

A Microcomputer Program to Evaluate the Benefits and Costs of Alternative Investment Strategies on Low-Volume Local Rural Roads

GREGORY R. PAUTSCH AND C. PHILLIP BAUMEL

The physical condition of local rural roads and bridges is deteriorating. Many roads have not been reconstructed since they were first surfaced; many bridges are 50 to 100 years old. At the same time, the money available to local governments to maintain and rebuild the system is declining. Some observers believe that the local road system must be restructured by reducing the number of miles of road and by paving some roads, reconstructing others, and reducing maintenance levels on still other roads. Residents living on or farming land on roads considered for abandonment, reduced maintenance, or conversion to private drives argue that these policies increase their transportation costs in amounts exceeding the savings to local governments. At the present time, local government officials have no methods of evaluating the changes in travel and investment costs associated with changing the number of miles and types of local rural roads. Described in this paper is a microcomputer program designed to enable county engineers and other local officials to estimate the change in travel and investment costs from alternative investment strategies on local rural roads and to compute benefit-cost ratios for the alternative investment strategies.

The local rural road system, defined as those roads that are under the jurisdiction of county and township governments, contains 71 percent of the 3.2 million mi of rural roads in the United States. The large number of miles and the rectangular regularity of the local rural road system date back to the Ordinance of 1785, which established townships and the 1-mi survey grids. The objective of Congress was to open the land for settlement.

Precise data on the present condition of the local rural road system are not available. However, there is ample evidence that the system is deteriorating rapidly. In a recent Illinois survey, farmers and agribusiness representatives rated about half the Illinois local rural roads as needing more than regular maintenance, and more than 20 percent of these roads were rated as needing major repair. Common complaints about the local rural roads in many states include the following:

1. Overweight vehicles are breaking up road surfaces.
2. Lack of hard surfaces creates dust and rideability problems.

3. Road widths and other design characteristics are inadequate for today's large farm equipment and heavy trucks.
4. Narrow lanes create safety problems.

Although local road deficiencies are significant, the condition of local bridges is also of great concern. On January 1, 1985, 184,977 bridges, or 61 percent of all the off-federal-aid bridges that had been inventoried, were deficient. In addition, 118,390, or 39 percent of the 306,388 off-federal-aid system bridges, are posted, or should have been posted, at less than legal weight limits. However, even this understates the magnitude of the problem. Bridges under 20 ft long were not included in the inventory, and there are thousands of structures under 20 ft in length that need replacement or rehabilitation.

The distribution of deficient bridges among states indicates that the local bridge problem is national in scope. States with the largest number of deficient bridges are Arkansas, Illinois, Indiana, Iowa, Kansas, Mississippi, Missouri, Nebraska, North Carolina, Oklahoma, Tennessee, and Texas. States in the northeast, midwest, southeast, and southwest are included in the groups with a high percent or a large total number of deficient bridges.

To a large extent, the county road system faces many of the same problems that the railroad system encountered in the late 1960s and early 1970s. The physical condition of the county road system is deteriorating. The continuing increase in farm size results in heavier vehicles traveling on these roads and causing more damage to the system; at the same time, the available money, in real terms, to maintain and rebuild the system is declining. Although federal and state motor fuel taxes have increased sharply in recent years, there is increasing pressure to reallocate a larger share of these funds to roads that are under city and state jurisdiction. Moreover, a substantial share of the funds to maintain local rural roads comes from property taxes. The recent decline in rural property values places downward pressure on this source of funds for rural roads. In addition, funds from federal revenue sharing are declining and are likely to continue declining in the future. The decline in the amount of federal general revenue sharing funds is likely to force local governments to reallocate some road funds to meet mandated expenditures such as mental health care. In short, the problem is lack of money to properly

maintain the existing system for the quantity, sizes, and types of vehicles that are traveling on the roads.

Public debate about county roads has focused mainly on the deteriorating condition of the system. The implicit assumption behind much of this debate is that the system should be maintained "as is." However, an increasing number of observers believes that the number of miles of local rural roads could be reduced by either abandonment or conversion to private drives. A 1976 editorial in the *Des Moines Register* states

County roads that served dozens of farms forty years ago may be serving only two or three farms today. Many roads that were once vital to a county's well-being have become, in effect, private roads, although the county is responsible for their upkeep. Such roads no longer belong in a county road system.

Some observers suggest additional investment alternatives should be considered including converting selected gravel or dirt roads to low-level maintenance roads—sometimes referred to as B level roads, simultaneously paving selected roads while abandoning other roads, upgrading bridges, and moving field or household driveways to increase the number of roads that could be considered for abandonment without landlocking property. Residents living on and operating farms on roads considered for abandonment, for conversion to private drives, or as low-level maintenance roads argue that these policies will force them to travel longer distances and incur higher travel costs and that the additional travel and maintenance costs will exceed the cost savings from removing these roads from the public system.

At present, local government officials have no methods of evaluating the changes in travel and investment costs associated with changing the number of miles and types of local rural roads. The microcomputer program described in this paper is designed to enable county engineers and other local officials to

1. Estimate the change in travel costs to the traveling public from alternative investment strategies on low-volume, local rural roads. The investment strategies include abandoning roads, converting roads to private drives, paving gravel and dirt roads, converting roads to low-maintenance B level roads, and upgrading bridges.

2. Estimate the change in investment costs from the alternative investment strategies.

3. Compute benefit-cost ratios for the alternative investment strategies.

The program, written in FORTRAN, can be executed on an IBM or IBM-compatible personal computer with at least 300K of storage. The personal computer must have a fixed disk of at least 3 megabytes (MB) of storage and be equipped with DOS version 3.0. The underlying logic of this program is described by Baumel et al. (1).

DATA REQUIREMENTS

Road and Bridge Network

The first data set to be created for the local rural road evaluation program is the road network. A network consists of a set of nodes connected by a set of arcs. A node represents a point

where trips originate, are relayed, or terminate. Arcs represent the roads that allow traffic to flow between the nodes. Each arc in the network is described by

- A beginning node,
- An ending node,
- A distance,
- A weight constraint,
- A width constraint,
- The length of any bridge on the arc,
- The width of any bridge on the arc, and
- A road surface code.

The program requires five types of arcs to be created in a complete rural road and bridge network. The first type of arc is called a study area arc. A study area arc is created by dividing the roads in the study area into half- or quarter-mile segments. In Figure 1, the roads in a 1-mi by 1-mi study area are divided into half- and quarter-mile segments. A node is placed at each intersection and at the end of each road segment. The node numbers must start at one and be sequential; a number cannot be skipped. All of the nodes on study area arcs should be assigned numbers before numbers are assigned to the nodes on all other types of arcs. The nodes on the study area arcs in the Figure 1 study area begin at 1 and move sequentially to 10. The road segment connecting Node 1 with Node 5 is represented by two arcs. The arc allowing traffic to flow from Node 1 to Node 5 has a beginning node number of 1 and an ending node number of 5, whereas the arc allowing traffic to flow from Node 5 to Node 1 has a beginning node number of 5 and an ending node number of 1.

The distance of study area arcs must be an integer. Because the road segment between Nodes 1 and 5 is 0.5 mi long, the distance for the two arcs representing this 0.5-mi road segment is equal to 50. The distance for a 1-mi road segment is 100, and the distance for a quarter-mile segment is 25. In Figure 1, a bridge is located on the road segment connecting Nodes 5 and 7. The distance of any arc that has a bridge is given a distance of 25. Hence, a node must be placed one-eighth mile away from both ends of the bridge.

