A FEASIBILITY STUDY OF TWO ALTERNATIVE WASTE MANAGEMENT SYSTEMS FOR REMOTE NORTHERN COMMUNITIES

BY

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ABSTRACT

An important factor for upgrading the standard of living for residents of remote northern communities is the improvement of service provided by waste management systems. Often the climatic, hydrologic and pedalogic conditions, as well as traditional settlement patterns, tend to preclude the use of systems conventionally used in more southerly latitudes. Thus provision of sewer and water services in the north requires innovative thinking and flexibility of approach to suit the needs of the particular community.

This practicum examines the feasibility of two such innovative systems for remote northern communities - household composting units and sewage ejectors. The paper investigates the feasibility of the two alternative systems using technical, economic, social and administrative criteria.

One of the conclusions which can be drawn from this study is that the technical problems associated with the two systems are limited and solvable. Another is that the proposed systems are economically competitive with satisfactory conventional systems under some circumstances, particularly for communities with a population below 500 - 700. The sociological problems of possible misuse and local unacceptability could be alleviated by educational programs.

Each of the two alternative systems studied in this practicum have different limitations and are therefore most useful under different sets of circumstances. Even though their uses are limited, these systems could increase the number of options for waste management systems available to isolated residents and communities in the north. The systems may also be viable alternatives for seasonal operations such as fishing camps, hunting lodges and fly-in resorts.

Increasing the number of feasible waste management options available for each specific site will increase the prospects for success of a comprehensive waste management program for Northern Manitoba as a whole. A greater diversity of systems will also contribute to knowledge of factors affecting waste management in the north.

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Finally, I would like to thank Ms. Joan Peterson for the editing and Mrs. Rose-Marie Sachse for typing this practicum.

CHAPTER I

INTRODUCTION

Waste Management

One of the policy objectives stated by the Government of Manitoba in its report, Guidelines for the Seventies, is the upgrading of the living conditions of residents of northern communities.[1] Generally, these communities are small, isolated and without a substantial tax base. An important factor for upgrading the standard of living within these communities is improvement in the level of service of water supply and waste management.

Waste management systems may be thought of as having several components which are shown in Figure 1. Each of these components has been divided into solid waste (garbage) and sewage (human waste as well as wastewater which is bathwater and water from sinks). This paper will only be concerned with the problems associated with the sewage aspect of waste management.

It should be noted that segregation of the components or functions into different divisions is not distinct for there are systems in which two functions may be accomplished at one time.

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1. See Guidelines for the Seventies, Vol. 3, p. 53: "Northern resources must be developed in ways which will result in optimum benefits for all Manitobans, especially those resident in the north. The quality of life of northerners must be the first concern."

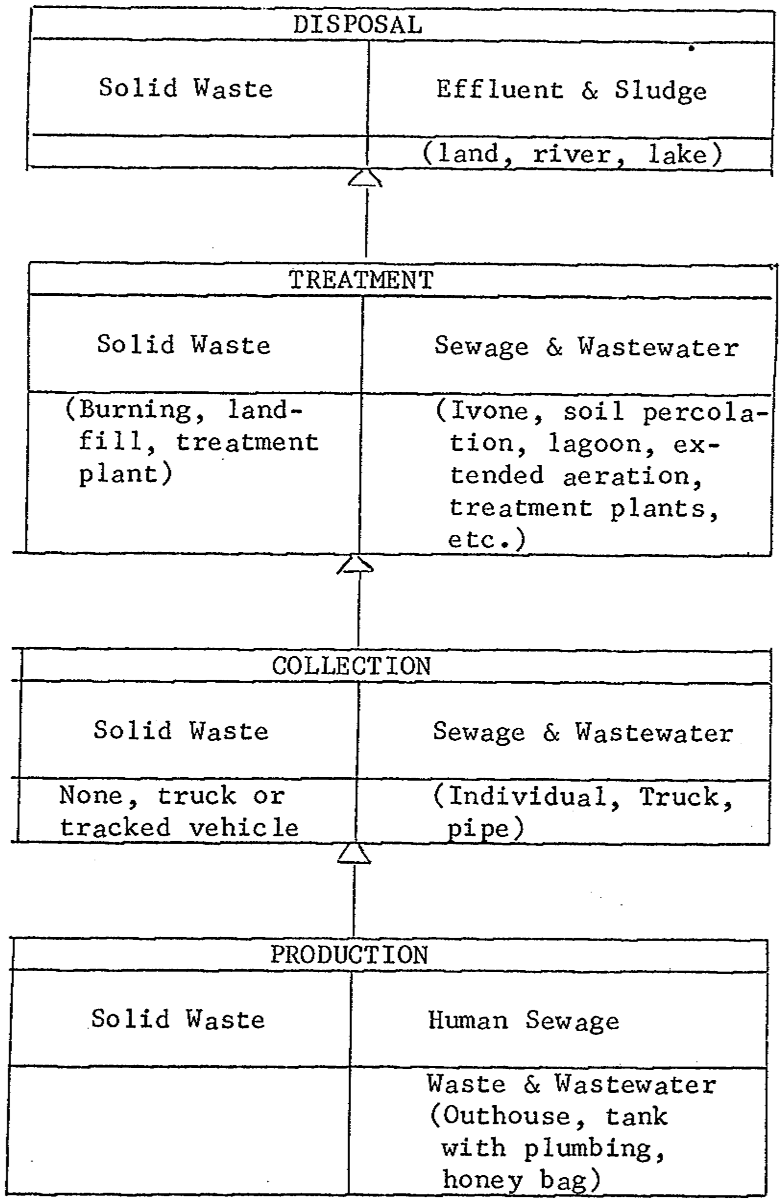

Figure 1

Components of Waste Management Systems*

*Adapted from D.J. Gamble and C.T. Janssen. "Evaluating Alternative Levels of Water and Sanitation Services for Communities in Northwest Territories." 1974.

A septic tank, for instance, not only serves as a collection device but also affords a degree of treatment. Similarly, treatment is afforded after the effluent is discharged to the land or watercourse by indigenous microorganisms and, to a more limited extent, within collection pipes.

Treatment of wastewater and sewage consists of the removal of water through evaporation, percolation, and evapotranspiration, then the break-down of organic material into simple compounds which can be utilized as nutrients by microscopic organisms. Often, mid-latitude technology does not afford effective treatment in the north because of climatic, geologic, hydrologic, and social conditions.

Objectives for the Improvement of Waste Management in the North

The inferiority of many existing northern Manitoba sanitation and water supply systems and food storage facilities is manifested in the health statistics of the region. One objective for the improvement of waste management services in northern Manitoba should therefore be to improve the quality of health in this area. Table 1[2] compares the disease types leading to hospitalization in 1973 of residents of the province as a whole,

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2. Hospital admission data was obtained from the Health Services Commission, 1973.

the northern region[3], the unorganized territories and members of Indian Bands of the northern region.

TABLE 1

HOSPITAL ADMISSIONS PER 1,000 POPULATION

	Salmonella infections other than Typhoid or Paratyphoid	Bacillary dysentery	Food Poisoning	Enteritis	Unspecified dysentery or diarrhea
Province	.017	.106	.03	.21	4.60
Northern region	-	.156	.03	.18	10.77
Unorganized territories	-	.75	.14	.89	19.48
Indian Bands of Northern Region	.20	.40	.06	.67	18.52

The relatively high incidence of gastro-intestinal disease in the north as compared to the province as a whole demonstrates a need for better sanitary practices and services within the northern region. However, the proper treatment of sewage and wastewater is only one aspect of sanitation which would affect the health of the community. Improper handling and storage of food as well as overall cleanliness may also lead to incidences of enteric disease.

[3] The statistics for the northern region are an average of rate/1000 population for the Local Government Districts of Churchill, Consol, Gillam, Grand Rapids, Leaf Rapids, Lynn Lake, Mystery Lake, Snow Lake, the cities of Flin Flon and Thompson, the town of The Pas and the unorganized territories.

The data above include only hospital admissions and do not take into account the probable high incidence rate of untreated gastroentritis, particularly in the remote communities or unorganized territories. The Indian Bands show the highest rates, and values of 25-30 hospital admissions related to enteric diseases are not uncommon. Health data based on cases reported to the Preventative Medical Services further illustrate the point. Although the Norman region[4] contains 7% of the population of Manitoba, more than 25% of all reported cases of gastrointestinal diseases occur there.[5] Reportable cases include typhoid fever, paratyphoid fever, other Salmonella infections not associated with food, bacillary dysentery, diarrhea of the new-born and E. COLI enteritis. In many communities, there is a risk of typhoid epidemics particularly in the spring during runoff, largely because of poor sanitation practices. The high costs of health care in the north further amplifies the need for improved sanitation and water supply facilities.

The incidence of these diseases can be further related to the mortality rate of Manitoba native people. Data collected by the Continuing Liaison Committee on Health in Indian and Metis Communities indicates that the death rates of Indians aged fifteen

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4. The Norman region encompasses the northern area of Manitoba and is used by Department of Health and Social Development.

5. "Summary of Communicable Diseases," Department of Health and Social Development, Province of Manitoba, 1974.

and under is more than twice that of non-Indians in the same age group.[6] This age factor becomes more significant when it is noted that in the age distribution of Indian people, 51% of the population is less than 15 years of age, whereas only 27% of the non-Indian population falls within this age group. Although these figures cannot be related directly to sanitation problems in the north, poor sanitation is regarded as one of the most significant factors resulting in high mortality rates among the young in the Indian population of Manitoba.

Another objective for waste management systems is to improve the aesthetics and convenience of toilets in the north. By southern standards, the present systems (primarily outhouses) in use in the remote communities are inconvenient or uncomfortable, especially during the winter months. Residents of these communities have expressed a need for more modern, convenient systems.[7] The rapid increase of communications and transportation services has

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6. Continuing Liaison Committee on Health, "Health Status of Manitoba Native People," Jan. 1975.

7. Northern Association of Community Councils. Western Region Conference and Annual General Conference 1974. Resolutions were passed for N.A.C.C. to approach government agencies and departments to improve water and sewage systems for the communities of Duck Bay, Crane River, Mallard, Pikwitonei and Thicket Portage.

led to an increased awareness in the north of technical amenities such as more convenient sanitation systems.

Although the main thrust of improved waste management in the north is to improve the health and standard of living, ecological considerations are also important. In many systems, the emphasis is on minimum environmental damage. However, through efficient recycling of organic "waste" materials and sewage-borne nutrients, positive environmental impacts could occur. Reduced fertilizer and water treatment costs are examples of positive environmental effects. Over the past few years, there has been an increasing interest in "soft technology"[8] or technologies which stress positive environmental effects, low energy consumption, fresh-water saving and the maintenance of natural and cultural diversity. Interest in these considerations has been expressed in Manitoba by the Department of Northern Affairs and such agencies as the Manitoba Housing and Renewal Corporation.

These three objectives of improving health, providing more aesthetic and convenient systems and decreasing adverse environmental effects must be considered in the decision to provide either conventional or innovative systems for remote northern communities.

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8. [illegible] Milton, "Communities That Seek Peace with Nature," The [illegible]ist, Dec. 1974.

Conventional Systems

There are 69 communities under the jurisdiction of the Department of Northern Affairs which have populations varying between 15 and 1,288. The present level of service for these communities is given in APPENDIX I.[9] There are at least six conventional methods either in operation, or under consideration for use in remote communities. Of these, four are individual systems capable of servicing one household, and two are community systems which can service the majority of homes in a community. Based on the data collected by I. Gillies, community systems seem to be economically feasible only for communities with a population over 600-700. Costs for these systems are given in APPENDIX III. The systems presently in use or under consideration are listed below:

1. Individual Systems

   a) The outhouse/pit privy is the most common treatment mode presently in use in remote northern communities. Where proper soil conditions occur (thick, moderately permeable soils), the treatment level is high. However, in many cases where

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9. This data has been obtained from an unpublished paper entitled "Materials for a Sewer and Water Policy," written by Ian Gillies in 1974 while associated with the Manitoba Department of Northern Affairs.

little overburden or less compacted soils occur, they drain into lakes, rivers or streams. Outhouses are also cold in the winter, as well as being inconvenient, and the social acceptability of this method of treatment is rapidly declining. Many communities serviced by outhouses have requested a higher level of service.[10] The cost of an outhouse is approximately $250.00.[11]

b) Septic tanks and fields are another system presently in use in residences and such places as schools, nursing stations, stores and Band halls in northern Manitoba. The system is composed of an in-house flush toilet which empties into a two-chambered holding tank. The watertight holding tank has a capacity to retain floating and settled solids, producing an anaerobic effluent. This effluent is then periodically pumped to either a sub-surface tile field or a Nodak field. These two fields are explained in more detail below.

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10. Northern Association of Community Councils, Op. Cit.

11. This figure is based on those used by the Water Resources Branch in "Outline of Costs for Sewer and Water Service for Northern Communities."

1) The sub-surface tile field consists of a system of narrow trenches which allows the water to percolate through the gravel back-fill soil.[12] Breakdown of the organic material is effected by aerobic facilitative and anaerobic soil bacteria. Failure of sub-surface percolation fields occurs frequently, usually as a result of anaerobic clogging of the soil systems in the side and bottom of the trenches.[13] The system will also fail if overloading results in a significant reduction of the aerobic surface in the trenches or if the lines freeze. One adaption which has been used to alleviate the problem of freezing is a syphoning septic tank. However, it has been shown that 70% of the syphon-type septic tanks found in Manitoba do not operate correctly.[14]

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12. P.H. McGauhy, "Septic Tank Usage and Their Effects on the Environment: State of the Art Review," Sanitary Engineering Research Laboratory, University of California.

13. Anon, "Causes and Prevention of Failure of Septic Tank Percolation Systems", Sanitary Engineering Research Laboratory, University of California.

14. J. Cousins, "Failure of Syphon-Type Septic Tanks", Manitoba Department of Agriculture, 1973.

2) Where soil of low permeability or hard surficial deposits occur, a Nodak field or mound system is often used. The field is enclosed in an above-surface gravel mound, sealed with clay to prevent lateral flow and seeded with water-tolerant grasses to evapotranspire the water. This system also relies on soil bacteria to break down the organic material. Limited success in northern Manitoba has been realized because of freezing and breaks occurring in the lines.[15] If the system freezes, it becomes unusable until it can be repaired in the spring. Research into such improvements as the proper regulation of flow may make the Nodak or subsurface trenched fields viable alternatives in the north.

