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A Regional Approach to Solid Waste Management in Oxford County

Ian Smith
Wilfrid Laurier University

A REGIONAL APPROACH TO SOLID WASTE MANAGEMENT IN OXFORD COUNTY

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IAN SMITH

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SOLID WASTE MANAGEMENT

IN

OXFORD COUNTY

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To my wife Laverne; without your moral support during those periods of intense frustration this story would have had a far different ending.

Ian Smith

TABLE OF CONTENTS

		Page
LIST OF MAPS		V
LIST OF TABLES		VI
LIST OF APPENDICES		VII
CHAPTER		
I	Introduction and Background Information	
	Definition of Terms	3
	Historical Development of the Locational School	5
II	Oxford County: The Existing Waste Management Practice	
	Geographic Location	14
	Review of Existing Solid Waste Disposal Sites	15
	Twenty Year Population Projection for Oxford County	22
	Twenty Year Solid Waste Projection for Oxford County	28
III	An Examination of Possible Disposal Methods	
	Sanitary Landfill	33
	Grinding and Pulverization	40
	Incineration	44
	Composting	48
	Black Clawson's Hydrosposal/Fibreclaim System	52
	Summary of Disposal Methods	55

IV	Model Development	
	Network Analysis	58
	Location Analysis	
	Developing the Mathematical Model ..	62
V	Model Application to Oxford County	
	Preliminary Location Selection	66
	Isosuitability Map	67
	Analysis of the Area of Prime Suitability	68
	Site Selection	77
VI	Conclusions	80
	Bibliography	92

LIST OF MAPS

Map Number		Following Page
1	Location Map of Oxford County in Southern Ontario	14
2	Political Map of Oxford County	14
3	Existing Solid Waste Management Sites in Oxford County	16
4	Sample Grid System	64
5	Grid System for Oxford County	67
6	Isosuitability Map for Oxford County	68
7	Area of Maximum Suitability for Oxford County	70

LIST OF TABLES

Table Number		Page
1	Oxford County Population Projections to 1991	26
2	Oxford County Per Capita Solid Waste Projections to 1991	30
3	Oxford County Municipal Solid Waste Projections	31
4	Land Area Requirements for Sanitary Landfill Systems with Capacity for 25,000 Tons of Waste Per Year	37
5	Approximate Operating Costs for Small Landfill Operations	41

LIST OF APPENDICES

Appendix		Page
I	Standards for Waste Disposal Sites	83
II	Industrial Solid Waste Survey	90

CHAPTER 1

Introduction and Background Information

The concept of the eco-system assumes that all organisms are living together in a long-term balanced state that is constantly re-adjusting to keep pace with changes in the environment. Man, taken as a species, has been responsible for more of these changes than all other organisms combined.[1] The magnitude of these changes is increasing at a startling rate in response to increased human demands for more sophisticated goods and services. Escalating world population and higher levels of consumerism in the developed nations are pushing the delicate eco-balance to the point where many biologists and social scientists warn that unless this trend is slowed, irreparable damage may be caused to this balance.[2] This could result in a vegetative imbalance that could drastically affect our food producing ability, and the oxygen content of our atmosphere.

Perhaps the largest single factor contributing to this situation is the "throw-away society" that has evolved in the developed nations of the Western World. Alvin Toffler, in his book Future Shock, describes this trend as a monster that is fed by our desire to have things made as easy as possible for us.[3]

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[1] R. Rienow and L. Rienow "Ecology: The Relentless Science", in Ecological Crisis, ed. by Glen A. Love and Rhoda M. Love, (New York: Harcourt Brace Jovanovich, Inc., 1970), p. 19.

[2] P. Ehrlich, "Eco-Catastrophe", Ecological Crisis, ed. by Glen A. Love and Rhoda M. Love, (New York: Harcourt Brace Jovanovich, Inc., 1970), p. 3.

[3] A. Toffler, Future Shock, (New York: Bantam Books Inc., 1972), p. 51.

During 1971 in Canada this monster generated, as an unwanted by-product, enough refuse to build a four lane highway raised three feet above ground level and stretching from Toronto to Vancouver.[4]

Until now, nature has compensated for our casual attitude toward the handling of waste through the natural destructive processes. However, we may soon exceed nature's ability to keep up with this accelerating pace. The problem could be solved by ultimately reducing the overall quantity of waste produced. This can be effected in two ways: reducing the quantity of material produced at the generation source, or recovering a greater portion of that which is initially classed as waste.

Attempting to develop a solution, the Ontario Provincial Government has recently taken a bold first step in upgrading the standards for solid waste disposal in this province. The first stage of this upgrading process resulted in the establishment of the Waste Management Act (1970), which provides for the regulation, supervision, and development of waste disposal systems (Appendix No. 1). This action was followed closely by the introduction of the Environmental Protection Act (1971), that established stricter supervision and regulations in other areas of environmental concern such as air and water quality.

These acts will take some years to implement completely, and could create serious problems, problems that would not

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[4]R.H. Clark, and J.H. Brown, Municipal Waste Disposal, Problem or Opportunity, (Ontario Economic Council, 1971).

necessarily be spread uniformly across the province as no two areas share the exact same physical geography.

One of the most serious problems that is evolving from the implementation of the standards outlined in the Waste Management Act, stems from the great expense that is involved. If this cost were spread among only several hundred residents of a rural municipality, the per capita cost would escalate to such a high per capita level that the project would be prohibitive.

A possible solution to the cost distribution problem lies in changing the scale of the operation. Many services that require high initial capital expenditures become more feasible as the number of people served is increased. In terms of municipal services, the concept of regionalism applied to many of the rural areas of the province would appear to be a solution. There is, however, always the danger that by increasing the size of an operation, the point of diminishing returns is passed. At this point the transportation costs of serving a large area would increase to the point where they would begin to reduce the savings made by the increased operational scale. A regional solution would make it possible to meet the new solid waste management standards, while at the same time remaining within the economic constraints of most rural municipalities.

DEFINITION OF TERMS

In order to have a full understanding of the problems involved in dealing with waste, some basic definitions must be considered.

Waste will be considered as any material which the owner considers will cost him more to keep than to discard.[5] Building on this definition, solid waste will be considered as those unwanted residues of used, natural or man-made resources, and of human activity which are managed or handled in a solid state.[6]

Solid waste appears in a variety of forms from a variety of different sources. Domestic waste produced in the maintenance of a home and family is probably the most obvious, but in fact it accounts for only a small percentage of the waste produced by western society. The major contributors to solid waste include industrial, agricultural and commercial concerns. Vectors are insects or animal life that congregates in and around open dumps to feed on refuse or lower order life. Leachate is a liquid waste that exists usually at the base of poorly drained dumps and landfill sites. The leachate is produced by rain water filtering through the refuse and mixing with other liquids that make up part of domestic waste.

This study, as many others that attempt to deal with complex questions generated by today's society, must incorporate input that has traditionally fallen outside the geographic sphere. This

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[5] Aspects of Waste Management, Information Services Branch Ministry of the Environment Ontario, Toronto 1973, p. 1.

[6] Policies for Solid Waste Management, U. S. Dept. of Health, Education, and Welfare, Washington, 1970, p. 3.

approach to problem solving is in keeping with the views of many geographers including Fred Lukerman, who believes that geography holds both content and method of study in common with other sciences. He believes that the differentiations between sciences comes from what the scientific method reveals about the phenomena rather than the methodology itself.[7]

Geography tends to concern itself with the past and present. This is understandable when you consider that most distributional patterns that were the subject of geographic study, usually remained relatively unchanged for long periods of time. For this reason, geography should incorporate more studies that look to the future rather than the past. Peter Haggett believes that geographers as a whole have been "concerned with local, regional and global yesterdays rather than tomorrows."[8]

One area where geographers are particularly able to make contributions to tomorrow is in the area of location studies. Many of the early foundations of location studies were laid by economists. Their concerns were centered around the location of industry that was largely oriented toward agriculture. Early

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[7]Fred Lukerman, "Geography as a formal intellectual discipline, and the way in which it contributes to human life," The Canadian Geographer, VIII No. 4(1964), p. 167.

[8]Peter Haggett, "Forecasting Alternative Spatial Ecological and Regional Futures: Problems and Possibilities," in Directions in Geography, ed. by R.J. Chorley (London: Methuen and Co. Ltd., 1973), p. 234.

economists such as Adam Smith, J.S. Mills, and David Ricardo[9] contributed greatly to the location of early British industries. Their goals were mainly to improve economic feasibility rather than seeking an optimum location.

Modern society operates from a very powerful industrial base. Naturally the location of major industries exerts great influence on the location of residential areas, commercial and service organizations and transportation routes. For this reason industrial location theory has dominated the field of location studies.

Industrial location theory has developed through three distinctly different phases. Each new phase was developed to make use of new factors as they became relevant.

Least-cost location specifies that a firm will locate so as to minimize its costs of production and distribution. The most noted contributor to this early phase was Johann Von Thunen. Von Thunen assumed a homogeneous land surface with one population centre. Land use was shown to occur in concentric zones surrounding the populated area. Those products that required the highest transport cost were located closest to the market and usually received the highest selling price.[10]

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[9] Richard J. Chorley and Peter Haggett, Socio Economic Models in Geography, Methuen and Company, London, 1967, p. 369.

[10] August Lösch, The Economics of Location, Yale University Press, London, 1967, p. 7.

This phase was continued by Launhardt who developed the concept of ton-miles as an expression of both distance and weight. The new measure multiplied by the varying transportation costs related to either land or water transport was responsible for modifying the size and shape of the market area.[11]

Alfred Weber continued the least-cost location path, but hypothesized that other factors were instrumental in location theory, namely transportation costs, labour costs, and agglomerating forces. Weber realized that either labour costs and/or agglomerating costs can exert an influence on location when they more than compensate for any increase in transportation costs that might be incurred at the new location. Despite his relative sophistication compared to Von Thunen, Weber's theories maintained the basic premise that least-cost location was also the maximum profit location.[12]

August Lösch was the first exponent of the second phase that based industrial location on the nearness to the market to be serviced. Losch's model assumes a homogeneous plain dotted with agriculturally self-sufficient farms, uniform transportation features in all directions, and an even distribution of raw

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[11] R.J. Chorley and Peter Haggett, Models in Geography. Methuen and Co. Ltd., London: England, 1968, p. 369.

[12] R.C. Estall and R.O. Buchanan, Industrial Activity and Economic Geography, Hutchinson and Company, London: England, 1973, p. 25.

materials. He experimented with different shaped market areas in an attempt to completely cover the plain with a uniform grid system. His optimum solution was a hexagon with production occurring at the centre and being distributed only within the hexagon in which it was produced.

Lösch realized that the market range varies with the order of the goods and services being provided. The result was that the plain was covered with a range of hexagonal nets each one made up of specific sized hexagons representing the market area of a certain commodity. The coincidence of a number of centres from different sized hexagons indicates that these areas will tend to be larger population centres producing a range of goods and services.[13]

A third and latest industrial location school is based on profit maximization. The factors included in the location process are: transportation costs, production costs, demand for the product, and all cost reducing or revenue increasing factors. Melvin Greenhut devised a mathematical theory that appears as

1) $L = T - C$

2) $C = S\ A$

3) $T = S\ P$

Where L is location, C is total cost, T is total revenue, S is

[13] August Lösch, The Economics of Location, Yale University Press, London 1967, p. 92-137.

sales radius, A is average cost not including freight charges, and P is the net mill price.[14]

Greenhut established the fact that locational equilibrium exists where the average cost is equal to the net mill price. If net mill price is greater than or less than average cost, a state of disequilibrium will exist. It then follows that there will be a tendency toward location movement that will establish equilibrium.

Location theory specifically oriented toward solid waste management is a recent branch of location studies that developed from the profit maximization phase of industrial location, and is essentially based on cost minimization. A model to locate solid waste management sites can be considered essentially as an exact reversal of industrial location problem where the objective is to centralize material effeciently rather than distribute material from a central location.

The University of California at Berkeley assembled a study group to investigate broad scale interactions of waste disposal systems. The investigations were based on a linear programming model designed to predict waste generation, to outline collection routes, and the method of treatment and disposal of domestic solid waste.[15] The objective was to optimize the transport of solid

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[14]M. Greenhut, Plant Location in Theory and Practice - The Economics of Space, The University of North Carolina Press, Chapel Hill, North Carolina, 1956.

[15]Robert Clark, "Solid Waste: Management and Models", Models for Environmental Pollution Control, (Ann Arbor Science Publishers), Ann Arbor Michigan, 1973, p. 272.

waste from sources, through treatment and processing to final disposal using existing sites and equipment. The Californian model provided acceptable results for optimizing the use of a given set of components. The major use is in large urban areas or regions composed of several centres, each disposing of their waste separately. The model is unable to determine the location of new disposal sites that might optimize the total system further except through a process of trial and error.

A similar approach toward optimizing a given set of waste disposal sites was developed by Marks, ReVelle, and Liebman.[16] Their model provided for the use of the average round-trip between the disposal site and the solid waste generation area rather than a straight distance measurement. The time distance measurement was especially accurate in large urban centres where frequent periods of heavy traffic would provide inaccurate data if a linear measurement was used. This model also made provision for the location of intermediate points where solid wastes could be transferred from collection vehicles to larger capacity vehicles more suited to long-haul transport. The major use for this model will be in developing solid waste collection routes, and in locating transfer stations rather than locating final disposal sites.

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[16] D.H. Marks, J.C. Liebman; C.S. ReVelle, "Mathematical Models of Location: A Review", Proceedings of the American Society of Civil Engineers, Urban Planning and Development Division, Vol. 96 No. I, (1970), p. 83.

Robert Clark and Billy Helms from the National Research Centre in Cincinnati makes use of linear programming to select from among several alternatives, a site to dispose of solid waste from two or more communities or generation areas. They required two types of data to make their program operational; the straight-line distance between each disposal area and each generation area, and the average number of tons of solid waste produced per year at each generation area.[17] This model has several major limitations when applied to real situations. Disposal sites must be presented to the model for evaluation relative to all other sites presented for consideration. For this reason it is impossible to determine whether truly optimum location has been selected. The use of straightline distance instead of an actual measurement, either time or distance, also takes away from the usefulness of this model.

A research group at Northwestern University headed by S.J. Wersan approached the disposal site location problem in much the same way as Clark and Helms, except that they increased the potential utility of the model by using "L" shaped pathways instead of straightline distances.[18] The "L" shape approximates

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[17]Billy P. Helms and Robert M. Clark, "Locational Models for Solid Waste Management", Proceedings of the American Society of Civil Engineers, Urban Planning and Development Division, Vol. 97 No. I (1971), p. 2.

[18]Robert M. Clark, "Solid Waste: Management and Models", Models for Environmental Pollution Control, (Ann Arbor Science Publishers), Ann Arbor Michigan, 1973, p. 279.

more closely most road systems, thus providing results based on data that represents reality more closely than the Clark, Helms model.

