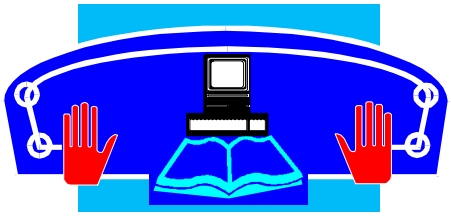

Guidelines For The Planning, Design, Operation & Maintenance Of Solid Waste Modified Landfill Sites In The Northwest Territories
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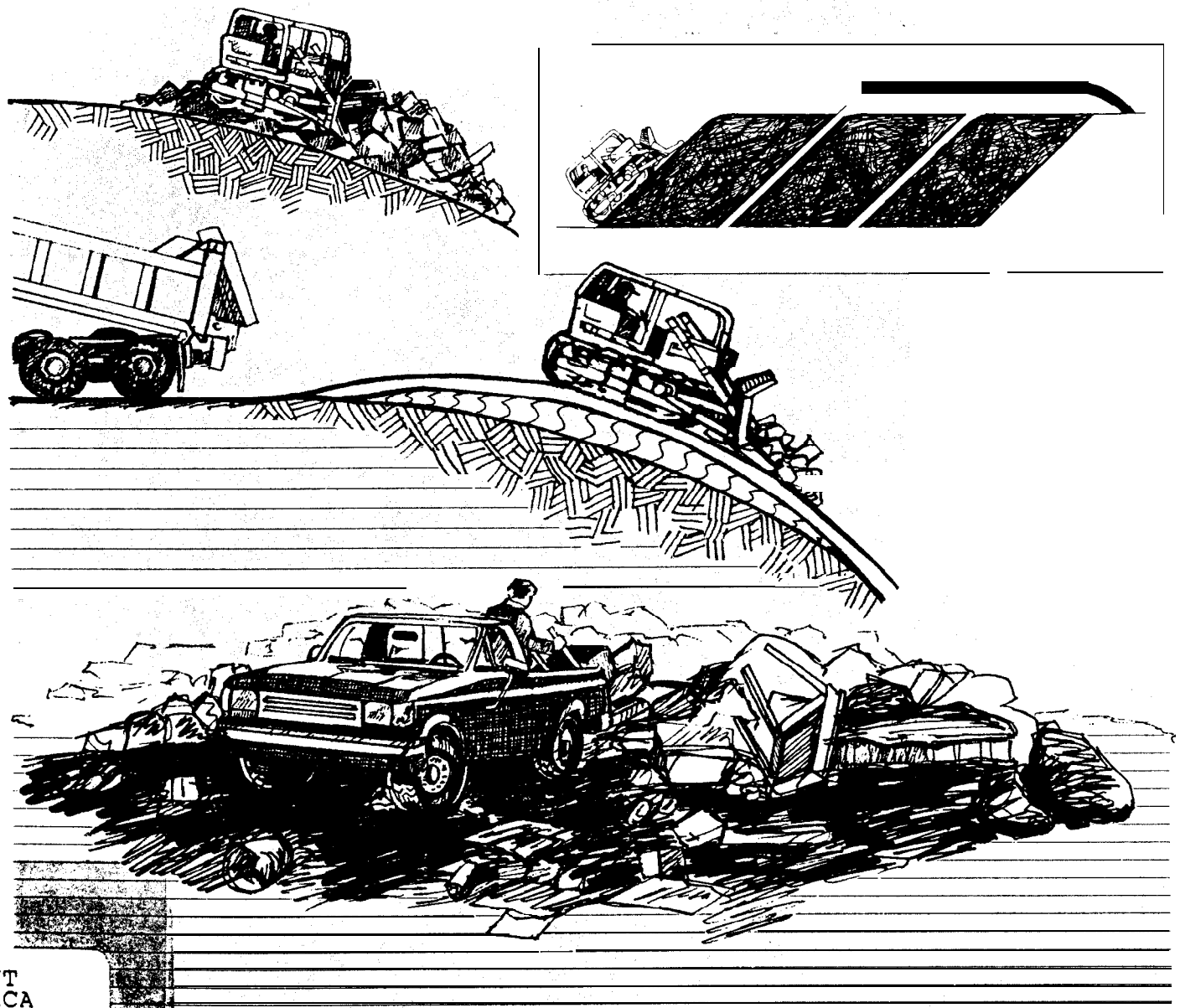
Volume I: Planning & Design
Gary W. Heinke, Ph. D., P.Eng. & Jeffrey Wong



Northwest Territories Municipal and Community Affairs
March 1990

GUIDELINES FOR THE PLANNING, DESIGN, OPERATION, AND MAINTENANCE OF SOLID WASTE MODIFIED LANDFILL SITES IN THE NORTHWEST TERRITORIES

VOLUME I: PLANNING AND DESIGN

For the

Department of Municipal and Community Affairs

Government of the Northwest Territories

By

Gary W. Heinke, Ph.D., P.Eng.

Jeffrey Wong

March 1990

FOREWORD

This document (Volume I) was developed to establish planning and design guidelines for solid waste modified landfill sites. Its companion document, Volume II: Operation and Maintenance provides detailed guidance on these issues.

Volume I has been prepared to assist consultants with the planning and design of solid waste modified landfill sites for communities of the NWT. It will also be helpful to community officials who require knowledge of the planning and design process.

Separate guidelines for the collection, treatment and disposal of hazardous and bulky wastes are in the process of being developed by the Government of the NW'T.

ACKNOWLEDGEMENTS

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1. OBJECTIVES OF GUIDELINES

1.1 PURPOSE OF STUDY

The open dump/landfill is the most often used method of solid waste disposal by communities of the Northwest Territories. The main reasons for this are its low cost, low maintenance needs, and lack of a suitable alternative. Basically, the method involves dumping the waste at a designated site and covering it periodically with local cover material. Despite its apparent simplicity, this method can be an effective means of waste disposal particularly in smaller communities where the volumes of generated wastes are too little to require daily covering. Generally, if the open dump/landfill site is properly managed, it can prove to be a practical and safe alternative.

The advantages associated with the open dump/landfill quickly lose their appeal if these sites are plagued by mismanagement, or even worse, outright neglect. Large piles of garbage indiscriminately dumped and left uncovered for an extended period of time are not only aesthetically unpleasant, but they could also become a source of disease through insect and animal vectors. In some situations, the problems may be resolved by relatively simple solutions, such as, erecting a fence to keep the animals out or, "cleaning up" the site. Under other circumstances, the solutions may not be so simple. Problems of drinking water contamination, air pollution, airplane safety, and environmental degradation are significant problems requiring more effective solutions. To deal with these problems, some communities have found the need to redesign their disposal sites while others have found it necessary to redesign and relocate them. In either case, it has been recognized that implementation of an acceptable management program is essential to the efficient operation of an effective waste disposal site.

A method of waste disposal which has been used with some degree of success by a number of communities in the NWT is the modified landfill. The modified landfill is an engineered landfill. All aspects of the disposal site from planning, to design, to operation and maintenance are 'engineered'. Wastes are deposited at a designated location and are compacted and covered on a regular basis. The modified landfill is designed to reduce the potential for hazards and nuisances to people and the environment in an economic manner.

The GNWT has recognized that there is a need for a set of guidelines to assist administrators, planners, engineers, government officials, and others in the planning, design, operation, and maintenance of a solid waste disposal site. It is the purpose of this study to show that a modified landfill is the most effective waste disposal method for communities in the Northwest Territories and to establish guidelines for its planning, design, operation, and maintenance.

1.2 OBJECTIVES OF GUIDELINES

The objectives of the guidelines are as follows:

(1) to identify and evaluate the modified landfill method and any alternatives to it in their application to communities in the NWT,

(2) to outline the conditions under which a modified landfill is feasible,

(3) to provide parameters to guide the planning and design of a solid waste modified landfill site.

The operation and maintenance aspects are the subject of Volume II, which is prepared as a separate document.

1.3 ORGANIZATION OF VOLUME I

These guidelines are set out in a logical progression from the planning study to the detail design stage.

Section 2 provides a general description of the current state of solid waste disposal in the NWT. For specific information on a particular community, the reader is directed to a separate report entitled "An Update of the Status of Solid Waste Management in Communities of the Northwest Territories, by G.W. Heinke and Jeff Wong, December 1990 [4b]. A special questionnaire on solid waste disposal was prepared for all communities. For those that responded, the information is included in that report.

Section 3 describes the objectives of a solid waste management system.

Section 4 outlines alternative solid waste disposal methods with emphasis on methods which are feasible under the restricting conditions of NWT communities.

Section 5 provides guidelines for the planning of the disposal site. It considers community conditions such as population, waste characteristic and volumes, and design life. A detailed out I i ne of the siting criteria is included in this section.

Section 6 provides guidelines for the detailed design of the modified landfill disposal site. It includes the three types of modified landfill methods and provides detailed designs of the disposal areas, access roads, site drainage, and fencing.

Section 7 is. a regulatory review.

In larger communities oil drums are emptied directly onto the collecting vehicle for transport to the dump site. In som smaller immunities the drums are transported to the dump where they are emptied and then returned to the residences. Some residents prefer to haul their own garbage to the disposal site despite the availability of regular service.

Honey bags are considered a solid waste, however, they are not collected along with the domestic solid wastes nor are they to be disposed of with the domestic solid wastes: Residents place honey bags in separate containers, often oil drums cut in half, and placed by roadside for collection. The GNWT plans to phase out the honey bag system within ten years, replacing it with holding tanks or piped systems. It is probable that not all communities maybe converted to these systems within this time period and as such, provisions should be made to accommodate honey bag disposal in future plans where applicable.

Once a year, following snowmelt, each community organizes a spring clean-up to collect and dispose of loose refuse which has accumulated about the community during the winter months. Also during this period, metal wastes and large, bulky items such as old appliances or discarded snowmobiles are disposed of by the collection crews.