Estimates of capital costs for the installed tank and field fall between $2,000 - $2,500 with the most probable value being near $2,400. An additional $500 for the construction of facilities brings the total to $2,900. Further cost information is given in APPENDIX III.

15. Personal communication with Mr. D. Berg, Frontier School Division.

c) Another individual system which is occasionally found in remote communities is the chemical toilet. There are several variations of chemical toilets available from commercial outlets. The least convenient are generally the least expensive. An example of this type of system is the Pot-pourri type of toilet. In this system, there is a five gallon disposable receptacle for the sewage which is chemically-treated to mask the odours. The system has the advantages of being a low water user and being portable. The safe and efficient disposal of the filled receptacles is a problem, and dangers may exist if the containers are improperly handled. There is no provision in this system for the disposal of "gray-water", that is, bathwater and washwater. The cost for the toilet itself is about $80.00. An installed toilet of this type in a remote community would likely cost about $180.00. Operating costs are high due to the costs of the chemicals which must be added. A 16 oz. container presently costs $1.99. Two or more containers would be required per week. If $5.00 is the weekly cost for chemicals, the annual cost is $260.00.

A more convenient type of chemical toilet would store the liquid and solid waste in a permanent holding tank. This would not entail a weekly disposal problem, but would require the addition of chemicals with each use. It is purported by the manufacturers that the chemicals break down the solids to a liquid form and control odour. The estimated cost of this system is about $380.00 but chemical costs are high at $15.00 per week.[16] Because of the inconvenience and possible safety hazard of the first system and the high costs of the second, chemical toilets are not considered suitable for remote communities.

d) A final type of individual collection and disposal system is the combustion toilet. This system incinerates the solid and liquid wastes using fossil fuels (usually propane) as an energy source. Gaseous by-products are vented to the atmosphere. There is no liquid effluent and no water is used. However, again there is no provision for the disposal of gray-water. Also odours have created dissatisfaction with the system in many instances. These odours have been particularly noted outside of the building.

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16. "Proposed Water and Sewer services for the Community of Moose Lake," Water Resources Branch, Province of Manitoba, 1974.

Combustion toilets in Manitoba are presently used only in non-permanent dwellings such as summer cottages. Doubts have been expressed whether the system would handle peak loads (such as in the morning) adequately and whether the burn cycle could be controlled to destroy all the material if the system were to be used repeatedly.[17] The costs for this system including a vent pipe and a propane bottle are estimated to be $1,140.[18]

2. Community Systems

For the remote communities with a population over 700, community collection and treatment facilities may be feasible in many cases. There are two options for collection systems: the use of either a vehicle or a pipe. Once collected, the waste may be treated either in a lagoon or at a treatment plant. An in-depth discussion of the processes involved in lagoon operation and treatment plants would be complex and is beyond the scope of this practicum. However, both processes utilize microbial degradation to break down the complex organic

17. Personal communication with Mr. Gordon Swain, Co-ordinator of Program Planning to Water Resources Branch.

18. Water Resources Branch.

material found in the sewage to more simple compounds which can be utilized in the metabolism of the micro-organisms. The lagoon accomplishes this in an aquatic medium whereas the treatment plant uses soil micro-organisms. The costs of treatment by either of these two methods is competitive in most cases at about $75,000 for a community of about 500 people.[19] The selection of one of the two treatment methods will depend largely on the topography of the community.

If the vehicular collection method is used, the waste is removed from large holding tanks of various capacities located at the homes and transported by truck to the lagoon or treatment plant. Tracked vehicles may be used, thus obviating the necessity for a road network. Breakdowns in trucks and tracked vehicles will have serious consequences on the community sanitation system. The costs of truck collection systems estimated for 52 northern communities[20] range from $177,000 -$380,000 with a mean of $241,500. This corresponds to an average capital cost per household of $2,173. In considering an

19. "Sewer and Water Services for Northern Communities: Cost Estimates," Water Resources Branch, 1973; "Proposed Water and Sewer Services for the Community of Moose Lake," 1974.

20. Gilles, Op. Cit.

average cost, it is important to note that the cost/household for each community will vary greatly, being lower for communities with a large population and higher for communities with small populations. The average cost figure is useful only for illustrative purposes. The average operating cost for a truck collection system is about $56,000 or $500 per household/year. The inside facilities would add about $500 /household to the capital cost.

The other conventional community collection system is the sub-surface piped system. This system is presently in use in some of the largest northern communities such as a portion of the town of Wabowden. This type of system, using either conventional concrete or ductile iron pipe, provides a high level of service. The waste is pumped year-round through the pipe to the lagoon or treatment plant. The costs will vary greatly depending on the population of the community, density within the community, location and topography. To prevent freezing, the pipe should be buried at least 15 feet or wrapped with heat tape. Heat tape contains an electricity-conducting wire. When current is passed through the wire, enough heat is generated to keep the pipe warm. Both propositions are costly. Estimates of capital costs for sub-surface piped systems in remote northern Manitoba communities range from $180,000 - $4,025,000 with a mean value of $632,000 or $5,688 /household. The average operating cost for a community system is about $9,500 or $85 /household/year.[21] The costs of sub-surface piped systems make them feasible only for communities of about 1,000 population.[22] For communities with a small but growing population, a truck or piped system is appropriate since the marginal cost of adding one additional home to the system is quite small. Both systems are well-suited to new sub-divisions where homes are built closer together than in older spatial arrangements. Both systems can be designed to handle the gray-water produced in the residences.

Constraints Affecting the Use of Waste Management Systems in Remote Northern Communities

There are many features of these remote communities which constrain the use of conventional systems in the north. Environmental, technical, economic, social and administrative factors in these communities create unique difficulties which often cannot be solved using the technology available in southern Manitoba. Conditions which can be found in northern Manitoba are similar to those found in many other parts of Northern Canada.

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21. Ibid.

22. Ibid. Conclusion drawn from figures contained in this unpublished report.

The constraints operating in northern Manitoba which will affect the use of various waste management systems are as follows:

1. Climatic Conditions:

Climatic conditions tend to preclude the use of conventional systems such as septic tanks and fields, lagoons and oxidation ditches, although these systems are used in some cases with varying degrees of success. Low temperatures can result in technical problems such as pipes freezing.

In the following table[23] climatic conditions of selected northern communities are compared with those of Winnipeg:

TABLE 2

COMPARISON OF CLIMATIC CONDITIONS IN WINNIPEG AND SELECTED NORTHERN COMMUNITIES

	Churchill	Brochet	Norway House	Winnipeg
Latitude	58° 45'	57° 53'	53° 59'	49° 54'
Elevation (ft. a.s.L.)	115	1150	712	786
Mean daily temp. (°F) °C	- 7.3 (18.9)	- 5.2 (22.7)	- 2.0 (28.5)	2.4 (36.2)
Mean maximum temperature °C (°F)	- 3.3 (26.1)	- 0.1 (31.7)	4.2 (39.5)	7.8 (46.0)
Mean minimum temperature °C (°F)	-11.4 (11.7)	-10.3 (13.6)	- 8.1 (17.5)	- 3.2 (26.3)

(cont'd)

23. This data is obtained from "Temperature and Precipitation - Prairie Provinces, 1941-1970", Environment Canada Atmospheric Environment.

TABLE 2 (cont'd)

	Churchill	Brochet	Norway House	Winnipeg
No. of days with frost	255	234	223	205
Mean precip- itation	15.61	16.78	18.06	18.39

Low temperatures over a prolonged period of time reduce the length of the treatment season, cause the freezing of lagoons to a depth greater than in more southerly locations and can cause damage to treatment machinery. The freezing of sub-surface trenched fields or Nodak fields and breaks in the lines can also be attributed to low temperatures. This is most likely to occur when the system is used intermittently as is the case when the system serves a school.[24] Frost heaving may also cause lines to break as it may cause uneven flow distribution throughout the field, resulting in hydrologic overloading in places. In cold climates, pipes serving either a community or an individual home must be buried more deeply to prevent freezing, thereby increasing costs. Another option is to wrap the lines in heat tape which uses electrical current to warm the lines sufficiently to prevent freezing. This method would also substantially increase both the capital and operating costs.

24. Personal Communication with Mr. Berg, Frontier School Division.

2. Permafrost:

Many of the communities in northern Manitoba are in the zone of discontinuous permafrost. (See Fig. 7, p. 49). Adaptation to permafrost conditions would increase the costs of laying pipe and other associated construction activities.

3. Hydrologic and Pedalogic Features:

Northern communities differ markedly from one another and from most southern communities in their geologic, hydrologic and pedalogic features. The Precambrian and northern Paleozoic areas of the province are characterized by little overburden, and numerous rock outcrops occur.[25] The costs of trenching for laying pipes are increased in areas where rock outcrops occur. Rugged terrain as well as numerous wetland and marshy areas tend to preclude the use of vehicular pump-out services and sub-surface sewer systems.

4. Ground Water Conditions:

In many of the northern regions, there is either no ground water potential or shallow aquifers which are easily contaminated. Many of these aquifers are quite saline with high levels of total dissolved solids.[26] The possibility

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25. Geological Map of Manitoba 65-1, Mines Branch. Department of Mines, Resources and Environmental Management.

26. Memoranda from J. Little, Groundwater Technologist, Department of Mines, Resources and Environmental Management.

of contamination of aquifers is a factor to be considered in assessing the type of management system. The particular system used will also depend on the type of soil present. As thick impervious soils provide the lowest probability of aquifer contamination, areas where these soils are found can be serviced by outhouses. Sandy loam is the most suitable type of soil for treatment in the use of septic tanks and fields.

Other communities have no groundwater potential and must therefore rely on surface sources for community water supplies.[27] As populations of these communities increase, the potential for shoreline pollution will increase and will become a constraint on effluent disposal. The low mixing rate of northern waters aggravates this problem. Although public health representatives advise the boiling of drinking water or the addition of bleach, there is evidence that their advice is often unheeded.

5. Spatial Arrangements:

The typical spatial arrangements of native communities is another constraint on the feasible systems. In many remote communities, homes may follow both sides of a watercourse

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27. Ibid.

with much open space and only foot-paths between the dwellings. An example of a typical layout is shown in Figure 2. This type of layout will eliminate piping and trucking as economical disposal methods. Where new subdivisions are being constructed, the piping and trucking of sewage may yet be feasible collection methods, since the homes will be situated more closely together in orderly patterns.

6. Isolation:

Isolation is another factor which will affect the choices of available systems for the communities. Distances from communities capable of servicing these systems affect the length of time necessary to bring about repairs.

7. Economic Constraints:

Economic constraints will also play a role in the acceptability of various conventional systems. The high operating costs of chemical and combustion toilets indicate that they would be less economical than other systems. Costs for community systems vary greatly from $177,000 - $4,055,000 depending on the community.[28] Community systems seem to become less expensive than individual systems for communities with more than 600 - 700 people.[29]

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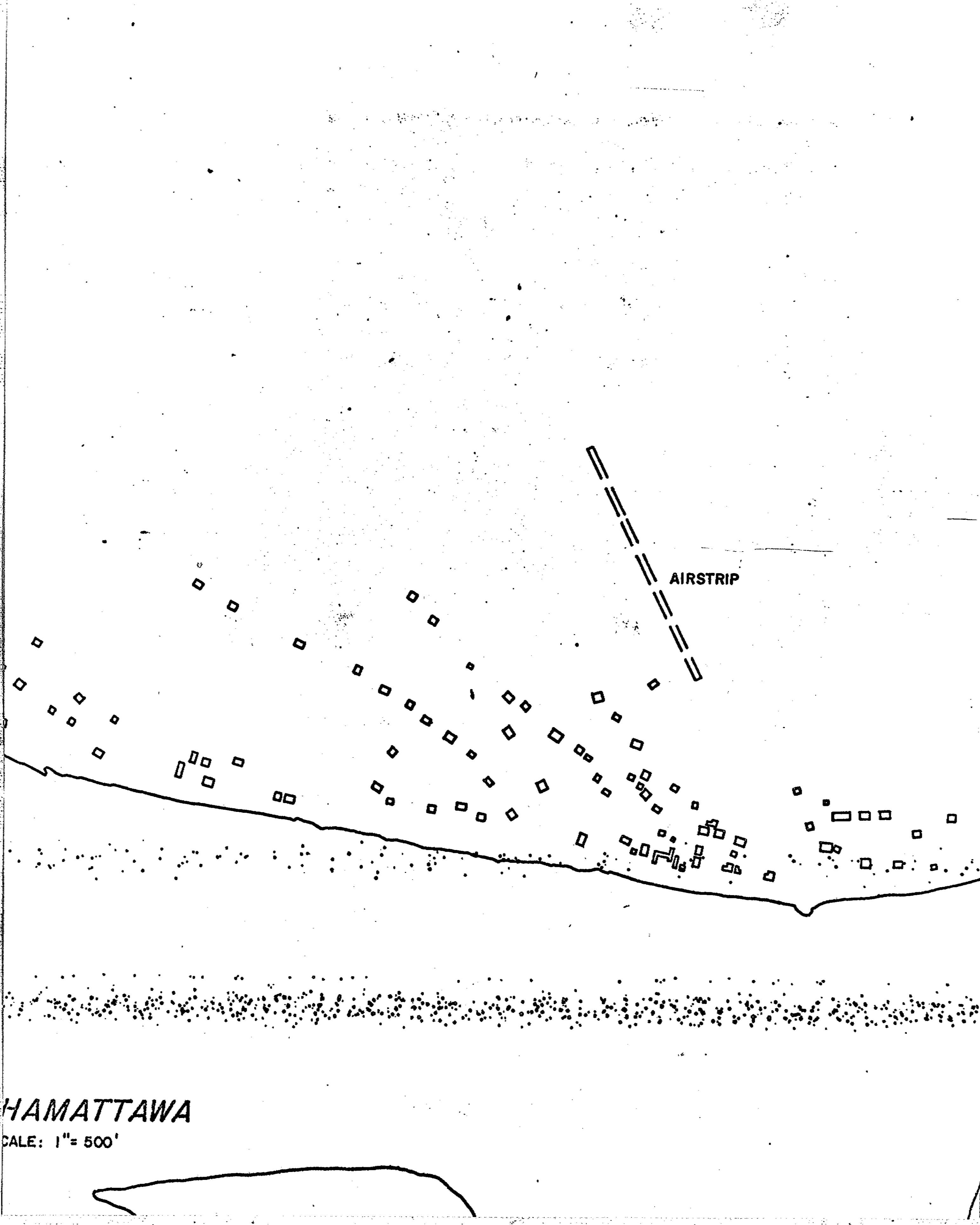
28. Gillies, Op. Cit.

