Staff Paper Series

Staff Paper P92-25

October 1992

# RURAL ROADS, INVESTMENT AND DISINVESTMENT IN A MINNESOTA COUNTY

Jerry Fruin

Dan Halbach

Department of Agricultural and Applied Economics
University of Minnesota

DEPARTMENT OF AGRICULTURAL AND APPLIED ECONOMICS

UNIVERSITY OF MINNESOTA

COLLEGE OF AGRICULTURE

ST. PAUL, MINNESOTA 55108

Staff Paper P92-25 October 1992

# RURAL ROADS, INVESTMENT AND DISINVESTMENT IN A MINNESOTA COUNTY

Jerry Fruin

Dan Halbach

Department of Agricultural and Applied Economics
University of Minnesota

This paper was presented to the University of Minnesota Center for Transportation Studies and State and Local Policy Program of the Hubert H. Humphrey Institute of Public Affairs Research Symposium in Minneapolis, Minnesota on October 1, 1992.

## Introduction

An adequate road system is essential for the economic and social well-being of the U.S. rural population. The typical rural family relies on the road system for essential communication between town and city service centers. Children are bused to school. Farm produce is shipped, farm supplies are delivered, and repair parts, groceries, and household supplies are purchased many times throughout the week. Many vehicles, such as school buses and milk trucks, require year-round accessibility. Many rural families have one or more members who commute to factory or service jobs just as regularly as families who live in the cities. It is neither possible nor desirable for rural families to live in isolation.

Technological advancements have imposed the need that rural residents have better and safer roads. Faster speeds of passenger vehicles require smoother road surfaces for easy control and wider roads and intersections for safety. The heavier weights of vehicles require stronger roadbeds and bridges. Many rural roads do not meet reasonable standards for today's use. Other roads, adequate now, will deteriorate if funds are not available for required maintenance. On the other hand, the number and mileage of rural roads in some areas maybe excessive because of the technological advances in transportation, agriculture, and related industries (Fruin 10).

## Background

The local rural road system--that is those roads maintained and controlled by counties or townships--consists of 2.2 million miles and represents 71% of the 3.2

million miles of rural roads in the United States. The system is generally laid out in rectangular grids, particularly in the Midwest where the regularity of the county roads dates back to the Ordinance of 1785 that established the one-mile survey grids to open the land for settlement.

Many of today's local rural roads and bridges were first built in the late 1800s and early 1900s when overland transportation was limited to horse and wagon or the recently built railroad lines. The discovery of large petroleum reserves in Texas and Oklahoma spurred the development of the automobile and truck industries during the 1920s and 1930s and created a need to get rural American "out of the mud." Roads were surfaced, and some bridges were replaced to accommodate trucks with gross weights of six to seven tons. About 70% of today's rural bridges were built before 1935, but even those constructed in the 1940s were designed only for 15-ton loads.

By 1950 about 50% of the local rural roads were improved with all-weather gravel or paved surfaces. Thus the widths, grades, bases, surface designs, and capacities of many local rural roads and bridges are based on the traffic needs of the 1940s and 1950s.

The declining number of farms and the increasing size of farm trucks and implements are changing the traffic on the local rural road system. There are no weight limits on "implements of husbandry" (farm equipment). Today some farmers use a tractor and two wagons to haul 600 to 900 bushels of grain with a gross weight of 28 to 36 tons. Many bridges are over 55 feet long, so that the entire load is on the bridge at one time. Some single-axle wagons hold over 800 bushels of grain; after deducting about 6,000 pounds of hitch weight, the loaded weight ranges up to 50,000 pounds per axle.

As farm size has increased, so have the trucks serving agriculture. Tandem-axle trucks with gross weights of 27 tons are common on rural roads and bridges. In 1975, the U.S. Congress permitted states to set higher weight limits for trucks on the interstate highway system. Most states adopted the federal limits and raised the weight limits to the federal standard of 20,000 pounds per axle, 34,000 pounds per two-axle tandem, and 80,000-pound maximum overall weight.

The introduction of low-cost unit grain trains in the corn and wheat states has encouraged the use of larger farm vehicles to haul grain longer distances. Some farmers are buying tandem-axle and semi-trailer trucks to move their grain out of the field quickly, to increase their marketing options, to reduce hauling costs, and to eliminate the safety hazards of farm tractor-wagon combinations. These heavy vehicles place additional stress on the local road and bridge system.

In most instances, a farmer increases his farm size by buying or leasing land from neighboring farms, thereby reducing the total number of farms. This reduction in the number of farms means that some rural roads may no longer by needed for access to homes, schools, and markets. Some observers believe that the miles of rural roads might be reduced without denying access to the remaining farms and residences.

And finally, the declining rural population has resulted in a reduction in the number of rural schools. To help minimize the cost of transporting school children farther to fewer schools, school boards are purchasing 72-89-passenger school buses. These school buses weigh up to 15 tons when loaded and cannot cross bridges that are posted at less than their gross weights.

Precise data on the current condition of the local rural road system are not available since no ongoing coordinated data collection exists for local rural roads. However, there is ample evidence that the system is deteriorating rapidly. In a recent Illinois survey, farmers and agribusiness representatives rated about half of the Illinois local rural roads as needing more than regular maintenance; over 20% of these roads were rated as needing major repair.

USDA's Office of Transportation reveals that almost half of the rural road and bridge mileage has an earth, gravel, or loose kind of aggregate surface. Over one-third of this rural mileage is classified by township officials as barely adequate or even worse. County officials estimate that the annual average cost of maintenance of a mile of rural road ranges from $1,890 for loose aggregate or gravel, up to $5,109 for concrete or paved surfaces.

Common complaints about the local rural roads include:

1. Overweight vehicles breaking up road surfaces.
2. Lack of hard surfaces creating dust and rideability problems.
3. Road widths and other design characteristics inadequate for today's large farm equipment and heavy trucks.
4. Narrow lanes creating safety problems.

While the local road deficiencies are significant, the condition of local bridges is also of great concern. Deficient bridges on local rural roads create serious safety and traffic constraints. On 1 January 1986, 167,985 bridges or 55% of all off-federal-aid bridges that had been inventoried were deficient. In addition, 121,507 or 40% of the 304,948 on-federal-aid bridges were posted, or should have been posted, at less than legal weight limits. The estimated replacement and rehabilitation costs of these deficient off-system bridges is $20.4 billion. However, even this understates the magnitude of the problem. Bridges under 20 feet long were not included in the inventory, and thousands of such bridges need replacement or rehabilitation.

Because of the above reasons, the financing of the rural road system is becoming a major concern to rural officials. Local rural road and bridge construction and maintenance funds are typically obtained from highway user taxes and local property taxes. Highway user tax collections have increased recently because of large increases in fuel and truck road use taxes. However, the increased fuel efficiency of new model cars tends to reduce income from fuel taxes and there is severe competition for funds from state, federal and municipal jurisdictions for their infrastructure and from competing transportation modes such as rapid transit.

## Literature Review

The most extensive study of rural road management was done by Baumel (1) at Iowa State. Baumel used a benefit cost analysis to analyze alternative strategies using three study areas of 100 square miles each. Using Dijkstra's algorithm, Baumel created a network model consisting of nodes (intersection, farm gate, or similar dwelling) connected by arcs (the road in between the node). Data was collected pertaining to quantity, origins and destinations by vehicle type for household and farm travel. Data collection was performed by professional statisticians and interviewers. Baumel considered several alternative strategies and the results of their analyses showed that in each of the study areas, low volume roads could be removed with savings in maintenance costs to the county greater than the increased travel cost incurred by the traveling public. The study also concluded that impact on farm travel cost was greater than that of household travel cost.