The models mentioned here demonstrate that certain factors must be considered in determing new locations for solid waste disposal sites. All of the models required that some measure of the amount of solid waste produced be incorporated with a distance factor measuring the distance between the generation areas and the disposal sites under consideration. All models examined require that the location of all sites being considered, be identified before the actual model application could begin. This pre-identification makes it difficult to justify the use of the term "optimum" when referring to the final site selected, unless all points within the specified region were identified and tested.

This thesis will explore the possibility of developing a regional approach to solid waste disposal in Ontario's predominately rural Oxford County. The selection of Oxford County arose primarily from a recommendation in a recent Regional Government study that mentioned solid waste disposed as one of the most critical problems facing the County.[19] The optimum size for a regional solid waste management system is not fixed due to variations in population density and rural to urban mix. For

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[19] The Oxford Area Local Government Study Interim Report, Brian Turnbull and Associates, Waterloo, 1972, p. 15.

this reason, determing the optimum size for such an operation will not be part of the present study. The focus of this study will be to determine a disposal method for solid waste generated by the County, and primarily the location of the major disposal sites.

The overall concern in this study is to examine and reorganize a series of spatially distributed factors in such a way as to create a new pattern that will more effectively meet the health requirements of present and future populations of Oxford County while at the same time being economically acceptable.

Chapter II provides an overview of existing waste disposal methods and locations outlining many of the shortcominings in terms of provincially acceptable methods. Domestic solid waste production and population are projected for a twenty-year period beginning in 1971. The projections will indicate the potential volume of solid waste that must be disposed by the system being planned.

CHAPTER II

Oxford County:

The Existing Waste Management Practice

Oxford County: Geographic Location

Oxford County is located in Southwestern Ontario and is bounded on the north by Perth and Wellington Counties, on the east by Brant, on the south by Norfolk and Elgin Counties, and on the west by Middlesex. These counties together form the central portion of Southwestern Ontario. The County is approximately seven hundred and sixty-five square miles[1] in area with a 1971 population of 80,349.[2] Woodstock with a population of 26,173[3] is the largest urban centre, and is located in the approximate geographic centre of the County.

Ingersoll, with a population of 7,783 located in the western central part of the County, and Tillsonburg, population 6,608, located in the extreme south of the County, are the only other urban centres in the County.

Roughly forty per cent of Oxford residents live in a rural environment (farms, or unincorporated places), and fifty-one per cent of the residents live in the urban centres of Woodstock, Ingersoll and Tillsonburg. With such a large rural population it is understandable that fifty-eight per cent of the County is under cultivation, primarily oats and hay.[4]

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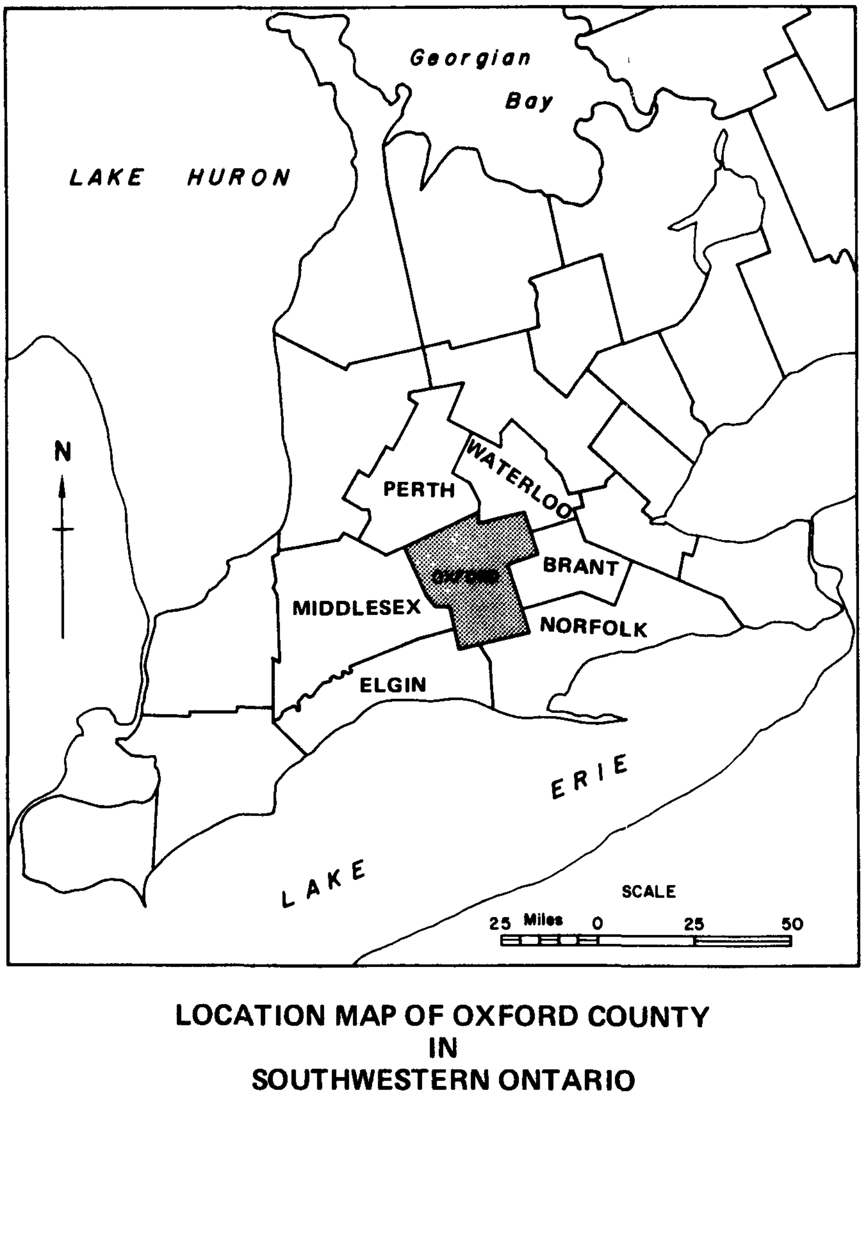
[1] R.E. Wickland and H.R. Richards, The Soil Survey of Oxford County (Research Branch, Canada Department of Agriculture and The Ontario Agricultural College, 1961), p. 8.

[2] Statistics Canada, 1971 Census of Canada, Population Census Divisions and Subdivisions (Ontario), p. 6-42.

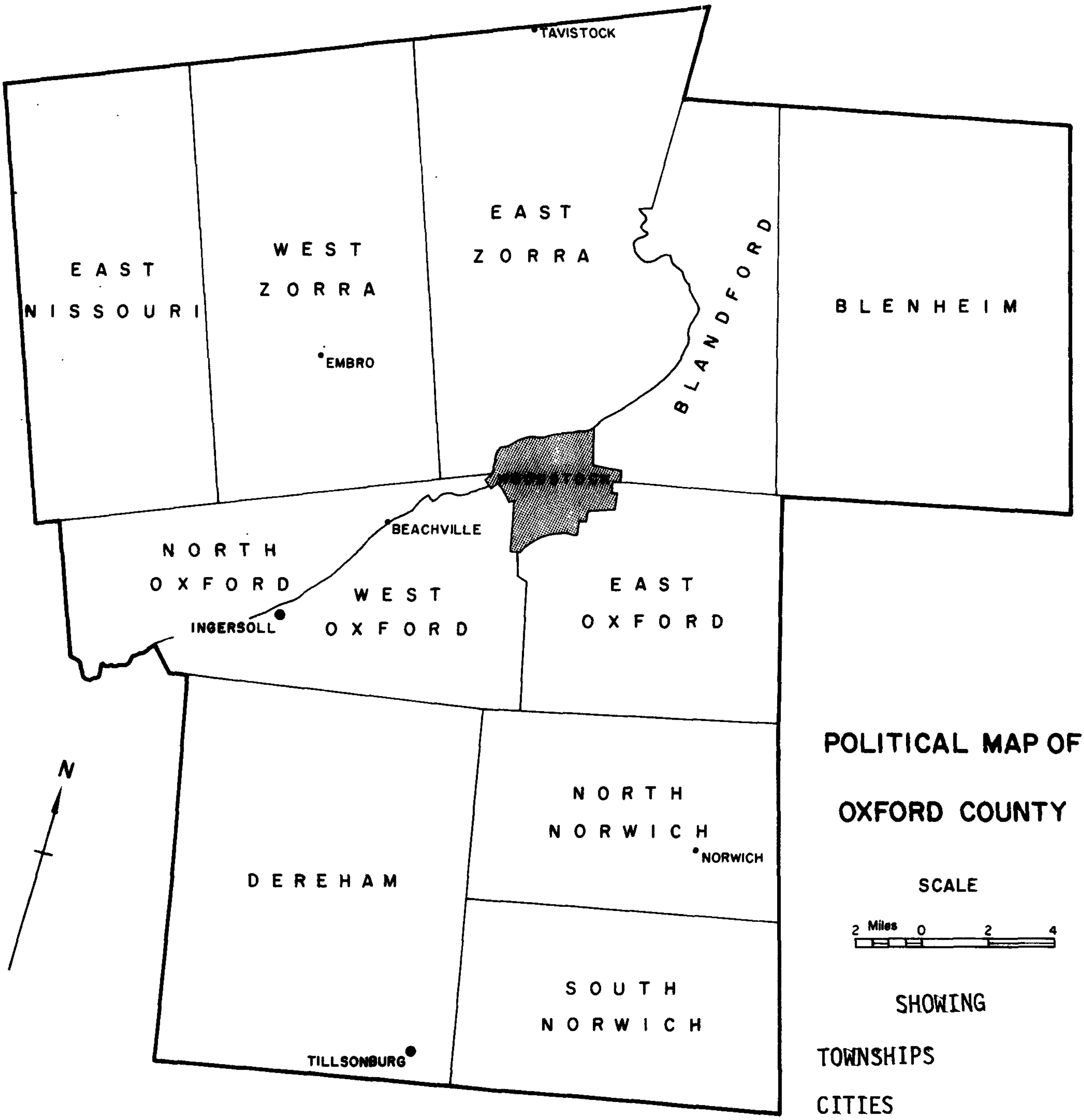
[3] Ibid p. 6-42.

[4] Wickland and Richards, p. 17.



**LOCATION MAP OF OXFORD COUNTY
IN
SOUTHWESTERN ONTARIO**

Map 1



POLITICAL MAP OF OXFORD COUNTY

SHOWING

TOWNSHIPS

CITIES

TOWNS

It would seem that Oxford County is representative of many medium density counties in Ontario that are being forced to upgrade their existing waste disposal methods.

Oxford County: Review of Existing Solid Waste Disposal Sites

There are currently thirteen waste disposal sites operating in Oxford County of which only two are of sufficient size, and possess the necessary physical attributes (see Appendix I) for further development.[5] These are the ninety acre site located in the Township of East Nissouri for the residents of that Township, and the one hundred acre site privately owned by Ingersoll Sanitation Company in the Township of North Norwich. Four of the remaining sites meet the minimum operating standards established by the Ministry of the Environment, but are unacceptable for further development.

The city of Woodstock with a population of 26,173[6] presently operates a landfill site for all municipal waste. It is located in the south west corner of the city near the intersection of Mill Street and Parkinson Road.

The site of seven and half acres shares its boundaries with agricultural land, an elementary school, and a low density residential area. Filling takes place in a natural depression

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[5] The Oxford Area Local Government Study Interim Report, Brian Turnbull and Associates, Waterloo, 1972, p. 16.

[6] 1971 Census of Canada Population Catalogue 92-706, p. 6-42.

with cover material currently being hauled from the outlying areas. Without further land acquisition the site has a limited life expectancy, and it is questionable whether the adjacent land would meet with Ministerial approval.

Nearly fifty per cent of the solid waste, measured in tons, disposed of at this site is classified as industrial refuse.[7]

Along with the annual 'Spring Clean-up' to remove oversized articles, the city provides a free collection service to residents on a weekly basis throughout the year. In addition, commercial and industrial office refuse is collected by the city twice weekly on a twelve month basis. However, the city does not provide any collection services for other industrial waste.

The disposal site experiences only one major problem, that of blowing paper. A ten foot fence has been erected between the site and the elementary school; but, unfortunately, it is continually being plugged by the paper, thus announcing the site in a rather non aesthetic manner.

The town of Tillsonburg, located in the extreme southern arm of the County, has a population of 6,608.[8]

Presently, the town has a three acre waste disposal site located on concession twelve of Dereham Township. The method of disposal is by open dump. The site with its limited growth

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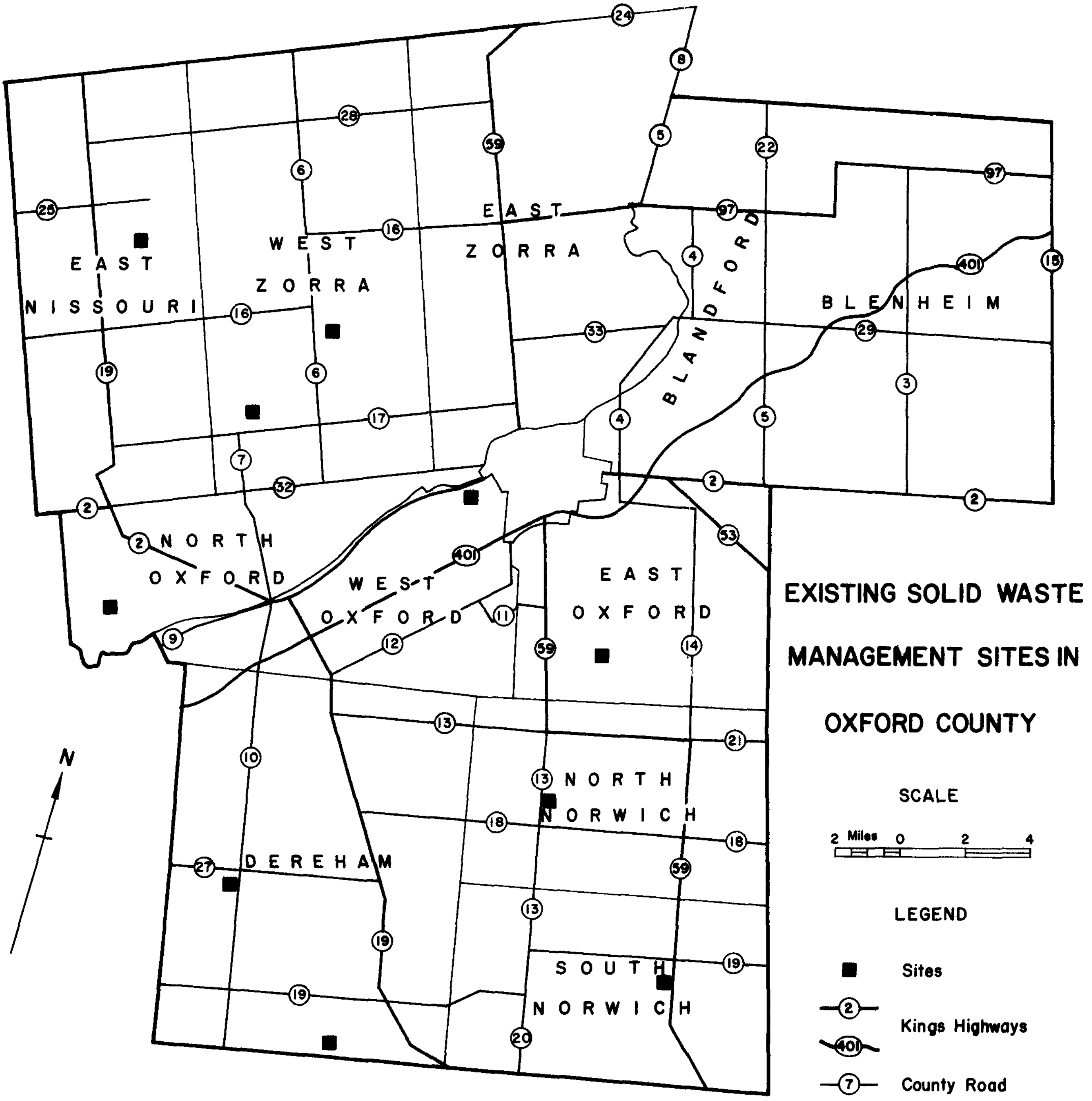
[7]City Engineer for the City of Woodstock, personal interview, August 3, 1972.

