USING THE TI-59 PROGRAMMABLE CALCULATOR TO ESTIMATE OPERATING COSTS AND HAULING RATES FOR BULK MILK ASSEMBLY

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PREFACE

This bulletin is an update of A.E. Research 79-18 published in September 1979. At that time the concept of using a programmable calculator to estimate bulk milk assembly costs was a new one which was unfamiliar conceptually and operationally to both handlers and haulers. In addition the availability and relative ease of access to different units (e.g., annual vs. average daily miles) of information was not known. The need for better information on hauling was nevertheless evident and a decision was made to prepare a simplified program with the expectation that with practice and experience a more suitable and easier to operate program could be developed in the future. The revised program is now available and is included in this bulletin. There are two major changes from the earlier program. First, the data entries have been put in forms which are more readily available for handlers and haulers. For example, route miles are now listed as daily rather than annual averages, the relief driver wage is incorporated in the average driver wage and is removed as a separate entry, and maintenance costs are entered as averages per mile rather than as a gradient. Because of these changes it has been necessary to change the data entry register numbers from those used in the previous program; care should be taken that the figures are placed in the appropriate registers. Second, tax savings to haulers from depreciation allowances and the investment tax credit are now incorporated in the program resulting in estimates of fixed and total costs which will be lower than if the same cost figures were run on the previous program.

A further addition has been made which consists of programming the calculations for determining a stop charge and hundredweight payments to haulers for costs incurred in pumping and transporting milk. The manual calculations for making these cost allocations were described in the original bulletin. This bulletin contains a description of using the program to make these calculations rapidly and without error.

INTRODUCTION AND PURPOSE

The New York State dairy industry is vitally dependent on an efficient and competitive transportation system for assembling and transporting milk from farms to processing plants. Much of the state's milk assembly operation is carried out by independent contract haulers who operate their own truck(s). The independent owner-operator has often proved the best as well as the lowest-cost option for accomplishing the hauling function. The use of a relatively large number of independent haulers over a wide range of route conditions does, however, create significant coordination needs for the participants. This publication is directed to assisting with one aspect of the coordination requirements; the determination of equitable hauling rates.

The rate paid to haulers for bulk milk assembly is, ideally, negotiated on a route-by-route basis. Typically in practice the request for a rate change is initiated by a hauler and justified on the basis of an increase in labor, fuel or other costs. But since many cost increases affect all haulers, what began as a request for a rate change by an individual hauler often becomes a concurrent request by all haulers. If the handler agrees to a rate increase while lacking specific information about the effect of the cost increase on individual routes, the increase is often applied as a flat, across-the-board adjustment. Such uniform rate changes in assembly systems with highly divergent route conditions tend to favor some haulers over others. As a result some assembly routes can be substantially more profitable than others, while the system as a whole is neither efficient nor equitable for either the dairymen or the haulers. A detailed knowledge of assembly costs is essential for operating an efficient system.

At the same time, rapidly rising transportation costs have placed the small contract hauler at a competitive disadvantage to larger operators as the management function becomes more critical. The small operator, who drives and maintains the truck, has less time available for analyzing the business. A quick means of

estimating changing route costs should prove an essential management tool during these inflationary times.

The purpose of this publication is to present a ready means of estimating the effect of a change in the cost of the one factor, like fuel, on overall operating costs. The resultant estimates are useful to both handlers and haulers. Handlers may use the estimates in planning for anticipated future cost changes. Haulers must keep track of costs to be sure that rates are sufficient to accumulate capital for timely replacement of the tank truck fleet. Together the estimates provide a common basis from which rate negotiations can be started.

The estimates are developed using economic engineering techniques by combining individual item costs, from fuel and tires to purchase price and maintenance, into uniform operating costs per unit of product, time and distance. These estimates may be broken out into fixed and variable cost components. To make the calculations speedy and accurate a TI-59 programmable calculator is used*[1]. With its assistance the effect of a fuel price increase on total per mile costs, to mention one example, can be determined within seconds.

The program is kept relatively short by omitting much of the detail and special considerations which are a part of day-to-day operations. Thus the results should be viewed as approximations only. The estimates include operating costs only; other factors such as returns to management and risk are not included. The appropriate payments for management and risk vary widely from firm to firm so that no rule-of-thumb figure can be established. Allowances for these factors and other items specific to particular routes must be established during negotiations.