2.3 SOLID WASTE DISPOSAL SITE

The solid waste disposal site is often a neglected area of a community's municipal services, receiving only a fraction of the attention or funding required to properly locate and maintain it in a safe and efficient manner. In the past, solid waste disposal sites were frequently located close to the community for economic reasons, without consideration for the potential problems of smoke nuisances, water contamination, health risks, aircraft safety, and aesthetics. The effects of such neglect are evident today as increasing pressures from concerned residents have forced some communities to close inadequate disposal sites prematurely and to establish new sites designed and located to avoid such problems. Furthermore, the Ministry of Transport has indicated that many of the existing sites do not meet current regulations of minimum distance from airports. A separate study is under way to clarify/modify the existing MOT regulations as applied to N.W.T. airports. This study [7] is not yet completed, but should be consulted before locating a new disposal site.

Most communities in the Northwest Territories dispose of solid wastes at an open dump/landfill. This involves piling waste at a designated site and occasionally burning the piled waste to reduce volume. If local cover material is available, the piled waste may be covered to prevent the spread of wind blown debris and scavenging by animal and insect vectors. This method of solid waste disposal is widespread since it requires little or no initial site preparation and minimal maintenance requirements. For some communities, severe climatic conditions and the lack of available cover material or equipment has rendered open dumping the only method currently possible.

The Department of Municipal and Community Affairs has stipulated in their General Terms of Reference for Solid Waste disposal that a modified landfill disposal method is the minimum acceptable solid waste disposal system [3].

The type of community refuse generated is dependent upon the extent and type of activities in the community. For most small communities in the Northwest Territories, solid waste is primarily domestic in source and characteristics. Since combustible materials comprise the greatest proportio n of domestic waste, burning is frequently practised at the disposal site to reduce volume.

Non-combustible items, such as discarded vehicles, machinery, and other bulky wastes have a tendency to accumulate. These are segregated from the other wastes at the disposal site and can be a visual nuisance if they are not disposed of in an orderly manner.

2. EXISTING SOLID WASTE DISPOSAL SYSTEM

2.1 INTRODUCTION

An effective solid waste disposal system should provide an efficient means of waste disposal without harming public health or the environment. This should be achieved in a manner which is considered 'aesthetically acceptable by the community. In principle, this concept appears simple but in practice it is difficult to realize. This is particularly true for many of the communities of the Northwest Territories who, for reasons unique to their Arctic environment, generally do not currently practice effective nor efficient solid waste disposal.

The problem of solid waste disposal has improved in recent years. Concerns over public health and increasing environmental awareness has prompted some communities tore-assess their solid waste disposal systems. Consequently, old disposal sites which proved to be inadequate or had reached the limit of their useful lives are now being replaced by better planned landfill sites.

The following discussion outlines the current system of solid waste collection and disposal in the Northwest Territories and addresses some of the major concerns with the existing system. This is a general description of the solid waste disposal system for the N.W.T. and individual communities may deviate from this description due to unique circumstances. For detailed information about a particular community, the reader is referred to the community profiles in the report entitled "An Update of the Status of Solid Waste Management in Communities of the Northwest Territories" [4b].

2.2 SOLID WASTE COLLECTION SYSTEM

An important objective of any system of solid waste collection is to transport wastes from their point of generation to a disposal site in a safe and effective manner. This may be achieved in a number of different ways. Communities of the Northwest Territories have developed a common method of solid waste collection which has proven to be adequate considering the severe climatic conditions, equipment limitations, and the type of wastes generated.

Empty 205 L oil drums are commonly used to store garbage prior to collection. Oil drums are readily available in any northern community and are large enough to hold several days accumulation of garbage. Furthermore, the oil drums will not be easily blown over by strong winds and can be used as safe containers for burning combustible wastes in communities where burning of wastes for the purpose of volume reduction is permissible. Some communities, particularly most Kitikmeot Region communities, have established by-laws to eliminate the practice of burning of wastes in oil drums at the home, in order to eliminate the smoke and fly ash from blowing over the community. Residents place domestic wastes in these oil drums at roadside in front of their homes. In some communities, the oil drums are placed on truck-height stands, one or two stands per block.

Garbage is collected on a regular basis, with the frequency varying amongst the different communities depending on the size of the community and the prevailing weather conditions. The Department of Municipal and Community Affairs recommends that a minimum level of service of once weekly is sufficient to maintain acceptable sanitary and aesthetic conditions within a community [3]. In larger communities, collection occurs at least two times per week. The type Of collection vehicle also depends on the size of the community. The collection vehicle may range from an open cart pulled by a truck to a full-sized packer truck. Pick-up trucks and side loading Haul-All units are commonly used to collect solid wastes in many of the communities.

Honey bags present a special problem for disposal. In some communities honey bags are treated as a liquid waste, so they are disposed of at the lagoon site. In other communities, honey bags are considered a solid waste and are taken to the solid waste site for disposal. The Department of Municipal and Community Affairs recommends that they be categorized as solid wastes [3], consequently any new construction in communities where the honey bag system operates must include in its plans a separate area for honey bag disposal.

2.4 CONCERNS OF EXISTING SYSTEM

Concerns of the existing solid waste disposal system are: i) proximity to airports, ii) planning and design concerns, and iii) operation and maintenance concerns.

2.4.1 Proximity to Airports

An issue of particular concern to the Territorial government is the separation of solid waste disposal sites and airports. In its Manual of Airport Bird Hazard Control, Transport Canada recommends that garbage dumps containing food garbage should not be located within an 8 km radius of an airport [8], for reasons of potential danger from bird flocks to aircraft. At the present time, of the NWT disposal sites conform to this guideline. If the guideline were to become a regulation, the capital costs associated with relocating the site and constructing new access roads would be very substantial. In addition, the fate of any future solid waste disposal projects could be affected. Based on a separate study [7] discussions are under way between the government of the NWT and Transport Canada to clarify and resolve this issue. The findings should be incorporated into a future edition of these guidelines.

2.4.2 Planning and Design Concerns

The following planning and design concerns are recognized: location, area required, cover material, fencing and oil disposal.

Location

Poorly located solid waste disposal sites present numerous problems for operators and community residents alike.

- Too close to the community
  - unpleasant odor or smoke
  - aesthetically unpleasant
- Too close to important bodies of water
  - community water supply
  - fishing
- Too far from the community
  - cost of building and maintaining access road
  - travel time between disposal site and community
- Inaccessible
  - access road is restricted by blowing snow or flood waters

8. Eight communities did not respond to the questionnaire. Nine other communities, who responded, did not provide sufficient information in order to judge the acceptability of their waste disposal facility. Together they represent 28% of the NWT communities. Another attempt should be made to complete the survey.

TABLE 2.1 COMPARISON OF STATUS OF SOLID WASTE DISPOSAL FACILITIES

	Christensen 1982 [2]	Heinke & Wong 1990 [4b]
Public Health Deficiency	58% (35/62)	18% (8/44)
Environmental Deficiency	32% (20/62)	11% (5/44)

The 1982 study by Christensen of the Water and Sanitation section of the NWT Government revealed that 58% of the solid waste disposal facilities had public health deficiencies while 32% had environmental deficiencies. Typically, public health deficiencies were related to a generally uncontrollable solid waste disposal site or a lack of bagged sewage segregation at the site, whereas environmental deficiencies involved poor management capability or an unorganized self haul system of waste disposal. It should be pointed out that the 1982 study did not carry out a questionnaire survey. Assessments were made based on the basis of existing records in Yellowknife.

It should also be pointed out that in the 1990 study by Heinke and Wong [4b] it was not possible to include nine communities in the assessment because of insufficient information in the completed questionnaire. Furthermore, no responses were received from eight communities. There, no judgement can be made about public health or environmental deficiencies in 17 communities or 28% of the 61 NWT communities. Therefore, a direct comparison with the 1982 Christensen study is difficult to make. The comparison shown in Table 2.1 is only for the 44 communities for which adequate information was available from the survey. It appears that a significant reduction in both public health deficiency and environmental deficiency has occurred.

3. OBJECTIVES OF SOLID WASTE MANAGEMENT

3.1 BASIC OBJECTIVES

3.1.1 Public Health and Safety

The primary objectives of any solid waste management system, regardless of climatic conditions, are to collect and dispose of wastes in a manner which protects the public health and achieves this through safe and economic means. Potential health risks exist at all stages of the waste management system from storage to collection to disposal, although some have more deleterious effects than others.

Wastes left uncovered in storage barrels or at open dump sites provides a food source for disease vectors. Under the proper conditions, infestations of disease carrying bacteria, insects and rodents will breed and increase the risk of disease transmission to humans. It should be an objective of a waste management system to minimize the potential for vector breeding through proper disposal of wastes.

Communicable diseases transmitted from human faecal wastes remains a concern of many communities that still rely on the honey bag system of human waste disposal for all or part of their disposal needs. Although the system has been planned to be phased out within the next ten years in favour of piped or pumpout methods, it is unwise to assume that it will be phased out completely. Consequently, the health implications associated with broken bags or improper disposal methods through direct or indirect contact must be considered in the planning of these waste management systems where a honey bag system is likely to exist in the future.

Burning of combustible wastes is frequently practised by individuals in open drums and by operators at the disposal site. This has the advantage of reducing the volume by 40-70 percent; a significant amount when collection may be suspended for days as a result of inclement weather conditions. The smoke generated can be a nuisance to residents of the community. Smoke from open burning contains chemicals that are known to be irritants to the eyes and human respiratory system and some are considered to be carcinogenic. Any nuisance caused by smoke will be aggravated during periods of atmospheric inversion conditions.

Of particular concern to public safety is the potential danger from bird flocks to aircraft. Since solid waste disposal sites may increase the number of birds in the area, appropriate separation distances between airports and solid waste disposal sites must be required.

3.1.2 Environmental Protection

Any solid waste management program must consider environmental impacts, as improper design and operation can lead to environmental damage. Since all solid waste disposal operations will have some impact on the local environment, it should be an objective of the management program to minimize this impact.

