computer-aided transportation corridor selection in the guelph-dundas area of ontario

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Society, at least a considerable segment of it, has changed its views concerning the role of transportation in determining the quality of daily life. For example, an ideal highway location was defined recently as "a path of maximum social benefit at least social cost" (3). Professional planners and engineers must respond to these concerns. They must be able to present and defend their proposals not only in terms of the traditional cost-benefit studies but also in terms of aesthetics and environmental effects. Such considerations add complexity to the traditional techniques. Time and manpower limitations dictate that the traditional planning procedures be revised and improved.

A number of procedures have been developed to aid the planning engineers in handling the increasing complexity of the location problems. Graphical analysis procedures and computer-aided methods represent the two most widely applied methods.

GRAPHICAL METHODS

The graphical procedures have some considerable attraction. A by-product of the techniques is the production of several map overlays that can be exhibited during public hearings and that will explain to the public the reasoning used by the planning agencies. Production of the map overlays is a manual operation that can be handled with equipment and personnel in many engineering offices (1, 3, 4, 5).

On the other hand, production of the overlays is a time-consuming and expensive process. In cases where large numbers of factors are involved, large numbers of overlays are required. The graphical technique may not speed up the planning process in such cases. Bias is possible, for it is rarely practical to revise the overlays and test the effects of these changed concepts on the selection of the corridors. Subjectivity seems certain to enter into the analysis, during either the combining of the overlays or the weighting of the routes chosen. Finally, to emphasize the importance of one factor or group of factors in any certain or consistent way is seemingly impossible.

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COMPUTER-AIDED METHODS

Computer-aided regional location methods contain greater flexibility than the graphical methods. Rather than the values of a series of factors being mapped manually in gray scales or color scales, the models are stored in numerical form as matrices within the computer. If the models are described in terms of codes that represent natural or cultural conditions, values can be assigned and numerical "cost models" can be constructed that correspond to the graphical gray scales. However, these numerical models can be rapidly and economically modified by simply changing the values assigned to the various condition codes. The engineer is thus free to modify the various factor overlays as often as he desires. This is the first major advantage of the computer-aided procedures.

The computer-aided methods also have additional advantages. For example, the various factor models represent data banks that can be used for any number of purposes for which information on the environment of an area is required. The data banks can be revised and updated as new information becomes available, probably more easily than can the graphical overlays. Furthermore, the various numerical cost models can be analyzed, by minimum path techniques, for example, to produce a ranked series of alternatives. Although these rankings must be reviewed by the engineer in charge of the project, they are a valuable source of information on the alternatives generated. Finally, numerical models allow the engineer to combine them in known proportions, by means of weighting factors, so as to emphasize certain factors or groups of factors. This capability is not available in the graphical methods. For these reasons, the computer-aided methods are the subject of this report (2, 6, 7, 8, 9).

USE OF GCARS IN THE GUELPH-DUNDAS STUDY

An operational computer-aided corridor selection system, the Generalized Computer-Aided Route Selection System (GCARS), was available. The Canadian government had initiated the Canada land inventory program in 1961, and preliminary results were available for several areas in Ontario. Increasing demands for more sophisticated data analysis in route selection were becoming evident.

Thus, it seemed appropriate to apply GCARS to new data sources in a southern Ontario test area in order to evaluate and test the capabilities of such types of analysis. The Guelph-Dundas area was chosen because it was accessible, was representative of much of rural southern Ontario, contained a good variety of conditions within a compact area, and was an area of current interest to the Ontario Department of Transportation and Communications.

GCARS was developed at Purdue University between 1966 and 1969 as a research and teaching tool to analyze and demonstrate the potential role of the computer in the regional planning field (7, 8, 9). The early concepts and experiments were based on the premise that transportation corridor selection includes some operations that involve judgment and some that are merely routine. Therefore, it seemed that a man-machine interactive system would allow the engineer to exercise his judgment to its fullest and the machine to perform all the necessary calculations. The results of these early experiments were sufficiently promising to cause the development of more sophisticated versions used in this study.

Figure 1 shows the basic concepts of the system. Appropriate mathematical and statistical methods are applied to some basic information for each factor in order to develop numerical cost models. These models are shown as solid 3-dimensional surfaces in Figure 1, whereas in actual practice they are stored as matrices within the computer.

Desirable routes will follow the valleys across such cost models. The most desirable combines directness and low elevations so as to obtain the lowest total cost. Less desirable routes follow other valleys and pass over the intervening high cost areas. Sometimes such alternatives are shorter than the first choice and, although they have a higher cost per unit length, may be more desirable. Thus, the various choices should be compared in terms of overall length and total cost.

If a grid network is laid on such cost models such that each link in the network is assigned the cost of traversing it, minimum path analysis will discover the optimal path. Preventing the further use of the links forming central portions of the chosen path and reanalyzing the revised network will produce a second minimum—a second best alternative. Repeating the process will allow the generation of a ranked series of alternatives.

Figure 1 also shows that models for several factors can be superimposed and summed to produce cost models for any desired combination of factors. Before summation, each model can be multiplied by a weighting factor and thus be enhanced to any desired degree. Repeated minimum path analysis on networks derived from such combined models will generate a series of ranked alternatives in terms of combinations of factors.

GUELPH-DUNDAS AREA

The Guelph-Dundas area is approximately 7½ miles wide and 20 miles long and is oriented northwest-southeast. It lies northwest of the city of Hamilton in southern Ontario and extends from the lip of the Niagara escarpment just north of the town of Dundas in Wentworth County to southwest of the city of Guelph in Wellington County. Figure 2 shows the location of the test area.

The area has a variety of topography, geology, soils, and land uses. It was extensively glaciated in the recent geologic past.

In the southern portions of the area (in this discussion the Dundas end of the test area is the southern end, and the Guelph end is the northern end), the topography is quite flat; silty and sandy soils were formed from glacial lakes overlying the dolomite bedrock at shallow depths. These are interspersed with some silty glacial till that forms a series of low terminal moraines. Farther north, the soil becomes extremely thin so that over many areas the bedrock is essentially exposed at the surface. In the same area there are several groups of drumlins. Their axes lie almost true east-west at about 45 deg to the long direction of the test area. They range between 25 and 100 ft high.

Beverly Swamp, an extensive swampy area, lies between the drumlins and the first of a series of glacial moraines that cross the test area. The swamp is caused mostly by poor drainage into the near-surface bedrock. Peat and muck materials are rarely more than 6 ft deep and do not pose a major obstacle to construction. However, the area is valuable for wildlife breeding, and its preservation is of considerable concern to many persons in the region.

Three moraines that cross the area are, from south to north, Moffat, Galt, and Paris. The Galt and Paris moraines essentially merge around Puslinch Lake and to the east are separated by an outwash plain (composed of sand and gravel), which ranges up to about 2 miles wide. Another outwash plain lies to the north of the Paris moraine and extends to the Speed River, which lies just outside the limits of the test area. Many eskers and kames and several kettle lakes and minor muck pockets are associated with these moraines. Most of the moraines are sandy till, but several sections are sandy or gravelly.

The area was developed for agriculture by settlers around 1800, but much of the area is not ideal for farming because the soils are too thin or the topography is too rough. Only about 50 percent of the area is currently being farmed. Most of the farmland is used for beef and dairy cattle pasture, but important acreages are used for raising hay and corn ensilage for winter feed.