In past years it was common for rates to reflect the haulers out-of-pocket costs plus a premium for management and risk. This meant among other things that

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*The bracketed numbers refer to additional information on this point included with the footnotes on page 17 following the text.

haulers were compensated based on what they actually paid for their turck. During periods of relatively stable prices this approach proved adequate but pro-blems began to appear when replacement truck prices started moving up sharply. The hauler who had to replace his truck with a much more expensive new one found that he had no accumulated reserves to use to allow purchase at the higher price and had to drop out of the industry. One solution to this situation would be to raise the rate whenever a new truck is purchased. This would, however, not be equitable and would provide a strong incentive for all haulers to buy new equipment! A second and preferable procedure is to provide on going payments with which the hauler may build some equity for the time when a replacement must be purchased. A reasonable improvement in equity should be assured if the rates are periodically adjusted to reflect the "current replacement" of a similar vechicle. This "replacement cost" approach is used in this bulletin. It will generally give a good approximation to the long term costs faced by a hauler but may not be appropriate in some cases, such as a route which would not be economical once the present truck wears out (2).

Data requirements for the program are substantial. In some cases a considerable initial effort will be required to establish a system for collecting and updating the necessary information. If it is done properly this data collection procedure should lead to better record keeping and an improved understanding of the hauling system and the major factors influencing costs. If not, the estimates provided by the program will be inaccurate and misleading.

This report is organized as follows. The first section involves the estimation of hauling costs and includes a description of the basic program, an example application, suggested procedures for collecting data, and an overview of ways of adapting the model for a range of different conditions. The second section describes the use of the program to calculate stop charges and allocation of costs based on time, distance and volume. The program itself is included in the Appendix.

SECTION I

Estimating Hauling Costs

Steps for operating the TI-59 program are detailed in Figure 1. This figure also includes an example which may be run to check to see that the program has been typed in correctly. The data for the example have been developed from information supplied by a group of handlers and haulers in upstate New York and reasonably accurately represents aggregate cost conditions for that area for early 1980. These data do not, however, necessarily represent actual costs for any one specific route and are not indended to be used in any application of the program to an actual situation.

Definitions and Guidelines for Data Collection

The results of the program are, of course, only as good as the data which are entered by the user. A strict adherence to the definitions and collection guidelines listed below will help to assure that the program results are valid and compatible for cross-firm comparisons.

01. Average Daily Route Miles - Use the total average daily miles traveled from garage to garage. In the case where more miles are traveled one day than another, total the two days and divide by two.

> Ex. Day 1 - 75 miles
> Day 2 - 105 miles
> ____
> Total   180/2 = 90 Avg. miles per day

02. Average CWT Delivered Per Day - Use average daily deliveries over the entire year taking into consideration all routes and the flush period, if any.

03. Truck Costs - Truck are available with an extremely large selection of optional equipment from engines, axles and transmissions, down to radios, air conditioners and seats. To standardize cost estimates the specifications of a serviceable truck must be agreed upon by haulers and handlers. Examples of such specifications are listed in Figure 2. With these specifications, prices can be collected from cooperating new truck dealers. In most cases fleet prices will be assumed to apply.

Truck investment costs are frequently lumpy with a large initial investment (down payment), a stream of interest and repayment costs and finally a return in the form of the salvage value (trade-in or scrap value). In order to make a nonuniform series of costs and returns comparable they are converted to an equivalent uniform annual series of payments (3).

Figure 1: Operating Instructions for Part I of the TI-59 Program

Entering the Program from Magnetic Cards:

Turn Claculator off. Turn calculator on.
Press Key 1. insert side 1
Press Key 2. insert side 2

DATA INPUT

Item*	Example Value	Press Key	Example Display	Your Value	Press Key	Your Display
Fixed Costs						
Average Daily Route Miles	110	STO 01	110	____	STO 01	____
Average CWT Delivered Per Day	299	STO 02	299	____	STO 02	____
Truck Chassis Cost ($)	46000	STO 03	46000	____	STO 03	____
Chassis Expected Life (years)	7	STO 04	7	____	STO 04	____
Chassis Salvage Value ($)	9200	STO 05	9200	____	STO 05	____
Tank Cost ($)	18000	STO 06	18000	____	STO 06	____
Tank Expected Life (years)	10	STO 07	10	____	STO 07	____
Tank Salvage Value ($)	3600	STO 08	3600	____	STO 08	____
Insurance	1400	STO 09	1400	____	STO 09	____
Registration Fees	280	STO 10	280	____	STO 10	____
Highway Tax	120	STO 11	120	____	STO 11	____
Interest Rate	.12	STO 12	.12	____	STO 12	____
Miscellaneous Costs	1000	STO 13	1000	____	STO 13	____
Driver Hourly Wage ($/hr.)	7.50	STO 14	7.50	____	STO 14	____
Hours/Day for Driver(s)	8	STO 15	8	____	STO 15	____
Variable Costs						
Miles Per Gallon	5	STO 20	5	____	STO 20	____
Fuel Cost ($/gallon)	1.10	STO 21	1.10	____	STO 21	____
Cost New Tire	200	STO 22	200	____	STO 22	____
Cost Recapped Tire	85	STO 23	85	____	STO 23	____
Number of Tires	10	STO 24	10	____	STO 24	____
Bias or Radial Ply Tires - Enter 1 if Radial, 0 if Bias	0	STO 25	0	____	STO 25	____
Ton-Mile Tax Rate	.017	STO 26	.017	____	STO 26	____
Annual Maintenance	600	STO 27	600	____	STO 27	____
Average Annual Repair in $/Mile	.075	STO 28	.075	____	STO 28	____
Miscellaneous Variable Costs	0	STO 29	0	____	STO 29	____