29. Ibid. Based on figures contained within the report.

Figure 2

TYPICAL LINEAR SETTLEMENT PATTERN



Method and Criteria For Comparison of the Systems

Provision of sewer and water services suited to particular communities in the north requires innovative thinking and flexibility of approach. The Manitoba Department of Northern Affairs is presently conducting research into the applicability of a number of innovative systems for the remote northern communities. This practicum will examine the feasibility of two types of household systems. These are:

1. Household Composting Units:

   Two types are presently available in Canada. One is a compact electrically-assisted unit. The other is a large, unassisted, self-contained composting unit. These two systems will be analysed separately since different costs, technical concerns and social factors are involved.

2. Sewage Ejectors:

   These systems are presently in use in many areas of southern Manitoba. They operate by ejecting the liquid from a septic tank to an enclosed treed area.

   The feasibility of implementing any proposed waste management program (or almost any other program for that matter) depends upon the following criteria. Successful implementation will depend upon positive answers to these questions:

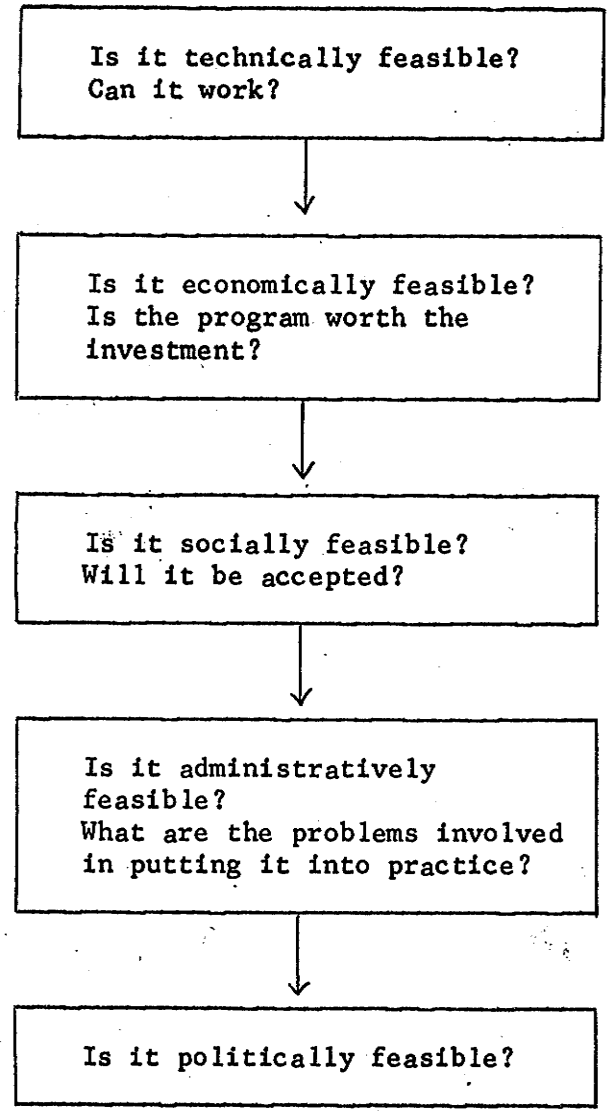


Figure 3

Criteria for Assessing Feasibility of Waste Management Systems

This approach will be applied to these options for waste management. Certainly none of the systems examined will provide total solutions to the problems of waste management in the north nor will they be suitable to all situations. However, if they prove to be feasible for certain conditions, they will increase the options available and possibly provide increased services at lower cost than conventional systems. By their implementation, the water quality, health and quality of life of some northern residents may be improved.

CHAPTER II

ALTERNATIVE SYSTEMS TO BE CONSIDERED

In view of the ineffectiveness of some conventional systems and the problems of construction and high costs of others, there is a need to explore new waste management techniques.

Composting Units

One such possible innovation is the household composting unit of which two models are presently available in Canada:

1. The Clivus-Multrum:

   The Clivus-Multrum is a patented self-contained household waste management unit which has been used successfully in Sweden for many years. It operates by an aerobic composting process wherein soil bacteria break down the accumulated organic "waste" material. The system is simple, involving no mechanical processes or moving parts, hence no internal upkeep. There is no liquid effluent which alleviates disposal problems and health hazards. The final product is a humus-like material, free of pathogenic organisms, which may be removed and returned to the soil. The unit consists of a large fibre-glass container (8' x 8' x 4') with inlet chutes for toilet waste and kitchen waste and vent leading to the roof. The main container is divided into three chambers with a sloping bottom to encourage the slow movement of the composted material to the frontal storage compartment. Once the system has been operative for a year or more, the material can be removed every few months and returned to the soil. (Figure 4).

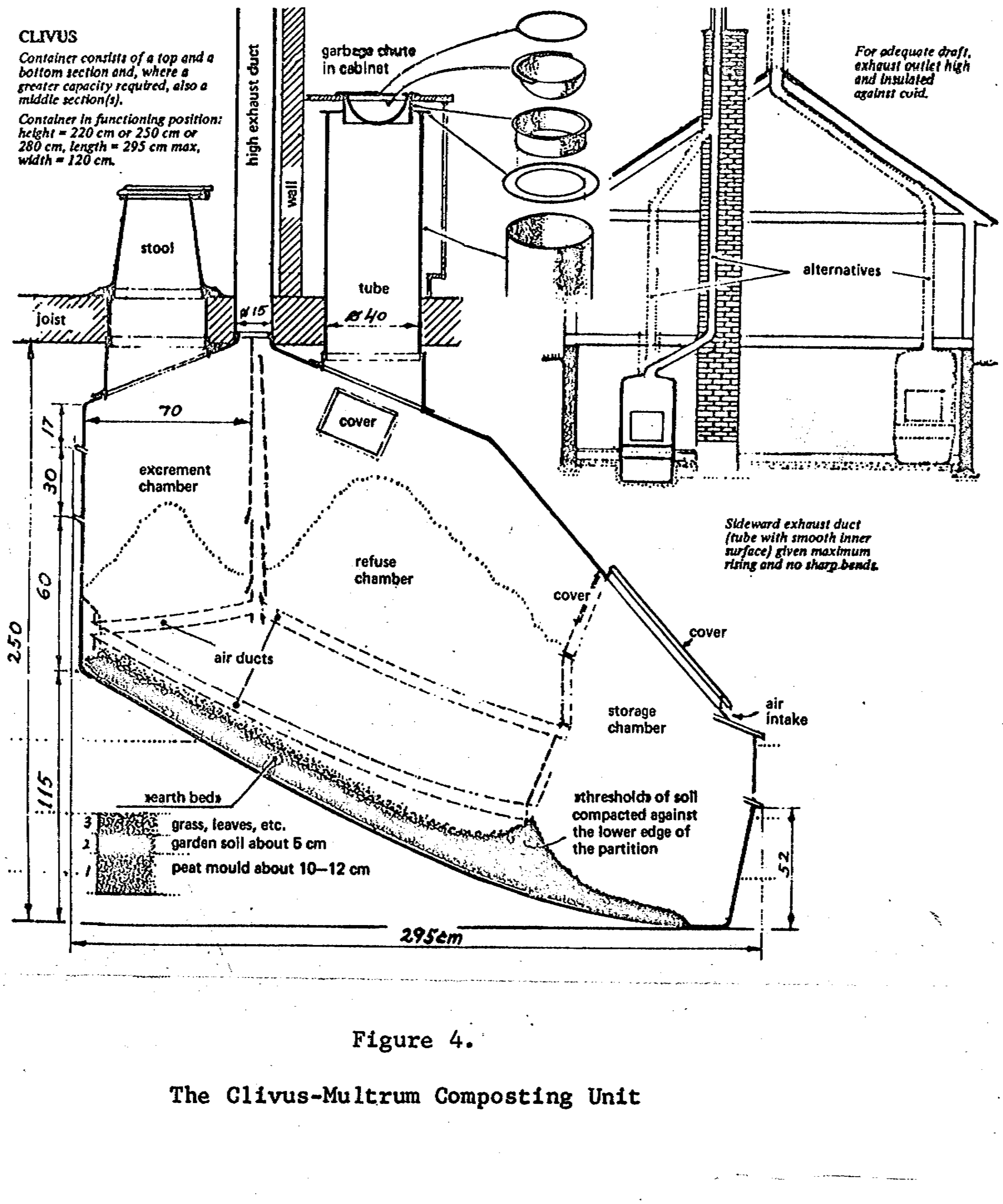


Figure 4.

The Clivus-Multrum Composting Unit

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1. Available from Clivus-Multrum, U.S.A. 14A Eliot Street, Cambridge Massachusetts.

The other two components serve as receptacles for toilet and kitchen waste respectively. The waste enters these compartments by vertical chutes from a waterless toilet and a kitchen waste receptacle. The toilet pedestal is wider at the bottom than the top to prevent fouling of the sides as there is no flushing mechanism. It is critical to the successful operation of a Clivus that aerobic conditions be maintained, that the system remains relatively dry and that the internal temperature remains relatively high (30° C.). Aerobic conditions are assisted by ventilation of the unit which draws fresh warm air into the unit, draws it through the accumulated wastes and out through a roof-vent pipe. Under aerobic conditions no odours will be generated. To maintain aerobiosis, it is necessary to restrict the amount of water entering the Clivus. Large amounts of fluid such as household waste-water should be directed into a separate system such as a soak-pit, tile field or ejector. Small amounts of water entering the system from urine and kitchen waste can be evaporated by the heat generated in the composting process. Small amounts of water in the form of urine are also necessary to maintain the microbial decomposition process since water is a necessity for the metabolic processes of the microorganisms.

Insulation will maintain the heat generated by the bacterial action, thus encouraging the degradation process and helping to eliminate the pathogenic organisms which can enter the unit.

To "prime" the Clivus and put it into operation, a layer of peat moss (4 - 5 inches thick) as well as some soil and cut grass, dead leaves or similar organic material should be spread over the bottom of the unit. This material contains the organisms necessary to initiate the composting process and will serve to soak up urine and other material entering the system. The denitrifying bacteria of the soil among others will serve to break down the organic material accumulating in the toilet and kitchen waste compartments. The kitchen waste such as vegetable peelings, coffee grounds and egg shells will increase the organic input and serve as "fuel" for the composting bacteria.

A unique feature of the Clivus is that the excrement and garbage chambers are never emptied. The composted material does not show up in the storage compartment until about two years after installation. The final decomposed product is odourless humus, about 5 - 10% of the original weight. The surplus may be removed with a small scoop and is an excellent soil conditioner and fertilizer.

Two technical advantages of the system relate to the saving of water and fuel. With the elimination of the flush toilet, water consumption and therefore delivery cost to the individual consumer would be diminished. For a family of four, the annual water-saving advantage of a Clivus over a flush system would be about 14,000 gallons.[2] There would also be a saving in power since the system requires no pumps or vehicular collection system. If properly insulated, the only power required is that sufficient to keep the vent-pipe warm, to prevent the condensation of water vapour.

The possible technical problems of a Clivus composting unit have to do with the installation and insulation of the unit. Installation may be a problem in some areas since 5 - 7 feet of overburden are required under the house. Since the chutes from the toilet and kitchen should be vertical, the Clivus must be situated under the house in a basement or crawl-space. Few if any houses in northern Manitoba have basements. Use of the Clivus in new homes without basements requires an excavation below the house to contain and support the unit. For this reason the composting unit is more easily installed as part of a new house. This is not a prerequisite; however, costs of installation in an existing home could prove prohibitive. This fact would not be a serious limitation in the

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2. Based on 2.5 gallons per flush and 4 flushes per individual per day.

long run since there are a number of both new and replacement housing programs anticipated at the present time.

If the crawlspace in which the unit is placed is unheated, the Clivus must be insulated to maintain a relatively high internal temperature (greater than 30° C.). This temperature must be maintained for satisfactory rates of pathogen degradation and optimum organic decay. In permafrost areas, it would be more difficult and costly to effectively insulate the unit.

The costs of the Clivus, chutes, insulation and other necessities are about $1,700. Installed in a northern community, the cost of a Clivus system, including transportation and labour, will approach $2,400. An additional system to handle the gray-water will increase costs by about $1,000. (See APPENDIX III, footnote 5). This includes the cost of plumbing; however, the estimate varies largely, depending on the disposal mode used. Operating costs are very low, about $10.00/year or less, for power to keep the water from condensing in the vent, and a nominal cost for repairs which would amount to no more than $10.00 per unit and which could result if the toilet chute was damaged, if the ground settled and misaligned the vent or some such occurrence.

2. <u>The Electrically-Assisted Composting Unit</u>:

Another waste management system which uses a natural composting process is the electrically-assisted composting unit.[3] There are several outlets distributing these systems. Despite the differing names, the units are virtually identical.