Some quarrying of the dolomite for construction materials has been undertaken in the southern part of the area. Sections near the edge of the Niagara escarpment and around some newly constructed or proposed reservoirs have been designated as recreational sites. Wildlife refuges and conservation areas have been set up or are proposed for several sections. The largest of these surrounds Beverly Swamp. Figures 3, 4, 5, and 6 summarize some of the conditions in the area. The data used for building the GCARS models were obtained from much more detailed maps as discussed in the following sections.

Figure 1. Basic concept of GCARS.

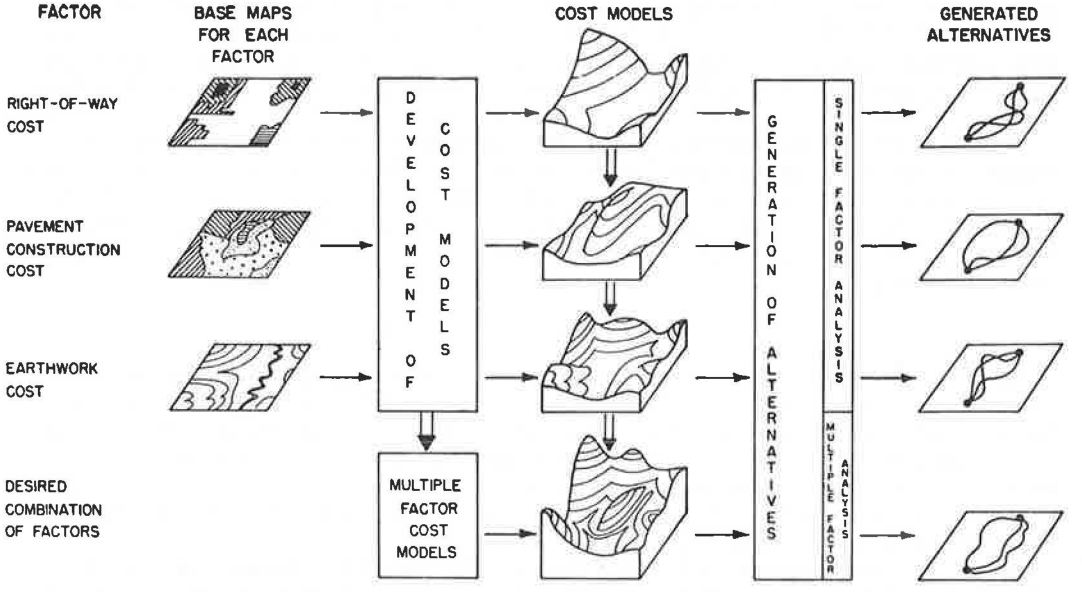


Figure 2. Guelph-Dundas test area.

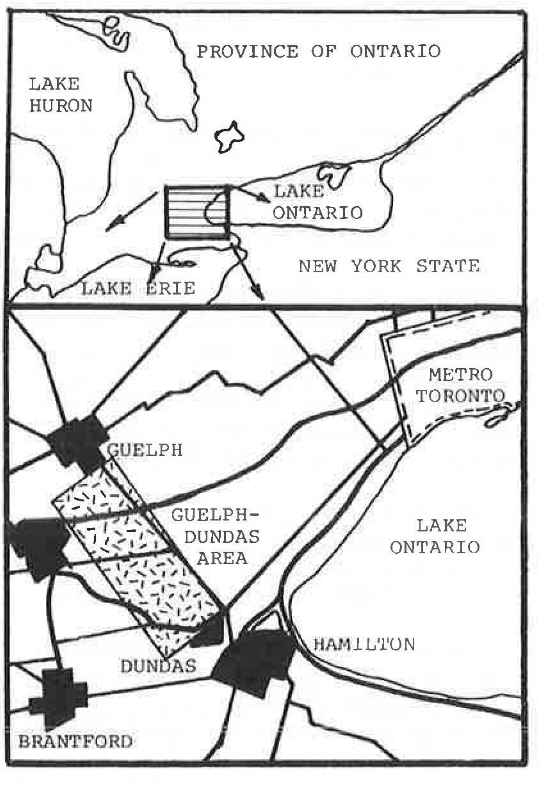


Figure 3. Topographic conditions.

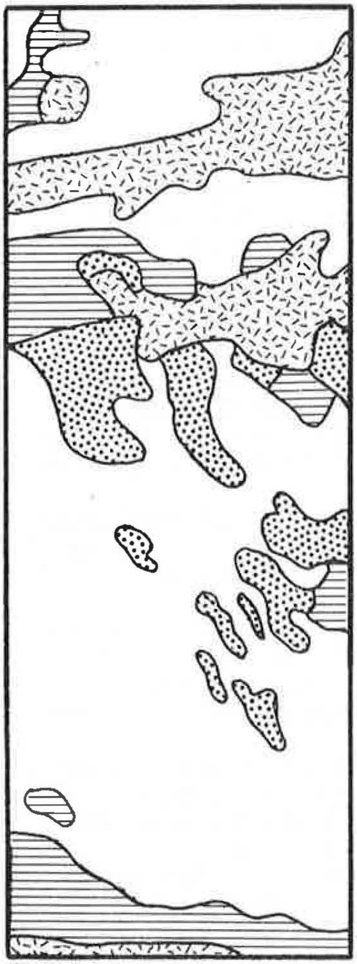


Figure 4. Surficial materials.

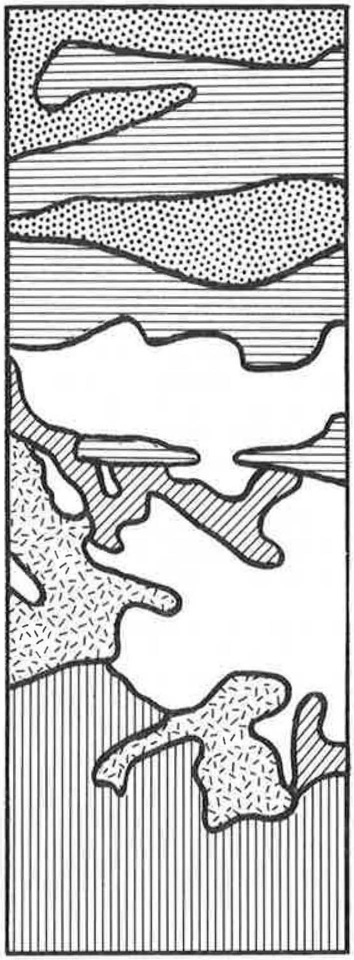
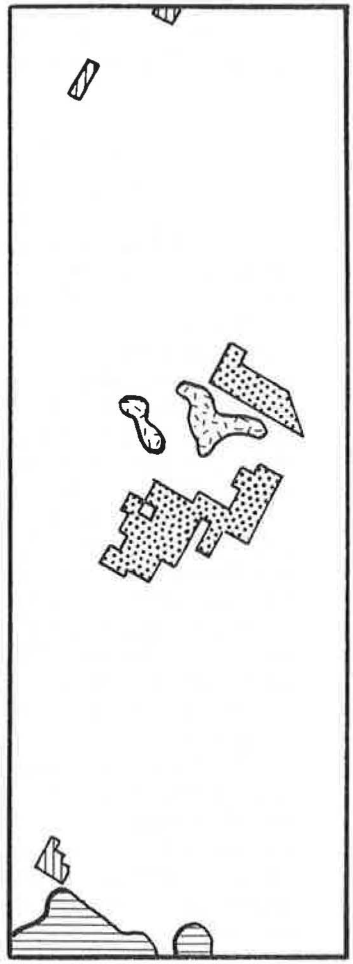


Figure 5. Recreation capabilities.



