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Oiled Debris Disposal and Storage Sites: Beaufort Sea Coast

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**OILED DEBRIS DISPOSAL
AND STORAGE SITES:
BEAUFORT SEA COAST**

by

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for the
Research and Development Division
Environmental Emergency Branch
Environmental Impact Control Directorate
Environmental Protection Service
Environment Canada

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ABSTRACT

A study was performed to locate landfill disposal and temporary storage sites for oiled debris from sand and shingle beaches along the Beaufort Sea Coast from the Alaska-Yukon border to Cape Bathurst. Approximately 217 landfill disposal sites and 223 temporary storage sites have been located. These sites are shown on 1:150,000 scale strip maps and on 1:20,000 to 1:70,000 scale aerial photographs in the report.

This study involved establishing guidelines for site selection, design, construction and reclamation for landfill disposal sites, temporary storage sites and access roads. Limitations on construction, utilization and reclamation due to seasonal problems with terrain stability, logistics support and cost effectiveness were considered. All of the sand and shingle beaches in the study area were identified using aerial photographs and these beaches are shown on 1:150,000 scale strip maps. In addition, alternative or novel landfill disposal and temporary storage techniques were reviewed.

RÉSUMÉ

On a mené une étude en vue de situer des emplacements pour l'enfouissement et le stockage temporaire des débris mazoutés provenant des plages de sable et de galets situées le long de la mer de Beaufort, de la frontière entre l'Alaska et le Yukon jusqu'au Cape Bathurst. Quelque 217 lieux d'enfouissement et 233 emplacements de stockage temporaire ont pu être localisés. Ces emplacements sont indiqués sur des cartes-bandes à échelle 1:150 000 et sur des photographies aériennes à échelle de 1:20 000 à 1:70 000, dans le rapport.

L'étude portait aussi sur la formulation de lignes directrices pour le choix de l'emplacement, la conception, la construction et le réaménagement des terrains d'enfouissement et de stockage temporaire des déchets et des voies d'accès. On a tenu compte des problèmes saisonniers de stabilité du terrain, de soutien logistique et de coûts-avantages, qui risquent d'entraver la construction, l'utilisation et le réaménagement. Toutes les plages de sable et de galets visées par l'étude ont été explorées à l'aide de photographies aériennes, et ces plages sont représentées sur des cartes-bandes à échelle 1:150 000. En outre, on a examiné d'autres techniques, existantes et inédites, d'enfouissement et de stockage temporaire des déchets.

FOREWORD

R.M. Hardy & Associates Ltd. performed the study as described in this report under contract to the Department of the Environment.

Mr. W. Robson, of the Environmental Protection Service, acted as the scientific authority for this study. Mr. P.J. Blackall, Environmental Emergency Branch, acted as the Arctic Marine Oil Spill Program coordinator.

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1 INTRODUCTION

Offshore exploration in the Beaufort Sea area is continuing; consequently, the potential exists for an offshore oil spill. Since some of this oil may eventually be deposited on shore, the Environmental Protection Service, Department of the Environment, decided that it was necessary to predetermine locations suitable for landfill disposal or temporary storage of oiled debris from sand and shingle beaches (Logan et al, 1975; Owens, 1977). For this project, other beaches consisting of mudflats, tundra and rapidly eroding cliffs were not considered to be cleanable.

The main purpose of this study was to identify suitable landfill disposal and temporary storage sites along the Beaufort Sea Coast, from the Alaska-Yukon border to Cape Bathurst, including the Eskimo Lakes.

The first part of the study consisted of establishing guidelines, based mainly on geotechnical considerations, for landfill disposal sites, temporary storage sites and access roads. Site selection, design, construction and reclamation guidelines were established. In establishing these guidelines, limitations on construction, utilization and reclamation due to seasonal problems with terrain stability, logistics support and cost effectiveness had to be considered. This included the basic limitation that, generally, oiled debris could be cleaned from the beaches only during the months of July, August and September.

The second part of the study consisted of identifying all of the sand and shingle beaches in the study area, and locating suitable landfill disposal and temporary storage sites as close as possible to these beaches. These sites were located using aerial photographs.

Alternative or novel landfill disposal and temporary storage techniques were also reviewed. In addition, a field program was proposed (presented under separate cover) to evaluate the terrain conditions at representative sites in order to verify the air photo interpretation and geological assumptions as related to the guidelines.

2 GUIDELINES

Guidelines were established for site selection, design, construction and reclamation of landfill disposal and temporary storage sites for oiled sand and shingle beach material. These guidelines, based mainly on geotechnical considerations, were established so that the sites could be selected on a rational basis. It was realized, however, that environmental or socio-economic concerns at the time of a spill could be of such importance that they may take precedence over the geotechnical considerations.

2.1 Landfill Disposal Guidelines

In this study, the basic concept for disposing of the oiled debris was to excavate a large pit in the ground in which the debris would be buried (Hrudey et al, 1973; Stearns et al, 1977). The guidelines, therefore, relate to the selection, design, construction and reclamation of these sites and the required access roads.

Although the beaches will be cleaned during the summer, it will not be possible to bury the oiled debris in the summer in all cases. For those situations where the debris cannot be buried in the summer, it will have to be temporarily stored at some location and buried the following winter. Consequently, landfill disposal guidelines have been established for both summer and winter conditions.

2.1.1 Site Selection Guidelines - Disposal Pit and Access Roads.

2.1.1.1 General. Sites should be located:

- inland of maximum storm surge zone, or on land at least 3 m above mean sea level;
- as close as possible to the beach, in order to minimize costs and environmental disturbance (Table 1);
- on terrain that is as level as possible and at least 50 m from the toe or crest of significant slopes greater than 10 degrees; for significant slopes greater than 15 degrees, sites should be located at least 100 m from the toe or crest. (All ice-rich slopes must be checked individually to ensure that the above guidelines are satisfactory for the actual field conditions. Special attention will be required in hummocky moraine terrain.);
- on terrain that is at least 1.5 m above and 100 m away from the high water mark of streams, rivers and lakes; and
- where drainage is dispersed and not concentrated.

TABLE 1 TYPE OF COASTLINE AND DESIGN LIFE OF LANDFILL SITE**

Type of Mainland Coastline (other than hummocky moraine terrain)	Minimum Distance to Beach (m)	Design Life* (yr)
Sediment Sink Area	200	greater than 100
Sediment Source Area		
- cliffs with beaches less than 30 m wide	300 600	50 100
- cliffs with beaches greater than 30 m wide	200 400	50 100
Breached Thermokarst Lake	200	50
Shoreline or Sheltered Bays	400	100

* It was determined from the literature that the maximum rates of mainland coastline retreat over a 17-year period were up to 5.3 m/yr for cliffs without beaches and 3.3 m/yr for cliffs with beaches (Lewis and Forbes, 1975; MacDonald and Lewis, 1973). Using this information, rates of retreat for mainland coastline were established as follows:

- cliffs with beaches less than 30 m wide: an average retreat rate of 6.0 m/yr for both 50-year and 100-year situations; and
- cliffs with beaches greater than 30 m wide, and breached thermokarst lake beaches: an average retreat rate of 4.0 m/yr for both 50-year and 100-year situations.

** Table 1 neither applies to the shore along the west side of Shallow Bay, nor to mainland coastlines where the terrain consists of hummocky moraine (Section 5.1). There is a potential for extremely high ice contents in this terrain type and these situations should be reviewed separately. In addition, Table 1 does not apply to offshore island coastlines such as those that exist on Garry and Pelly Islands. No specific recommendations could be determined for the islands because of a lack of data.

Sites should not be located:

- on alluvial fans or active flood plains. (This does not mean that high terraces that exist within alluvial fans as remnant features cannot be used.);
- in recently drained lakes, taliks or large icing zones, and no closer than 100 m from the edges of these areas;
- in low lying sedge meadows;

- within three km or directly upstream of a settlement, unless a detailed review of potential contamination of the drinking water has been undertaken;
- within 1000 m of significant fish overwintering pools, unless a detailed review of the potential hazards shows that a lesser distance is acceptable;
- within bird sanctuaries, wildlife reserves, IBP (International Biological Protection) study areas, other areas known to be environmentally sensitive, or within either municipal or Department of National Defence control areas, if possible.

Access along fossil flood plains, active flood plains and wide river or stream beaches may be permitted, provided that strict control of spillage is exercised and that an assessment of potential oil pollution problems has been undertaken.

2.1.1.2 Summer construction. Locate sites and access roads on soil type with the following order of preference:

- (a) frozen sand, gravel or rock deposits with little (<0.5m) fine-grained soil at the surface,
- (b) frozen sand, gravel or rock deposits with some (>0.5 m) fine-grained soil at surface,
- (c) fine-grained soil with low ice content (<35 percent average) (It should be noted that summer construction in this type of terrain may be difficult due to the problems of handling fine-grained material when it is thawing.),
- (d) fine-grained soil with high ice content (>35 percent average) (Although access roads can be located over this type of terrain in the summer, construction of landfill disposal sites in such terrain in the summer is not recommended.).

2.1.1.3 Winter construction. (Oiled debris has been stockpiled at a temporary storage site.) Locate sites on soil type with the following order of preference:

- (a) fine-grained soil with low ice content (<35 percent average),
- (b) fine-grained soil with high ice content (35 to 75 percent average),
- (c) frozen sand, gravel or rock deposits with some (>0.5 m) fine-grained soil at surface,
- (d) frozen sand, gravel or rock deposits with little (<0.5 m) fine-grained soil at surface.

In order to preserve the potential granular borrow source areas, terrain listed in (a) and (b) should be selected prior to terrain listed in (c) and (d).

2.1.2 Design Guidelines - Disposal Pit and Access Roads.

2.1.2.1 General. The excavated pit should be about 4 to 6 m deep.

For either summer or winter construction of the landfill disposal site, it was established that the active layer should not penetrate down to the uppermost level of the

oiled debris, in order to prevent leakage of oil into the surrounding active layer. It was also established that the pore spaces in the surrounding permafrost had to be filled with ice so that oil from the debris would be contained within virtually impermeable boundaries.

It was calculated that the depth of the active layer in a well-drained granular fill would be about 2.5 m, and about 1.5 m in a fine-grained fill berm. The thickness of the berm over the oiled debris should be greater than these calculated values.

The elevation of the oiled debris in the pit relative to the active layer in the surrounding tundra must also be considered. In fine-grained soils, the debris can be backfilled to a level that is about 0.5 m higher than the maximum depth of the active layer in the surrounding tundra because of the relatively impervious nature of the fine-grained soil. In coarse-grained soil, the final elevation of the oiled debris should not be higher than the maximum depth of the active layer in the surrounding soil. An exception can be made for this case, however, if the oiled debris is capped with a relatively impervious layer of fine-grained soil, or if construction takes place in the winter.

The above considerations have, in part, led to the typical designs developed for the following conditions:

Summer Construction

Sand, gravel and rock deposits (Figures 1 and 2); fine-grained soil: only where ice content is low, less than about 35 percent average (Figure 3).

Winter Construction

Sand, gravel and rock deposits (Figures 4 and 5); fine-grained soil: not in extremely ice-rich soil, where average ice content is greater than about 75 percent (Figure 6).

Final designs should be based on site-specific terrain conditions.

2.1.2.2 Summer construction. The oiled debris should be interlayered with clean sand or shingle so that if oil is squeezed out of the debris there will be void spaces in the clean sand or shingle for the oil to move into. The oiled debris should be placed in about 1.1 m layers with 0.3 m layers of clean material above it. If the oiled debris consists of coarse shingle with cobbles, the layers of clean material may not have to be placed, particularly if the debris is not oil rich.

Drainage into the excavation from the surrounding active layer should be prevented by blading an interceptor ditch around the perimeter of the landfill site which includes the pit and spoil piles.

To provide positive surface drainage, the base of the pit should maintain a slope towards the perimeter. Sufficient sumps with pumps should be located at the base

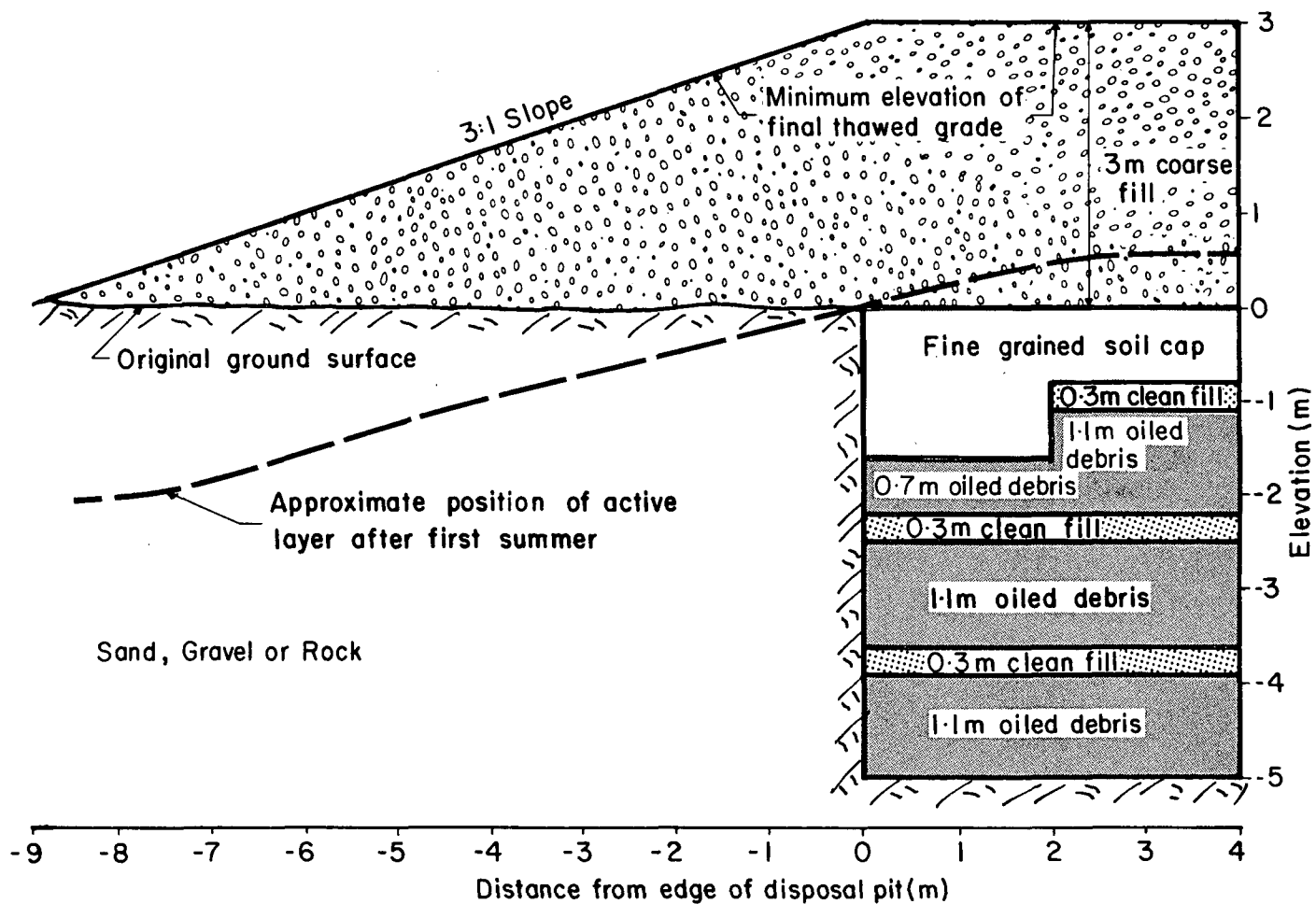


FIGURE 1 TYPICAL LANDFILL SECTION IN SAND, GRAVEL OR ROCK DEPOSIT
SUMMER CONSTRUCTION

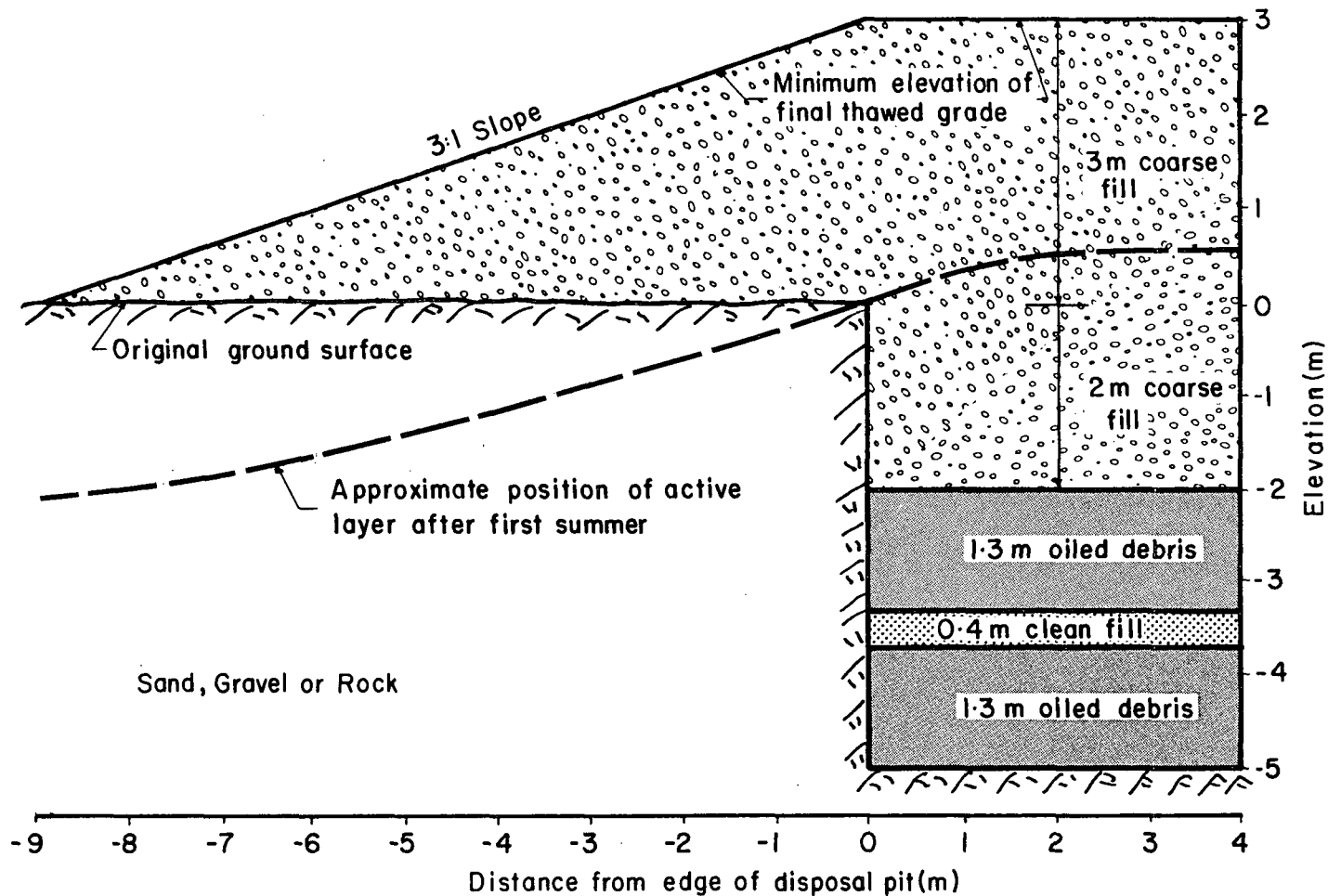
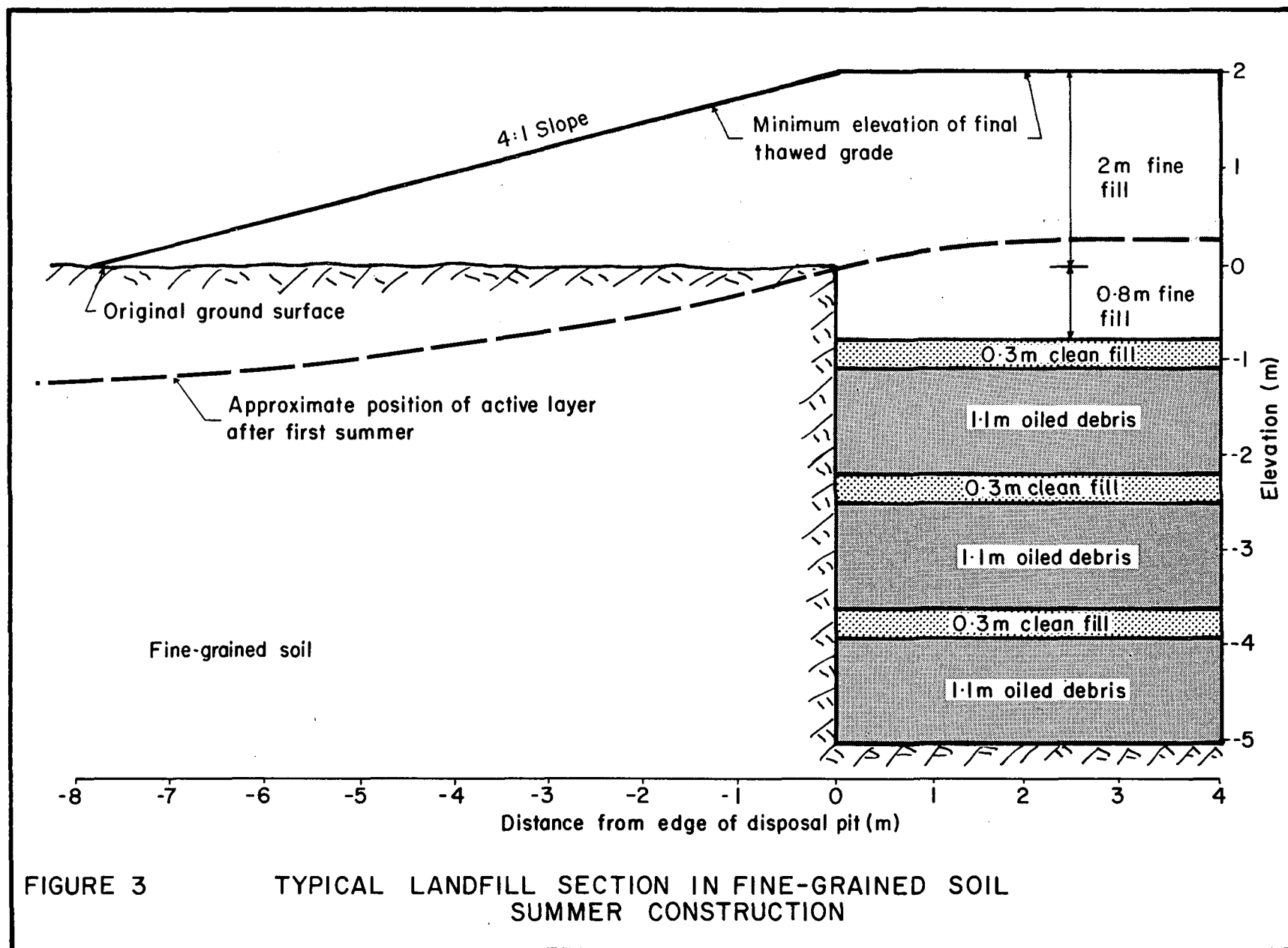
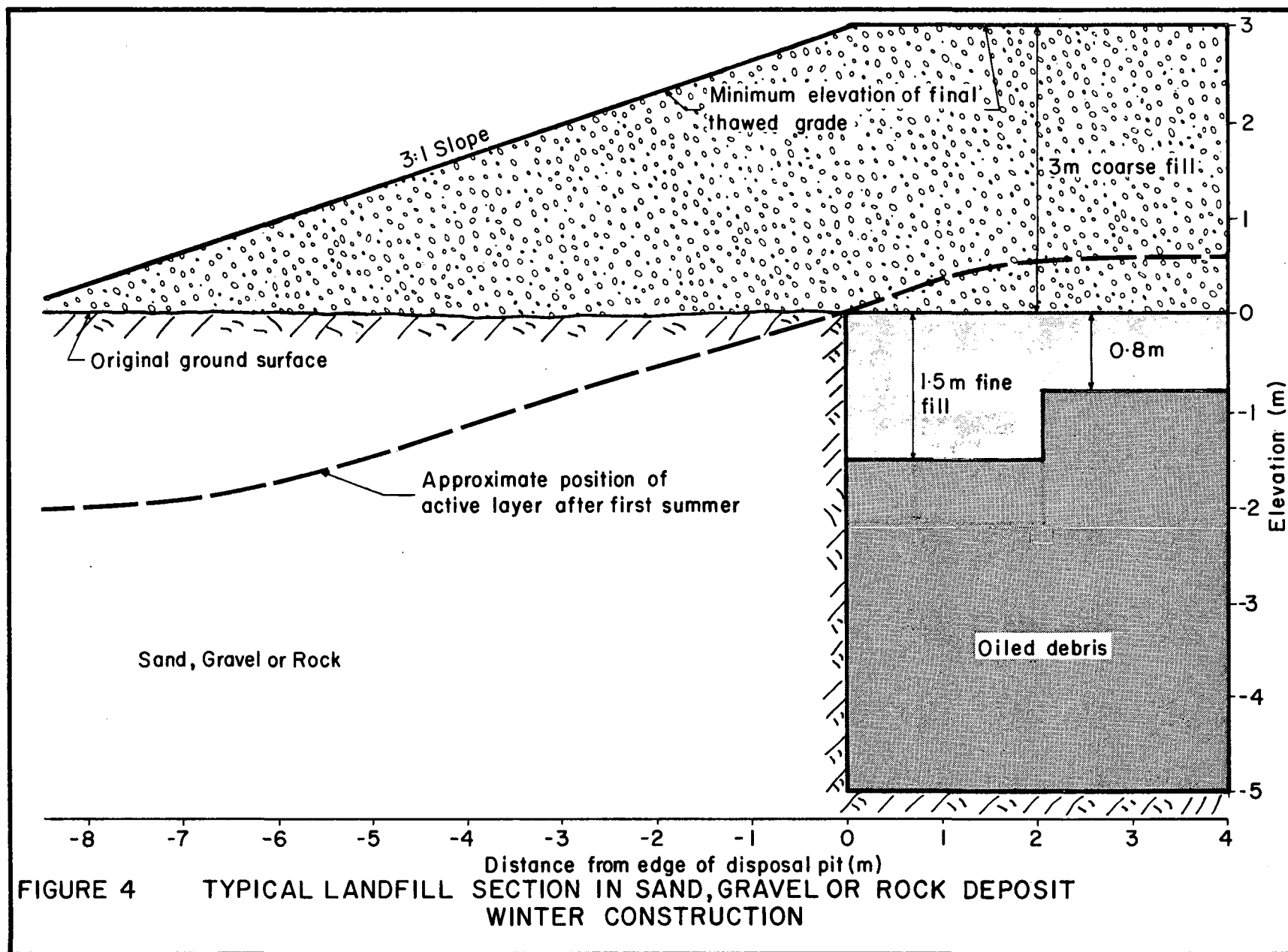
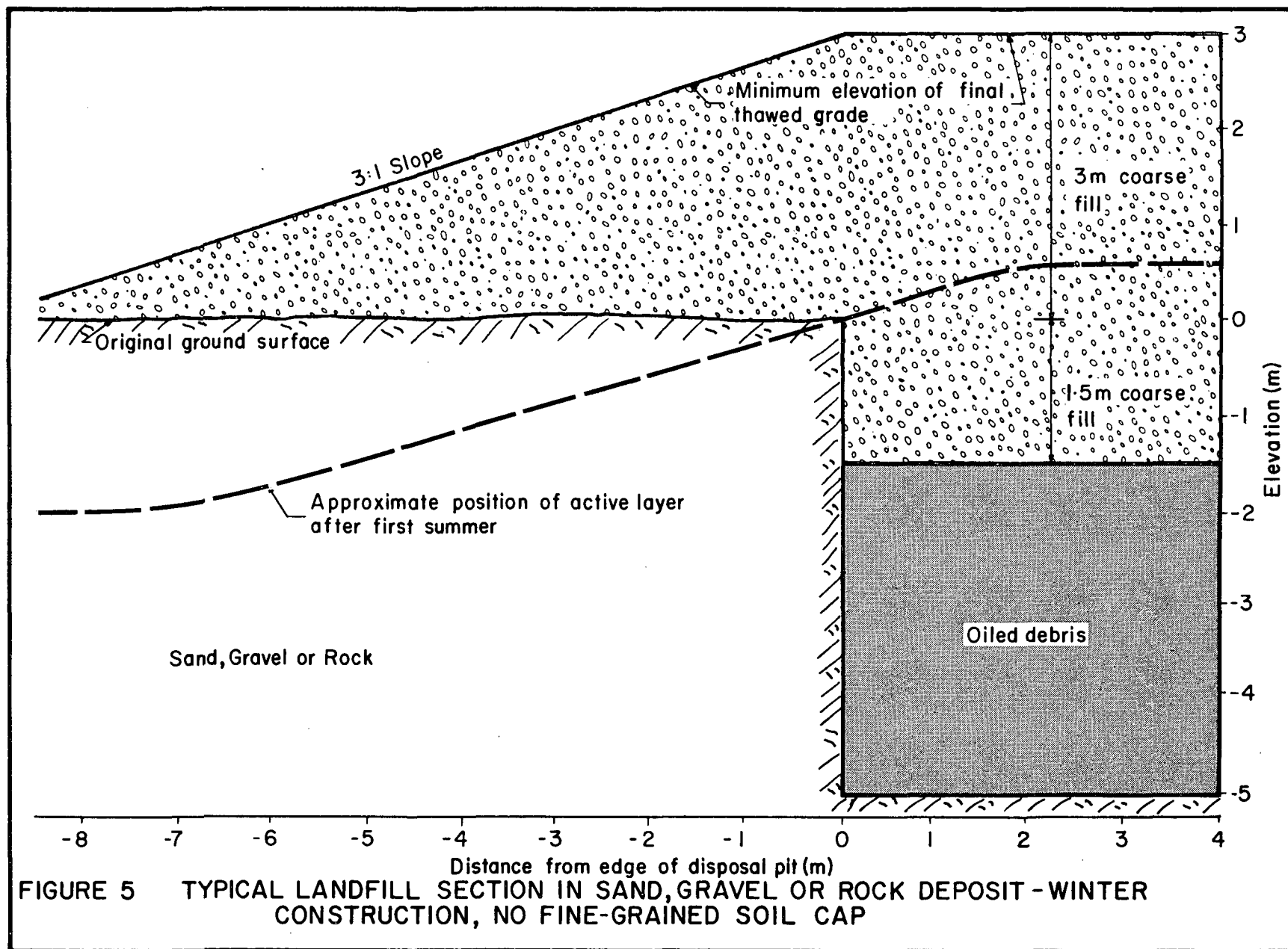
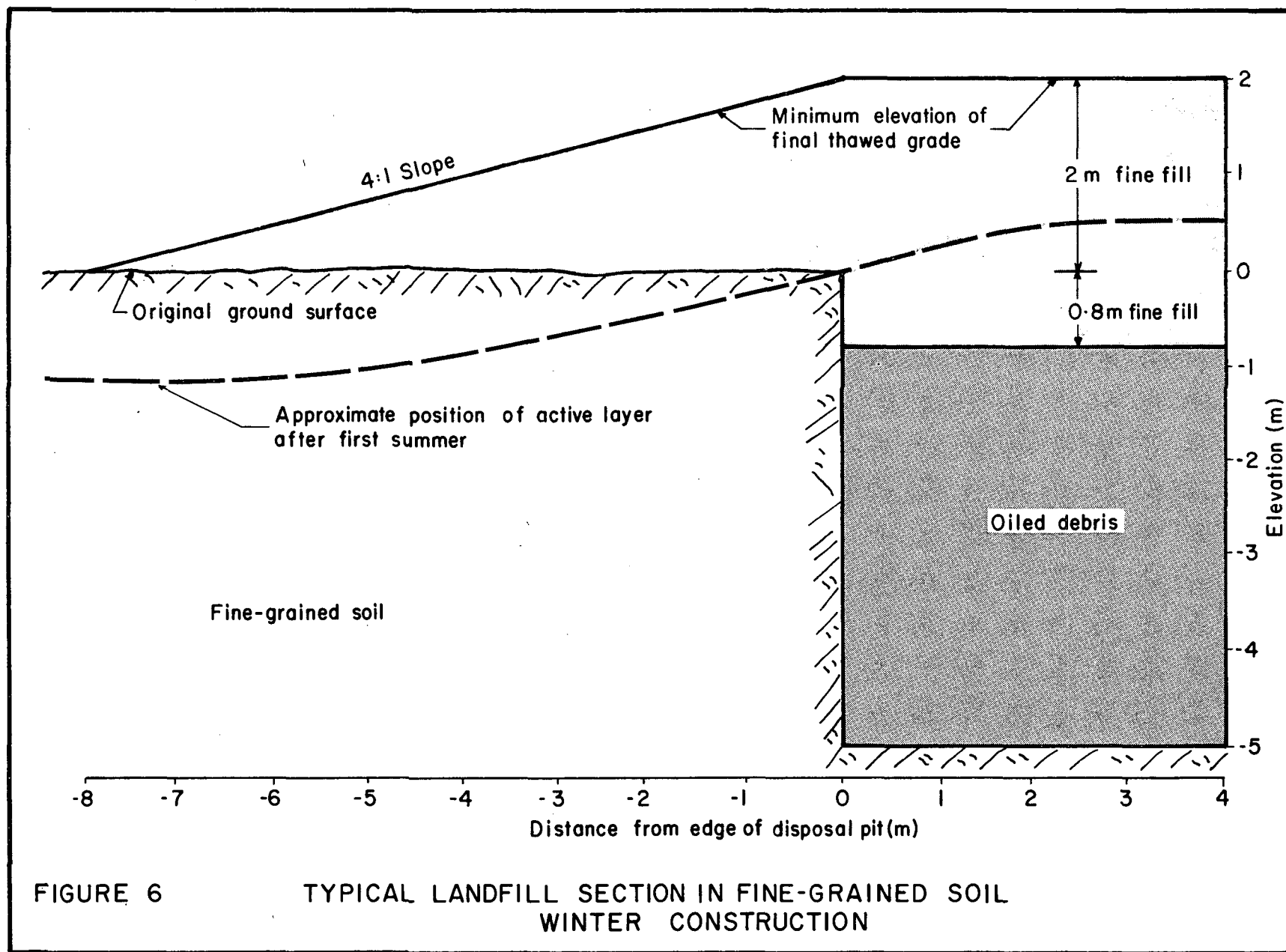


