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PHAER
Producers' Haul and Elevator Receipts

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1. INTRODUCTION

PHAER, Producers' Haul and Elevator Receipts, is a computer based system developed as an aid to rational planning in grain handling and transportation. Planning for these areas is a critical problem currently facing Canada as a nation and in particular, the three Prairie Provinces. Technological advances and rising operating costs, among other factors, have forced changes to be made in grain handling and transportation. Of grave concern to the grain producer is the increasing number of elevator and delivery point closures.[1] PHAER was designed to examine the effect of potential delivery point closures on the producers and on the neighboring delivery points. It has the capacity to do a number of calculations, but this paper will concern itself primarily with the calculation of the producers' haul and elevator receipts at a delivery point for any configuration of delivery points in any region of the Prairie Provinces.[2]

Because of the *physical size* of the three Prairie Provinces, which cover over 200,000 square miles of agricultural land, the concern of a large number of interested parties, (i.e. in addition to the direct involvement of up to 178,000 producers and 16 elevator companies administering 4,572 elevators at any of 1,666 delivery points, there is also the concern of the Federal Government, three Provincial Governments and innumerable Municipal Governments); and the *dynamic nature* of the grain handling and transportation situation it was necessary that PHAER be so designed that it would:

a) be easy to operate

b) be inexpensive to run

c) have maximum flexibility to allow for the addition of or changes in data, changes in data format, and technical refinements.

2. METHODOLOGY

The PHAER system was developed to manipulate data on the existing pattern of grain deliveries in a manner consistent with a model which was developed to measure the producers' haul and delivery point receipts.

The model may appear simple, as theoretically, a producer's haul is the product of bushels delivered and the distance over which he travels to make

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1 Since the end of the 1969-70 crop year there have been nearly 600 elevator and over 200 delivery point closures.

2 The PHAER system is applicable only to those areas described in the Dominion Land Surveys.

his deliveries. However, the model is complicated by the fact that producers may own more than one parcel of land and neither the amount of grain hauled from the individual parcels of land nor the hauling distance is known. This information had to be estimated from the data that was available and on certain basic assumptions which would be applicable to the entire Prairie Region.

2.1 Hauling Distance

For the hauling distance to be readily calculated the following assumptions were made:

(a) That part of the earth which contains the Prairie Region approximates the surface of a sphere. The region is flat and free of severe topographic features (such as mountains and rivers). Distances to be calculated are for the most part under 100 miles.

(b) That there exists a network of roads for the Prairie Region, running north-south or east-west, and that these roads are suitable for the transport of grain, see figure 1.

PRAIRIE ROAD NETWORK

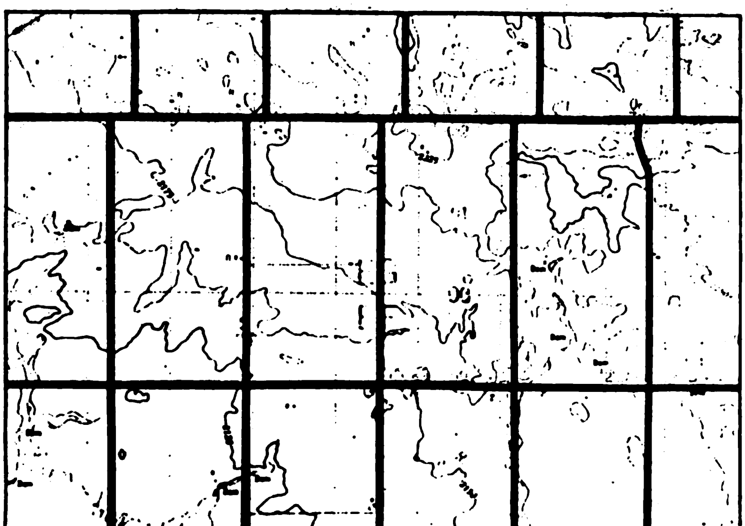

FIGURE 1

Hauling distance is estimated by summing the two sides which subtend the right angled triangle in which the two end points of the hypotenuse represent the origin and destination of haul.