[8]1971 Census of Canada Population Catalogue 92-706, p. 6-42.


EXISTING SOLID WASTE MANAGEMENT SITES IN OXFORD COUNTY
SCALE
2 Miles 0 2 4
LEGEND
Sites
Kings Highways
County Road
EAST NISSOURI
WEST ZORRA
EAST ZORRA
BLANDFORD
BLENHEIM
NORTH OXFORD
WEST OXFORD
EAST OXFORD
NORTH NORWICH
DEREHAM
SOUTH NORWICH
N

Map 3

potential is causing concern for the municipal officials; and that they are currently searching for a new site.

The town of Tillsonburg provides a weekly municipal garbage collection.

In addition to the domestic waste disposed at this site, some metals, plastic and wood residue from local industrial operations account for ten per cent of the material disposed of by weight.

The village of Embro with a population of 703[9] is located northwest of the city of Woodstock on Highway 6. The residential and commercial waste is collected weekly by a private hauler. The dump site currently being used is a one acre site just north of the village in the Township of West Zora.

The site appears to have imperfect drainage as evidenced by small pools of water and leachate at the base of the dump face. In addition, a tributary of the Thames River flows within one eighth of a mile of the site, causing an additional hazard.

The facility was recently visited by the Waste Management Branch of the Department of Energy and Resources Management who made the recommendation that it would prefer to see the site closed.[10]

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[9] 1971 Census of Canada Population Catalogue 92-706, p. 6-42.

[10] The Oxford Area Local Government Study Interim Report, Brian Turnbull and Associates, Waterloo, 1972, p. 16.

The village of Norwich has a population of 1,806[11] and is located in the southeast quarter of Oxford County. The village residents pay for a waste collection service provided weekly by a private hauler and the refuse is disposed of in a thirty-seven acre municipal dump site within the village limits.

Site maintenance costs are prompting municipal officials to investigate the possibilities of enlisting complete hauling and disposal services from an outside source.

The three predominately rural townships of Blandford, Blenheim and East Zora are located in the northeast corner of Oxford County. They have a combined population of 11,300 and operate a common dump site in Blenheim Township on concession road number 9. This operation is the only example in the County of several municipalities sharing the same facility. It is unfortunate that the site chosen is so poorly suited for a dump.[12] Personal observations indicated that the land being filled is a depression that abuts a Canadian National Railway right-of-way. The land is poorly drained and the eventual run-off joins the Black River. Quantities of leachate are noticeable at the base of the active dump face, and evidence of recent burning occurs in several parts of the site.

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[11] 1971 Census of Canada Population Catalogue 92-706, p. 6-42.

[12] The Oxford Area Local Government Study Interim Report, Brian Turnbull and Associates, Waterloo, 1972, p. 16.

A municipal employee is on duty at the site to manage the operation. His prime function is to sort large metal objects from the remainder of the refuse, as well as to direct haulers to the active area of the site. The dump is used primarily for domestic waste, but quantities of sandpaper residue indicate that some industrial wastes are deposited.

The Township of Dereham is a rural township located in the southeast corner of the County, with a population of 5,323.[13] The municipality operates a two acre site on concession road 7 within the municipal boundaries. The slope of the site is moderate with apparently good drainage on the surface. As there is no organized municipal waste pick-up operating within the Township, all waste disposed of at this site is hauled privately by residence.

The Township of East Nissouri has a population of 3,352 persons most of whom rely on farming for their livelihood.[14] Other than the police village of Thamesford, there are no significant settlements in terms of domestic waste production. A ninety-nine acre dump site serves as the disposal method for the township. At the present time only one small portion of the site is being used. There is little ~~evidence of~~ proper waste

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[13] 1971 Census of Canada Population Catalogue 92-706, p. 6-42.

[14] Ibid p. 6-42.

management practices being followed, as waste is disposed of ~~directly into surface water~~, and fires appear numerous as little cover material is applied.

The Township of North Norwich is the only municipality in Oxford County to make use of the Transfer Station Concept. A transfer station is a small, temporary site used to store solid waste until enough has been accumulated to make it economically feasible to transport it to the final disposal site. Transfer stations are a facet of the collection system rather than the disposal system. Their prime value is in providing an easily accessibilty disposal location to areas of medium and low population density. In the case of North Norwich a transfer station was provided for the residents near their former dump site that was closed when they contracted their waste disposal to Ingersoll Sanitation Company.

The town of Ingersoll with a population of 7,783[15] is located fifteen miles southwest of the city of Woodstock. The residents are served by a weekly collection service operated by Ingersoll Sanitation Company. The service includes not only domestic waste but also commercial and industrial waste collection. The refuse is disposed of at a private one-hundred acre site in North Norwich Township.

The site has good accessibility by major roads, and is well hidden from passersby. Surface drainage appears to be poor

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[15] 1971 Census of Canada Population Catalogue 92-706, p. 6-42.

as large ponds of water remain on the site several days after thunder shower activity.

The Township of South Norwich with a population of 3,146 is located in the extreme southeast corner of the County. The site is only three acres in size but is operated as a Trench and Fill Landfill site rather than an unsupervised dump. The actual mechanics of the site operation are faulty as open trenches remain uncovered for several weeks until each trench is filled. This leads to frequent invasions by flocks of sea gulls as well as vectors.

The Township of East Oxford operates an eight acre disposal site located on concession road 7 within the township. The site is in a well drained area of rolling hills which presently provide cover material. There is some evidence that large metal objects have been separated from the general refuse for salvage. Covering the waste material presents a problem. The size of the disposal operation does not warrant the full time presence of the heavy equipment required to do the job regularly. For this reason covering only takes place weekly rather than daily.

No municipal collection service is provided, and little or no industrial waste is deposited at this site.

The Township of North Oxford is in the shape of an elongated triangle located directly west of the city of Woodstock. The three acre disposal site located on concession road 4 of the Township is close to a branch of the Thames River. The water table appears to be close to the surface as any holes dug for cover material quickly fill with water.

In addition to the unacceptable moist conditions at this site there is evidence that fires occur frequently.

The municipality does not provide any domestic collection service, nor does it provide a disposal site for any industrial or commercial concerns.

The information presented in this section has been included to provide an accurate picture of domestic waste disposal methods as they currently exist in Oxford County.

The next section will demonstrate how the existing inadequacies in the waste disposal system will be magnified over the next twenty years as increased pressure will be exerted on the system by a growing population.

Twenty-Year Population Projection for Oxford County

The new approach to solid waste management in Oxford County should be designed to meet the needs of the people of the County up to that point in time. The speed at which the way of life in Ontario generally, and Oxford County specifically is changing makes it increasingly more difficult to project the needs of future populations. Assuming that some foresight is good, we must examine general trends, try to determine their course, and apply these anticipated changes to project the magnitude, distribution and general needs of future populations.

Population Projection (Size and Distribution)

Oxford County is located completely within the Lake Erie Development Region as defined in 1966 in the white paper Design for Development, produced by the Regional Development Branch of the Ontario Ministry of Treasury, Economics and Intergovernmental Affairs.

From 1951 to 1966 while the population of Ontario as a whole was increasing fifty-one per cent, the population of the Lake Erie Region increased only thirty-seven per cent. Since that time statistics indicate that the population of the Lake Erie Region has grown nine and one tenth per cent compared to the provincial figure of eight and nine tenths per cent.[16]

Recent population projections by the Regional Development Branch for the Lake Erie Region conclude that most areas within the Region should experience a growth rate of fifteen per cent during the period 1971-1981 and thirty-two per cent by 1991.[17] This allows for moderate growth, but not the major growth that is expected along the shore of Lake Erie at Nanticoke. It is not expected that any significant amount of additional growth will be experienced in Oxford County because of the distance between Nanticoke and the southern edge of the County, and the fact that

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[16] Ontario Ministry of Treasury, Economics and Intergovernmental Affairs, Design for Development Prospects for the Lake Erie Region, 1972, p. 7.

[17] Ibid

the intervening centres of Simcoe and Delhi should block the northward developmental thrust. Applying fifteen and thirty-two per cent growth figure respectively, the 1981 and 1991 population projection figures for Oxford County would be 92,401 and 106,060.

As the eventual purpose of these projections is to determine solid waste production to the year 1991, it will be important to consider the changing rural - urban distribution. It is important to make this distinction since rural residents traditionally generate less solid waste per capita than urban residents.[18]

The rural-urban mix will not be constant through the twenty years being planned for. It is a well-known fact that the percentage of our population that is classed as rural is shrinking each year. Donald Whyte in his article entitled Rural Canada in Transition indicates that Ontario in 1961 had a population that was considered to be twenty-three per cent rural.

Whyte further states that present trends indicate a further six per cent decrease in the rural share of the Canadian population every ten years. This does not necessarily mean that the rural population will decrease in absolute terms, only that "the rural population may increase somewhat in absolute terms, but decline relative to the total."[19]

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[18]H. Jacobs and A. Biswasi, Solid Waste Management Problems and Perspectives, (Ottawa: Environment Canada, 1972), p. 1.

[19]Donald R. Whyte, "Rural Canada in Transition", in Rural Canada in Transition, ed. by Marc Tremblay and Walton Anderson, (Ottawa: Agriculture Economics Research Council of Canada, 1966), p. 10.

In making population projections it is necessary to consider urban and rural municipalities separately, as the general fifteen per cent population increase projected for the period 1971 and 1981 will not apply equally to both urban and rural populations. For the purpose of the projections it is, however, assumed that all places designated as urban will experience the same percentage growth as all other urban places, and that all rural places will experience the same growth as all other rural places. It will also be assumed that the growth of rural population will be smaller than that experienced by urban places.

Projection Methodology

The 1971 Census figures for all places, both urban and rural, were increased by fifteen per cent to arrive at a 1981 base population figure (see Table 1). The total rural figure for 1981 was then decreased by six per cent. This decrease was removed from each rural municipality in accordance with its particular portion of the total rural population. Conversely the total sum removed from the rural population was added to the urban municipalities. Each urban municipality received a portion based on its percentage of the total urban population. This procedure maintains the total County growth at fifteen per cent over the ten year period, and also recognizes the six per cent rural population decrease.

Similarily the 1991 populations were calculated using the new 1981 population as the base figure, and following the same methodology.

TABLE 1

OXFORD COUNTY POPULATION PROJECTIONS TO 1991

Urban Municipalities	1971	1981	1991
Woodstock	26,173	32,130	38,501
Ingersoll	7,783	8,428	10,095
Tillsonburg	6,608	8,110	9,716
Beachville	995	1,220	1,460
Embro	703	863	920
Norwich	1,806	2,214	2,651
Tavestock	1,490	1,827	2,187
Urban Totals	45,558	54,792	65,530
Rural Municipalities			
Blandford	1,459	1,579	1,704
Blenheim	4,636	5,008	5,390
Dereham	5,323	5,752	6,200
East Nissouri	3,352	3,624	3,907
North Norwich	2,548	2,755	2,970
South Norwich	3,146	3,401	3,666
East Oxford	2,295	2,483	2,679
North Oxford	1,774	1,922	2,072
West Oxford	2,845	3,075	3,315
East Zorra	5,213	5,631	6,063
West Zorra	2,200	2,379	2,564
Rural Totals	34,791	37,609	40,530
County Totals	80,349	92,401	106,060

Solid Waste Projection

The preceeding section provided population projections for Oxford County to the year 1991. These projections provide data not only on the population size, but also on the rural-urban mix of the population for the twenty year life expectancy of the waste disposal system being planned.

It is necessary to have future population figures as the first step in projecting how much domestic solid waste will be produced. It is a difficult task to project population figures with the hope that time will prove them reasonably accurate, but to project the attitude of future societies toward waste production is even more uncertain.

The amount of solid waste that an area generates is usually determined by weighing the waste on a regular basis. This is accomplished at disposal sites, where the weight of each vehicle leaving a site is subtracted from the vehicle's weight upon entering the site, yielding the weight of materials left for disposal.

Unfortunately, the Woodstock site is the singular example of a site equipped with a scale; consequently, detailed records of waste quantities for the remainder of the County are not available. In order to obtain reasonably accurate information about the 1971 Oxford County solid waste production, the Urban and Regional Planning firm of Brian Turnbull and Associates used the following four data sources. The information is necessary only to provide a rough estimate of waste production in the county, thus absolute accuracy is not required.

(1) Municipal and County Records

(2) Private Collectors

(3) Industrial Survey (see Appendix 2)

(4) Estimated and Weighed Refuse from Other Municipalities.

The figures that the Turnbull study derived from these four data sources represent the cumulative total of household, commercial and industrial waste for Oxford County during 1971 (see Table 2).

Although most of the 1971 figures derived from the Turnbull Study could be accepted without further explanation, the Tillsonburg figure of 16.33 pounds per capita per day required further explanation. Several major industries involved in export packaging and agricultural product processing are responsible for the high per capita figure.