FIGURE 2 TYPICAL LANDFILL SECTION IN SAND, GRAVEL OR ROCK DEPOSIT
SUMMER CONSTRUCTION, WITHOUT FINE-GRAINED
SOIL CAP









of the pit walls so that any excess accumulation of water that may disrupt construction could be removed. Water pumped from the sumps should be discharged into the drainage ditch around the site. If oil from the debris is contaminating this water, it should be cleaned prior to discharge into the ditch.

The spoil piles should be located at least five m from the original perimeter of the pit, to allow room for some sloughing of the soil.

The walls of the pit should be nearly vertical just before filling operations begin. A wedge of soil should be left against the pit walls to be cleaned out last; this will provide thermal protection for the walls for as long as possible.

After placing the oiled debris in the pit, berm the excavated material over the pit area making sure to extend the berm beyond the edges of the pit walls as shown in Figures 1, 2, and 3. The site should be built up and graded sufficiently so that when thaw settlement occurs, significant amounts of water will not be ponded. Ensure that the bermed area does not unduly affect the local drainage system by providing for drainage around the bermed area.

Access roads should be constructed of gravel; they should be about 1.2 m thick and four to eight m in width, depending on whether single or double-lane traffic is required. Where feasible, sand or shingle borrow from the beach may be used if its removal does not unduly affect the long-term stability of the beach. A small percentage of fine-grained soil binder may be required to stabilize surface courses of access roads constructed from beach materials. In certain cases, such as where borrow material is limited or the ground is very soft, it may be advantageous to lay an industrial fabric over the tundra and to place the borrow on top of the fabric.

2.1.2.3 Winter construction. A working pad of snow should be placed over the site, excluding only the area where the actual pit will be excavated. In order to comply with local regulations, the working pad should consist of a minimum snow cover of about 8 to 15 cm.

After the oiled debris has been placed in the pit, remove as much of the snow as possible from the area that will be under the sloped sides of the berm. Care should be taken to minimize disturbance of the tundra. Berm all of the excavated material over the pit, making sure to extend the berm beyond the edges of the pit walls, as shown in Figures 4, 5 and 6. Sand interlayers are not required as the debris and the base of the berm above it will be maintained in a continually frozen condition.

The terrain at the site should be built up and graded sufficiently so that when thaw settlement occurs, significant amounts of water will not be ponded. Ensure that the

bermed area does not unduly affect the local drainage system by providing for drainage ways around that area.

Winter access area roads should be constructed of snow in a manner that complies with local regulations. Generally, this would mean that the access ways should be levelled and then an 8 to 15 cm layer of compacted snow placed on top. Where practical, ice-surfaced roads can be used.

2.1.3 Construction Guidelines - Disposal Pit and Access Roads.

2.1.3.1 General. Equipment that is generally available in the Beaufort Sea area or equipment that can be flown to a staging area should be used. This equipment should be suitable for cleaning sand and shingle beaches, and excavating in frozen, coarse and fine-grained material and rock.

Temporary, on-site equipment repair service should be provided.

Construction equipment will be transported to the oiled beaches by means of barges. Because the near shore water depths are very shallow in many areas along the Beaufort Sea coast, earthfill offloading ramps will have to be constructed from the beach to the barge. These ramps can be built with equipment that can be offloaded from the barge into shallow water or transported to the site in pieces by helicopter. In some cases, it may be necessary to have dredging equipment on the barge so that it can get closer to shore. This may be of limited use, however, as it is expected that permafrost conditions will exist under much of the shallow water. It may also be helpful to have prefabricated surface panels to lay over the earthfill ramps in order to facilitate offloading of equipment.

2.1.3.2 Summer construction. Sufficient equipment should be available to excavate the disposal pit as rapidly as possible, e.g., within 7 to 10 days.

Borrow will be required for construction of access roads from the beach to the disposal pit site and to some of the borrow areas. Coarse-grained material for the roads can be obtained from the beach or from borrow pits. Some fine-grained borrow may be required to be used as binder in the coarse-grained material in order to enhance its trafficability characteristics. The access roads should be constructed by end dumping the material on the tundra. In some cases, such as where borrow material is limited or the ground is very soft, it may be advantageous to lay an industrial fabric over the tundra and to place the borrow on top of the fabric.

A perimeter drainage ditch should be constructed around the site by blading a trench into the active layer. The ditch should be located as close as possible to the final position of the spoil piles in order to minimize the area of disturbance.

To excavate the pit, the frozen soil should be loosened by blasting where ripping is not feasible. Blasting should be carried out under the supervision of a certified blaster. The drill holes for blasting should be carefully located by survey and the depth of hole should also be carefully controlled.

Dozers should be used to rip and push the material into spoil piles. This material should not be located closer than five m from the edge of the pit: this is to allow for some thawing and sloughing of the pit walls before the spoil pile is encroached upon. Pit and spoil pile dimensions should be selected and located in order to minimize dozer push lengths and surface disturbance. In addition, to minimize the areal extent of surface disturbance, spoil piles should be as high as possible.

Oiled sand and shingle material on the beaches should be scraped or pushed into windrows or stockpiles using graders, dozers and loaders. Oiled debris should subsequently be loaded onto hauling equipment and transported to the site.

Clean sand or shingle material on the beaches should be scraped or pushed into windrows or stockpiles using graders, dozers and loaders. Subsequently, the material is to be loaded onto hauling equipment and transported to the landfill disposal site for use as interbedding material between layers of oiled debris. All beach borrow material must be carefully selected, keeping the long-term stability of the beach in mind. If sufficient coarse-grained material for the interbedding material is available from the spoil pile at the disposal site, it may not be necessary to use borrow from the beach. The ability of the graders dozers, loaders and hauling equipment to move easily on the wet and dry portions of the oiled beach area must be critically evaluated prior to final selection of the equipment.

Oiled debris should be placed in the pit in layers no more than 1.1 m thick and covered with about a 0.3 m layer of clean sand, shingle or gravel. The oiled debris and the clean material are to be compacted using available equipment. Figures 1, 2 and 3 show the level to which the pit can be filled with oiled debris.

When a typical design such as that shown in Figure 1 is selected, the fine-grained soil cap should be placed over the piled debris and compacted. It should be noted that difficulties may be encountered in placing and compacting the fine-grained soil cap, particularly if the water or ice content of the soil is high. The spoil should then be pushed over the pit area and graded.

2.1.3.3 Winter construction. A snow road should be constructed from the temporary storage site to the landfill disposal site, and a snow pad should be constructed at the disposal site.

The pit can be excavated as discussed in Section 2.1.3.2 except that the spoil piles can be located as close to the edges of the pit as considered safe under the specific field conditions because there will be no thawing of the pit walls.

Oiled sand and shingle should be ripped or blasted loose at the temporary storage site, loaded onto hauling equipment and transported to the landfill disposal pit.

Oiled debris should be compacted in the pit with available equipment. The debris should be placed in the disposal pit up to a level shown in Figures 4, 5 and 6. Clean interbedding material is not required.

When a typical design such as that shown in Figure 4 is selected, the fine-grained soil cap should be placed over the oiled debris and compacted. To make this cap relatively impermeable, some water may have to be sprayed over it so that some of the voids become ice filled. The spoil should then be pushed over the pit area and graded. An effort should be made to replace as much of the topsoil as possible on top of the berm and built-up areas.

2.1.4 Reclamation Guidelines - Disposal Pit and Access Roads. Seed and fertilize all disturbed areas around the site using the following mixtures:

<u>Seed Mixture</u>	<u>Percentage by Weight</u>
Arctared creeping red fescue	33
Tundra bluegrass	33
Alyeska arcticgrass	17
Climax timothy	17
Seed at 40 kg/ha	

<u>Fertilizer Mixture</u>	<u>Percentage by Weight</u>
N	10
P ₂ O ₅	30
K ₂ O	10
Fertilize at 450 kg/ha	

Seeding should not take place from mid-July to late August, as the seeds will probably germinate but not establish well enough to survive winter kill. If seeding cannot be done during the construction season, it can be done the following spring with a helicopter mounted seed bucket. In this case, the seed mix would remain the same but the rate should be increased to 50 kg/ha.

For revegetation of sand dune areas, it may be necessary to apply a mulch and tackifier slurry, to resist wind erosion, along with the seed fertilizer. In some cases, snow fences located around the berm should be considered for extra wind protection. Where fine-grained soil is locally available, it can be used to cover the sandy berm to help resist wind erosion. These guidelines are mainly applicable to the landfill sites located from Hutchinson Bay to Cape Dalhousie on the Tuktoyaktuk Peninsula.

Fill and grade other disturbed areas. Follow seeding and fertilizing instructions given previously.

An inspection of the seeded areas should be carried out the next year, a few weeks after snow melt but no later than the first week of July. If less than 30 percent of the seed has germinated, the area should be reseeded and fertilized. If small local areas are suffering from erosion, mulches, tackifiers or erosion control mats should be used to provide additional protection.

2.2 Temporary Storage Guidelines

Although the oiled will be cleaned during the summer, it will not always be possible to bury the oiled debris at that time. In some cases, it will not be possible to locate landfill sites that are suitable for summer construction in the area. In other cases, access to the landfill site in the summer will be too difficult. Under these conditions, the oiled debris will be stored at a temporary storage site until it can be buried during the winter.

In this study, the basic concept for temporary storage of the oiled debris involved piling it on an impermeable liner on the ground surface, with earth dykes around it (Auld et al, 1974; EBA, 1977; Thornton and Blackall, 1976). Therefore, the guidelines relate to the selection, design, construction and reclamation of these sites and the required access roads.

2.2.1 Site Selection Guidelines - Temporary Storage. Sites should be located:

- inland of maximum storm surge zone, or on land at least three m above mean sea level;
- close to the beach: the site should be within 200 m of the beach but should not be closer than about 20 m;
- on terrain that is as level as possible and at least 50 m away from the toe or crest of significant slopes greater than 10 degrees. (All ice-rich slopes must be checked individually to ensure that the above guideline is satisfactory for the actual field conditions. Special attention will be required in hummocky moraine terrain.);

- on terrain that is at least 1.5 m above and 100 m away from the high water mark of streams, rivers and lakes; and
- where drainage is dispersed and not concentrated.

Locate sites on terrain with the following priority:

1. frozen sand, gravel or rock deposits,
2. low ice content, fine-grained soil,
3. high ice content, fine-grained soil.

Sites should not be located:

- on alluvial fans or active flood plains. (This does not mean that high terraces that exists within alluvial fans as remnant features cannot be used.);
- in recently drained lakes, taliks or large icing zones, or closer than 100 m from the edges of these areas;
- within three km or directly upstream of a settlement, unless a detailed review of potential contamination of the drinking water has been undertaken;
- within 1000 m of significant fish overwintering pools, unless a detailed review of the potential hazards shows that a lesser distance is acceptable;
- within bird sanctuaries, wildlife preserves, IBP study areas, other areas known to be environmentally sensitive, or within either municipal or Department of National Defense control areas, if possible.

Access along fossil flood plains, active flood plains and wide river or stream beaches may be permitted, provided that strict control of spillage is exercised and that an assessment of potential oil pollution problems has been undertaken.

2.2.2 Design Guidelines – Temporary Storage. The oiled debris can be stored on the ground surface. An impermeable liner should be placed under the debris within the dyked area to prevent or greatly minimize the amount of oil that could get into the local ground water. Considerable care will have to be taken to prevent the liner from being punctured by the material on the surface of the ground or from the oiled debris during placement. For example, a 15 to 25 cm layer of sand could be placed over the site to level it, a 10 mil polyethylene sheet could be laid on top, and then oiled sand from the beach could be carefully placed over the top (Figure 7). Depending on the condition of the ground surface at the site and the grain size (sand or shingle) of the oiled debris, various combinations of levelling course and liner can be used.

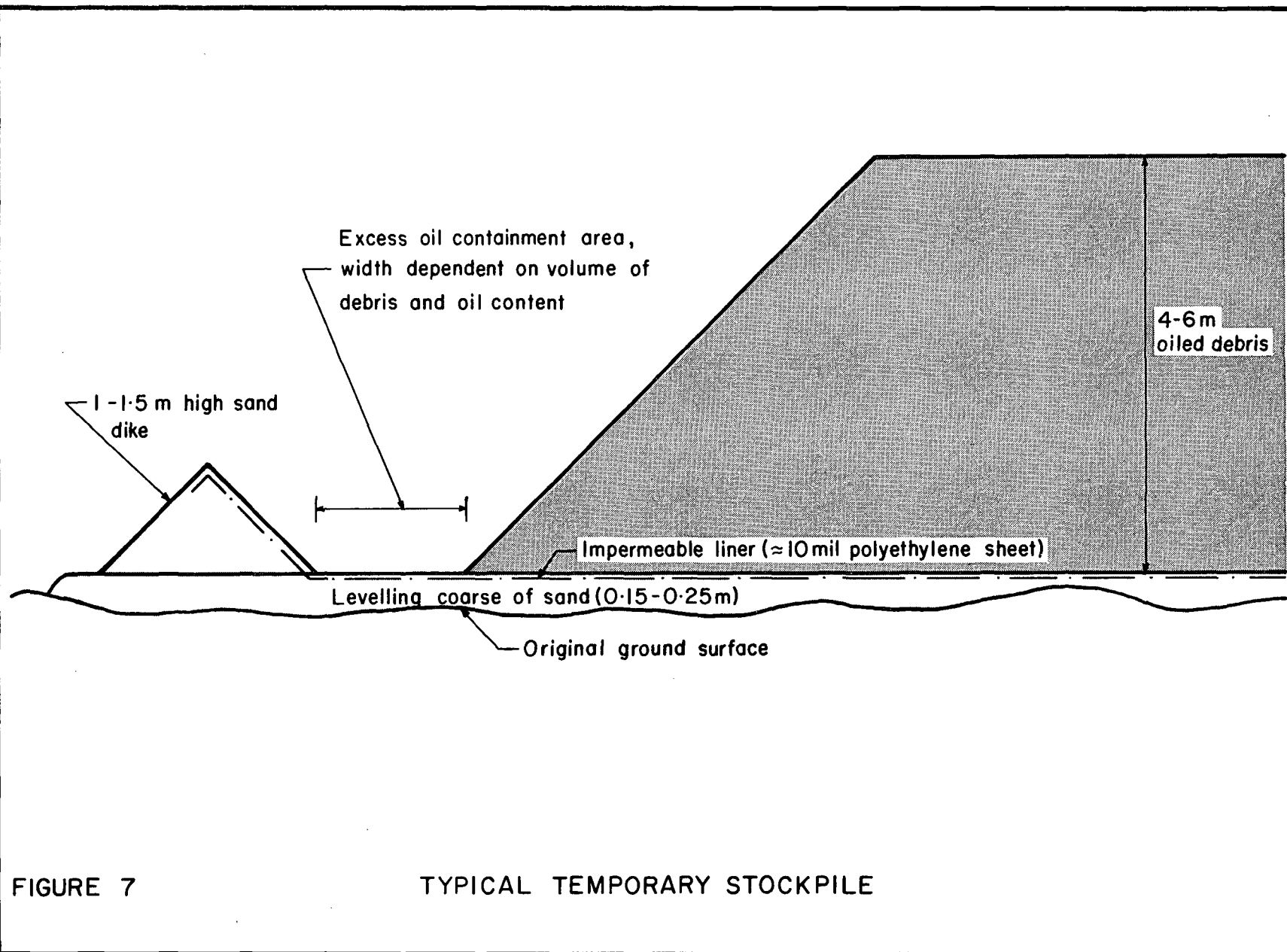


FIGURE 7

TYPICAL TEMPORARY STOCKPILE

Dykes should be constructed around the perimeter of the site. These dykes should consist of clean material from the beach or other borrow source, and should be about 1 to 1.5 m in height, depending on the volume of the debris and how oil rich it is. The impermeable liner should extend from under the debris to the top of the dyke.

The oiled debris should be piled about five m high. Sufficient space should be left between the bottom edge of the debris and the perimeter dykes so that oil leaking from the pile will not overtop the dyke. The quantity of excess oil will be dependent on the residual amount of oil retained in the unsaturated part of the debris, the initial amount of oil and water in the debris, and the volume of the debris. The dyked area can be determined on this basis, including storage capacity for water accumulated from summer rain storms.

After the oiled debris has been stored, monitoring program should be set up to ensure that significant quantities of oil are not escaping outside the dykes. In addition, monitoring of any free oil that accumulates between the dyke and the pile of oiled debris should be maintained.

2.2.3 Construction Guidelines - Temporary Storage. Equipment that is generally available in the Beaufort Sea area or equipment that can be flown to a staging area should be used. This equipment should be suitable for cleaning sand and shingle beaches, and excavating in frozen, coarse and fine-grained material and rock.

Temporary, on-site equipment repair service should be provided.