The weight constraint of an arc is the weight of the heaviest vehicle that the arc can carry, whereas the width constraint is the width of the widest vehicle that the arc can accommodate. Both the weight and width constraints must be integers. The weight constraint is measured in tons, whereas the width constraint is measured in feet. The length and width of any bridge on an arc must be integers and both are measured in feet. If an arc does not have a bridge, the bridge length and width of that arc are set at zero.

The surface code of a study area arc can be any of the following numbers:

| Type of Road | Code |
|----------------------|------|
| Paved county road | 1 |
| Gravel county road | 2 |
| Dirt county road | 3 |
| Paved noncounty road | 4 |

A paved noncounty road is a state or Interstate highway located in the study area.

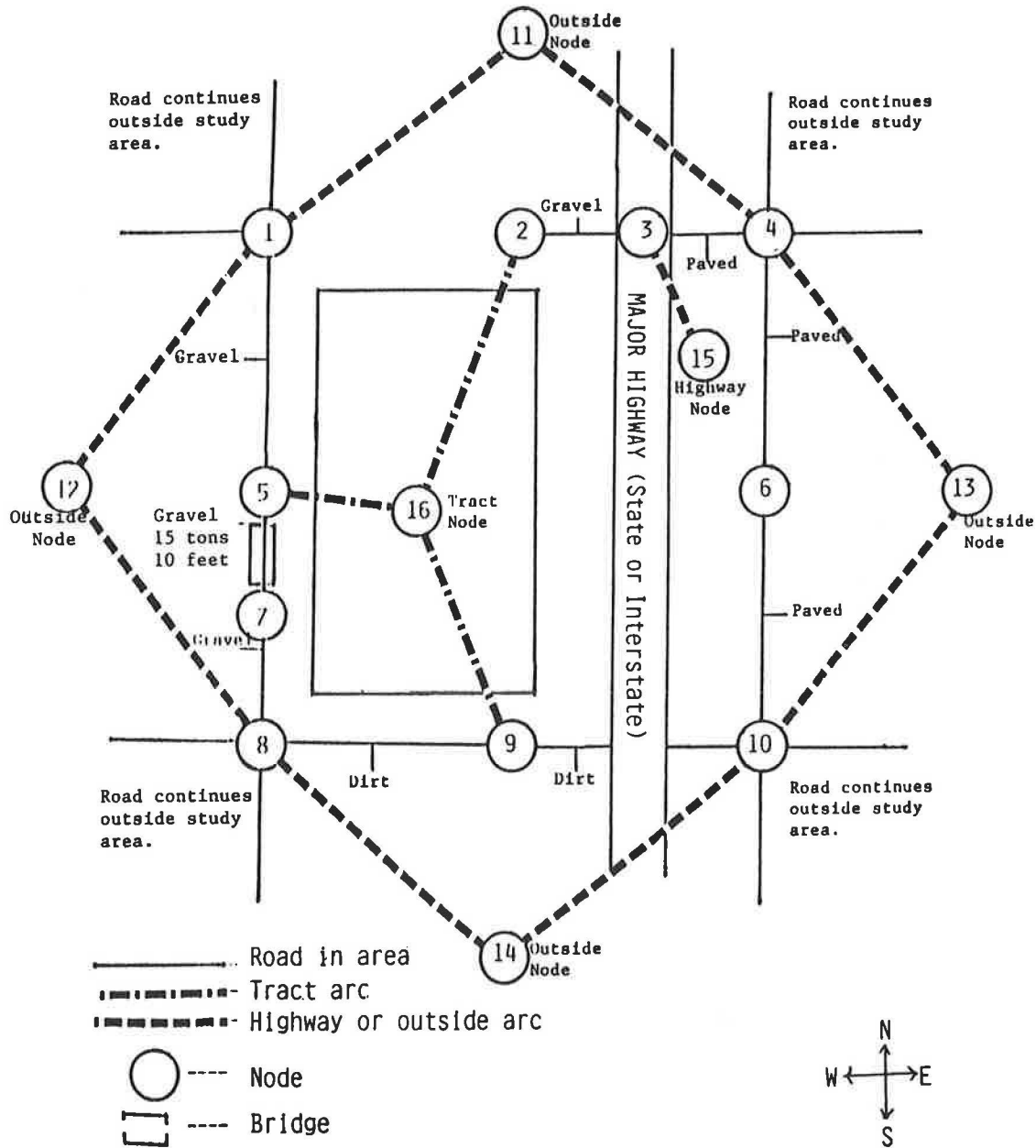


FIGURE 1 A sample network of a 1-mi by 1-mi study area divided into half- and quarter-mile segments.

The second type of arc to be created is an outside arc. Outside arcs allow the computer to route vehicles through the study area when they travel to destinations outside the study area. Outside nodes are placed north, south, east, and west of the study area. The node number for the outside nodes must start with the next number following the last number assigned to a study area arc and move sequentially. In Figure 1, the nodes placed on the study area arcs start at 1 and continue to 10. Hence, the numbers assigned to the outside nodes start at 11 and continue to 14.

Outside arcs are formed by connecting the outside node to the nodes on the edge of the study area that allows traffic to leave the study area. In Figure 1, the west outside node is connected to Nodes 1 and 8 because they allow travel westward out of the study area. The west outside node is not connected to

Nodes 5 and 7 because they do not allow travel westward out of the study area. Hence, if a farmer has a tract of land located west of the study area, it would be given the west outside node as the destination. Any trip to that outside tract is routed from the origin node within the study area to the west outside node. This allows for the calculation of within-study-area travel costs to destinations outside of the study area.

The third type of arc to be created is a highway arc. Highway arcs connect the highway node to the within-study-area nodes serving as access points to the highway. Thus, a highway node is placed on each state or Interstate highway in the study area. The numbers assigned to the highway nodes follow the last number assigned to an outside node and move sequentially. In Figure 1, the highway node is assigned the value of 15 because the last number assigned to an outside node is 14. Only Node 3

serves as an access point to the highway; hence, only Node 3 is connected to Node 15. Highway arcs allow trips to and from distant locations under the assumption that travel to and from distant locations maximizes the use of state or Interstate highways. Therefore, the destination of any out-of-state trip is the highway node. The computer routes the trips to the closest access to a state or Interstate highway that is in the general direction of the true destination.

The distance of all outside arcs and highway arcs is set at 10,000 and the surface code is equal to 5. The weight and width constraints of outside arcs and highway arcs are set at a value so that all legal-sized vehicles are able to travel over these arcs. The program does not consider bridges on outside arcs and highway arcs; hence, the length and width of bridges on outside arcs and highway arcs should be set at zero.

The next type of arc to be created is a tract arc. The origin or destination of many farm trips is tracts (fields) of farmland. Tracts of farmland often have multiple-access points. In most cases, the access used depends on the origin of the trip. Each tract of land within the study area is assigned a tract node. The numbers assigned to tracts follow the last number assigned to a highway node and continue sequentially. A tract arc is formed by connecting the tract node to the nodes in the study area that serve as access points to the tract of land. Hence, in Figure 1, the tract node—Node 16—is connected to Nodes 2, 5, and 9 because these nodes serve as access to the tract of land. When a farmer travels from tract to tract, the origin and destination should be coded as each tract node number. The computer finds the cost-minimizing route between the two tracts by finding the optimal access points to use for each trip.