The hauling distance in miles can be expressed as:

Distance =

$$1.1508 \cdot \left\{ |lat_D - lat_O| + |long_D - long_O| \cdot \cos\left(\frac{lat_O + lat_D}{2}\right)\right\} \quad (1)$$

where:

1.1508 is the conversion factor from nautical miles to statute miles.

lat denotes latitude expressed in minutes.

long denotes longitude expressed in minutes.

the argument of the cosine is expressed in degrees.

subscript D denotes destination.

subscript O denotes origin.

Simply stated the producers' hauling distance is the sum of the north-south and east-west components of the great circle distance between the producers' points of origin and destination. The north-south distance is given by the first term in equation (1) and the east-west distance is given by the second term.

If the assumption in a) holds, the error arising in the distance as calculated by equation (1) is well under one per cent. The hauling distances estimated by this equation were found to be, on the average (for each delivery point), well within a mile of the average haul distances measured clerically on topographical maps.

2.2 Delivery Effort

For the purpose of this paper, delivery effort is the product of the producers' bushels delivered to a delivery point and the distance over which they were hauled (expressed in bushel-miles). To calculate the delivery effort, therefore, the points of destination and origin are located and the number of bushels hauled from each point of origin calculated.

The producer's point of destination is located by the actual longitude and latitude of the delivery point.

However, the calculation of the producers' points of origin and the bushels hauled from each point is complicated by two factors:

1) a producer may haul his grain to more than one delivery point.

2) more than 70 per cent of the producers' farms have more than one parcel of land and there is no way of knowing from which parcel of land the grain is delivered.

In view of the latter, the basic assumption had to be made that the producer's bushels are evenly distributed throughout the entire farm.

If the producer's farm contains only one parcel of land, that farm can be no larger than one section (i.e. one square mile) if it is to be described by the Dominion Land Survey System. Therefore, it is reasonable to use the latitude and longitude of the centroid of that farm to locate the point of origin. However, if a producer hauling to two delivery points 20 miles apart has a farm consisting of two equal size parcels of land each parcel one mile from its closest delivery point, the centroid of the farm would fall mid-way between the two parcels of land. The producers' delivery effort would be grossly overestimated if he hauled to the nearest delivery point. A modification of the definition of the origin of the farm had to be made in those instances where the producer operates more than one parcel of land.

The calculation of the delivery effort is based on the logic that if a producer is hauling to two delivery points, the grain hauled will originate from the centroid of the land closest to that delivery point. For each of the producer's delivery points, therefore, the land is partitioned into two areas; those parcels of land which are closest to the delivery point (the B area) and those which are not (the C area). The centroid of each of the two areas is then calculated. The bushels delivered from each area are determined with the constraint that the proportion of total bushels delivered from each parcel of farm land cannot be greater than the proportion of the area of that parcel of farm land to the total farm area, see Figure 2.

Two cases may arise. In the first case the receipts at a grain delivery point are greater than the bushels that can be contributed by the B area. In this event, the delivery effort is calculated as follows: the amount of bushels delivered from the centroid of B is taken to be the amount of bushels that is consistent with the area of B. The remaining receipts are taken to be delivered from the centroid of C. The delivery effort is then the product of the amount of bushels delivered from the centroid of C, and its corresponding haul distance to the delivery point, summed with the product of the bushels delivered from the centroid of B, and its corresponding haul distance to the delivery point.

In the second case, the receipts at a grain delivery point are equal or less than the bushels that can be contributed by the B area. The delivery effort is then the product of the bushels delivered from the centroid of B, and its corresponding haul distance to the delivery point.