DEVELOPMENT OF GCARS FACTOR MODELS

A primary goal of the Guelph-Dundas study was the evaluation of environmental and social factors. The choice of factors was governed to some degree by the availability of data. It was decided to investigate a new potential data source: the Canada land inventory.

Canada Land Inventory

In 1961 the Canadian government passed the Agricultural Rehabilitation and Development Act that initiated a cooperative federal-provincial program to develop the Canada land inventory, a comprehensive survey of land capability and use. It includes information on present land use and assessments of land capability for agriculture, forestry, recreation, and wildlife (11, 12, 13).

Data are collected by provincial personnel and are generally recorded on 1:50,000 topographic base maps. The federal administration is responsible for overall coordination, establishment of national classification standards, and publication of final results. Data shown on 1:50,000 maps will ultimately be replotted on 1:250,000 scale colored regional maps, which will be sold to the general public. However, it is possible to obtain, by special request, copies of the more detailed 1:50,000 maps for use in highway location studies.

On occasion the provincial authorities expand their classification schemes to make them more detailed than the national classifications. For example, the Ontario wildlife classification uses 13 animal categories, and the national classification uses only 2 animal categories (13).

The capability inventories belonging to the Canada land inventory have certain standards in common. All utilize a 7-class rating scheme, where class 1 represents the ideal, class 7 the worst, and class 4 the average conditions. An area mapped as a single class includes those regions having "the same relative degree of limitation or hazard" (12).

Subclasses represent those regions having "similar kinds of limitations or hazards" (12) and by their letter codes are intended to convey the reason for an area being classified as less than ideal. Class 1 areas by definition do not need subclasses. The Ontario wildlife inventory shows the ultimate wildlife capability of each area according to class and natural limitations (subclass). It also shows a degree-of-effort rating, which represents the amount of effort and cost required to bring the area from its present state to its ultimate capacity (13).

The highway engineer is responsible for identifying and avoiding as much as possible those areas having superior capabilities for any resource and environmental factor. Construction of a highway inevitably causes some changes to preexisting conditions. If the road can be located on land marginally useful for agriculture, recreation, forestry, or wildlife, the improved accessibility may serve to improve the utility of this land for other purposes while protecting the more desirable areas. Thus models of the resource and environmental factors for use by GCARS need only identify and classify those areas having above-average capabilities. Accordingly, some simplification of the Canada land inventory classifications was possible.

Chosen Models

In addition to the Canada land inventory, topographic, geologic, and agricultural soil maps and air photographs were available for the entire area. It was ultimately decided to develop and evaluate the following 7 factor models: earthwork costs, foundation costs, right-of-way acquisition costs, recreation potential, wildlife potential—deer, wildlife potential—waterfowl, and wildlife potential—upland birds. Models 1 and 2 measured the construction costs of earthwork and pavement and subgrade support. The right-of-way costs model included not only costs of acquisition but consideration of the land's suitability for other uses, chiefly agriculture. Thus, this model to some extent measured environmental and social considerations as well as economics. Models 4 through 7 were used to analyze some of the important environmental concerns expressed by area residents.

Methods of Model Development

Data for each model were first compiled in map form at 1:25,000 scale. A grid was prepared on a transparent overlay, and the conditions at each mesh point were recorded on a coding form according to a predetermined 2-digit numeric code. Data from the coding forms were keypunched onto computer cards, and the cards were error-checked. Each grid was ¼ square mile, and the digitized data on the computer cards described conditions within $^{1}/_{16}$ square mile cell.

This system represents probably the simplest possible method of preparing data for machine computation. It is effective, rapid, and economical. All 7 models were converted to computer card form and error-checked in 1 week by 2 laboratory technicians. The original manuscript maps were saved and used during the analysis phases of the project.

Earthwork Cost Model

Aerial photographs and topographic maps were used in classifying and coding the terrain (Table 1). The value scheme to convert the codes to values before the minimum path analysis was attempted represents but one of many that might be used. A computer-aided system makes it possible to use different value schemes without having to recompile the basic topographic data.

Foundation Cost Model

A surficial geology map was developed by air-photo interpretation and checked against published geological reports and agricultural soils reports. Table 1 also gives the 14 categories mapped and coded.

The weights used to convert the codes to values for analysis are based on Ulbricht's methods (10). By utilizing 160 pavement sections, traffic records, and a panel of 6 experienced engineers to rate each section, he developed a mean soil rating based on a 10-point scale. He was able to show that these mean soil ratings were proportional to the soil support factors required by the AASHO design equations. Thus, larger ratings meant larger soil support factors, greater equivalent pavement thicknesses, and longer pavement life for any pavement design under a given traffic condition. Alternatively, if a standardized useful pavement life is desired, cheaper, thinner pavements can be built on soils having higher ratings.

The ratings proposed for the Guelph-Dundas test area were developed by comparing local soils with the soils studied by Ulbricht. However, they were computed on a 10-point scale so that high values represent soils on which high construction costs can be expected.

Right-of-Way Acquisition Cost Model

Information for the right-of-way costs model was obtained from the Canada land inventory and agriculture maps. The suggested ratings give high values to land uses that should not be disrupted (Table 1). Use of minimum path analysis procedures will produce routes that avoid the high-cost areas as much as possible while remaining reasonably direct.

Recreation Potential Model

Information was gathered on existing and proposed parks and conservation areas from local authorities and on areas having high recreation potential or historical interest from the Canada land inventory.

Canada land inventory capability classes 5 through 7 were ignored, for they are the least likely to be developed if other more suitable sites with greater potential are available. However, parks or conservation areas could be developed in such low capability areas just to provide open space. Accordingly, all existing or proposed sites have to be indicated regardless of their classification in the Canada land inventory. Table 1 gives the recreation model classifications, codes, and ratings.

Figure 6. Land use.

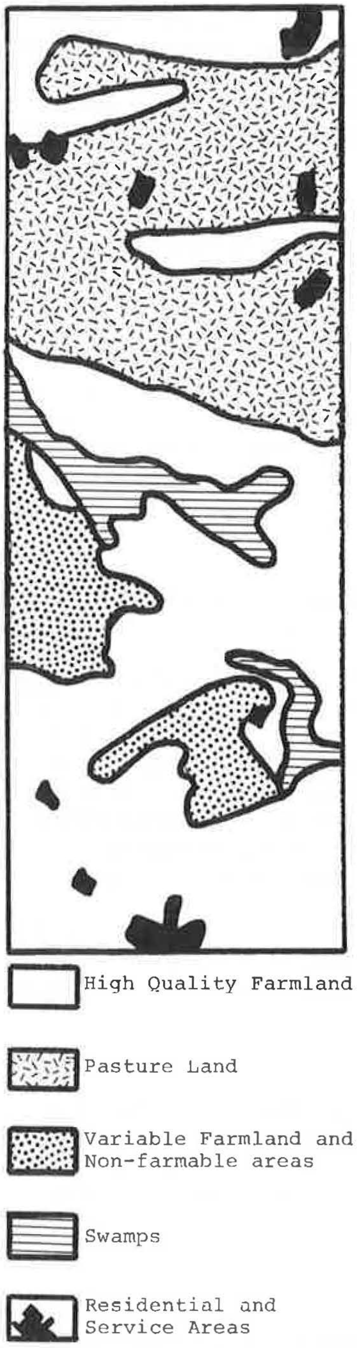


Table 1. Cost model codes and ratings.