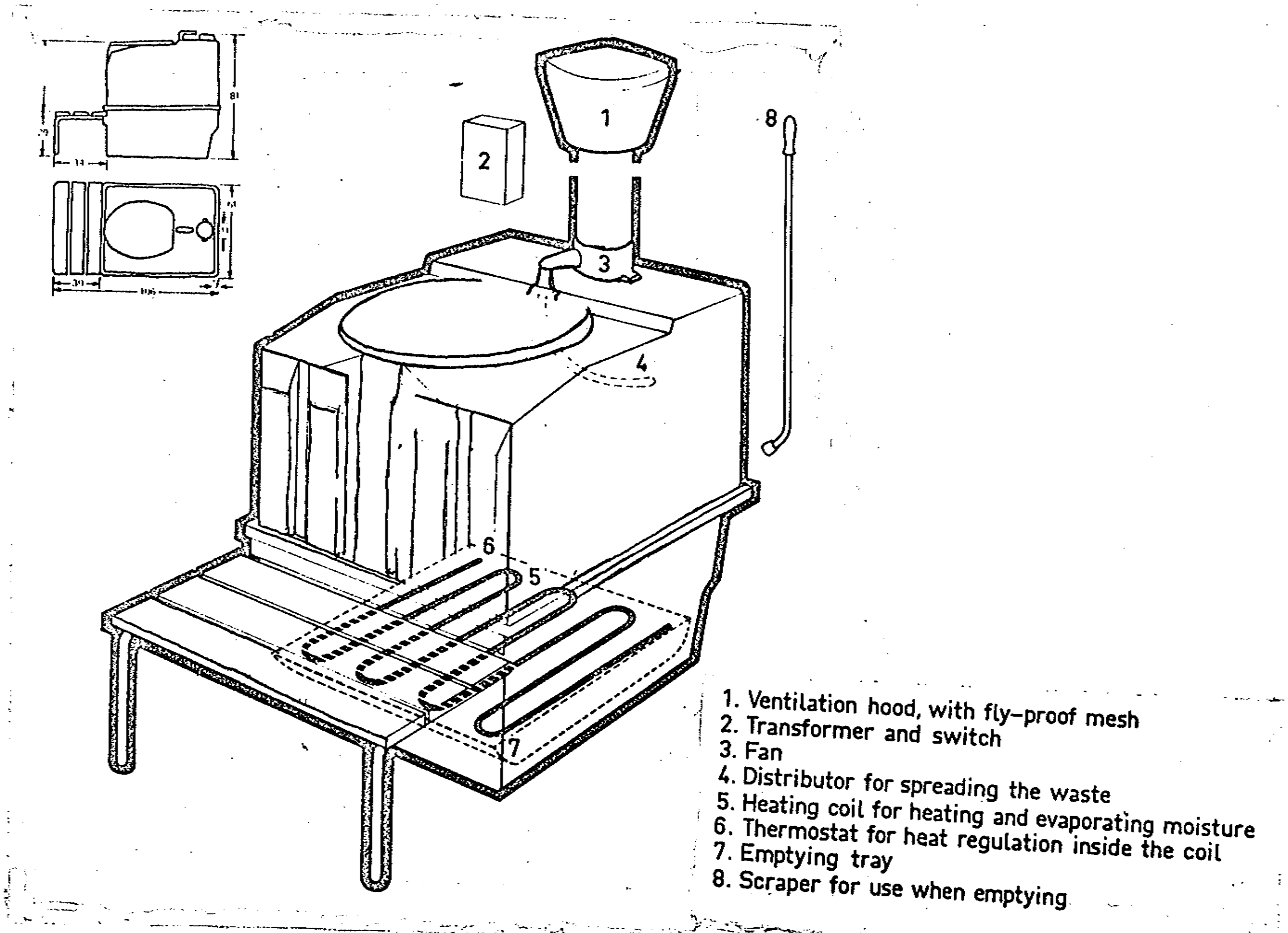

Figure 5.

The Electrically-Assisted Composting Unit

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3. Two distributors of the electrically-assisted composting toilets are Bio-Utility Systems Inc., P.O. Box 135, Narberth, Pa. and Humus Toilet Corporation Ltd., 8156 Jean Brillon, Ville LaSalle, Quebec, Canada H8S 4B6.

The operation is similar to that of the Clivus insofar as it requires the maintenance of aerobic conditions and the exclusion of excess water. However, in the electrically-assisted composting toilet, the process is assisted and accelerated by the addition of a heating element, humidity control and stirring mechanism. This obviates the need for large storage capacity, and the unit requires a floor space of only about 2 by 4½ feet. The small size means that this system can be installed indoors in old as well as new homes and no excavation is required.

As is true of the Clivus, the electrically-assisted version is odourless as long as aerobic conditions are maintained. In this toilet, the aerobic conditions are maintained by a small fan which provides continuous air flow from outside through the "waste." Fresh air is supplied as stale, humid air is vented to the atmosphere. Because of the smaller size and amount of waste found in the assisted unit, it is more sensitive to excess water and the presence of toxic substances than the Clivus. Consequently, anaerobiosis and odours could result if large amounts of water or chemicals toxic to soil microflora are added to the system. Anaerobic conditions are characterized by an oxygen-deficient environment with formation of such malodorous compounds as hydrogen sulphide and methane. These gases could constitute a hazard as they are flammable. An explosion could occur if a significant quantity of gas were generated in the unit and a glowing cigarette butt was thrown in. The aerobic decay process can be further assisted by the addition of kitchen waste, small amounts of garden soil or grass clippings. This would help to heterogenize the waste, improving its crumb structure. The humus becomes less susceptible therefore to clogging of the soil pore spaces and hence, anaerobiosis.

Bacteriological tests have been carried out on the humus product of the electrically-assisted composting unit. The conclusions of the tests were as follows:

> 'It was found that a normally utilized and normally functioning Mullbank toilet produces a product that is fully acceptable as sanitized for use as fertilizer or soil amendment.[4]'

The assisted composting toilet has a designed capacity for four people. Short overloads can be tolerated, but prolonged use by more than four people would require the installation of an additional unit. With four people using the system, the drawers which collect the humus product at the bottom should only need to be emptied about three times a year.

The technical problems of the system are its sensitivity to water and chemicals, its dependence on power and possibilities of maintenance difficulties. Should a problem develop with the system or the power be cut off, the system would fill quickly because of its small size. It has been estimated that use could continue only four days with four people using the unit. In remote communities, it may be impossible to bring about a repair in this amount of time. As with the Clivus-Multrum, a separate system is necessary to handle the gray-water separately from the isolated fecal and kitchen wastes.

The capital cost of an electrical composting toilet, vents and connections is about $680. Transportation and installation would bring the total installed cost to around $1,000. A gray-water system such as a field would add about $1,000. The operating cost would include the power and maintenance.

As the stirrer motor operates for only about one minute after each use and the heaters are thermostatically controlled, the average daily consumption of energy is 3 to 4 kilowatts.[5] The Manitoba Department of Northern Affairs has found under northern conditions that the electrical composting toilet

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4. K. Vardmaa, "The Mullbank Toilet," <u>Compost Science</u>, 15 (5), Nov.-Dec., 1974, p. 25.

5. <u>Literature of Bio-Utility Systems</u>, Inco., Narberth, Pa.

requires slightly more current - using approximately 5 kilowatts per day.[6] At rates for northern communities,[7] this represents an annual cost of about $20. Since the shell of the unit is made of impact-resistant polyethylene and the only moving parts are two simple motors (one for the fan and one for the stirrer), maintenance costs are expected to be low, probably less than $20.00/unit/year.

Because of their convenience, low maintenance, lack of flush and relatively low costs, both the unassisted and assisted composting toilets are well-suited to use in vacation homes and remote resorts such as fly-in lodges. In these circumstances, the Clivus would not require insulation. Freezing over the winter would not interfere with the process over the following summer. Most of the composting bacteria would be dormant over the winter; however, a significant start-up period would be required the following year to replenish the microorganisms killed by the winter temperatures. Less maintenance and emptying of the humus product would be required in this case than if the unit were used year-round.

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6. Personal Communication with Mr. M. McKernan, Consultant, Department of Northern Affairs, Manitoba.

7. The first 75 kilowatts are 7.5¢/K.W. The next 120 K.W. are 2.1¢/K.W. and the balance is 1.134¢/K.W.

Sewage Ejectors

Another innovation which may prove useful, for individual homes under certain conditions in remote communities, is the sewage ejector or sewage jet system. This system is presently in use to a limited extent in the northwestern agricultural section of the province, and more extensively in rural Saskatchewan. The most northerly installations are in the vicinity of The Pas.

The sewage ejector uses a septic tank for collection of sewage and primary settling. The ejector itself involves a discharge from the two-celled septic tank to the ground of a treed or bush area.

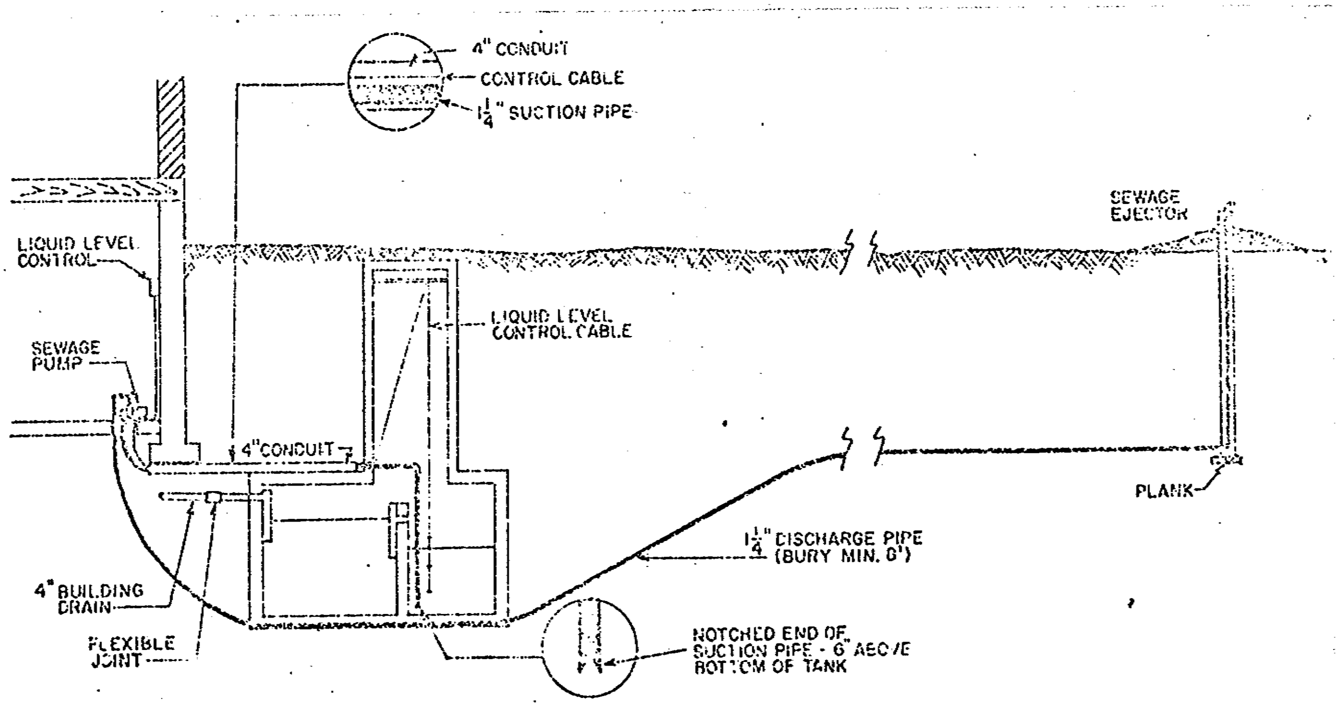

Figure 6.

The Sewage Ejector

The ejector system thus performs the same function as a field or mound system - that of secondary treatment of a septic tank effluent. Fields have proved unsatisfactory in the north in many cases because of the small amount of overburden and the likelihood that aquifers may be contaminated. Mounds have a propensity for freezing. The sewage ejector is particularly applicable to areas with clay soil and high watertables. The possibility of contamination of aquifers is lessened because most of the fluids are removed by evaporation and evapotranspiration through the vegetation, a phenomenon dealt with in the following paragraphs. Exposure to air and sunlight destroys the bulk of the bacteria present in the liquid, further lessening the chance of contamination of the aquifers.

The system has been found to work well in the winter because the water level in the pipes falls below the frost level in the ground when the discharge pump is not operating. This is an important technical consideration when designing the system. During the winter, the wastewater freezes when ejected, accumulating over the winter months. This has not proven to be a problem since the ejector will operate even while covered with snow. From an aesthetic point of view, this may not seem pleasant, however, it should be noted that the ejector is situated at a minimum distance of 200 feet from the residence and is surrounded by trees and a fence. In the spring, the water and waste is slowly released as the ice melts, posing no health hazard providing the area is adequately fenced to prevent access to children.

It is also important when designing or installing a sewage ejector that the area into which the waste is ejected be treed. The trees will evapotranspire water which is absorbed through their root system. Evapotranspiration is a phenomenon in which "a moisture and energy exchange... (takes) place in a single complicated interface,"[8] that of the soil/vegetation surface. Simply put, evapotranspiration is the process wherein "luxury" uptake of water occurs, exceeding the metabolic requirements of the plants. Although a great deal of research into methods of measuring evapotranspiration rate has taken place, there is at present no universally accepted measurement method for vegetation in a natural setting. There are a large number of factors affecting the flow of water including percolation, evaporation from the soil and the consumptive use by plants. The evapotranspiration rate will also be affected by meteorological variables such as humidity, temperature, photoperiod and wind velocity. The rate will also vary according to vegetation type and size. Notwithstanding these factors, it has been estimated that an evapobed of grass of 1,700 square feet can potentially evapotranspire up to 250 gallons per day.[9] It is claimed by the Manitoba Department of Agriculture

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8. R.C. Ward, "Measuring Evapotranspiration: A Review," Journal of Hydrology, (13), 1971, p. 9.

9. A.P. Bernhart, Treatment and Disposal of Wastewater from Homes by Soil Infiltration and Evapotranspiration, 1973.

that .... "during the growing season, a single large tree can use up to 100 gallons of water per day..." [10]

Although the trees are not able to absorb complex organics, they will take up simple organic compounds such as carbonate ions. Certain trees, such as varieties of spruce or red pine, have mycorrhizal affiliations with fungi capable of breaking down more complex organic material.[11] The trees will also reduce air currents in the disposal area and prevent any odours from spreading.

Answers to a questionnaire mailed to the 46 residences north of the 51st parallel using a sewage ejector revealed that consumer satisfaction was very high.[12] Of the twenty-eight individuals who returned the questionnaire, only one expressed dissatisfaction with the system on the grounds of maintenance problems. One other individual mentioned a problem of intermittent freezing over one winter, but nevertheless seemed satisfied with the overall performance of the system. Both of these complaints seem to be a result of faulty installation. The great majority of those answering the questionnaire had systems which had performed faultlessly even throughout the winter for periods as long as five years.

10. "Ejector Sewage Disposals", Rural Water Services, Manitoba Department of Agriculture Technical Notes, 1974.

11. Personal Communication with Dr. Waygood, Department of Botany, University of Manitoba.

12. <u>Evaluation of Consumer Satisfaction with Sewage Ejector System</u>, Report prepared for Planning and Policy Development Branch of Northern Affairs, 1974.

Several individuals indicated that they had had more success with a sewage ejector system than they would have had with any other.

As odours are occasionally produced when the tank is being pumped out, the system is most suitable where there are relatively large distances between dwellings. The ejector is thus well-suited to many remote communities where the development has taken place along a water course with considerable distance between homes. Since public health regulations in Manitoba[13] specify that the ejector be 200 feet from a residence, the ejector could be located 200 feet behind the home, away from the watercourse, to prevent health hazards, providing the area was adequately fenced and percolation was slow enough to provide adequate retention time for pathogen elimination and organic decay. Other regulations will be discussed in the chapter concerned with administrative feasibility. The sewage ejector thus lends itself well to the layout of many native communities as well as farms and isolated resorts.