OUTPUT

Press Key	Value Output	Example Display	Your Display
A	Total Annual Fixed Costs (TFC)	33885.96	____
R/S	TFC/Mile	.844	____
R/S	TFC/CWT	.310	____
R/S	TFC/Minute	.193	____
B	Total Annual Variable Costs (TVC)	15033	____
R/S	Total Annual Costs (TC)**	48919.88	____
R/S	TC/CWT	.448	____
R/S	TC/Mile	1.22	____
R/S	TVC/CWT	.138	____
R/S	TVC/Mile	.374	____

*Definitions of these terms and suggested sources of information are included in the following section.

**TC = TFC + TVC.

Figure 2: Truck Specificaitons: Single Chassis

Specifications for a Single Chassis Truck
Suitable for a 4,000 Gallon, Farm Pickup Truck

Cab: 151" conventional

Wheel base: Approx. 218"

Engine: Detroit diesel - 671 N   Engine heater
                        Low oil pressure warning   Vertical exhaust
                        Spin-on oil filter   Luberfiner - 750
                        Spin-on water filter   Farr air cleaner
                        Plastic fan blade   Delco Remy H.D. alternator
                        Jake brake   Ammeter

Clutch: 14" double disc

Transmission: Fuller R.T.O. 915

Rear Axle: Timken 38,000# 4:44 ratio

Suspension: Hendrickson spring & saddle mount. Extended leaf, 50"
                                                                aluminum beam

Front Axle: Rockwell FL 901 - 18,000 lb., Shepard power steering

Brakes: S-Cam. Rear - 16 1/2" x 7 8" dia.
                               Front - 16 1/2" x 5"
                               Hand valve for all wheels
                               Front wheel limiting valve
                               Alcohol kit

Tires: Front - General high miler - 11:00 x 20
                        Rear - General D.C.L.   10:00 x 20

Other Options: Double frame or frame reinforcement
                        Dual 50 gal. step tanks
                        Stemco hubs
                        Tow hooks, fron and rear
                        Bostrom Viking driver seat
                        Passenger seat
                        Air horn
                        Electric wiper motor
                        Radiator shutters
                        West Coast mirrors

Source: Dennis R. Lifferth and Walter C. Wasserman, Milk Transportation
         and Processing: Analysis of Alternative Milk Marketing Systems
         USDA Farmer Cooperative Service, mimeograph, undated, p. 139.

04. Truck Life - The expected number of miles of service would be available from service managers. Dividing this figure by the annual route miles will give the expected life in years.

05. Truck Salvage Value - This figure will perhaps be one of the more diffi-cult to estimate accurately. Dealers can give a good indication of what a particular five year old truck is worth today. This, however, will not necessarily indicate future salvage values since new truck prices have been rising rapidly in recent years, carrying used and junk truck prices up with them. The problem of estimating future salvage values is therefore one of projecting the rate of inflation for this equipment. Individual judgment must be used. A 20% of replacement cost rule-of-thumb is being used by some individuals in the industry.

06 & 07. Tank Cost and Tank Life - Available from the suppliers. Annual costs are calculated in the same manner as truck costs (see above).

08. Tank Salvage Value - Use current scrap metal values which have remained relatively constant over time, or if tanks are rehabilitated, use expected net value.

09. Insurance - Annual rates for liability and cargo, available from insurance agents and brokers. A standardized policy should be used. Such a policy might include $300,000 - $500,000 liability, collision for the value of the truck with $200 - $500 deductible and cargo coverage in case of upset. Some states, like New York, mandate other coverage.

10. Registration Fees - Annual fees available from the New York State Depart-ment of Motor Vehicles or comparable department in other states.

11. Highway Tax - Listed in New York State Department of Taxation and Finance Highway Tax Law Bulletin, October 1, 1974, or similar bulletins from other states, and in Federal tax codes. The tax should be calculated on an annual basis.