Classification	Code	Proposed Rating	
Earthwork model			
Flat terrain	10	0	
Flat terrain on bedrock	11	2	
Rolling terrain	20	4	
Hilly terrain	30	8	
Rough and broken terrain	40	10	
Water bodies	90	12	
Foundation model			
Glacial till			
Drumlins	01	5.2	
Sandy till	02	5.3	
Kame moraines, kames	03	2.5	
Sands and till	04	5.3	
Silt and clay till	08	5.5	
Glacio-fluvial materials			
Sands	05	1.5	
Outwash gravels	06	1.5	
Eskers	07	1.5	
Thin material on bedrock	09	4.9	
Swamp	10	9.7	
Quarry	20	6.3	
Gravel pit	30	6.3	
Alluvium	80	7.0	
Water bodies	90	10.0	
Right-of-way model			
Urban and urban-related	01	10	
Cemeteries	02	8	
High-quality farmland	10	6	
Good farmland	20	4	
Pasture	30	2	
Nonfarmland	40	1	
Swamps	50	1	
Water bodies	09	10	
Recreation model			
Recreation sites			
Parks			
Existing	01	10	
Proposed	02	4	
Other areas[a]			
Existing	03	10	
Proposed	04	6	
Reservoirs			
Existing	05	10	
Proposed	06	8	
Historical sites			
Existing	07	10	
Proposed	08	8	
Lakes	09	10	
Recreation capability			
Class 1	10	10	
Class 2	20	8	
Class 3	30	6	
Class 4	40	4	
Wildlife model		Primary Species	Additional Species
Wildlife capability[b]			
Class 1A	1	10.0	1.00
Class 1B	2	9.5	0.75
Class 1C	3	7.0	0.50
Class 2A	4	8.0	0.75
Class 2B	5	7.5	0.50
Class 2C	6	5.0	0.25
Class 3A	7	6.0	0.50
Class 3B	8	5.5	0.25
Class 3C	9	3.0	0.00

[a] Animal sanctuaries and conservation and reforestation areas.
[b] Alphabetic suffix is degree-of-effort rating.

Wildlife Potential Models

Wildlife data from the Ontario land inventory were analyzed on 3 separate models. The first showed the distribution of deer; the second, waterfowl (geese and ducks); and the third, upland birds (partridge and grouse).

Only the best capability classes—highest, high, and above-average production—were considered at all. Areas belonging to these classes were given only the best 3 degree-of-effort ratings, for it was pointless to be unduly concerned about areas of high ultimate potential that would be very expensive to bring to that potential.

Although models were constructed for deer, waterfowl, and upland birds, it quickly became apparent that a single wildlife potential model was desirable because any particular area could support a variety of species at various capability levels. Thus, a more complex ranking system was developed incorporating 2 ratings for each class and degree-of-effort combination (Table 1). These double ratings were analyzed in a special computer program as follows:

1. Designate a series of importance weighting factors for all animal species (species to be ignored were weighted 0);
2. Find species having highest type A rating;
3. If more than one species have equally high type A ratings, select species having largest importance weighting factor as primary species; and
4. Compute final rating as $W_p + W_2 + \ldots + W_N$, where W_p is type A rating for primary species and W_2 and W_N are type B ratings for species 2 and N.

The final set of importance weighting factors used in the study are as follows:

Category	Factor
Deer	5
Geese	4
Ducks	3
Partridge	3
Grouse	2

Obviously, different wildlife models can be built by varying these factors. The resulting combined model can be weighted and combined with other models to produce corridor selections.

GENERATION AND ANALYSIS OF ALTERNATIVES

Single-Factor Analyses

The first step in a route-location study is the analysis of alternatives generated by individual highway location factors. These analyses indicate the minimum path or best locations for the route in terms of each location factor. The engineer thus gains an appreciation of the effects of each factor on route locations within the study area and also an appreciation of the conflicts among the factors.

Before minimum path analysis can begin, a suitable origin and destination must be selected and defined by the nearest nodes. For the Guelph-Dundas test area, the route origin is the terminus of the Guelph Bypass. Although 3 destinations for the route at the Dundas end were proposed and studied, this report shows examples of the eastern terminus only.

Figure 7 shows the 5 corridors developed for the earthwork cost model. Choices 1 and 2 follow predominantly western routes, and 3, 4, and 5 follow central routes. Considerable crisscrossing of the region is caused by moraines, drumlins, and steep terrain.

Corridors minimizing foundation costs are shown in Figure 8. A 13 percent spread in the relative path values of choices 2 through 5 and a 26 percent difference between those of choices 1 and 2 can be attributed to the good foundation conditions provided by the predominantly granular materials along the eastern boundary of the test area.

Figure 7. Corridors minimizing earthwork costs.

GUELPH-DUNDAS TEST AREA

ANALYSIS OF CORRIDOR		ANALYSIS – SUMMARY		
FACTOR UTILIZED	WEIGHT	CHOICE NUMBER	RELATIVE PATH VALUE	NUMBER OF LINKS
EARTHWORKS	1.0	1	1,000	124
		2	1,246	138
		3	1,443	126
		4	1,656	144
		5	1,918	126

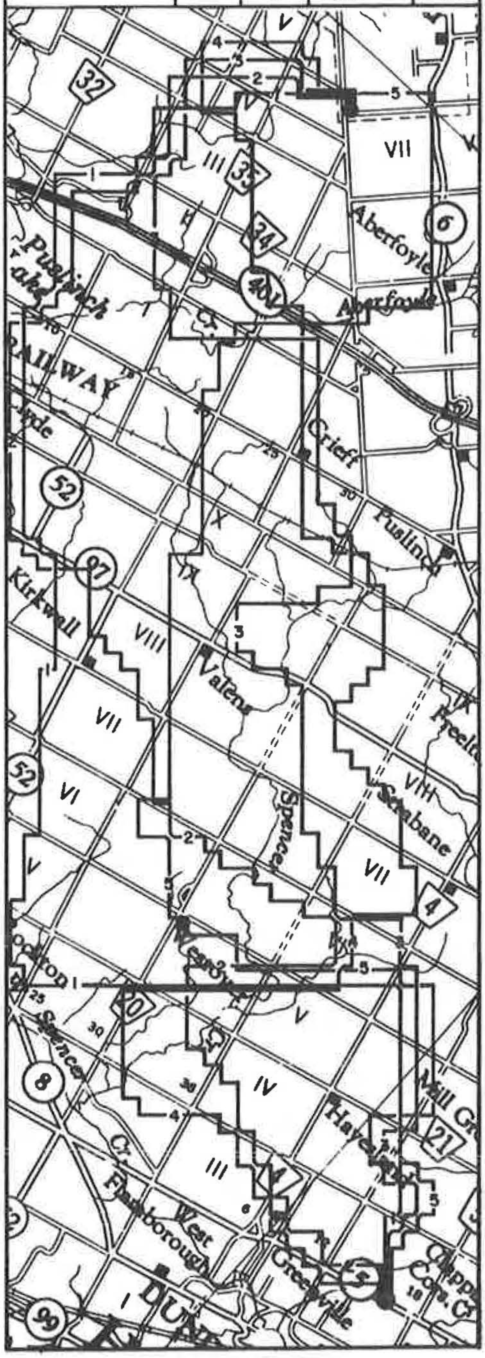


Figure 8. Corridors minimizing foundation problems.