The degree to which a solid waste disposal site can adversely affect the environment is influenced by the characteristics and quantities of wastes, and site location. In general, municipal solid waste disposal operations in small communities produce relatively little environmental impacts. Data collected on the characteristics of garbage in northern communities reveals that 65 percent of domestic solid waste is composed of non-hazardous paper and food wastes. In many communities, the greatest problem stems from the burning of garbage and the adverse effects of smoke and soot. In others, surface and groundwater contamination may be an additional concern.

The collection and disposal of hazardous wastes with normal community wastes is normally not permitted, nevertheless small quantities of hazardous wastes such as paint and discarded batteries are sometimes collected and disposed of with normal community solid waste. A separate report **[10]** deals with the possible co-disposal of some hazardous wastes in modified landfill sites.

In 'assessing the environmental impact of a waste disposal site field investigations need to be carried out. Abnormalities in growth or colour of vegetation caused by vegetation stress, smoke from burning garbage, soot, dust, gas and odour are some of the more visible impacts that can be observed on a routine site evaluation. If the problem is thought to be severe, a water sampling program and/or a leachate collection and analysis program may be necessary.

The outcome of the aforementioned tests may result in a need for further detailed hydrogeological studies depending on the size of the site and extent of the problem, or it may be necessary to provide site modifications or change operating procedures to control adverse environmental effects.

3.1.3 Aesthetics

Maintaining or enhancing the aesthetics of a community is an objective of secondary importance for an effective solid waste management system.

Freezing temperatures, untrained personnel, frozen ground and a lack of cover material are no longer sufficient excuses for improper waste disposal. Clean work places, homes, and communities are important for the morale of the residents. This is most clearly reflected in some communities by the annual spring clean up. During the winter, garbage that had not been collected because of adverse conditions is often mercifully buried or frozen in snow only to be exposed during spring melt. The accumulated wastes produce such public disfavour that annual spring clean ups are organized to rid the community of the wastes in a proper manner.

Open dumps, in addition to being an eyesore for the residents of a community are also a source of blowing paper, dust and odour. General negligence and a lack of proper containment facilities result in public disfavour and concern. This is a particular concern in smaller communities where the disposal site is often located adjacent to the main road leading to the community and presents a glaring eyesore for residents and visitors alike. Exposure to such negligence breeds carelessness and eliminates any incentive to keep the community clean. An effective solid waste management system should promote a responsible attitude toward solid waste disposal by example.

3.2 DISPOSAL OBJECTIVES

3.2.1 Reduce Air Pollution

There are generally two types of emissions that may result from solid waste disposal sites; gaseous and particulate.

Gaseous emissions are mostly produced by biodegradation of organic material. The quantity and quality of gas released is primarily determined by the type and extent of microbial activity and its opportunity for reaction within the landfill or surrounding environment. Over 90 percent of the gas volume produced is methane and carbon dioxide. Both gases are potentially harmful. Methane can diffuse through the relatively porous fii material and may accumulate to explosive concentrations. Carbon dioxide is soluble in water and reacts to form carbonic acid which can dissolve mineral matter, particularly carbonates in refuse soil and rock.

In cold climates, levels of gaseous emission are not significant since the cold climate makes biological degradation of putrescible matter extremely slow. Hence, gaseous emissions from solid waste modified landfill sites in northern communities are not as important an issue as it is in more temperate regions.

Of greater concern are particulate emissions. Controlled open burning is permissible at disposal sites of all NWT communities. In the majority of the communities, open barrel burning is permissible. The resulting smoke contains sizeable particles of soot and pieces of charred paper. Such particulate are a nuisance in that they will soil whatever they happen to land on and cause reduced visibility for motorists. If the airport is located close to the disposal site as is often the case in northern communities, blowing smoke across the runway may produce dangerous visibility problems for pilots.

3.2.2 Reduce Water Pollution

The potential for surface and groundwater pollution has been one of the primary environmental concerns associated with the land disposal of solid wastes. Factors such as location, nature of wastes deposited, and substandard operational procedures are recognized as principal contributors to the problem of groundwater pollution.

The contaminated liquid effluent produced at waste disposal sites is referred to as leachate. The composition and quantity of leachate is affected by the type of waste deposited and the manner in which they are landfilled, the climatic and hydrogeological characteristics, and the conditions of the landfill itself; age, chemical and biological activity, moisture, pH. These conditions can be expected to vary, thus leachate characteristics can vary significantly from one site to another or within a site.

There are several mechanisms by which contaminants are leaching from a waste disposal site:

downward movement of surface water into the solid waste,
mixing of liquid and solid wastes, and
contact of buried waste with the water table.

As leachate percolates through the underlying strata, many of the organic, inorganic and biological constituents originally contained in it will be removed by the filtering and adsorption properties of the materials of the strata. The extent of this action depends on the characteristics of the soil, especially the clay content. It is neither correct nor safe to assume that leachate will be diluted by ground water since very little mixing occurs in aquifers as flow is laminar.

In order to reduce the risk for groundwater pollution, it is necessary to understand the way biological, chemical and physical characteristics of the soil and geologic materials interact with the wastes. Also, a knowledge of the amount and projected use of water resources of the area and the direction of groundwater movement is essential.

3.2.3 Improve Aesthetics

The severe climate combined with permafrost soil or rock prevent the majority of the communities from operating a sanitary landfill. Although the engineered disposal site is receiving increased popularity, by far the most common form of solid waste disposal in NWT communities is still the open, uncontrolled garbage dump. As long as the great majority of these sites remain accessible to users any time of day or night, without any form of supervision, it can be expected that disposal sites will be messy and aesthetically unfavorable.

By locating the site out of view and downwind of the community, the aesthetics of the surroundings can be vastly improved. However in situations where economics or resources dictate site location, other mechanisms of improving aesthetic values must be evaluated. Regardless, the basic objectives are to control odour, control blowing paper and trash, and to achieve this in a clean and orderly manner.

Well defined storage and disposal areas are essential at all disposal sites and are found in most small communities and certainly in the larger communities. Clear, concise signs to define storage and disposal areas and the types of wastes to be deposited in each area are beneficial for the users and aid in the orderly disposal of wastes.

When a disposal site has reached capacity, steps must be taken to ensure that the facility is properly closed and that the general aesthetics of the area are restored.

3.2.4 Reduce Scavenging

Scavenging at unsupervised community disposal sites not only endangers the health and safety of individuals but it may also lead to the possibility of liability claims against the owner or operator of the disposal site. For these reasons it is to the best interest of all parties concerned to consider methods by which scavenging can be reduced or even eliminated.

The following areas of the waste disposal operation should be considered when addressing the problem:

. fencing,
. hours of operation and,
. supervision

Although fencing around solid waste sites is not currently mandatory, it should be instilled where it is necessary and practical to control access to the site. Perimeter fencing has been used in communities with variable success. In order for it to be an effective means of control, the fence must be well maintained and entrance gates must be installed to restrict unauthorized access after hours.

The hours of operation should be established and the hours posted at the entrance to notify users of the site. If the site is supervised, the hours of operation may be limited by the operating budget. At all other times the site should be closed to restrict unauthorized access.

Supervision during normal hours of operation could prevent unauthorized scavenging Unfortunately, supervision is not always practical in many communities, particularly in the small communities where waste volumes do not warrant continuous supervision. When sufficient cover material is available, more frequent covering/burning/compaction of wastes may be a more effective method of reducing scavengin-g than supervision.

On the other hand scavenging is currently perhaps the only practiced method of recycling of wastes. Further work needs to be carried out in each community on how recycling of useable but discarded material and goods could be accomplished without the dangers to public health and safety of the scavengers.

4.1 DISPOSAL ALTERNATIVES

The disposal objectives of an effective solid waste management program can be realized in a number of different ways. Some of the methods that are currently being used or have been used in the past for solid waste disposal in northern communities are:

open dump/landfill,
modified land fill,
sanitary landfill,
burning and landfill,
incineration and landfill,
milling and compaction,
ocean disposal, and
recycling and reuse

The choice of a suitable method is site specific so it depends on the size of the operation, equipment availability, economics, terrain conditions and public acceptance.

4.1.1 Open Dump/Landfill

The open dump/landfill is without question the most used method of waste disposal in the Northwest Territories.

The open dump/landfill, as the name implies, is not an open dump in the strict sense nor a sanitary landfill but a combination of the two methods with certain characteristics borrowed from each.

The true open dump is typically an unsupervised, uncontrolled operation without regular covering or compaction of wastes. Wastes of all types are dumped at a designated site without any attempt to segregate the domestic wastes from the human or bulky wastes. Any site operations which may be practiced typically include only the clean-up of the access road and any necessary work to keep the working area accessible. As a result, in spring and early summer, there are often unsightly, offensive accumulations of exposed garbage and sewage which are a hazard to public health. Generally, open dumps are a nuisance and are an unfavorable method of waste disposal.

The virtues of the open dump, particularly its ease of operation and low costs are highly appealing to northern communities where such factors as severe weather, permafrost, and lack of equipment add extra burden to the already difficult task of effective waste disposal. As a consequence, the current system has more or less evolved to one in which wastes are progressively dumped according to some plan and then covered periodically with earth fill and compacted whenever possible. Separate areas are established at the site for bulky wastes and honey bag disposal. By introducing a limited form of control, the disposal site can potentially accomplish the objectives of reducing air pollution, reducing water pollution, and improving aesthetics to a degree of acceptability favorable to the residents. Unfortunately, where this method fails is when the control breaks down; cover or compaction is not provided as often as needed or indiscriminate dumping takes place. Under these conditions the site merely degenerates to an open dump.

4.1.2 Modified Landfill

In some respects, the modified landfill operation shares some characteristics of the open dump/landfill. In both cases refuse is periodically compacted by mechanical means and covered with a layer of earth or other suitable material. Although the schedule for compaction and cover is typically more frequent for a modified landfill operation, it must still deal with the problems of exposed refuse, attraction to animals and birds, surface and groundwater contamination, open burning, and scavenging.