More concisely, these two cases may be expressed as follows:

Case 1 if $\frac{B}{A} \times T \leqslant t$ then $b = \frac{B}{A} \times T$ and $c = t - b$

Case 2 if $\frac{B}{A} \times T > t$ then $b = t$ and $c = 0$

The possibility that $B = 0$, $b = 0$, for $C > 0$ and $c > 0$, is also allowed. The delivery effort is given by

PHAER DELIVERY EFFORT

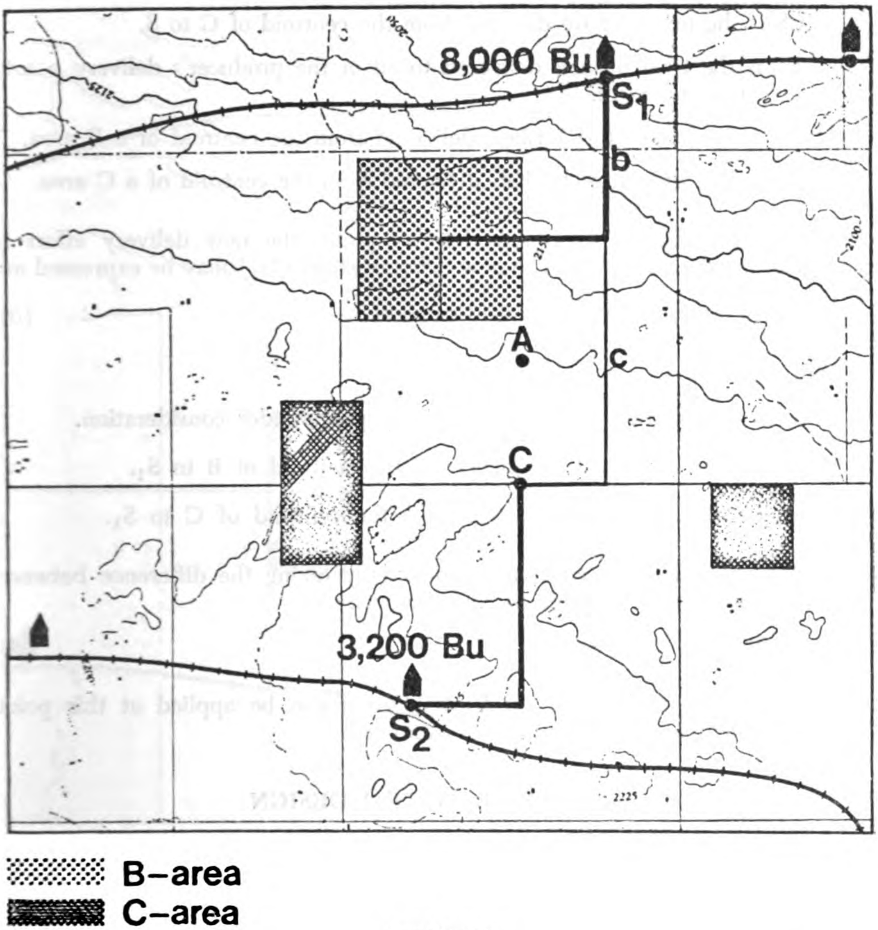

FIGURE 2

$$D = b\,\overline{BS} + c\,\overline{CS}$$

where

S is the Delivery Point under consideration.

A is the total area of the farm.

B is that area of the farm which is closer to S.

C is that area of the farm which is not closer to S.

t is the bushels delivered to S from the farm.

$\overline{BS}$ is the present haul distance from the centroid of B to S.

$\overline{CS}$ is the present haul distance from the centroid of C to S.

T is the total bushels delivered to all of the producer's delivery points from his farm.

b is the amount of bushels delivered from the centroid of a B area.

c is the amount of bushels delivered from the centroid of a C area.

On the selection of a new delivery point, the new delivery effort is calculated in the same way. The new delivery effort (D_1) may be expressed as:

$$D_1 = b\overline{BS_1} + c\overline{CS_1} \qquad (3)$$

where

S_1 is the location of the new delivery point under consideration.

$\overline{BS_1}$ is the new haul distance from the centroid of B to S_1.

$\overline{CS_1}$ is the new haul distance from the centroid of C to S_1.

The extra delivery effort is calculated by taking the difference between the two, see Figure 3. This is expressed as:

$$\text{Extra Haul} = D_1 - D \qquad (4)$$

A cost per bushel-mile for hauling grain can be applied at this point and the producer's extra haul costs estimated.