Twenty-Year Solid Waste Projection for Oxford County (to 1991)

In order to determine the total amount of solid waste to be disposed of by the system under consideration, it was necessary to project the 1971 per capita waste production figure.[20] When projecting the amount of solid waste to be produced by future populations, it is tempting to anticipate that they will be more environmentally conscious than we are, and that their per capita solid waste production will be considerably reduced from our present

[20] Brian Turnbull and Associates, Oxford Area Waste Management Study, Kitchener, Canada, 1973, p. 69.

output. However, the projections used in this study did not assume that great progress would be made in reducing the accelerated pace of our solid waste production. A recent study by Beatty and Nobbs,[21] of the London, Ontario, area, twenty miles west of Oxford County, projected that the per capita domestic solid waste production figure will increase at the rate of one and one-half per cent per year. Although there are differences in the rural-urban mix between the London population and that found in Oxford County, they are both subject to the same product packaging and consumer goods. Calculating the per capita waste projections for each municipality is achieved by increasing the per capita figure by 1.5 per cent per year cumulatively to the year 1991 (see Table 2).

The figures on Table 3 represent the total solid waste projection figures using the population projection figures in Table 1, and the per capita solid waste generation figures in Table 2.

Disposal methods must now be examined and evaluated to determine the economics of implementation in Oxford County.

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[21] Robert A. Beatty and Richard A. Nobbs, Ecologically Sound Solid Waste Management, London, Canada, 1973, p. 21.

TABLE #2

OXFORD COUNTY PER CAPITA SOLID WASTE PRODUCTION PROJECTIONS TO 1991

Urban Municipalities	1971*	1981	1991
Woodstock	5.05	5.82	6.70
Ingersoll	5.03	5.78	6.66
Tillsonburg	16.33	18.83	21.79
Beachville	2.10	2.40	2.77
Embro	1.70	1.93	2.22
Norwich	2.73	3.16	3.66
Tavistock	4.50	5.19	6.00
Rural Municipalities			
Blandford	1.30	1.50	1.70
Blenheim	2.20	2.53	2.93
Dereham	1.60	1.85	2.15
East Nissouri	1.40	1.60	1.86
North Norwich	1.30	1.50	1.70
South Norwich	1.90	2.20	2.53
East Oxford	1.50	1.80	2.09
North Oxford	1.20	1.40	1.60
West Oxford	1.20	1.40	1.60
East Zorra	1.20	1.40	1.60
West Zorra	1.20	1.40	1.60

Figures are pounds per capita per day

*Source: Oxford Area Waste Management Study, Brian Turnbull and Associates Urban and Regional Consultants 1973, p. 69.

TABLE 3

OXFORD COUNTY MUNICIPAL SOLID WASTE PROJECTIONS (IN TONS)

Urban Municipalities	1971	1981	1991
Woodstock	24,121	34,126	47,077
Ingersoll	7,144	8,890	12,269
Tillsonburg	19,693	27,869	38,637
Beachville	381	534	738
Embro	218	304	372
Norwich	900	1,288	1,770
Tavistock	1,223	1,730	2,394
Rural Municipalities			
Blandford	346	432	528
Blenheim	1,861	2,312	2,882
Dereham	1,554	1,942	2,432
East Nissouri	856	1,058	1,326
North Norwich	608	754	921
South Norwich	1,090	1,365	1,692
East Oxford	628	815	1,021
North Oxford	388	491	605
West Oxford	623	785	968
East Zorra	1,141	1,438	1,770
West Zorra	481	607	748
Total	63,256	86,740	118,150

CHAPTER III

An Examination of Possible Disposal Methods

Disposal Methods

Projected quantities of waste from each municipality in Oxford County have been established for the life expectancy of the solid waste disposal system under study. At present, the technology exists to dispose of solid waste in three distinctly different fashions; burying, burning and reclaiming. Each of these broad disposal methods has advantages and disadvantages depending on: the composition and volume of the waste, the geographic distribution of the population being served, and the physical characteristics of the area such as climate, soil and ground water.

In addition, it is not uncommon to find several disposal methods working within the same system. This is usually accomplished by having one system acting as a primary process followed by a more traditional final disposal method. The purpose of the first process is usually to speed up the breakdown procedures being used in the final disposal stage.

A number of systems currently in use as well as several new highly technical systems will be examined and comments provided on their strengths and weaknesses in fulfilling the needs of Oxford County. The problem will be to determine the most satisfactory method or methods of treatment; bearing in mind, the conservation of natural resources on one hand and the cost to the population on the other.

In order that the disposal methods discussed in this chapter can be realistically evaluated for their suitability for Oxford County, a preliminary cost analysis will be included for each method.

SANITARY LANDFILL

Up to the present time dumping, and the more sophisticated offshoot, Sanitary Landfill have been the most often used form of solid waste disposal in Canada.[1] In its most primitive form open dumps often remain the cheapest method in economic terms, but the most expensive in terms of aesthetics and environmental quality. Open dumps allow the indiscriminate dumping of most kinds of waste, both solid and liquid onto land that is usually undesirable for building or agricultural purposes.

It is not uncommon that this land is poorly drained. This often results in pollution of the ground water system as well as providing an excellent breeding ground for flies and rodents. General organization of the site and long range planning are rarely part of a dump disposal system. This is not necessarily the result of neglect, but more often the result of ignorance on the part of municipal officials. The location of many dumps; both abandoned and still operational, indicates that the prime factor in choosing the site had been visual isolation. In other words, if the site was not visible from the road, and people were unlikely to complain about the smell, a good site had been selected.

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[1] R.H. Clark and J.H. Brown, Municipal Waste Disposal Problem or Opportunity, The Ontario Economic Council, 1971, p. 33.

With this background the Waste Management Branch of the Department of Energy and Resources Management legislated against open dumps in all but the most sparsely populated ares of the province (see Appendix I). This has resulted in some municipalities attempting slight alterations to dump sites, and projecting the opinion that what they have created is a sanitary landfill operation. This has led many people to be skeptical, when the merits of a Sanitary Landfill operation are discussed. Sanitary Landfill is defined by the American Society of Civil Engineers as:

> "A method of disposing of refuse on land without creating nuisances or hazards to public health or safety, by utilizing the principles of engineering to confine the refuse to the smallest practical area, to reduce it to the smallest practical volume, and to cover it with a layer of earth at the conclusion of each day's operation, or at such more frequent intervals as may be necessary."[2]

Operational Methods

The operation of a Sanitary Landfill site involves three basic operations; spreading, compacting and covering. Two general methods of employing the above mentioned operations have evolved; the area method, and the trench method.

Area Landfill Method

In an Area Sanitary Landfill operation the solid wastes are placed on the land; a bulldozer or similar piece of equipment

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[2]Committee On Sanitary Landfill Practice of the Sanitary Engineering Division, American Society of Civil Engineers Manual of Engineering Practice, Number 39, New York, 1959, p. 1.

spreads and compacts the wastes, then the wastes are covered with a layer of fill material, and finally the earth is compacted. This method is most suited to flat or gently sloping land, but it can be adapted slightly for use in quarries, ravines or other suitable depressions.

Trench Landfill Method

In the Trench method of Sanitary Landfill, a trench is cut in the ground and the solid wastes are placed in it. The solid wastes are then spread in thin layers, compacted and covered with the earth initially excavated to form the trench. This method is best suited for flat land where the water table is not near the ground surface. Normally the material excavated from the trench can be used for cover material thus minimizing the hauling of suitable cover material.

In both methods it is essential that cover material to a depth of six inches be used at the completion of each day's operation. This thin layer keeps waste from blowing as well as serving to divide the waste into cells or cubes to help promote the biological degradation of organic materials. In addition, this type of construction gives physical strength and stability to the site. As a final cover, a minimum of two feet of compacted soil is recommended. This should be placed over the fill as soon as possible to help assure that wind and water erosion do not expose the waste.

Site Selection

Site selection is among the most important factors in the eventual successful operation of a Sanitary Landfill Operation.

In selecting a site, the following must be taken into consideration: the land area required, accessibility from areas of waste production, availability of suitable cover material, soil and geological characteristics, ground water level and drainage pattern.

The amount of land required to operate a successful landfill site is conditional on three major criteria: the projected waste disposal production rate, the degree of compaction, and the life expectancy of the operation. In the case of Oxford County, the waste projections for twenty years were calculated previously in Table 3. The degree of compaction refers to the amount of pressure that can be exerted on the refuse in order to reduce the volume. The usual degree of compaction found in Sanitary Landfill Sites is thirty pounds per cubic foot.[3]

If Sanitary Landfill disposal were to be implemented in Oxford County, it would be assumed that the compaction density would be close to the figure of thirty pounds per cubic foot suggested by Clarke and Brown. Table 4 is provided as a guide

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[3]R.H. Clarke and J.H. Brown, Municipal Waste Disposal Problem or Opportunity, The Ontario Economic Council, 1971.

TABLE 4

LAND AREA REQUIREMENTS FOR SANITARY LANDFILL SYSTEMS

WITH CAPACITY FOR 25,000 TONS OF WASTE PER YEAR

Cell Depth In Feet	Finished Rise In Feet	Area Requirement (Composition Density 30 lbs/ft^3)	Cover Material (Cubic Yards/Ton of Waste)
2	4.5	404	3.35
	7.0	192	2.14
	9.5	128	1.75
	12.0	96	1.57
	14.5	77	1.47
	17.0	64	1.40
4	6.5	190	1.87
	11.0	96	1.29
	15.5	64	1.12
	20.0	48	1.04
6	8.5	128	1.42
	15.0	64	1.07
	21.0	43	.97
8	10.5	95	1.22
	19.0	48	.97
	27.0	32	.92
10	12.0	76	1.14
	23.0	38	.95

Area = Area in Acres

Volume = Volume in cubic yards of cover soil per ton of waste solid

Source: Clark, R. H. and Brown, J. H. Municipal Waste Disposal Problem or Opportunity p. 39.

to the acreage requirements for a site disposing of 25,000 tons of waste per year over a twenty year period.

Accessibility

One of the most important factors to consider when attempting to minimize the cost of the complete disposal system is the site accessibility. The site should be easily reached by truck using major roadways. Secondary roads and those with poorly constructed roadbeds are often unuseable for long periods during the spring and winter seasons. The building of suitable roads greatly increases the disposal cost in many cases.

Availability of Suitable Cover Material

The volume of cover material needed to operate a Sanitary Landfill operation disposing of 25,000 tons of waste per year is listed in Table 4. Suitable cover material is defined as:

> "earth that is easily workable, compactable, free of large objects that would hinder compaction, and does not contain organic matter of sufficient quantity and distribution conducive to the harborage and breeding of vectors."[4]

Geology, Soil and Groundwater

These three factors have been grouped together as they are linked in determining the amount of pollution that ultimately is spread to the subterranean environment. Solid wastes ordinarily contain many contaminants which if spread could cause

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[4]United States Environmental Protection Agency, Recommended Standards for Sanitary Landfill Design, Construction and Evaluation (Washington, D.C., 1971), p. 1.

a serious health hazard. The groundwater table must be located in order that excavations for sanitary landfill operations do not exceed the historical high groundwater level (see Table 4).

A survey of Well Logs for Oxford County published by the Ontario Water Resources Commission indicates that the static water level ranges from ground level to one hundred and twenty-five feet below ground level. However, the most frequent depth at which the water table was located was in the twenty-five to fifty foot range.

The type of soil used both in preparing a site, and for cover material is important to the overall effectiveness of the operation. Water filtering through the refuse, as well as leachate that is produced within the refuse will quickly pollute the groundwater system. No soil will completely stop this liquid movement, but soils made up of clay or small silt sized particles will impede the flow.

Sites located near large surface drainage features should be avoided because of the danger of polluting the surface water system, not only through leachate, but also during flooding.

Sanitary Landfill Implimentation Cost

This section on cost is not intended to be a comprehensive examination of all costs associated with operating a complete collection and disposal operations. The intent is merely to determine the approximate cost of operating a sanitary landfill disposal system in Oxford County.

The major components of the total cost will be contributed by the cost of land, equipment, and labour.

Land costs within the County vary, with the cheapest land usually not being suitable for a Sanitary Landfill operation. It will be assumed that suitable land is available for one thousand dollars per acre.[5]

The 1971 waste production in Oxford County is estimated to be 63,256 (see Table 3). R.H. Clarke and J.H. Brown estimate that a labour force of four full-time employees would be suitable to operate a single Sanitary Landfill site capable of disposing of this quantity of waste. In addition one front end loader, and one bulldozer would be required to distribute the refuse and the cover material.

The complete cost breakdown is presented in Table 5. These costs are intended to be an indication of cost relative to other disposal methods.

GRINDING AND PULVERIZATION

Pulverization and grinding are similar operations employed primarily to reduce the volume of waste prior to disposal in a sanitary landfill site. Because the finished product from both of these operations is largely the same, it is felt that they can be dealt with in one section. Neither of these techniques is strictly a disposal method as are the others mentioned in

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[5] R.H. Clarke and J.H. Brown, Municipal Waste Disposal Problem or Opportunity, The Ontario Economic Council, 1971, p. 36.

TABLE 5

APPROXIMATE OPERATING COSTS FOR SMALL LANDFILL OPERATIONS

Tonnage Per Year	15,000	25,000	50,000	100,000
Personnel	2	3	4	5
Land Cost for 20 Years in $1,000 units	57.0	95.0	190.0	380.0
Equipment & Site Development in $1,000 units	39.0	73.0	98.0	100.0
Amortization in $1,000 units Per Year	10.6	18.7	32.0	53.5
Soil Cover in $1,000 units Per Year	18.3	30.5	61.0	122.0
Labour in $1,000 units Per Year	18.7	32.6	55.5	64.2
Other Operating Costs in $1,000 units Per Year	7.5	11.0	14.0	16.0
Total Operating Cost in $1,000 units Per Year	55.1	92.8	162.5	255.7
Cost in Dollars Per Ton	3.68	3.70	3.25	2.56

Amortization at 9.25% over 20 years.

Source:

Clark & Brown, Municipal Waste Disposal Problem or Opportunity, p. 41.

this chapter. Grinding and pulverization should be thought of as additional operations that can be built into overall systems, primarily sanitary landfill or biological degradation commonly called composting.

The main advantages of this system in addition to reducing the volume of waste, are that much of the odour is removed from the refuse, vectors are far less likely to be a problem and blowing paper is largely eliminated.

Covering the refuse in a sanitary landfill site at the completion of each day was implemented largely as a solution to the same set of problems. Thus with the inclusion of one of these processes the need for daily cover is removed. A further advantage to this system is that the compaction density mentioned previously as thirty pounds per cubic foot is increased by about thirty-three per cent.[6] The compaction density accomplished with the same effort would be forty-five pounds per cubic foot. This again will result in extending the life of a sanitary landfill site.

The city of St. Catharines, Ontario, has recently incorporated pulverization as a first step in its solid waste management operation. The inclusion of this primary operation has made possible the use of disposal sites within the city limits that

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[6]R.H. Clarke and J.H. Brown, Municipal Waste Disposal Problem or Opportunity, (Ontario Economic Council, 1972), p. 50.

otherwise would never have been acceptable to local residents. The complete pulverization mill in St. Catharines is not a permanent structure, thus when the present site has completed its useful life expectancy, the total operation can be relocated at a new site.

Operational Methods

Grinding and pulverization do not effect any chemical changes to the refuse, they simply effect the physical properties.