The distinguishing characteristic of the modified landfill from the open dump/landfill is that the former is well planned whereas the latter receives very little planning if any at all.
Every aspect of the modified landfill is engineered from its conception to its closing. The site is carefully selected, disposal areas are identified, cover materials are stockpiled, and access roads are constructed. In some cases drainage facilities are constructed and fencing is installed.

Three methods of organizing a modified landfill are recognized; the area method, the trench method and the depression method. These will be examined in detail in section 6.1. In all cases the wastes are deposited by a planned sequence at specified locations and then compacted and covered with suitable cover material.

Modified landfills are appropriate to small populations where it is not feasible to have continuous supervision or dedicated equipment at the site to continually cover the small daily or weekly accumulations of waste.

If the modified landfill is well planned, designed, operated and maintained it can provide a relatively inexpensive disposal method and a good level of service for sparsely populated communities.

4.1.3 Burning and Landfilling

Authorization for burning of combustible solid wastes within the community is under the discretion of the community Council. At the disposal site, garbage maybe burnt providing it does not create a significant nuisance or hazard from smoke, odour, and fire. Burning and landfilling is an attractive method of waste disposal because it has the capability of reducing waste volumes by 40 to 70 percent, reduces the amount of windblown material, and renders garbage somewhat less accessible to foraging birds, animals, and people. However, not all wastes are combustible, and those wastes which are not permitted to be burned such as animal carcasses, rubber and plastic materials and used engine oils must be separated from the combustible wastes prior to burning.

The following processes for burning and landfilling have been recognized:

. open burning,
. trench burning,
. burning in oil drums and,
. controlled trench burning.

Open burning at the disposal site must be controlled to prevent significant hazard from smoke, odour and fire. This requires isolating a safe area within the site to contain the burning debris and burning only when wind conditions will not allow smoke, odour, and ash to blow in the direction of the community.

Trench burning has limited potential in the NWT since it may only be practised in communities where soil conditions and equipment availability permits the construction of trenches. This method of disposal reduces the nuisance of blowing debris and ashes which prevail in the open burning method since excavated material can seine as cover material.

205 L oil drums used to store wastes prior to collection may serve a dual purpose as burning wastes in oil drums is frequently practised and can provide a level of volume reduction almost as great as open burning. However, if proper ventilation is lacking, reduced combustion and subsequent dangers of smoke, sparks and fly ash can arise. The burning may be initiated by the resident or by the operator at the waste disposal site.

Controlled trench burning is similar to trench burning except that ventilation is mechanically provided to enhance the combustion process. Air pollution can be considerably reduced as a result and by placing a screen over the mouth of the trench, ash release may be reduced.

4.1.4 Sanitary Landfill

The sanitary landfill is an operation in which solid wastes are deposited and compacted in a controlled area and then covered with a layer of soil at the end of each working day. The sanitary landfill is becoming the acceptable standard of landfill practice in North America for municipal sites serving populations greater than 5,000 to 10,000 people.

Operations involve dumping wastes on the working face of a designated site and spreading and compacting wastes into layers 0.3 to 0.6 m thick. At the end of each working day a final layer of soil 150 mm thick is spread over the exposed wastes. When the design depth of the area is reached, a final layer of cover material at least 600 mm thick is applied.

Daily covering requires a considerable volume of cover material. A volume of cover equivalent to 20 to 25 percent of the total waste volume is necessary to maintain the recommended schedule demanded by sanitary land filling.

In the majority of NWT communities this volume of cover is not available. In addition, sanitary landfilling requires that earth moving equipment be available on a daily basis. This is not always possible particularly in smaller communities where the single bulldozer may be required for other purposes in the community. Besides, the volume of wastes generated are generally insufficient to warrant daily covering and in many cases, weather conditions would not allow it.

4.1.5 Incineration

Incineration facilitates refuse disposal by reducing solid waste to a readily transportable inert residue by high temperature burning in an incinerator. An incinerator is composed of a furnace into which refuse is charged and ignited.

In the past, incineration seemed to be a promising alternative to open dumps since heat from incinerators could be harnessed for building heating systems, domestic water heating, and electrical power generation. It is estimated that normal domestic garbage has an energy equivalence of 11.6 MJ/kg. However there are concerns that the mechanical complexity of incinerators and the possibility of breakdown may preclude the use of incinerators particularly in remote communities where service and parts may be unavailable for prolonged periods.

The community of Pangnirtung has been using an engineered incinerator since 1982 with no significant problems. Other units are being operated in Tuktoyaktuk and Norman Wells by Esso Resources Ltd.

4.2 OTHER ALTERNATIVES

Wastes may be pre-processed by volume reduction through such equipment as shredders, hammer mills, and impact mills. The purpose of these methods is to make the handling and disposal of the wastes cheaper and hence more manageable prior to landfilling or incineration. Benefits of volume reduction are not considered great enough to offset the high capital and operating costs associated with such facilities in northern communities.

Ocean disposal of wastes has been practiced in some of the communities in the past, but is no longer permitted.

Recycling is gaining popularity throughout North America in cities where the quantities of recoverable material and populations are significantly large to complement the aspiring recycling programs. However, in northern communities, recycling is thought not practical given the small volumes of recoverable material and the lack of local markets. In some communities, stock-piled bulky waste items such as used vehicles and scrap metal may be shipped to southern communities for recycling at considerable expense. The issue of recycling in northern communities needs further consideration. This should include the possibility of replacing the current unsafe scavenging by proper means for recycling of materials and goods within the community, as well as the possibility of shipping certain material out of the community.

4.3 DISPOSAL SELECTTON

Figure 4.1 outlines a simplified disposal selection scheme. If adequate cover material is available, a sanitary or modified landfill method of solid waste disposal should be selected otherwise the open dump will prevail. In most northern communities, population size and waste production is too small to necessitate daily covering, thus the modified landfill method of solid waste disposal with periodic covering should be the method of choice. Three types of modified landfill methods are recognized and shown in figure 4.1. It should be noted that if burning of wastes is permissible in the community, burning and landfilling or incineration can be incorporated with any of the disposal methods outlined.

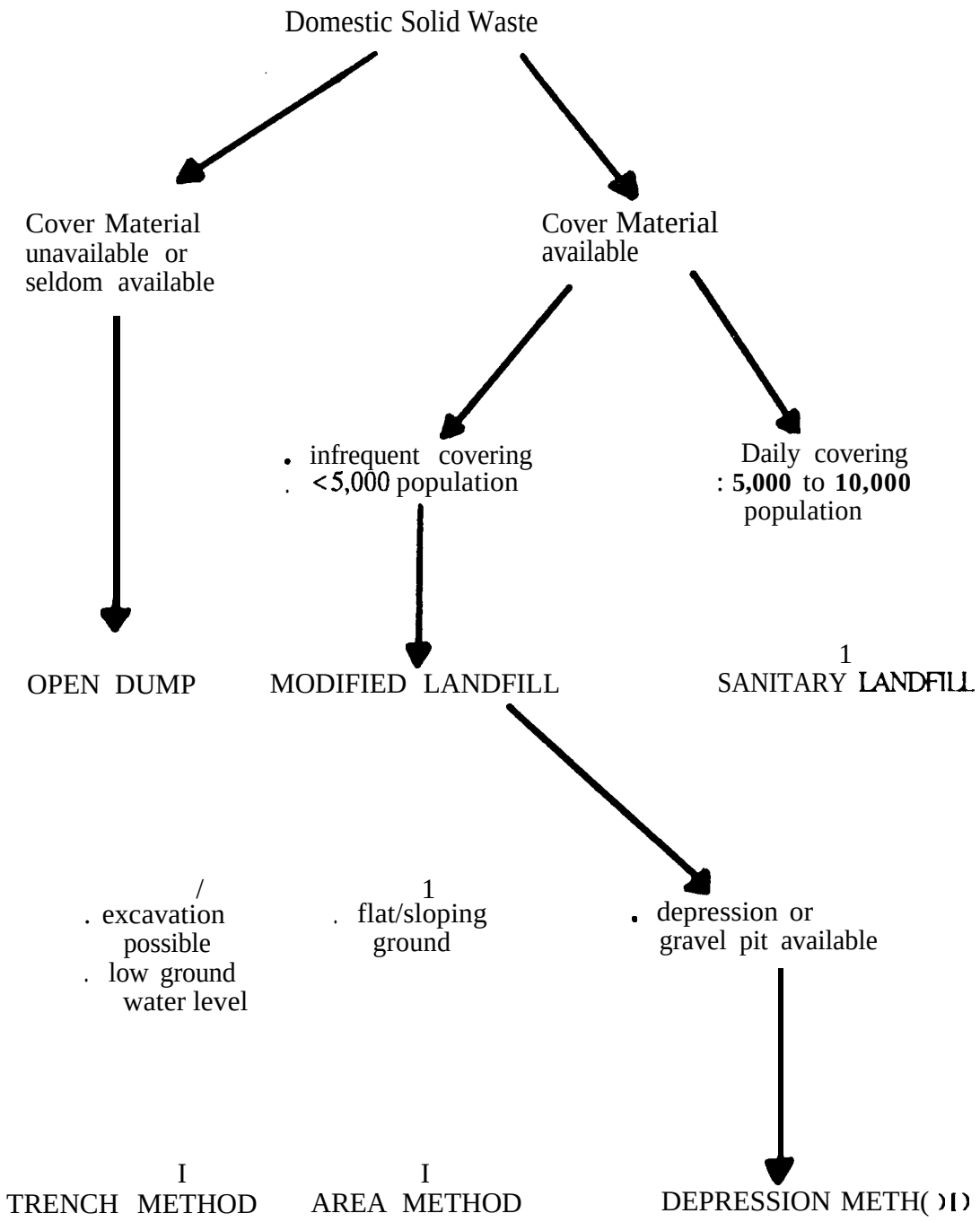


Figure 4.1 Disposal Selection

5. GUIDELINES FOR THE PLANNING OF THE DISPOSAL SITE

5.1 COMMUNITY CONDITIONS

The community population, characteristics of solid waste, solid waste volume, solid waste collection, and design life of the disposal site will influence the methods and equipment used in landfilling operations.