12. Interest Rate - The interest rate reflects the value and cost of capital tied up in the truck and tank over their service lives. For this program the yield for industrial bonds rated "A" is suggested for use (4). This rate is available in major newspapers or by telephoning local banks.

13. Miscellaneous Fixed Costs - These costs should include annual garaging, bookkeeping, heat, office, and other expenses which are necessary to oper-ate the milk hauling business. These items are likely to differ from operator to operator so that the actual costs should be used if available. Other fixed costs which do not fit into the above categories may also be included here. A lease contract on trucks or tanks may be included here on an annual cost basis. See the following section for several examples.

14. Drivers' Wages - The average hourly wage rate including fringe benefits should be used. If a significant number of drivers are unionized the rate stipulated in the contract may be used. Wages should include the value of all fringe benefits and payroll taxes. If the drivers are not unionized or a significant number are independent owner-operators, then the prevailing local rate (including fringes) must be used. In a situation where there is

more than one driver during the day and the hourly rates are different, use a weighted average hourly rate:

$$
\begin{array}{lll}
\text{Ex.} & \text{Driver 1 -} & \$ 7.40/\text{hr. x 8 hrs.} = \$ 60 \\
& \text{Driver 2 -} & \$10.00/\text{hr. x 7 hrs.} = \$ 70 \\
& & \$130 \div 15 \text{ hrs.} = \$8.67/\text{hr.}
\end{array}
$$

Relief driver wages should be included in calculating the average rate.

15. Hours/Day for Driver - An eight-hour day may be assumed unless information from the hauler or contract specifications indicate that a different length of day should be used.

20. Fuel Consumption in MPG - Available from operators or as estimates from truck dealers.

21. Fuel Cost ($/Gallon) - Use average local pump prices.

22 & 23. Cost of New Tire and Cost of Recapped Tire - Use fleet prices collected from local dealer (5).

24. Number of Tires - Part of the specifications under (03) above.

25. Type of Tire (Bias Ply or Radial) - Indicate most common type of tire used by pressing 0 for bias ply or 1 for radials (6).

26. Ton-Mile Tax Rate - Rates are listed in the New York State Department of Taxation and Finance Truck Mileage Tax and Fuel. Use Tax bulletin, Regulations 21, April 1, 1970, or similar publicaitons for other states. If fuel is bought outside the state of operation a fuel use tax must also be paid (not included in program).

27. Annual Periodic Maintenance - This figure includes oil, chassis lubrication, filters, plugs and points (if necessary). This cost is available from local service stations and can be calculated on an annual basis according to expected mileage and service intervals recommended by the manufacturer.

28. Average Annual Repair Cost Per Mile - Repair costs are among the most difficult costs to determine. The rate would be best determined for several trucks over more than one year. Repair costs should include parts and labor on an annual basis divided by annual miles driven. If field data are not available applicable cost information may be collected from fleet service managers with similar type hauls.

29. Miscellaneous Variable Cost - To be used for items related to operating the truck but included elsewhere. Examples included mileage based rental rates for the truck or tank.

After punching in all these values you can easily check to see that the correct numbers were entered by punching in the following sequence of steps:

SBR

CLR

RST

INV

2nd LST

This will cause the calculator to print out a list of values stored in each register beginning with the first. These numbers can be checked with the values you intended to enter. In case of an error simply press the correct figure and STO --. To stop the list once it is running simply press R/S.

ADAPTING THE MODEL FOR DIFFERENT CONDITIONS

The basic program applies to the simplest possible bulk hauling situation; the hauler follows one or more route per day using self-owned equipment. This section contains explanations for adapting the basic program for different conditions such as leased rather than owned equipment. The changes include straightforward modifications in the input data and increase in complexity up to permanent changes in the program itself. The following examples indicate how several kinds of changes may be made. They should be used as guidelines for other modifications of the program to meet specific user requirements.

Changing Constants Incorporated in the Program: Tire Life

To keep the user supplied data inputs down to a reasonable number, several values are stored internally in the program as "constants." Examples are tire life and tax rates. The stored values, however, may not be appropriate for all routes and would need to be changed; routes with many hills and curves, for example, may give tire life below the assumed averages. These changes may be made by following the examples below.