GUELPH-DUNDAS TEST AREA

ANALYSIS OF CORRIDOR		ANALYSIS – SUMMARY		
FACTOR UTILIZED	WEIGHT	CHOICE NUMBER	RELATIVE PATH VALUE	NUMBER OF LINKS
FOUNDATIONS	1.00	1	1,000	96
		2	1,260	90
		3	1,311	134
		4	1,337	112
		5	1,387	132

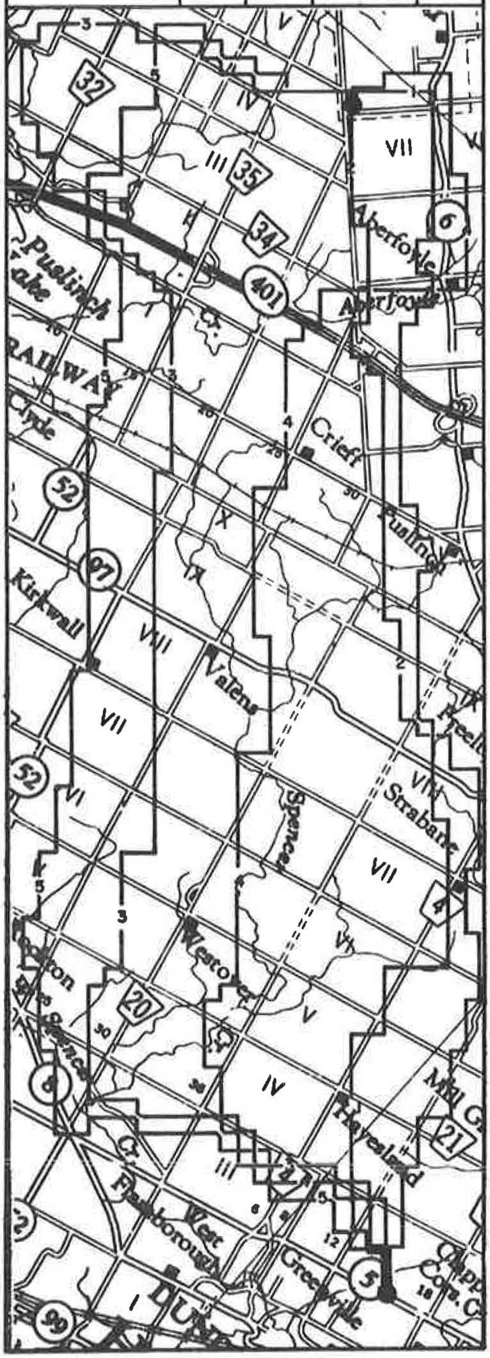


Figure 9 shows the corridors that minimize impact on valuable agricultural land. Choice 5 along the eastern boundary is the shortest of all the routes but is 90 percent more expensive than choice 1. The wide variety in route lengths and route costs reflects the varying land values and prime agricultural land locations in the test area.

Figure 10 shows the corridors that minimize disruption to potential and existing recreation areas. The relative path values of all choices are the same because none actually crosses a potential or existing recreation site.

Figure 11 shows the corridors that minimize the disruption to wildlife habitats. All are located in the western portions of the area to avoid passing through Beverly Swamp.

Multiple-Factor Analyses

Fourteen multiple-factor combinations were studied. The 2-factor analyses of earthwork and foundation cost factors allow the engineer to investigate route-independent construction costs. Adding the land use (right-of-way acquisition) cost factor produces a closer approximation of the true construction costs that include grading, paving, and land. Adding the recreation and wildlife factors minimizes the route's effect on the environmental and ecological conditions in the area and thus can be considered as benefit factors. Thus, by weighting the 5 factors in varying proportions, alternatives can be generated for certain chosen balances of economic costs and environmental benefits.

Figure 12 shows the alternatives generated by a 2-factor analysis. More clearly defined corridors are produced by the combination of earthwork and foundation costs than by either factor alone (Figs. 7 and 8).

Figure 13 shows the results of a 3-factor analysis. Land acquisition costs and the impact of the route on prime agricultural land modify the construction costs. Increasing the importance of the land use model increases the attractiveness of the eastern corridor because the land use considerations tend to overwhelm the more expensive construction in the eastern area.

The recreation factor is added to generate the corridors shown in Figure 14. All choices avoid Beverly Swamp. The recreation factor thus helps increase the separation of the 2 general alternative corridors (Figs. 13 and 14).

Figure 15 shows the corridors generated for an 80 percent cost and a 20 percent benefit weighting. Earthwork, foundation, and land use factors are considered costs, and recreation and wildlife factors are considered benefits. Two main corridors are generated. Total cost difference among the corridors is only 11.9 percent, and route length varies by 35 percent.

Figure 16 shows the corridors generated for a 50-50 costs-benefits ratio. The western corridor is strengthened and the eastern corridor is weakened as the environmental considerations are increased in importance.

A number of other factor-weighting combinations were examined, and for all 80-20 and 50-50 costs-benefits ratios, the western corridor was preferred. It becomes more strongly preferred as benefits are increased in importance, but choice 1 is always in a midwestern position.

CONCLUSIONS

For this study, GCARS was used in approximately 30 analyses in which factors had different weightings. The conclusions developed from these analyses were presented to a larger planning team that had used manual methods to study the area.

The conclusions developed by the GCARS analyses agreed closely with those developed by the manual analyses. However, the GCARS analysis was completed in about one-quarter of the time. Each GCARS run took only about 3 min of computer time at a cost of about $20; total analysis cost was approximately $500. This compared favorably with the cost of the manual analysis because lower manpower costs compensated for computer costs.

The preparation of data for computer analysis need cost no more and take no longer than that for manual analysis. Thus, the use of the computer in route selection can be justified economically. In addition, computer-aided analyses yield 2 valuable additional benefits: (a) a much more rapid analysis period and (b) a more comprehensive and

Figure 9. Corridors minimizing impact on agricultural land.