5.1.1 Community Population

Future demands for waste disposal service and the economics of alternative methods of providing services depend to a large extent on the size of the population to be served, now and in the future.

Population data and forecasts for NWT communities are provided by the Bureau Of Statistics, Government of the Northwest Territories [6].

5.1.2 Characteristics of Solid Waste

The characteristics of solid waste generated by NWT communities can be described as:

. domestic,
. industrial and,
. commercial.

Domestic wastes are comprised of typical household wastes such as food, packaging materials and cardboard, and household articles. Bulky goods such as discarded stoves, empty 205 L oil drums, miscellaneous equipment, and recreational vehicles are also considered domestic wastes.

Industrial wastes vary with the type of industry of concern. Typical industries include oil exploration, mining, and fishing. Some industrial wastes are not disposed of at community dumps with domestic wastes since they may contain potentially toxic and hazardous wastes requiring special handling and disposal methods. In such cases, individual industries may be responsible for operating and maintaining private waste disposal facilities. These are not covered in these guidelines, but separate guidelines are being developed (10).

Commercial wastes are wastes generated by local businesses, services and facilities, and government agencies. Wastes of commercial origin may include large packaging materials, oil drums, building materials, paper, and arts and crafts wastes. Normally, they can be disposed of at the community waste disposal site. Commercial wastes from cleaning establishments, photography shops and others may be hazardous and need to be dealt with separately (10).

Bulky wastes can be of a domestic, industrial or commercial origin. Large metal items including discarded vehicles, snowmobiles, appliances, oil drums, machinery, and holding tanks should be hauled to the bulky waste disposal area. Although construction wastes are often bulky, materials can be deposited in the refuse disposal area where they are burned and covered along with the general refuse.

Very little reliable information exists regarding solid waste composition in N.W.T. communities. Early estimates of solid waste composition are available from a 1974 study by D. Forgie (9) for Environment Canada. This study examined the composition of solid wastes from three communities to develop data for incinerator design and simulation of solid wastes from small northern communities and work camps. More recently, a study by Heinke and Wong [4a] reported the waste composition from three communities of the Baffin Region: Iqaluit, Pangnirtung and Broughton Island. The results of the study are summarized in Table 5.1.

Table 5.1 Data Summary of Waste Composition for NWT Communities

	90 by weight		
Component	**Iqaluit**	**Pangnirtung**	**Broughton Island**
Food	21.4	19.3	15.9
Cardboard	14.4	12.1	9.3
Newsprint	**5.0**	**0.4**	**0.3**
Other Paper Products	**18.5**	**15.2**	**14.0**
Cans	**5.4**	**5.5**	**5.0**
Other Metal Products	**4.0**	**3.9**	**6.5**
Plastic, Rubber, Leather	**13.3**	**8.8**	**8.9**
Glass, Ceramics	**3.1**	**2.6**	**1.7**
Textiles	**3.5**	**4.1**	**3.3**
Wood	**4.5**	**13.4**	**20.0**
Dirt	**3.4**	**3.1**	**4.8**
Diapers	**3.5**	**11.6**	**10.3**
	100.0	**100.0**	**100.0**

Solid wastes generated in most small NWT communities are primarily domestic in character. Table 5.1 shows that the major components of the refuse are food, cardboard, other paper products and plastic. Disposable diapers and construction wood are also major components in two of the three sampled communities.

5.1.3 Solid Waste Volume

Knowledge of the waste generation rates and quantities are necessary in determining site capacity. Ideally, such parameters should be based on historical data of solid waste generation for the community under investigation. When such information is unavailable, waste volumes can be estimated on the basis of the Government of the Northwest Territories General Terms of Reference [3].

The Government of the Northwest Territories recognizes two production rates for solid waste; residential and school. These design rates are shown in Table 5.2

Table 5.2 Waste Generation Rates Currently used for NWT Communities [3]

Classification	Production Rate (uncompacted)
General Community Refuse	
. Residential	0.010 m^3 per person per day
. School	0.001 m3perstudent per day
Bagged Sewage	
. Residential	**0.0015** m^3 per person per day
. School	0.0002 m^3 per student per day

The production rates listed in Table 5.2 do not include bulky wastes. Bulky waste generation rates should be estimated on a site specific basis. The per capita production rates for schools is additive to the residential rate.

A detailed study by Heinke and Wong [4a] to determine the composition and quantity of solid wastes typically disposed at solid waste disposal sites in communities of the Northwest Territories, recommends that a figure of 0.014 m^3/person/day should be used as the production rate for residential refuse rather than the figure of 0.010 m^3/person/day outlined in Table 5.2, particularly if similar studies to be carried out in other NWT regions were to support the higher waste production rates found in the Baffin region.

The total community refuse volume (m^3) in any year is :

$$365\ V\ P_1 (1+G)^n + 0.084\ V\ P_1^2 (1+G)^{2n}$$

Total community refuse volume (m^3) during the planning horizon is:

$$\frac{365\ V\ P_1}{\ln (1+G)} [(1+G)^{PH} - (1+G)] + \frac{0.084\ V\ P_1^2}{2 \ln (1+G)} [(1+G)^{2PH} - (1+G)^2]$$

Where,

V = Average residential refuse volume (m^3 per person per day)
P_n = Population in n^{th} year
G = Average community population growth rate
PH = Planning horizon (years).

Example

The volume of general refuse generated by a community of 1,000 population during a 20 year planning horizon is as follows:

v = 0.014 m^3 per person per day
P_1 = 1,000 persons
G = O. OIOpersons/year (or 10persons peryear per 1000 population)
PH = 20 years

$$\frac{365(0.014)\ 1000}{\ln(1 + 0.01)}\left[(1 + 0.01)^{20} - (1 + 0.01)\right] + \frac{0.084\ (0.014)\ 1000^2}{2\ln(1 + 0.01)}\left[(1 + 0.01)^{2(20)} - (1 + 0.01)^2\right]$$

$$= 514000\ [0.21] + 59000\ [0.47]$$

$$= 108000 + 28000$$

$$= 136000\ m^3 *$$

* *Note that this is an uncompacted volume. Through compaction and burning, this may be reduced to as much as one-third to one-quarter of the uncompacted volume.*

5.1.4 Solid Waste Collection

Collection Schedule

The Government of the Northwest Territories recommends that the minimum level of service for solid waste collection is once weekly per residence *[3]. This* level of service is sufficient to maintain acceptable sanitary and aesthetic conditions within a community without requiring special storage containers.

Bagged sewage should be collected 5 times per week with no two consecutive days without service. Bagged sewage should be collected and disposed of separate from other community solid waste.

Collection of bulky wastes does not require frequent service so collection scheduling could be monthly or seasonally.

Collection Vehicles

The size and type of the collection vehicle will depend on the volume of refuse and available funding. Vehicles may range from 1/2 ton pick-ups capable of hauling oil drums to the disposal site to compactor vehicles. Increasing the capacity of the collection vehicle reduces the frequency of trips to the disposal site, and so reduces the truck mileage, labour time and fuel consumption. The most cost effective choice of a garbage truck is in the range from 1/2ton to 1 ton capacity and factors such as convenience and alternate uses should be considered in making the choice. Collection vehicles should be covered to reduce the problem of wind blown debris.

Vehicles for bagged sewage disposal should be capable of containing the bags in such a manner as to not expose the operators to potential health hazard resulting from broken bags during the collection process.

Crew Size

The number of crew members per collection vehicle depends on the volume of waste collected and the type of collection vehicle. The optimum crew size is a driver plus one or two helpers, but a single operator can be employed in small communities where waste volume is small

5.1.5 Design Life

The community plan should be referred to during the design stage of the disposal site when it is available. Community plans may be obtained from the Community Planning Division, Department of Municipal and Community Affairs. The plan typically considers the community land use needs, the extent of the present land use, and the direction of community growth.

Unless otherwise specified, the disposal site should be designed for a 20 year planning period. Methods for estimating the annual total requirements for the 20 year design life is given in 5.1.3.

Compaction and burning can reduce garbage volume and influence the design life of the disposal site. Compaction can reduce waste volume by a 3:1 ratio, and if burning is permitted a volume of reduction of 4:1 can be expected.

5.2 SITING CRITERIA

The criteria for selecting an acceptable solid waste disposal site in a northern commu n ity are similar to those for other communities. The site should:

- be located sufficiently far from the airport to not create safety problems to aircraft from scavenging birds.
- be of sufficient capacity for at least a 20-year life,
- not be a nuisance or danger to public health,
- be in a watershed that drains away from the community water supply,
- not be visible from the community,
- be sufficiently distant from the community to avoid smoke and odour problems.
- not create significant environmental impacts to land, birds and animals,
- maintain economic travel distance from the community to the disposal site
- take account of special geological and terrain conditions
- consider the availability of cover material
- consider geotechnical features of the site
- consider climatic features of the community
- consider accessibility to the site

Those points of special importance to the NWT are discussed below.

5.2.1 Proximity to Airports

Transport Canada has established guidelines for the development of landfill within the vicinity of airports [8]. The guidelines recommend a minimum separation of 8 km between airports and municipal solid waste sites which include food storage disposal. The 8 km separation distance is measured from the boundary of the waste disposal area to the centre of the runway. The rationale for the separation distance is to reduce the potential for bird aircraft strikes resulting from birds feeding at the landfill site or by birds migrating to the site.

It has been recognized that the 8 km separation distance is excessive for NWT communities where the volume of air traffic is small and the bird density is low. At present, none of the community landfill sites comply with the 8 km guideline.