Example: Tire Life

On a rough, curvey route a hauler finds that radial tires last on average only 90,000 miles rather than the 100,000 miles assumed. To make the adjustment the proper program location must first be found and the following changes made:

Press	Display	Object
GTO 243	---	Locate part of program requiring change
LRN	243 004	Put calculator in mode to make changes
23	244 00	Insert new number which reduces life by 10,000 miles. (The calculator automatically shows you the next step, not the one you have just completed. To see it push BST - you should get 243 03).
LRN		Return to operating mode

The way this change works is to reduce 40,000 to 30,000; pushing 3 replaces the 4. The 30,000 is the difference in mileage of a radial over the 80,000 miles assumed for a bias ply. The new total is thus 90,000 rather than 100,000 miles.

If this change is to be permanent it may be stored on a magnetic card by following these steps:

Press 1 2nd WRT - insert card, turn over
Press 2 2nd WRT - insert card

If the display number does not flash the program has been transferred properly.

Incorporating Different Operating Characteristics: Leased Equipment

If equipment is leased rather than owned the lease rate may be included in register 13 or 29, or if the lease includes both fixed and variable aspects both may be used. (If all equipment is leased with a service contract an interest rate - register 12 - still must be entered for the program to operate.) A fixed rental rate should be entered in register 3. If the rate is established on a monthly basis it must be adjusted to reflect the actual annual fee (7). Rates which vary according to distance or other factors should be included as a variable cost in register 29. Costs which are variable by the mile must be multiplied by total annual miles or, if the tank payment is based on the volume of milk delivered, by the cwt. delivered. Instructions for inserting into the program new instructions for calculating variable costs per mile and similar changes are described follow- ing the example.

Example

A hauler signs a seven-year lease for a bulk tank which includes a $1,500 nonrefundable payment plus one-half cent per hundredweight delivered.

There are two steps needed to incorporating these new conditions. First, the initial payment is a partial payment for the tank and should be treated as any other cost by inserting the payment, $1,500, into register 06 with the life

established at 7 years placed in register 07. Second, the cwt rental rate must
be multiplied by hundred pounds delivered to determine the rental fee. Average
daily pounds delivered is stored in register 02 which must be multiplied by 365
to calculate the annual total. These steps can be accomplished as follows:

Press	Display	Function Performed
GTO 275	---	Locate appropriate place in the program
LRN	275 95	Put in learn mode
2nd INS	275 00	Clear space (this instruction moves all the following steps ahead by one place)
x	276 95	Multiply rate times capacity (the calculator automatically advances you by one step so that you do not see what was just inserted)
2nd INS	276 00	Clear space
RCL	277 95	Recall average daily cwt delivered
2nd INS	277 00	Clear space
2	278 95	Completes RCL command
2nd INS	278 00	Clear space
x	279 95	Multiply by 365 to give annual value
2nd INS	279 00	Clear space
3	280 95	Begin inserting 365
2nd INS	280 00	Clear space
6	281 95	
2nd INS	281 00	Clear space
5	282 95	
LRN	---	Exit learn mode

When using this modification it is important that register 29 is not used
for anything but the rental rate. If it is the entire value stored in this
register will be treated as the rental rate, leading to a substantial over-
estimate of the cost.

If this change is to be permanent it may be stored on a magnetic card by
following these steps:

Press 1 2nd WRT - insert card, turn over

Press 2 2nd WRT - insert card

If the display number is not flashing, the program was transferred properly.

SECTION II

Determining Hauling Rates from the Program Estimates

Hauling costs may be divided into three categories - on-farm, travel, and volume - based on where they are incurred. These categories take account of variable costs of travel (fuel, tires and maintenance) and the fixed costs of the tank, truck, insurance and the scheduled driver. Fixed costs including labor are substantial, comprising approximately two-thrids of total assembly route costs, and must be allocated across a full day's activities on a cost per minute basis.

On-farm costs are fixed costs which include the time required to perform routine chores at each stop. These chores include hooking up, agitating the milk, sampling, and rinsing the farm tank. The driver's personal time for lunch and rest breaks is also included with the on-farm costs.

Travel or mileage costs include both fixed and variable cost segments. The variable costs are related to the miles traveled while the fixed costs include the proportionate share of the overhead costs for the time the truck is traveling. The final category, volume costs, involves pumping time at the farm and plant.

These three components of the hauler rate are summarized in Figure 3 below. For completeness, this figure also indicates how the producer rate is related to hauler payments. Producers are assessed in a slightly different fashion than the haulers are paid so that there is not a direct pass-through of each cost item, as shown in the Figure.

Figure 3:   Cost Components Included in the Hauler Rate and Producer Payment

Hauler Rate	Route Costs	Producer Rate
Stop Payment	On-farm labor, excluding pumping time, plus share of fixed cost, plus waiting and personal time	Stop Charge
Mileage Payment	Transport (garage to first farm, last farm to plant and plant to garage) cost	Location Differential
	Assembly (first to last farm) costs plus share of fixed cost and labor	
Volume Payment	Plant pumping and wash time plus farm pumping time	Volume Change

Steps for making these calculations using the TI-59 program are outlined in Figure 4.