The final type of arc to be created is a new arc. New arcs allow for new access points to tracts of farmland to be inserted into the county road network. Because abandoning a road segment or a group of road segments may landlock some property, new arcs placed on a remaining road adjacent to the tract allow the farmer to travel to his tract of farmland. A new arc is formed by connecting the tract number to the node number representing the location of the new access point.

The distance for tract arcs and new arcs is set at 10,000 so only trips that have the tract node as an origin or destination are routed over the arc. This high distance value prevents overhead traffic from "driving through the field." The surface code for tract arcs is 6, and the surface code for new arcs is 8. The weight and width constraints of tract arcs and new arcs must be set at a value such that all vehicles are able to travel over these arcs. The length and width of any bridge on tract arcs and new arcs is set at zero because bridges are not located on these arcs.

Trip Information Data

The second data set to be created is the trip information data set. The trip origin node number, destination node number, number of trips, and vehicle type code number must be entered into this data set. The various vehicle code numbers for various types of vehicles are given in Table 1. The sample study area in Figure 2 includes three households numbered 1, 2, and 3. Suppose they furnished the following trip information, assuming all trips are one-way, that is, they do not include return trips:

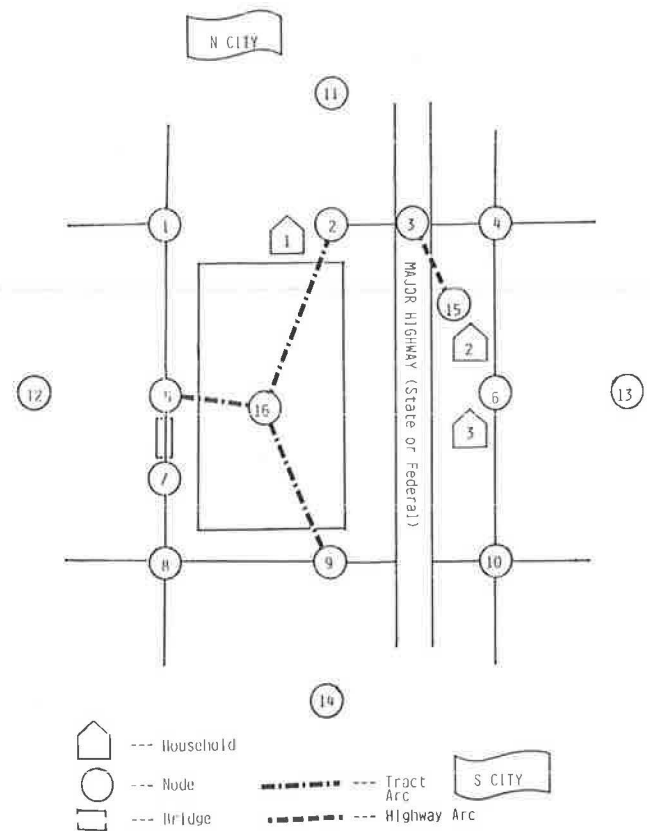


FIGURE 2 Sample study area.

TABLE 1 VEHICLE CODE NUMBERS

| Vehicle Code Number | Vehicle Description |
|---------------------|--|
| 1 | Automobile |
| 2 | Commercial van |
| 3 | Pickup |
| 4 | Single-axle truck, half-loaded |
| 5 | Tandem-axle truck, empty |
| 6 | Tractor pulling equipment |
| 7 | Tractor pulling equipment with timeliness |
| 8 | Pickup pulling trailer |
| 9 | Garbage truck |
| 10 | Commercial semitrailer, empty |
| 11 | Tractor |
| 12 | Combine, 2-row |
| 13 | Combine, 4-row |
| 14 | Combine, 6 or 8-row |
| 15 | Tractor pulling 125-bu wagon, empty |
| 16 | Tractor pulling 250-bu wagon, empty |
| 17 | Tractor pulling 350-bu wagon, empty |
| 18 | Tractor pulling 450-bu wagon, empty |
| 19 | Tractor pulling 550-bu wagon, empty |
| 20 | Tractor pulling two 350-bu wagons, empty |
| 21 | Tractor pulling two 450-bu wagons, empty |
| 22 | Single-axle truck with pup, empty |
| 23 | Farm semitrailer, empty |
| 24 | Tandem-axle truck with pup, empty |
| 25 | Single-axle truck pulling 250-bu wagon, empty |
| 26 | Single-axle truck pulling 350-bu wagon, empty |
| 27 | Tandem-axle truck pulling 450-bu wagon, empty |
| 28 | Tractor pulling grain buggy, empty |
| 29 | Tandem-axle truck pulling 550-bu wagon, empty |
| 30 | Tandem-axle truck pulling two 350-bu wagons, empty |

TABLE 1 *continued*

| Vehicle Code Number | Vehicle Description |
|---------------------|---|
| 31 | Tandem-axle truck pulling two 450-bu wagons, empty |
| 32 | Commercial semitrailer, loaded |
| 33 | Tandem-axle truck, loaded |
| 34 | Farm semitrailer, loaded |
| 35 | Single-axle truck with pup, loaded |
| 36 | Tandem-axle truck with pup, loaded |
| 37 | Tractor pulling 125-bu wagon, loaded |
| 38 | Tractor pulling 250-bu wagon, loaded |
| 39 | Tractor pulling grain buggy, loaded |
| 40 | Tractor pulling 350-bu wagon, loaded |
| 41 | Tractor pulling 450-bu wagon, loaded |
| 42 | Tractor pulling 550-bu wagon, loaded |
| 43 | Tractor pulling two 350-bu wagons, loaded |
| 44 | Tractor pulling two 450-bu wagons, loaded |
| 45 | Single-axle truck pulling 250-bu wagon, loaded |
| 46 | Single-axle truck pulling 350-bu wagon, loaded |
| 47 | Tandem-axle truck pulling 450-bu wagon, loaded |
| 48 | Tandem-axle truck pulling 550-bu wagon, loaded |
| 49 | Tandem-axle truck pulling two 350-bu wagons, loaded |
| 50 | Tandem-axle truck pulling two 450-bu wagons, loaded |

Household 1—

Five trips per week to N city in a car,
 Four trips per month to N city in a pickup truck,
 Two trips per day to the field (Node 16 in the figure) in a pickup truck,
 Two trips per day to the field during fall harvest in a tractor pulling a 450-bu wagon,
 Five trips to the field in a 6-row combine during harvest, and
 Five trips per year from S city in a tandem-axle truck pulling a pup trailer.

Household 2—

Ten trips per week to S city in an automobile,
 One trip per month to N city in a pickup truck,
 Two trips per year to a distant location in an automobile using a major highway, and
 Three trips per week to a neighbor, Household 1, in a pickup truck.

Household 3—

Fifteen trips per week to a city east of the study area in an automobile,
 Five trips per year to N city in a commercial semitrailer, and
 Four trips per year from S city in a single-axle truck.

In smaller study areas, many trips originating within the study area go to outside locations, and many trips to locations within the study area begin at origins outside the study area. A complete description of trip data for a given household must include information on all trips to and from locations inside and outside the study area.

Once trip data have been collected for all households in the study area, the three steps in adjusting the data for the local rural road evaluation program are as follows:

Step 1. First, trip information must be converted to common units, such as number of trips per year. Because there are 52 weeks in a year, 12 months, or 365 days, and one-quarter of these per season, the following conversions should be used:

1 trip per day = $1 \times 365 = 365$ trips per year.
 5 trips per week = $5 \times 52 = 260$ trips per year.
 1 trip per month = $1 \times 12 = 12$ trips per year.
 1 trip per day per season = $1 \times 365 \times \frac{1}{4} = 91$ trips per year.