Several papers stemming from this study were more specific about certain aspects of the study. In estimating farm vehicle travel cost, Baumel (2) revealed that most of the variance in travel cost is a function of size and type of the equipment as well as the type of the road surface. Zaniewski (22) found that road roughness of paved roads had little influence on travel cost, but that nonpaved roads indeed had adverse effects on travel cost.

Tucker and Thompson (18) examined the impact of rural road management on grain marketing costs and addresses the question of the implications on the agriculture and rural communities from rural road improvement. They developed a linear programming transportation model to deal with the problem of distributing a homogenous product (in this case grain) from many spatially separated sources to a specific destination (in this case, an elevator). The model provided an optimal commodity flow at a minimum farm to market cost. After examining several scenarios, Tucker and Thompson showed that road deterioration places an added cost to grain producers and that producer costs decrease as road development increases. However, the decrease in grain transportation alone cannot justify an increase public investment of road maintenance. Specifically, road deterioration led to cost increase which was 39 times less than the corresponding investment to achieve this benefit. That is, public investment to repair a deteriorated road and decrease producer cost would cost 39 times greater than the benefit received by the producer. Furthermore, changes in the condition of the rural road system have little effect on optimal grain marketing traffic flow, the impact has a greater effect on producers than elevators, and the benefits to the grain industry are relatively small compared to the investment involved.

Hitzhusen and Nyamaah (12) developed a circuity cost model for measuring costs and benefits of rural bridge rehabilitation, closure or posting and estimating and comparing the costs and benefits using a case study. They found a substantial increase in savings to motorist could be made by adopting the circuity cost model compared to that of the county procedure (in this case, Wayne County, Ohio). Also found was that there were substantial costs incurred by the traveling public when bridges were posted.

Chicoine and Walzer (3) did the first major study which examined the physical and financial condition of rural road infrastructure in four midwestern states (Illinois, Minnesota, Ohio, Wisconsin). Information was collected through mail surveys to farmers, township representatives, and agribusiness. Information was studied to examine the need for updating of managerial practices, maintaining and upgrading roads and the financial resources available for maintaining and upgrading. There was an effort made to incorporate views of the farmers, road users and the government officials responsible for the roads. Several recommendations were made to aid local officials in better managing their road network and finances.

Chicoine and Walzer also edited a book (4) which offered numerous chapters from different authorities providing a broad background in the physical and financial resource condition of the rural infrastructure.

Smith, Wilkinson, and Anschel (1973) examined the impact of unimproved roads in the eastern Kentucky coal fields on resident participation in social recreation, education, and medical activities. They found that lack of access to all-weather roads had no measurable adverse effect on human resource development and cultural integration.

The Midwest Research Institute (1969) developed criteria for evaluating low volume rural roads for potential abandonment. These criteria were to be used to calculate a benefit-cost ratio for each road, and type of users, type of road, and access requirements. Each factor was assigned an arbitrary weight and aggregated into an index. The costs of retaining a road included the 20-year routine maintenance and capital costs, liability risks, and vacating costs. The benefit index does not include any monetary measures of the value of an individual road to the traveling public. This procedure does not measure the change in cost to the traveling public from eliminating a road or set of roads from the network, nor does it measure the maintenance and resurfacing cost transferred to roads that inherit additional traffic.

Johnson (13) developed models that could be used to estimate the benefits of road improvements, including building a new road, replacing and upgrading bridges, and widening or resurfacing a road. The analysis was conceptual rather than empirical, and no measured benefits were presented.

### Research Objective of the Methodology

The objective of this research is to evaluate a number of strategies for the use of limited funds to maintain and/or improve the rural transportation infrastructure. The basic concept is that the rural road infrastructure in one or more small areas will be studied intensively. Scenarios will be developed to consider the effects of different levels of road maintenance, development of optimal networks of paved roads, elimination of maintenance and/or the revision to private ownership of little used roads and different levels of bridge improvements. Decision criteria will be cost based. Possible cost components include:

A.
1. Vehicle operating expense by road or surface type by type of vehicle.
2. Opportunity cost of travel by trip type/person type.
3. Road maintenance costs by road category.
4. Bridge maintenance costs by bridge type.
5. Road upgrading costs--total or annualized.
6. Bridge upgrading costs--total or annualized.

B.
1. Opportunity costs of land added or dropped from road system.

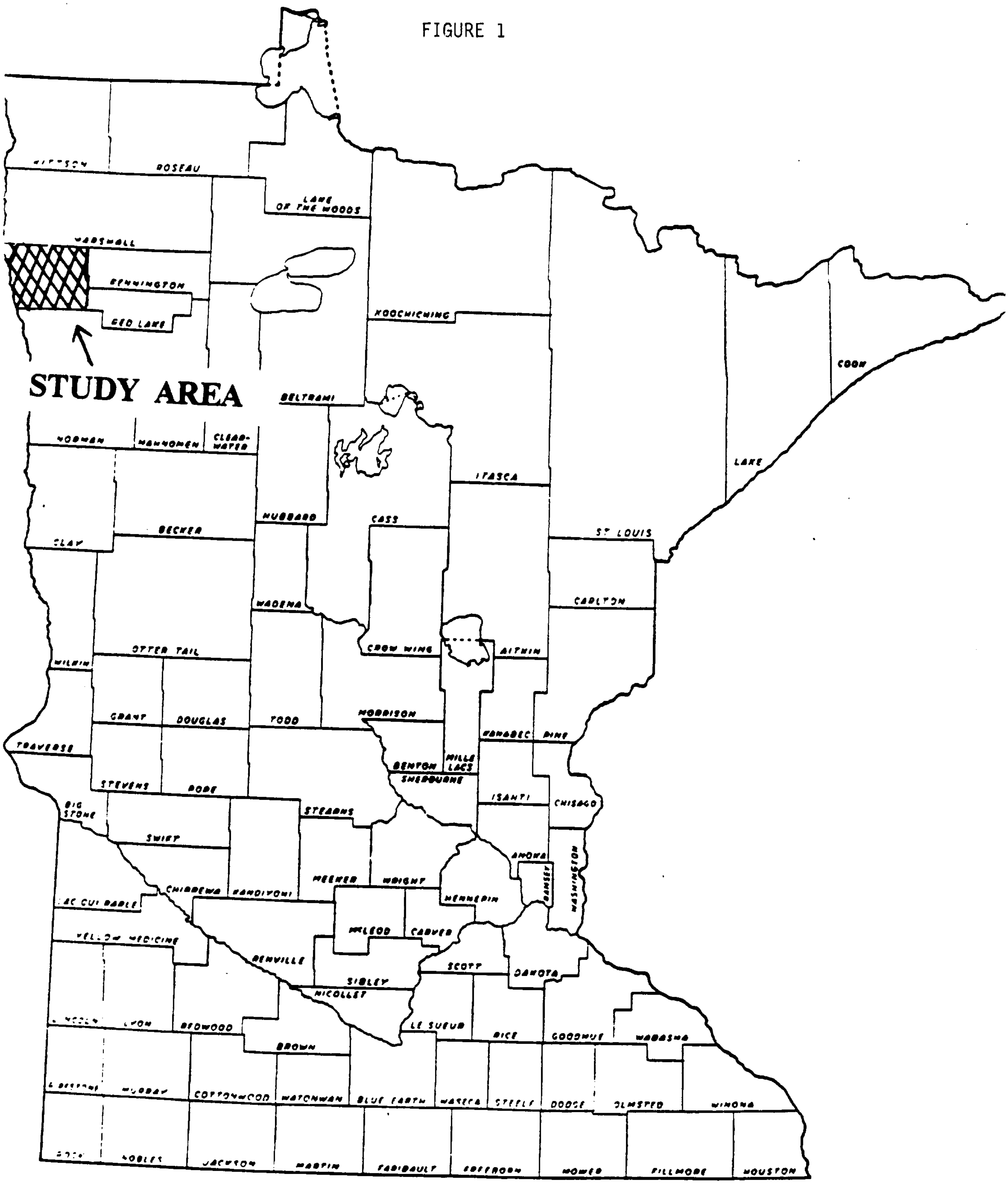
A number of possible criteria exist for determining the "best" management scenario. An example would be to minimize the total costs A1-A6. Another example would be to minimize total vehicle operating costs not exceeding a given maintenance budget (Halbach 11).