This portion of the program uses estimates from the program described above and consequently cannot be run unless steps A and B have been run previously. The steps for this program are included in the Appendix beginning at 336.

Figure 4: Operating Instructions for Part II of the TI-59 Program
After Running Part I:

DATA INPUT						
Item	Example Value	Press Key	Example Display	Your Value	Press Key	Your Display
Number of Farm Stops	9	STO 30	9	_____	STO 30	_____

OUTPUT			
Press Key	Value Output	Example Display	Your Display
C	Stop Payment	3.54	_____
R/S	Mileage Payment/Mile	.734	_____
R/S	Volume Payment/cwt	.071	_____

The procedure followed in the program can best be explained by manually running through the calculating it makes internally.

Item	Includes	Amount	
Stop Payment	On-farm labor time (excluding pumping time) plus share of waiting and personal time (8)	10	mns. per farm labor time
		x 9	no. farm stops
		90	
		+ 75	waiting and personal time
		165	total stop time
		x.193	FC/Mn (from Figure 1)
		31.84	total stop cost
		÷ 9	
		$3.54	stop payment
Mileage Payment	Assembly time plus mileage costs	480	total minutes in day
		-165	stop time
		-53.39	farm pump time (9)
		-27.18	plant pump time (10)
		- 30	wash time (11)
		204.42	total route time
		x.197	FC/Mn (from Figure 1)
		$39.59	time cost

Item	Includes	Amount	
		110	miles
		x.374	VC/mile
		$41.14	mileage cost
		41.14	
		33.66	
		$80.68	total cost
		÷110	miles
		.733	mileage payment/mile (12)
Volume Payment	Plant pumping and washing time plus on-farm pumping time	53.39	farm pump time (9)
		+27.18	plant pump time (10)
		+30.00	wash time (11)
		110.57	total volume time
		x.193	
		21.34	total volume cost
		÷299	cwt delivered
		.071	volume payment

CONCLUSIONS

The calculated hauling cost of 44½ cents per hundredweight must be used only as a base or guideline rate. There are numerous other factors that should be considered in arriving at an actual rate. The actual rate must include a return for hauler management and risk not included in the cost estimates as well as including differentials for specific route characteristics such as road conditions and grade. Thus each route or group of routes served by a hauler must be analyzed separately with the final rate determined through individual negotiations.

The procedure described above if properly implemented is a means of achieving a closer correlation between hauling rates and actual route costs. It should provide an incentive for both producers and haulers to improve efficiency in the milk assembly system and serve the long-run interests of all participants.

FOOTNOTES

[1] The program is readily transferable to another programming language such as that used on the HP-97 calculator. Some knowledge of programming is needed.

[2] More precisely the appropriate rate should fall somewhere between the replacement cost and the "actual" cost based on current equipment costs. The replacement cost figure is utilized here because there is often a substantial lag in incorporating replacement cost figures in the hauling rate. This lag is a result of the time necessary to assemble the cost figures and negotiate rates, which then remain in effect for a year. At the end of this period during a time when equipment costs are rising rapidly the rate is actually below the true replacement cost rate and is assumed to approximate the minimum rate needed to keep haulers in the industry.

[3] The Annual Equivalent Cost (AEC) formula used in the program is:

$$AEC = EC \frac{i(1+i)^n}{(1+i)^n - 1} - SV \frac{i}{(1+i)^n - 1}$$

EC - equipment cost
SV - salvage value at end of nth year
i - interest rate

Source: Gerald W. Smith, Engineering Economy: Analysis of Capital Expenditures. Iowa State University press, Ames, 1968, p. 99.

For further information see Smith or another book on engineering economy.

From the equivalent cost must be subtracted the appropriate tax savings available to the hauler. These include an investment tax credit (14% is used in the program which includes 10% federal and 4% New York State). Also straightline depreciation tax savings are deducted (a rate of 20% is assumed). Straightline depreciation was chosen because it approximates the method used by many smaller firms. Its use will lead to an underestimate of tax savings and thus a small overestimate of the equivalent cost for firms with sufficiently high incomes which use an accelerated depreciation such as double declining balance. The 20% tax rate is considered to be a good estimate for the entire industry but may be an underestimate for some large or more profitable operations.