Step 2. Origin and destination nodes are next assigned to each trip, that is, for the requested route. Each household is given a location node based on the closest node in the study area. A household located exactly between two nodes is assigned to the node nearest the middle of the arc on which it lies. In the example, Household 1 is located near Node 2, whereas Households 2 and 3 are closest to Node 6. Hence, travel originating at Household 1 is given an origin node of 2. Travel originating in the field in the sample study area is assigned an origin node of 16, the node of that tract of land. Travel originating outside the study area is given the appropriate outside node as its origin, or if travel originated at a distant location, the major highway node, Node 15. Similarly, a destination node for each requested route is assigned. Trips to Household 2, for example, have Node 6 as destination node. Trips to N city are assigned Node 11 as destination node, because N city is outside and north of the study area, and Node 11 is the north outside node.

Step 3. The third step is to assign vehicle code numbers to each vehicle, based on the numbers given in Table 1. For example, the code of 1 is assigned to the automobile. School buses and postal vehicles are excluded from Table 1. School bus and postal service vehicles are routed based on larger geographic areas, and any change in school bus and postal travel costs must be calculated by hand. Table 2 presents a list of the coded travel information given for the sample study area in Figure 2.

TABLE 2 CODED TRAVEL INFORMATION FOR SAMPLE STUDY AREA

| Origin Node No. | Destination Node No. | Yearly Trips | Vehicle Code No. |
|-----------------|----------------------|--------------|------------------|
| 2 | 11 | 520 | 1 |
| 2 | 11 | 96 | 3 |
| 2 | 16 | 1,460 | 3 |
| 2 | 16 | 183 | 18 |
| 2 | 16 | 183 | 41 |
| 2 | 16 | 10 | 14 |
| 14 | 2 | 5 | 24 |
| 14 | 2 | 5 | 36 |
| 6 | 14 | 1,040 | 1 |
| 6 | 11 | 24 | 3 |
| 6 | 15 | 4 | 1 |
| 6 | 2 | 312 | 3 |
| 6 | 13 | 1,560 | 1 |
| 6 | 11 | 5 | 32 |
| 6 | 11 | 5 | 10 |
| 14 | 6 | 8 | 4 |

Vehicle Grouping Information

Another required data set is vehicle groupings. Vehicle groupings allow several vehicles to be routed together to increase the efficiency of the computer. The vehicles in each grouping should have similar weight and width characteristics and the

ratios of costs per mile of traveling over a gravel surface to a paved surface, the costs per mile of traveling over a dirt surface to a paved surface, and the costs per mile of traveling over a B level road surface to a paved surface must be similar. For each vehicle grouping, the following information is required:

- The representative weight (tons),
- The representative width (ft),
- The representative ratio of cost per mile of traveling over a gravel surface to that over a paved surface,
- The representative ratio of cost per mile of traveling over a dirt surface to that over a paved surface,
- The representative ratio of cost per mile of traveling over a B level road surface to that over a paved surface, and
- The total number of vehicles in the grouping.

In addition, the vehicle code numbers in Table 1 and the variable cost in cents per mile of traveling over a paved surface must be entered into the vehicle grouping data set.

The representative weight and width of a vehicle grouping must be an integer value. The weight is expressed in tons, and the width is expressed in feet. The three representative ratios are rounded to two decimal places. The variable cost in cents per mile of traveling over a paved surface for a vehicle is rounded to one decimal place. The total number of vehicles in a vehicle grouping can be any integer value of 15 or less.

Road and Bridge Maintenance, Reconstruction, and Resurfacing Costs

The next type of data required is the road maintenance, reconstruction, and resurfacing cost data set. This data set requires that maintenance costs be separated into fixed and variable maintenance cost per mile of gravel, dirt, paved, and B level roads. The variable maintenance cost of a road is a function of the average daily traffic (ADT) level of the road. The fixed maintenance cost of a road is the maintenance cost required, independent of traffic levels. If the variable maintenance cost of paved roads is calculated using kip loads, zero is inserted for the paved-road variable maintenance cost. An explanation of using kip loadings to calculate variable maintenance cost of paved roads is presented later in the text.

The method used to calculate reconstruction and resurfacing costs for the local rural road evaluation program is based on Iowa data. Data sources in other states may vary, and the procedure used to calculate reconstruction and resurfacing costs may need to be modified according to the available data. The method for calculating reconstruction and resurfacing costs and the number of years between reconstructions and resurfacings for Iowa roads is described by Baumel et al. (1).

Reconstruction and resurfacing costs for highway group Numbers 3–8 in Hamilton County, Iowa, are given in Table 3. Reconstruction costs on gravel and dirt roads are spread over a 60-year period. The frequency at which reconstruction and resurfacing costs are charged to paved roads is coded in the program.

The real interest rate, bridge maintenance cost per square foot, cost for inserting a new access point into the road network, per-acre rental value of farmland in the county, and the cost of converting the right-of-way into agricultural production

TABLE 3 RECONSTRUCTION AND RESURFACING COSTS PER LANE MILE BY HIGHWAY GROUP NUMBER, HAMILTON COUNTY, IOWA

| Highway Group No. | Reconstruction ^a Costs (\$) | Resurfacing ^a Costs (\$) |
|-------------------|--|-------------------------------------|
| 3 | 183,687 | 32,877 |
| 4 | 123,505 | 30,094 |
| 5 | 58,141 | 25,881 |
| 6 | 26,121 | 17,454 |
| 7 | 12,399 | 6,621 |
| 8 | 7,824 | 4,213 |

^aCalculated from (2).

are additional information needed in the maintenance, reconstruction, and resurfacing data set. The annual per-acre farmland rental values can be estimated in two steps. First, the average rental rate per acre of the crop-reporting district is calculated as a percent of the average land value in the crop-reporting district. To obtain the estimated county land rent per acre, the year's average county farmland value is multiplied by the percent that the average crop-reporting district rental rates are of farmland value.

The estimated value of the cost of converting the right-of-way into agricultural production by type of terrain for Iowa data is presented in Table 4. The bridge maintenance cost per square foot is the annual square foot cost of keeping the bridge in the current condition.

TABLE 4 ESTIMATED VALUES OF CONVERTING THE RIGHT-OF-WAY INTO AGRICULTURAL PRODUCTION BY TYPE OF TERRAIN FOR IOWA DATA

| Type of Terrain | Cost per Mile (\$) |
|---|--------------------|
| Flat, minimal side ditch and grade | 700 |
| Rolling, little if any end-haul dirt to move | 1,000 |
| Flat, good cross section of ditches and centerline profile | 8,500 |
| Rolling, substantial end haul, good cross section of centerline profile and ditches | 16,000 |

Paved County Road Information

The final data set concerns paved county roads. The following information is required in the paved county road data set:

- Beginning node of each paved county road segment,
- Ending node of each paved county road segment,
- Number of years since each paved county road segment was reconstructed,
- Whether the road segment is paved of rigid or flexible pavement,
- Structural number or slab thickness of each paved county road segment,
- Design term of each paved county road segment, and
- Average annual paved-road variable maintenance cost.