## Area Characteristics of the Study Area

The area that was modelled and simulated was the NW 1/3 of Polk County Minnesota in the Red River Valley (Figure 1). It was selected with the assistance of the Minnesota Association of County Engineers. The exact area (which is almost as large as a small county) contains about 580 sq. mi. and is definitely rural. The largest town is East Grand Forks with a population of 8,500. The area has nearly complete one square mile grid network of roads that are primarily township or county roads with a few state and federal roads (Figure 2).

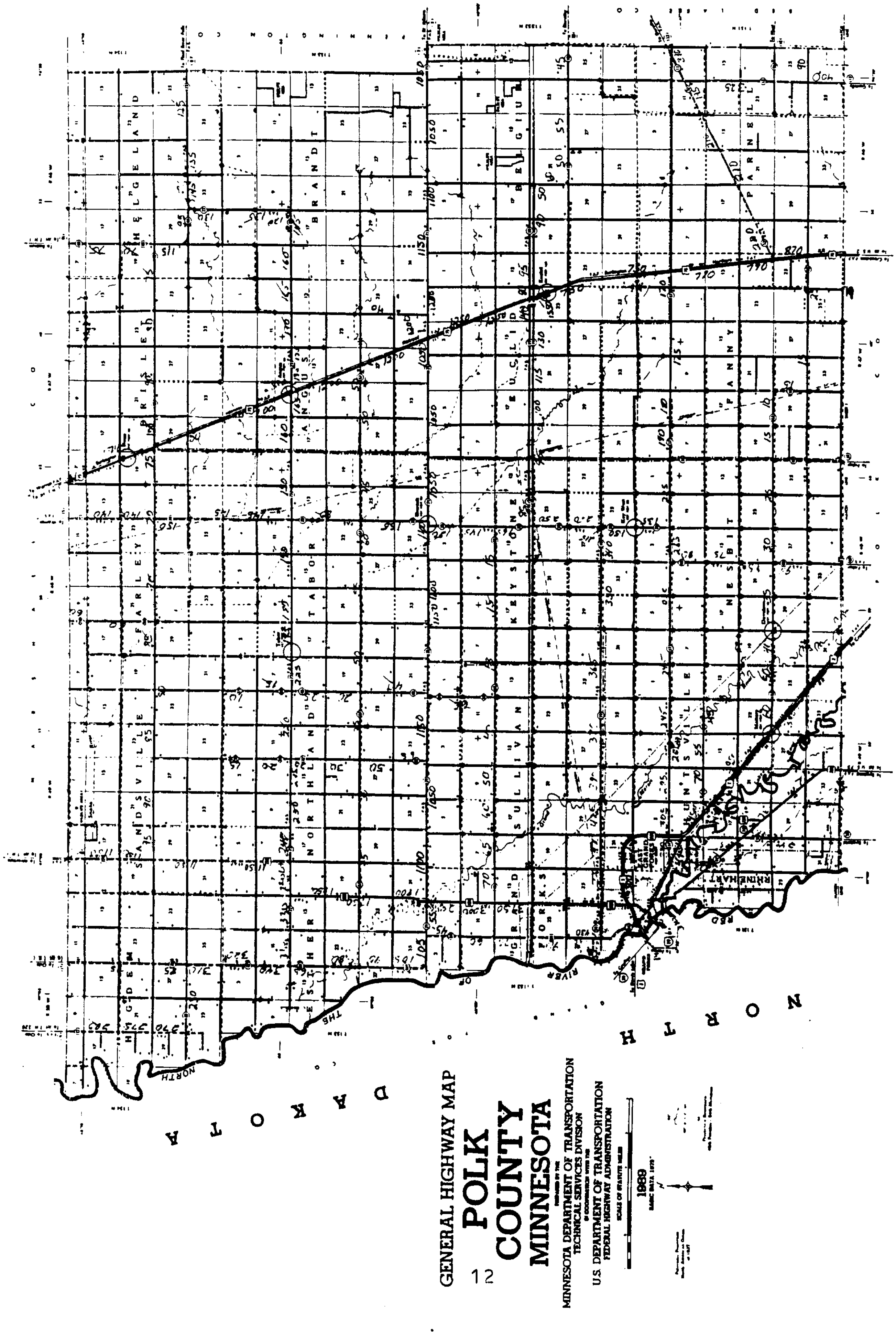
The western third of the area is the flood plain of the Red River Valley. Farmers there raise sugar beets and potatoes and engage in very highly intensive agriculture. There are two to three farms or residences per square mile on average. The center third of the area has less intensive agriculture, with some sugar beets and potatoes but proportionately more wheat and small grains. There are one to two households per sq. mi. The eastern 1/3 is more suited for small grains then intensive agriculture and has less than one family dwelling unit per sq. mi.

FIGURE 1



STUDY AREA
ROSEAU
LAKE OF THE WOODS
MARSHALL
PENNINGTON
KOOCHICHING
COOK
BELTRAMI
NORMAN
MAHNOMEN
CLEARWATER
LAKE
ITASCA
HUBBARD
CASS
BECKER
ST LOUIS
CARLTON
WADENA
OTTER TAIL
CROW WING
AITKIN
WILKIN
GRANT
DOUGLAS
TODD
MORRISON
KANABEC
PINE
TRAVERSE
BENTON
MILLE LACS
SHERBURNE
STEVENS
POPE
ISANTI
CHISAGO
BIG STONE
STEARNS
SWIFT
ANOKA
MEEKER
WRIGHT
CHIPPEWA
KANDIYOHI
HENNEPIN
RAMSEY
WASHINGTON
MCLEOD
CARVER
RENVILLE
SCOTT
DAKOTA
SIBLEY
NICOLLET
LE SUEUR
REDWOOD
BROWN
RICE
GOODHUE
WABASHA
COTTONWOOD
WATONWAN
BLUE EARTH
WASECA
DODGE
WINONA
JACKSON
MARTIN
FARIBAULT
FREEBORN
MOWER
FILLMORE
HOUSTON

FIGURE 2



GENERAL HIGHWAY MAP
POLK COUNTY
MINNESOTA
MINNESOTA DEPARTMENT OF TRANSPORTATION
TECHNICAL SERVICES DIVISION
U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
1989
NORTH DAKOTA
RED RIVER OF THE NORTH

The area has two major federal roads, U.S. 2 going into E. Grand Forks in the southwest corner of the area, and Highway 75 which bisects the area in a north-south direction. There is also a north-south state highway near the Red River.