[4] With the annual equivalent cost figure the annuity represents partially debt servicing and partially an increase in equity. Thus over the life of the good the interest rate must represent, in different proportions, both the cost of borrowed capital and the value of equity to the owner. Typically for small operators equity has a higher opportunity cost than borrowed capital because the risk is greater, and it should receive a higher return. The interest payments from equity are, however, taxable while debt servicing costs are tax deductible so that the other tax rate for both is applicable. After these adjustments are made and the average rate for debt and equity is calculated the yield of industrial bonds rated "A" is assumed to be a good approximation to the true value.

5/ Tire costs are calculated assuming that an average carcass is retreadable once and that a bias ply carcass has a total service life of 60,000 miles and a radial a life of 100,000 miles. These are averages for all the tires on a truck since the actual mileage depends on which axle it is placed on as well as road conditions, etc.

6/ Operationally, this entry provides a "switch" which changes the base of the cost from 60,000 miles for bias ply tires to 100,000 miles for radials.

7/ Some leases require a substantial payment at the beginning of the contract. If this payment is nonrefundable it should be entered in register 3 or 7 as equipment cost. Even if the payment is refunded at the expiration of the lease the compounded interest figure over the period can be substantial. This amount too, should be entered as a cost.

8/ The figures for this example are based on a 1978 study of hauling routes in the New York State order area.

9/ On the farm milk is assumed to be pumped at the rate of 560 pounds/minute.

10/ At the plant milk is assumed to be pumped at the rate of 1,000 pounds/minute.

11/ A truck is assumed to be washed only once a day.

12/ Figures may not match exactly these in Figure 4 because of rounding error.