Construction equipment will be transported to the oiled beaches by means of barges. Because the near shore water depths are very shallow in many areas along the Beaufort Sea Coast, earthfill offloading ramps will have to be constructed from the beach to the barge. These ramps can be built with equipment that can be offloaded from the barge into shallow water or transported to the site in pieces by helicopter. In some cases, it may be necessary to have dredging equipment on the barge so that it can get closer to shore. This may be of limited use, however, as it is expected that permafrost conditions will exist under much of the shallow water. It may also be helpful to have prefabricated surface panels to lay over earthfill ramps in order to facilitate offloading of equipment.

Borrow will be required for construction of access roads from the beach to the temporary storage site and to some of the borrow areas. Coarse-grained material for the roads can be obtained from the beach or from borrow pits. Some fine-grained borrow may be required to be used as binder in the coarse-grained material in order to enhance its trafficability characteristics. The access roads should be constructed by end dumping the

material on the tundra. In some cases, such as where borrow material is limited or the ground is very soft, it may be advantageous to lay an industrial fabric over the tundra and to place the borrow on top of the fabric.

Place a levelling course of sand or other suitable material over the site. Construct the dykes around the perimeter of the site. Lay the impermeable liner over the site and extend it up to the top of the dyke. Ensure that the liner is properly protected from puncture. The liner should be overlapped and sealed along the joints. When borrow material is obtained from the beach, careful consideration must be given to the long-term stability of the beach.

Oiled sand and shingle material on the beaches should be scraped or pushed into windrows or stockpiles using graders, dozers and loaders. Subsequently, the oiled debris is loaded onto hauling equipment and transported to the temporary storage site.

In the winter, after the oiled debris and the impermeable liner have been taken from the temporary storage site to the landfill disposal pit, the material in the dykes should be levelled across the site or taken back to the beach. Fine-grained material should be obtained from the spoil excavated from the disposal pit or borrow pit. This should be used to construct about a 15 cm layer across the surface of the site for reclamation purposes.

2.2.4 Reclamation Guidelines - Temporary Storage. Seed and fertilize all disturbed areas around the site using the following mixtures:

<u>Seed Mixture</u>	<u>Percentage by Weight</u>
Arctared creeping red fescue	33
Tundra bluegrass	33
Alyeska arcticgrass	17
Climax timothy	17
Seed at 40 kg/ha	
<u>Fertilizer Mixture</u>	<u>Percentage by Weight</u>
N	10
P ₂ O ₅	30
K ₂ O	10
Fertilize at 450 kg/ha	

Seeding should not take place from mid-July to late August as the seeds will probably germinate but not establish well enough to survive winter kill. If seeding cannot be done during the construction season, it can be done the following spring with a helicopter mounted seed bucket. In this case, the seed mix would remain the same but the rate should be increased to 50 kg/ha.

Fill and grade other disturbed areas. Follow seeding and fertilizing instructions given previously.

An inspection of the seeded areas should be carried out the next year, a few weeks after snow melt but no later than the first week of July. If less than 30 percent of the seed has germinated, the area should be reseeded and fertilized. If small, local areas are suffering from erosion, mulches, tackifiers or erosion control mats should be used to provide additional protection.

3 LIMITATIONS ON CONSTRUCTION, UTILIZATION AND RECLAMATION

The guidelines presented in Section 2 include many of the limitations on construction, utilization and reclamation of landfill disposal and temporary storage sites. Some of the major limitations are highlighted in this Section.

3.1 Time of Construction

One of the more significant limitations is that summer construction of a landfill disposal site located in ice-rich permafrost is not practical. There are problems associated with handling thawing permafrost spoil, sloughing pit walls and generally sloppy ground conditions at the site. Since much of the terrain along the coastline consists of ice-rich permafrost, there are many areas in which oiled debris will have to be temporarily stored for winter burial.

In order to haul the oiled debris from the beach to a disposal pit in the summer, access roads need to be built. Borrow for these roads can be obtained from the beach or local pits. Substantial costs will be incurred in road construction.

Another disadvantage of summer construction of landfill disposal sites is the potential pressure on availability of equipment. The summer season is only about three months long and, since there may be a limited amount of construction equipment available in the Beaufort Sea area, construction of a disposal pit in one place may mean that a beach at another location cannot be cleaned.

3.2 Construction Equipment

The equipment available in the Beaufort Sea area for shore cleanup and construction of disposal pits or temporary storage sites may be limited. It is entirely possible that equipment will have to be barged or flown in. The equipment used should be sufficiently versatile: it should clean sand or shingle beaches; excavate frozen, fine or coarse-grained material; and operate on soils that have poor trafficability characteristics, such as some beach sands. This means the the construction equipment will generally consist of dozers, loaders, graders, and tandem trucks. More specialized equipment, such as elevating scrapers, would probably be difficult to use in many situations, even though they would be the most effective kind of equipment to use to clean up those parts of sand beaches where traction would not be a problem.

3.3 Terrain Features

The problems associated with ice-rich terrain have previously been discussed; however, there are other major limitations due to terrain features. In many places, sand and shingle beaches have high cliffs immediately behind them so that there is virtually no access to the land behind the beach. In other areas, such as along the Malcolm and the Firth Rivers, because the terrain consists mainly of alluvial fans or flood plains, there are virtually no suitable locations for landfill sites, even though there are considerable lengths of sand and shingle beaches. In other areas, the land behind the beach consists of moderately to steeply sloping terrain, so that no flat sites of reasonable extent can be located.

In such cases, oiled debris cleaned from the beaches will have to be barged away or hauled over long distances for disposal. Consequently, a great deal of consideration should be given to preventing oil from reaching these beaches, particularly if they are in environmentally or socio-economically sensitive areas.

3.4 Barging

A significant limitation for cleanup of some beaches is that near shore water depths are so shallow that equipment barges can not get close enough to shore to offload the equipment. In some cases, the barges will not be able to get within several tens to several hundred meters of the shoreline. In such situations, a channel will have to be dredged in toward the shore or an earth causeway will have to be built out to the barge.

Under the best of conditions, the practicality of dredging might be questioned, but in the Beaufort Sea it may prove exceedingly difficult in most shallow water situations because there is a good possibility that permafrost may exist just under the sea bed. The building of causeways of 50 to 100 m in length may prove to be an equally unattractive option when the time, costs, and demand on equipment are critically evaluated.

These problems become more acute when barging oiled debris from a beach to another location is required, because barges loaded with debris require even deeper water than equipment barges.

No satisfactory solution was found for these problems. A great deal of consideration should be given to preventing oil from reaching these beaches. The general location of these beaches is given in Section 5.2.

3.5 Cost

Cost should be considered a major limitation. In general, the more often the material has to be handled and equipment mobilized, the more costly it will be to finally dispose of the oiled debris. For similar conditions, it would cost less to bury the debris in the summer than to stockpile it in the summer and bury it in winter. In either case, if the oiled debris had to be barged to another location for stockpiling or burial, this would substantially add to the cost. These costs are discussed in more detail in Section 5.3.

4 CLASSIFICATION OF COASTLINE

The coastline in the study area was classified into broad categories by the use of aerial photographs, as follows:

Sand beaches

Uniform fine to medium sand; widths are generally from 15 to 200 m, with some greater than 300 m; the highest beach ridge may contain fine gravel and may be littered with driftwood.

Shingle beaches

Mixed cobbles, gravel and sand; generally from 15 to 200 m in width; the highest beach ridge usually consists of very loose cobbles and gravel, and may be littered with driftwood.

Cliffs

Eroding sea cliffs are generally 8 to 50 m high; they are often fronted by a very narrow beach less than 10 m wide.

Mudflats

Tidal flats and low lying river delta flats; fine-grained sediment and organic material.

Tundra

Low lying tundra areas such as on the outer delta or on the mainland side of some lagoons.

Landslides

Only exceptional large landslides are shown; these are usually retrogressive thaw flow-slides in ice-rich, fine-grained soils.

Sloping shoreline

Basically a sand cliff that has been eroded at the top by wind and at the base by water; generally, there is no beach fronting the sloping shoreline.

In many locations more than one type of beach is present; these areas are identified as complex beaches. For example, definable sand and shingle beaches are found in front of eroding cliffs. There are also situations in which two types of beach are not clearly separable at the scale of mapping used. An example of this is where a spit may have a shingle beach on the side facing the sea and a sand beach on the side facing the mainland.

Maps 1 to 7 (Appendix H), show the various types of beaches along the shoreline in the study area. Cleanable sand and shingle beaches are highlighted by means of a solid line for easy reference. Narrow sand beaches located behind wide mudflats, especially along the Tuktoyaktuk Peninsula, are highlighted on the maps by means of a thin, wavy line. Because the sand on these beaches is probably not very deep, and because the beaches are so narrow, they are not considered to be cleanable in this study; they were highlighted for information only. Landfill or temporary storage sites were not identified in these areas.

5 LANDFILL DISPOSAL AND TEMPORARY STORAGE SITES

Utilizing the guidelines in Section 2 and the aerial photographs, landfill disposal and temporary storage sites were located as close as possible to the sand and shingle beaches. These sites are shown on 1:150,000 scale strip maps, Maps 1 to 7 (Appendix H). Map 8 is the general key map. These sites are shown in more detail on 1:20,000 to 1:70,000 scale aerial photographs (Appendices A to G). The aerial photographs in Appendix A correspond to the sites located on Map 1; Appendix B to Map 2; etc.

Detailed information is provided along with the aerial photographs in Appendices A to G. This information consists of the following:

- Landfill Site:* Available working area at the site, estimated from aerial photographs; and comments on ice content and type of terrain.
- Temporary Stockpile:* Available working area at the site, estimated from aerial photographs; and comments on ice content and type of terrain.
- Beach:* Type of beach material and its approximate width.
- Borrow Sources:* Type of borrow and its location.
- Access:* Length of summer or winter access roads from beach or temporary storage site to landfill disposal site; comments may be included concerning terrain conditions along the access routes.
- Development:* General comments that are considered applicable, e.g., suitability of the landfill site for summer construction.
- General:* The airphoto number; landfill site outline, temporary stockpile site outline; borrow area; approximate airphoto scale; and summer and winter access routes.

For reasons of space, the comments on each airphoto are brief. An explanation of some of the terms used and comments included follows.

Available area: Total available area for construction of the landfill site or temporary stockpile; this includes area for stockpiles of excavated soil, space for equipment, etc. The actual available area for the disposal pit or temporary stockpile would be less than indicated.

Ice wedges: The existence of ice wedges is noted for some sites. The consequence for temporary stockpile construction is that significantly more sand borrow

is required to level the site due to the trench-like depressions on top of the ice wedges. In fine-grained soil, the presence of ice wedges will dictate winter construction of the landfill site.

Unless otherwise indicated, lacustrine deposits consist of silt or clay; morainal deposits consist of clay till; and marine deposits consist of mixed silt and clay, with minor amounts of sand. Unless otherwise indicated, the soil in thermokarst lake basins will be the same as that of the surrounding terrain, but with a thin veneer of silt or clay.

Narrow shingle beaches in front of cliffs may not contain sufficient sand for construction of temporary stockpile sites. In contrast, barrier beaches mapped as shingle beaches generally contain considerable sand on the lagoon side of the barrier beach.

The term "ice-cored" used in describing a terrain type means that the terrain relief is due largely to underlying massive ice. In sand and gravel deposits, the top of this massive ice is usually more than six m below ground surface. It may be closer to the ground surface in hummocky moraine or other fine-grained soils, or in sand and gravel with a thin veneer of hummocky moraine over the top.

Where the design life of the landfill site is specified, it has been calculated using the rates of coastline retreat listed in Section 2.1.1; where it is not specified, the design life is greater than 100 years.

Access routes shown are the best routes selected from airphoto interpretation. They are not necessarily the only possible access routes.

Comments stipulating winter construction mean that the site is best suited for winter construction from a geotechnical point of view. This does not necessarily mean that the site must be constructed in winter, as other factors may be more important.

Approximately 217 landfill disposal sites and 223 temporary storage sites have been located. Some potentially cleanable beaches such as inland spits do not have temporary storage or landfill disposal sites nearby. Consequently, if these beaches are to be cleaned, the oiled debris will have to be barged to another area.

5.1 Geological Considerations

From the limited bore hole information available for the terrain along the Beaufort Sea coast, some general correlations have been made between terrain type, ice content and summer or winter construction. Most fine-grained silt and clay deposits of lacustrine, marine, deltaic or morainal origin have moderate to high ice contents and are only suitable for winter construction. A possible exception to this may be the marine sediments from Mason River to Cape Bathurst (Section 5.1.7).

Coarse-grained soils such as sand and gravel deposits of alluvial, deltaic, or glaciofluvial origin may have low ice contents, depending upon topographic setting and geological history. For example, most well-drained gravel and sand terraces have low ice contents and should be suitable for summer construction. They are also suitable as borrow sources. By contrast, low-lying deltaic sand plains may have relatively high ice contents and may only be suitable for winter construction.

Some coarse-grained soils are ice-cored, i.e., they have massive ice bodies at depth. If the massive ice occurs beneath the six m depth and the upper soil has a low ice content, these areas may be suitable for summer construction. Previous studies (Rampton, 1974) indicate that the top of the massive ice usually is more than six m below the ground surface in sand and gravel deposits in the Eskimo Lakes area, but that it can be much closer to the ground surface if the deposit has a veneer of hummocky moraine. Field investigations in these terrain types would be required to determine their suitability for either summer or winter construction.

Available data (MacDonald and Lewis, 1973; MacKay, 1972) indicate that the bottom sediments in shallow water near shore are permanently frozen with a thin (up to one m) active layer developed by late summer. The presence of this permafrost would make dredging for barge access to the beaches difficult. The only shallow areas that may be unfrozen would be those influenced by water temperatures warmer than the open sea water of the Beaufort Sea. These unfrozen shallow areas would be limited to river mouths of relatively warm rivers and some breached thermokarst lake basins.

Existing surficial geology maps at a scale of 1:250,000 (Rampton, 1971, 1972) were used for background information in the selection of landfill sites. Detailed airphoto interpretation was used for selection of suitable areas for landfill disposal sites, temporary stockpiles, access routes, and possible borrow pit locations.

5.1.1 Yukon Coast. From the Alaska/Yukon border to Trent Bay, the beaches consist mainly of shingle or mixed shingle and sand material. Narrow beaches in front of eroding cliffs tend to be composed mainly of coarse material (a mixture of cobbles, gravel and coarse sand). Barrier beaches and spits are composed of coarse material on the seaward side but mainly sand on the landward or lagoon side.

Exposed cliffs consist mainly of ice-rich, fine-grained soils of morainal, marine, or lacustrine origin. Retrogressive thaw flow slides are common on exposures of these fine-grained soils. In some areas, preglacial (Tertiary), low ice content gravels are exposed in the cliffs. Gully formation due to runoff erosion is a common process acting on cliff exposures of these soils.

Selected landfill and temporary stockpile sites in this area are located on low ice content gravel terraces (mainly summer construction), and both lacustrine and morainal deposits (winter construction), with moderate to high ice contents. In general, because of the high amount of ground ice in these soils, ice-cored morainal deposits were not selected for landfill sites where other terrain was available. However, behind some cleanable beaches no alternative was available.

On the Yukon Coast, a large percentage of the terrain is moderately to steeply sloping, with flat; wet depressions and extensive alluvial fans. Relatively few well-drained, flat to gently sloping cleanable beaches for landfill sites are available. As a result, several cleanable beaches have no suitable landfill sites, e.g., the east half and detached portions of Nanaluk Pit, and some narrow shingle beaches in front of cliffs (Maps 1 and 2, Appendix H). It may be possible to barge oiled debris from these beaches to the nearest temporary stockpile or landfill disposal site.

5.1.2 Modern Mackenzie Delta. The outer portion of the modern Mackenzie Delta consists entirely of low-lying deltaic flats. The area is flooded every year during spring breakup and occasionally during summer storm surges. No cleanable sand or shingle beaches exist in this area, and there is no terrain suitable for landfill disposal sites (Map 2, Appendix H).

5.1.3 Outer Pleistocene Delta. The beaches on the north side of Richards Island and on the outer islands consist mainly of uniform fine to medium sand. Due to shallow bars and shoals, access to the sand beaches on the outer islands may not be possible with conventional barges. However, where possible, landfill sites were selected for these beaches (Map 3, Appendix H).

Narrow sand beaches behind extensive mudflats are common on the shoreline of Richards Island. It is expected that the sand is in thin layers, overlying fine-grained soil. Exposed cliffs in this area consist of ice-rich marine and deltaic sediments (silt and sand), often with a thin veneer of moraine (clay).

5.1.4 Tuktoyaktuk Peninsula. The beaches on the north side of Tuktoyaktuk Peninsula consist mainly of sand beaches, except for the stretch of coastline from approximately Whitefish Station to Toker Point. In this area, the beaches consist mainly of fixed gravel and sand, with some high beach ridges of cobbles and gravel. Beaches on the east side of Richards Island and from McKinley Bay to Liverpool Bay consist of thin, narrow sand fronted by mudflats (Map 4, Appendix H).

Exposed cliffs in the area are mainly in sand and silt of deltaic, lacustrine, or marine origin. The deltaic sand deposits have a variable ice content. Poorly drained deltaic sand areas tend to have moderate to high ice contents, while well-drained areas have low ice contents. The lacustrine and marine deposits generally have moderate to high ice contents.

Landfill sites were selected in well-drained, deltaic sand (or sand and gravel) suitable for summer construction, where possible. However, many sites were only selected in well-drained, lacustrine silt deposits which are only suitable for winter construction. From Hutchison Bay to Cape Dalhousie, landfill sites are located on deltaic sand deposits with a veneer of windblown sand.

A large percentage of the terrain in the Tuktoyaktuk Peninsula is poorly drained. Suitable locations for landfill sites are limited and some cleanable beaches do not have a nearby landfill disposal site (Map 4, Appendix H).

5.1.5 Eskimo Lakes. The shoreline of the Eskimo Lakes is characterized by steep cliffs in Pleistocene deltaic sand or gravel; this is capped in some areas by a thin veneer of clay-like hummocky moraine. These cliffs are sometimes fronted by tidal flats, which appear to be wave cut benches resulting from rapid cliff retreat.

Narrow sand beaches are scattered throughout the area and occur at the base of some cliffs. The small beaches in the southwest corner of the Eskimo Lakes consist of mixed gravel and sand (Map 5, Appendix H).

To a large extent, the present-day relief of the terrain around the Eskimo Lakes is due to ice coring. Most selected landfill sites are in Pleistocene deltaic sand or gravel that has underlying massive ice. Although it is believed that this massive ice occurs below the six m depth in most cases (Rampton, 1974), field investigation is required to verify this. The ice content in the top six m of soil in these deposits may be low enough for summer construction of the selected landfill sites. A feature in this terrain is the occurrence of large ice wedges. Because of these factors, borrow sources were selected for most landfill sites on the assumption that summer construction may be feasible. Temporary stockpile sites were also selected in case winter construction is required.

Landfill sites were also located on well-drained areas within old, drained thermokarst lake basins. It is expected that this terrain has a wide variation in ice content in the top six m of soil. Sites selected in this terrain should be considered suitable for winter construction only, but site-specific investigations may reveal that a few of these sites are suitable for summer construction.

5.1.6 Liverpool Bay. The shoreline of Liverpool Bay is characterized by steep cliffs that are fronted by tidal flats. Narrow sand beaches commonly occur at the base of the cliffs. The tidal flats appear to be wave cut benches resulting from rapid cliff retreat (Map 6, Appendix H).

Some sand beaches occur on the north side of Liverpool Bay, north of Campbell Island. The landfill sites selected for these beaches are on ice-cored terrain consisting of sand with a thin, hummocky moraine veneer, or in old thermokarst lake basins developed in this same terrain. Most of these landfill sites are considered to be suitable only for winter construction, but pre-construction investigation may reveal that a few sites are suitable for summer construction. (Refer to the description of these terrain types in Section 5.1.5.)

5.1.7 Wood Bay to Cape Bathurst. The coastline from Wood Bay to Cape Bathurst is characterized by long, narrow sand beaches in front of steep cliffs. The cliffs are mainly composed of fine-grained soils of marine or morainal origin (Map 7, Appendix H).

Most of the selected landfill sites are in fine-grained marine or morainal soils. They were assumed to be suitable only for winter construction. However, the exposed cliffs in the marine sediments north of Mason River to Cape Bathurst show a notable lack of thaw-induced slope failures. This indicates that the fine-grained marine sediments in this area may have relatively low ice contents. Landfill sites located on this terrain in this particular area may be suitable for summer construction. Field investigations would be required to determine the actual ice contents of these marine sediments.

On both sides of Harrowby Bay, beaches consist of mixed sand and gravel. Most landfill sites in this area are located on gravel or sand terraces and should be suitable for summer construction.

The terrain on Nicholson Peninsula is very sensitive to disturbance. Gully erosion and thermokarst development have occurred on most seismic trails. Extensive thaw-induced slumping is occurring on the exposed cliffs. The terrain consists mainly of ice-cored hummocky moraine. The selected landfill sites are located on this terrain type. A field investigation would be useful to determine if the ice contents are too high for practical winter construction. Sand borrow is available from existing borrow pits and there are some existing roads on the peninsula.

In general, it was possible to select suitable landfill sites or temporary stockpiles close to each cleanable beach in the Wood Bay to Cape Bathurst area. However, long haul distances along the beach are necessary in some instances because of

the limited number of access points in the cliffs, and the probable insufficient quantities of clean beach sand with which to build access ramps.

5.2 Access from Sea In Summer

Equipment to clean up oiled debris from beaches and to construct summer landfill disposal or temporary storage sites must be moved to the beaches by barge. In some cases, neither temporary storage nor summer landfill disposal sites will be located near the oiled beaches; therefore, the debris will also have to be barged. In general, these barges will have to be moved with ocean-going tugs which have a draft of about two m. River tugs have a draft of about 1.1 m and, in some cases, these could be used to move the barges in and out of the shallower water. The loaded equipment barges would have a draft of about one m, while barges loaded with oiled debris would have a draft of about 1.5 to 2 m.

For this study, the shoreline was divided into segments based on barge accessibility, which is a function of near shore water depth. Unfortunately, there is very little information on near shore water depths in the area. Consequently, only general conclusions could be made. In addition, the exact location of spits and sand bars is constantly changing because of the dynamic environment in which they exist. In most cases, site-specific surveys will have to be carried out in order to determine if barges can actually reach the desired beach.

5.2.1 Map 1 - Yukon Coast.

5.2.1.1 Yukon/Alaska border to Phillips Bay. The sand and shingle beaches, as well as the long narrow spits, are easily accessible by ocean tugs and barges. Some lateral traversing of cleanup and haul equipment may be required on the long spits located in front of large alluvial fans, such as at the Malcolm and Firth rivers. Only selected locations on these spits may be useful for inland access to disposal sites.

5.2.1.2 West side of Phillips Bay to Kay Point. The outer spits at Kay Point may be accessible by ocean tug and barge, provided a shallower draft river tug is available for moving the equipment barges to the beach. The inner shorelines in Phillips Bay and near the Babbage River are not accessible by ocean tug and barge.

5.2.1.3 Kay Point to King Point. The sand and shingle beaches identified in this area are generally accessible by ocean tug and barge. Provision for lateral traversing of equipment along some of the narrow beaches may be required after the equipment has been offloaded. Such specific details will have to be reviewed on a site-specific basis.

5.2.2 Map 2 - Shallow Bay.

5.2.2.1 King Point to Trent Bay. The sand and shingle beaches identified in this area are generally accessible by ocean tug and barge. Some movement of equipment along the beaches may be required after the barges have been offloaded.

5.2.2.2 Trent Bay to Tent Island. This area is only accessible by barge, with difficulty. An ocean tug would have to be aided by a shallower draft river tug to help "loiter-in" the equipment laden barges to the oiled beach. The construction of a short causeway may have to be considered in some locations.

5.2.3 Map 3 - Outer Delta.

5.2.3.1 Garry Island, Kendall Island, Pelly Island and Hooper Island. Many of the sand beaches that have been identified in this area are inaccessible by barge because of shoals and spits at shallow depths which are located several hundred meters from the shoreline. Because of the inaccessibility of these beaches, other oil spill countermeasures should be seriously considered.

5.2.3.2 North Head. The sand beaches identified in this area could be approachable by barge and ocean draft tugs. However, in view of possible shoals at shallow water depths, provision should be made to augment the ocean tug with a shallower draft river tug. Also, on some beaches that have been identified, a short causeway may have to be constructed for offloading equipment.

Some lateral traversing along the beach by cleanup and landfill equipment may be required after the equipment has been offloaded at a suitable beach.

5.2.4 Map 4 - Tuktoyaktuk Peninsula.

5.2.4.1 Whitefish Station to Peninsula Point. The sand and shingle beaches identified in this area may be approached by barges. Shallow draft river tugs may have to be used to "loiter" the equipment barge to the beach.

Since shallow bars may exist across the mouth of breached thermokarst lakes, the inner lagoon shorelines may not be approachable by barge, even though the water is generally deeper in these areas than it is just offshore.

5.2.4.2 Peninsula Point to Warren Point including Tuktoyaktuk Harbour. The sand and shingle beaches which have been identified in this area are, generally, approachable by barge. Some lateral traversing along the beach after the equipment has been offloaded may be required. The inner shorelines of breached thermokarst lakes may not be

accessible by barge, depending on the presence or absence of shallow bars at the outlets to the open sea.

Also, provisions for the use of shallow draft river tugs to "loiter" shallow draft equipment barges should be made for specific beaches.

5.2.4.3 Warren Point to Atkinson Point. The sand and shingle beaches identified in this area are accessible by barge with some difficulty, provided a shallow draft river tug is used as a "loitering" craft.

5.2.4.4 Atkinson Point to Russell Inlet. The outer shoals and spits could be approached by tugs and barges. The inner shores along the Tuktoyaktuk Peninsula and the small islands, particularly where mudflats are shown, are not accessible by tugs and barges.