## Area Traffic

Area traffic was divided into three categories for modeling purposes. These were:

a. Agricultural marketing traffic
b. Personal travel
c. Overhead traffic

Agricultural marketing trips by vehicle type were estimated for each crop by township from ASCS data and interviews with elevators and processors and assigned to a 1 mile square section. For modeling purposes, it was assumed that all truckloads of ag commodities in a section would enter the road system at the southwest corner of the section.

Personal travel, that is, the number of automobile trips by residents of the area, was estimated from secondary data from an Iowa State University study by Baumel (1). Over 2000 households in 3 rural locations in Iowa were interviewed about trip frequency, purpose and destination. The average number of trips per household for all purposes was 2.13 round trips per day including business trips, commuting trips, grocery trips, childcare trips, etc. NW Polk County residents were interviewed to determine traffic patterns. The estimated 2.13 trips per farm or rural dwelling were assigned to 3 or 4 destination locations depending on traffic patterns determined from the interviews.

The third type of traffic is overhead traffic. Overhead traffic is traffic going through but not having an origin or destination in the area. Overhead traffic trips were derived from the Minnesota Department of Transportation (MDOT) average daily traffic (ADT) data. MDOT periodically takes a traffic count on all county and state roads. Personal and agricultural traffic trips were subtracted from the ADT on each road. The remainder was assumed to be overhead traffic trips.

## Surface Type and Jurisdiction

Table 1 shows the number of miles for each category of surface type and political jurisdiction in 1989, the baseline year. Type of surface is across the top, and political jurisdiction on the side. Township and county roads, which are supported entirely by property taxes and other local revenues, accounted for 835 miles or 74% of the 1,135 total miles of road in the are. County state aid highways (CSAH), which are supported in part by state fuel taxes and vehicle fees, accounted for 238 miles or 21% of the roads in the study area. State and federal roads, which receive no local funding, accounted for 62 miles or 5.5% of the area's road mileage.

Over 20% of the total area road mileage is dirt surfaced township roads. The remainder of the township and county roads are gravel surfaced. The CSAH roads are more than half gravel surfaced with the remainder hard surfaced. The state and federal roads are all hard surfaced, i.e., concrete or bituminous.

TABLE 1

POLK COUNTY MINNESOTA STUDY AREA
BASELINE NETWORK ROAD MILES

| | Concrete | Bituminous | Gravel | Dirt | Total |
|---|---|---|---|---|---|
| Township/County | 0.0 | 0.6 | 603.9 | 230.1 | 834.6 |
| percent of total | 0.0 | 0.1 | 53.2 | 20.3 | 73.6 |
| CSAH | 28.2 | 75.6 | 134.9 | 0.0 | 238.7 |
| percent of total | 2.5 | 6.7 | 11.9 | 0.0 | 21.0 |
| State | 17.7 | 9.1 | 0.0 | 0.0 | 26.8 |
| percent of total | 1.6 | .8 | 0.0 | 0.0 | 2.4 |
| U.S. | 34.8 | 0.0 | 0.0 | 0.0 | 34.8 |
| percent of total | 3.0 | 0.0 | 0.0 | 0.0 | 3.0 |
| Total | 80.6 | 85.3 | 738.8 | 230.1 | 1134.9 |
| percent of total | 7.1 | 7.5 | 65.1 | 20.3 | 100.0 |

1989 Baseline Total Vehicle Operating Costs

Computer simulations were done to compute vehicle operating costs (VOC) for the baseline road network by purpose and vehicle type in 1989. Vehicle operating costs include fuel, oil, maintenance and other types of variable costs associated with operating vehicles on different surfaces. Not included were the fixed costs of time depreciation, insurance or license fees. Driver wages or the opportunity costs of driver time were not included for personal travel or overhead traffic. Agricultural travel had driver costs of $8.40/hr for farm labor or $12.60/hr for commercial drivers.

Table 2 shows the breakdown of the simulated vehicle operating costs for the area in 1989 for personal travel by surface type and jurisdiction. Total costs (for 2.13 round trips per household per day) were $1.438 million. Although only 7.1% of the roads are concrete surfaced, 47.5% of the personal travel VOC occurred on concrete surfaced roads. Sixty-five percent of the roads are gravel, but only 32.8% of the VOC occurred on gravel. The CSAH system is 21% of the road network, but 36.5% of the personal travel VOC occurred there. Seventy-three percent of the roads are township roads, but only 21% of the VOC occurred there. The baseline simulated VOC for personal travel 1989 totaled $1,438,100.

Table 3 shows the breakdown of the simulated 1989 baseline ag traffic VOC required to move the major crops from the farms to local elevators or processors. Notice much of the cost (66.4%) occurred on concrete and bituminous roads and only 1.6% was incurred on dirt surfaced roads. The CSAH system accounted for 51% of the ag marketing traffic VOC but includes only 21% of the roads. Township and

TABLE 2

POLK COUNTY MINNESOTA STUDY AREA

**BASELINE PASSENGER CAR TRAVEL COSTS**

**IN 000s**

| | Concrete | Bituminous | Gravel | Dirt | Total |
|---|---|---|---|---|---|
| Township/County | 0 | 0 | 283.2 | 24.6 | 307.8 |
| % of total | 0 | 0 | 19.7 | 1.7 | 21.4 |
| CSAH | 112.9 | 222.5 | 188.8 | 0 | 524.3 |
| % of total | 7.9 | 15.5 | 13.1 | 0 | 36.5 |
| State | 293.6 | 36.0 | 0 | 0 | 329.6 |
| % of total | 20.4 | 2.5 | 0 | 0 | 22.9 |
| U.S. | 276.2 | 0 | 0 | 0 | 276.3 |
| % of total | 19.2 | 0 | 0 | 0 | 19.2 |
| Total | 682.9 | 258.6 | 472.0 | 24.6 | 1438.1 |
| % of total | 47.5 | 18.0 | 32.8 | 1.7 | 100.0 |

TABLE 3

POLK COUNTY MINNESOTA STUDY AREA

**BASELINE AG TRAFFIC COSTS**

**IN 000s**

| | Concrete | Bituminous | Gravel | Dirt | Total |
|---|---|---|---|---|---|
| Township/County | 0 | 0 | 155.6 | 12.4 | 168.0 |
| % of total | 0 | 0 | 20.4 | 1.6 | 22.0 |
| CSAH | 58.3 | 242.2 | 88.1 | 0 | 388.7 |
| % of total | 7.6 | 31.8 | 11.6 | 0 | 51.0 |
| State | 124.2 | 5.0 | 0 | 0 | 129.2 |
| % of total | 16.3 | .6 | 0 | 0 | 16.9 |
| U.S. | 76.6 | 0 | 0 | 0 | 76.6 |
| % of total | 10.1 | 0 | 0 | 0 | 10.1 |
| Total | 259.0 | 247.3 | 243.7 | 12.4 | 762.4 |
| % of total | 34.0 | 32.4 | 32.0 | 1.6 | 100.0 |

county traffic roads accounted for only 22% of the ag marketing VOC although they account for 73% of the total mileage. The total simulated baseline ag marketing VOC was $762,400 or only about half of the personal travel VOC total of $1,438,000.