Grinding can be achieved by a variety of methods. The principal method involves a combination of knife-like shredders and rotating rolls of vibrating teeth that effectively dismember any and all but the largest pieces of normal domestic waste.

The concept of pulverization generally involves a series of swing hammers that mechanically pound the refuse to pieces.

Both of these methods must employ some type of feed system. Usually a conveyor carries the refuse from either a cement dumping platform or a holding hopper depending on the size of the operation. After the refuse has passed through the system, it is ready to be removed by truck to the actual landfill site for final disposal.

Implementation Costs

As mentioned previously, this type of operation is not a disposal method in itself. It must be accompanied by a final disposal stage, usually Sanitary Landfill or Composting. With the inclusion of pulverization, the cost also increases due to added labour and energy costs. The one area where visible economic cost reductions can be realized is in the area of land costs. As previously mentioned it is estimated that approximately thirty-three per cent of the refuse volume can be reduced through pulverization. For a 50,000 ton per year operation this would reduce the 20 year land costs from $190,000 (see Table 5), to $126,667 a saving of $63,333. This would have the effect of reducing yearly amortization payments by about $6,500 over a twenty-year period. The overall effect of this land reduction will be to reduce the disposal cost per ton from $3.25 per ton to $3.12 per ton. The additional cost per ton of operating a pulverization unit in a disposal system designed to accommodate 50,000 tons of refuse per year would be $2.43.[7] This would bring the total disposal costs to $5.55 per ton. This final figure will be used only to provide a relative rating method by which to compare the cost of disposing of waste by various methods.

INCINERATION

Incineration is one of the oldest disposal methods known to man, but it has evolved to the point where a highly engineered physical plant is required. Much of the recent engineering has been made necessary by increased pressure for improved air

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[7] Ibid Table 4.1.

management practices. This has primarily occured in the field of air pollution abatement equipment that filter solid particles from the emissions.

The Waste Management Act of 1970 defines incineration as:

> "the treatment of waste by controlled burning, including measures for limiting air pollution, to reduce the volume of the waste and to leave it in a more stable form for disposal."[8]

Incineration as a method of solid waste disposal has been in use in Canada on a large scale since the early 1930's when the city of Montreal built two units each capable of disposing of three hundred tons per day.[9] More recent installations are designed to make use of the heat produced in the incineration process. The heat energy is converted into steam power that in many cases is marketable to nearby industry or municipal operations. In addition to this worthwhile by-product, metals can be recovered from the ash and re-cycled to help offset the cost of the operation.

There are numerous other beneifts as well. Large quantities of infectious waste are reduced into smaller quantities of inert waste that can be easily disposed of in a small landfill operation. The degree of reduction achieved depends largely on physical make-up of the waste.

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[8]Department of Energy and Resources Management, Bill 94 The Waste Management Act, Interpretation Number 15.

[9]R.H. Clarke and J.H. Brown, Municipal Waste Disposal Problem or Opportunity, (Ontario Economic Council, 1972), p. 57.

Incineration is often able to cut down collection and haulage costs as they can be located close to the centre of large waste production areas.

There are two basic types of incineration currently being marketed by designers; the batch feed method, and the continuous feed method. As the names imply they represent different methods of feeding the refuse into the incinerator. The continuous feed method employs a conveyor that spreads the refuse evenly over the incineration base. This method is generally much more expensive in terms of initial capital expense, but it increases the capacity of the disposal operation. The very nature of this feed system helps to create a more even heat over a long period of time, thus making it a very desirable partner for a steam generating incineration system.

The batch feed system has several less desirable characteristics as refuse is usually dumped directly from the collection trucks into the fire box. Combustion is less complete because several layers are deposited at the same time and combustion can take place only on the surface. A further disadvantage to the batch feed system is that the heat produced is not evenly distributed over the fire box, thus making it a far less desirable system to accompany a steam generating incineration system.

Incineration can have several drawbacks depending on the area being served. A very large capital output is required initially, and ongoing operating and maintenance are also high.

It must also be remembered that incineration is not a final disposal method. It requires the operation of a small landfill site to dispose of the ash as well as large and nonflammable articles.

It is generally quite difficult to adjust incineration capacity to accommodate projected disposal production over a long term. One of the objectives of this study is to plan a solid waste management system with a useful life expectancy of twenty years. The risk of incineration not keeping up with increasing production is much greater in a predominately rural setting like Oxford County than it is in a large urban municipality that has been developed and already supports a dense population.

Incineration Cost

An incinerator is capable of reducing refuse to an average of twenty-five per cent of the collected weight. Thus in addition to considering the cost of all of the equipment and facilities necessary to operate the incinerator, the cost of a small landfill site must also be included. Preliminary costing will be continued on the basis of a 50,000 ton per year production rate as has been the case with Sanitary Landfill and Pulverization.

After incineration, the 50,000 tons of refuse collected would be reduced to 12,500 tons of ashes and nonflammables that would remain to be disposed of by sanitary landfill. This would involve a cost of roughly $3.75 per ton (see Table 5).

The cost of operating an incinerator capable of disposing of 50,000 tons per year including amortization costs over a twenty year period would be $8.28 per ton.[10] Thus the total cost of disposal by incineration would be $11.93 per ton. This compares with $3.25 per ton required by a landfill operation, and $5.55 per ton required to operate a pulverizing operation capable of disposing of 50,000 tons of refuse each year.

It was mentioned earlier that one of the advantages of incineration was the ability to recover some metals, and to market steam produced in the burning process. These preliminary cost figures do not include either of these recoverable by-products as the cost of including recovery systems is not warranted by disposal systems accommodating less than several hundred thousands tons per year.

COMPOSTING

Composting is a process that transforms solid waste into a humus-like material by way of aerobic degradation (breakdown in the presence of oxygen). The new material is organically very stable and most often used as a soil conditioner along with artificial fertilizers. As a soil conditioner it improves the soil structure, provides for better aeration and increases the soils capacity for holding water.

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[10] R.H. Clarke and J.H. Brown, Municipal Waste Disposal Problem or Opportunity, (Ontario Economic Council, 1972), p. 65.

Composting first became popular in several of the high population density countries of Europe. The main purpose of the operation at that time was not the disposal of solid waste, but the high demand for the end product, compost. The situation is somewhat different presently in North America where the only justification for a composting operation is to dispose of solid waste. The North American attitude toward composting has not developed to the same extent as it has in parts of Europe. The main reason for this is the abundance of low priced chemical fertilizers available on the North American market.

Operational Methods

Composting usually involves an initial sorting procedure of some type where non-degradable items such as tins, refrigerators, building refuse, etc., are either sold as scrap or disposed of in an accompanying sanitary landfill operation. Sorting can be achieved reasonably easily and inexpensively if residents are willing to separate their waste into that which is biodegradable and that which is not. A public that is truly concerned with the environmental implications of such a system is needed if pre-collection sorting is to take place. Past experience designates that this type of concern is difficult to inject into most groups of people. For this reason a sorting procedure should be considered as an essential first step in any composting operation.

There are two basic methods of composting, one which relies heavily on completely natural processes, and one which employs some mechanical operation to speed up the degradation process.

In order to achieve a finished compost of reasonably uniform sized particles, it is necessary to include pulverization as a stage in the process. In addition to improving the final compost, pulverized waste degrades much faster than refuse that has not been pulverized. This is usually accomplished by the use of shredders, tumble mills, or hammer mills that mix and greatly reduce the average particle size.

Windrows as a Composting Method

This process relies heavily on the slow natural degradation of waste. The sorted material is piled in heaps of three to five feet in height and about ten feet wide. These heaps must be turned over approximately twice a week for six to twelve weeks to achieve a crude compost. Many European plants require from four to six months of turning to achieve complete degradation. The turning must be maintained during the complete process so that the aerobic processes are maintained. For most of this period odours are prevalent making this type of operation a most unwelcome neighbour.

This complete process can be carried on either inside large warehouse-size sheds, or outside. For obvious reasons, the building of large sheds adds immensely to the total cost of the operation because of the large square footage of enclosed space that is required.

Mechanical Digestion as a Composting Method

This is not in fact a completely different process than that which takes place in the Windrow method previously discussed. In reality this method simply involves the inclusion of additional mechanical procedures that simulate the conditions of a Windrows method. The basic ingredients of air, water and heat are controlled, with the result that a reasonable compost is produced in about six days. It is, however, usually recommended that a final period of several weeks be spent in natural outside windrows.

Cost

Estimating the cost of a composting operation is more difficult than other disposal methods that have been previously examined because of the variety of companies marketing this type of equipment, and the varying qualities of compost that result. It is also necessary to consider several economic factors about the specific area being planned for. For example, in areas where either land costs and or labour costs are extraordinarily high, the natural Windrows degradation method becomes uneconomical. On the contrary, it is possible to operate an economical Windrows system in parts of the world where land and or labour costs are much lower than they are in Ontario, most notably Central Europe and Israel. For this reason, it will be assumed that a totally natural composting system would be unacceptable in Oxford County.

As previously mentioned, the variety of mechanical composting systems available presents a problem. R.H. Clarke and J.H. Brown, have listed operating cost in dollars per ton for several major systems.[11] As in any manufacturing process, economies of scale and the size of the operation can account for a considerable cost per ton range. All other systems that have been costed thus far have assumed a solid waste production rate of 50,000 tons per year. To keep the comparison relative, only systems of approximately the same capacity will be used.

> "System number one is currently handling 63,000 tons of refuse per year at a cost of $5.14 per ton. System two is capable of handling 40,000 tons of refuse per year at a cost of $8.91 per ton. The third system again capable of handling 40,000 tons per year at a cost of $7.50 per ton."[12]

These figures were calculated from 1970 data, and have been included for rough comparison.

BLACK CLAWSON'S HYDROSPOSAL/FIBRECLAIM SYSTEM

The concept of re-cycling solid waste has grown out of ecological concerns and the projected end of many of our non-renewable resources. Initial reaction resulted in the formation of many private, grant-sponsored organizations that were

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[11] Ibid, p. 79.

[12] Ibid, p. 79.

equipped to handle only small quantities of selected and pre-sorted solid waste. These organizations relied heavily on volunteer manual labour.

In contrast to this, engineering companies began to incorporate much available technology from mechanical separation industries, and the pulp and paper industry to develop, capital intensive operations for waste re-cycling. One system that has had much initial success in this field is Black Clawson, a multi-divisional pulp and paper, and chemical organization based in New York City. The process they developed will be examined as an example of advanced technology grappling with the re-cycling issue.

The city of Franklin Ohio recently employed Black Clawson Ltd. to design a re-cycling plant to dispose of the one hundred and fifty tons of waste generated each day. As this process is quite complex, and its understanding is not critical to the thesis, the 'Operational Method' section will be brief.[13]

Operational Method

Refuse is fed through a wet pulping machine that converts the waste into a slurry. The first materials to be recovered are the ferrous metals that are ejected from the pulper through holes in the side of the tub. They are then sorted by magnetic separators, and are ready for re-cycling.

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[13] Hydrosposal/Fibreclaim Solid Waste Recycling Plant, Franklin Ohio. (Lithoed in U.S.A.)

The slurry then passes into a liquid cyclone that uses centrifugal force to separate the heaviest remaining particles. These include glass, some aluminium and heavier plastics.

Finally, the fiber recovery takes place by mechanically separating the long paper fibers from coarser organics such as, rubber, textiles, plastics, leather, etc. That which remains in the slurry is de-watered and burned.

The Black Clawson Hydrosposal/Fiberclaim system relies heavily on a viable market for its many recoverable substances. This is necessary if the large capital cost associated with its installation is to be offset.

Several critics of the system have raised questions regarding the possibilities of health hazards existing either with the operation itself, or the recovered paper fiber.

Cost

The Black Clawson re-cycling system relies heavily on an available market for its products. A market feasibility study was recently completed in London, Ontario, where it was determined that all reclaimed material could be marketed with the exception of Ferrous metals.[14] It was further determined that even including the revenue generated from the sale of these products, the cost per ton would be in the range of $12.47 to $16.93 per ton.[15]

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[14] R.A. Beatty and R.A. Nobbs, Ecologically Sound Solid Waste Management, A Feasibility Study of Closing the Resources Gap, London, Ontario, 1973, p. 93.

[15] Ibid, p. 102.

Despite the fact that this cost range assumes a production rate of over 190,000 tons refuse per year, it is clear that the cost of such a system in Oxford County would be prohibitive. Drastic changes would be necessary in the value scales adopted by our society before such a system would achieve any hope of feasibility.

Summary of Disposal Methods

This chapter has briefly examined five different disposal methods. The main purpose was to determine the relative advantages and disadvantages of each system for the needs of Oxford County. The County is considered to be in the mid-range as far as population density in Ontario is concerned. Thus it is not well suited to systems that are capital intensive such as incineration and the Black Clawson's Hydrosposal/Fiberclaim system and Mechanical Composting. These systems require that a great percentage of the cost per ton disposal rate is taken by large amortization payments when the relatively small amounts of refuse produced by Oxford County are considered. Within the time span currently being planned for, social value structure may change drastically. This in turn could increase the selling price of some of the products recovered from capital intensive disposal methods offsetting the large amortization payments. The same relative effect could be created by increasing land costs, or a change in the now largely unmeasurable value of environmental aesthetics.

One properly managed Sanitary Landfill operation could certainly handle refuse from Oxford County for the foreseeable future. In addition, such a system brings with it a high degree of flexibility. Because it is land intensive, the landfill sites could be converted to other uses at such time as land costs increased relative to labour or capital costs. If only a minor change took place in relative costs, a grinding or pulverization stage could be added to the system which would reduce the land needs.

A further flexibility is built-in as the system could again be decentralized through the use of transfer stations, or additional terminal disposal sites if haulage costs increased out of porportion with other costs involved.

For these reasons, it is felt that any regional solid waste management system being considered for Oxford County should employ a single sanitary landfill site as the disposal method.

The remainder of this thesis will concentrate on the development and application of a methodology that will locate a sanitary landfill site that will efficiently meet the needs of Oxford County at least until 1991.

CHAPTER IV

Model Development

The problem of designing a system can be logically divided into at least two distinct but interrelated parts. The first part must answer the question, what components will the system be made up of? The focus of Chapters II and III have specifically dealt with this question. Existing and projected waste disposal requirements of the population were examined, as was the feasibility of various mechanisms or components to meet those expected needs. The remainder of this thesis will deal specifically with the position that these component parts must take in order that the best overall solution result.

Much will be contributed to the answer of this second question from theories and models developed by other geographers. The solution will draw primarily from two major bodies of geographic theory, Location Theory and Network Development and Analysis. These areas both attempt solutions to problems that involve the spatial distribution of phenomena.

Location Theory has traditionally dealt with finding the optimum site for a specific phenomenon that tends to be static in location, while Network Analysis on the other hand, tends toward solutions of dynamic problems. Closely associated with Network Analysis is Topology which is concerned with those aspects of the geometry of a figure that is independent of distance and angularity.