Technical problems would be encountered in situations where bedrock outcrops occur or where permafrost is found. In these cases, deep trenching or heat-tape would be necessary to prevent freezing, either of which would raise the costs considerably.

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13. Manitoba Revised Regulations, R3, Section 170, Sub. 3, p. 210.

Heat tape costs about $1.95/foot for 8 watt/foot tape.[14] Operating costs could be decreased by using a timing device which would turn on the current one-half hour before the pumping began. Trenching through bedrock could cost $55/cubic yard.[15] It is important to note, however, that costs for nearly any collection system whether it be pipe, truck, or septic tank and field will be greatly increased where rock outcrops occur.

Another technical difficulty involves the health hazard which may occur if children or animals gain access to the area near the ejector. For this reason, a sturdy fence is necessary around the area.

The cost of installing a sewage ejector, according to the owners surveyed, varies from $750 - $2,000. An average cost for more northerly installations would likely be about $2,500 including indoor facilities. Higher costs would be encountered in Precambrian areas if installation in these areas proved feasible. However, it may be possible for three or four households to use the same ejector depending on their proximity to each other. This would decrease the costs of trenching and piping.

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14. Thermon Canada Limited, 431 Newbold Street, London, Ontario.

15. "Sewer and Water Services for Northern Communities: Cost Estimates," Water Resources Branch, Department of Mines, Resources and Environmental Management, 1974.

CHAPTER III

ECONOMIC ANALYSIS

For a comprehensive economic analysis, an engineering study would be required to determine the costs for each community of piped and truck systems as well as the feasibility of other systems. Since this has not been done, it is necessary to use the best cost estimates available. The following data were obtained from conversations with contractors, distributors and people working in the field. Some of the costs, notably those of the piped and truck systems, were extracted from a report entitled "Materials for a Sewer and Water Policy for Manitoba's Remote Communities" by Ian Gillies. These, in turn, were derived from crude estimates made by engineers at the Water Resources Branch, Department of Mines, Resources and Environmental Management.[1]

The cost estimates and references for the conventional systems are found in APPENDIX II. These cost estimates are approximate. Their accuracy will depend on the surficial geology and the degree of dispersal of homes within the settlement. Putting

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[1] Mr. J. McKonkey, associated with the Water Resources Branch, Department of Mines, Resources and Environmental Management, prepared the initial cost estimates. However, he has expressed dissatisfaction with the accuracy of the figures. They are, nevertheless, the best estimates for community systems available at the present time.

pipe through bedrock is very costly (greater than $100 per foot).[2] In communities with large numbers of bedrock outcrops, the estimates are less accurate than for others. Surface bedrock will affect the costs of all systems except the assisted composting toilet and the combustion toilet. It will, however, also affect a gray-water system associated with these systems. An estimate includes the cost of a system to handle the gray-water in the households. To some extent, these higher costs have been taken into account in the estimates, but the degree of error of the estimates will be higher in Precambrian areas.

The following economic analysis is divided into three sections. In the first section, a comparison of costs will be made between the conventional and alternative systems on an annual cost per household basis. Costs for four communities will be compared, a large and a small community from each of the Paleozoic and Precambrian areas of the province. The second section is a comparison

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2. Personal Communication with Mr. C. Main, South Indian Lake Development Corporation, Department of Northern Affairs, Manitoba; and Mr. Don Blasko, Wardrop and Associates, Consulting Engineers, Winnipeg, Manitoba.

between the costs of proposed systems[3] and the projected costs of alternative systems for the communities of Manigotogan, Moose Lake and Cross Lake. The third section develops a framework for a more comprehensive economic analysis which includes the effectiveness of the systems.

Cost Comparisons of Conventional and Alternative Systems for Four Selected Communities (Section I)

In this section, the costs of the conventional and innovative systems are compared on a per household annual cost basis. The four communities were selected on the basis of size and location to include one large and one small community from the Precambrian area of northern Manitoba and one large and one small community from the Paleozoic region of the province. The relevant characteristics of the four selected communities are given in Table 3, and the locations are shown on the map found in Figure 7.

The number of households for the above communities was obtained by using an average figure of five individuals per household, an admittedly low family population figure by northern standards.

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3. The proposed systems were condensed from Proposed Water and Sewer Services for the Community of Moose Lake, and the preliminary design study for the community of Manigotogan and Proposed Water and Sewer Services for the village of Cross Lake, prepared by F. Barlishen and W.M. Woroby, Water Resources Branch, Department of Mines, Resources and Environmental Management, 1974.

TABLE 3

DESCRIPTION OF SELECTED COMMUNITIES

Community	Latitude	Longitude	Population[1]	Physiographic Area[2]	Superficial Characteristics[3]	Spatial Distribution[4]	Present Level Of Service[5]	Groundwater Potential[6]	Water Supply[7]	Infrastructure	Additional Information
A Berens River	52°22'	97°02'	942	Pre-cambrian	Thin overburden and many rock outcrops	Situated on both sides of a river with no bridge	Outhouses	Poor	Carried by pail from surface sources	Internal road network and airstrip	Shoreline pollution has been evidenced by high culiform counts[8]
B Thicket Portage	55°19'	97°42'	318	Pre-cambrian	Little overburden of varying thickness rock outcrops	Highly dispersed community on a ridge of land between two lakes	Outhouses	Low	From either of the two lakes by pail or hydrant		School is served by a small lagoon

(cont'd)

TABLE 3 (cont'd)

DESCRIPTION OF SELECTED COMMUNITIES

C Duck Bay	52°10'	100°09'	543	Paleozoic	10 feet or more of overburden Little change in relief	Settlement pattern is linear along a road to a point of land	Outhouses Chemical toilets	Saline aquifers ________ High in iron, a hardness and suspended solids	Pumped from lake, treated and distributed by truck	Served by road	
D Barrows	52°49'	101°27'	198	Paleozoic	Thick overburden (50-100 feet)	Scattered at a crossroad Low dispersion	Outhouses	Good	Wells	Served by road	Nodak field services school

1. Source: Statistics Canada 1971
2. Source: Geological Map of Manitoba, Mines Branch, Dept. of Mines, Resources and Environmental Management
3. Source: Memoranda from J. Little, Groundwater Technologist, Dept. of Mines, Resources and Environmental Management, 1973
4. Source: Ibid.
5. Source: Material for a Sewer and Water Policy for Northern Manitoba, I. Gillies, Dept. of Northern Affairs 1974
6. Source: J. Little, op. cit.
7. Source: J. Little, op. cit.
8. Source: Personal Communication M.P. O'Flaherty, Medical Services Branch, Health and Welfare, Canada.

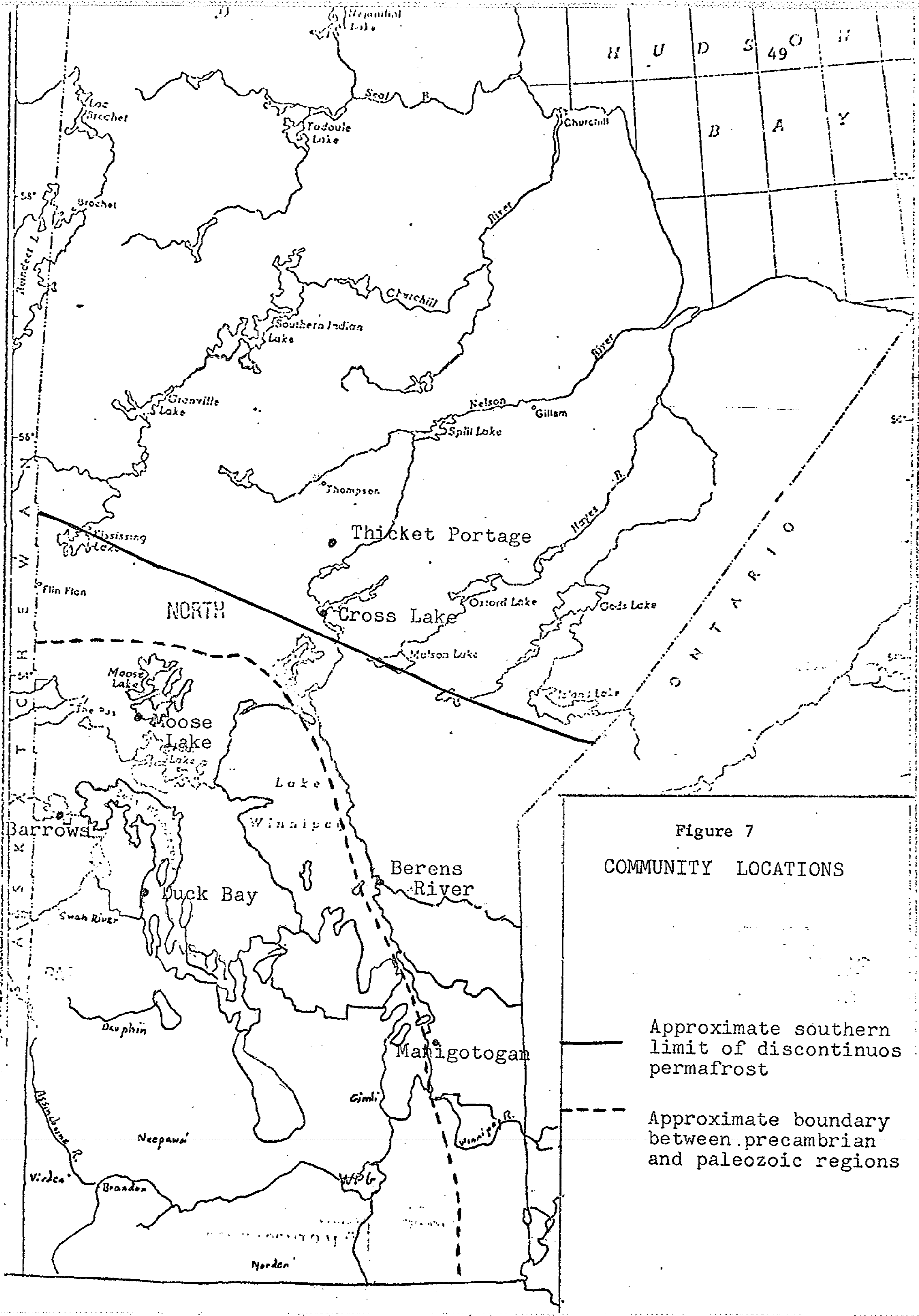

Figure 7

COMMUNITY LOCATIONS

To obtain comparability, an annual cost was obtained for each system by amortizing the capital costs for an expected lifetime of 20 years using a 10% discount rate. The total annual costs are thus composed of the annual portion of the debt retirement, plus the operating and maintenance costs. These detailed costs are found in APPENDICES III and IV and summarized for the four communities in Table 4. Outhouse systems and chemical toilets have not been included in this analysis because of their inapplicability for reasons other than cost, i.e. odours, possible risk of water source contamination and social unacceptability. The costs given in Table 5 have been reduced to a total annual cost including amortized capital costs on a per community and per household basis.

Several observations can be made from Tables 4 and 5 regarding the costs of various waste management systems for northern communities:

- Combustion units and chemical toilet systems are more expensive on an annual cost per household basis than are the other individual systems.
- Community systems are more economical for larger communities and are apparently more economical for communities in the Paleozoic topographic areas. They are apparently feasible for several communities

TABLE 4

COMPARISON OF ANNUAL AND CAPITAL COSTS FOR FOUR COMMUNITIES*

Community (Households)		Septic Tank/ Field	Chemical Toilet	Combustion	Truck Community System	Sub-surface Piped Community System	Clivus-Multrum Composting Unit	Electrically Assisted Composting Unit	Sewage Ejector
A (188)	Annual Operating and Maintenance	$9,400	$146,640	$ 82,720	$ 60,000	$ 10,000	$ 3,760	$ 7,520	$ 9,400
	Capital Costs	$545,200	$ 71,440	$402,320	$360,000	$818,000	$684,000	$394,800	$470,000
B (64)	Annual Operating and Maintenance	$ 3,200	$ 49,920	$ 28,160	$ 86,000	$ 9,000	$ 1,280	$ 2,560	$ 3,200
	Capital Costs	$185,600	$ 24,320	$136,960	$264,000	$418,000	$232,960	$134,400	$160,000
C (109)	Annual Operating and Maintenance	$ 5,450	$ 85,020	$ 47,960	$ 45,000	$ 10,000	$ 2,180	$ 4,360	$ 5,450
	Capital Costs	$316,100	$ 41,420	$233,260	$249,500	$410,500	$396,760	$228,900	$272,500
D (40)	Annual Operating and Maintenance	$ 2,000	$ 31,200	$ 17,600	$ 53,000	$ 8,000	$ 800	$ 1,600	$ 3,000
	Capital Costs	$116,000	$ 15,200	$ 85,600	$219,000	$200,000	$145,600	$ 84,000	$100,000

* Per Household costs are given in Appendix III and IV.

TABLE 5

BREAKDOWN OF ANNUAL COMMUNITY AND HOUSEHOLD COSTS FOR FOUR COMMUNITIES

Community (Households)	Septic Tank/ Field	Chemical Toilet	Combustion	Truck Community System	Sub-surface Piped Community System	Clivus-Multrum Composting Unit	Electrically Assisted Composting Unit	Sewage Ejector
Annual Community Cost A (188)	$ 73,200	$155,000	$130,000	$102,100	$105,706	$ 83,800	$ 53,700	$ 64,400
Annual cost per household	$ 390	$ 824	$ 690	$ 543	$ 562	$ 445	$ 286	$ 343
Annual Community Cost B (64)	$ 24,900	$ 52,800	$ 44,160	$116,900	$ 57,900	$ 28,500	$ 18,300	$ 22,000
Annual cost per household	$ 390	$ 824	$ 690	$ 1,826	$ 904	$ 445	$ 286	$ 343
Annual Community Cost C (109)	$ 42,500	$ 89,900	$ 75,200	$ 74,200	$ 58,000	$ 48,500	$ 31,200	$ 37,400
Annual cost per household	$ 390	$ 824	$ 690	$ 680	$ 532	$ 445	$ 286	$ 343
Annual Community Cost D (40)	$ 15,600	$ 33,000	$ 27,600	$ 78,600	$ 31,400	$ 17,800	$ 11,400	$ 13,700
Annual Cost per household	$ 390	$ 824	$ 690	$ 1,965	$ 785	$ 445	$ 286	$ 343

with populations in excess of 1,000 people in the Precambrian area of the province. Communities in Paleozoic regions may be economically serviced by a community system if the population is in excess of approximately 800 people.