The breakdown of the simulated area overhead travel VOC by surface type and jurisdiction is shown in Table 4. The total baseline simulated overhead VOC exceeded $5.5 million. Note that this is a small area and the amount of overhead traffic in other areas will vary depending on location and traffic pattern. In this case, much of the overhead traffic was not on the state and federal system but on CSAH roads going east and west through the region.

Table 5 breaks down the total 1989 simulated VOC for all three purposes by surface type and jurisdiction. The total simulated VOC was $7.7 million. Ag marketing traffic accounted for 10% of the total VOC, personal travel accounted for 19% of the total, and overhead traffic accounted for 71% of the total.

Over half of the total VOC occurred on concrete highways, nearly 30% on bituminous highways, 20% on gravel, and only 1/2 of 1% on dirt roads. The CSAH system which has 21% of the road mileage accounted for 35% of the VOC. The township and county roads with 73% of the road milage had only 11% of the total simulated VOC.

<u>Less Intensive Crop Production Scenario</u>

This is an intensive ag area with sugar beet and potato production. The average yield of sugar beets there is 19.5 tons/ac and the average yield of potatoes is 9

TABLE 4

POLK COUNTY MINNESOTA STUDY AREA

**BASELINE OVERHEAD TRAFFIC COSTS**

**IN 000s**

| | Concrete | Bituminous | Gravel | Dirt | Total |
|---|---|---|---|---|---|
| Township/County | 0 | 0 | 369.4 | 0 | 369.4 |
| % of total | 0 | 0 | 6.7 | 0 | 6.7 |
| CSAH | 159.5 | 1198.1 | 446.7 | 0 | 1804.3 |
| % of total | 2.9 | 21.7 | 8.1 | 0 | 32.7 |
| State | 816.7 | 545.3 | 0 | 0 | 1362.0 |
| % of total | 14.8 | 9.9 | 0 | 0 | 24.7 |
| U.S. | 1976.0 | 0 | 0 | 0 | 1976.0 |
| % of total | 35.9 | 0 | 0 | 0 | 35.9 |
| Total | 2952.1 | 1743.5 | 816.0 | 0 | 5511.5 |
| % of total | 53.6 | 31.6 | 14.8 | 0 | 100.0 |

TABLE 5

POLK COUNTY MINNESOTA STUDY AREA
TOTAL BASELINE VEHICLE OPERATING COSTS
PASSENGER, AG AND OVERHEAD
IN 000s OF DOLLARS

| | Concrete | Bituminous | Gravel | Dirt | Total |
|---|---|---|---|---|---|
| Township/County | 0 | 0 | 808.2 | 37.0 | 845.2 |
| percent of total | 0 | 0 | 10.4 | .5 | 10.9 |
| CSAH | 330.7 | 1663.0 | 723.6 | 0 | 2717.3 |
| percent of total | 4.3 | 21.6 | 9.4 | 0 | 35.3 |
| State | 1234.4 | 586.3 | 0 | 0 | 1820.7 |
| percent of total | 16.0 | 7.6 | 0 | 0 | 23.6 |
| U.S. | 2328.9 | 0 | 0 | 0 | 2328.9 |
| percent of total | 30.2 | 0 | 0 | 0 | 30.2 |
| Total | 3894.0 | 2249.3 | 1531.8 | 37.0 | 7712.7 |
| percent of total | 50.5 | 29.2 | 19.9 | .5 | 100.0 |

tons/acre. For wheat a yield of 1 to 2 tons/acre is normal. If wheat was grown on all crop acreage and had the average county yield, the ag marketing VOC would be only $178,000. The breakdown by surface and jurisdiction is shown in Table 5A. If only wheat is grown, ag traffic accounts for only 3% of the total VOC rather than 10% when sugar beets and potatoes are grown.

Road Improvement Simulations

One of the research objectives was to determine to what extent selected road improvements would provide cost savings. Changes were made to the computer model to simulate paving of road segments (i.e., the indicated road surface type was changed in the computer model) and the VOC recalculated. One of the simulations analyzed the VOC changes caused by the actual 1990 changes to the network.

In 1990 Polk County paved 16.3 mi. of gravel roads on their CSAH system with bituminous. These roads are shown on Figure 3. Note that several miles were paved on the road leading to Thief River Falls. Tables 6 through 9 show the simulated vehicle operating costs after these 1990 road improvements. The new total VOC is $7,768,600 compared to the 1989 baseline of $7,712,000. There was a reduction in vehicle operating costs of $53,400 resulting from paving those 16.3 miles. There is a savings in local passenger VOC of $13,900, ag marketing $8,200 and overhead VOC $31,300.

TABLE 5A

# BASELINE AG TRAFFIC COSTS

# ALL CROPLAND IN WHEAT

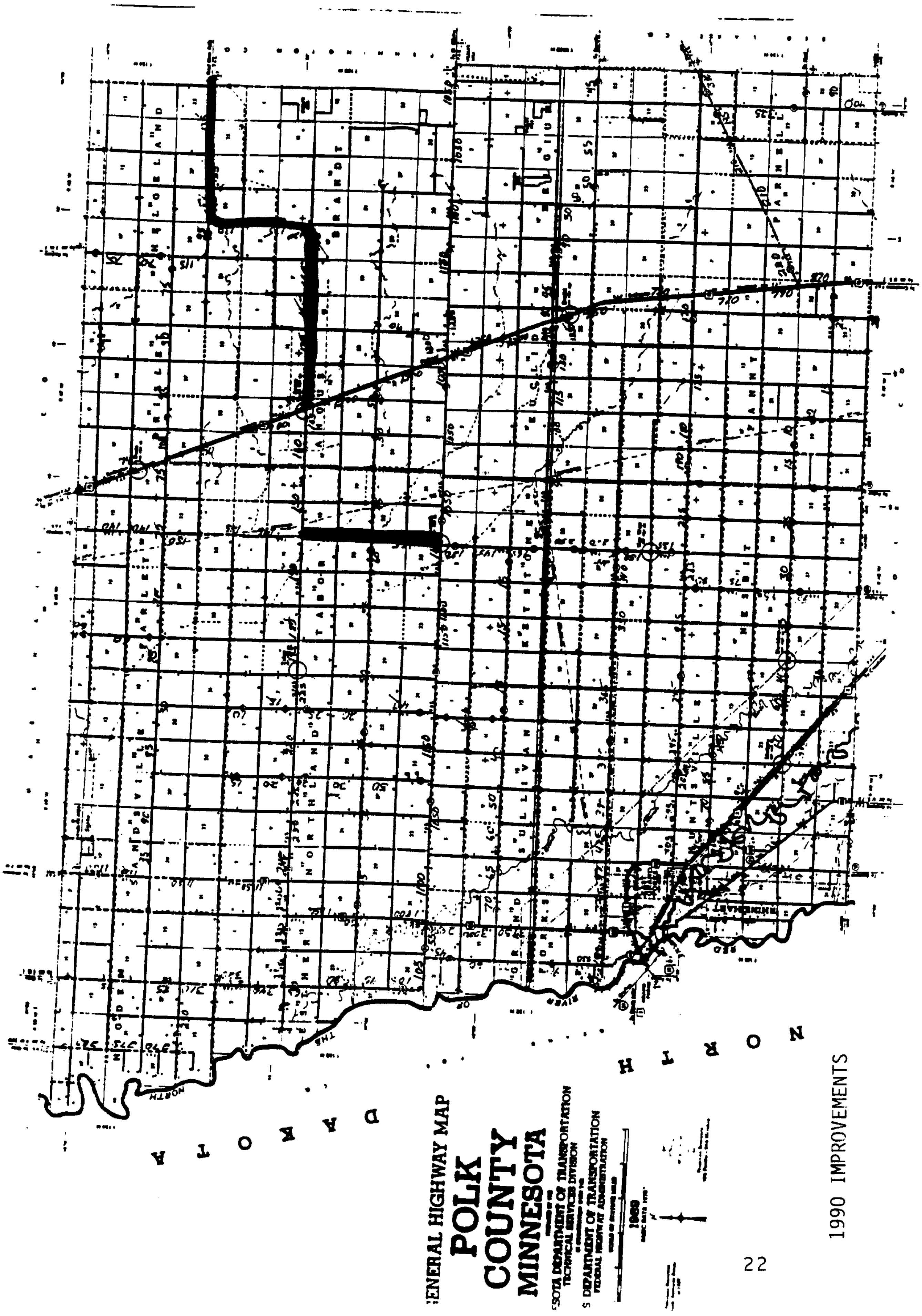
# (NO SUGAR BEETS OR POTATOES)