5.2.4.5 Cape Dalhousie. The outer areas in this region can be approached by barges and oceans tugs; however, they cannot reach the sand beaches that are fronted by mudflats.

5.2.5 Map 5 - Eskimo Lakes. Near shore bathymetric data for the Eskimo Lakes is limited. It is not known from this information whether the sand and shingle beaches that have been identified in this map area are accessible by tugs and barges. From the airphoto interpretation, it appears that some of the identified beaches may be accessible by shallow draft tugs and barges.

5.2.6 Map 6 - Liverpool Bay.

5.2.6.1 Tuktoyaktuk Peninsula East Coast. The sand and shingle beaches identified in this area are generally accessible by ocean tugs and barges. In view of possible shallow shoals and bars adjacent to some of the identified beaches, the use of shallow draft river tugs to "loiter" the equipment barges should be considered.

5.2.6.2 Smoke River to Hepburn Spit (Nicholson Peninsula). The sand and shingle beaches identified in this area appear to be readily accessible by ocean tug and barges. Some lateral traversing may be necessary along narrow beaches with high cliffs.

5.2.7 Map 7 - Wood Bay to Cape Bathurst. All sand and shingle beaches identified in this area are generally approachable by ocean tug and barges. The east shoreline of Wood Bay from Anderson River to Maitland Point has only very limited hydrographic data. At some specific spits, such as those identified in Harrowby Bay, Cy Peak Inlet and on Cape Bathurst, provision should be made to use shallow draft river tugs to "loiter" the barges. Lateral traversing may be required along the narrow beaches adjacent to the high cliffs.

5.3 Relative Cost of Disposal

It was not possible within the terms of reference of this study to develop a separate cost estimate for disposal of the oiled debris on each beach. There are over 200 potentially cleanable beaches. Many factors, such as summer or winter burial, barging requirements, amount of oiled debris to remove from the beach, distance to landfill disposal or temporary storage site, etc. affect the cost. As a result, it was decided to establish a standard size for a beach cleanup, and then to compare the relative costs of cleaning up this beach for the following cases:

- Case 1: Bury debris in summer in landfill site located close to the beach that was cleaned.
- Case 2: Bury debris in winter in landfill site located close to the beach that was cleaned. In this case, the debris would have to be stockpiled in the summer at a temporary storage site.
- Case 3: Bury debris in summer in landfill site located 30 km away from the beach that was cleaned. In this case, the debris would have to be barged 30 km to the landfill site.
- Case 4: Bury debris in winter in landfill site located 30 km away from the beach that was cleaned. The debris would be barged 30 km to a temporary storage site and then buried the following winter in a nearby landfill site.

The standard size cleanup was established as 15 000 m³ of oiled debris. This correspond to:

- 5.0 km beach with a depth of contamination of 30 cm and a width of oiled beach of 10 m, or
- 1.0 km beach with a depth of contamination of 30 cm and a width of oiled beach of 50 m, or
- 5.0 km beach with a depth of contamination of 10 cm and a width of oiled beach of 30 m, or
- other combinations, as shown in Table 2.

Several other assumptions were made; these are discussed in Appendix I.

The approximate costs calculated for cleaning up and burying 15 000 m³ of oiled debris from a single beach (no other local beaches were cleaned; the complete mobilization and demobilization costs were charged to the one cleanup) were as follows:

Case 1	-	\$2.1 million
Case 2	-	\$3.2 million
Case 3	-	\$3.8 million
Case 4	-	\$4.6 million

Example calculations are shown in Appendix I.

TABLE 2 VOLUME OF OILED DEBRIS FROM BEACHES

Length of Oiled Beach (km)	Width of Oiled Beach (m)	Depth of Contamination (cm)	Volume of Oiled Debris (m ³)
1	10	10	1,000
1	10	20	2,000
1	10	30	3,000
1	50	10	5,000
1	50	20	10,000
1	50	30	15,000
2.5	10	10	2,500
2.5	10	20	5,000
2.5	10	30	7,500
2.5	50	10	12,500
2.5	50	20	25,000
2.5	50	30	37,500
5	10	10	5,000
5	10	20	10,000
5	10	30	15,000
5	50	10	25,000
5	50	20	50,000
5	50	30	75,000

6 ALTERNATIVE OR NOVEL DISPOSAL AND STORAGE METHODS

6.1 Landfill Disposal Sites

This section considers those methods of disposal which might be feasible, but which are substantially different than the below-grade mode of burial in a disposal pit. Basically, the criteria that should be satisfied are that the oiled debris should be disposed of in a manner that is environmentally safe in the long term, technically feasible, and reasonably economical.

The following methods are considered and discussed. Their advantages or disadvantages are listed.

- Above-ground sump (dyked perimeter)
- Natural topographic depressions
- Underground silos
- Narrow trenches
- Utilization as pad construction material.

6.1.1 Above-Ground Sumps. The disposal method selected must attempt to isolate the contaminated debris from the ground and from the atmosphere. This can be done by placing the debris on an above-ground pad; containing the perimeter with impervious dykes; and capping the debris with fine-grained soil that would reduce thaw depth, be relatively impervious and act as a revegetation growth medium.

This alternative would involve construction of an impervious, erosion-resistant dyke, as shown in Figure 8. The dyke would be about 4.5 m high and would be designed to retain about 3 m of debris. It would be constructed with a clay core, and a 3:1 exterior side slope having a 0.6 m thick rip rap or coarse gravel facing. The interior slope would be constructed at about 2:1 to allow placement of an impervious plastic liner. This liner would be keyed into the permafrost about three m from the interior dyke toe, as shown in Figure 8. The impervious liner would penetrate the frozen ground about 0.6 m; it would have about five percent slack built into it to account for dyke settlement. The dyke would become less pervious with time, as it is anticipated that some of the dyke core would freeze back within a few years of the end of construction.

Access to the sump area during backfilling could be provided by one or more ramps of suitable slope. The debris would be placed with about 0.3 m interlayers of clean sand to absorb excess oil. A final layer of clean sand would be placed on top. A one m

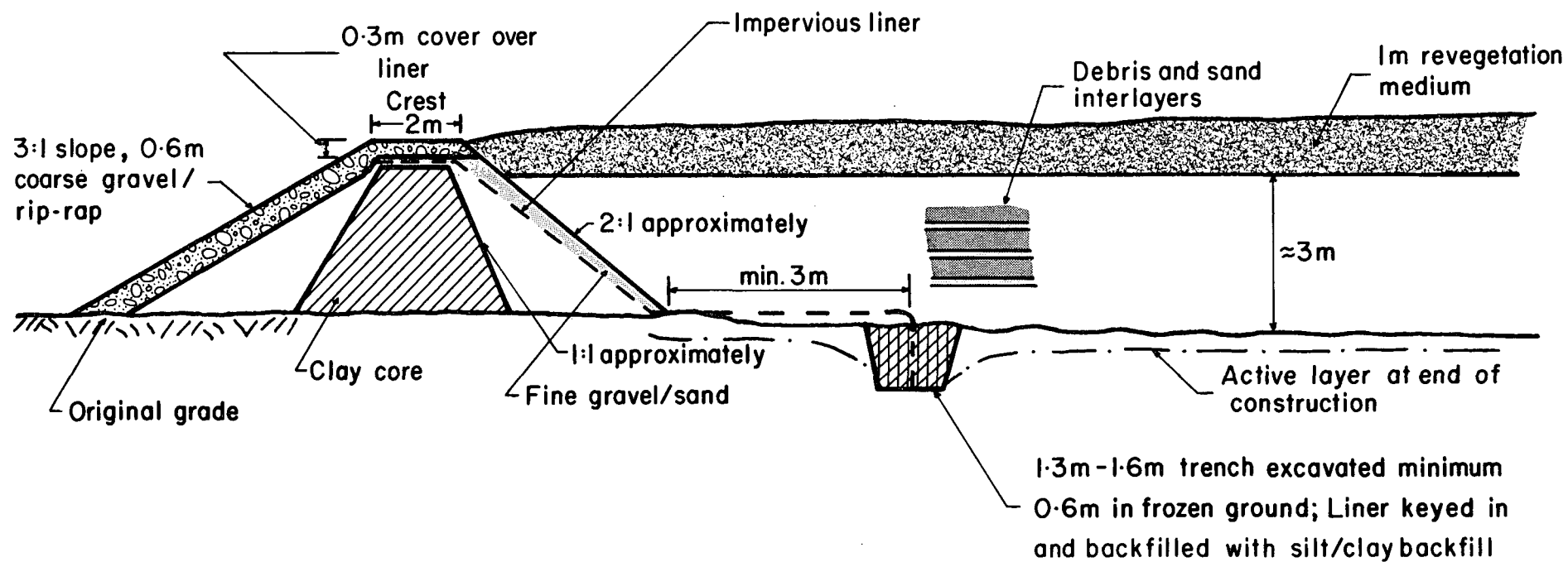


FIGURE 8

ABOVE GRADE DISPOSAL SUMP

layer of fine-grained soil would be placed on top to provide a growth medium for revegetation purposes, and to limit thaw penetration into the oiled debris. The surface of this layer would be graded towards the perimeter to provide positive drainage for precipitation.

It is estimated that a 150 by 300 m dyked perimeter would require 36 000 m³ of coarse-grained materials, 18 000 m³ of fine-grained core material, about 15 000 m² of impervious liner, and 45 000 m³ of fine-grained surface soil. This configuration could contain about 128 000 m³ of debris and sand interlayer material. These calculations indicate the very high ratio of fill material to debris (about 1:1.3).

The above-ground configuration for the disposal of sump drilling fluids was pioneered in Alaska in connection with the Prudhoe Bay oil development. They were essentially unlined structures, which likely permitted some leakage of the contained fluids. The present application would require a more carefully engineered structure.

The major problem would be the construction of a clay (or fine-grained soil) core in the dyke. The fill material would have to be obtained from a borrow pit. Thawing, stripping, stockpiling and draining would have to be carefully undertaken, in order to obtain core material with a water content that was suitable for good compaction.

Construction feasibility and economic considerations would ultimately decide the potential of this alternative. A major advantage of the above-ground sump is that it could be built in the summer on terrain that would be unsuitable for summer construction of a disposal pit. The costs involved with mobilizing equipment to the area twice would be avoided.

6.1.2 Natural Topographic Depressions. It has been suggested that natural depressions in hummocky terrain might be used as containment areas for oiled debris. However, certain problems immediately arise when considering this alternative; these problems are primarily related to drainage. In order to be effective, the ground underlying the depression must be frozen; it should not be the site of a recently drained lake. Two cases must be considered: (a) a completely enclosed topographic depression and (b) an open-ended depression. A completely enclosed depression underlain by frozen ground is very likely to be the site of a small lake because of the impermeable nature of the permafrost table. Alternatively, it may be that the site of a recently drained lake is freezing back, and is overlain by fine-grained lacustrine deposits. There is, therefore, considerable doubt about the subsurface conditions beneath a closed essentially dry, topographic depression. In either case, the closed topographic depression is not likely to

provide a suitable site for oiled debris. In the study area, closed, dry depressions do not commonly occur close to the coastline.

The other possibility is the open-ended depression (i.e., old drainage channel or coulee). This could be considered as a disposal site, providing a dyke or dam is constructed at the lower end of the depression. The primary problem here is associated with drainage. Such a depression, if underlain by frozen ground, is probably the location of significant groundwater flow through the active layer in summer. The manipulation of the subsurface flow around (or through) the disposal area would be a major problem. The collection and concentration of the surface groundwater flow may induce erosion problems that would be difficult or costly to solve.

The complex drainage and erosion measures that would probably be required for this alternative make the natural topographic depression a poor alternative for oiled debris disposal, and would only be considered if other suitable sites were not available.

6.1.3 Underground Silos. A further possible method of disposal that might be considered involves the drilling or excavation of large-diameter vertical silos to considerable depth. These silos would be used for direct disposal of oiled debris, with no clean sand interlayers. The cuttings or spoil from the hole would be mounded over the general area, to form a natural soil berm. In this way, the contaminated material is contained by the permafrost at depth, and only natural soil is exposed to the atmosphere, or would come into contact with water in the active layer.

This method has a further advantage in that the exact volume to be disposed need not be known in advance, as several shafts at fairly close spacing would usually be required, and the drilling of extra shafts should not cause undue problems. If the schedule of drilling, temporary storage of excavated material, backfilling and berming is organized in a progressive fashion, then this method would involve minimal disturbance to the surrounding terrain during summer. Heavy drilling equipment could be operated from a temporary, one m gravel pad during drilling. To prevent influx of surface water, it would likely be necessary to case the active layer around the hole.

Clearly, the major concern is the type and sizing of equipment to perform this task. Hole depths could be up to 150 to 200 m close to the coast, without danger of penetrating the base of the permafrost in most parts of the study area, provided the site was located at least 0.5 km from the coast. Diameters will be heavily dependent on the equipment that can be made available, and the predominant soil type. In fine-grained, icy soil types, holes one m in diameter should be feasible using relatively conventional

augering techniques. Current oil and gas well drilling practice in the Mackenzie Delta involves the drilling of a 0.6 to 0.8 m hole for approximately the top 60 m, to set the surface conductor casing. Large-diameter shafts have also been drilled in unfrozen shale bedrock to considerable depths in connection with the mining industry in parts of the U.S.A. The equipment requirements, capabilities, costs and transportation methods are not discussed here; but it appears that the method is feasible, and that it has some attractive advantages.

As an illustration, an example is considered where shafts 1.22 m in diameter are drilled to a depth of 150 m. Assuming no interlayers of clean sand, this would provide a storage capacity of about 180 m^3 , and assuming 20 percent increase in volume of the excavated material, about 215 m^3 of spoil would be generated. The spacing of the holes decides the final height of the soil berm in the disposal site area. At a spacing of nine m, the initial height of the berm would be about 2.6 m, with some settlement occurring later.

In order to obtain $18\,000 \text{ m}^3$ of storage capacity, however, about 100 holes of these dimensions would be required. Clearly, the economic viability of this method will be limited by the speed at which the holes can be drilled. At this stage of investigation, it might be concluded that this method is only suitable for relatively small volumes of debris. This method certainly requires considerable additional study of equipment requirements before further conclusions are reached.

6.1.4 Narrow Trenches. Many of the considerations associated with the below-ground sump disposal method apply equally in this instance. However, instead of a square or rectangular sump area, there may be certain distinct advantages to a trenching and backfilling operation. The prime advantage is the continuous nature of the construction sequence. Trenching, backfill storage, backfilling with debris and berming can all take place as sequential operations, so that no part of the excavation is open for very long. The geometry of the operation also allows easy access to the excavation, if, for example, a temporary road pad were constructed along one side of the excavation. The other major advantage is that the volume of debris need not be known exactly in advance, and the trenching/backfilling operation can proceed as long as suitable terrain is available. The major disadvantage of the method is the greatly increased extent of the disposal site. In addition, this technique would tend to be more sensitive to the topography of the site selected. The slope parallel to the trench would have to be less than one percent (average).

The trench would be excavated with vertical sides, likely to a greater depth than that considered for the sump, and equipped with pumping equipment to remove surface groundwater and melt-water from the trench side-slopes.

Generally, the same guidelines as those discussed for sumps would be followed regarding site location. It is estimated that a trench excavated six m deep, eight m wide and one km long would provide storage for $36\,000\text{ m}^3$ of debris and clean sand interlayers.

6.1.5 Utilization as Pad Construction Material. Bitumen and aggregate mixtures are commonly used as asphaltic paving materials in road construction. Provided the bitumen content lies between about seven and nine percent, a satisfactory asphalt mixture can be attained. If the bitumen content is much higher than this, the asphalt displaces excess bitumen and loses dimensional stability.

It has been suggested that the oiled debris from a sand beach could be used directly as a pad construction material. As the oiled sand would be used in an above-ground and uncontained application, the suitability of this "disposal" technique would depend on the stability of the sand/oil mixture, and whether the oil could be successfully retained in the sand pore spaces. This, in turn, is dependent on the condition of the oil as gathered from the beach, which hydrocarbon fractions remain, and the permeability of the oil in the temperature range of interest.

It should be noted that temperatures within the base layers of a pad constructed on permafrost in the study area would rarely rise above about $+5^{\circ}\text{C}$. Near-surface layers might reach temperatures of 15 to 20°C for short periods of time. Therefore, rapid "curing", or loss of lighter fractions, should not be expected within much of the pad. For the most part, therefore, the prime concern is the stability of the sand/oil mixture at temperatures below about 5°C , and very often much below 0°C .

The suitability of a particular hydrocarbon to asphalt construction application is primarily related to two factors: (a) the viscosity-temperature relationship for the hydrocarbon, and (b) the quality control and uniformity of the final mixture. If the viscosity at the design temperature is too high, or the bitumen content exceeds about nine percent, the asphalt mixture loses stability. As a result, the pad deforms and ruts readily under traffic loads, and is unsuitable as a roadway.

Some experience is available with attempts at road construction using crude oil in different forms. A trial portion of roadway near the Great Canadian Oil Sands at Fort McMurray was constructed using local tar sand material, in which the bitumen contained a range of intermediate and heavy fractions. This roadway rutted very easily, and did not perform well under traffic.

Further experience was gained in studying properties of Atkinson Point crude oil, and its possible application with a sand road pad construction material. The use of this crude oil in sand/oil mixtures for roadway construction was not generally recommended.

In summary, it is anticipated that because of a very high viscosity, and a very poor level of quality control, the oiled debris gathered from beaches would not prove to be a suitable material for pad or road construction.

6.2 Temporary Storage Sites

Alternative temporary storage methods are discussed in this section.

6.2.1. Portable Dams. Portable dams have been reviewed with regard to their use as a temporary storage structure for oiled debris. In this method, a sand levelling course would have to be placed over the storage site and an impermeable membrane laid down. The sand dyke around the perimeter, discussed in Section 2.2, would be replaced with a portable dam. The dam would consist of metal support frames, at about 40 cm centres, which would be placed on a layer of sand or gravel. A thick, impermeable, prefabricated membrane would form the walls of the dam. The membrane would be about 1 to 1.5 m in height and would extend from the walls to under the oiled debris. The contact between this membrane and the bottom liner would have to be sealed to contain the oil from the debris.

The main advantage of portable dam is that the amount of borrow material required would be substantially reduced. The disadvantages of a portable dam are that it is quite expensive and that the integrity of the dam may be jeopardized if the support frames settle differentially due to thaw settlement of the permafrost beneath them. Consequently, it is recommended that portable dams not be relied upon as the main method for containing oiled debris at temporary storage sites. Nevertheless, portable dams appear to be a feasible alternative to sand dykes with impermeable lines. The use of portable dams should be carefully considered.

6.2.2 On-Beach Storage. The idea of storing debris on the oiled beach is inherently attractive. On-beach storage would mean that the debris would only have to be moved short distances. In addition, ground behind the beach would not have to be used; the disturbance to the local terrain would be restricted to the beach.

The basic concept would be to place the oiled debris at the back of the beach, using as little of the beach area as possible. The debris would then have to be protected from the erosive force of high waves that may occur during a storm.

Protection could be provided in two ways. One way would be to push clean beach material around the debris to act as sacrificial soil that would have to be eroded away prior to losing the oiled debris. The shortcoming of this method was that the amount of sacrificial material required could not be rationally determined. Consequently, it was not possible to determine the risk of having the oiled debris spread out on the beach again after the next storm. The second way to provide protection would be to place adequate rip rap along the sides of the debris. The major limitation was that this method required a considerable amount of large size rip rap, which would be very difficult to obtain.

Even though on-beach storage appears to have some practical limitations as a general method for temporarily storing oiled debris, the method has such significant advantages that it should be studied in more detail.

7 CONCLUSIONS

7.1 General Conclusions

Site selection, design, construction and reclamation guidelines for landfill disposal sites, temporary storage sites, and access roads were developed based mainly on geotechnical considerations. Limitations on construction, utilization and reclamation due to seasonal problems with terrain stability, logistics support and cost effectiveness were considered when the guidelines were being developed.

All of the beaches in the study area were classified using aerial photographs. Suitable landfill disposal and temporary storage sites were located as close as possible to the sand and shingle beaches.

Alternative landfill disposal and temporary storage techniques were reviewed. In addition, a field program was proposed, in a separate report, to evaluate the terrain conditions at representative sites in order to verify the airphoto interpretation and geological assumptions that were significant with respect to the guidelines.

7.2 Specific Conclusions

1. The basic method adopted for disposing of oiled debris was to excavate a large pit in the ground and to bury the debris in it. Some typical designs for generalized cases were presented.
2. The basic method adopted for temporarily storing oiled debris was to pile it on an impermeable liner on a pad on the ground surface, with earth dykes around the pad. A typical design for a generalized case was presented.
3. One of the major limitations with regard to disposal of oiled debris was that disposal pits could not be constructed in the summer in ice-rich soil. There is a considerable amount of such soil along the Beaufort Sea coast.
4. Barging equipment to an oiled beach or barging oiled debris from a beach is a difficult task because the near shore water is shallow in many areas. Shallow draft barges and tugs will be required in many areas in order to get reasonably close to shore.
5. The cost of disposing of oiled beach material can be very high. For similar conditions, summer disposal will generally be less costly than winter disposal. The costs will increase significantly if the oiled debris has to be barged to a disposal area. For the example used in this report, the estimated cost to dispose of 15 000 m³ of oiled debris for four cases was as follows:

Summer burial	(no barging)	\$2.1 million
Winter burial	(no barging)	\$3.2 million
Summer burial	(barging)	\$3.8 million
Winter burial	(barging)	\$4.6 million

6. All of the beaches from the Alaska-Yukon border to Cape Bathurst, including the Eskimo Lakes, were classified into broad categories as follows:

- sand beaches
- shingle beaches
- cliffs
- mudflats
- tundra
- landslide
- sloping shoreline.

This study showed that there are a great number of sand and shingle beaches along the Beaufort Sea coast. These beaches were shown on 1:150,000 scale strip maps.

7. Approximately 217 landfill disposal sites were located with the use of aerial photographs in the vicinity of the sand and shingle beaches identified. In addition, approximately 223 temporary storages sites were located. The sites were selected mainly with regard to geotechnical considerations. These sites were shown on 1:150,000 scale strip maps and on about 1:20,000 to 1:70,000 scale aerial photographs. Some field work is required to verify the airphoto interpretation and the geological assumptions as related to the guidelines.
8. Access from the sea to the sand and shingle beaches was evaluated. This evaluation was severely restricted because of the lack of data on near shore water depths. Nevertheless, a general assessment of beach access was presented for the study area. This assessment indicated that access to the beach for ocean tugs and barges was limited in many areas. The use of shallow draft barges and river tugs to "loiter" these barges to the beach would have to be considered in many cases. In some cases it will not be possible to get a barge within several hundred metres of the shoreline. For such inaccessible beaches, considerations should be given to preventing the oil from reaching the shore if the area is environmentally or socio-economically sensitive.
9. The following alternative or novel landfill disposal techniques were reviewed:

- Above-ground sumps
- Natural topographic depressions
- Underground silos
- Narrow trenches
- Utilization as pad construction material.

It was concluded that these techniques are not as generally applicable for the ultimate disposal of oiled debris as the below-grade disposal pit technique. The above-ground sump was the best of the alternatives reviewed. Its suitability would depend primarily on economics. Since only fill construction operations are involved, this method can be used where the terrain consists of fine-grained soil and a summer disposal pit operation would not be recommended.

10. The following alternative temporary storage techniques were reviewed:

- Portable dams
- On-beach storage.

The conclusion was that these techniques are not as generally applicable as the earth dyke technique for temporary storage. Both alternatives are feasible and may be useful in some cases. On-beach storage has the potential for significant advantages over the other two methods and should be studied in more detail than was possible for this project.

REFERENCES

1. Auld, R.G., Marion, T.L., Purdy, I.L., R.H.B. Sangster. State-of-the-Art Review of Petroleum Spill Containment Dykes in the North. Environment Canada (1974).
2. EBA Engineering Consultants Ltd. A Study of Spray-on Liners for Petroleum Product Storage Areas in the North. Department of the Environment. EPS-4-EC-77-2 (1977).
3. Hrudey, S.E., Michalchuk, J., J.D. McMullen. A Preliminary Assessment of Water Pollution from Abandoned Oil and Gas Drilling Sumps in the N.W.T. Environmental Protection Service, Department of the Environment (1973).
4. Lewis, C.P., D.L. Forbes. Coastal Sedimentary Processes and Sediments, Southern Beaufort Sea. Technical Report No. 24, Beaufort Sea Project. Department of the Environment (1975).
5. Logan, W.J., Thornton, D.E., S.L. Ross. Oil Spill Countermeasures for the Southern Beaufort Sea and Appendix, Report No. 31a and No. 31b, Beaufort Sea Project. Department of the Environment (1975).
6. MacDonald, B.C., C.P. Lewis. Geomorphic and Sedimentologic Processes of Rivers and Coasts, Yukon Coastal Plain. Environmental-Social Committee Northern Pipelines, Task Force on Northern Oil Development. Report No. 73-79 (1973).
7. Mackay, J.R. "Offshore Permafrost and Ground Ice, Southern Beaufort Sea, Canada. Can. Jour. Earth Sci. Vol. 9. pp. 1550-1561 (1972).
8. Owens, E.H. Coastal Environments of Canada: The Impact and Cleanup of Oil Spills. Department of the Environment. EPS-3-EC-77-13 (1977).
9. Rampton, V.N. "Surficial Geology and Landforms". Geol. Surv. Can. NTS. 97F, 107C, 107D, 107E, Open File 96 (1972).
10. Rampton, V.N. "Surficial Geology and Landforms". Geol. Surv. Can. NTS. 107B, 117A, 117C, 117D, Open File 191 (1972).
11. Rampton, V.N. "The Influence of Ground Ice and Thermokarst Upon the Geomorphology of the Mackenzie-Beaufort Region". Research in Polar and Alpine Geomorphology. Proceedings of the Third Guelph Symposium on Geomorphology. pp. 43-59 (1974).
12. Stearns, R.P., Ross D.E., R. Morrison. Oil Spill: Decisions for Debris Disposal, Literature Review and Use Study Reports. Office of Research and Development, U.S. Environmental Protection Agency. Vol. II (1977).
13. Thornton, D.E., P.J. Blackall. Field Evaluation of Plastic Film Liners for Petroleum Storage Areas in the Mackenzie Delta. Department of the Environment. EPS-3-76-13 (1976).