- Of the alternative systems, the least expensive is the assisted composting toilet which is the lowest cost alternative for all four communities examined. However, it is less acceptable from an aesthetic point of view than the Clivus or sewage ejector and is only useful in homes of less than five individuals. One unit may suffice for homes of five individuals where there are young children. For homes in which an overloading condition would occur, two assisted composting units would be used. This would entail a greater space requirement and a doubling of cost.
- Ejector systems are likely to be less expensive than septic tank and field systems.

Comparison of Proposed and Alternative Systems for Three Communities (Section II)

The Water Resources Branch of the Department of Mines, Resources and Environmental Management has conducted studies to determine the most economic method of improving sewer service to several communities of northern Manitoba. Reports proposing water and sewer services for the communities of Moose Lake, Cross Lake have been completed, and preliminary cost estimates have been made for Manigotogan. A summary of the cost estimates for the proposed systems for these three communities can be found in APPENDIX V. Cost estimates are also available for Wabowden, but they are not comparable since there is a lagoon serving part of the community which could be used for sewage treatment for the remaining area.

1. Manigotogan:

Preliminary cost estimates have been made for Manigotogan for a truck sewage collection and lagoon treatment system. Manigotogan is a village with an estimated population of 147 and approximately 40 households. The population is apparently declining. The village is situated on both sides of the Manigotogan River, east of Lake Winnipeg within the Precambrian area of the province. Presently the area is serviced primarily by outhouses. The best cost estimates for a community system prepared by the Water Resources Branch for Manigotogan yield capital costs of $122,000 and an annual cost, including amortized capital, of $27,196. These are summarized with the costs of the alternative systems (including gray-water disposal costs) in

Table 6.

TABLE 6

SUMMARIZED COSTS OF PROPOSED AND ALTERNATIVE SYSTEMS FOR MANIGOTOGAN

	Proposed Truck System	Clivus-Multrum Composting Unit	Electrically Assisted Composting Unit	Sewage Ejector
Capital Costs	$122,000	$145,600	$ 84,000	$100,000
Annual Costs	$ 27,196	$ 17,800	$ 11,400	$ 13,700
Annual/Household Costs	$ 679	$ 445	$ 286	$ 343

Since the Clivus is most easily installed in new homes, and the assisted composting toilet is useful for households with four or less people, the most technically and economically feasible alternative may be to use a combination of Clivus, assisted composting toilets and sewage ejector systems.

2. Moose Lake:

Moose Lake is a community located within the western Paleozoic region of the province. The present population is 750 and seems to be expanding at approximately 1% per year.[4] There are about 150 households in the community. The terrain is gently rolling, there is little relief, and the community

4. "Proposed Water and Sewer Services for the Community of Moose Lake", Water Resources Branch, Department of Mines, Resources and Environmental Management, 1974.

is quite compact. The homes are mostly serviced by outhouses, with septic tanks and fields servicing the store and nursing station. The costs for the proposed truck and lagoon system and the alternative systems including gray-water disposal costs are shown in the following table:

TABLE 7

SUMMARIZED COSTS OF PROPOSED AND ALTERNATIVE SYSTEMS FOR MOOSE LAKE

	Proposed Truck System	Clivus-Multrum Composting Unit	Electrically Assisted Composting Unit	Sewage Ejector
Capital Costs	$290,500	$546,000	$315,000	$375,000
Annual Costs	$ 47,160	$ 66,750	$ 42,900	$ 51,450
Annual Cost/ per Household	$ 314	$ 445	$ 286	$ 343

For this community, it seems that the comprehensive community system is the most economical alternative. Although the assisted composting unit is less expensive, it could not be used universally throughout the community. The cross-over point in population for costs of Clivus-Multrum composting units versus costs of community systems for communities situated in the Paleozoic region is thus less than 750 individuals, probably in the vicinity of 500 - 600.

3. <u>Cross Lake</u>:

The proposed system for the community of Cross Lake was not designed to serve the whole community, but rather only portion not on Indian reserve land. This portion of the population is comprised of 170 persons (from 43 households) of a total of 1,917. The community is located in the Pre-cambrian area of the province, and granitic rock outcrops occur frequently throughout the community. The water supply for the community is from both wells and Cross Lake. Most homes use outhouses. The Water Resources Branch sub-surface piped estimates compared to the estimates for the alternative systems for the village are as follows:

TABLE 8

SUMMARIZED COSTS OF PROPOSED AND ALTERNATIVE SYSTEMS FOR CROSS LAKE

	Proposed	Clivus-Multrum Composting Unit	Electrically Assisted Composting Unit	Sewage Ejector
Capital Costs	$237,800	$156,500	$ 90,300	$107,500
Annual Costs	$ 63,645	$ 19,135	$ 12,300	$ 14,750
Annual Costs per Household	$ 1,480	$ 445	$ 286	$ 343

For a community such as Cross Lake situated in the Precambrian region, the piped community system seems uneconomical. If the homes situated on the Cross Lake Indian Reserve had been in-cluded, the cost per household would have been less. For communities such as this one, the alternative systems seem particularly attractive from an economic standpoint. A combination of the alternative systems may prove to be the most viable alternative.

A Framework for More Comprehensive Economic Analysis (Section III)

The preceeding economic analysis has assumed that all systems give the same level of service. However, for any area or community, different systems will yield a different effectiveness for removing pathogens, B.O.D. or any other measure of degree of treatment. In many instances, systems such as outhouses or septic fields are ineffectual in treatment of waste which increases the possibility of contamination of aquifers. Similarly, different waste management systems are not equal in terms of convenience and aesthetic appeal or environmental appropriateness.

Generally as expenditures are increased for a waste management system, the degree of treatment which can be attained also increases. Thus the costs for a community will be a function of the desired level of pathogens, B.O.D., heavy metals or total dissolved solids removal. The marginal cost of achieving high levels of treatment may be defined as the additional cost of achieving incremental amounts of increased treatment. The marginal cost will be a function of the degree of treatment such that, as increasingly purer effluents are desired, marginal cost will increase. A typical function is shown in Figure 8. Political decisions regarding increasing the level of service to various communities would be based on the marginal cost of increasing the degree of treatment.

For northern communities the most undesirable component of sewage is the pathogenic or disease-causing potential. Number of pathogens has been chosen in this example for illustrative purposes only. The theory could be applied similarly to B.O.D. removal, another measure of purity, convenience or aesthetic appeal. No treatment on the graph is represented by P*. Although some money must be spent before any treatment is obtained, very low costs would be associated with a zero level of treatment. As higher treatment levels are desired, the extra cost of purifying

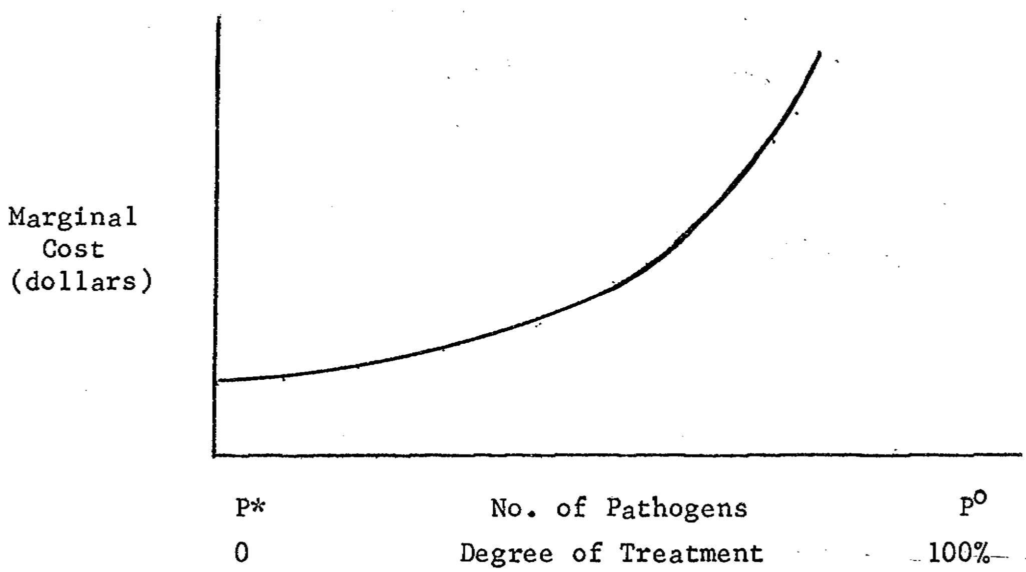

Figure 8.

Graph of Marginal Cost and Degree of Treatment the water becomes greater until the point where removing the last few persistant pathogens or the last few pounds of B.O.D. is reached. Very high costs would be associated with treating the waste to a 100% level. The total costs for treating the waste to a level Px would be the area under the curve. As the marginal costs for providing higher levels of treatment increases exponentially, the total costs also rapidly increase.

For most situations, less effective systems such as outhouses and septic tanks and fields would be found low on the curve, whereas a piped service to each household with a well-managed lagoon system would result in high costs and high levels of treatment. This is demonstrated by the cost data presented in Section I for the various treatment modes. Thus by measuring the effectiveness of each system and finding the cost of servicing the particular area in question, a cost-effectiveness curve could be drawn.

To determine whether an alternate system would provide increased or decreased effectiveness for the costs involved, it is only necessary to determine whether the point associated with the cost and efficiency of that system lies above or below the curve for conventional systems. The degree of treatment necessary in any situation will be largely a decision made in the political arena, on the basis of biological studies for the given community. If the effectiveness of the alternate system is greater or equal to the desired level and lies beneath the costs of conventional systems, then it is the most economically sound alternative. If one were examining the feasibility of Clivus-Multrum composting units and found that higher levels of service and less danger of contamination occurred using the Clivus than conventional methods at the same cost level, then the Clivus should be selected as the most viable alternative. If higher levels of convenience and reliability were desired than the Clivus could afford, then higher costs would be anticipated.

The effectiveness which may be obtained for a given expenditure is not only dependent on the type of system, it is also a function of other parameters such as soil type, depth of aquifers, climate, latitude, and quality and consistency of management. All these factors would affect the position of the cost-effectiveness curve. As an example, it would be expected that costs for most systems would be higher in the Precambrian area of the province than in the Paleozoic region. The relation between these communities is shown in Figure 9. It can be seen from the diagram that for a given marginal cost, x, the attainable degree of treatment will be lower for a community situated in the Precambrian area of the province than in the Paleozoic region.

For a given size of population, the alternative system may be more economically feasible for the Precambrian community than for the Paleozoic community as is shown in the diagram. The other factors mentioned will similarly change the conventional curve.

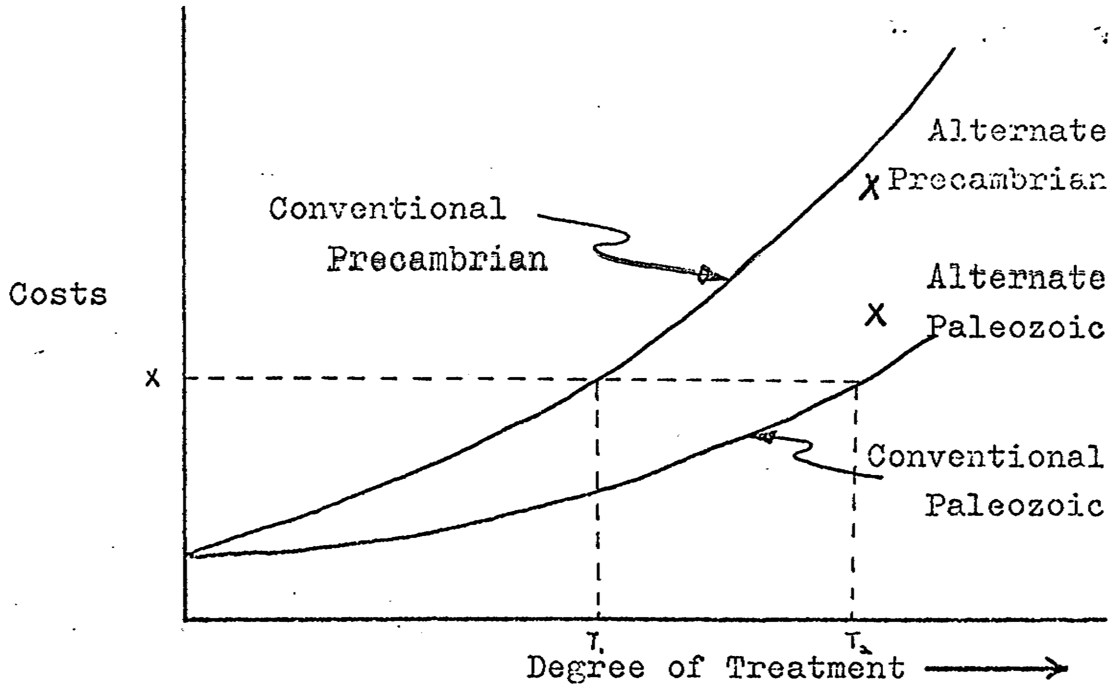

Figure 9

Cost-Effectiveness Curve for the Precambrian and Paleozoic Regions

In order to measure the cost effectiveness of alternative systems, comprehensive data would be required on the effectiveness of the various systems under given or similar conditions. It would also be necessary to know how the effectiveness curve would accommodate differences in soil and climatic conditions.

<u>Summary</u>

Using the data available, it is apparent that the alternative systems considered in this practicum are cost competitive with conventional systems for northern communities and are especially attractive for those communities with populations below approximately 700. In many cases, the most rational approach to the alternative systems may be to use whichever system is best suited to the household. An integrated approach to the planning of waste-management systems would have the advantage of flexibility as well as solving some of the limitations of the alternative systems. An integrated use of these alternatives could overcome the limitations of individual systems - the limitation, for instance, of the electrically-assisted composting unit to households with less than four users or the difficulty in installing the Clivus unit in older homes.

The previous economic discussion has focused only on strict monetary costs without consideration of social costs and benefits of the systems. One such benefit of the Clivus and assisted composting toilets is the minimal ecological damage. Both of these systems effect almost perfect nutrient recycling. The nitrogen and phosphorous entering the systems are ultimately returned to the soil to be reused by vegetation. The rate of eutrophication in Manitoba's northern receiving waters would therefore be decreased since water-based "sewage" is neither created nor discharged to water courses. Another benefit derived from the use of composting systems is the water-saving through the absence of a flush system. This is difficult to quantify and identify as an economic benefit since a significant water-saving would alter the rate structure, but it would constitute a benefit which may offset a portion of the monetary costs.