**IN 000s**

| | Concrete | Bituminous | Gravel | Dirt | Total |
|---|---|---|---|---|---|
| Township/County | 0.0 | 0.0 | 44.2 | 5.0 | 49.1 |
| % of total | 0.0 | 0.0 | 24.7 | 2.8 | 27.5 |
| CSAH | 16.3 | 39.9 | 18.7 | 0.0 | 74.9 |
| % of total | 9.2 | 22.4 | 10.5 | 0.0 | 42.0 |
| State | 23.8 | 2.6 | 0.0 | 0.0 | 26.3 |
| % of total | 13.3 | 1.4 | 0.0 | 0.0 | 14.8 |
| Federal | 28.1 | 0.0 | 0.0 | 0.0 | 28.1 |
| % of total | 15.7 | 0.0 | 0.0 | 0.0 | 15.7 |
| Total | 68.1 | 42.5 | 62.8 | 5.0 | 178.5 |
| % of total | 38.2 | 23.8 | 35.2 | 2.8 | 100.0 |

Existing cropping pattern ag traffic costs are 762.4 !!!

FIGURE 3




1990 IMPROVEMENTS

TABLE 6

POLK COUNTY MINNESOTA STUDY AREA

**1990 IMPROVEMENTS TO BASELINE**
**16.3 MILES PAVED**
**PASSENGER CAR TRAVEL COSTS**

**IN 000s**

| | Concrete | Bituminous | Gravel | Dirt | Total |
|---|---|---|---|---|---|
| Township/County | 0 | 0 | 270.8 | 25.1 | 295.9 |
| % of total | 0 | 0 | 19.1 | 1.8 | 20.8 |
| CSAH | 95.4 | 278.1 | 158.3 | 0 | 531.8 |
| % of total | 6.7 | 19.5 | 11.1 | 0 | 37.3 |
| State | 286.3 | 34.0 | 0 | 0 | 320.2 |
| % of total | 20.1 | 2.4 | 0 | 0 | 22.5 |
| U.S. | 276.2 | 0 | 0 | 0 | 276.2 |
| % of total | 19.4 | 0 | 0 | 0 | 19.4 |
| Total | 657.9 | 321.1 | 429.2 | 25.1 | 1424.1 |
| % of total | 46.2 | 21.9 | 30.1 | 1.8 | 100.0 |
| Baseline Total | 682.9 | 258.6 | 472.0 | 24.6 | 1438.1 |
| % of total | 47.5 | 18.0 | 32.8 | 1.7 | |

TABLE 7

POLK COUNTY MINNESOTA STUDY AREA

**1990 IMPROVEMENTS TO BASELINE**
**16.3 MILES PAVED**
**AG TRAFFIC COSTS**

**IN 000s**

| | Concrete | Bituminous | Gravel | Dirt | Total |
|---|---|---|---|---|---|
| Township/County | 0 | 0 | 152.7 | 12.3 | 165.0 |
| % of total | 0 | 0 | 20.2 | 1.6 | 21.9 |
| CSAH | 571.1 | 264.4 | 61.7 | 0 | 384.2 |
| % of total | 7.6 | 35.2 | 8.2 | 0 | 51.0 |
| State | 123.6 | 4.9 | 0 | 0 | 128.5 |
| % of total | 16.4 | .7 | 0 | 0 | 17.0 |
| U.S. | 76.4 | 0 | 0 | 0 | 76.4 |
| % of total | 10.1 | 0 | 0 | 0 | 10.1 |
| Total | 257.1 | 270.3 | 214.4 | 12.3 | 754.2 |
| % of total | 34.1 | 35.8 | 28.4 | 1.6 | |
| Baseline Total | 259.0 | 247.3 | 243.7 | 12.4 | 762.4 |
| % of total | 34.0 | 32.4 | 32.0 | 1.6 | |

TABLE 8

POLK COUNTY MINNESOTA STUDY AREA

**1990 ROAD IMPROVEMENTS TO BASELINE**
**16.3 MILES PAVED**
**OVERHEAD TRAFFIC COSTS**

**IN 000s**

| | Concrete | Bituminous | Gravel | Dirt | Total |
|---|---|---|---|---|---|
| Township/County | 0 | 0 | 369.4 | 0 | 369.4 |
| % of total | 0 | 0 | 6.7 | 0 | 6.7 |
| CSAH | 159.5 | 1263.1 | 350.4 | 0 | 1773.0 |
| % of total | 2.9 | 23.1 | 6.4 | 0 | 32.4 |
| State | 816.7 | 545.3 | 0 | 0 | 1362.0 |
| % of total | 14.9 | 10.0 | 0 | 0 | 24.9 |
| U.S. | 1976.0 | 0 | 0 | 0 | 1976.0 |
| % of total | 36.1 | 0 | 0 | 0 | 36.1 |
| Total | 2952.1 | 1808.4 | 719.8 | 0 | 5480.3 |
| % of total | 53.9 | 33.0 | 13.1 | 0 | |
| Baseline Total | 2952.1 | 1743.5 | 816.0 | 0 | 5511.5 |
| % of total | 53.6 | 31.6 | 14.8 | 0 | |

TABLE 9

POLK COUNTY MINNESOTA STUDY AREA

**1990 IMPROVEMENTS -- ALL TRAFFIC COSTS**
**PASSENGER, AG, OVERHEAD**
**IN 000s**

| | Concrete | Bituminous | Gravel | Dirt | Total |
|---|---|---|---|---|---|
| Township/County | 0 | 0 | 792.8 | 37.4 | 830.3 |
| % of total | 0 | 0 | 10.3 | .5 | 10.8 |
| CSAH | 311.9 | 1806.6 | 570.5 | 0 | 2689.0 |
| % of total | 4.1 | 23.6 | 7.5 | 0 | 35.1 |
| State | 1226.5 | 584.1 | 0 | 0 | 1810.7 |
| % of total | 16.0 | 7.6 | 0 | 0 | 23.6 |
| U.S. | 2328.6 | 0 | 0 | 0 | 2328.6 |
| % of total | 30.4 | 0 | 0 | 0 | 30.4 |
| Total | 3867.1 | 2390.8 | 1363.3 | 37.4 | 7658.6 |
| % of total | 50.5 | 31.2 | 17.8 | .5 | |
| Total Baseline | 3894.0 | 2249.3 | 1531.8 | 37.0 | 7712.0 |
| % of total | 50.5 | 29.2 | 19.9 | .5 | |
| | | | Reduction in VOC | | 53.4 |

## Other Savings due to Road Improvements

There are also savings in maintenance costs for bituminous paved roads when compared to the maintenance costs for gravel roads. This difference in Polk County averaged approximately $1050 per mile per year for 1988-90 or an annual maintenance savings of $17,100 when 16.3 miles of gravel road are paved.