The intent is that a solution to the problem will result from a synthesis of ideas developed out of these general areas of study.

Network Analysis

The philosophy out of which network analysis developed is that man should have a better understanding of the flows of people, material and ideas. The end result should be that movement of all kinds can be made more efficiently.

Networks are made up of three basic parts: a set of nodes or points, an interconnecting series of links or routes, and the intervening space not occupied by either points or routes. In terms of this study, the centres of solid waste production serve as nodes, and the road system connecting the centres become the links.

Traditionally network analysis has served to aid in the design of new transportation systems, or at least to determine the most efficient method of travelling to each point within a given system. In this study, network analysis is used to determine the most centrally located area within the county for the establishment of a Sanitary Landfill site capable of disposing of all solid waste generated within the county.

The problem has been essentially recognized by William Bunge in his classification of network problems in Theoretical Geography.[1] It involves connecting one point to all other

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[1]William Bunge, Theoretical Geography, Land Studies in Geography, Stockholm, 1962, p. 183.

points in the network in the shortest possible distance. Bunge's problem differs from the problem posed in this study in two major ways. The location of the single point connected to all other points is given in Bunge's model. The purpose of this study is to locate the point that best solves the problem. The second difference is that Bunge's solution is based on a single variable, distance. A second variable namely weight transported will be equally important to the solution of the problem.

Location Analysis

The field of Location Analysis as discussed in Chapter I, has become one of the most popular areas of study within geography during the past decade. Simply stated, Location Analysis involves establishing the position of some phenomenon so that it best serves the needs of all involved groups. To be more specific, it often combines aspects of economic, urban and transportation geography into abstract concepts or models of spatial distribution.[2]

Secondary factors also have a great effect on the location of Sanitary Landfill operations in Ontario due to the increasing ecological pressures mentioned in Chapter I. Any serious attempt to choose a site for a Sanitary Landfill operation must consider these important factors, not because of short term economic benefits, but because of the possible long term ecological results.

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[2]National Academy of Sciences, The Science of Geography Washington, D.C., 1965, p. 44.

The examination of past studies related to the location of regional solid waste disposal sites indicated that some measure of the amount of solid waste produced, and a distance factor providing a measurement between each generation area in the region and the disposal sites being considered, are principal factors. These factors provided the initial input in the site selection. This is not to say that the ecological factors were considered less important, but only that they would be considered in either of two ways. Each one could have been defined and quantified, and included as initial input along with the economic factors. This would have added considerably to the complexity of the solution process. The second method of considering ecological input was to choose the location first on the basis of a mathematical model using distance and waste production rates, and then to choose the closest site that fulfilled all of the necessary environmental criteria.

In order to design a system of solid waste disposal in Oxford County, it was necessary to represent the waste produced as centres of waste production, and the road system connecting those centres as links in a network (see Map No. 3). The waste production rates for 1971 were used to represent the quantity of waste produced. The production location or centroids were represented by the centre of each urban municipality, or by the largest residential centre in each of the rural municipalities.

The network superimposed over these centroids was made up of all the King's Highways, County Roads and County Suburban Roads as defined by the Road Map County of Oxford.[3] These roads were selected as they provided each production centre with a link to the network, and in addition all were suited to year round travel by the type of heavy vehicles needed in the operation.

A check was made with the Ministry of Transportation and Communications to see if any additional links were planned for the Oxford County road network. Mr. F. DeVisser, Head of the Area Transportation Systems Office, replied that the only such link being planned was the eventual extension of Highway 403 westerly from Brantford to join Highway 401 at Woodstock. The exact route of this proposed extension was not certain, however, it was not expected to affect the network used in this study as it will have neither its origin nor its destination as one of the waste production centres.[4] This highway extension will be primarily to serve people in the Hamilton-Brantford area by improving their accessibility to the major road networks of south western Ontario.

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[3]Ure and Smith, Road Map County of Oxford, Woodstock, (1967).

[4]F. DeVisser, Head, Area Transportation Systems, Ministry of Transport and Communications Ontario, personal letter, January 25, 1974.

Developing the Mathematical Model

The greatest weakness in the solid waste disposal models discussed in Chapter 1 was that they all required that several sites be suggested and the model would determine the relative suitability of each site. In order to assess the relative practicality of many sites the slow process of trial and error had to be adapted. In a region like Oxford County where solid waste was being generated by eighteen separate municipalities a truly optimum location would be unlikely to result from a straight application of one of the models. In order to solve this problem, a method of assessing the relative practicality of a large number of possible sites was required. Erik Bylund successfully used a grid system laid over a large area, to assess several factors when predicting settlement patterns in Inner North Sweden.[5] The grid system method of assessment provides two valuable services: it identified a great number of regularly spaced locations, while at the same time providing a theoretical linkage system connecting these points. Although the linkage system is not necessarily an accurate representation of an actual road system it does make possible the "L" shaped pathways used by the research group from Northwestern University mentioned in Chapter 1.

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[5]Erik Bylund, "Theoretical Considerations Regarding the Distribution of Settlement in Inner North Sweden", in Cultural Geography: Selected Readings, ed. by F.E. Dohrs and L.M. Sommers, (New York: Thomas Y. Crowell Co., 1967), p. 135.

In order to measure the relative suitability of each intersecting point in the grid system a suitability index figure was calculated in three steps for each of these points according to the following formula.

$$q = a_1 x_1 + a_2 x_2 + a_3 x_3 + \ldots\ldots a_{18} x_{18}$$

OR

$$q = \sum_{i=1}^{18} a_1 x_{1j}$$

The objective is to choose a node in the grid that minimizes q.

where: a_1 represents the yearly production of solid waste measured in tons, at one municipality.

x_1 represents the shortest possible distance, following the grid system between one municipality and the node being considered.

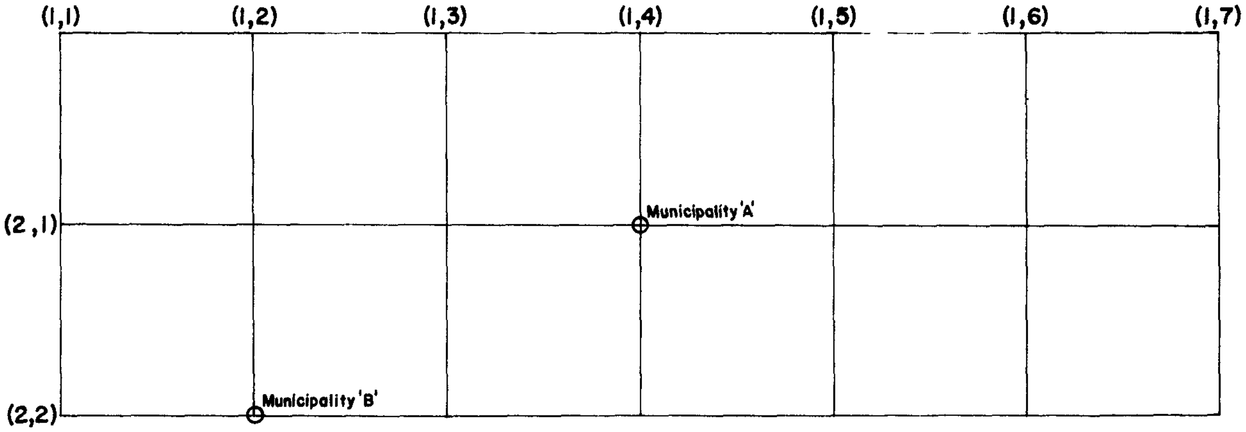
q represents the number of ton miles required to transport the total amount of solid waste produced in the system in one year to the node being considered.

18 represents the number of municipalities.

The first operation was simply to determine the number of links in the grid system between the point being considered, and one of the eighteen identified waste producing municipalities. The second step was to multiply the number of grid links by the annual amount of solid waste measured in tons for that specific municipality. The new figure is a function of both the distance between two points, and the weight transported between those two points. The final step in calculating the suitability index for the spot under consideration, involved repeating the first two steps for each of the remaining municipalities and adding them.

Map No. 4 represents a hypothetical situation in which municipalities A and B produce 25,000 and 15,000 tons of solid waste per year respectively. A large scale grid system was placed over the municipalities such that each municipality was located on or near a vertex created by the grid. Calculating the suitability index for point (1,1) involved the three steps mentioned previously. Municipality A is four grid links removed from point (1,1). Municipality A thus contributes 100,000 ton links to the suitability index of point (1,1). Municipality B produces 15,000 tons of solid waste and is located three links from point (1,1); thus, 45,000 ton links are contributed from Municipality B toward the suitability index number of point (1,1). The total suitability index number is 145,000. The same methodology was followed to calculate that 105,000 is the suitability index number for point (2,1). Thus in terms of relative locational suitability point (2,1) ranked more favourable than point (1,1).

On the basis of the suitability index, several areas stood out as being superior relative to other sites. Each of those sites that appear as superior would be examined in terms



EXAMPLE OF GRID SYSTEM

Map 4

of existing land use as well as ecological considerations. This hypothetical situation was included to illustrate the methodology developed to calculate the suitability index. No attempt was made to carry the methodology further by superimposing a hypothetical land use and physical characteristics to the region. This methodology will be applied to Oxford County in Chapter V.

CHAPTER V

Model Application to Oxford County

Chapter IV outlined the development of the mathematical model that would locate a regional landfill site on the basis of the two primary factors namely tons of waste produced by municipality, and "L" shaped distance between generation area and disposal site. This method will now be applied to Oxford County. The results will indicate those nodes within the County where the number of ton miles required to transport all the solid waste in the County would be minimized.

The second part of the methodology will then be employed to determine the exact site location from within those areas defined by the model. Those factors taken into consideration in the final selection include soil composition and structure, availability of cover material, drainage, water table level, existing land use and proximity to a major paved highway.

Preliminary Location Selection

Selecting an appropriate grid size is crucial to the accuracy of the model. Too large a grid would result in information that would be too general to be of any real value in choosing appropriate locations in terms of accessibility. A very small grid would provide us with desirable results, but the wasted repetition that would result would do nothing to increase the accuracy of the study. A grid pattern of one mile squares was used as it most closely matched the grid system established by the county road network, and would produce meaningful results in ton miles.

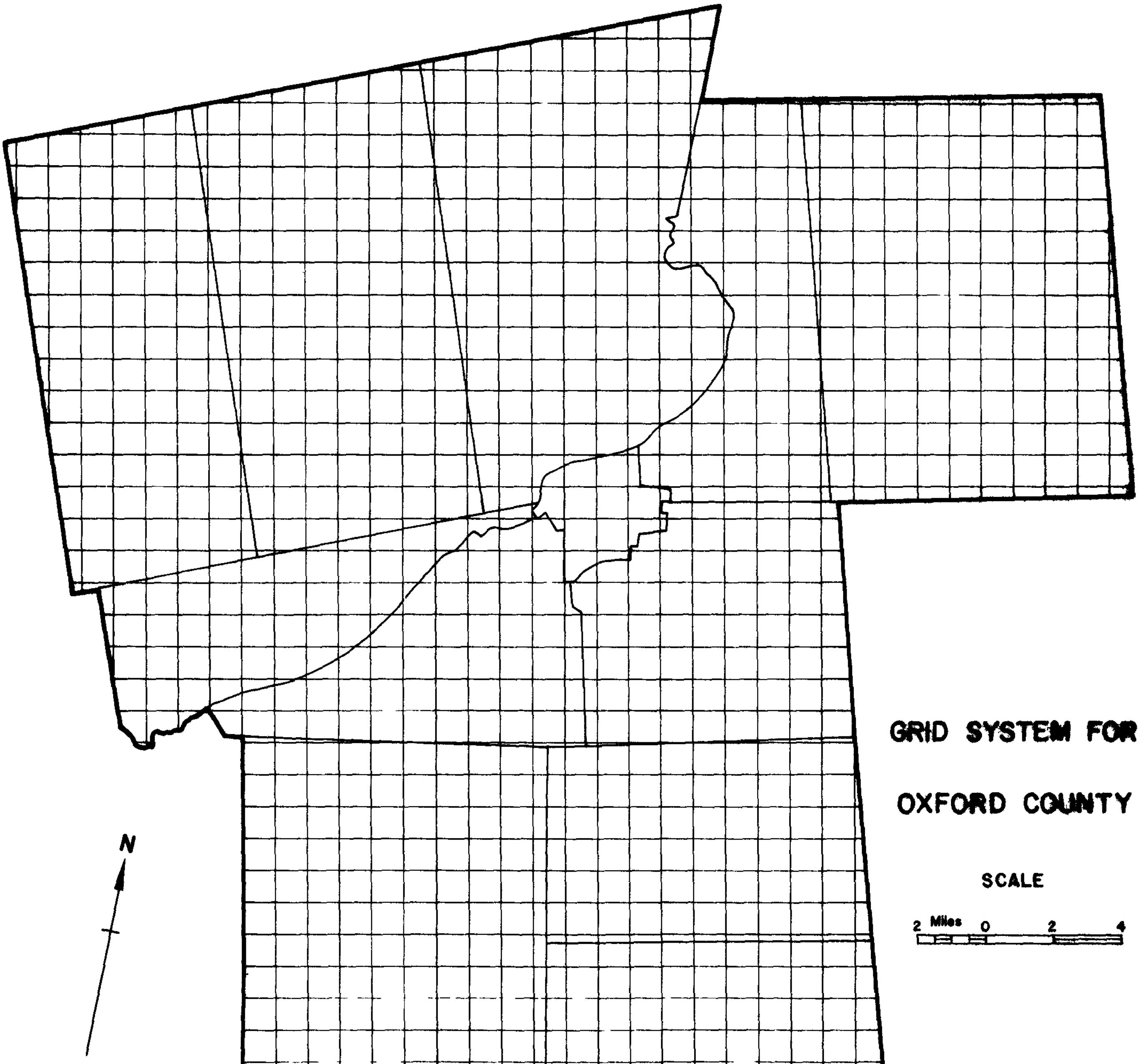
The grid system was fitted over Oxford County such that the horizontal grid lines ran parallel with the southern boundary of the County. The grid system included over 900 vertices or points, each of which was tested for its general suitability according to the model developed in the previous chapter (Map 5).

The annual solid waste production figures by Municipality (Table No. 3) was multiplied by the number of one mile links in the grid that separate the municipality from each node in the grid system. Once this figure is calculated for each of the eighteen municipalities at a given point on the grid, the products will be summed. The sum will be the number of ton miles that would need to be travelled along the grid in order to haul all domestic solid waste produced in the county in one year, to that specific point.

It should be noted at this point that the links in the grid system do not exactly follow the highway network in the county. For the most part, as mentioned previously, the highways in the county run in a perpendicular or near perpendicular pattern although the two grid systems are not completely coincidental, they provided meaningful results.