If the road segment is rigid pavement, the slab thickness can be any integer between 6 and 11. The design term can be any

TABLE 5 VEHICLE AXLE WEIGHTS BY TYPE OF VEHICLE IN POUNDS

| Vehicle Description | No. of Axles | Individual Axle Loadings (lb) ^a | | | | | |
|--------------------------------|--------------|--|---------|---------|--------|--------|--------|
| | | First | Second | Third | Fourth | Fifth | Sixth |
| Automobile | 2 | 1,750 | 1,750 | — | — | — | — |
| Commercial van | 2 | 2,800 | 2,400 | — | — | — | — |
| Pickup | 2 | 1,750 | 1,750 | — | — | — | — |
| Single-axle truck, half-loaded | 2 | 6,150 | 13,300 | — | — | — | — |
| Tandem-axle truck, empty | 2 | 6,900 | 11,700T | — | — | — | — |
| Tractor with equipment | 3 | 3,800 | 12,800 | 4,000 | — | — | — |
| Pickup with trailer | 3 | 1,750 | 1,750 | 6,000T | — | — | — |
| Garbage truck | 2 | 7,000 | 29,000T | — | — | — | — |
| Commercial semitrailer, empty | 3 | 9,000 | 13,400T | 9,500T | — | — | — |
| Tractor | 2 | 3,800 | 12,800 | — | — | — | — |
| Tractor with equipment | 3 | 3,800 | 12,800 | 4,000 | — | — | — |
| Combine, 2-row | 2 | 8,000 | 3,000 | — | — | — | — |
| Combine, 4-row | 2 | 12,615 | 3,700 | — | — | — | — |
| Combine, 6-row | 2 | 13,926 | 4,640 | — | — | — | — |
| Tractor, empty wagon | | | | | | | |
| 125 bu | 4 | 3,800 | 12,800 | 500 | 500 | — | — |
| 250 bu | 4 | 3,800 | 12,800 | 520 | 520 | — | — |
| 350 bu | 4 | 3,800 | 12,800 | 730 | 730 | — | — |
| 450 bu | 4 | 3,800 | 12,800 | 1,070 | 1,070 | — | — |
| 550 bu | 4 | 3,800 | 12,800 | 2,190 | 2,190 | — | — |
| Two 350 bu | 6 | 3,800 | 12,800 | 730 | 730 | 730 | 730 |
| Two 450 bu | 6 | 3,800 | 12,800 | 1,070 | 1,070 | 1,070 | 1,070 |
| Tractor/grain buggy, empty | 3 | 3,800 | 12,800 | 7,240 | — | — | — |
| Truck, empty | | | | | | | |
| Single axle with pup | 3 | 5,500 | 6,600 | 6,640T | — | — | — |
| Farm semitrailer | 3 | 9,000 | 13,400T | 9,500T | — | — | — |
| Tandem axle with pup | 3 | 6,900 | 11,700T | 6,640T | — | — | — |
| Truck/wagon, empty | | | | | | | |
| Single axle/250 bu | 4 | 5,500 | 6,600 | 520 | 520 | — | — |
| Single axle/350 bu | 4 | 5,500 | 6,600 | 730 | 730 | — | — |
| Tandem axle/450 bu | 4 | 6,900 | 11,700T | 1,070 | 1,070 | — | — |
| Tandem axle/550 bu | 4 | 6,900 | 11,700T | 2,190 | 2,190 | — | — |
| Tandem axle/two 350 bu | 6 | 6,900 | 11,700T | 730 | 730 | 730 | 730 |
| Tandem axle/two 450 bu | 6 | 6,900 | 11,700T | 1,070 | 1,070 | 1,070 | 1,070 |
| Trucks, loaded | | | | | | | |
| Commercial semitrailer | 3 | 9,800 | 28,800T | 29,400T | — | — | — |
| Tandem axle | 2 | 20,000 | 34,000T | — | — | — | — |
| Farm semitrailer | 3 | 9,800 | 33,000T | 33,000T | — | — | — |
| Single axle with pup | 3 | 6,800 | 20,000 | 24,000T | — | — | — |
| Tandem axle with pup | 3 | 20,000 | 34,000T | 24,000T | — | — | — |
| Tractor, loaded wagon | | | | | | | |
| 125 bu | 4 | 3,800 | 12,800 | 4,000 | 4,000 | — | — |
| 250 bu | 4 | 3,800 | 12,800 | 7,520 | 7,520 | — | — |
| Auger wagon | 3 | 3,800 | 12,800 | 20,000 | — | — | — |
| 350 bu | 4 | 3,800 | 12,800 | 10,530 | 10,530 | — | — |
| 450 bu | 4 | 3,800 | 12,800 | 13,670 | 13,670 | — | — |
| 550 bu | 4 | 3,800 | 12,800 | 17,590 | 17,590 | — | — |
| Two 350 bu | 6 | 3,800 | 12,800 | 10,530 | 10,530 | 10,530 | 10,530 |
| Two 450 bu | 6 | 3,800 | 12,800 | 13,670 | 13,670 | 13,670 | 13,670 |
| Truck/wagon, loaded | | | | | | | |
| Single axle/250 bu | 4 | 6,800 | 20,000 | 7,520 | 7,520 | — | — |
| Single axle/350 bu | 4 | 6,800 | 20,000 | 10,530 | 10,530 | — | — |
| Tandem axle/450 bu | 4 | 18,660 | 34,000T | 13,670 | 13,670 | — | — |
| Tandem axle/550 bu | 4 | 14,820 | 30,000T | 17,590 | 17,590 | — | — |
| Tandem axle/two 350 bu | 6 | 10,000 | 27,880T | 10,530 | 10,530 | 10,530 | 10,530 |
| Tandem axle/two 450 bu | 6 | 10,000 | 15,000T | 13,670 | 13,670 | 13,670 | 13,670 |

^aT indicates a tandem axle, otherwise the axle is single (1).

number between 6.5 and 13.9 rounded to one decimal place. If the road segment is of flexible pavement, the structural number can be any integer between 1 and 6, whereas the design term can be any number between 2.0 and 4.7 rounded to one decimal place.

The basic assumption underlying the maintenance cost for a paved road is that a portion of the cost varies directly with the number of axle loadings passing on the road. Therefore, the first step in estimating the maintenance costs is to express all vehicles in terms of equivalent 18,000-lb (18-kip) axle loadings that the road sustains through one pass by each vehicle.

Pavements are designed to withstand the projected number of 18-kip loadings during the expected life of the road, usually 20 years. An increase in the projected number of 18-kip loadings within a given period of time increases the maintenance cost of the road surface.

The measure of pavement condition used is the pavement serviceability index (PSI). This surface roughness index ranges from 5.0 downward to 0.0 with the upper limit being the indication of the best condition possible.

The design term relates the number of passes of a standard 18,000-lb axle load to the load-carrying capacity of the various pavement layers. The design term indicates the number of standard axle loads that can pass over a pavement before the roughness (PSI) reaches 2.0 for each flexible or rigid pavement thickness. The design term for each paved road should be computed from pavement type and thickness information supplied by the county and the state department of transportation records.

Table 5 indicates the number and type of axles and the loading on each axle for all vehicles used in the local rural road evaluation program. The program calculates the number of 18-kip equivalent loads that each vehicle applies to a pavement. The 18-kip equivalent number is multiplied by the vehicle yearly traffic level on the road to obtain the total number of 18-kip loadings the vehicle applies to the road. Summing over all vehicle types yields the annual number of 18-kip loadings applied to a road.