A study is presently being prepared to investigate the problem of landfill proximity to airports in the Northwest Territories [7].

Until the establishment of a revised separation guideline, a minimum separation distance of 2 km has been recommended by the NWT government. This separation distance is site specific and will vary with the volume and type of aircrafts using the airport facilities, the density and type of birds visiting the landfill site, and the migratory pattern of the birds.

Nevertheless, the community waste disposal site should be located upwind of airports and in areas where birds attracted to the site will not pose a hazard to aircrafts.

The results of ongoing discussion between Transport Canada and the Government of the NWT should be incorporated into a future edition of these guidelines.

5.2.2 Geology and Terrain

Geology

Knowledge of the geology of a site is required to predict the extent of the potential contaminant zone and the potential for excavation. This requires a geological study of the site to determine the stratigraphy, soil types, and soil grain sizes.

Terrain

The surrounding terrain is an important factor when evaluating the suitability of a disposal site. This is often accomplished through air photo examination and/or field examinations. By making use of natural barriers, major landforms, depressions, and drainage patterns, the earthwork required for site preparation, operation and maintenance can be minimized.

5.2.3 Availability of Cover Material

The location of the solid waste disposal site, for practical and economic reasons, is influenced by the availability of cover material. A minimum cover material thickness is necessary to properly maintain a site. Cover material volumes are dependent upon the surface area to be covered and the thickness of the soil needed to achieve the final design thickness after compaction. Minimizing the area of exposed waste will reduce the cover material requirement.

Whenever possible, the use of on site cover material should be maximized. When sufficient cover material is unavailable, borrow material must be brought to the site thereby increasing operating costs.

Cover material can be any type of soil or other suitable material that compacts well, does not crack excessively when dry and is relatively free of organics and large items.

5.2.4 Geotechnical Factors

A hydrogeological study of the proposed area is necessary to establish site suitability with respect to the following site selection criteria:

- water infiltration rate,
- ground water flow system,
- hydraulic gradient,
- hydraulic conductivity,
- ground water chemistry,
- existing wells and
- anticipated loadings.

The extent or complexity of the hydrogeological investigation will depend upon the size of the disposal site and the specific site conditions.

Other geotechnical aspects which may require consideration are foundation problems arising from thaw sensitive and heave prone permafrost soils, soil erosion and possible flooding.

Landfill sites located on permafrost can affect the groundwater and ground ice balance by altering the thermal properties of the soil. A site used for landfilling operations is subject to heat generation as a result of vehicular traffic, removal of surface soil for cover material and burning of wastes. The heat generated causes the ground ice to melt and subsequently increases effective soil pressure of the region which can result in consolidation.

5.2.5 Climatic Factors

Climatic factors of concern when locating a disposal site are limited to atmospheric conditions such as predominate wind direction, wind speed, and the likelihood of localized temperature inversions.

Short term air pollution caused by burning wastes can be reduced by locating sites downwind from the community.

Temperature inversions occur when a cold air mass is trapped in a topographic low point such as a valley by a warmer air mass above. When this situation arises, upward flow of air is prevented and airborne pollutants become trapped near ground level. Areas susceptible to temperature inversions should be avoided when locating disposal sites.

5.2.6 Accessibility

The location of the disposal site must be accessible to vehicular traffic year round. Access roads subject to frequent flooding or snow drifting can be a nuisance for users of the site and may even suspend operations if the conditions are severe enough.

The construction of an all weather access road is a major expense in the design of a solid waste disposal site. Where possible, it is recommended that existing all weather roads be utilized or extended to meet the requirements. Often a common road is used for sewage disposal and solid waste disposal thus making maintenance and snow clearing costs more efficient and cost effective.

6.1 MODIFIED LANDFILL DISPOSAL OPTIONS

The basic landfilling methods of a modified landfill disposal site are:

. the area method,
. the trench method and,
. the depression method.

Depending on the characteristics of the site such as topography, the amount of available cover material, hydrogeologic conditions and the amount and types of solid wastes to be handled, any one or a combination of the above methods may be planned.

6.1.1 Area Method

The area method of a modified landfill is used *on* flat or sloping ground where soils are unsuitable for excavation or a high ground-water table exists.

For sloping ground, solid waste is dumped out of the collection vehicle and allowed to accumulate on the working face of the slope. Periodically the waste should be spread and compacted along the working face using a bulldozer. When the design thickness of compacted waste is attained, a final layer of cover is spread and compacted over the exposed waste. The slope is then ready to receive the next layer of waste. See figure 6.1 for the sequence of operations on sloping ground.

For flat ground, the refuse is end-dumped onto the slope of the working face of the designated area or garbage cell. Each cell is dimensioned to receive an annual volume of compacted waste. Compaction and spreading of waste is achieved by means of a bulldozer. Periodically, a layer of *cover* material should be spread over the exposed waste and compacted. This process of spreading, compaction and covering should be repeated as wastes accumulate along the working face until the design capacity of the cell is reached. At this point, the compacted waste should then be covered with a final layer of fill. Recommended thicknesses are 0.15 m to 0.2 m on the slope face and a minimum of 0.5 m on the top layer. Since the top layer will eventually serve as a driving surface for collection vehicles, it should also have a granular topping as needed. See figure 6.2 for the sequence of operations on flat land.

6.1.2 Trench Method

The trench method is used where the soils can be excavated to a depth of at least 2 m and groundwater levels are low.

In this method, a trench is excavated and wastes are deposited into the trench. The size of the excavated trench should be designed to contain the annual volume of compacted waste for the community. The wastes should be spread and compacted periodically and then covered with a thin layer of cover material. The cover material for the trench method is the excavated material which should be stockpiled nearby. Each cycle of spreading, compaction and covering constitutes a lift.

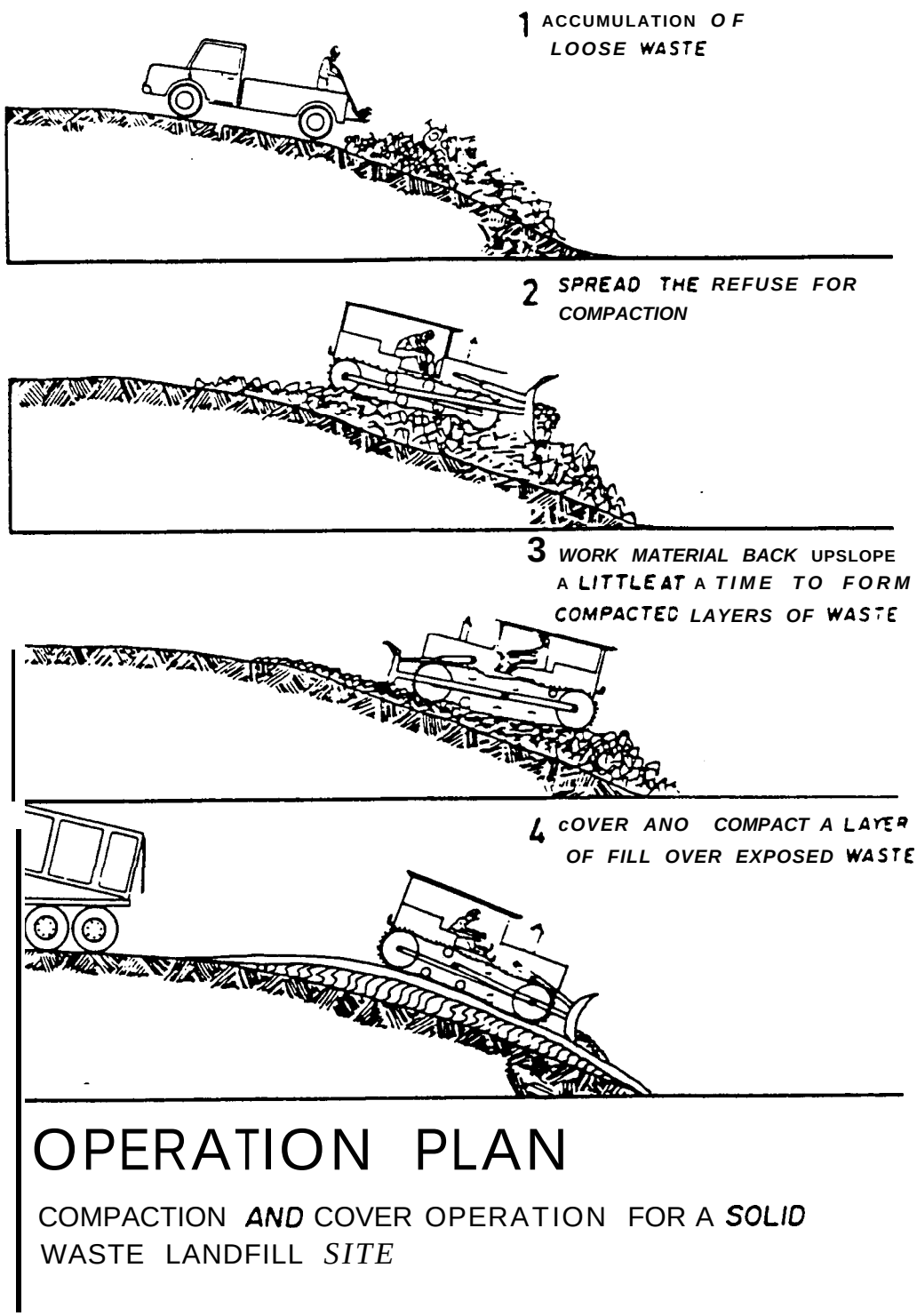


FIGURE 6.1 AREA METHOD ON SLOPING GROUND

Source: General Terms of Reference for a Community Solid Waste Management Study, Government of the Northwest Territories.