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APPENDIX A
AERIAL PHOTOGRAPHS AND DESCRIPTION OF SITES
MAP 1, YUKON COAST

LANDFILL SITE LI-1, TEMPORARY STOCKPILES TI-1

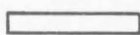
- LANDFILL SITE: A, B, and C have available areas of 30,000 m², 37,000 m², and 60,000 m² respectively. A and B are on gravel terraces within a large alluvial fan; C is on ice-rich clay and silt.
- TEMPORARY STOCKPILE: Two locations available on high portion of alluvial fan with areas of 8,000 m² and 15,000 m².
- BEACH: Gravel and sand, 65 m wide, lagoon directly behind it.
- BORROW SOURCE: Use beach material.
- ACCESS: 1.5 km (summer) to A and B and 3 km (winter) to C across gravel alluvial fan.
- DEVELOPMENT: Site reconnaissance required to determine flood levels respective to A and B. If not acceptable use Site C. Removal
(continued on next page)



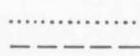
AIRPHOTO No. A13138-154

APPROX. SCALE 1:70,000

LANDFILL SITE OUTLINE



TEMPORARY STOCKPILE

ACCESS ROUTE, SUMMER
WINTER

BORROW AREA



LANDFILL SITE L1-1, TEMPORARY STOCKPILE T1-1 - Continued

DEVELOPMENT:
(cont'd)

of highest beach ridge in front of the lagoon may result in contamination or alteration of the lagoon environment.

LANDFILL SITE LI-2, TEMPORARY STOCKPILES TI-2, TI-3

LANDFILL SITE: Available area of 35,000 m² on lacustrine ice-rich clay and silt.

TEMPORARY STOCKPILE: TI-2 and TI-3 have available areas of 50,000 m² and 40,000 m² respectively on ice-rich clay and silt.

BEACH: Gravel and minor sand, less than 30 m wide.

BORROW SOURCE: Use beach material. Beach is mainly gravel; sand is limited in quantity.

ACCESS: 3 km from TI-2 to the landfill site (winter), 8.5 km from TI-3 to landfill site (winter).

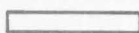
DEVELOPMENT: Winter construction of landfill site.



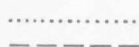
AIRPHOTO No. A13231-70

APPROX. SCALE 1:70,000

LANDFILL SITE OUTLINE



TEMPORARY STOCKPILE

ACCESS ROUTE, SUMMER
WINTER

BORROW AREA



LANDFILL SITE LI-4, TEMPORARY STOCKPILE TI-4

LANDFILL SITE: A and B have available areas of 50,000 m² and 40,000 m² respectively. Both are on gravel terraces.

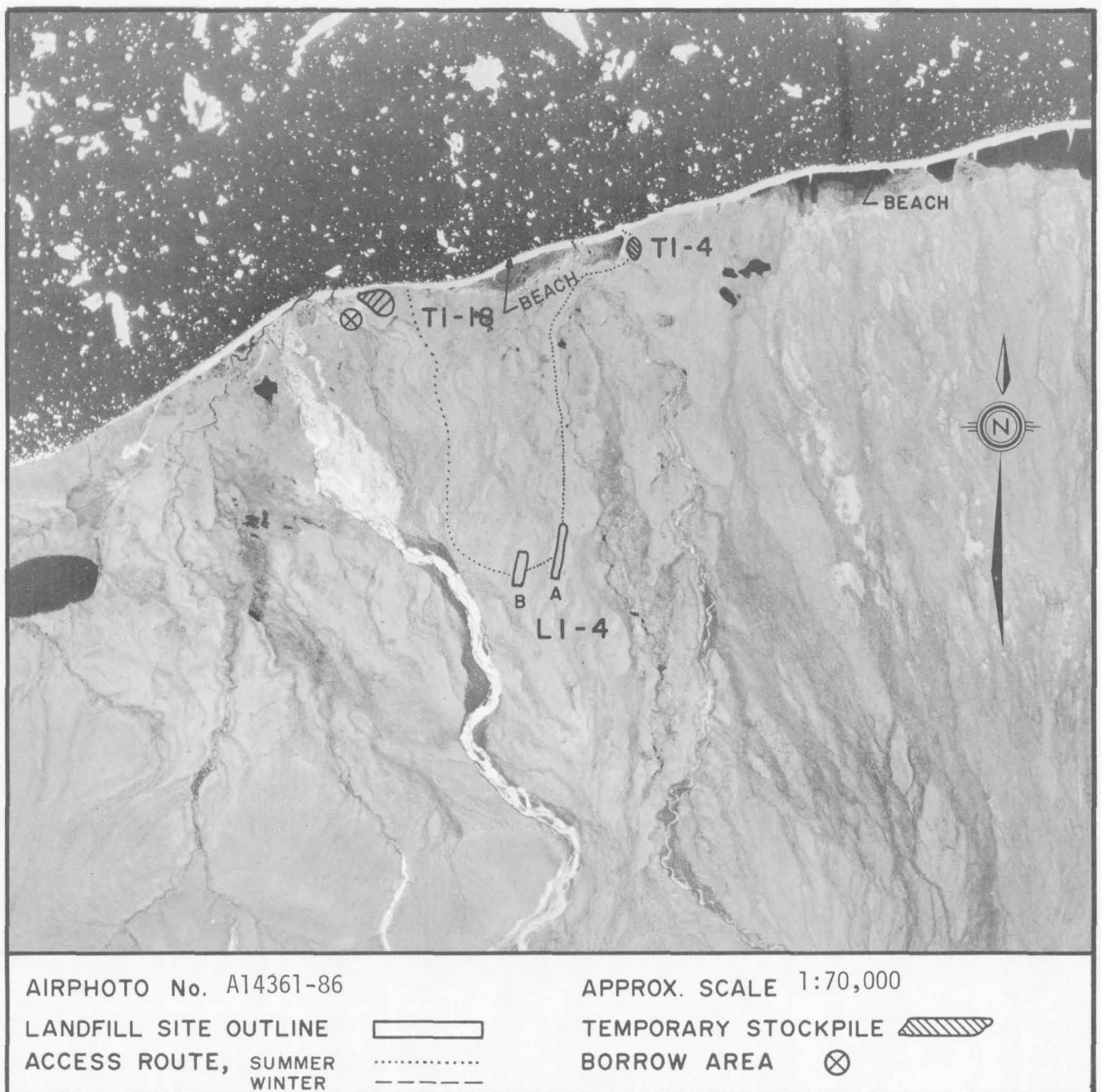
TEMPORARY STOCKPILE: Available area of 20,000 m², contained on higher portion of alluvial fan.

BEACH: Gravel and sand, 100 m wide.

BORROW SOURCE: Use beach material.

ACCESS: 3.5 km along gravelly alluvial fan, one major creek crossing near TI-4.

DEVELOPMENT: Summer construction of landfill site may be possible.



TEMPORARY STOCKPILE T1-18

TEMPORARY STOCKPILE: Available area of 50,000 m² on a poorly drained lacustrine plain with several small ponds.

BEACH: Gravel and sand; 100 m wide.

BORROW SOURCE: Use beach material.

ACCESS: 3.5 km to L1-4.

DEVELOPMENT: Site T1-18 is an alternative to hauling oiled debris down the beach to T1-4. It is poorly drained and will require more sand than most temporary storage sites to construct the pad. Also, cleanup of the site will be more difficult due to the poor site conditions; some thermokarst development may occur after the site is abandoned. L1-4 may be a summer operation, thus eliminating the need for T1-18.

LANDFILL SITE LI-5, TEMPORARY STOCKPILE TI-5

LANDFILL SITE: Available area of 40,000 m² on a gravel terrace surrounded by a large alluvial fan.

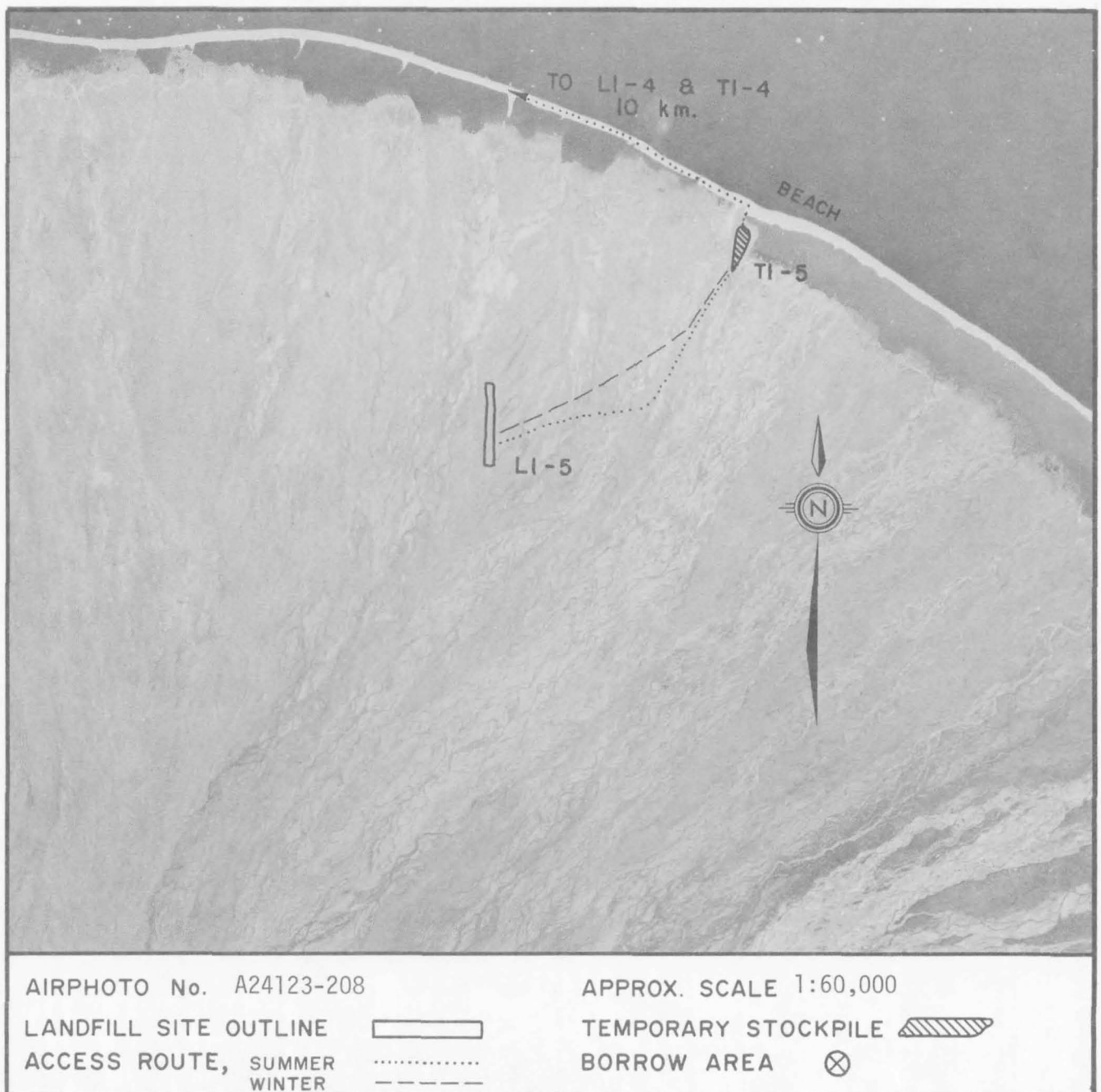
TEMPORARY STOCKPILE: Available area of 20,000 m², erosional remnant probably containing clay and silt with moderately high ice content.

BEACH: Gravel and sand, 100 m wide.

BORROW SOURCE: Use beach material.

ACCESS: 3 km along a gravelly alluvial fan (summer or winter).

DEVELOPMENT: May be suitable for summer use. If LI-5 is not high enough above possible flood level, transport oiled debris to LI-4 (10 km).



LANDFILL SITE LI-6, TEMPORARY STOCKPILE TI-6

LANDFILL SITE: Available area of 30,000 m² on marine deposit of ice-rich silt and clay.

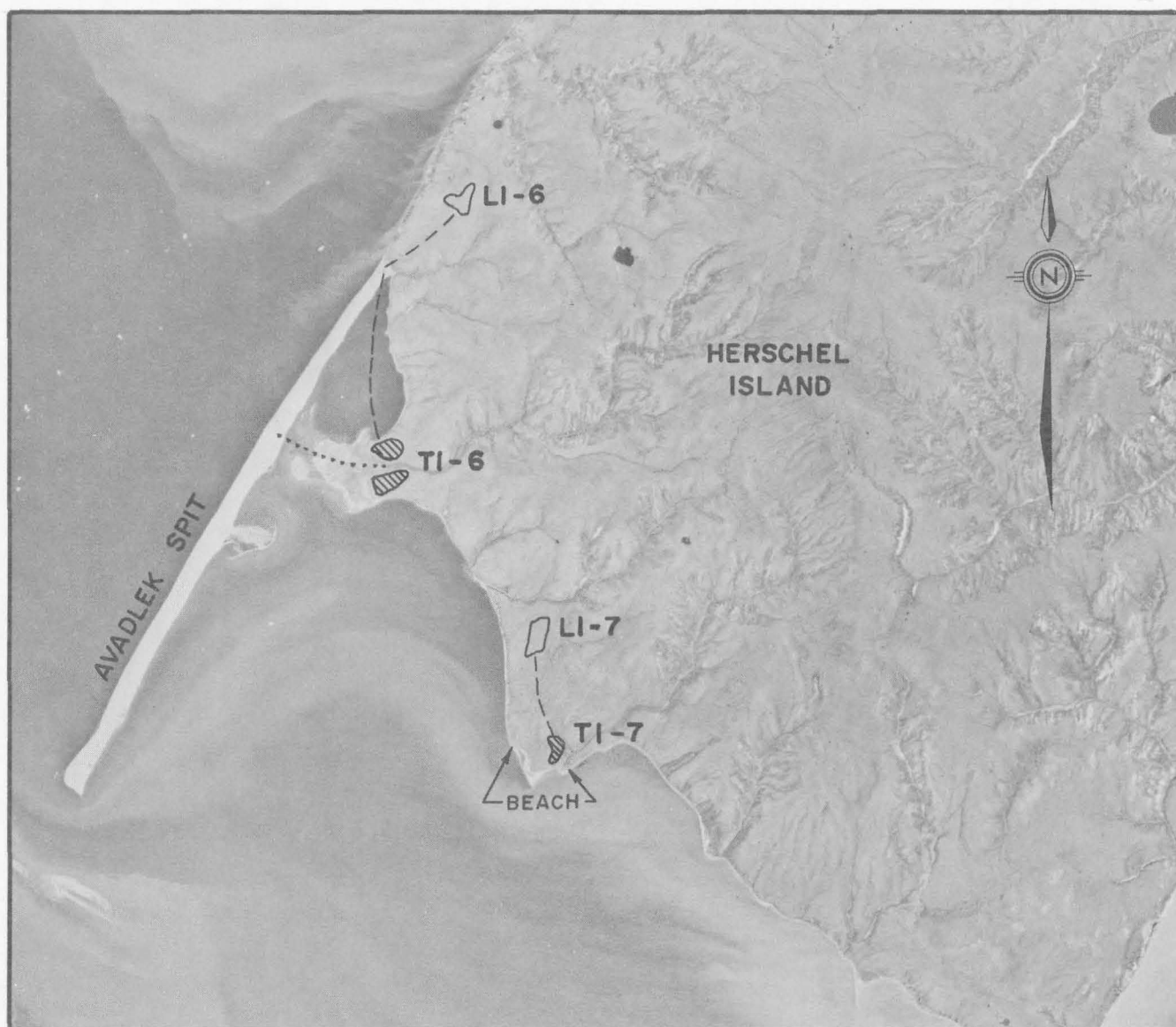
TEMPORARY STOCKPILE: Two sites on a sandy terrace with a total available area of 45,000 m².

BEACH: Gravel and sand spit, 200 m wide.

BORROW SOURCE: Use beach material.

ACCESS: 2 km from stockpile to landfill site (winter).

DEVELOPMENT: Winter operation due to high ice content. Summer development of temporary stockpile would require an earth fill across shallow water from the spit to the stockpile site.



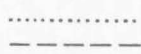
AIRPHOTO No. A24123-70

APPROX. SCALE 1:60,000

LANDFILL SITE OUTLINE



TEMPORARY STOCKPILE

ACCESS ROUTE, SUMMER
WINTER

BORROW AREA



LANDFILL SITE L1-7, TEMPORARY STOCKPILE T1-7

LANDFILL SITE: Available area of 45,000 m² on a sandy terrace underlain by ice-rich marine sediments.

TEMPORARY STOCKPILE: Available area of 10,000 m² on a sandy alluvial fan.

BEACH: Sand and gravel, 30 m wide.

BORROW SOURCE: Use beach material.

ACCESS: 1 km across a sandy terrace (winter).

DEVELOPMENT: Winter operation of landfill site. Landfill site could be used to dispose of material from spits and beaches immediately southwest of Herschel Island.

LANDFILL SITE LI-8

LANDFILL SITE: Sand and gravel on an alluvial fan.

TEMPORARY STOCKPILE: None required.

BEACH: Sand and gravel.

BORROW SOURCE: Use beach material.

ACCESS: 100 m from beach across a terrace on an alluvial fan (summer).

DEVELOPMENT: Summer operation is feasible. Borrow material should be removed from the spit end of the beach only, to avoid beach displacement and accelerated cliff retreat adjacent to R.C.M.P. buildings.



LANDFILL SITE LI-9, TEMPORARY STOCKPILE TI-9

LANDFILL SITE: A, B, and C have available areas of 15,000 m², 15,000 m², and 20,000 m² respectively on gravel and sand terraces.

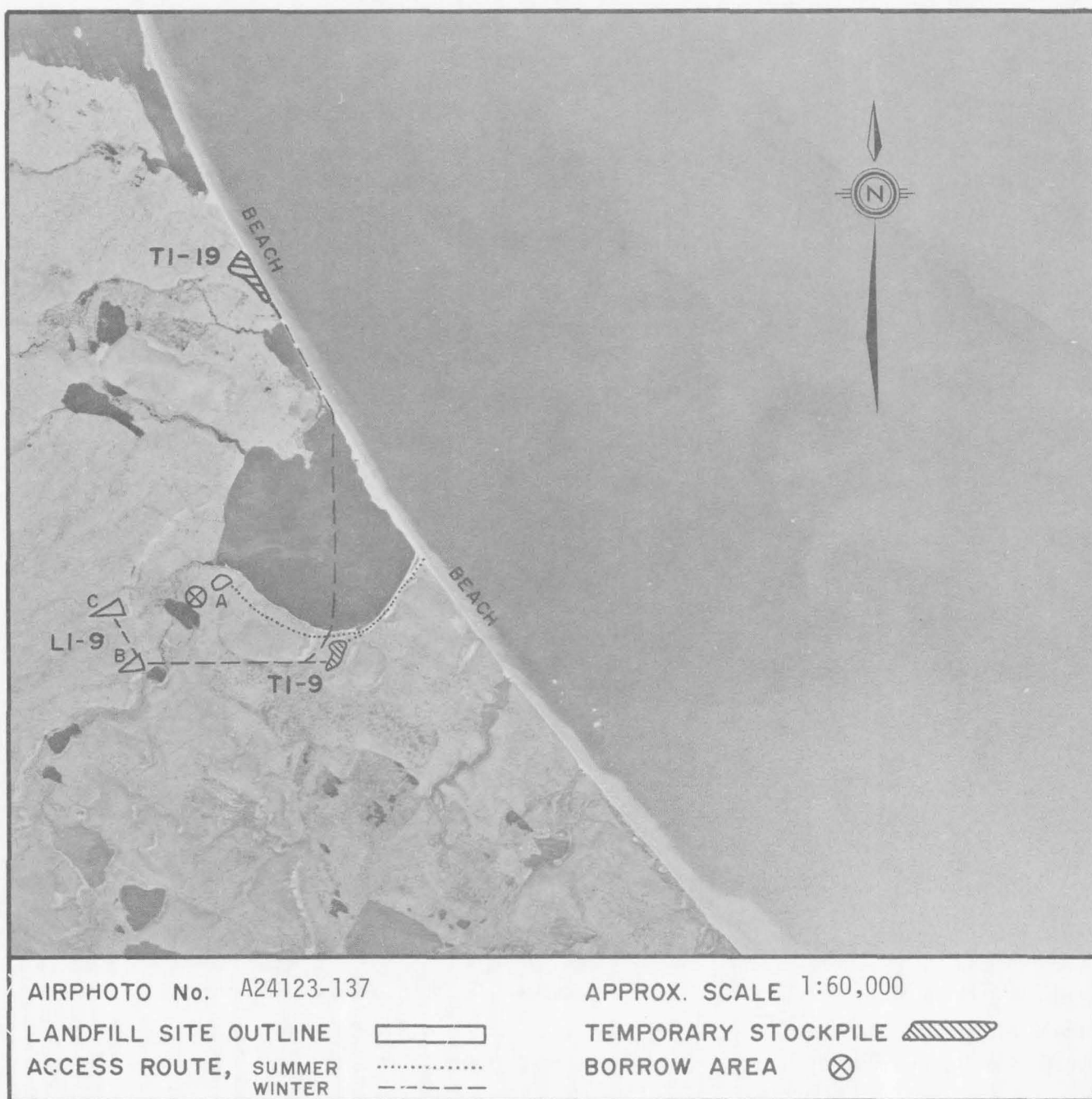
TEMPORARY STOCKPILE: Available area of 15,000 m² on rolling moraine with ice-rich silt and clay.

BEACH: Gravel and sand, 25 - 100 m wide.

BORROW SOURCE: Use beach material, supplement with sand and gravel plus minor fines from location shown on the edge of the gravel terrace.

ACCESS: 2 km to A (summer) on well drained terrain, 2 km to B and C (winter) across low wet terrain.

(Continued on next page)



LANDFILL SITE L1-9, TEMPORARY STOCKPILE T1-9 - Continued

DEVELOPMENT: Removal of highest beach ridge in front of the lagoon may result in contamination or alteration of the lagoon environment. A can be a summer operation, but B and C would have winter access only.

TEMPORARY STOCKPILE T1-19

TEMPORARY STOCKPILE: Available area of 35,000 m² on low lying tundra.

BEACH: Gravel and sand, 25 to 100 m wide.

BORROW SOURCE: Use beach sand.

ACCESS: 4.5 km to L1-9 (winter).

DEVELOPMENT: T1-19 is an alternative to hauling oiled debris down the beach to T1-9. It is low lying, wet tundra and will require more than average borrow for construction of the pad. Cleanup will be more difficult and some thermokarst may occur after the site is abandoned.

TEMPORARY STOCKPILES T1-10, T1-11

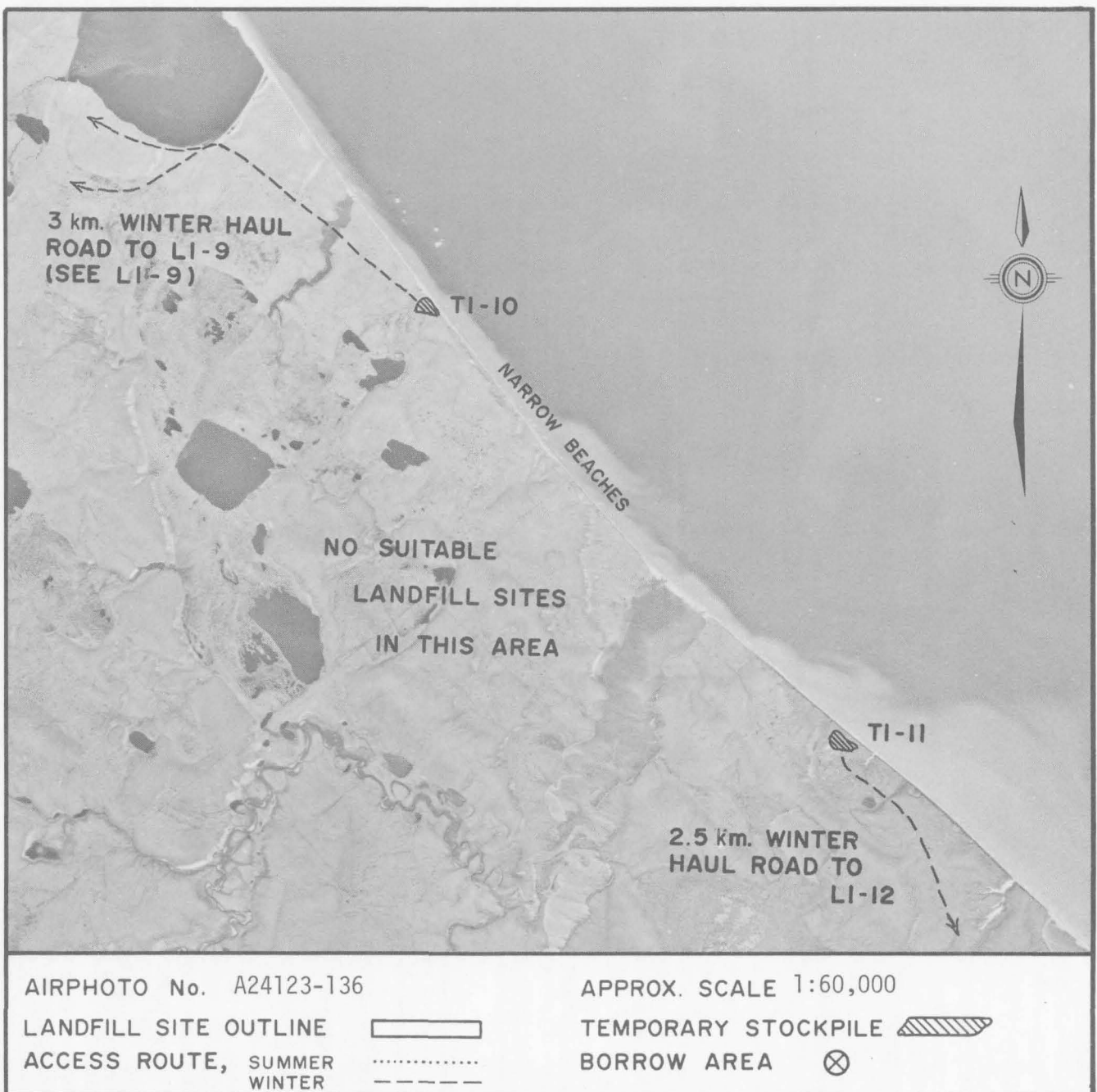
TEMPORARY STOCKPILE: T1-10 and T1-11 have available areas of 15,000 m² and 30,000 m² respectively. Both are on lacustrine silt and clay with a moderate to high ice content.