The Iowa Department of Transportation reports an average total annual paved-road maintenance cost. This number is multiplied by an area cost factor to obtain the average total annual paved-road maintenance cost per mile. The annual paved-road fixed-maintenance cost per mile is subtracted from average total annual paved-road maintenance cost per mile to yield the average annual paved-road variable maintenance cost. For a more complete discussion on how to use kip loadings to calculate paved-road variable maintenance cost, see Baumel et al. (1).

CREATING THE DATA SETS

Creating the Network Data Set

The data set name for the network must be called NET. Each arc in the network requires one line of data. The column fields are shown in Table 6. All values must be justified to the right so that only blanks precede the value in its column field.

TABLE 6 COLUMN FIELDS FOR THE NETWORK DATA SET

| Information | Column Field |
|---------------------------------|--------------|
| Beginning node of the arc | 1-5 |
| Ending node of the arc | 6-10 |
| Distance of the arc | 11-20 |
| Weight constraint of the arc | 21-30 |
| Width constraint of the arc | 31-40 |
| Length of any bridge on the arc | 41-45 |
| Width of any bridge on the arc | 46-50 |
| Surface code of the arc | 51-55 |

TABLE 7 COLUMN FIELDS FOR THE TRIP INFORMATION DATA SET

| Information | Column Field |
|---------------------|--------------|
| Beginning node | 1-10 |
| Ending node | 11-20 |
| Number of trips | 21-30 |
| Vehicle code number | 31-40 |

Creating the Trip Information Data Set

The name for the trip information data set is TRIP. The column fields for the data set are given in Table 7. All values must be justified to the right so that only blanks precede the value in its column field.

Creating the Maintenance, Reconstruction, and Resurfacing Cost Data Sets

The data in Table 8 show the estimated values of the information required in the maintenance, reconstruction, and resurfacing cost data set for Hamilton County, Iowa. The name of the data set for the maintenance, reconstruction, and resurfacing cost is MRR. There are 10 lines in MRR, and each piece of information must be placed on a specific line and in a specific column field. Table 9 gives a list of the information required for each line and the specified column fields in which each piece of information is placed. Each piece of information is justified to the right in the column field, so there are only blanks preceding the number, not trailing the number, in the column field. Because data sources in other states may vary, the format for the MRR data may need to be modified according to the available data.

Creating the Vehicle Group Data Set

The vehicle grouping data set is called VEHGROUP. Each vehicle grouping requires three lines of data. Table 10 provides a list of the information required for each line and the specified column field in which each piece of information is placed. The number of vehicle groupings can be any value. As the number of vehicle groupings increases, the number of data lines in VEHGROUP increases. Table 11 gives a list of the relevant information pertaining to each vehicle grouping, assuming the first vehicle group consists of an automobile, a commercial

TABLE 8 ESTIMATED VALUES OF THE DATA REQUIRED IN THE MAINTENANCE, RECONSTRUCTION, AND RESURFACING COST DATA SET FOR HAMILTON COUNTY, IOWA

| | Cost (\$) |
|---|------------|
| Fixed maintenance cost per mile of road | |
| Gravel | 2,376.00 |
| Dirt | 2,206.00 |
| Paved | 1,160.00 |
| B Level | 505.00 |
| Variable maintenance cost per ADT per mile of road | |
| Gravel | 4.70 |
| Dirt | 1.52 |
| Paved | 0.00 |
| B level | 0.00 |
| Reconstruction cost per lane-mile for Highway Group | |
| 3 | 183,867.00 |
| 4 | 123,505.00 |
| 5 | 58,141.00 |
| 6 | 26,121.00 |
| 7 | 12,399.00 |
| 8 | 7,824.00 |
| Resurfacing cost per lane-mile for Highway Group | |
| 3 | 32,877.00 |
| 4 | 30,094.00 |
| 5 | 25,881.00 |
| 6 | 17,454.00 |
| 7 | 6,621.00 |
| 8 | 4,213.00 |
| Annual rental value of farmland per acre | 140.91 |
| Cost per mile of converting right-of-way into agricultural production | 700.00 |
| Real interest rate (percent) | 5.60 |
| Annual bridge maintenance cost per square foot | 0.80 |
| Time between reconstructions of gravel and dirt roads (years) | 60 |
| Cost for a new access point | 470.00 |

van, a pickup, and a pickup pulling a trailer, whereas the second vehicle group consists of a loaded tandem-axle truck, a loaded commercial semitrailer and a loaded farm semitrailer.

Creating the Paved County Road Data Set

The paved county road data set is called PAVEMENT. Table 12 gives a list of the information required for each line and the specified columns in which each piece of information is placed. If a paved-road segment was reconstructed 30 years ago or more, a 1 is placed in Column 15. A 2 is placed in Column 15 if the paved road segment was reconstructed more than 15 but less than 30 years ago, while a 3 is placed in Column 15 if the paved road segment was reconstructed 15 years ago or less. If a road segment is paved of rigid pavement, a T is placed in Column 20; if paved of flexible pavement, an F is placed in Column 20. The number of data lines in the PAVEMENT data

TABLE 9 INFORMATION REQUIRED FOR EACH LINE AND THE SPECIFIED COLUMNS FOR EACH PIECE OF INFORMATION IN THE MRR DATA SET

| Line | Column | Information |
|------|--------|--|
| 1 | 1-10 | Fixed maintenance cost per mile of gravel road |
| | 11-20 | Fixed maintenance cost per mile of dirt road |
| | 21-30 | Fixed maintenance cost per mile of paved road |
| | 31-40 | Fixed maintenance cost per mile of B level road |
| 2 | 1-10 | Variable maintenance cost per mile of gravel road |
| | 11-20 | Variable maintenance cost per mile of dirt road |
| | 21-30 | Variable maintenance cost per mile of paved road |
| 3 | 31-40 | Variable maintenance cost per mile of B level road |
| | 1-15 | Reconstruction cost per lane-mile of Highway Group 3 |
| | 16-30 | Resurfacing cost per lane-mile of Highway Group 3 |
| 4 | 1-15 | Reconstruction cost per lane-mile of Highway Group 4 |
| | 16-30 | Resurfacing cost per lane-mile of Highway Group 4 |
| 5 | 1-15 | Reconstruction cost per lane-mile of Highway Group 5 |
| | 16-30 | Resurfacing cost per lane-mile of Highway Group 5 |
| 6 | 1-15 | Reconstruction cost per lane-mile of Highway Group 6 |
| | 16-30 | Resurfacing cost per lane-mile of Highway Group 6 |
| 7 | 1-15 | Reconstruction cost per lane-mile of Highway Group 7 |
| | 16-30 | Resurfacing cost per lane-mile of Highway Group 7 |
| 8 | 1-15 | Reconstruction cost per lane-mile of Highway Group 8 |
| | 16-30 | Resurfacing cost per lane-mile of Highway Group 8 |
| 9 | 1-10 | Annual rental value of farmland per acre |
| | 11-20 | Cost of converting the right-of-way to farmland |
| | 21-25 | Annual bridge maintenance cost per square foot |
| 10 | 26-30 | Annual interest rate |
| | 1-5 | Number of years between reconstruction of gravel roads |
| | 6-10 | Number of years between reconstruction of dirt roads |
| | 31-40 | Cost for a new access point |

set depends on the number of paved county road segments in the study area. Table 13 gives an example of the information for the paved county roads in the sample network shown in Figure 1.