BULK MILK ASSEMBLY PROGRAM

000	76	LBL	053	08	08	106	55	÷
001	11	A	054	65	×	107	71	SBR
002	53	(	055	71	SBR	108	35	1/X
003	43	RCL	056	33	X²	109	95	=
004	03	03	057	75	-	110	99	PRT
005	65	×	058	93	.	111	91	R/S
006	93	.	059	02	2	112	43	RCL
007	08	8	060	65	×	113	50	50
008	06	6	061	53	(	114	55	÷
009	54	)	062	53	(	115	53	(
010	65	×	063	43	RCL	116	43	RCL
011	71	SBR	064	06	06	117	02	02
012	89	π	065	65	×	118	65	×
013	75	-	066	93	.	119	03	3
014	43	RCL	067	08	8	120	06	6
015	05	05	068	06	6	121	05	5
016	65	×	069	75	-	122	54	)
017	71	SBR	070	43	RCL	123	95	=
018	33	X²	071	08	08	124	99	PRT
019	75	-	072	54	)	125	91	R/S
020	93	.	073	55	÷	126	43	RCL
021	02	2	074	43	RCL	127	50	50
022	65	×	075	07	07	128	55	÷
023	53	(	076	54	)	129	53	(
024	53	(	077	85	+	130	43	RCL
025	43	RCL	078	43	RCL	131	15	15
026	03	03	079	09	09	132	65	×
027	65	×	080	85	+	133	02	2
028	93	.	081	43	RCL	134	01	1
029	08	8	082	10	10	135	09	9
030	06	6	083	85	+	136	00	0
031	75	-	084	43	RCL	137	00	0
032	43	RCL	085	11	11	138	54	)
033	05	05	086	85	+	139	95	=
034	54	)	087	43	RCL	140	99	PRT
035	55	÷	088	13	13	141	42	STO
036	43	RCL	089	85	+	142	41	41
037	07	07	090	43	RCL	143	91	R/S
038	54	)	091	14	14	144	76	LBL
039	85	+	092	65	×	145	89	π
040	53	(	093	03	3	146	53	(
041	43	RCL	094	06	6	147	53	(
042	06	06	095	05	5	148	43	RCL
043	65	×	096	65	×	149	12	12
044	93	.	097	43	RCL	150	65	×
045	08	8	098	15	15	151	71	SBR
046	06	6	099	95	=	152	34	┌X
047	54	)	100	42	STO	153	54	)
048	65	×	101	50	50	154	55	÷
049	71	SBR	102	99	PRT	155	53	(
050	89	π	103	91	R/S	156	43	RCL
051	75	-	104	43	RCL	157	49	49
052	43	RCL	105	50	50	158	75	-

```
159  01    1          211  92  INV SBR     263  85    +
160  54    )          212  76  LBL         264  43  RCL
161  54    )          213  12   B          265  27   27
162  92  INV SBR      214  71  SBR         266  85    +
163  76  LBL          215  35  1/X         267  43  RCL
164  33  X²           216  55   ÷          268  28   28
165  53   (           217  43  RCL         269  65   X
166  43  RCL          218  20   20         270  71  SBR
167  12   12          219  65   X          271  35  1/X
168  55   ÷           220  43  RCL         272  85    +
169  53   (           221  21   21         273  43  RCL
170  43  RCL          222  85   +          274  29   29
171  49   49          223  53   (          275  95   =
172  75   -           224  53   (          276  42  STO
173  01    1          225  53   (          277  51   51
174  54    )          226  43  RCL         278  99  PRT
175  54    )          227  22   22         279  91  R/S
176  92  INV SBR      228  85   +          280  43  RCL
177  76  LBL          229  43  RCL         281  50   50
178  34  ГX           230  23   23         282  85    +
179  53   (           231  54   )          283  43  RCL
180  53   (           232  55   ÷          284  51   51
181  01    1          233  53   (          285  95   =
182  85   +           234  06   6          286  99  PRT
183  43  RCL          235  00   0          287  42  STO
184  12   12          236  00   0          288  53   53
185  54   )           237  00   0          289  91  R/S
186  45  YX           238  00   0          290  43  RCL
187  43  RCL          239  85   +          291  53   53
188  04   04          240  43  RCL         292  55   ÷
189  54   )           241  25   25         293  53   (
190  42  STO          242  65   X          294  03   3
191  49   49          243  04   4          295  06   6
192  43  RCL          244  00   0          296  05   5
193  07   07          245  00   0          297  65   X
194  48  EXC          246  00   0          298  43  RCL
195  04   04          247  00   0          299  02   02
196  48  EXC          248  54   )          300  54   )
197  07   07          249  54   )          301  95   =
198  43  RCL          250  65   X          302  99  PRT
199  49   49          251  71  SBR         303  91  R/S
200  92  INV SBR      252  35  1/X         304  43  RCL
201  76  LBL          253  65   X          305  53   53
202  35  1/X          254  43  RCL         306  55   ÷
203  53   (           255  24   24         307  71  SBR
204  43  RCL          256  54   )          308  35  1/X
205  01   01          257  85   +          309  95   =
206  65   X           258  43  RCL         310  99  PRT
207  03   3           259  26   26         311  91  R/S
208  06   6           260  65   X          312  43  RCL
209  05   5           261  71  SBR         313  51   51
210  54   )           262  35  1/X         314  55   ÷
```

```
315   53   (
316   43   RCL
317   02   02
318   65   ×
319   03   3
320   06   6
321   05   5
322   54   )
323   95   =
324   99   PRT
325   91   R/S
326   43   RCL
327   51   51
328   55   ÷
329   71   SBR
330   35   1/X
331   95   =
332   99   PRT
333   42   STD
334   42   42
335   91   R/S
336   76   LBL
337   13   C
338   53   (
339   53   (
340   43   RCL
341   30   30
342   65   ×
343   01   1
344   00   0
345   85   +
346   07   7
347   05   5
348   54   )
349   65   ×
350   43   RCL
351   41   41
352   54   )
353   55   ÷
354   43   RCL
355   30   30
356   95   =
357   99   PRT
358   91   R/S
359   53   (
360   53   (
361   43   RCL
362   15   15
363   65   ×
364   06   6
365   00   0
366   75   -

367   53   (
368   43   RCL
369   30   30
370   65   ×
371   01   1
372   00   0
373   85   +
374   07   7
375   05   5
376   85   +
377   71   SBR
378   23   LNX
379   85   +
380   71   SBR
381   32   X:T
382   85   +
383   03   3
384   00   0
385   54   )
386   54   )
387   65   ×
388   43   RCL
389   41   41
390   85   +
391   43   RCL
392   01   01
393   65   ×
394   43   RCL
395   42   42
396   54   )
397   55   ÷
398   43   RCL
399   01   01
400   95   =
401   99   PRT
402   91   R/S
403   53   (
404   53   (
405   71   SBR
406   23   LNX
407   85   +
408   71   SBR
409   32   X:T
410   85   +
411   03   3
412   00   0
413   54   )
414   65   ×
415   43   RCL
416   41   41
417   54   )
418   55   ÷

419   43   RCL
420   02   02
421   95   =
422   99   PRT
423   91   R/S
424   76   LBL
425   23   LNX
426   53   (
427   53   (
428   43   RCL
429   02   02
430   65   ×
431   01   1
432   00   0
433   00   0
434   54   )
435   55   ÷
436   05   5
437   06   6
438   00   0
439   54   )
440   92   INV SBR
441   76   LBL
442   32   X:T
443   53   (
444   53   (
445   43   RCL
446   02   02
447   65   ×
448   01   1
449   00   0
450   00   0
451   54   )
452   55   ÷
453   01   1
454   01   1
455   00   0
456   00   0
457   54   )
458   92   INV SBR
```