BEACH: Gravel and cobbles, 5 to 10 m wide.

BORROW SOURCE: Use beach sand (if available) or fines in the exposed cliffs.

ACCESS: 3 km haul from T1-10 to L1-9. 2.5 km from T1-11 to L1-12.

DEVELOPMENT: Shingle beaches in front of the temporary stockpiles may not contain enough sand for their construction.



LANDFILL SITE LI-12, TEMPORARY STOCKPILES T1-12, T1-13

LANDFILL SITE: A and B have available areas of 38,000 m² and 35,000 m² respectively, on rolling moraine with a moderate to high ice content.

TEMPORARY STOCKPILE: T1-12 and T1-13 have available areas of 12,000 m² and 20,000 m² respectively on lacustrine silt and clay with a high ice content.

BEACH: Gravel and sand, 50 - 200 m wide.

BORROW SOURCE: Use beach material.

ACCESS: 1 km from T1-12 (winter), 4 km from T1-13 (winter).

DEVELOPMENT: Winter operation of landfill site due to high ice content of the site. Removal of highest beach ridge in front of
(continued next page)



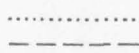
AIRPHOTO No. A22975-29

APPROX. SCALE 1:60,000

LANDFILL SITE OUTLINE



TEMPORARY STOCKPILE

ACCESS ROUTE, SUMMER
WINTER

BORROW AREA



LANDFILL SITE L1-12, TEMPORARY STOCKPILES T1-12, T1-13 - Continued

DEVELOPMENT:
(cont'd)

the lagoon may result in contamination or
alteration of the lagoon environment.

LANDFILL SITE LI-14, TEMPORARY STOCKPILE TI-14

LANDFILL SITE: Available area of 40,000 m² on rolling moraine, mainly silt and clay with a moderate to high ice content.

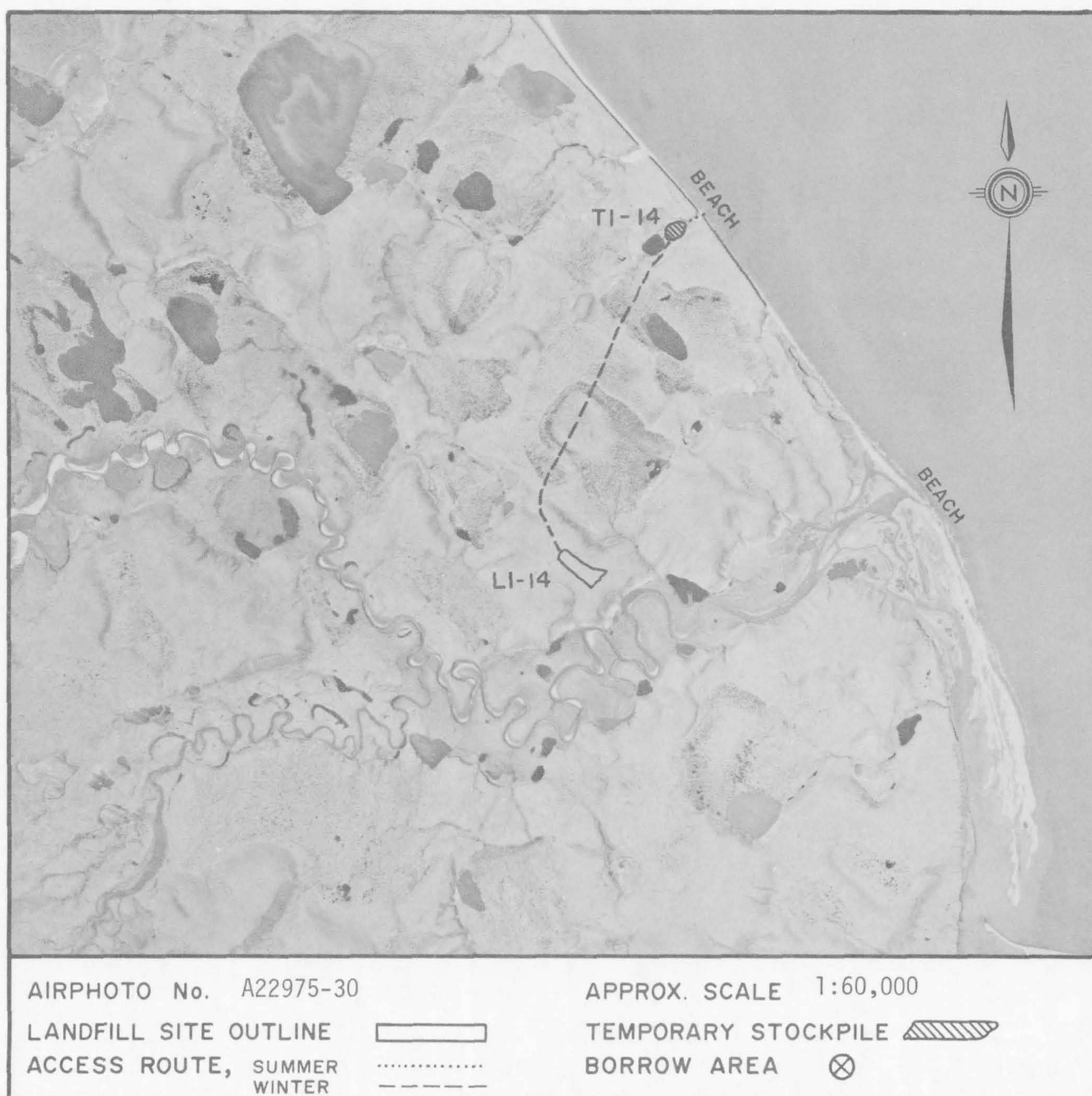
TEMPORARY STOCKPILE: Available area of 15,000 m² on a recently drained lake basin.

BEACH: Gravel and sand, 10 to 200 m wide.

BORROW SOURCE: Use beach material. Sand is available mainly southeast of the river mouth. The narrow portion of the beach north of the river mouth is gravel.

ACCESS: 3 km across wet tundra (winter).

DEVELOPMENT: Winter construction of landfill site.



LANDFILL SITE LI-15, TEMPORARY STOCKPILE TI-15

LANDFILL SITE: Available area of 24,000 m² on a sand and gravel terrace.

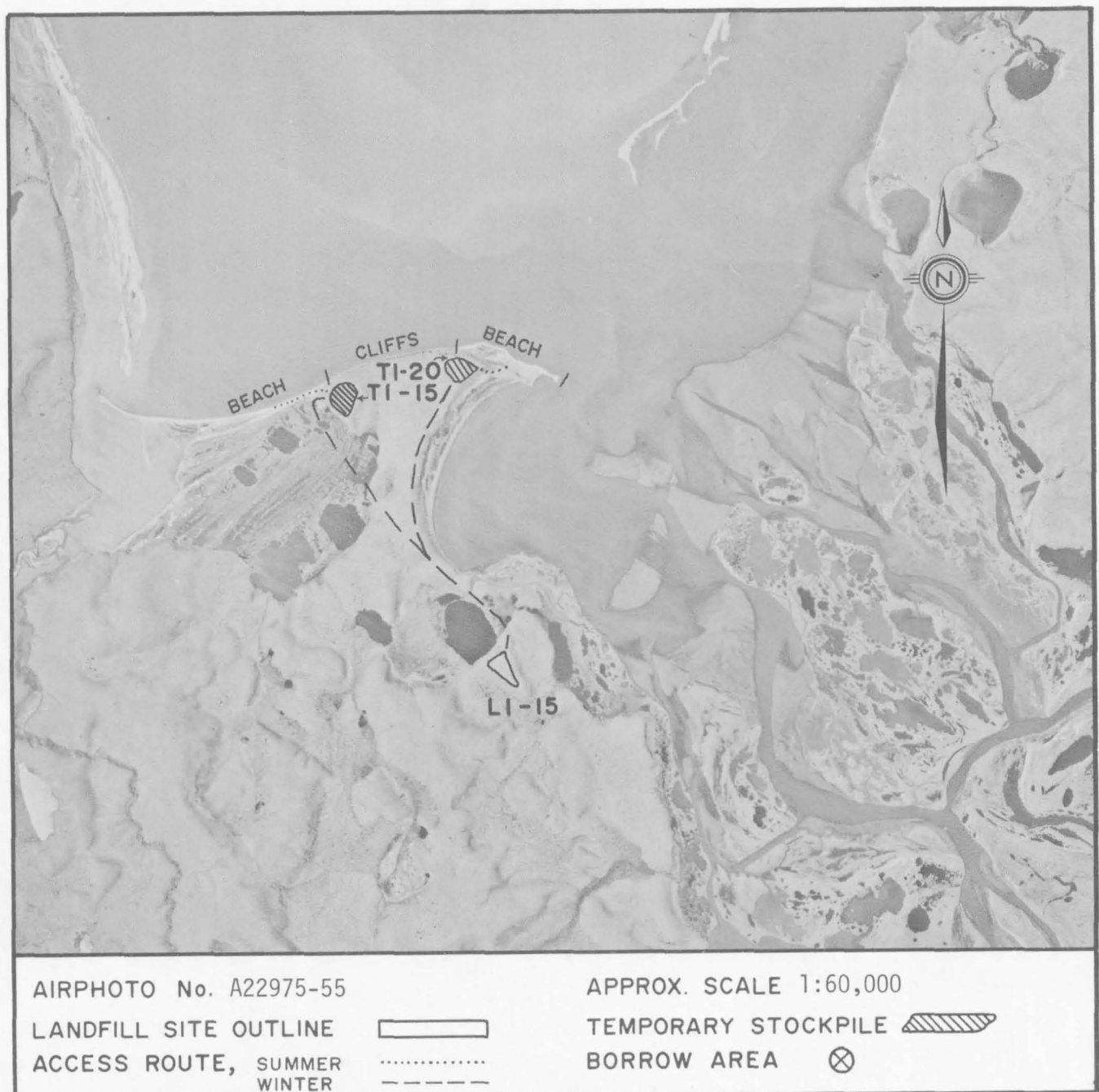
TEMPORARY STOCKPILE: Available area of 40,000 m² on a lacustrine plain containing silt and clay with a high ice content.

BEACH: Sand and gravel, 50 m wide.

BORROW SOURCE: Use beach material.

ACCESS: 2.5 km across low wet tundra (winter).

DEVELOPMENT: Winter operation of landfill site because of poor access.



TEMPORARY STOCKPILE T1-20

TEMPORARY STOCKPILE: Available area of 40,000 m² on a poorly drained lacustrine plain containing silt and clay with a high ice content.

BEACH: Sand and gravel, 50 m wide.

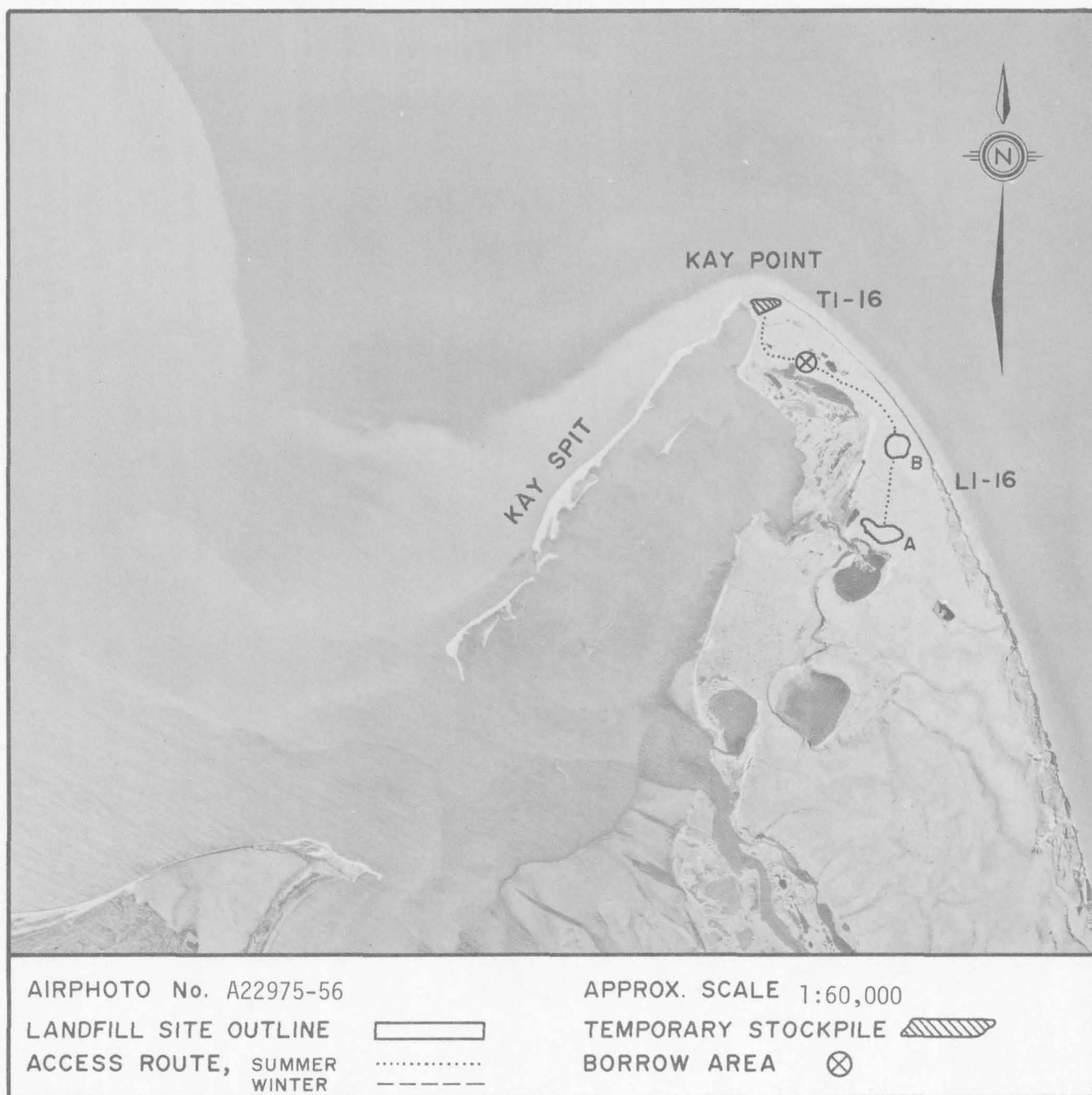
BORROW SOURCE: Use beach sand.

ACCESS: Construction of an earth fill ramp may be required up the steep slope to the stockpile site.

DEVELOPMENT: T1-20 has poor conditions, but the beach in front of it has no access to T1-15. T1-20 is poorly drained, which will require more borrow for pad construction and an earth fill ramp may be necessary for access. Cleanup will be more difficult than usual and thermokarst may develop after the site is abandoned.

LANDFILL SITE L1-16, TEMPORARY STOCKPILE T1-16

- LANDFILL SITE: A and B have available areas of 25,000 m² and 22,000 m² respectively on a sand and gravel terrace.
- TEMPORARY STOCKPILE: Available area of 15,000 m² on a lacustrine plain containing silt and clay with a high ice content.
- BEACH: Gravel and sand spit, 50 - 150 m wide.
- BORROW SOURCE: Use beach material or sand and gravel from borrow location shown on terrace.
- ACCESS: 2 km across well drained lacustrine plain and sand and gravel terrace (summer).
- DEVELOPMENT: Could be a summer operation. Landfill site A is more suitable because B has a design life of only 20 years due to rapid coastal retreat.



LANDFILL SITE LI-17

LANDFILL SITE: Two sites, each having available areas of 25,000 m² on a sand and gravel terrace.

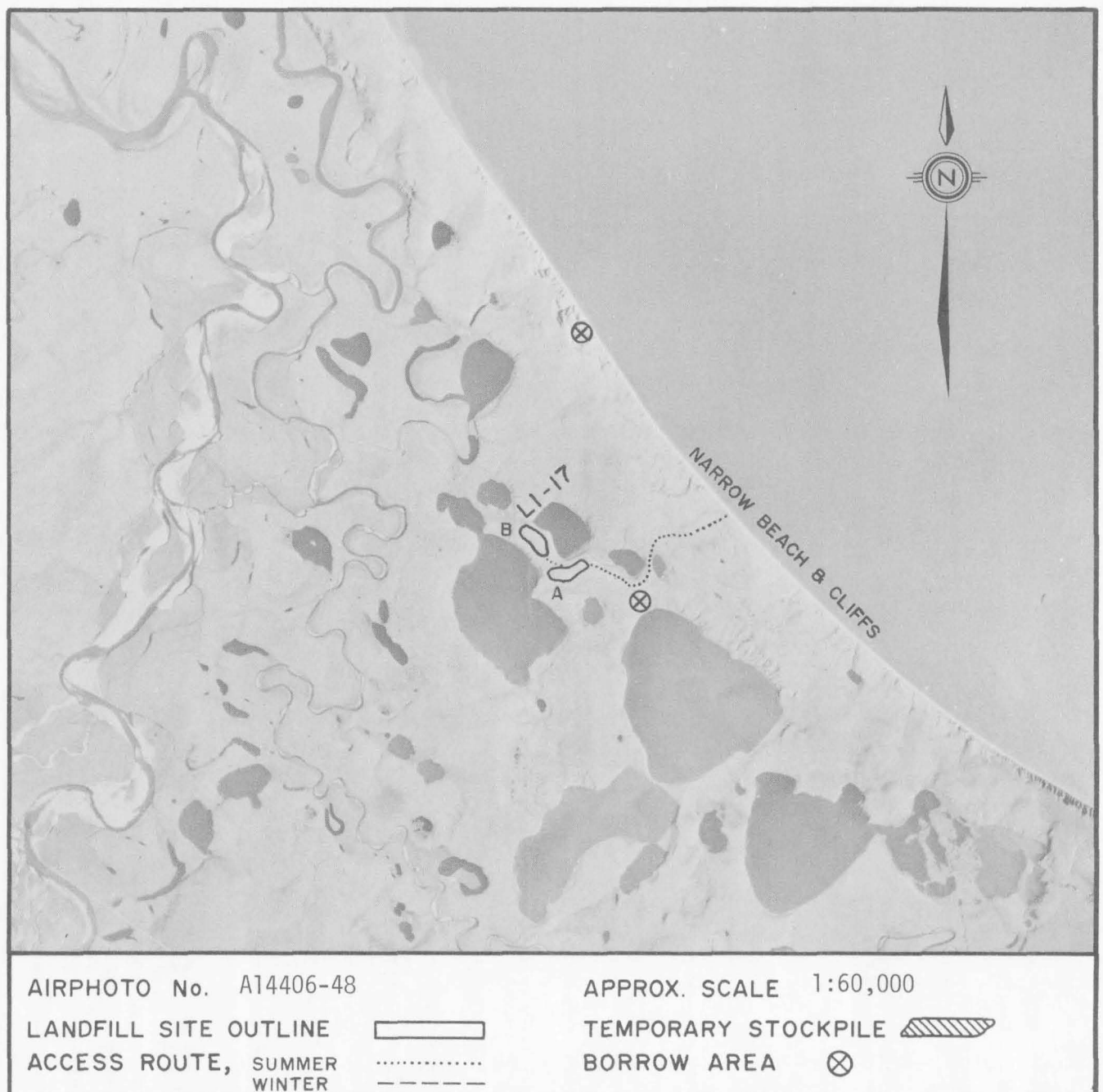
TEMPORARY STOCKPILE: No suitable sites, none required for summer construction.

BEACH: Gravel and sand, 30 m wide.

BORROW SOURCE: Use beach material or sand and gravel from the two locations shown.

ACCESS: 1.5 km across rolling well drained terrain (summer).

DEVELOPMENT: Probably summer operation. Use borrow areas to supplement beach material for road construction. Access from beach is steep and may require construction of a ramp.



APPENDIX B
AERIAL PHOTOGRAPHS AND DESCRIPTION OF SITES
MAP 2, SHALLOW BAY

LANDFILL SITE L2-1, TEMPORARY STOCKPILE T2-6

LANDFILL SITE: A, B, and C have available areas of 15,000 m², 22,000 m² and 45,000 m² respectively on a sand and gravel terrace.

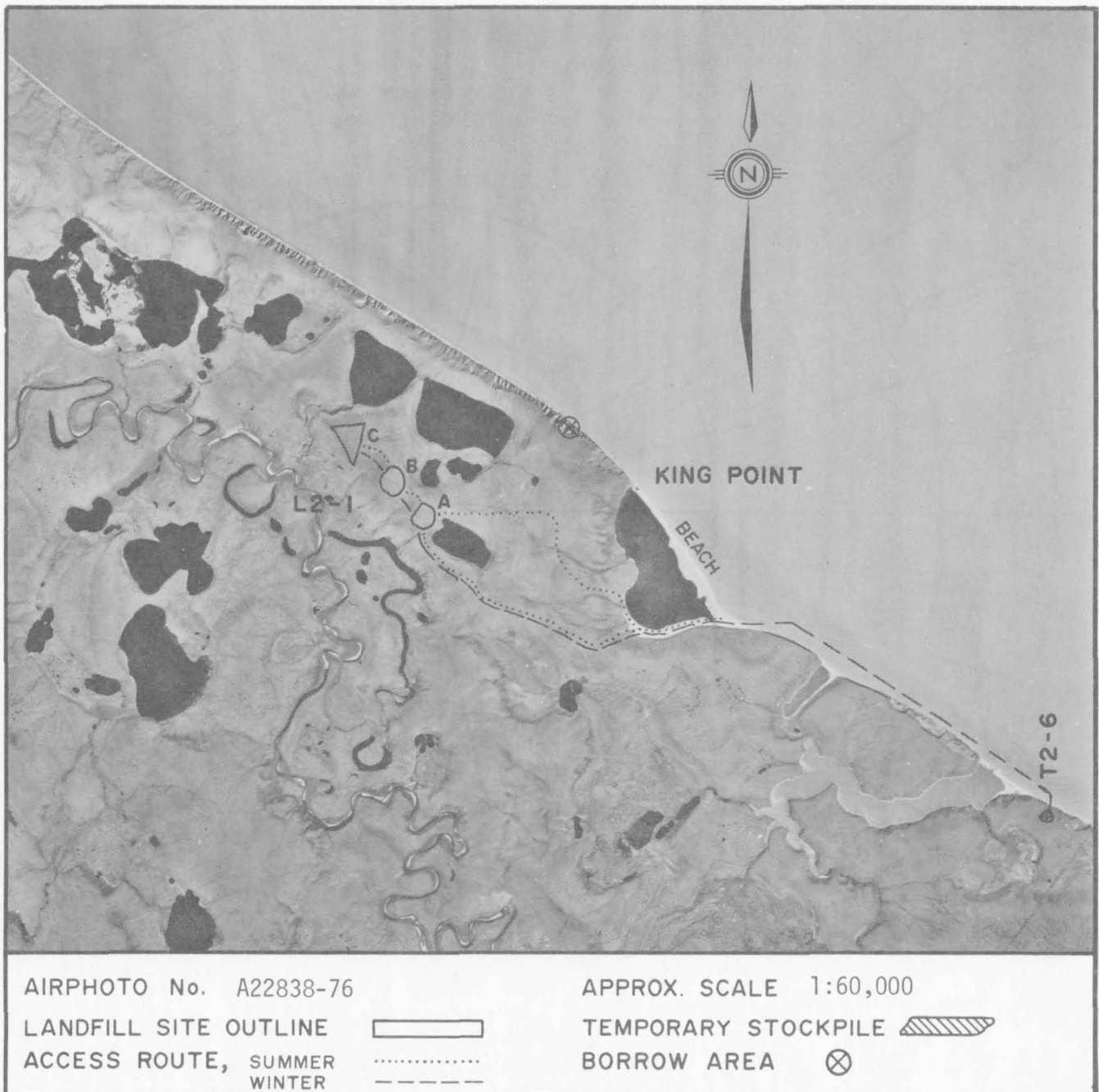
TEMPORARY STOCKPILE: Available area of 7,000 m² on a lacustrine plain containing silt and clay with a high ice content. Slope 5 - 10%.

BEACH: Gravel and sand, 100 m wide near landfill site and 50 m wide near temporary stockpile.