Isosuitability Map

Once these figures were calculated for each of over 900 points in the grid system it was possible to construct an Isoline map of the county that links all points in the county that have


N
GRID SYSTEM FOR
OXFORD COUNTY
SCALE
2 Miles 0 2 4

equal suitability, in terms of location, for establishing a regional landfill operation (Map No. 6).

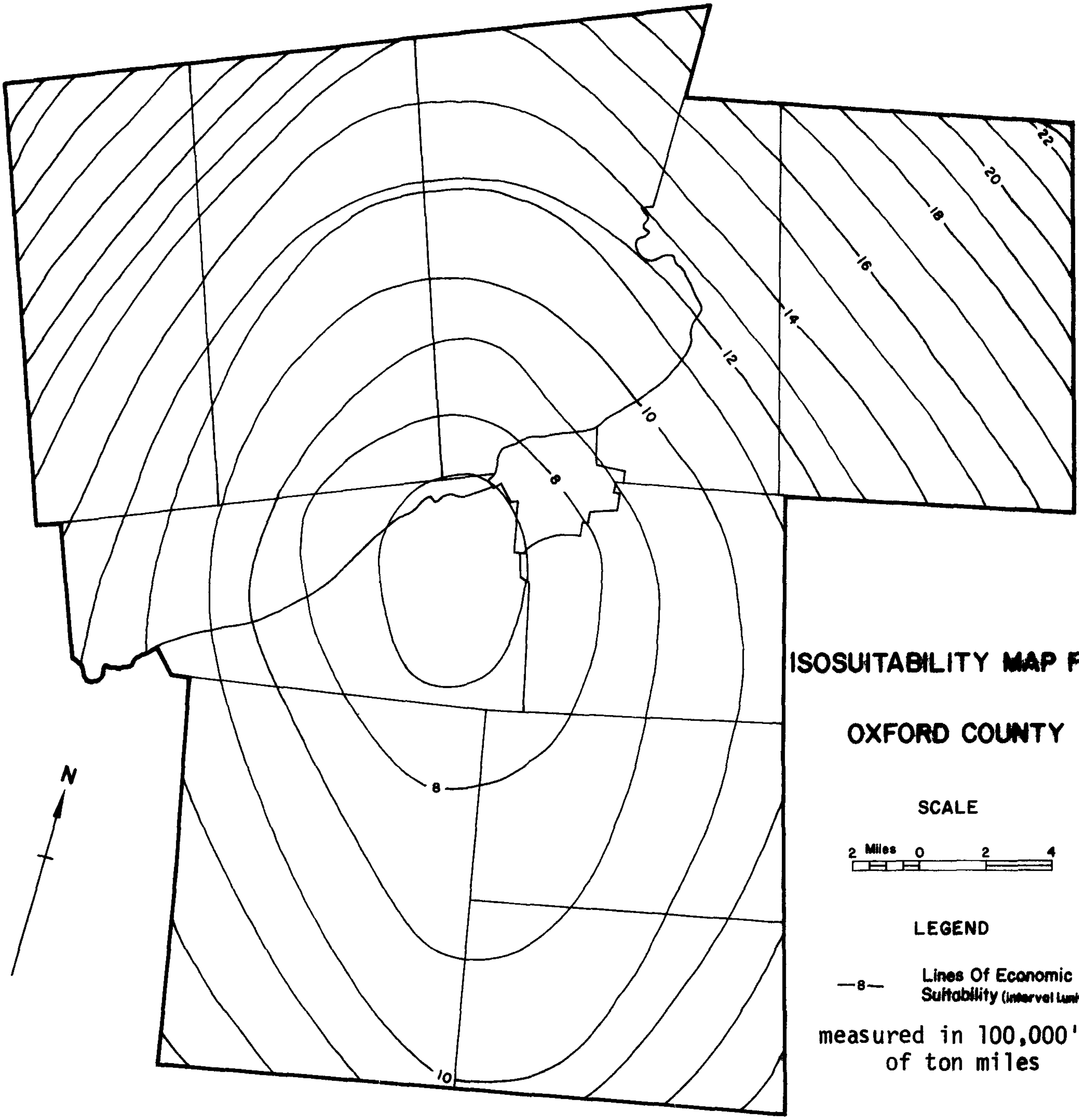
The pattern produced on this map very clearly shows the influence of Woodstock, the largest municipality in the county. It is not surprising that when ton miles are considered, the suitability index varies almost in direct proportion to the distance from Woodstock. Perhaps the most surprising result is the relatively slight southern pull of Tillsonburg, the second largest municipality. This small influence is easily explained when the location of Tillsonburg is considered. Because it is somewhat isolated at the extreme south end of the county, all other municipalities in the county are acting to counteract its influence.

Analysis of the Area of Prime Suitability

The area within Oxford County where the number of ton miles was minimized was located immediately southwest of the city of Woodstock (Map No. 7). It was expected that the regional Sanitary Landfill site would be proposed somewhere within these ten square miles; which lay primarily in the Township of West Oxford, and to a lesser extent in East Oxford, East Zorra and the city of Woodstock.

Existing Land Use

Most of the land specified as highly suitable on Map 7 is currently being used for agricultural purposes, primarily dairy



ISOSUITABILITY MAP FOR

OXFORD COUNTY

SCALE

2 Miles 0 2 4

LEGEND

—8— Lines Of Economic Suitability (interval Limit)

measured in 100,000's of ton miles

Map 6

farming, although the principal crops of spring grains and cultivated hay are also common.[1] In addition, a diverse number of land uses are present to a lesser extent. These include the residential southwest corner of the City of Woodstock, most of the Village of Beachville, and the residential settlements of Sweaburg and Folden Corners. In addition, there is ribbon development along Highway #2 between Woodstock and the Village of Beachville. The only other identifiable blocks of land of a significant size are those that are owned by The Oxford County Public Utilities Commission located along the eastern boundary of this area of high suitability, and a strip of property along the Thames River that is owned by the Thames River Conservation Authority.

The Waste Management Act as outlined in Appendix I makes note of specific guidelines that must be followed when establishing a new Sanitary Landfill operation. Most of these requirements can be built in during the initial construction process. This does not reduce the importance of careful examination during the site selection process. Care at this stage can reduce both the initial capital cost as well as the long term operating cost. Those items that were considered at this stage included the following: access roads, good drainage, isolation from the

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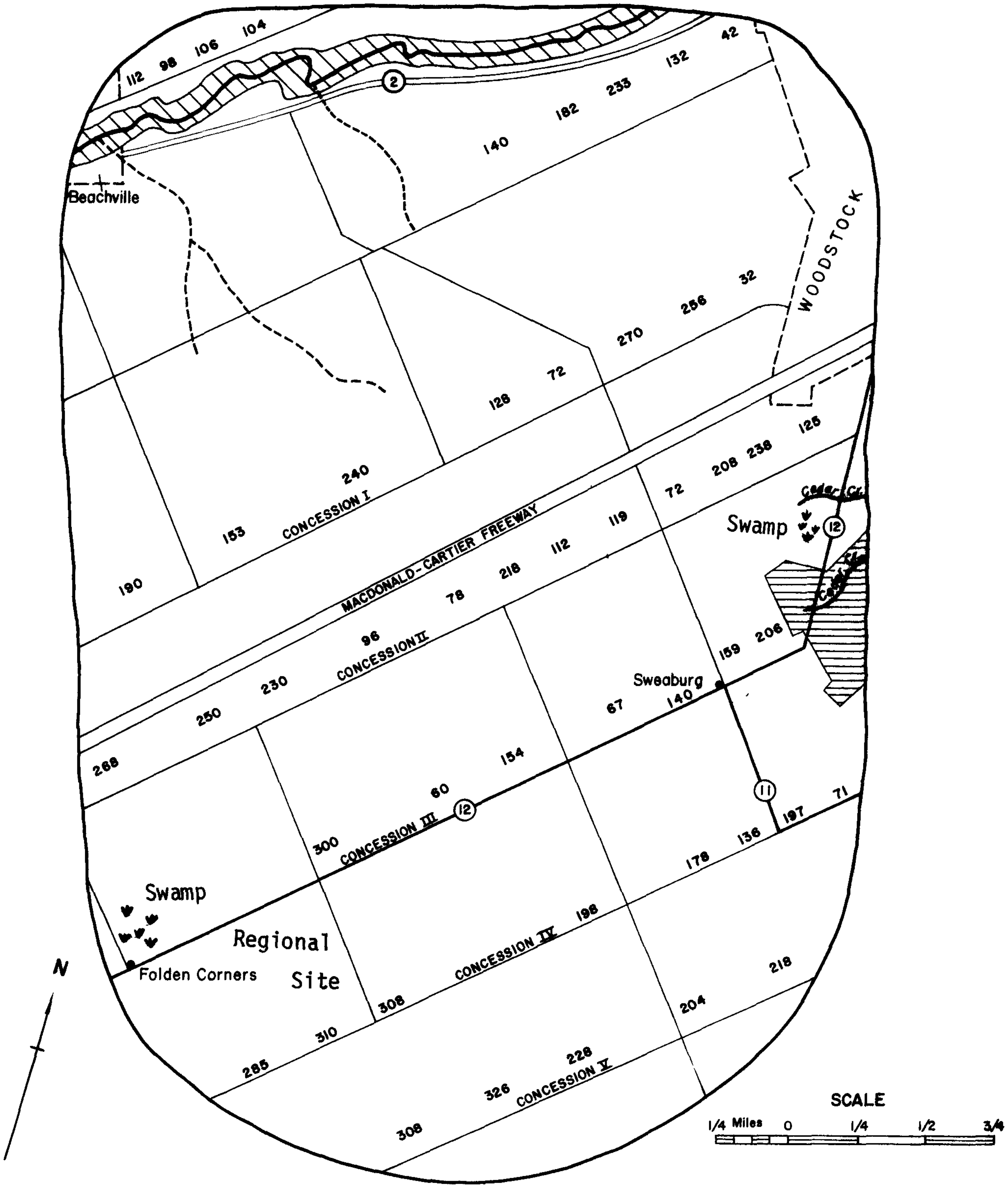
[1] Ontario Department of Agriculture, Soil Survey of Oxford County, Toronto, 1961, p. 45.

water table, and availability of cover material. The area defined as being relatively more suitable in terms of location, was assessed in terms of each of the pertinent requirements from the Waste Management Act.

Highway Network

The area where the number of ton miles is minimized is well served by major highways and county roads (Map 7). The Macdonald-Cartier Freeway, the major arterial route in the county, crosses the area of maximum suitability from the northeast to the southwest. This route serves primarily as an intraprovincial roadway connecting points in Southern Ontario. This is not to say that it does not serve some function on a micro or county level, only that this function is secondary to its intraprovincial function. As the Macdonald-Cartier Freeway does not directly connect any of the high solid-waste production areas in the county with the area of highest relative suitability, the only area that might make use of the Macdonald-Cartier Freeway Freeway as a link to the site area would be Blenheim Township located in the northeast corner of the county. For this reason, the effect of the Macdonald-Cartier Freeway on the final site selection was minimal.

The highway network that was most useful in connecting this area of high suitability both internally and externally was made up of the following links: County Roads 6, 12, and



AREA OF MAXIMUM SUITABILITY FOR OXFORD COUNTY

LEGEND

- (2) Kings Highway
- (12) County Road
- Township Road
- 273 Water Table Level (in feet below soil surface)
- Public Utilities Commission Property
- Thames River Conservation Property

Map 7

40; and Kings Highways numbers 19, and 2 (Map 3). Together these routes served to link all areas in the county with the area named as most suitable. One exception to this as noted previously, was the extreme northeast section of the county, principally Blenheim Township. As this township was the furthest removed geographically from the area under consideration, and was served directly by the Macdonald-Cartier Freeway, it was expected that this would serve as its link.

To summarize the Highway Network, most major highways and county roads were laid out in perpendicular pattern that coincided with the grid system used in the preliminary part of the site selection process. In addition, the area designated as the area of Maximum Suitability (Map 7) was well connected to all areas in the county by a road network suitable to withstand heavy traffic year round.

Drainage

The principal feature of the drainage pattern in this area was the Thames River that flows across the northwest corner in a southwesterly direction. All parts of the area under consideration drained into this river system. The area south of the Thames was served by five intermittent streams and Cedar Creek which drained a marshy area locally known as the Sweaburg Swamps. A similar marshy area was located near the community of Foldens which drained out of the area to the west, but ultimately into the Thames River. The small area north of the Thames River was served by several inconsequential intermittent streams.

Topography

The area under study was primarily a drumlin field[2] that has undergone severe modification only in the Thames River Valley. Even here the incline was never greater than 150 feet in a quarter of a mile. The remainder of the area could be classified as moderately rolling with few examples of well defined drumlines. The deviation ranged from 950 feet to 1100 feet above sea level. As mentioned previously, there were two swampy areas, one near Sweaburg and the other near Foldens.

Soils

The search for a suitable waste disposal site must consider the capabilities of the various soils in the Maximum Suitability area. Soil is a complex mass of solids, liquids and gases that combine in an infinite number of ways. The way in which they combine affects the propensity of that particular soil to encourage or discourage various biological and chemical activities that are important to the proper functioning of a sanitary landfill operation. The purpose of soil in such an operation is to house the biological and chemical breakdown of the waste, not to merely hide the waste. These breakdowns can occur with or without oxygen (aerobic or anerobic degradation) being present. It is most desirable to have oxygen present for these

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[2]Ibid, p. 44.

breakdowns. With an oxygen deficiency, many noxious intermediate products result that produce objectionable odours.[3] In conjunction with the physical property of soil, permeability is of prime importance. Permeability refers to the capacity of soil to transmit water and air. It is a major factor in the ability of aerobic degradation taking place. The degree of permeability must also be taken into consideration in conjunction with the level of the ground water table. A very permeable soil combined with a high water table level provide virtually no protection against ground water contamination. Thus an area exhibiting these characteristics would be a poor selection for a sanitary landfill site.

The area of Maximum Suitability is primarily covered in a complex soil composed of the Honeywood Series and the Guelph Series. The two swampy areas show variation from this as does the Thames River flood plain. North of this flood plain are two belts, the first is in the Fox Series and the second is in the Guelph Series. A short examination of these three soil series will help determine their individual suitability to accommodate a sanitary landfill operation.

The Honeywood-Guelph complex Series covers roughly ninety per cent of the area. It is a Grey-Brown Podzoic soil made up

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[3]Soil Properties and Processes in Relation to Waste Recycling and Disposal. Procedures of the International Conference on Land for Waste Management (Ottawa, Canada, 1973), p. 63.

of two basic soil textures, silty alluvial deposits and loam fill. The mixture is slightly stony which results in excellent drainage.[4] The excellent drainage and the existence of stony cover material from the drumlins in the area are indications that this soil type would be well able to house a Sanitary Landfill Operation.