GUELPH-DUNDAS TEST AREA

ANALYSIS OF CORRIDOR		ANALYSIS – SUMMARY		
FACTOR UTILIZED	WEIGHT	CHOICE NUMBER	RELATIVE PATH VALUE	NUMBER OF LINKS
AGLAND CAPABILITY	1.00	1	1,000	130
		2	1,411	124
		3	1,589	126
		4	1,781	146
		5	1,904	96

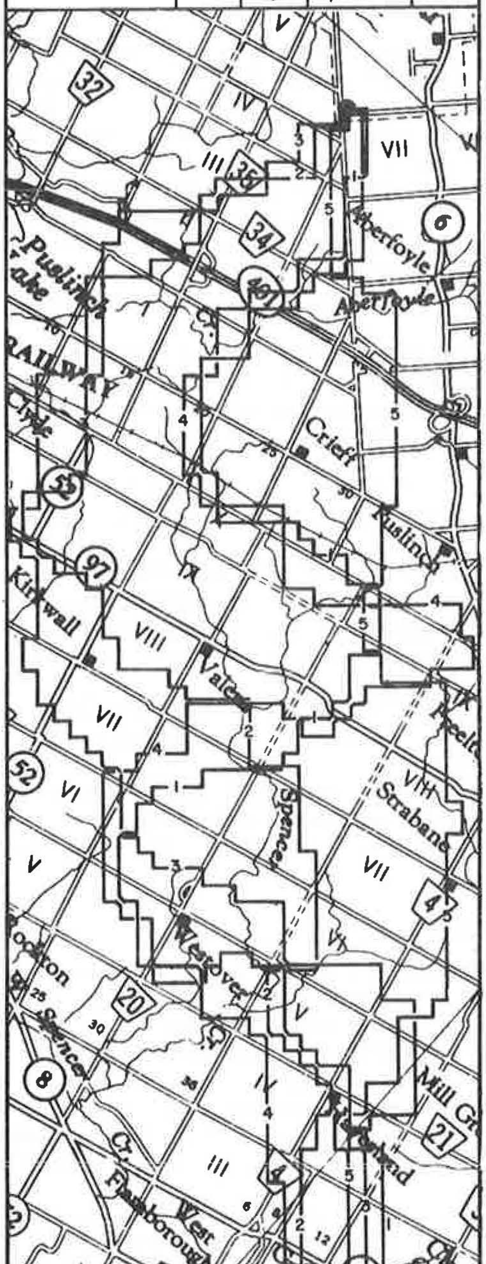


Figure 10. Corridors minimizing impact on recreation areas.

GUELPH-DUNDAS TEST AREA

ANALYSIS OF CORRIDOR		ANALYSIS – SUMMARY		
FACTOR UTILIZED	WEIGHT	CHOICE NUMBER	RELATIVE PATH VALUE	NUMBER OF LINKS
RECREATION	1.0	1	1,000	82
		2	1,000	84
		3	1,000	86
		4	1,000	98
		5	1,000	100

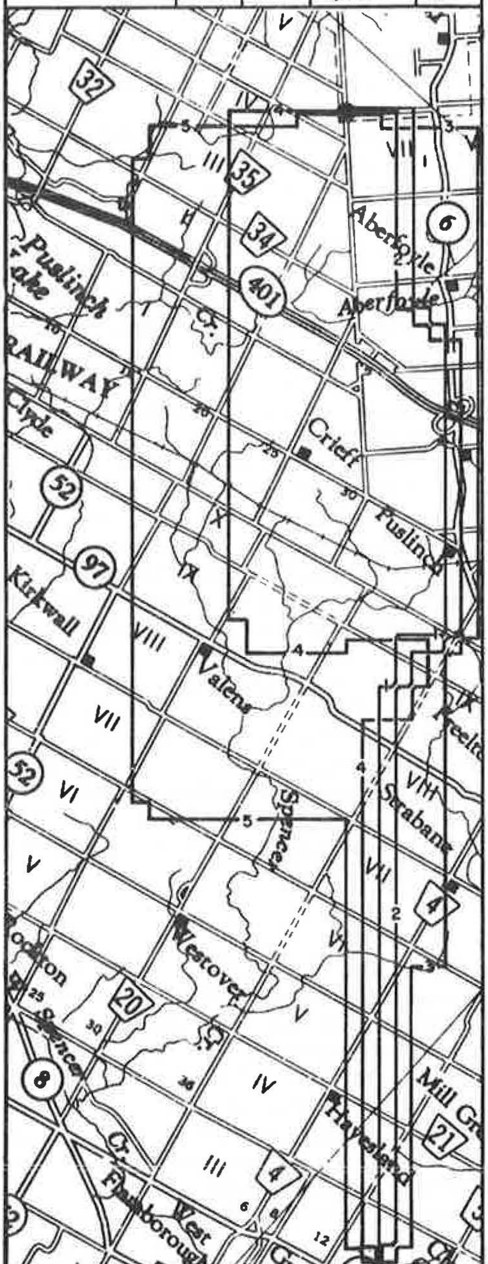


Figure 11. Corridors minimizing impact on wildlife habitats.

GUELPH-DUNDAS TEST AREA

ANALYSIS OF CORRIDOR		ANALYSIS – SUMMARY		
FACTOR UTILIZED	WEIGHT	CHOICE NUMBER	RELATIVE PATH VALUE	NUMBER OF LINKS
WILDLIFE	1.0	1	1,000	124
		2	1,046	126
		3	1,159	130
		4	1,181	122
		5	1,198	128

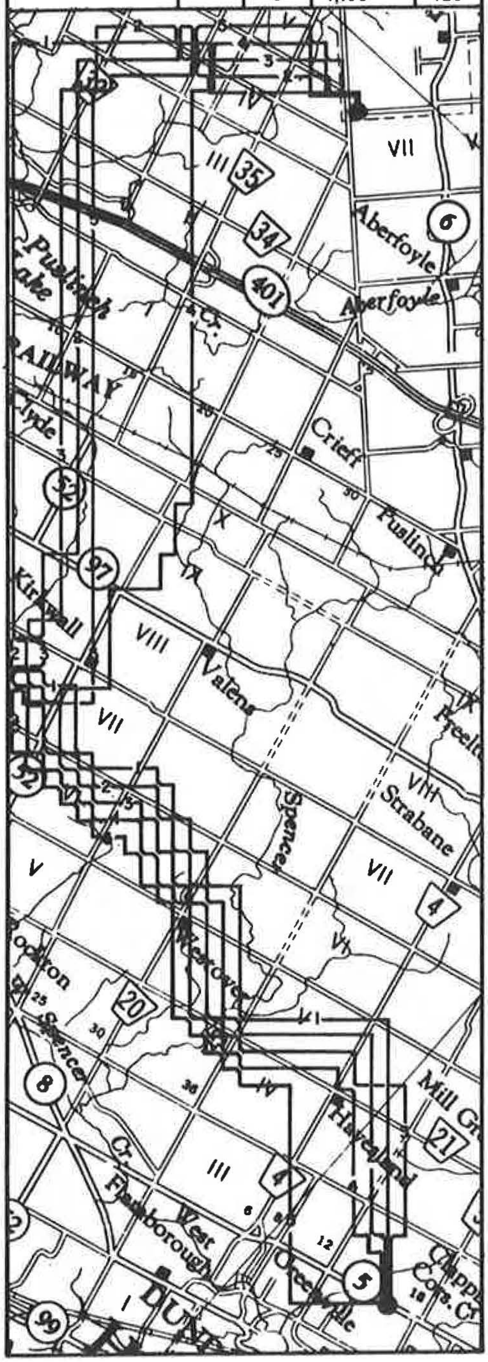


Figure 12. Corridors generated by 2-factor analysis.