BORROW SOURCE: Use beach material and supplement with sand and gravel from the gullied cliffs at location shown.

ACCESS: 2 km from beach to L2-1 (summer), 6 km from T2-6 to L2-1 (winter).

(continued on next page)



LANDFILL SITE L2-1, TEMPORARY STOCKPILE T2-6 - Continued

DEVELOPMENT:

Summer operation except for oiled debris stored at T2-6. Removal of the highest beach ridge in front of the lagoon may result in contamination or alteration of the lagoon environment. Use inner beach for borrow material if possible. Containment barriers will be required at the temporary stockpile to contain the oiled debris because of the slope.

LANDFILL SITE L2-2, TEMPORARY STOCKPILE T2-2

LANDFILL SITE: A, B, and C have available areas of 15,000 m², 10,000 m², and 7,500 m² respectively. A is on rolling moraine and B and C are on a sandy terrace.

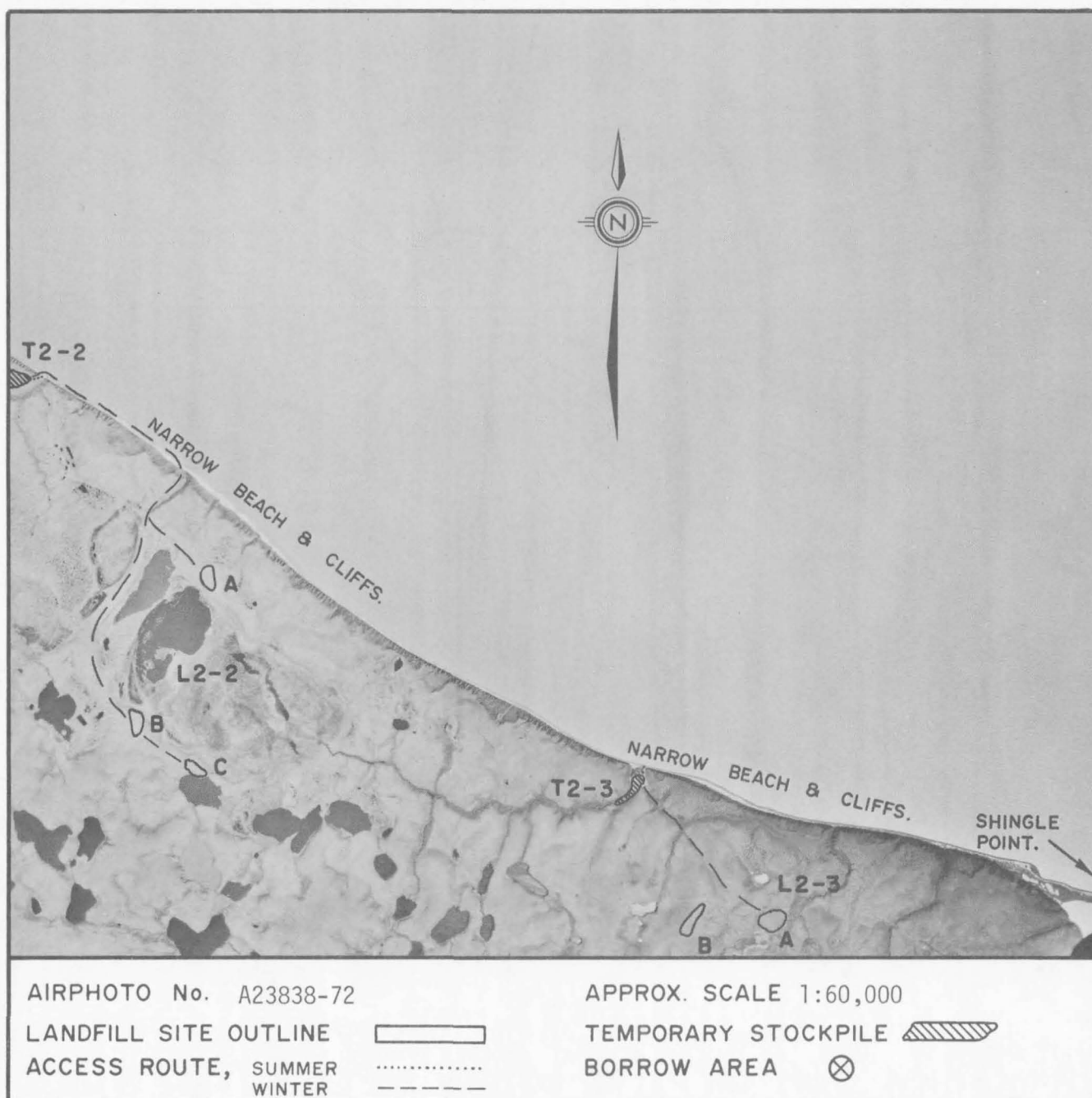
TEMPORARY STOCKPILE: Available area of 20,000 m² on a lacustrine plain.

BEACH: Gravel and sand, 30 m wide.

BORROW SOURCE: Use beach material. Beach is mainly gravel; sand is limited in quantity.

ACCESS: 2.5 km from T2-2 to A and 4 km to B and C (winter). Access from beach is up a steep sided gully.

DEVELOPMENT: Winter operation. Ramp required for T2-2 because of the steep slope to the beach. Some fill is required to
(Continued on next page)



LANDFILL SITE L2-2, TEMPORARY STOCKPILE T2-2 - Continued

DEVELOPMENT: construct a winter road in the gully for a distance of 400 m to 500 m.

LANDFILL SITE L2-3, TEMPORARY STOCKPILE T2-3

LANDFILL SITE: A and B have available areas of 22,000 m² and 15,000 m² on rolling moraine with a moderate to high ice content.

TEMPORARY STOCKPILE: Low sand area behind the beach with an available area of 15,000 m².

BEACH: Gravel and sand, up to 30 m wide. Also, some material from shingle point spit may be disposed of at this location.

BORROW SOURCE: Use beach material.

ACCESS: 1.5 km on well drained rolling moraine (winter).

DEVELOPMENT: Winter operation of landfill site. Temporary stockpile would require a berm along the beach for protection against storm surges.

LANDFILL SITE L2-5, TEMPORARY STOCKPILE T2-5

LANDFILL SITE: A, B, and C have available areas of 55,000 m², 12,000 m², and 12,000 m² respectively on a gravel terrace.

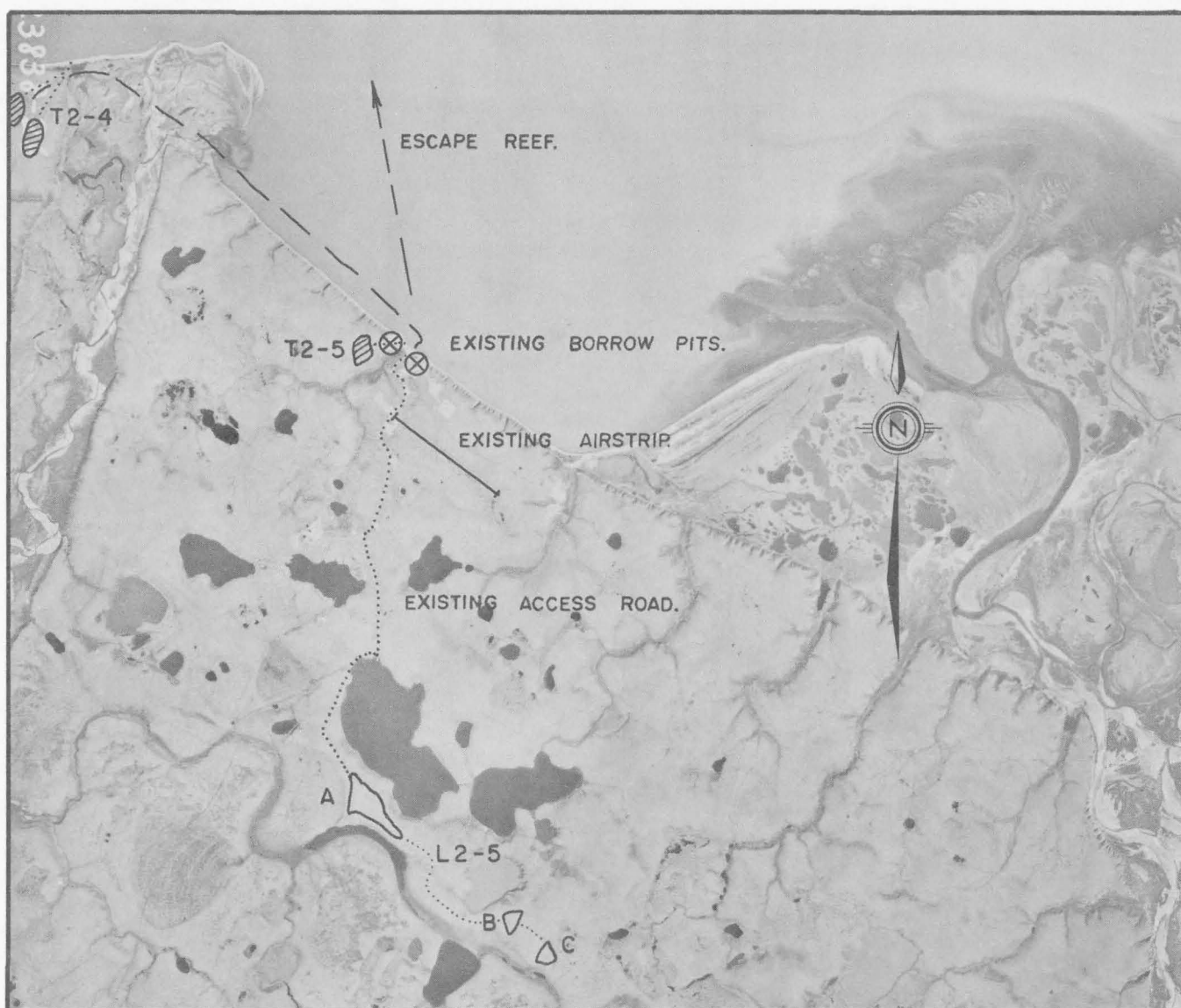
TEMPORARY STOCKPILE: Available area of 30,000 m² on well drained rolling moraine.

BEACH: Gravel and sand, 50 m wide.

BORROW SOURCE: 2 existing gravel pits in Tertiary gravels.

ACCESS: 3.5 km on existing gravel road (summer).

DEVELOPMENT: Summer construction. Some material from T2-4 and Escape Reef could be barged or hauled to this site because of the high storage capacity and existing facilities.



AIRPHOTO No. A23838-26

APPROX. SCALE 1:60,000

LANDFILL SITE OUTLINE



TEMPORARY STOCKPILE

ACCESS ROUTE, SUMMER
WINTER

BORROW AREA



TEMPORARY STOCKPILE T2-4

TEMPORARY STOCKPILE: Two sites, each having available areas of 20,000 m² on rolling moraine.

BEACH: Sand and gravel, 50 m wide.

BORROW SOURCE: Use beach materials.

ACCESS: 7 km haul to L2-5 (winter).

DEVELOPMENT: An earth fill ramp may be required to aid access up a steep gully to the stockpile site.

APPENDIX C
AERIAL PHOTOGRAPHS AND DESCRIPTION OF SITES
MAP 3, OUTER DELTA

LANDFILL SITE L3-1

LANDFILL SITE: Available area of 10,000 m² on thin morainal deposits overlying ice-rich marine silts.

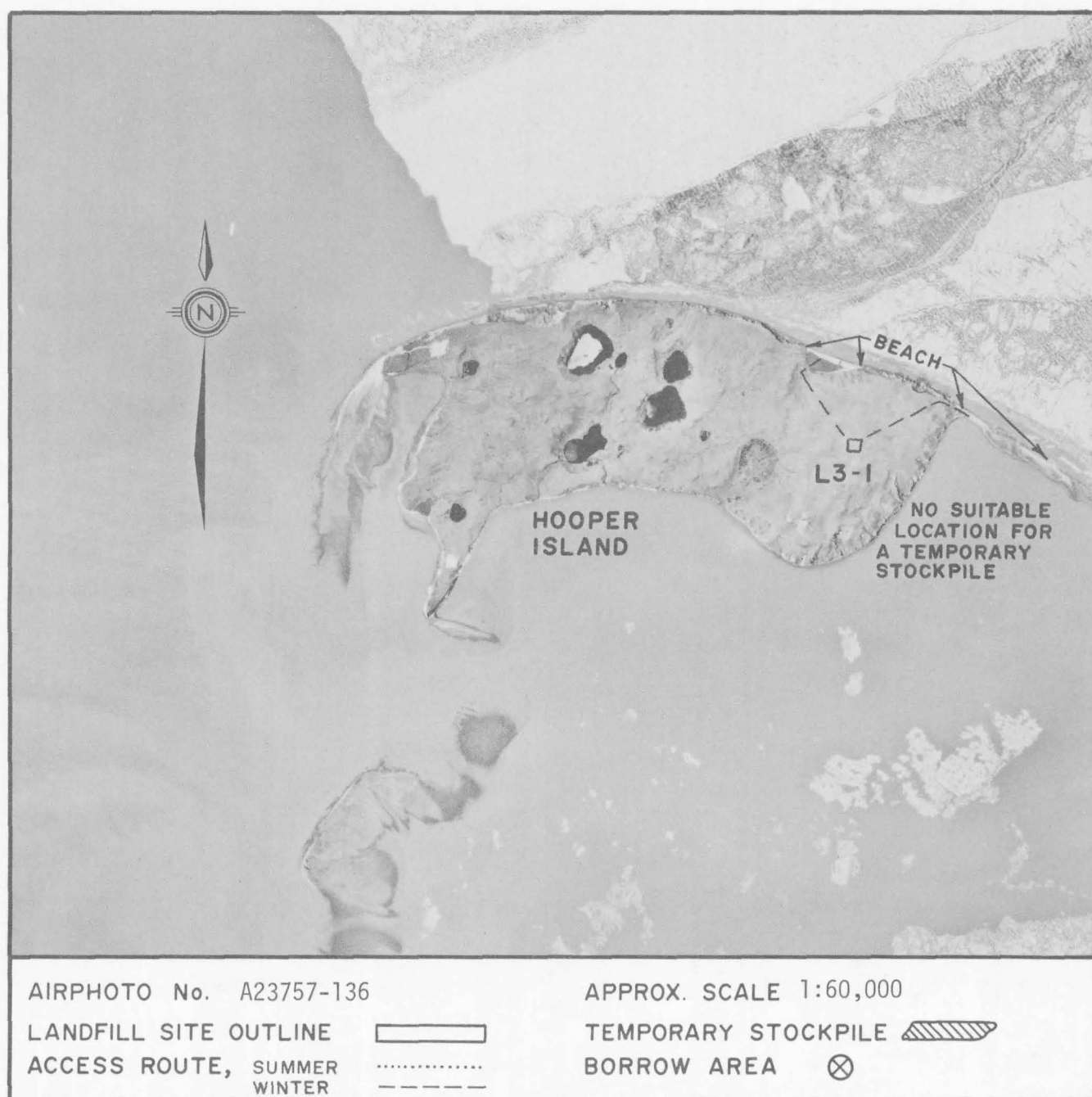
TEMPORARY STOCKPILE: No suitable sites.

BEACH: Mainly sand, some fine gravel, 50 m wide.

BORROW SOURCE: Use beach material from spit.

ACCESS: 0.7 km on hilly terrain (winter).

DEVELOPMENT: Winter construction of the landfill site, build stockpiles on beach and protect with dykes if feasible.



LANDFILL SITE L3-2, TEMPORARY STOCKPILES T3-2, T3-3

LANDFILL SITE: Available area of 30,000 m² on thin morainal deposits overlying ice-rich marine silts. Several ice wedges present.

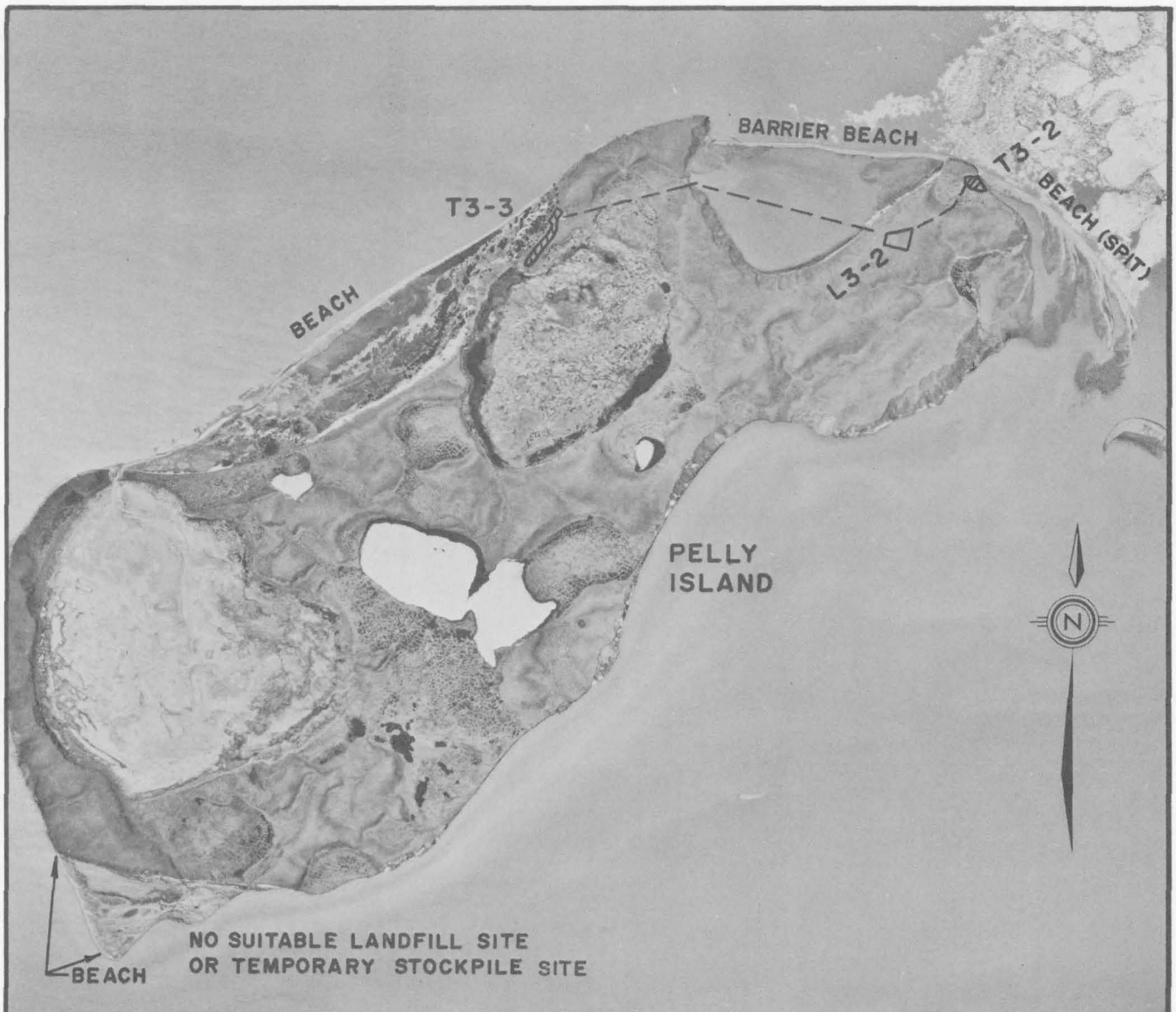
TEMPORARY STOCKPILE: T3-2 and T3-3 have available areas of 10,000 m² and 25,000 m² respectively on low tundra.

BEACH: Two sand beaches 50 - 100 m wide, one sand spit 100 m wide.

BORROW SOURCE: Use beach material, preferably from the spit.

ACCESS: 600 m from T3-2 (winter), 2.5 km from T3-3 (winter).

DEVELOPMENT: Winter construction of L3-2. It may be possible to haul material from the detached spit east of the island to the landfill site, if a temporary stockpile can be built on the spit and protected from wave action.



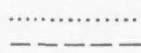
AIRPHOTO No. A23757-140

APPROX. SCALE 1:60,000

LANDFILL SITE OUTLINE



TEMPORARY STOCKPILE

ACCESS ROUTE, SUMMER
WINTER

BORROW AREA



LANDFILL SITE L3-4, TEMPORARY STOCKPILES T3-4, T3-5

LANDFILL SITE: A and B have available areas of 45,000 m² and 15,000 m² on a gently sloping well drained sand and gravel terrace.

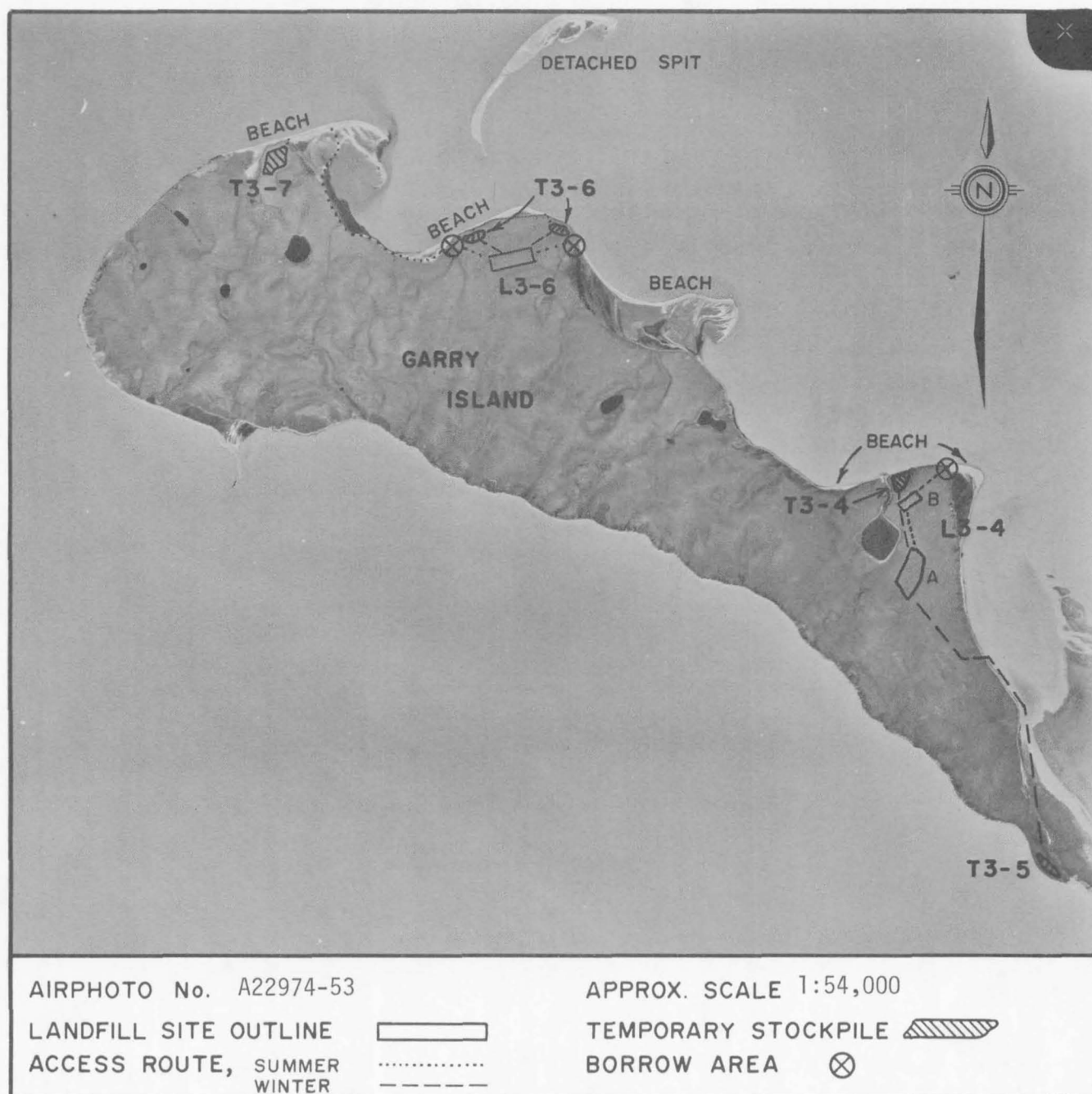
TEMPORARY STOCKPILE: T3-4 and T3-5 have available areas of 10,000 m² each on a sand and gravel terrace.

BEACH: Mainly sand, 30 - 100 m wide.

BORROW SOURCE: Edge of sand and gravel terrace as shown, or beach sand.

ACCESS: 0.8 km to L3-4 from adjacent beaches (summer), 2.5 km from T3-5 (winter).

DEVELOPMENT: Landfill site can be a summer operation. T3-5 would only be required for cleanup of the small beach adjacent to it. Hauling from T3-5 would be a winter operation.



LANDFILL SITE L3-6, TEMPORARY STOCKPILES T3-6, T3-7

LANDFILL SITE: Available area of 35,000 m² on a well drained sand and gravel terrace.

TEMPORARY STOCKPILE: If required, T3-6 has two sites with available areas of 10,000 m² each. Also, T3-7, if required, has an available area of 24,000 m² on thin morainal deposits overlying silty marine sediments.

BEACH: Mainly sand, 50 to 150 m wide.

BORROW SOURCE: Two possible sources on edge of sand and gravel terrace as shown. Also beach material.

ACCESS: 500 m from two beaches and 2 km from the farthest beach (summer).

DEVELOPMENT: Probably summer construction. Check ice content of upper 6 m of landfill site before proceeding with summer construction. May have capacity for some oiled debris from the detached spit north of the island.

LANDFILL SITE L3-8, TEMPORARY STOCKPILE T3-8

LANDFILL SITE: Available area of 30,000 m² or more on a fine grained fluvial terrace containing fine sand and silt with a moderate to high ice content.