3. PHAER SYSTEM DESIGN

The magnitude of the data input and the complexity of the logic behind the enquiries were the two controlling factors which determined the design of the system. For efficient and economical operation, it was imperative that the system be constructed in two separate phases, see Figure 4.

3.1 Phase One

The first phase processes the input data and creates two master files, one on the producers, the other on the delivery points. The input data on the producer include details on the grain he delivers, the delivery points he uses, size and location of his farm and the age and weight of his farm truck(s). The input data on the delivery points include the number, capacity and receipts of elevators at the points and their location.

In addition to the input data on the producers, the producers' master file contains other information such as the value of the grain delivered, the location of the centroids for the A, B and C areas of the producers' farm and the delivery effort for each of the delivery points used by the producers.

PHAER EXTRA-HAUL

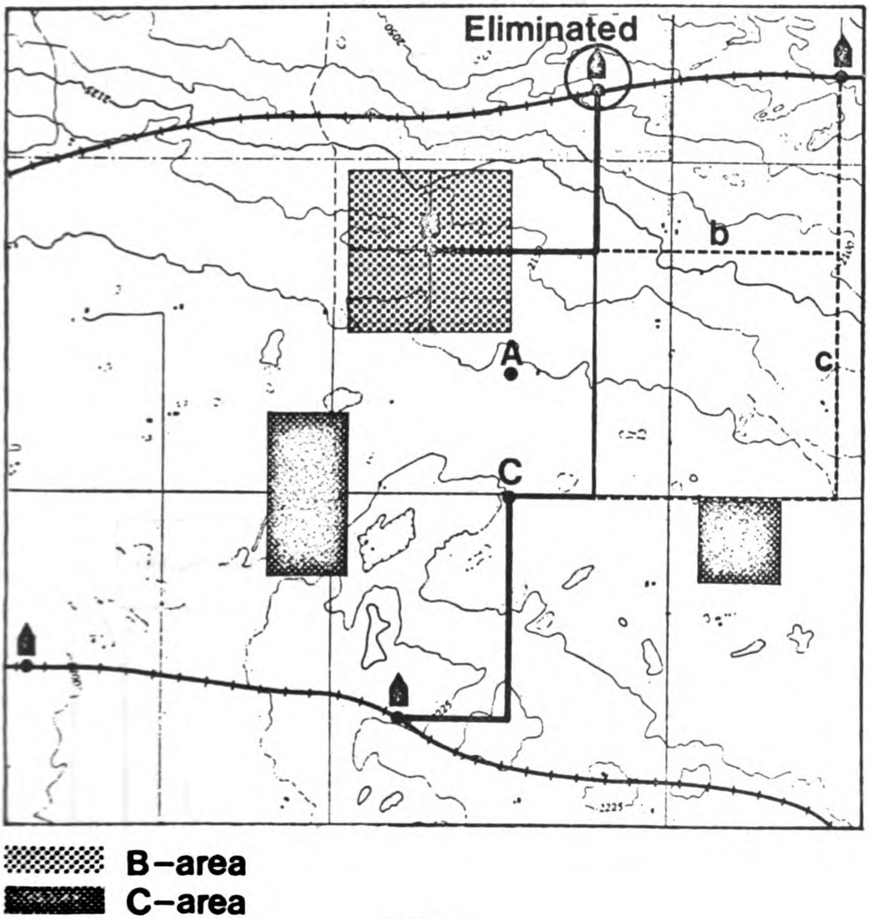

FIGURE 3

(An explanation of the A, B and C areas as well as the delivery effort is given in section 2.2.)

The delivery point master file contains a summation of all the input data on the elevators by delivery point as well as the location of the delivery point and the value of the grain receipts. Although specifically designed for use in PHAER, these master files can be used for other applications, for example, the mapping of grain hinterlands.

This phase of PHAER requires the largest proportion of the computer's resources, but once the master files have been created, they need only be run for a subsequent up-date, which, by nature of the data, normally occurs annually.