There are also savings in driver and passenger time as roads are improved and trips take less time. These may be savings in wages for hired drivers or savings in opportunity costs for unpaid or self-employed drivers. Such savings are difficult to quantify but if we assume that a cost savings of the minimum wage of $4.20/hr. for one person in each personal travel and overhead vehicle, the savings in driver wages and opportunity cost due to the 1990 improvements would be $81,900. Total savings are shown in Table 10. Note who benefits from those improvements. With or without including a driver cost of $4.20/hr., about 45% of the benefits went to overhead traffic that is passing through the region. Also note that the reduction in maintenance costs accounted for over 20% of the total savings.

## Bridge Replacements

Polk County has a program of replacing bridges on township roads that in need of substantial repair or functionally obsolete. Six area bridges or township roads were replaced in 1991. These are shown on Figure 4. The computer model of the 1989 road network was changed to simulate the abandonment rather than replacement of those six bridges. The simulated increase in total VOC was $7,680 (Table 11). An

TABLE 10

## SAVINGS FROM 1990 IMPROVEMENTS

## 16.3 MILES PAVED

| | NO DRIVER OPPORTUNITY COST | 1 PERSON PER CAR AT $4.20 PER HOUR |
|---|---|---|
| Local cars | 13,900 | 18,100 |
| Ag products | 8,250 | 8,250 |
| Overhead | 31,250 | 38,300 |
| Reduced Maintenance (1050 per mile) | 17,100 | 17,100 |
| TOTAL | 70,500 | 81,750 |

TABLE 11

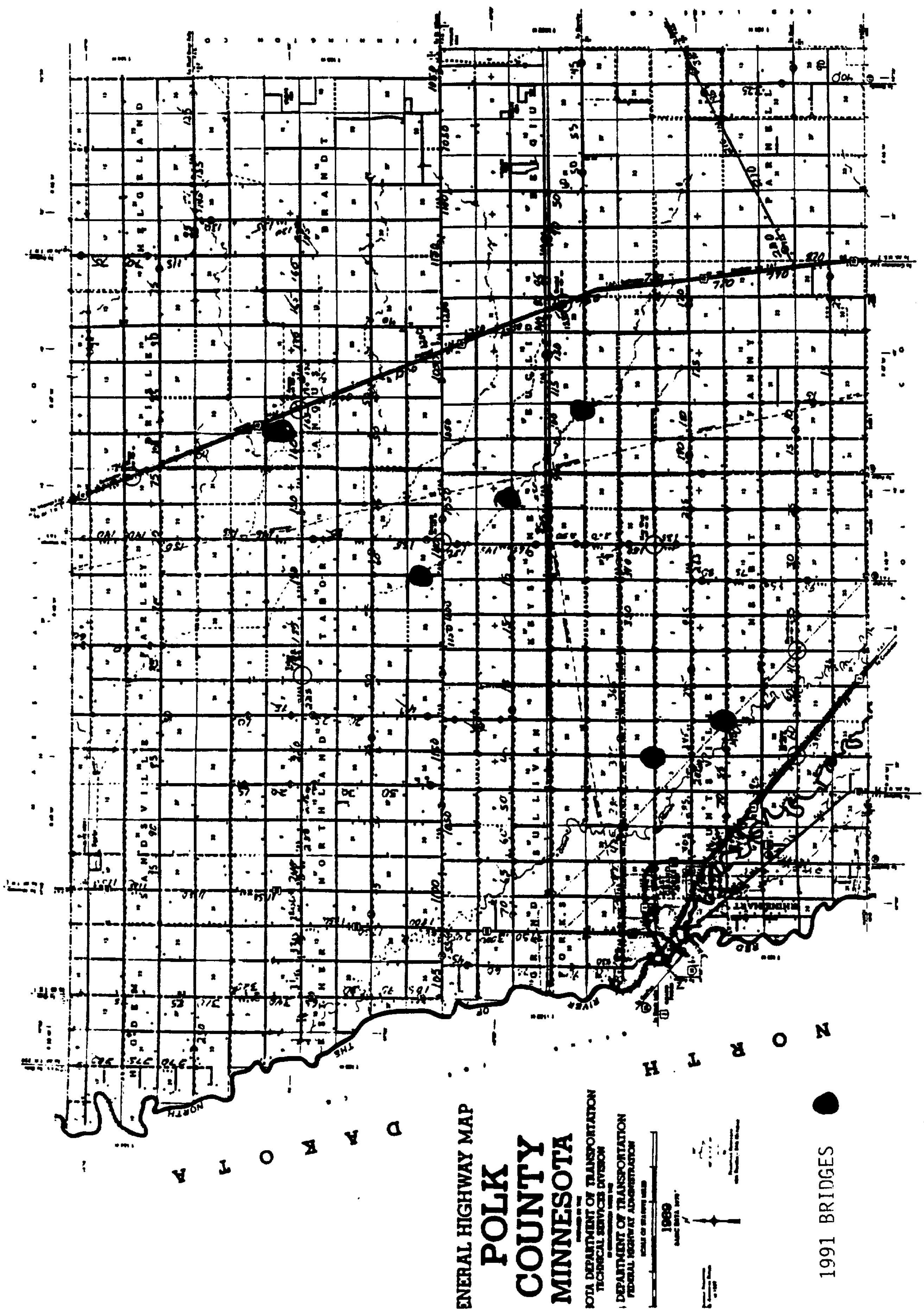
INCREASE IN TRAVEL COSTS IF 6 BRIDGES

HAD BEEN ABANDONED RATHER THAN

REPLACED IN 1991

| | |
|---|---|
| Passenger Car Increase | 5,170 |
| Ag Traffic Increase | 2,510 |
| Overhead | 0 |
| Total Increase | 7,680 |

FIGURE 4


ENERAL HIGHWAY MAP
POLK
COUNTY
MINNESOTA
OTA DEPARTMENT OF TRANSPORTATION
TECHNICAL SERVICES DIVISION
DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
1989
NORTH
DAKOTA
1991 BRIDGES

analysis of the simulation results indicated that two of the bridges accounted for most of the increase in VOC so that four of the bridges could have been abandoned with very little increase in total area VOC.

Road Abandonment

What happens to VOC if some of the less used roads are abandoned? The model was changed to simulate the abandonment of all the roads that trip optimization models indicated would be used for less than an average of one round trip per day. Using that criteria simulations were run with 366 of the 1138 miles of area roads abandoned were run.

Table 12 shows the breakdown by surface type and jurisdiction of the roads with less than one round trip a day. Note that most of the simulated abandonments were of township roads and that nearly 3/4 of the dirt surfaced roads were simulated as abandoned. Simulated abandonments accounted for about 33% of the total roads in the area and over 40% of the township roads.