GUELPH-DUNDAS TEST AREA

ANALYSIS OF CORRIDOR		ANALYSIS – SUMMARY		
FACTOR UTILIZED	WEIGHT	CHOICE NUMBER	RELATIVE PATH VALUE	NUMBER OF LINKS
EARTHWORKS	2.0	1	1,000	118
FOUNDATIONS	1.0	2	1,136	108
		3	1,199	134
		4	1,303	124
		5	1,324	96

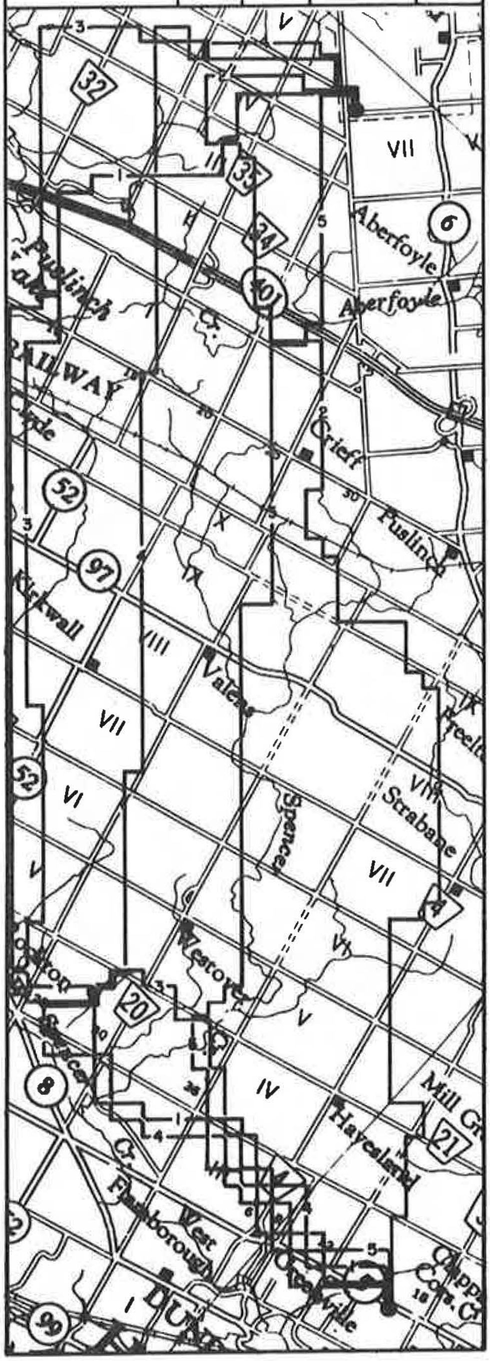


Figure 13. Corridors generated by 3-factor analysis.

GUELPH-DUNDAS TEST AREA

ANALYSIS OF CORRIDOR		ANALYSIS – SUMMARY		
FACTOR UTILIZED	WEIGHT	CHOICE NUMBER	RELATIVE PATH VALUE	NUMBER OF LINKS
EARTHWORKS	1	1	1.000	80
FOUNDATIONS	1	2	1.080	88
LAND USE	2	3	1.081	102
		4	1.134	112
		5	1.160	90

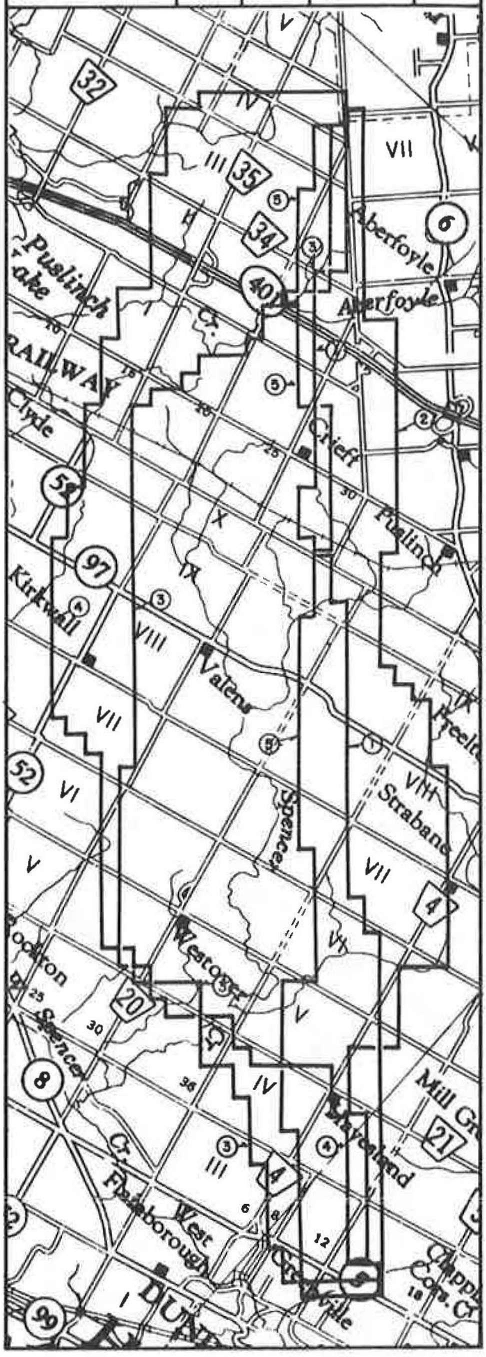


Figure 14. Corridors generated by 4-factor analysis.

GUELPH-DUNDAS TEST AREA

ANALYSIS OF CORRIDOR		ANALYSIS – SUMMARY		
FACTOR UTILIZED	WEIGHT	CHOICE NUMBER	RELATIVE PATH VALUE	NUMBER OF LINKS
EARTHWORKS	1	1	1,000	86
FOUNDATIONS	1	2	1.007	104
LAND USE	1	3	1.100	86
RECREATION	1	4	1.125	116
		5	1.177	104