PHAER
SYSTEM FLOW CHART

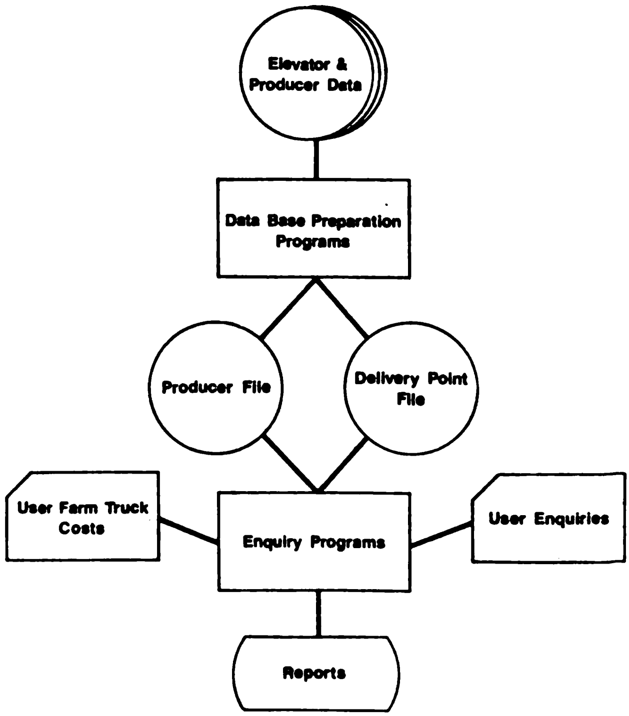

FIGURE 4

3.2 Phase Two

The second phase processes the users' proposals on various delivery point configurations, calculates the effects of such proposals and prints reports for each of the proposed delivery point configurations.

The effects calculated by PHAER include the nearest alternative delivery points, the added receipts at the nearest alternative elevator, the new handling to capacity ratio and estimates of the following: the producers average present haul to the delivery point to be eliminated, the average extra haul to the nearest alternative delivery point in miles and bushel-miles, the average extra haul costs, and a distribution of the extra haul costs.

3.3 User Enquiries

The user's proposals, or enquiries, are in the form of a list of delivery points together with an indication of whether each delivery point is to be eliminated or ignored. A computer run can contain a number of enquiries but the number of "eliminates" specified cannot exceed 510.

The option to ignore delivery points was built into the system because in many instances the user would know *a priori* that within selected configurations certain delivery points should not be considered as an alternative. The ignored option creates the impression within the system that the specified delivery point does not exist, see Figure 5.

If the user indicates that a delivery point is to be eliminated, then the delivery point is considered closed and the grain hauled to that delivery point is dispersed to surrounding delivery points, see Figure 6. The sole criteria for selecting the alternative delivery point is the shortest hauling distance.