Table 13 shows the change in personal travel VOC is these roads were abandoned. Personal travel VOC would increase from $1,438,100 to $1,442,300 or about $4200. These would be no change in VOC for overhead traffic because no routes with overhead traffic would be abandoned. A valid estimate for the increase in ag traffic VOC could not be obtained because the crops have to be moved out of the fields whether hauled over a road or a field lane. Consequently, it is impossible

TABLE 12

POLK COUNTY MINNESOTA STUDY AREA

## ROAD NETWORK MILEAGE WITHOUT ROADS WITH LESS THAN ONE TRIP PER DAY EACH WAY

| | Concrete | Bituminous | Gravel | Dirt | Total |
|---|---|---|---|---|---|
| Township/County | 0 | 0 | 427.4 | 60.5 | 487.9 |
| change | - | (-.6) | (-174.0) | (-169.6) | (-346.7) |
| CSAH | 28.2 | 72.6 | 118.4 | 0 | 219.2 |
| change | - | (-3.0) | (-16.5) | - | (-19.5) |
| State | 17.7 | 9.1 | 0 | 0 | 26.8 |
| change | - | - | - | - | - |
| U.S. | 34.8 | 0 | 0 | 0 | 34.8 |
| change | - | - | - | - | - |
| Total | 80.6 | 81.7 | 545.8 | 60.5 | 768.8 |
| change | - | - | - | - | (-366.1) |

TABLE 13

POLK COUNTY MINNESOTA STUDY AREA

## REDUCED NETWORK PASSENGER TRAVEL COSTS

### IN 000s

| | Concrete | Bituminous | Gravel | Dirt | Total |
|---|---|---|---|---|---|
| Township/County | 0 | 0 | 258.0 | 24.3 | 309.3 |
| % | 0 | 0 | 19.8 | 1.7 | 21.5 |
| CSAH | 113.3 | 221.1 | 190.0 | 0 | 524.5 |
| % | 7.9 | 15.3 | 13.2 | 0 | 36.4 |
| State | 294.2 | 36.5 | 0 | 0 | 330.7 |
| % | 20.4 | 2.5 | 0 | 0 | 22.9 |
| U.S. | 277.9 | 0 | 0 | 0 | 277.9 |
| % | 19.3 | 0 | 0 | 0 | 19.3 |
| Total | 685.4 | 257.6 | 475.0 | 24.3 | 1442.3 |
| % | 47.5 | 17.9 | 32.9 | 1.7 | |
| Total Base Line | | | | | 1438.1 |
| | | | | Added VOC | 4.2 |

to estimate a dollar and cents impact on ag traffic. There will be some increase in ag traffic VOC but probably proportionally no more than for local passenger traffic.

Conclusions

A. Some local rural roads (such as many of Polk County's CSAH roads), are important for both local traffic and for regional overhead traffic and should clearly receive significant nonlocal funding.

B. Some rural road improvements such as hard surfacing of selected roads can be justified on the basis of the savings in vehicle operating and road maintenance costs or on the basis of those cost savings plus intangible benefits such as improved safety.

C. The abandonment of some rural bridges would have little impact on total area vehicle operating costs. The cost effectiveness of replacing rural bridges should be carefully considered on a case-by-case basis.

D. Some local roads (up to 40 % in the Polk County study area) could have reduced maintenance or be abandoned with very little increase in costs due to motorists having to drive further.

Bibliography


1. Baumel, C. Phillip, Sherry B. Miller, and Gregory Pautsch (1989). "The Local Rural Road System Alternative Investment Strategies," CARD Technical Report 89-TR6, Iowa State University, Ames, Iowa.

2. Baumel, C. Phillip, Steve Hanson, and Cathy Hamlett (1987). "Estimating Farm Vehicle Travel Costs on Local Rural Roads," North Central Journal of Agricultural Economics, Vol. 9, July 1987.

3. Chicoine, David L. and Norman Walzer (1984). Office of Transportation and Agriculture Marketing Services, U.S. Department of Agriculture, Washington, D.C., Oct.

4. Chicoine, David L. and Norman Walzer, eds. (1986). Financing Local Infrastructure in Nonmetropolitan Areas. New York: Praeger.

5. Dantzig, G. D. (1963). Linear Programming and Extension. Princeton University Press, Princeton, New Jersey.

6. Dantzig, G. B., R. P. Harvey, F. Z. Lansdowne, W. D. Robinson and F. S. Maier (1979). "Formulating and Solving the Network Design Problem by Decomposition," Transpn. Res. B., Vol. 1313, pp. 5-17.

7. Department of the Army, Headquarters (1980). "Pavement Maintenance Management," Technical Manual TM5-623.

8. Ford, L. R. and D. R. Fulkerson (1962). Flows in Networks. Princeton University Press, Princeton, New Jersey.

9. Haas, R. and W. R. Hudson (1978). Pavement Management Systems. McGraw-Hill.

10. Fruin, Jerry E. (1977). "Issues in Rural Road Management," Rural Roads of America, ESCS-74, U.S. Department of Agriculture, Washington, D.C., December.

11. Halbach, D. Walter (1991). A Beginner's Guide to Transportation Modeling with Tranplan. Department of Agricultural and Applied Economics, University of Minnesota, Staff Paper P91-27, pp. 198.

12. Hitzhusen, Fredrick, J. and Kafi Nyamaah (1985). "Circuity Cost Model for Rehabilitation/Closures of Rural Bridges," North Central Journal of Agricultural Economics, Vol. 7, No. 2, July, pp. 41-50.

13. Johnson, Marc A. (1977) "Benefit Measure for Rural Road Improvement Projects," Roads of Rural America, ESCS-74, U.S. Department of Agriculture, Washington, D.C., December.

14. KUTC Newsletter (1988). (University of Kansas Transportation Center), Vol. 10, No. 2, May, University of Kansas, Lawrence, Kansas.

15. McNeil, S. and C. Hendrickson (1982). "Prediction of Pavement Maintenance Expenditure by Using a Statistical Cost Function," Transpn. Res. Rec. 846, pp. 17-76.

16. Minnesota, State of (1985). CSAH System. Program Evaluation Division, Office of the Legislative Auditor, April.

17. Sharaf, A. E., E. Reichelt, Y. M. Shahin and C. K. Sinha (1987). "Development of a Methodology to Estimate Pavement Maintenance and Repair Costs for Different Ranges of Pavement Condition Index," Transpn. Res. Rec. 1123, pp. 30-39.

18. Steenbrink, P. A. (1974). "Transport Network Optimization in the Dutch Integral Transportation Study," Transpn. Res. Vol. 8, pp 11-27.

19. Tucker, J. Dean and Stanley R. Thompson (1981). "Effect of Rural Road Development on Grain Assembly Costs," North Central Journal of Agricultural Economics, Vol. 3, No. 2, July, pp. 125-130.

20. Vermont Local Roads Program Fact Sheet (circa 1991). When to Pave a Gravel Road. St. Michael's College, Winooski, Vermont, 8p.

21. Wardrop, J. G. (1952). "Some Theoretical Aspects of Road Traffic Research," Proceedings, I.C.E. II (1), pp. 325-378.

22. Zaniewski, J. P. (1988). "Fuel Consumption Related to Roadway Characteristics," Transportation Research Record, Record 901, TRB National Research Council, Washington, D.C., pp. 18-29.