MODIFIED LANDFILL METHODS OF OPERATION

AREA METHOD - FLAT GROUND

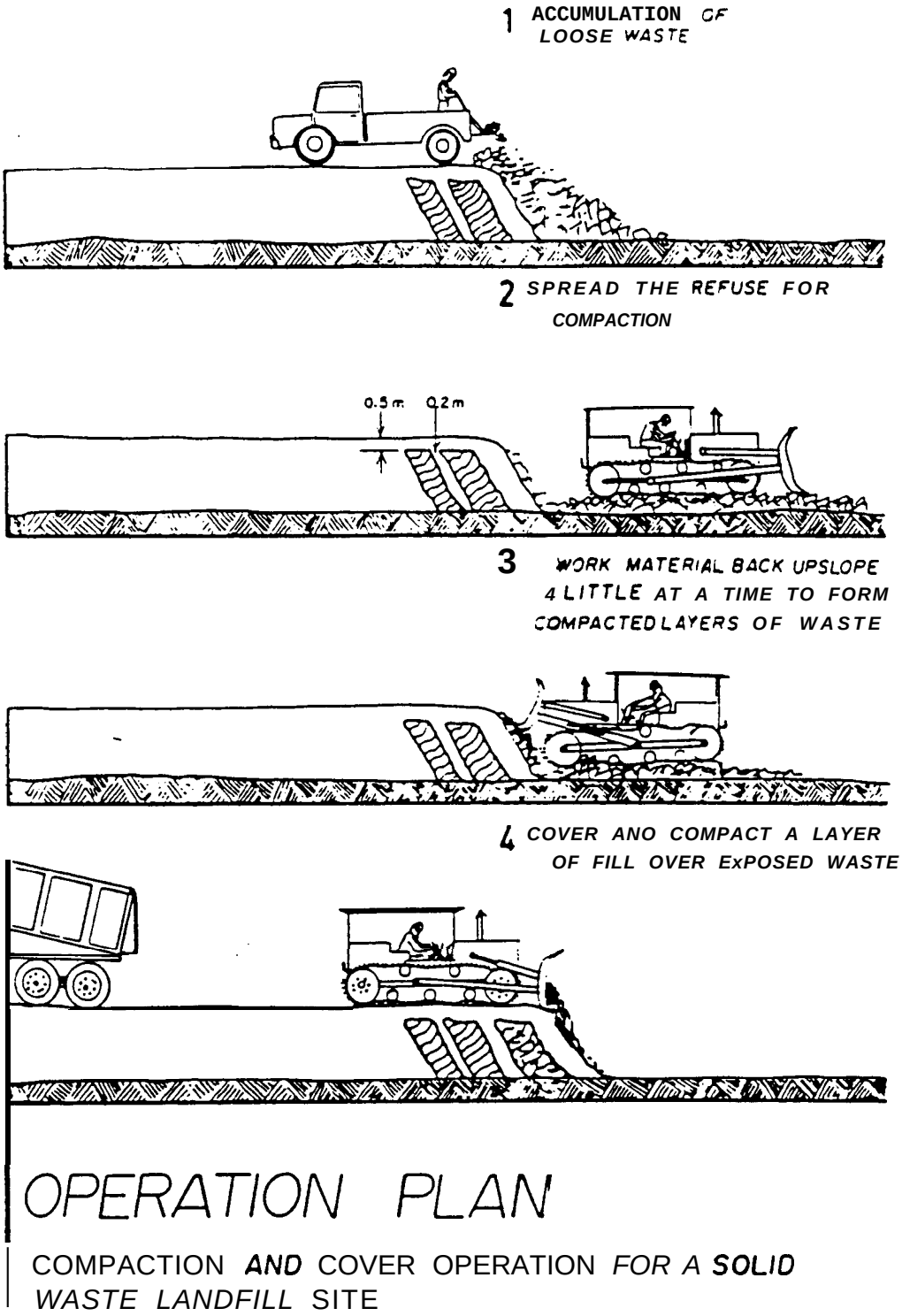


FIGURE 6.2 AREA METHOD ON FLAT GROUND

Source: General Terms of Reference for a Community Solid Waste Management Study, Government of the Northwest Territories.

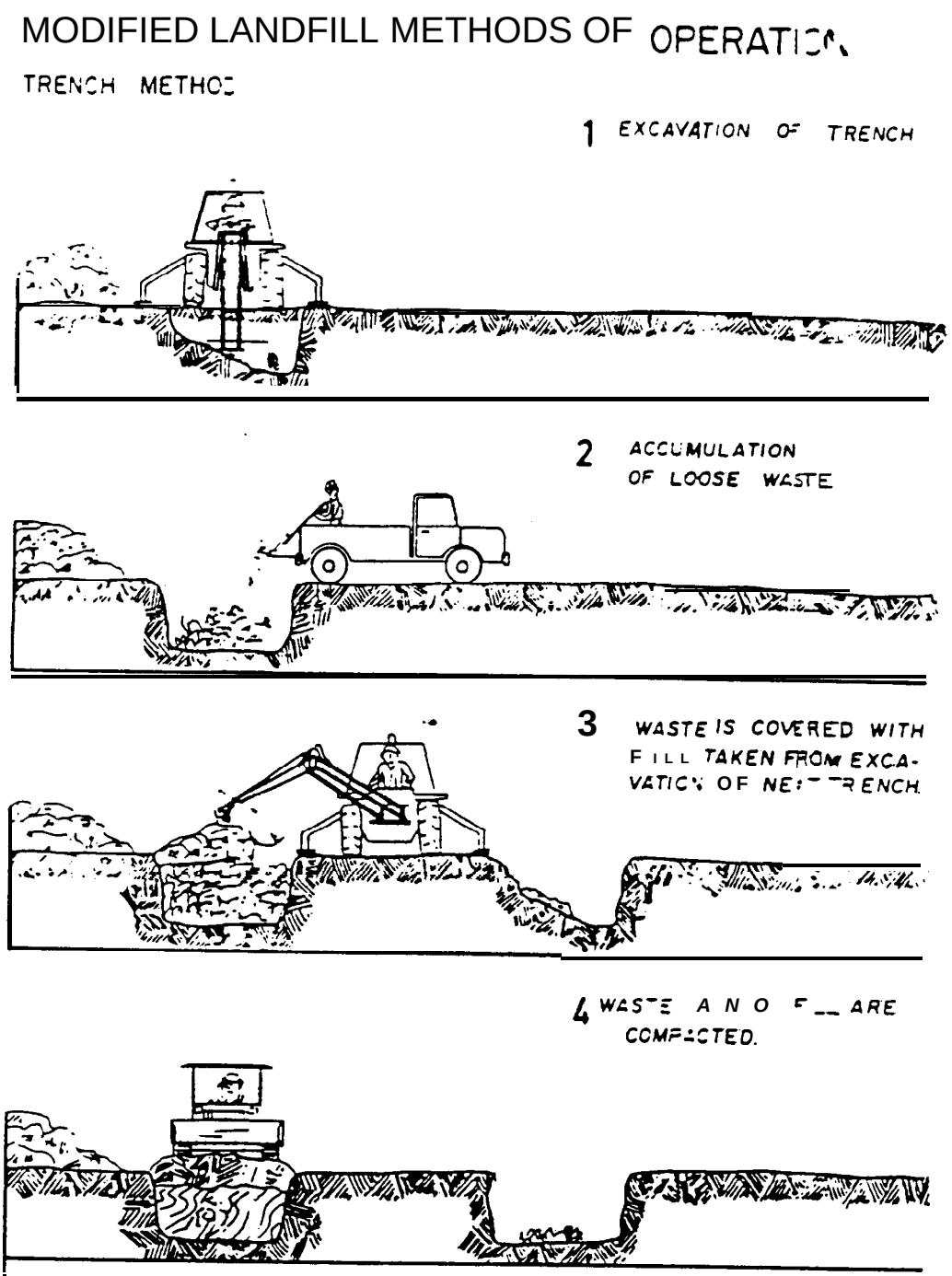


FIGURE 6.3 TRENCH METHOD

Source: General Terms of Reference for a Community Solid Waste Management Study, Government of the Northwest Territories.

After several lifts, when the trench is full, a final layer of cover is spread and compacted over the trench. Another trench should be excavated as planned and the process repeated for the new trench.

The following guidelines affect the capacity of a trench:

the maximum depth of the excavation should be controlled by the danger of groundwater pollution and,
the maximum acceptable height of the refuse above land is dependent upon the final land form proposed.

See figure 6.3 for the sequence of operations of the trench method.

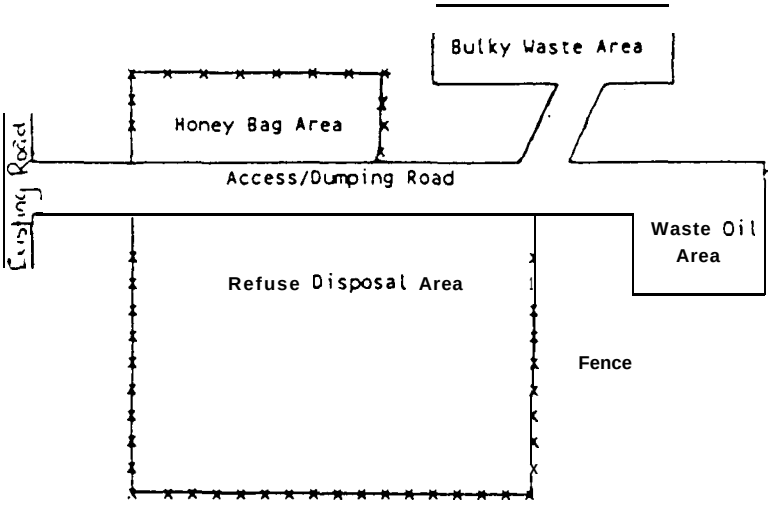
6.1.3 Depression Method

The depression method is used where a depression is available and filling to surrounding elevations or original ground contours is desirable. The depression may be a natural depression or man made as a result of mining or quarrying operations.

The procedure of landfilling in the depression method is similar to that of the trench method but because excavation is not necessary, cover material may not be available on site and must be transported to the site from borrow locations. The cost of this method of modified landfill is more attractive than the trench method since excavation and equipment costs are saved. Providing proper drainage facilities for this method can be a problem.