HOW TO RUN THE LOCAL RURAL ROAD EVALUATION PROGRAM

The disk provides three data sets and three execute files. The three data sets NAMES, TABLES, and VEHICLES, along with

TABLE 10 INFORMATION REQUIRED FOR EACH LINE AND THE SPECIFIED COLUMNS FOR EACH PIECE OF INFORMATION IN THE DATA SET VEHGROUP

| Line | Column | Information |
|------|--------|--|
| 1 | 1-75 | Number of vehicle groupings |
| 2 | 1-10 | Representative weight for Grouping 1 |
| | 11-15 | Representative width for Grouping 1 |
| | 21-35 | Representative ratio of cost per mile of travel over a gravel surface to a paved surface for Grouping 1 |
| | 36-50 | Representative ratio of cost per mile of travel over a dirt surface to a paved surface for Grouping 1 |
| | 51-65 | Representative ratio of cost per mile of travel over an Area B surface to a paved surface for Grouping 1 |
| | 66-75 | Total number of vehicles in Grouping 1 |
| 3 | 1-5 | First vehicle code number in Grouping 1 |
| | 6-10 | Second vehicle code number in Grouping 1 |
| | 11-15 | Third vehicle code number in Grouping 1 |
| | 16-20 | Fourth vehicle code number in Grouping 1 |
| | 21-25 | Fifth vehicle code number in Grouping 1 |
| | 26-30 | Sixth vehicle code number in Grouping 1 |
| | 31-35 | Seventh vehicle code number in Grouping 1 |
| | 36-40 | Eighth vehicle code number in Grouping 1 |
| | 41-45 | Ninth vehicle code number in Grouping 1 |
| | 46-50 | Tenth vehicle code number in Grouping 1 |
| | 51-55 | Eleventh vehicle code number in Grouping 1 |
| | 56-60 | Twelfth vehicle code number in Grouping 1 |
| | 61-65 | Thirteenth vehicle code number in Grouping 1 |
| | 66-70 | Fourteenth vehicle code number in Grouping 1 |
| | 71-75 | Fifteenth vehicle code number in Grouping 1 |
| 4 | 1-5 | First vehicle's variable cost per mile of traveling over a paved surface in Grouping 1 |
| | 6-10 | Second vehicle's variable cost per mile of traveling over a paved surface in Grouping 1 |
| | 71-75 | Fifteenth vehicle's variable cost per mile of traveling over a paved surface in Grouping 1 |
| 5 | | Pertains to Grouping 2 and is formatted the same as Line 2 |
| 6 | | Pertains to Grouping 2 and is formatted the same as Line 3 |
| 7 | | Pertains to Grouping 2 and is formatted the same as Line 4 |
| 8 | | Pertains to Grouping 3 and is formatted the same as Line 2 |
| 9 | | Pertains to Grouping 3 and is formatted the same as Line 3 |
| 10 | | Pertains to Grouping 3 and is formatted the same as Line 4 |

the user-created data sets, are placed on the fixed disk of the microcomputer. The three execute files are named PASS1.EXE, PASS2.EXE, and PASS3.EXE.

To begin the local rural road evaluation program, type PASS1 on the keyboard. The command PASS1 initiates the

TABLE 11 AN EXAMPLE OF VEHICLE GROUPING INFORMATION

| Vehicle Group | Description | Typical Value |
|---------------|--|---------------|
| 1 | Representative weight (tons) | 4 |
| | Representative width (ft) | 6 |
| | Representative ratio of cost (cents per mile) of travel over a gravel surface to that over a paved surface | 1.39 |
| | Representative ratio of cost (cents per mile) of travel over a dirt surface to that over a paved surface | 1.77 |
| | Representative ratio of cost (cents per mile) of travel over a B level to that over a paved surface | 1.98 |
| | Total number of vehicles | 4 |
| | Vehicle cost (cents per mile) of travel over a paved surface | |
| | <i>Code</i> <i>Vehicle</i> | |
| | 1 Automobile | 20.2 |
| | 2 Commercial van | 40.2 |
| | 3 Pickup | 24.4 |
| | 8 Pickup pulling trailer | 35.3 |
| 2 | Representative weight (tons) | 40 |
| | Representative width (ft) | 8 |
| | Representative ratio of cost (cents per mile) of travel over a gravel surface to that over a paved surface | 1.48 |
| | Representative ratio of cost (cents per mile) of travel over a dirt surface to that over a paved surface | 1.96 |
| | Representative ratio of cost (cents per mile) of travel over a B level to that over a paved surface | 2.16 |
| | Total number of vehicles | 3 |
| | Vehicle cost (cents per mile) of travel over a paved surface | |
| | <i>Code</i> <i>Vehicle</i> | |
| | 33 Loaded tandem-axle truck | 42.4 |
| | 34 Loaded farm semitrailer | 37.4 |
| | 32 Loaded commercial semitrailer | 55.4 |

execution of the first step of the local rural road evaluation program. The following question then appears on the screen:

> IS THIS RUN FOR THE BASE SOLUTION? (Y/N)

To run the base solution with all the roads in their present condition, type Y for yes. To run an alternative solution with an alternative investment strategy, type N for no.

Running a Base Solution

After Y is typed to the first question, the following message appears on the screen:

> ENTER THE NAME OF YOUR STUDY AREA

The study area name, which must start with a letter and consist of no more than 15 characters, is then typed on the

TABLE 12 INFORMATION REQUIRED FOR EACH LINE AND THE SPECIFIED COLUMNS FOR EACH PIECE OF INFORMATION IN THE DATA SET PAVEMENT

| Line | Column | Information |
|-----------|--|--|
| 1 | 1-5 | Beginning node of the first paved county road segment |
| | 6-10 | Ending node of the first paved road segment |
| | 15 | One if the road was reconstructed 30 or more years ago |
| | | Two if the road was reconstructed more than 15 years but less than 30 years ago |
| | | Three if the road segment was reconstructed 15 years ago or less |
| | 20 | T if the road segment pavement is rigid, or F if the road segment pavement is flexible |
| 21-25 | Structural number if the road segment pavement is flexible, or the slab thickness of the road segment is rigid | |
| 26-30 | Design term of the paved county road segment | |
| 2 | | Pertains to the next paved county road segment and is formatted the same as Line 2 |
| Last line | 1-25 | Average annual paved road variable maintenance cost |

keyboard. When PASS1 is completed, the following message appears:

> PASS ONE COMPLETED

After this message appears on the screen, type PASS2 on the keyboard. The command PASS2 initiates the second step of the local rural road evaluation program. When PASS2 is completed, the following message appears:

> PASS TWO COMPLETED

After this message appears on the screen, type PASS3 on the keyboard. The command PASS3 initiates the final step of the local rural road evaluation program. When PASS3 is completed, the following message appears:

> PASS THREE COMPLETED

The output of the base solution is then found in the data set called "RESULTS."