The two marshy pockets mentioned previously are covered in soil that is classified as Muck. These largely organic deposits usually accumulate in ponds or wet undrained depressions. These areas are commercially unattractive, however, because of the extremely poor drainage they would be unsuitable to support a sanitary landfill operation without major site improvements.

The strip of Fox Series soil just north of the Thames River is also mainly associated with other glacial outwash or as lacustrine material from glacial lakes. It is much more sandy than the Honeywood-Guelph Series and thus it is considered to have great permeability. The sandy nature of this soil makes it a fine soil for the growing of tobacco, the most valuable per acre cash crop in the county. The suitability of locating a sanitary landfill operation on this strip of Fox Series soil would have to be questioned for several reasons. The extremely sandy nature of the soil does not lend itself

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[4]Ibid p. 44

to physically supporting a landfill operation. A further disadvantage to the sandy nature of the soil would be its extreme permeability. This coupled with the location so close to the Thames River would create a great danger of contaminating the surface drainage system.

The small area of Guelph Series soil north of the Thames River is very similar to the Honeywood-Guelph soil. The major difference lies in the fact that it is more uniformly stony.[5] Despite the fact that the soil in this particular area would suit a Sanitary Landfill Operation as well as the Honeywood-Guelph soil, its location on the north side of the Thames River would make it somewhat more isolated in terms of the road network described earlier, and thus less desirable.

Water Table

The previous sections have dealt with drainage and soil considerations. These factors are critical to the site selection only insofar as they are related to the ground water. When any foreign substances are dumped in large quantities on or in the soil, it is almost impossible to guarantee that contaminants will not result. Some of these contaminants often do survive their passage through the unsaturated zone above the water table. This amount varies with the soil permeability, the depth of the unsaturated zone, the amount of precipitation and

[5] Ibid p. 24.

the amount and type of waste being disposed. In most cases, solid waste disposal sites should be located where the ground water table is at least ten feet below the land surface.[6] Normally, the figure of ten feet should be adjusted in accordance with those factors just mentioned, however, the water table is generally well buried throughout the area under consideration.

The water table of the area under consideration in Oxford County was studied from data accumulated from well logs provided by the Ministry of the Environment. A well log is a record of pertinent information concerning the types and levels of various soil stratification, water tables and bedrock encountered each time a well is drilled. In a rural area such as that currently under investigation, wells are numerous, providing a reasonable indication of the actual water table level. It must be noted that water table levels fluctuate with the seasons, as well as from year to year. Ideally, the maximum elevation of groundwater, should be used, however, this information is not available through the well logs. In most of the area under consideration, the seasonal fluctuation would not be a critical factor because of the extreme water table depth which varies between 20 feet and 310 feet. A definite pattern was difficult to perceive (Map No. 7), however, the water table

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[6] C. W. Westlund, "Geologic Factors in Land Waste Disposal", Proceedings of the International Conference on Land for Waste Management, Ottawa, 1973, p. 127.

was found to be generally further from the surface toward the western part of the area under consideration. The depth of the water table varies conditional upon a great many factors including the topography. As the ground surface is mainly a drumlinized plain, the water table undulates in response to these surface irregularities. It should be noted that few locations within the area under study would be unsuitable for a sanitary landfill site for reasons of water table proximity.

Site Selection

The site selection process will propose the exact site, and land requirement for the establishment of a regional sanitary landfill site to serve the needs of Oxford County to the year 1991.

Oxford County produced 63,256 tons of solid waste in 1971, and will produce 115,150 tons on a yearly basis by 1991 (Table 3). The projected yearly production figure for 1981 of 86,740 tons, provides an average yearly production figure for the period 1971-1991.

The height and depth of the landfill site must be established in order to predict accurately the amount of land required for the landfill site. As these dimensions increase, the total land area required would decrease (Table 4).

As previously discussed, much of the area defined as the Area of Maximum Suitability, has a very deep water table. For this reason most of the area could accept an excavation to a depth of eight feet for cell construction.

The next question is centered for the most part around aesthetics. It involves the finished height of the landfill site above ground level. It is not desirable to draw attention to the site by having an excessive rise in height unless the height is necessary for a future specific purpose. A rise of ten feet would blend in with the local topography and provide a reasonable surface to convert into a useful purpose at a future time. Assuming an excavation depth of eight feet and a finished rise of ten feet, ninety-five acres will be required to dispose of 25,000 tons of waste yearly for a twenty year period (Table 4). Oxford County will produce a yearly average of 86,740 tons of solid waste for the twenty year period leading up to 1991.

On this basis, a land requirement of 350 acres should be adequate to dispose of the Oxford's waste to 1991.

The selection of the actual site within the area of maximum suitability is largely an exercise in elimination, based on physical criteria outlined previously. Areas in or close to urbanized areas such as Woodstock and Beachville are less desirable. Much of the remaining area north of the Macdonald-Cartier Freeway drains directly into the Thames River, or the land is accessible only by Township roads. The area immediately south of the Macdonald-Cartier Freeway loses a great deal of its appeal also because of its inaccessibility.

The swampy areas at the extreme ends of County Road 12 are unacceptable because of the great danger of polluting the surface drainage system. The area southeast of Concession 4 would require major roadbed reconstruction and resurfacing in order to accommodate the flow of heavy trucks that will be generated by the landfill operation. The area that remains abuts County Road 12 thus having access to the extreme northwest and southern part of the County along County Road 19 (Map 3). The actual site selected is located in West Oxford Township Concession Road 4 Lot 10. The site is currently part agricultural and part woodlot. Access is achieved either directly from County Road 12, or from an abutting township road. The water table is located more than 300 feet underground, one of the lowest measurements in the area. Due to the rolling nature of the site, cover material is close at hand. The irregular topography will also assist in camouflaging the site from public view, both during and after the active life of the site.

CHAPTER VI

Conclusions

The intent of this thesis was to develop the basic framework for a regional approach to solid waste management. For the new system to be acceptable it was necessary to work within the constraints established by recent provincial government regulations. It was important to examine the disposal methods that operated within the county to determine if there were any components in the existing system that could be incorporated into the new system.

A series of projections were completed as part of the study to provide information on the 1991 population of Oxford County. It was necessary to have population projections as well as projections on the expected yearly production of solid waste in order to choose a disposal method with enough capacity to meet the need of that future population.

A variety of solid waste disposal methods are operating successfully today. It was necessary to examine the most common of these disposal methods, to determine which of them might operate successfully in Oxford County. It was determined that Sanitary Landfill would best fulfill the needs of the county for the next twenty years. This method has a major advantage over most others examined, because it does not require a great capital expenditure, and it provides flexibility to make use of technological innovations should they be developed within the twenty-year period being planned for.

The survey of the existinq facilities, projections, and the examination of the various disposal methods could be considered as background information that was necessary in order to work toward a solution that will serve Oxford's needs while complying with ministry regulations.

In order to minimize the ton miles travelled to haul the yearly production of solid waste for Oxford County a model was developed that defined the area where the ton miles travelled were minimized. This was established by covering the county with a grid system that included over 900 vertices. For each of these verticies a series of calculations were performed using grid distance and the amount of solid waste produced in each of eighteen municipalities to arrive at a suitability index. This index number provided a relative indication of the suitability of each point based on the ton miles necessary to haul all solid waste produced in the county during a one year period, to that particular point.

An isoline map was constructed to provide a clear indication of the zones of relative suitability. An area of maximum suitability was defined rather than a sinqle point for several reasons. Physical considerations as defined by the Ministry of the Environment were not considered in defininq the zones of relative suitability, but were taken into consideration during the final site selection process. The fact that an area of maximum relative suitability was defined by the methodology provided enough scope for a site to be chosen that was well within the physical requirements established by the Ministry of the Environment.

The primary value in the model is that it extends the concepts developed by Clark and Helms mentioned in Chapter 1, where by a large number of sites can be evaluated. The results of this evaluation indicate the relative acceptability of these sites defined by nodes in a grid system superimposed over the region.

Implementation: Although it was not intended that the implementation of a regional solid waste management system would be part of this study, it would be a logical next step.

Municipal co-operation would be the key to the successful establishment of a regional solid waste system, and it could serve as a model to be followed by other essential services that currently exist on a municipal level that might better be handled on a regional basis.

The improved waste management system that would be made possible by a regional approach would cost more than the current disposal method. For this reason, an extensive public information system should be implemented before the development of a solid waste management system. Taxpayers need assurance that higher costs mean great environmental protection.

Appendix I

STANDARDS FOR WASTE DISPOSALS SITES[1]

A. (1) The following are prescribed as standards for the location, maintenance and operation of a landfilling site that are to be met to the satisfaction of the Minister by an applicant for a certificate of approval therefor:

1. Access roads and on-site roads shall be provided so that vechicles hauling waste to and on the site may travel readily on any day under all normal weather conditions.

2. Access to the site shall be limited to such times as an attendent is on duty and the site shall be restricted to use by persons authorized to deposit waste in the fill area.

3. Drainage passing over or through the site shall not adversely affect adjoining property and natural drainage shall not be obstructed.

4. Drainage that may cause pollution shall not, without adequate treatment, be discharged into watercourses.

5. Waste shall be placed sufficiently above or isolated from the maximum water table at the site in such manner that impairment of groundwater in aquifers is prevented and sufficiently distant from sources of potable water supplies so as to prevent contamination

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[1]Ministry of the Environment for the Province of Ontario, The Waste Management Act, 1970, Queens Printer and Publisher, Toronto, 1970.

of the water, unless adequate provision is made for the collection and treatment of leachate.

6. Where required by the Minister, adequate measures to prevent water pollution shall be taken by the construction of berms and dykes of low permeability to isolate the site and effectively prevent the the egress of pollutants.

7. Where required by the Minister, samples shall be taken and tests made to measure the extent of egress of pollutants and such measures as are required by the Minister shall be taken for the collection and treatment of pollutants and for the prevention of water pollution.

8. The site shall be located a reasonable distance from any cemetary.

9. Adequate and proper equipment shall be provided for the compaction of waste into cells and the covering of the cells with cover material.

10. Where climatic conditions may prevent the use of the site at all times, provision shall be made for another waste disposal site which can be used during such periods.

11. Where required for accurate determination of input of all wastes by weight, scales shall be provided at the

site or shall be readily available for use.

12. All waste disposal operations at the site shall be adequately and continually supervised.

13. Waste shall be deposited in an orderly manner in the fill area, compacted adequately, and covered by cover material by a proper landfilling operation.

14. Procedures shall be established for the control of rodents or other animals and insects at the site.

15. Procedures shall be estalbished, signs posted and safeguards maintained for the prevention of accidents at the site.

16. The wast disposal area shall be enclosed to prevent entry by unauthorized persons and access to the property shall be by roadway closed by a gate capable of being locked.

17. A green belt or neutral zone shall be provided around the site and the site shall be adequately screened from public view.

18. Whenever any part of a fill area has reached its limit of fill, a final cover of cover material shall be placed on the completed fill and such cover shall be inspected at regular intervals over the next ensuing period of two years and where necessary action

shall be taken to maintain the integrity and continuity of the cover materials.

19. Scavenging shall not be permitted.

(2) A certificate of approval for a landfilling site is subject to the condition that the site shall continue to be maintained and operated in accordance with the standards approved therefor.

B. (1) The following are prescribed as standards for the location, maintenance and operation of an incineration site that are to be met to the satisfaction of the Minister by an applicant for a certificate of approval therefor:

1. The location of the incineration site shall be selected so as to reduce the effects of nuisances, such as dust, noise and traffic.

2. Incinerator waste shall be disposed of at a landfilling site.

3. The incinerator shall be located

   (a) so that it is accessible for the transportation of wastes thereto without nuisance;

   (b) taking into account meteorological considerations to minimize environmental effects; and

   (c) so that the services and utilities required for the operation of the incinerator are available, including facilities for the disposal of residue and of quenching and scrubbing water.

4. The design and capacity of the incinerator shall be in accordance with accepted engineering practices and of a type and size adequate to efficiently process the quantities of waste that may be expected, so that a minimum volume of residue is obtained, the putrescible materials remaining as residue are reduced to a minimum and a minimum of air pollution results.

5. The following equipment shall be provided as required for particular applications to the satisfaction of the Minister:

   (i) Scales for the accurate determination of the input of all wastes by weight.

   (ii) A storage pit or other storage facilities.

   (iii) A crane or other means of removing waste from the pit or other storage facilities.

   (iv) Means of controlling dusts and odours.

   (v) Such instruments as may be necessary for the efficient operation of an incinerator.

6. The incineration site shall include an unloading area

properly enclosed and of sufficient size for the intended operation.

7. Access roads shall be provided for vehicles hauling waste to the incineration site.

8. On-site fire protection shall be provided and, where possible, arrangements shall be made with a fire department or municipality for adequate fire fighting services in case of an emergency.

9. Scavenging shall not be permitted.

(2) A certificate of approval for an incineration site is subject to the condition that the site shall continue to be maintained and operated in accordance with the standards approved therefor.

C. (1) The following are prescribed as the standards for the location, maintenance and operation of a dump that are to be met to the satisfaction of the Minister by an applicant for a certificate of approval therefor:

1. The fill area shall not be subject to flooding and shall be so located that no direct drainage leads to a watercourse.

2. The site shall be at least two hundred yards from the nearest public road.

3. The site shall be at least one-quarter of a mile from the nearest dwelling.

4. The site shall be at least 100 feet from any watercourse, lake or pond.

5. The site shall not be on land cover by water.

6. Signs shall be posted stating requirements for the operation of the dump, including measures for the control of vermin and insect infestation.

7. The site shall be so located and operated as to reduce to a minimum the hazards resulting from fire.

8. The operator of the dump shall apply such cover material at such intervals as the Medical Officer of Health may direct.

9. Scavenging shall not be permitted.

(2) A certificate of approval for a dump is subject to the condition that the dump shall continue to be maintained and operated in accordance with the standards approved therefor.

Appendix II

OXFORD AREA WASTE MANAGEMENT STUDY[1]

INDUSTRIAL SOLID WASTE
SURVEY

(1) Name of Establishment:

(2) Address:

(3) Type of Business:

(4) Name of person to contact in the event that additional information is required:

Name:

Position:

Address:

Telephone No.:

(5) Brief description of the type or types of SOLID WASTE DISPOSED of (if any).

(6) Approximate the quanity of each type of solid waste disposed (i.e., tons/month, yards/month, etc.).

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[1]Brian Turnbull and Associates, Oxford Area Waste Management Study: Report and Recommendations, Kitchener, 1973.

(7) Describe current method of collection and disposal of above waste:

(a) wastes hauled by firm.

(b) wastes collected by contractor.

(c) If neither of the above methods are used, please explain.

(d) How & where are the wastes disposed; i.e., sanitary landfill in Woodstock?

(8) Is there a seasonal fluctuation in the waste generation and , if yes, please explain.

(9) If you have any questions or would like to give specific information difficult to fit into this form, please check this space and we will contact you. (___)

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