There are other advantages of these alternate systems which should be considered in decisions to increase the level of service of a northern community. One such advantage would be that the capital costs of these systems can be recovered more easily particularly in the case of the electrical composting toilet should the population of the community enter a state of decline. The population growth potentials of these communities are difficult to predict and often fluctuate within a large range. With individual systems such as the Clivus or assisted unit, it would be a relatively simple matter to stop installing more household systems or even to move the system to another location. With a piped system, or tc a lesser extent with a truck collection system, the community or government is essentially "locked in" to the amortization payments for twenty years.

Another consideration regarding the costs of these systems is that the costs for the in-house systems could be estimated within relatively narrow limits and would not be expected to differ significantly from the predicted costs. With piped or other community systems, the costs are more approximate and could differ significantly from those predicted for a large number of reasons. It is thus easier to arrive at decisions involving the alternative systems.

An important area of administrative concern relating to the economics of various waste management systems is the source of funding. A policy regarding funding administration has been developed by the Department of Northern Affairs. They have suggested that the capital cost for the installation of any individual or private system be split on a 50/50 basis between the province and the individual owner. The individual would then be responsible for total operation and maintenance of all systems within his/her property and retain complete ownership of the system. Capital costs for higher levels of service in the form of piped or truck collection would be shared on 75/25 basis between the province and the community. The in-house fixtures and plumbing would be shared on a 50/50 basis between the province and the property owner. For a comprehensive community system, the Department of Northern Affairs would assume responsibility for the first two years of operation as well as the training of an operator from the community. After the two years, the community would assume ownership and responsibility for operation and maintenance.[5]

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5. "A Water Supply and Sewage Management Policy for Remote Northern Communities", Department of Northern Affairs, 1975.

CHAPTER IV

SOCIAL FEASIBILITY

Regardless of how well an experimental system works technically, or how attractive it may seem from a cost point of view, it may be socially unacceptable to the potential users. Alternatively, social factors may negatively affect a system's operation and, thus, raise its ultimate cost.

Non-conventional waste management systems may be unacceptable to northern residents for a number of reasons. It may be difficult to obtain initial co-operation from residents of the communities or from government agents. Attempts to promote experimental techniques may be greated with suspicion on the part of the northern residents who are inclined to attach a certain degree of status to waste disposal systems conventionally used in the southern cities and towns. New and different systems may not be as enthusiastically accepted as more conventional facilities.

Acceptability by the potential users may depend in part on how aesthetic or unaesthetic they believe the proposed systems to be. Although sewage ejectors may appear to create a localized unaesthetic environment, it must be remembered that the ejector is located 200 feet from any residence in a fenced, treed area. Of the 28 individuals answering the questionnaire[1] mailed to owners of sewage ejectors, none found the system to be unacceptable for aesthetic reasons. Some individuals occasionally noticed odours during pump-out, but seemed to find this acceptable.

The electrically-assisted composting toilet may also seem unaesthetic since the waste is both visible and quite proximate to the user. However, since the unit produces no odours if functioning properly, this objection may be overcome. What might be a slightly displeasing characteristic of the process may be compensated for from the user's point of view by lower costs.

These possible objections are speculative and may quickly disappear if the new systems operate to specification.

The question of "felt need" on the part of northern residents is dependent in part on the awareness of waste management problems. There is no doubt that desire for adequate waste management systems is growing in the north. However, many northern residents have not had much exposure to more sophisticated waste management techniques. Thus to ensure that new systems are managed and used properly by the residents, it is necessary to present information to potential users in a manner they can relate to. There may be

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1. Les Sherwood, "An Evaluation of Consumer Satisfaction with Sewage Ejector Systems", Department of Northern Affairs, 1974.

language barriers in some instances, and educational backgrounds of the residents must be taken into account. Although these alternative systems are relatively simple in operation and resilient to a certain amount of mishandling, all systems are subject to breakdown if misused. The consequences of breakdowns would be particularly serious in isolated communities. Repairs may be difficult, and most smaller settlements cannot support skilled repairmen. Isolation creates difficulties in bringing in outside repair personnel. These problems are best handled by minimizing the probability of repairs through education and better communication links.

Potential misuse of the in-house waste systems (especially the Clivus and assisted composting toilet) increases as the use pressure increases and probably as the number of children with access to the system increases. Age-sex pyramids developed by the Department of Northern Affairs are extremely bottom heavy, indicating a high proportion of young children (about one-half the children are under fifteen years of age). Proper use of the Clivus and assisted toilets depends largely upon the exclusion of large amounts of water and chemicals which would be toxic to the bacteria from the system. The assisted unit is more sensitive in these respects than the Clivus. With education regarding the proper use of the systems, the sanitary risk incurred by misuse should be quite low for all systems. Thus, any program intending to upgrade the level of waste management service should be accompanied by an orientation program designed to ensure dependable operation of waste management processes, thereby decreasing the sanitary risk.

CHAPTER V

ADMINISTRATIVE CONCERNS

A major concern in implementing innovative waste systems in remote communities is the legality of the proposed system. Under present regulations, there is some question as to the legality of the three systems discussed in this practicum. Regulations pertinent to household systems are stated in section 34 of the Public Health Act which gives the Lieutenant-Governor in Council power to make regulations:

1. "Declaring certain conditions or circumstances to be insanitary conditions and declaring that certain acts contribute to insanitary conditions."[1]
2. "Respecting the prevention and removal or abatement of insanitary conditions on public or private property and the prevention of acts that contribute to insanitary conditions."[2]
3. "Respecting the construction, maintenance, cleansing and disinfection of drains, sewerage systems, sewers, sewage treatment plants, sewage disposal plants and the location cleans- and disinfection of water closets, cess pools, septic tanks, privies and other methods of disposing of sewage and waste.[3]

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1. *Public Health Act*, Section 34, Sub. 12.

2. *Ibid.*, Sub. 13.

3. *Ibid.*, Sub.16.

An insanitary condition defined by the Act is condition or circumstance:

(i) that is offensive,

(ii) that is or may or might become injurious to health,

(iii) that prevents or hinders the suppression of disease,

(iv) that contaminates or pollutes or may contaminate or pollute food, air or water,

(v) that might render food, air or water injurious to the health of any person;

and includes a nuisance and any circumstance or condition declared to be an insanitary condition under the regulations.[4]

The regulations are enforced by the Medical Officer of Health and the Public Health Inspectors. The regulations may be made so as to apply to the province as a whole or any part of the province.

The only one of the alternative systems discussed in this paper to which the regulations refer specifically is the sewage ejector. According to Section 170, Sub. 3 of the Revised Regulation, p. 210 R 3, Division V, sewage ejectors are permitted to discharge effluent on any property under the following conditions:

(a) The point of discharge shall not be closer than 100 feet to any boundary or property.

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4. *Ibid.*, Section 2, Sub. e.

(b) The point of discharge shall not be less than 200 feet from any building and not less than 150 feet from any well or watercourse.

(c) Must be adequately fenced to the satisfaction of the Medical Officer of Health.

(d) Must comply with such additional requirements as the Medical Officer of Health may deem necessary.

(e) The use of sewage ejectors is not permitted in any premises situated in a hamlet or other community having a population greater than 300.[5]

It is the final subsection (e) which would impose severe limitations on its use in the north. There would seem to be some doubt as to the relevance of this clause to the northern context when one considers the typical dispersed pattern of the northern communities. At the present time, the use of sewage ejectors is confined to the southern agricultural section of the province. Regulations are appropriate then where use in the compact prairie communities could indeed create a health hazard. In northern communities where homes may be scattered on both sides of a river, on islands or with large distances between homes, sewage ejectors would not result necessarily in insanitary conditions even in those with populations greater than 300. The first three sub-sections seem to protect adequately against

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5. Manitoba Revised Regulations, P. 210, R 3, Div. 5, Section 170, Sub. 3.

sanitary risk, rendering the final condition unnecessary. If ejector use in small communities in northern Manitoba provides satisfactory, this final subsection should be deleted in respect of communities having widely-dispersed settlement patterns.

The use of Clivus-Multrum or Mullbank units may be governed or restricted under regulation 169 which states:

> Sewage from every building that is not connected to a public or common sewer shall drain into a septic tank or other approved type of treatment system. [6]

Thus, unless a Clivus or Mullbank were considered "approved manufactured closets", their use in residences would be illegal since they are not "septic tanks" and their use is not yet "approved". Section 23 of the regulation covers those systems which are subject to such approval:

> Patent, modified, chemical and pail-a-day closets or toilets may be installed only with the written permission of the Medical Officer of Health. The type, location, construction and installation is subject to the approval of the Medical Officer of Health. [7]

Thus, it seems that if the Medical Officer of Health believes that there is value in a composting system and that those systems would not constitute an insanitary condition under the definition used in the Act, he would approve their use. It should be noted that a

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6. Manitoba Revised Regulations, P. 210, R 3, Sec. 169, Sub. 7.

7. Ibid., Sub. 4.

permit must be obtained before any sewage disposal system can be installed. The Clivus and the Mullbank may therefore be implemented within the existing structure of the law.

Sewage ejectors, on the other hand, may be easily implemented in communities under a population of 300. However, their use in communities over 300 would be prohibited by regulation. A change in this regulation would be necessary before there could be widespread use.

The Medical Officer of Health and Public Health Inspectors would likely require assurances that no health hazard would occur and proof of the effectiveness of the system before permitting widespread use of these systems. There is, therefore, a need for pilot projects and ongoing monitoring programs of the systems once in use. Pilot projects are currently being carried out under the Department of Northern Affairs, Planning and Policy Development Section, into the effectiveness of these systems and whether they will prove satisfactory under northern conditions. If their non-experimental use becomes more widespread, the monitoring of these systems will probably fall within the jurisdiction of the Public Health Inspectors who would inspect the systems to make sure they were being used according to specifications and not abused.

Another area affecting the administrative feasibility of improving waste management in the north through the use of these systems is the allocational problems of implementation. The problem of choosing criteria to use in the allocation of scarce resources, and the decision as to which communities should be given priority for improved level of service is a difficult one. A comprehensive treatment of this problem is beyond the scope of this practicum,[8] but the author will attempt to bring to the fore some of the relevant considerations.

As previously mentioned, one important factor reflecting the need for improved waste management techniques is the incidence of enteric disease within each community. This would only be one fairly unreliable indication of a need for improved service since enteric diseases are as often a result of spoiled food as poor sanitation. Data have been obtained from the Health Service Commission which indicated the Consul region[9] and the unorganized territories are regions of high priority, having 17.24 and 19.48 incidences/1000 population of unspecified dysentery or diarrhea. Further direction can be obtained from the data available for the Indian Bands. A limitation of this set of data is that the disease may not have been contracted within the native community.

8. Ian Gillies is currently writing a practicum for the Natural Resource Institute dealing with this problem for improving the level of service for water supply.

9. The Consul Area is in the vicinity of The Pas.

The disease occurrence will be listed under the individual's Band no matter where he is living. This factor would probably affect the statistics evenly and likely would not nullify any priorities determined.

The Indian Bands show the highest rates for the enteric diseases. Incidence rates as high as 33 or 36 per thousand population are not uncommon compared with 4.6 per thousand for the province as a whole.[10] Bands showing the highest incidence rates include: Moose Lake (36.67), The Pas (33.33), Barrens Lands (28.33), Nelson House (24.00) and Mathias Colomb (23.75). It may also be noted that in the past year, outbreaks of SHIGELLA (a water-born enteric disease) have occurred in the communities of South Indian Lake, Gods River and Gods Lake.

Although health statistics cannot be used to determine conclusively which communities should be given priority for improved water supply or waste management, they are useful in denoting possible critical areas. One such area of high incidence appears to be in the vicinity of The Pas. It has the highest incidence rate for the Local Government Districts with 17.24 per thousand population. The Indian Bands surrounding The Pas have rates as high as 33.33 for unspecified dysentery. Cases of enteritis and

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10. Personal Communication with Mr. K. Kavanagh, Manitoba Health Services Commission, Statistics Division, 1974.

bacillary dysentery seem also to occur frequently in this area.

Another criterion for priorizing improved sewer services could be the size of populations within the communities as well as the degree of dispersion. The concept of "creating the greatest good for the greatest number" would imply that community services should be considered for the largest communities first. The present level of service and the availability of skilled personnel are also factors which will affect the allocation of limited funds for improved waste systems.

All of these criteria will play a role, not only in the distribution of innovative systems, but also in the increase of the level of service through other waste management improvements.

The administration of any waste management system would likely be further complicated by the split jurisdiction of many northern communities. Part of the community may be situated on reserve land and thus administered by the federal government's Department of Indian Affairs and Northern Development. The rest may be outside the reserve and thus within the jurisdiction of the Manitoba Department of Northern Affairs. Other communities may be solely within the jurisdiction of one or the other of these departments. Since most remote northern communities cannot generate significant "municipal" revenues, construction and perhaps operation and maintenance will likely be funded by provincial or federal bodies.

The capital costs for many communities would therefore have to be cost-shared by the federal and provincial government. This may be done on either a 50/50 basis or may be figured as a proportion of the populations within each jurisdiction. This is feasible for the alternate systems discussed in this paper. For more sophisticated and complex systems, the degree of government involvement would likely be greater. Systems which could more easily be operated and maintained by the community could serve to promote the autonomy of the community. In any case, a test of the three pilot waste management systems discussed in this practicum requires co-operation among a number of different bodies: the communities themselves, Band councils, the Department of Northern Affairs, the federal Department of Indian Affairs and Northern Development, the Department of Mines, Resources and Environmental Management (Environmental Protection Branch and Water Resources Branch), Environment Canada, Water Services Board, Department of Agriculture, and the Manitoba Housing and Renewal Corporation.

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

It seems that there are no serious technical obstructions to implementing these two waste management systems. Technical problems which do occur seem limited and solvable. All systems seem to be economically competitive with satisfactory conventional systems especially for communities with populations below 500-700. If social values such as environmental considerations were considered in the economic analysis, the innovative systems would likely appear more favourable. Sociological problems of possible misuse and unacceptability could be alleviated by long-term educational programs which deal with sanitation issues as well as including an orientation in the use and maintenance of the actual system at the time of its installation. Social acceptability is difficult to predict because of the myriad factors involved. Pilot projects are extremely valuable as an aid in determining social feasibility.