Running a Reduced Solution

A reduced solution is run to evaluate an alternative investment strategy. After N is typed to the first question, the following message appears on the screen:

> ENTER THE NUMBER OF ROAD SEGMENTS TO BE ABANDONED

Type the number of road segments to be abandoned; if there are no road segments to be abandoned, type zero. The computer then asks for the beginning node (BN) and the ending node (EN) for each road segment to be abandoned. Type in the BN and EN for only one (not both) of the arcs representing the road segment. Remember that each road segment is represented by two arcs. For example, the road segment connecting Node 1 to

Node 5 in Figure 1 is represented by an arc with a beginning node of 1 and an ending node of 5 and by an arc with a beginning node of 5 and an ending node of 1. If the road segment connecting Node 1 to Node 5 is to be abandoned, then type, for example, BN = 1, EN = 5. After the BN and EN for all the abandoned road segments are entered, the following message question appears on the screen:

> ENTER THE NUMBER OF ROAD SEGMENTS TO BE UPGRADED

Type the number of road segments to be upgraded. If there are no road segments to be upgraded, type zero. The computer then asks for the BN and EN for each road segment upgraded. Again, type the BN and EN for only one of the arcs representing the road segment. The computer then prints out the present weight limit, width constraint, and surface code, and asks for new values for the weight limit, width constraint, and surface code for each road segment. If a characteristic of the road segment is not changed from the base network, simply type the present value for the new value. For example, if a bridge on a gravel road segment is to be upgraded to legal limits, type 40 for the new weight limit, 20 for the width constraint, and 2 for the new surface code. The computer then asks for the total upgrading cost for the road segment. If a road segment is to be paved, the computer asks for the design terms and whether the new pavement type is rigid or flexible. If the new pavement is rigid, the computer asks for the slab thickness number; if the new pavement is flexible, the computer asks for the structural number. After these questions are answered, the following message appears on the screen:

> ENTER THE NUMBER OF ROADS TO BE CONVERTED TO B LEVEL SERVICE

Type the number of road segments to be converted to B level service. If there are no road segments converted to B level service, type zero. The computer then asks for the BN and EN for each road segment converted to B level service. Type in the BN and EN for only one of the arcs representing the road segment. After these questions are answered, the following message appears on the screen:

> ENTER THE TOTAL NUMBER OF NEW ACCESS POINTS PUT INTO THE ROAD SYSTEM

Type the total number of new access points to be put into the road system. If there are no new access points, type zero. The computer then asks for the tract number and the new access location for each new access point put into the road system. After these questions are answered, the following message appears on the screen:

> ARE THERE ANY ROAD SEGMENTS TO BE CONVERTED TO PRIVATE DRIVES? (Y/N)

Type Y for yes if there are road segments to be converted to private drives. Type N for no if there are no road segments converted to private drives. If there are road segments to be converted to private drives, the following series of messages appears on the screen:

TABLE 13 AN EXAMPLE OF THE INFORMATION FOR THE PAVED COUNTY ROADS IN THE STUDY AREA PRESENTED IN FIGURE 1

| Road Segment | | Pavement | Slab Thickness or | Design Term | Years Since Last Reconstruction |
|-------------------|----------------|----------|-------------------------|----------------|---------------------------------------|
| Beginning Node | Ending Node | | Structural Number | | |
| 3 | 4 | Flexible | 1 | 2.1 | 15 |
| 4 | 6 | Rigid | 6 | 6.6 | 20 |
| 6 | 10 | Rigid | 7 | 6.5 | 31 |

NOTE: Average annual paved road maintenance cost = \$170.65.

TABLE 14 PRIVATE DRIVE MAINTENANCE COST CODE BY TYPE OF ACCESS

| Type of Access | Private Drive Maintenance Cost Code |
|----------------------|--|
| Residence only | 1 |
| Small to medium farm | 2 |
| Large farm | 3 |
| Field access only | 4 |

TABLE 15 FORMAT OF THE "RESULTS" DATA SET

| Annual Costs of Providing the System | Current | Previous | Change |
|---|---------|----------|--------|
| Annual costs to the county | | | |
| Total variable maintenance cost | | | |
| Total fixed maintenance cost | | | |
| Total reconstruction cost | | | |
| Total resurfacing cost | | | |
| Total upgrading cost | | | |
| Total bridge maintenance cost | | | |
| Total cost for new access points | | | |
| Annual cost to the county | | | |
| Annual cost to private drives | | | |
| Total maintenance cost | | | |
| Total reconstruction cost | | | |
| Total bridge maintenance cost | | | |
| Annual cost of private drives | | | |
| Annual net value of land | | | |
| Changes in annual cost of providing the system | | | |
| Annual costs to the traveling public | | | |
| Total annual travel cost | | | |

> ENTER THE NUMBER OF ROAD SEGMENTS TO BE CONVERTED TO PRIVATE DRIVES

Type the number of road segments converted to private drives. The total number of road segments converted to private drives cannot exceed 22. The computer then asks for the BN and EN for each converted road segment. Again, type the BN and EN for only one of the arcs representing the road segment. The computer then asks for the private drive maintenance code for each converted road segment. Table 14 presents the values of the private drive maintenance cost code by type of access.

After these questions are answered, the following message appears on the screen:

> PASS ONE COMPLETED

After this message appears on the screen, type PASS2. The command PASS2 initiates the second step of the local rural road evaluation program. When PASS2 is completed the following message appears on the screen:

> PASS TWO COMPLETED

After this message appears, type PASS3. The command PASS3 initiates the final step of the local rural road evaluation program. Each new solution is compared with a previous solution, either the base solution or an alternative solution. The computer then requests the following information concerning the previous solution:

> ENTER THE TOTAL VARIABLE MAINTENANCE COST FROM THE PREVIOUS SOLUTION

> ENTER THE TOTAL FIXED MAINTENANCE COST FROM THE PREVIOUS SOLUTION

> ENTER THE TOTAL RECONSTRUCTION COST FROM THE PREVIOUS SOLUTION

> ENTER THE TOTAL RESURFACING COST FROM THE PREVIOUS SOLUTION

> ENTER THE TOTAL VALUE OF LAND FROM THE PREVIOUS SOLUTION

> ENTER THE TOTAL BRIDGE MAINTENANCE COST FROM THE PREVIOUS SOLUTION

> ENTER THE TOTAL TRAVEL COST FROM THE PREVIOUS SOLUTION

> ENTER THE PRIVATE DRIVE MAINTENANCE COST FROM THE PREVIOUS SOLUTION

> ENTER THE TOTAL UPGRADING COST FROM THE PREVIOUS SOLUTION

> ENTER THE TOTAL COST FOR NEW ACCESS POINTS FROM THE PREVIOUS SOLUTION

> ENTER THE PRIVATE DRIVE RECONSTRUCTION COST FROM THE PREVIOUS SOLUTION

> ENTER THE PRIVATE DRIVE BRIDGE MAINTENANCE COST FROM THE PREVIOUS SOLUTION

All of the information from the previous solution is found in the output for that solution. After this information is entered, the following message appears on the screen:

> PASS THREE COMPLETED

The output of an alternative solution is found in the RESULTS data set. The format of the RESULTS data set is given in Table 15. The annual cost of providing the system consists of the annual costs to the county, the annual cost of private drives, and the annual net value of land. The annual cost to the traveling public is the total annual travel cost. The column headed "current" represents the costs associated with the investment strategy, whereas the column headed "previous" gives the costs before the investment strategy was implemented. The column headed "change" presents the difference between current costs and previous costs.

The RESULTS data set identifies the benefits and costs of the investment strategy. The benefits of an investment strategy

are defined as a reduction in either the annual cost of providing the system or the annual travel cost, whereas the costs of an investment strategy are defined as an increase in either the annual cost of providing the system or the annual travel cost. A benefit-cost ratio is calculated and interpretation of the ratio is presented in the RESULTS data set.

A disk containing the microcomputer program to evaluate the benefits and costs of alternative investment strategies can be obtained by mailing a check for \$12.50 made out to Iowa State University to: C. Phillip Baumel, Department of Economics, Iowa State University, Ames, Iowa 50011.

REFERENCES

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Publication of this paper sponsored by Committee on Low-Volume Roads.