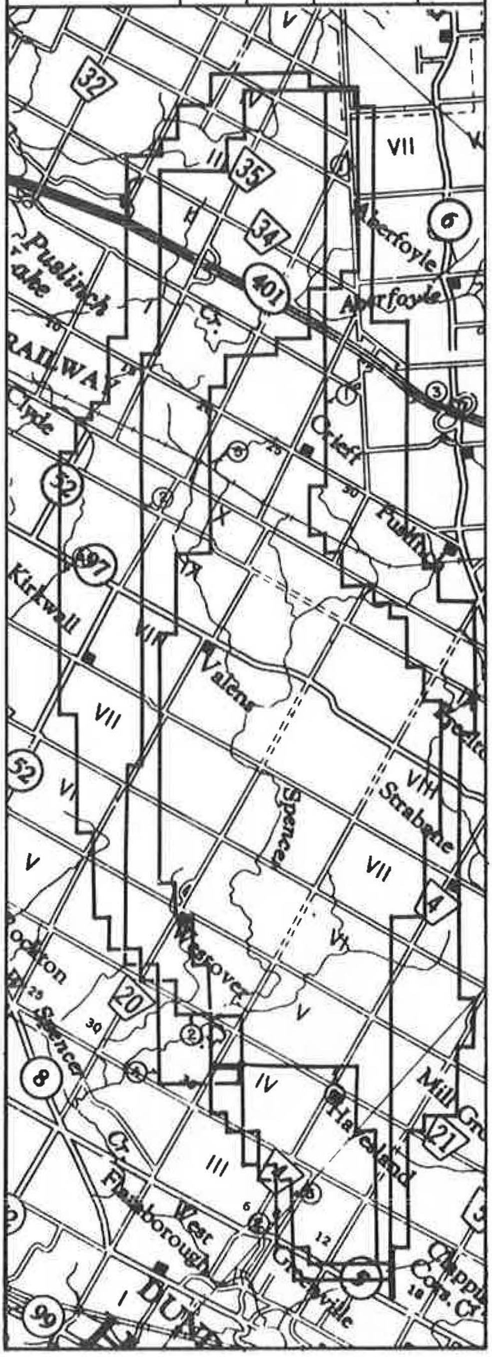


Figure 15. Corridors generated for cost-benefit ratio of 80/20.

GUELPH-DUNDAS TEST AREA

ANALYSIS OF CORRIDOR		ANALYSIS – SUMMARY		
FACTOR UTILIZED	WEIGHT	CHOICE NUMBER	RELATIVE PATH VALUE	NUMBER OF LINKS
EARTHWORKS	2	1	1.000	104
FOUNDATIONS	2	2	1.053	82
LAND USE	4	3	1.075	76
RECREATION	1	4	1.076	114
WILDLIFE	1	5	1.119	98

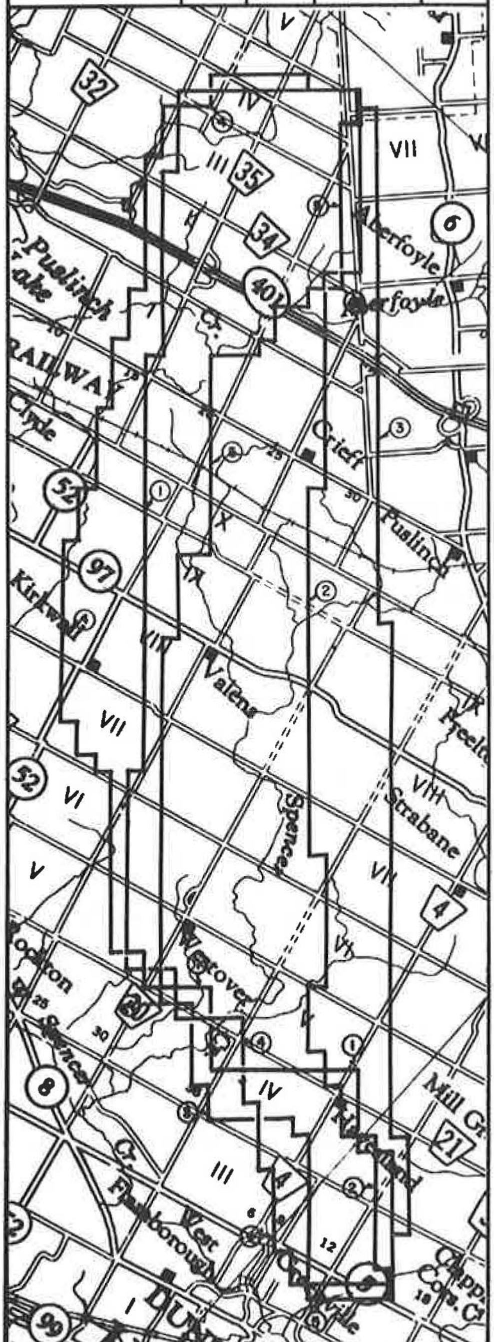
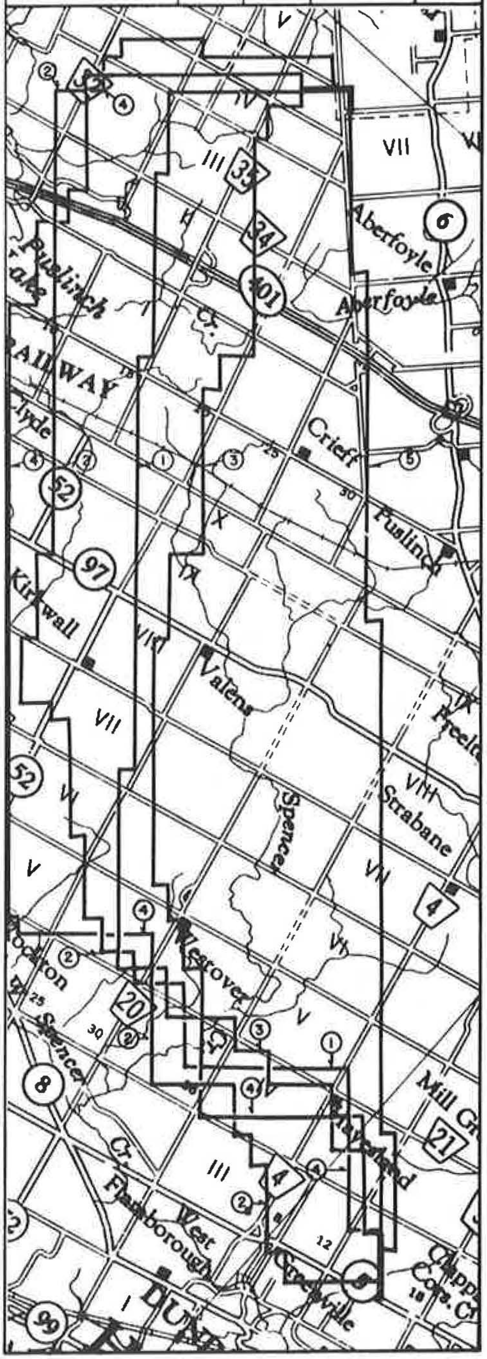


Figure 16. Corridors generated for cost-benefit ratio of 50/50.

GUELPH-DUNDAS TEST AREA

ANALYSIS OF CORRIDOR		ANALYSIS – SUMMARY		
FACTOR UTILIZED	WEIGHT	CHOICE NUMBER	RELATIVE PATH VALUE	NUMBER OF LINKS
EARTHWORKS	2	1	1,000	104
FOUNDATIONS	2	2	1.045	118
LAND USE	2	3	1.099	100
RECREATION	3	4	1.110	124
WILDLIFE	3	5	1.141	76



more quantifiable analysis providing both deeper insight into factor interactions and a ranked series of alternatives.

During this study, the Canada land inventory, used in conjunction with air photographs for checking purposes, was a useful data source. We also found that simple data digitization processes could be used economically to produce numerical models of the various factors that could be computer processed.

The study revealed some desirable additions to the basic GCARS system. Several of these are under active development and testing. Methods are being developed to allow some quantitative measure of the costs involved in increasing the environmental benefits so that rational, economically justifiable alternatives can be presented to the public for discussion.

As a consequence of this study, the Ontario Department of Transportation and Communications is actively reviewing the GCARS system and other computer-aided techniques for possible inclusion into its planning procedures.

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