The usefulness and feasibility of each of the systems varies with the community under consideration. In general, these systems are most economical for those communities with relatively small populations or widely dispersed settlement patterns. Communities with populations in excess of 700-1000 may find the level of service and costs of community-wide systems more satisfactory.

The alternate systems have further advantages in that the costs can be estimated quite accurately, and capital cost recovery is easy should the community enter a period of decline.

Clivus-Multrum composting units seem best-suited for installation in new homes in small communities with shallow (about 6') depths of overburden. Electrically-assisted toilets are particularly applicable to new or existing homes of four or less individuals which are located on bedrock or severely undulating overburden in readily-accessible areas.

The sewage ejector system seems well-suited under present regulations to homes in communities of less than 300 people with widely-dispersed spatial arrangements and bush or treed areas nearby. A combination of the three systems, depending on the suitability for each house, could give a higher level of service than a uniform policy for the community. All the systems are viable alternatives for seasonal operations, such as fishing camps, hunting lodges, and fly-in resorts.

The three systems may also prove useful in more southerly areas of Canada where there are impermeable soil layers or fluctuating water-tables.

Bearing the major government objectives of increasing the health and standard of living of the northern residents in mind, it is important to give a trial to as many alternatives as possible since some may prove acceptable and desirable for certain sets of conditions. The greater the number of options available for each specific site, the more successful will be a comprehensive waste management program for the north as a whole. There are many alternatives other than the three considered in this practicum which may prove feasible when examined with the technical, economic, social and administrative criteria in mind. Some of these include the use of swamplands and aquatic vegetation for taking up nutrients from sewage; the use of sewage effluents for commercial hydroponics ventures; overland flow systems, and rotating biological filter systems. A greater diversity of systems will contribute to the knowledge of waste management in the north.

A mechanism is necessary to enable the communities to priorize their own needs and communicate them to the agencies which can bring about changes in the services available to the residents. This would require the co-operation of the community representatives and various levels of different governments and would be an important factor in attaining the objectives of northern programs as a whole to promote self-determination in the direction of community development. If waste management could be expressed and discussed in the context of increasing the responsibility of communities for their own destiny, a consistency of objectives would occur with many of the other agencies and programs presently operating.

APPENDIX I

Present Levels of Service and Populations of Manitoba Northern Communities

Community	Population	Level of Service[1]	
Anama Bay	296	Homes Frontier School Nursing Station	Outhouses Nodak Field Nodak Field
Barrows	198	Homes Frontier School	Outhouses Nodak Field
Berens River	942	Homes Frontier School	Outhouses Treatment Plant
Bisset	148	Homes Frontier School	Outhouses or septic tank and field Septic Tank
Big Black River	43	Homes	Outhouses
Brochet	822	Homes D.I.A.N.D.[2] School Nursing Station	Outhouses Outhouse Septic Tank and Field
Bloodvein	373	Homes D.I.A.N.D. School	Outhouses Lagoon
Camperville	546	Homes	Outhouses

[1]Obtained from "Material for a Sewer and Water Policy for Manitoba's Remote Communities," Ian Gillies, Summer, 1974.

[2]The federal Department of Indian Affairs and Northern Development.

APPENDIX I (continued)

Community	Population	Level of Service	
Cormorant	451	Homes Frontier School Nursing Station	Outhouses Lagoon Chemical toilet
Crane River	485	Homes Frontier School	Outhouses Lagoon
Cross Lake	1,197	Homes D.I.A.N.D. School Nursing Station	Outhouses Treatment plant Septic Tank and Field
Dallas		Homes	Outhouses
Duck Bay	543	Homes Frontier School	Outhouses and Chemical Toilets Septic Tank and Field
Easterville	506	Homes D.I.A.N.D. School Nursing Station	Outhouses and Septic Fields Lagoon -
Fisher River	1,178	Homes D.I.A.N.D. School	Outhouses Lagoon
Garden Hill	1,288	Homes D.I.A.N.D. School Nursing Station Agency	Outhouses Lagoon Unknown Treatment plant
God's Lake Narrows	1,163	Homes D.I.A.N.D. School Nursing Station	Outhouses Treatment Plant Septic Tank/Field
God's River	214	Homes D.I.A.N.D. School Nursing Station	Outhouses Septic Tank/Field Septic Tank/Field

APPENDIX I (continued)

Community	Population	Level of Service	
Granville Lake	74	Homes	Outhouses
		D.I.A.N.D. School	Septic Tank/ Field
		Nursing Clinic	Unknown
Ilford	232	Homes	Outhouses
		Frontier School	Septic Tank/ Field
		Station-Hotel	Septic Tank/ Field
		Community Hall	Septic Tank/ Field
Jackhead	313	Homes	Outhouses
		D.I.A.N.D. School	Nodak Field
		Nursing Station	Septic Tank/ Field
Little Black River	234	Homes	Outhouses
		D.I.A.N.D. School	Septic Tank/ Field
		Nursing Station	Chemical Toilet
Little Grand Rapids	722	Homes	Outhouses
		D.I.A.N.D. School	Treatment Plant
		Nursing Station	Septic Tank/ Field
Loon Straits	33	Frontier School	Septic Tank/ Field
Manigotogan	147	Homes	Outhouses
		Community Building	Septic Tank/ Field
Matheson Island	66	Homes	Outhouses
		Frontier School	Septic/Field
Moose Lake	750	Homes	Outhouses
		Frontier School	Treatment Plant
		Store	Septic Tank/ Field

APPENDIX I (continued)

Community	Population	Level of Service	
Nelson House	1,504	Homes D.I.A.N.D. School Nursing Station	Outhouses Septic Tank/ Field Septic Tank/ Field
Norway House	5,328	Homes D.I.A.N.D. school, Hospital R.C.M.P.	Outhouses Treatment Plant
Oxford House	880	Homes D.I.A.N.D. School Nursing Station	Outhouses Septic Tank/ Field Septic Tank/ Field
Paungassi	201	Homes D.I.A.N.D. School	Outhouses Septic Tank/ Field
Pelican Rapids	217	Homes Frontier School	Outhouses Septic Tank/ Field
Pikwitonei	255	Homes Frontier School Nursing Station	Outhouses Nodak Field Pail-a-day
Pine Deck	98	Homes Frontier School	Outhouses Nodak Field
Poplar River	439	Homes D.I.A.N.D. School Nursing Station	Outhouses Treatment Plant Septic Tank/ Field
Princess Harbour	47	Homes Frontier School	Outhouses Septic Tank/ Field

APPENDIX I (continued)

Community	Population	Level of Service	
Pukatawagan	967	Homes D.I.A.N.D. School Nursing Station	Outhouses Lagoon Lagoon
Red Deer Lake	65	Homes	Outhouses
Red Sucker Lake	233	Homes D.I.A.N.D. School	Outhouses Treatment Plant
St. Therese Point	951	Homes D.I.A.N.D. School Nursing Station	Outhouses Septic Tank/ Field Septic Tank/ Field
Shamattawa	256	Homes D.I.A.N.D. School Nursing Station	Outhouses Outhouses Septic Tank/ Field
Sherridan	177	Homes Frontier School	Outhouses Septic Tank/ Field
South Indian Lake	590	Comprehensive system under construction	
Split Lake	635	Homes D.I.A.N.D. School	Outhouses Treatment Plant
Thicket Portage	318	Homes Frontier School Nursing Station	Outhouses Lagoon Septic Tank/ Field
Wabowden	809	Homes Trailer Court Nursing Station	Outhouses Lagoon Holding Tank/ Lagoon

APPENDIX I (continued)

Community	Population	Level of Service	
Warren's Landing	36	Homes Frontier School	Outhouses Septic Tank/ Field
Wasagomach	389	Homes D.I.A.N.D. School Health Centre	Outhouses Septic Tank/ Field Septic Tank/ Field
York Landing	65	Homes D.I.A.N.D. School Nursing Station	Outhouses Outhouses and Septic Tank/ Field Septic Tank/ Field

APPENDIX II

Specifications of Alternative Systems

Clivus-Multrum

Dimensions:	Length	-	2.95 m (9.60 feet)
	Width	-	1.20 m (3.94 feet)
	Height	-	2.50 m (8.20 feet)
Total Shipping Volume			
if shipped complete		-	224.53 - 247.19 cu. feet
if shipped dis-assembled[1]		-	161.38 cu. feet
Shipping Weight		-	1,439 pounds.

Mullbank Toilet

Dimensions:	Length	-	30 inches
	Width	-	21 inches
	Height	-	28 inches
	Weight	-	55 pounds
area needed		-	21 x 45 inches of floor
maximum power input		-	250 watts
average daily con-sumption		-	3 - 4 kilowatts suggested by manufacturer
vent kit		-	one P.V.C. coupling
		-	two P.V.C. 45^{o} elbows
		-	two 10' sections of 2" I.D. P.V.C. pipe
		-	two 6' sections of insulation.

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[1]Shipping costs may be further reduced by nesting the components. By nesting, 7 units may be shipped in the volume otherwise taken by 2 units.

APPENDIX III

Costs of Conventional Systems

1.	Outhouse Construction	$	250*[1]
2.	Septic Tank and Field Installation	$	2,400*[2]
	Septic Tank and Field Plumbing	$	500 [3]
	Annual Operating and Maintenance	$	50
3.	Chemical Option		
	(a) Pot-pourri Unit	$	70*[4]
	Installation and Transportation	$	110
	Annual Costs (Chemicals and receptacles)	$	260
	Costs "Gray-Water" System	$	1,000 [5]
	(b) Chemical Toilet with Tank		
	Unit and Installation	$	380*[6]
	Annual Costs (Chemicals and Emptying)	$	780
4.	Combustion		
	Unit and Installation	$	1,140*[7]
	Annual Costs (Propane, Maintenance, etc.)	$	440
	Gray-Water	$	1,000

Piped and Truck system will vary for different communities.

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*1 Used by Water Resources Branch, Department of Mines, Resources and Environmental Management and from personal communication with Mr. R. Stokes, Manitoba Water Services Board.

*2 Estimated from personal communication with Bunner and Campbell Plumbing and Heating, Winnipeg, Manitoba.

Julius Eliass, Plumbing Contractor, Winnipeg, Manitoba. Mr. R. Stokes, Manitoba Water Services Board, Mr. M. McKernan, Consultant, Winnipeg.

*3 Plumbing costs do not include water supply but do include bathtub $100, flush toilet $75, sink $30, pipes and fittings $55, transportation and installation $180, contingencies $40. Figures were obtained from Sutherland Buyers Catalogue, 1974.

*4 Eatons of Canada

*5 For all conventional systems requiring a system to handle washwater, the figure used is an average for a soak pit ($100), ejector system ($900), and tank and field ($2,000). The expenses for a tank and field would be less than if the system were handling sewage as well.

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[6]Estimates made by Water Resources Branch, Department of Mines, Resources and Environmental Management.

[7]Estimates made by Water Resources Branch, Department of Mines, Resources and Environmental Management.

APPENDIX IV

Costs of Alternative Systems

1. Clivus-Multrum composting unit.

unit	$1,300
shipment from U.S.A.	$ 360
Toilet	$ 50
vents, chutes, insulation, peat, heat type and thermostate	$ 350
F.O.B. Winnipeg	$2,060
transportation and installation in community	$ 340
Contingencies	$ 240
Total Cost	$2,640
Gray-Water system	$1,000
	$3,640
Annual costs power	$ 10
maintenance/repairs	$ 10
	$ 20

2. Mullbank Toilet

Unit	$ 630
Vent-Pipes, insulation	$ 70
Transportation and Insulation	$ 300
	$1,000

Contingencies	$ 100
	$1,100
Gray-Water System	$1,000
	$2,100
Annual costs - power	$ 20
maintenance	$ 20
	$ 40

Sewage Ejector

Tank, ejector, piping	$	700
installation and transportation	$	600
heat tape	$	380
plumbing	$	500
fence	$	100
		$2,280
Contingencies	$	220
		$2,500
Operating and Maintenance including pump-out of tank	$	50

APPENDIX V

Summary of Cost Estimates for Proposed

Systems for Northern Communities

Cross Lake (Pipeline System and Lagoon)

Sewage lagoon	$ 35,000
Service lines if in same trench as water distribution 5300 line-feet @ $10/ft..............	$ 53,000
Manholes, lift station	$ 35,000
1,500 feet of insulated forcemain	$ 18,000
Contingencies 10% and engineering 15%	$ 28,000
Bringing service to the home and plumbing	$ 68,800
	$237,800

Annual Costs

Debt retirement (237,800 over 20 years)	$ 55,645
Operating and maintenance on lagoon	$ 1,000
Operating and maintenance of lift-station and sewer lines (including partial salary of operator who would also look after water supply)..	$ 7,000
	$ 63,645

Moose Lake (Truck Sewage Collection and Lagoon)

Capital Costs

Sewage lagoon	$ 50,000
Holding tank and plumbing	$187,000
Trailer, tank and pump	$ 6,000
Garage	$ 10,000
Contingencies	$ 25,000
	$284,500
Tractor (shared with water supply)	$ 6,000
	$290,500

A Annual Costs

Debt retirement (284,500 over 20 years)	$ 33,286
debt retirement on tractor (6,000 over 8 years)	$ 1,124
Operating and maintenance tractor/trailer	$ 2,000
Operating and maintenance on lagoon	$ 1,000
Plant operator/tractor driver salary	$ 5,000
Plant helper salary (part-time)	$ 2,500
Heat, power, miscellaneous	$ 2,250
	$ 47,160

Manigotogan (Truck Sewage Collection and Lagoon)

Capital Costs

Sewage lagoon	$ 40,000
Holding tank and plumbing	$ 50,000
Trailer, tank and pump	$ 6,000
Garage	$ 10,000
Contingencies	$ 10,000
	$116,000
Tractor (shared cost with water supply)......	$ 6,000
Total	$122,000

Annual Costs

Debt retirement (116,000 over 20 years)	$ 13,572
Debt retirement of tractor (6,000 over 8 years)..	$ 1,124
Operation and maintenance of lagoon	$ 1,000
Operation and maintenance on trailer/truck	$ 2,000
Plant operator/tractor driver salary (shared with water supply)	$ 5,000
Plant helper salary (part-time)	$ 2,500
Heat, power, miscellaneous	$ 2,000
	$ 27,196

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