PHAER

BARRIERS TO NEAREST ALTERNATIVE

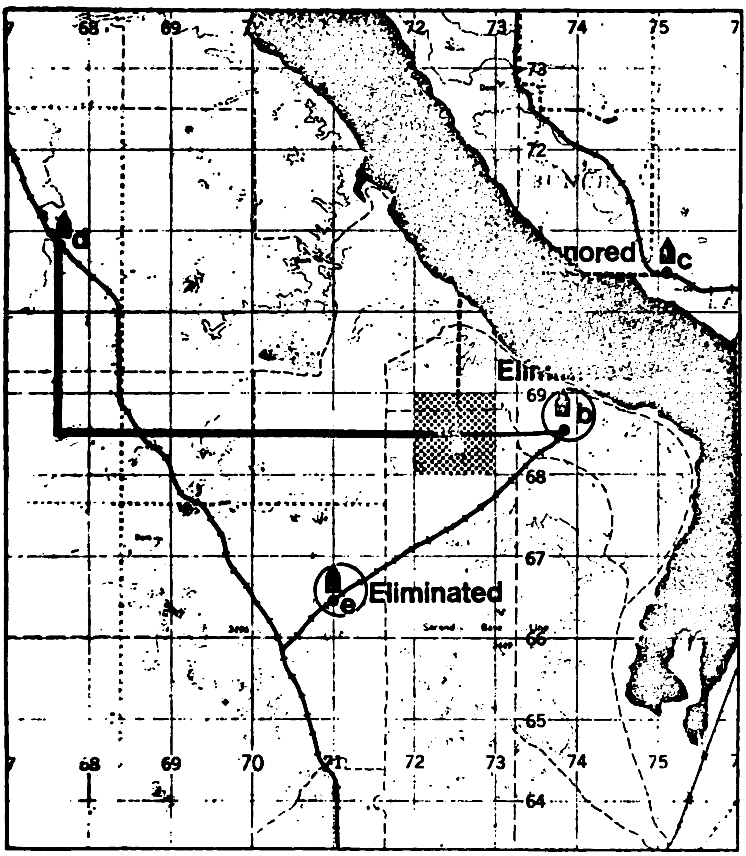

FIGURE 5

PHAER

CHOICE OF NEAREST ALTERNATIVE

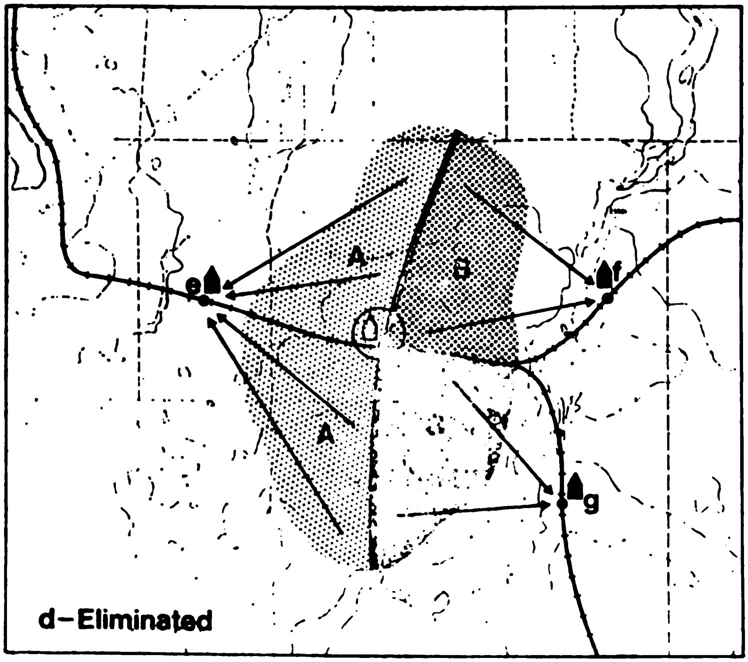

FIGURE 6

If the user wishes to obtain an estimate of the cost of producers' extra haul, the system is capable of handling costs on up to four categories of trucks, broadly classified by age and weight, for each of the three Prairie Provinces. These costs may be submitted to the system at the same time as the user enquiries, see Figure 4.

4. CONCLUSION

In its present state of development, PHAER can be used to analyse producers' haul and elevator receipts for any existing or proposed delivery point configuration in the Prairie Provinces. It has proven to be easy to use, inexpensive to run and has the required flexibility for future changes. The necessity of further refinements can only be determined by repetitive use and detailed field studies.

It is to be emphasized that the system, PHAER, is an analytical tool developed for the use of parties concerned with grain handling and transportation problems; it in no way pretends to provide the solution to the problem. The merit of PHAER lies in its ability to estimate producers haul to a delivery point and elevator receipts at that point under any hypothetical configuration of delivery points at relatively low cost and with little effort on the part of the user. The output for a specified area provides the basis for an analysis of each configuration to determine the optimum between the costs for extra road haul and the potential economies gained from the operation of a more efficient elevator system. This analysis will reduce the number of desirable configurations. They can then be looked at in greater detail for other socio-economic effects such as the effect on roads, railway operations, communities and general economic development in the area.

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