone will support a Long Term Dredged Material Management Plan that costs up to $87,264,000.

## Table23. Total Average Annual Transportation Benefits Associated with Maintaining Toledo Harbor - 20 Year Evaluation Period

| Average Annual Iron Ore Benefits | Average Annual Without Project Transportation Costs | Average Annual With Project Transportation Costs | Average Annual Benefits |
|---|---|---|---|
| Duluth, Minnesota | $ 22,375,700 | $ 20,831,000 | $1,544,700 |
| Presque Isle, Mn. | $ 4,258,700 | $ 3,964,700 | $ 294,000 |
| Silver Bay, Mn. | $ 40,250,900 | $ 37,326,100 | $2,924,800 |
| Two Harbors, Mn. | $ 1,905,300 | $ 1,772,300 | $ 133,000 |
| Sept Isles, Quebec | $ 9,676,700 | $ 9,283,200 | $ 393,500 |
| | $ 78,467,300 | $ 73,177,300 | $5,290,000 |
| **Average Annual Coal Benefits** | | | |
| **Canadian** | | | |
| Hamilton, Ont. | $ 16,793,800 | $ 16,227,300 | $ 566,500 |
| Montreal, Ontario | $ 807,200 | $ 765,100 | $ 42,100 |
| Nanticoke, Ont. | $ 4,045,400 | $ 3,972,500 | $ 72,900 |
| St. Catherines, Ont. | $ 645,300 | $ 625,200 | $ 20,100 |
| Sault St. Marie, Ont. | $ 21,913,300 | $ 21,734,000 | $ 179,300 |
| ThunderBay, Ont. | $ 379,000 | $ 361,400 | $ 17,600 |
| | $ 44,584,000 | $ 43,685,500 | $ 898,500 |
| **United States** | | | |
| Alpena, Mi. | $ 788,700 | $ 782,500 | $ 6,200 |
| Ashland, Mi | $ 1,206,800 | $ 1,186,500 | $ 20,300 |
| Cleveland, Oh | $ 193,300 | $ 192,600 | $ 700 |
| Dearborne, Mi | $ 6,493,600 | $ 6,487,600 | $ 6,000 |
| Detroit, Mi | $ 8,912,700 | $ 8,903,700 | $ 9,000 |
| Duluth, Mn | $ 1,179,300 | $ 1,161,000 | $ 18,300 |
| Escanaba, Mi | $ 5,689,300 | $ 5,478,000 | $ 211,300 |
| Gladstone, Mi | $ 415,700 | $ 411,100 | $ 4,600 |
| Green Bay, Wi. | $ 7,199,200 | $ 7,060,400 | $ 138,800 |
| Holland Mi | $ 3,526,600 | $ 3,496,600 | $ 30,000 |
| Harbor Beach, Mi | $ 367,200 | $ 365,300 | $ 1,900 |
| Manistee, Mi | $ 3,827,100 | $ 3,794,300 | $ 32,800 |
| Manitowoc, Wi. | $ 409,600 | $ 405,600 | $ 4,000 |
| Marinette, Wi. | $ 348,100 | $ 343,800 | $ 4,300 |
| Milwaukee, Wi | $ 1,289,700 | $ 1,277,000 | $ 12,700 |
| Marysville, Mi | $ 1,037,200 | $ 1,031,500 | $ 5,700 |
| Munising, Mi | $ 997,000 | $ 990,800 | $ 6,200 |
| Muskegon, Mi | $ 579,900 | $ 569,500 | $ 10,400 |
| Ontonagon, Mi | $ 3,726,000 | $ 3,694,700 | $ 31,300 |
| Presque Isle, Mi. | $ 217,300 | $ 214,500 | $ 2,800 |
| Saginaw, Mi | $ 397,200 | $ 393,300 | $ 3,900 |
| St. Clair, Mi | $ 830,300 | $ 827,100 | $ 3,200 |
| Wyandotte, Mi. | $ 711,700 | $ 710,200 | $ 1,500 |
| | $ 50,343,500 | $ 49,777,600 | $ 565,900 |
| **Total Average Annual Coal Benefits** | $ 94,927,500 | $ 93,463,100 | $1,464,400 |
| **Total Average Annual Grain Benefits** | | | |
| Chicago, Ill. | $ 31,903,300 | $ 30,340,400 | $1,562,900 |
| **Total Average Annual Transportation Benefits** | $205,298,100 | $ 196,980,800 | $8,317,300 |
| Present Worth 1$/Period | | | 10.49187 |
| **First Costs That Can Be Covered By Benefits** | | | **$87,264,000** |