6.2 DESIGN OF SITE FACILITIES

The solid waste disposal facility must include separate areas for disposal. Construction wastes such as wood, insulation and other combustible refuse are disposed of in the refuse disposal area while bulky construction wastes such as automobiles, old furnaces, holding tanks and other large non-combustible refuse are disposed of in the bulky waste area. In communities where honey bags are used, another area separate from the refuse disposal area and the bulky waste disposal area must be provided for their proper disposal. Also, if required, a special area should be provided for waste oil disposal. A typical solid waste disposal facility layout is illustrated in figure 6.4.



Note: An area large enough to stock-pile one year's supply of cover material must also be provided.

Figure 6.4 Typical Solid Waste Disposal Facility Layout

6.2.1 Refuse Disposal Area

Methods for determining the volume of refuse generated and the type of modified landfill operation for the selected site are outlined in sections 5.1.3. and 6.1 respectively.

For a community of 1000 people the volume of general refuse generated in 20 years is calculated from the example in section 5.1.3 to be 136000 m^3. This may be reduced to as much as 1/3 to 1/4 of the uncompacted volume, but cover material will add to the depth depending on frequency and extent of material used. A minimum area of 150 m x 150 m with a depth of 2 m (uncovered) is required to satisfy the 20 year planning horizon.

The access/dumping road must be constructed to facilitate collection vehicles from the entrance of the site to the unloading area. A typical cross section is shown in figure 6.5.

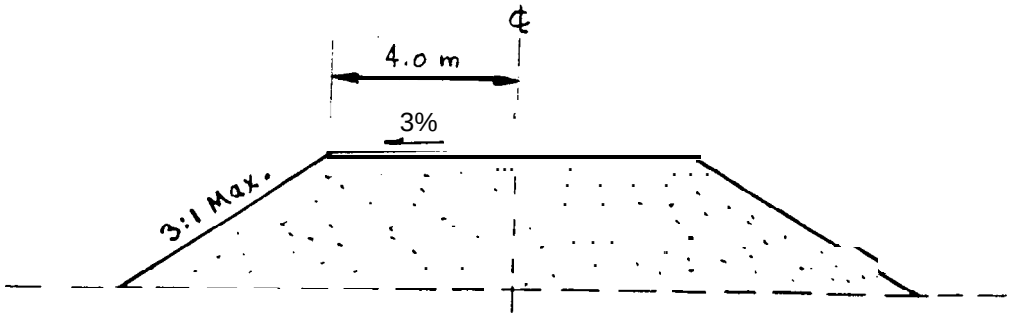


Figure 6.5 Typical Access/Dumping Road Cross Section

6.2.2 Bulky Waste Area

The bulky waste disposal area consists of an elevated pad of granular material. Gravel or coarse sand can be used as fill since it provides good drainage. A typical bulky waste pad cross section is illustrated in figure 6.6. An area 20 m to 50 m wide by 20 m to 50 m long is recommended but of course the size depends upon the needs of the community.

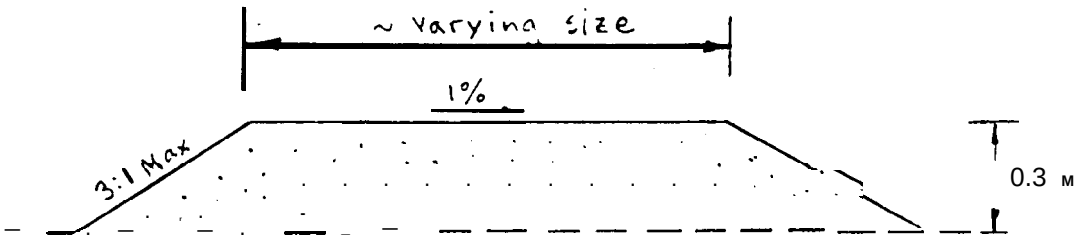


Figure 6.6 Typical Bulky Waste Pad Cross Section

6.2.3. Honey Bag Disposal Area

The volume required for honey bag disposal can be determined on the basis of a production of 0.5 m^3 per person per year **[4c].** The disposal area consists of a honey bag disposal cell surrounded by embankments of acceptable granular material. **A** typical honey bag cell cross section is illustrated **in** figure 6.7.

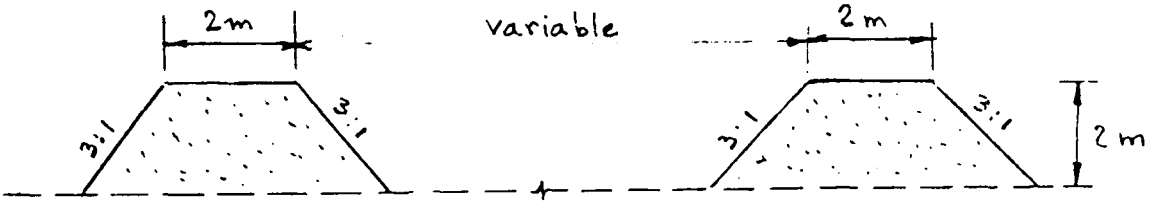


Figure 6.7 Typical honey bag disposal **cell** cross section

6.2.4 Waste Oil Area

The waste oil area consists of a cell surrounded by an embankment and lined with an oil resistant liner. Different liners require different installation procedures. It is best to consult with the liner manufacturer for details. A typical waste oil cell cross section is illustrated in figure 6.8

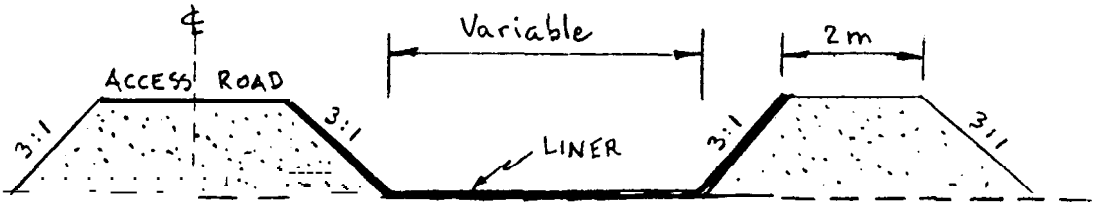


Figure 6.8 Typical Waste Oil Cell Cross Section

6.3 DESIGN OF ACCESS ROADS

An all weather road must be provided from the community to the disposal site. This road must be designed to safely accommodate vehicular traffic and the anticipated loads.
The road should be aligned to minimize snow drift accumulation and provide for adequate drainage.

A typical cross section for NWT road design is illustrated in figure 6.5.

6.4 DESIGN OF SITE DRAINAGE

Surface waters must .be. diverted away from water supply sources and recreational water bodies. This is achieved by installing temporary or permanent drainage control berms as required. A typical drainage control berm crossection is illustrated in figure 6.9,

Infiltration of surface water to the water below can be reduced by providing 0.6 -1.2 m of final cover and performing periodic grading.

Planned maintenance of the drainage channels and periodic filling of surface depressions to prevent pending is recommended.

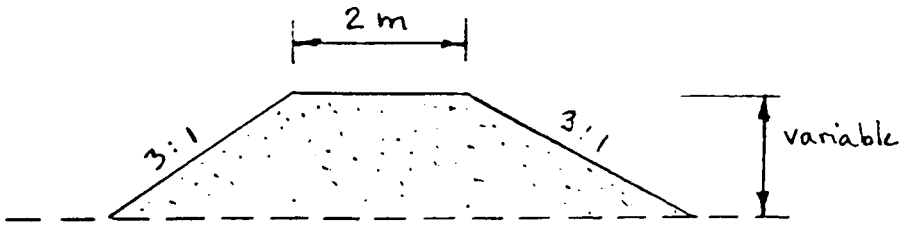


Figure 6.9 Typical Drainage Control Berm Cross Section

6.5 DESIGN OF SITE FENCING

Fencing is used to control or limit access to the landfill site and to control the spreading of blowing garbage. The Government of the Northwest Territories does not require fencing at the disposal site but its use is recommended since its benefits can justify the capital cost of the installation. Fencing may be portable or permanent and may be woven or chain linked. Wooden fences are not recommended as they can be a potential fire hazard during on site. burning of wastes. installation of snow fencing is recommended during the winter.

A gate should be provided at the site entrance and it should be locked when the site is closed to prevent trespassing.

Regular maintenance of the fence should be planned to ensure that it retains its effectiveness.

7. REGULATORY REVIEW

The planning and design of solid waste modified landfill sites must observe and comply with the relevant Federal and Territorial acts, regulations and guidelines, as well as with any community regulations and by-laws. The most important of these are listed below.

7.1 Territorial and Federal Act

1. NWT Public Health Act (11)

Of particular relevance are Regulation 214- General Sanitation Regulations (revised 1980). These describe among other regulations the responsibility of the community to establish facilities for the disposal of excreta (Item 18-24), and for the disposal of garbage and other wastes (Item 25-30)

2. NWT Environment Protection Act (12)

Enacted in 1974 and revised in 1981 and 1985 this act deals with discharge of contaminants and environment protection in general.

3. Northern Inland Waters Act (Federal) and the NWT Waterboards "Guidelines for Municipal Type Wastewater Discharges in the Northwest Territories". (13).

The Guidelines were issued in 1981 and deal primarily with wastewater discharges to inland water. However, Section 2.3 Effluent Discharges from Land Disposal Sites and Section 2.4 Discharges from Sanitary Landfill and Garbage Dumps, are briefly also dealing with matters of importance to this report.

4. Fisheries Act (Federal Government) (14)

This act (1985) deals in general with fish habitat protection and pollution prevention and is only indirectly applicable to landfills.

In addition to these acts there are local by-laws in some communities of relevance to solid waste disposal, such as the regulations in most communities of the Kitikmeot region that forbid burning of wastes stored in oil drums in front of the house.

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