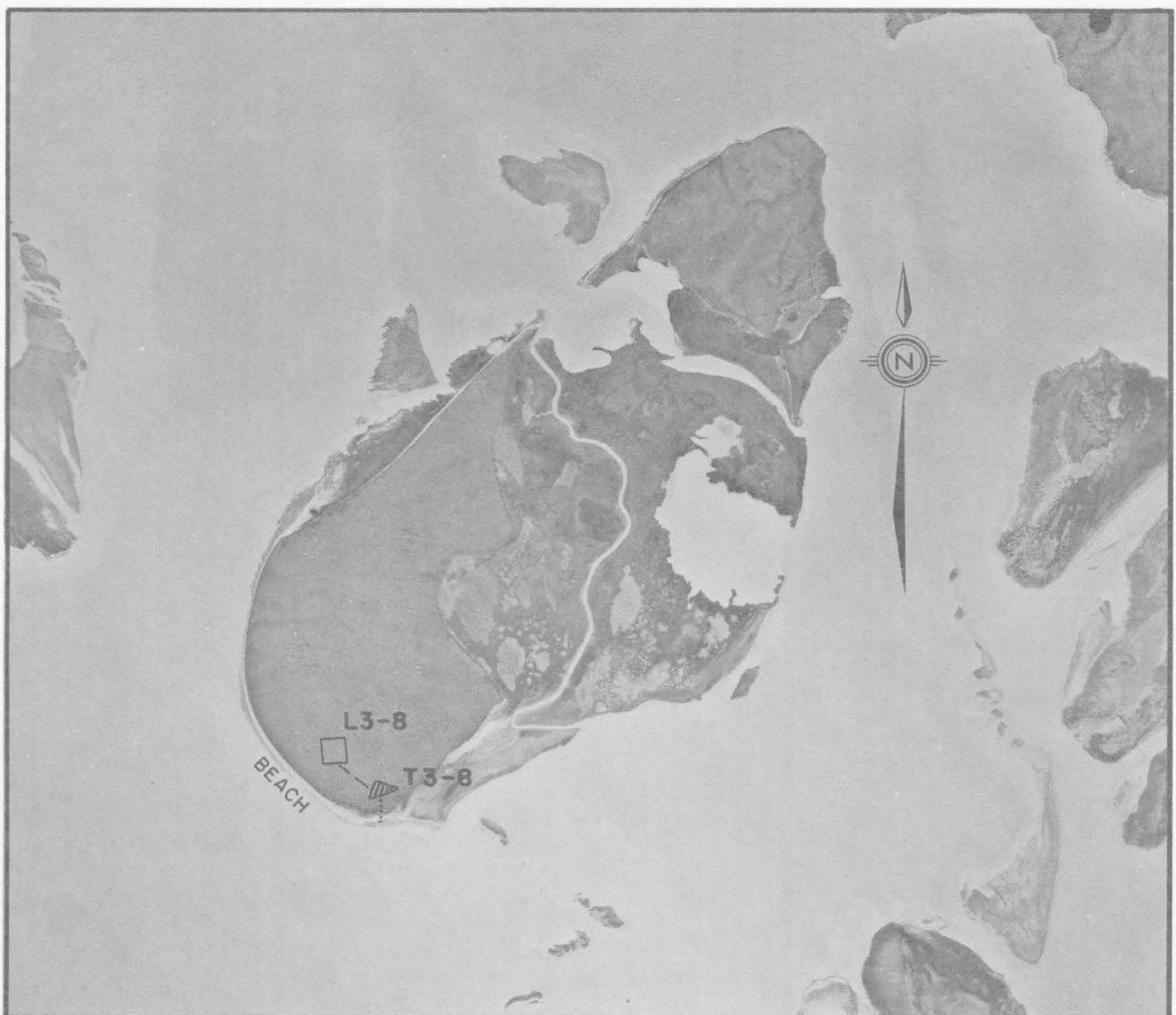
TEMPORARY STOCKPILE: Available area of 15,000 m² or more on same terrain as landfill site.

BEACH: Sand, 70 m wide.

BORROW SOURCE: Use beach material.

ACCESS: 300 m on fine grained fluvial terrace (winter).

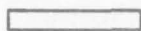
DEVELOPMENT: Winter construction. Site within Kendall Island Bird Sanctuary.



AIRPHOTO No. A22974-51

APPROX. SCALE 1:54,000

LANDFILL SITE OUTLINE



TEMPORARY STOCKPILE

ACCESS ROUTE, SUMMER
WINTER

BORROW AREA



LANDFILL SITE L3-9, TEMPORARY STOCKPILE T3-9

LANDFILL SITE: Available area of 10,000 m² on a thin morainal deposit overlying a marine silt with moderate to high ice content.

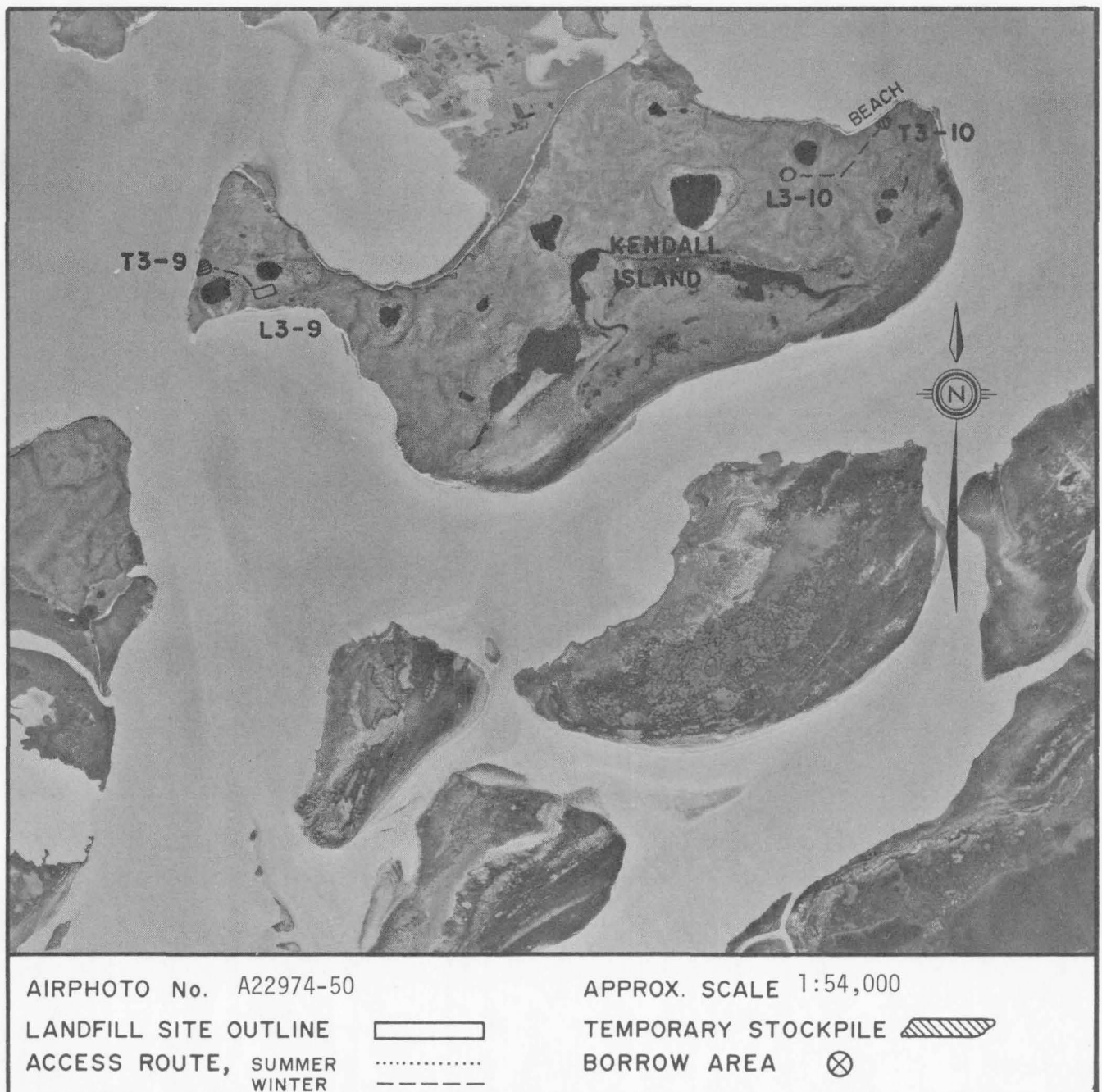
TEMPORARY STOCKPILE: Available area of 8,000 m² on same terrain as landfill site.

BEACH: Sand, 30 m wide.

BORROW SOURCE: Use beach material.

ACCESS: 400 m across well drained gently sloping terrain (winter).

DEVELOPMENT: Winter construction of landfill site. Site is within Kendall Island Bird Sanctuary.



LANDFILL SITE L3-10, TEMPORARY STOCKPILE T3-10

LANDFILL SITE: Available area of 6,000 m² on thin moraine overlying marine silts with a moderate to high ice content.

TEMPORARY STOCKPILE: Available area of 5,000 m² on same terrain as landfill site.

BEACH: Mainly sand, 10 - 30 m wide.

BORROW SOURCE: Use beach material.

ACCESS: 800 m on low-lying terrain (winter).

DEVELOPMENT: Winter construction of landfill site. Site is within Kendall Island Bird Sanctuary.

LANDFILL SITE L3-11, TEMPORARY STOCKPILES T3-11, T3-17

LANDFILL SITE: Available area of $40,000 \text{ m}^2$ on thin morainal deposit overlying marine silts with a high ice content.

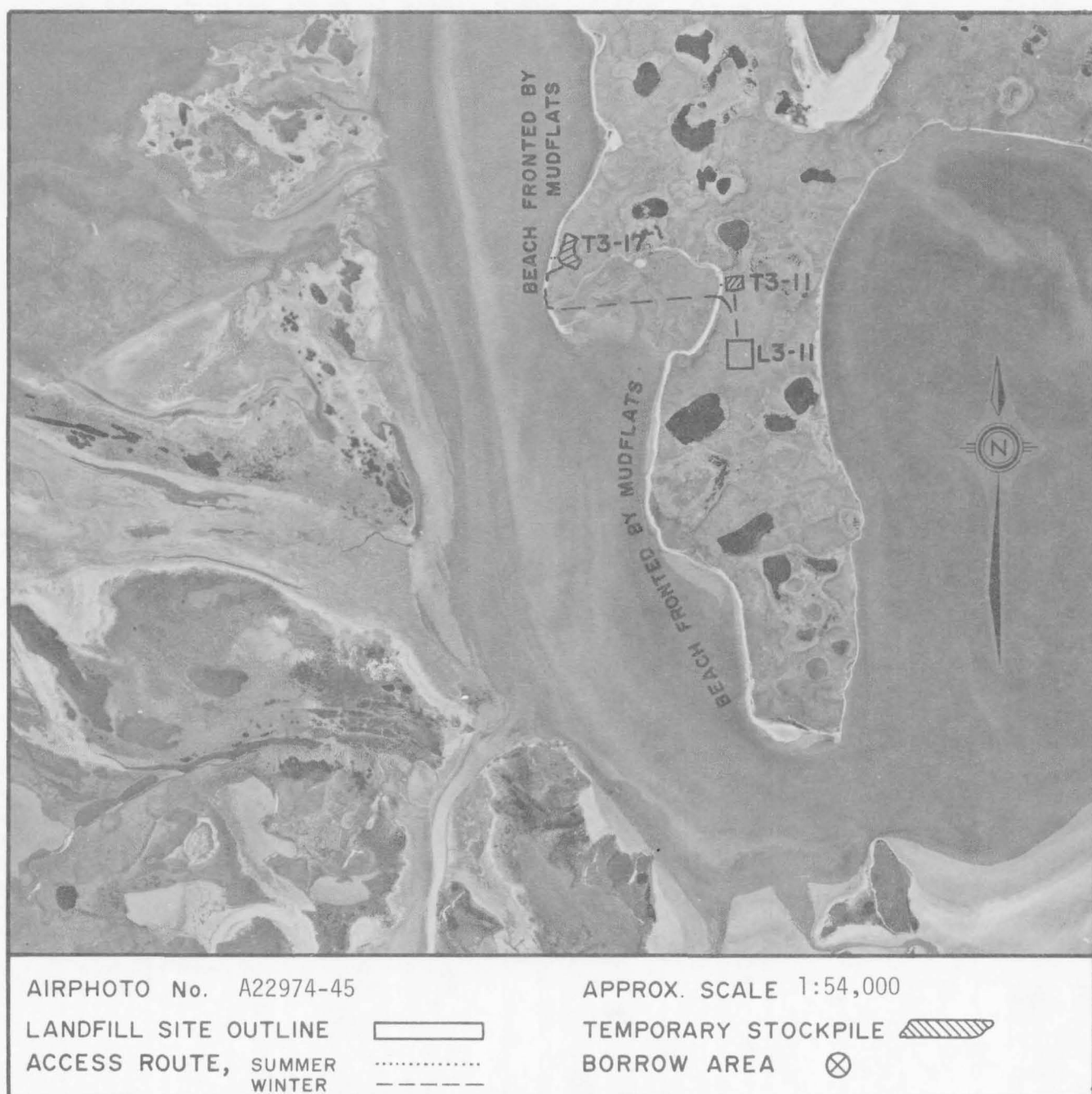
TEMPORARY STOCKPILE: T3-11 and T3-17 have available areas of $12,000 \text{ m}^2$ and $25,000 \text{ m}^2$ respectively on the same terrain as landfill site. T3-11 has a moderate to high ice content and T3-17 has a moderate ice content.

BEACH: Sand, 10 - 20 m wide fronted by mudflats.

BORROW SOURCE: Use beach material.

ACCESS: 500 m from T3-11 (winter) and 2 km from T3-17 (winter) to landfill site.

(continued on next page)

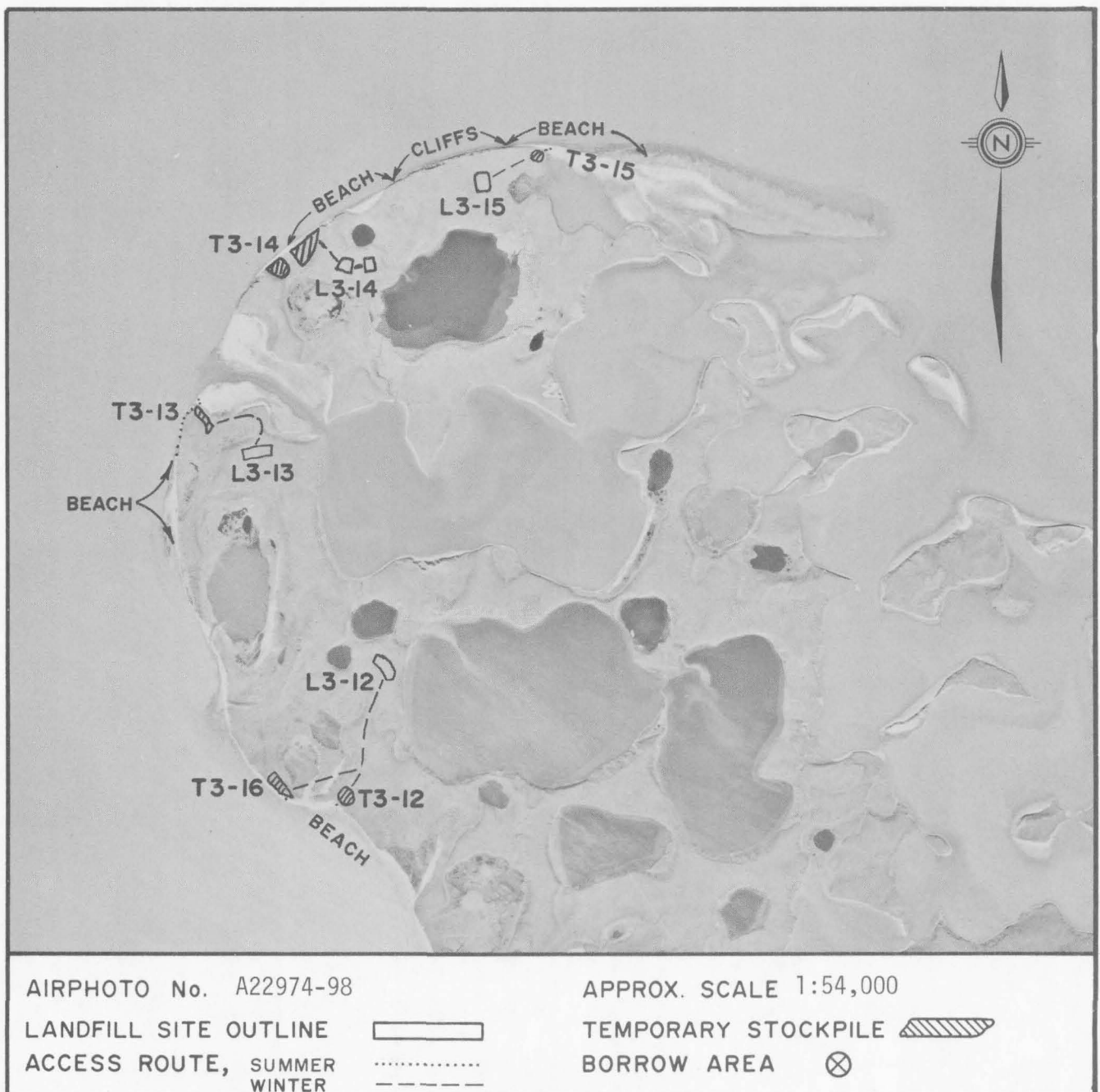


LANDFILL SITE L3-11, TEMPORARY STOCKPILES T3-11, T3-17 - Continued

DEVELOPMENT: Ice content should be checked prior to development.
 Mudflats will make access to beach difficult.

LANDFILL SITE L3-12, TEMPORARY STOCKPILES T3-12, T3-16

- LANDFILL SITE: Available area of 20,000 m² on thin moraine overlying marine silts with a moderate to high ice content.
- TEMPORARY STOCKPILE: T3-12 and T3-16 have available areas of 10,000 m² each, on the same terrain as the landfill site.
- BEACH: Sand, 10 - 50 m wide.
- BORROW SOURCE: Use beach sand, can supplement with small amount of fine material from exposed sea cliffs.
- ACCESS: 1 km across well drained rolling moraine (winter).
- DEVELOPMENT: Winter construction of landfill site.



LANDFILL SITE L3-13, TEMPORARY STOCKPILE T3-13

LANDFILL SITE: Available area of 20,000 m² on sandy marine deposits with a moderate to high ice content.

TEMPORARY STOCKPILE: Available area of 10,000 m² on same terrain as landfill site.

BEACH: Sand, 10 - 50 m wide.

BORROW SOURCE: Use beach material.

ACCESS: 500 m on well drained rolling terrain (winter).

DEVELOPMENT: Winter construction of landfill site.

LANDFILL SITE L3-14, TEMPORARY STOCKPILE T3-14

LANDFILL SITE: Two sites with available areas of 10,000 m² and 8,000 m² on a sandy marine deposit with a moderate to high ice content.

TEMPORARY STOCKPILE: Two sites with areas of 25,000 m² and 15,000 m² on a recently drained lake basin with a moderate ice content.

BEACH: Sand, up to 50 m wide.

BORROW SOURCE: Use beach material.

ACCESS: 300 m on well drained marine sands (winter).

DEVELOPMENT: Winter construction of landfill site.

LANDFILL SITE L3-15, TEMPORARY STOCKPILE T3-15

LANDFILL SITE: Available area of 15,000 m² on well drained marine sands with a moderate to high ice content.

TEMPORARY STOCKPILE: Available area of 6,000 m² on same terrain as landfill site.

BEACH: Sand, 150 m wide. A larger temporary stockpile could be built on the beach if it could be protected from storm surges.

(continued on next page)

LANDFILL SITE L3-15, TEMPORARY STOCKPILE T3-15 - Continued

BORROW SOURCE: Use beach material.

ACCESS: 500 m on well drained, rolling marine sand (winter).

DEVELOPMENT: Summer construction is more desirable because of the small size of the temporary stockpile. The ice content should be checked to determine if summer construction is possible.

APPENDIX D
AERIAL PHOTOGRAPHS AND DESCRIPTION OF SITES
MAP 4, TUKTOYAKTUK PENINSULA

LANDFILL SITE L4-1, TEMPORARY STOCKPILE T4-1

LANDFILL SITE: Available area of 30,000 m² on glaciofluvial sand with a moderate ice content.

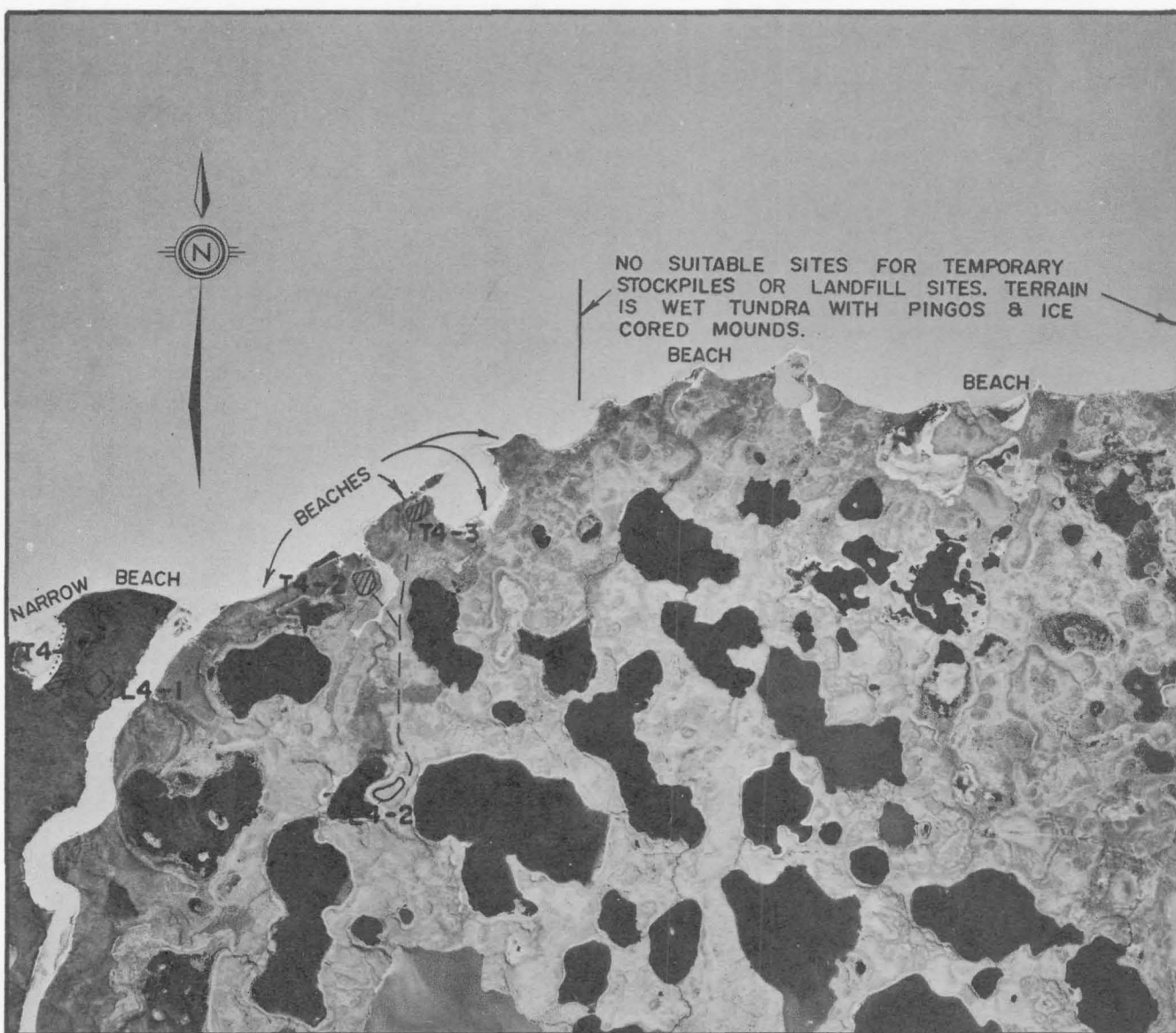
TEMPORARY STOCKPILE: Available area of 25,000 m² on a lacustrine plain modified by thermokarst.

BEACH: Mainly sand, narrow, up to 25 m wide, backed by cliffs.

BORROW SOURCE: Use beach material.

ACCESS: 300 m from temporary stockpile to landfill site on well drained, gently sloping terrain.

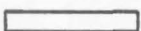
DEVELOPMENT: Winter construction due to high ice content.



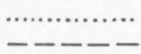
AIRPHOTO No. A22974-151

APPROX. SCALE 1:54,000

LANDFILL SITE OUTLINE



TEMPORARY STOCKPILE

ACCESS ROUTE, SUMMER
WINTER

BORROW AREA



LANDFILL SITE L4-2, TEMPORARY STOCKPILES T4-2, T4-3

LANDFILL SITE: Available area of 20,000 m² on moraine modified by thermokarst.

TEMPORARY STOCKPILE: T4-2 and T4-3 have available areas of 27,000 m² and 20,000 m² respectively on a well drained lacustrine plain.

BEACH: Mainly sand, 25 to 30 m wide.

BORROW SOURCE: Use beach material.

ACCESS: 1.5 km from T4-2 (winter) and 2 km from T4-3 (winter) to the landfill site.

DEVELOPMENT: Winter construction of landfill site due to ice contents.

LANDFILL SITE L4-4, TEMPORARY STOCKPILES T4-4, T4-5

LANDFILL SITE: Available area of 30,000 m² on a well drained lacustrine plain with a medium to high ice content.

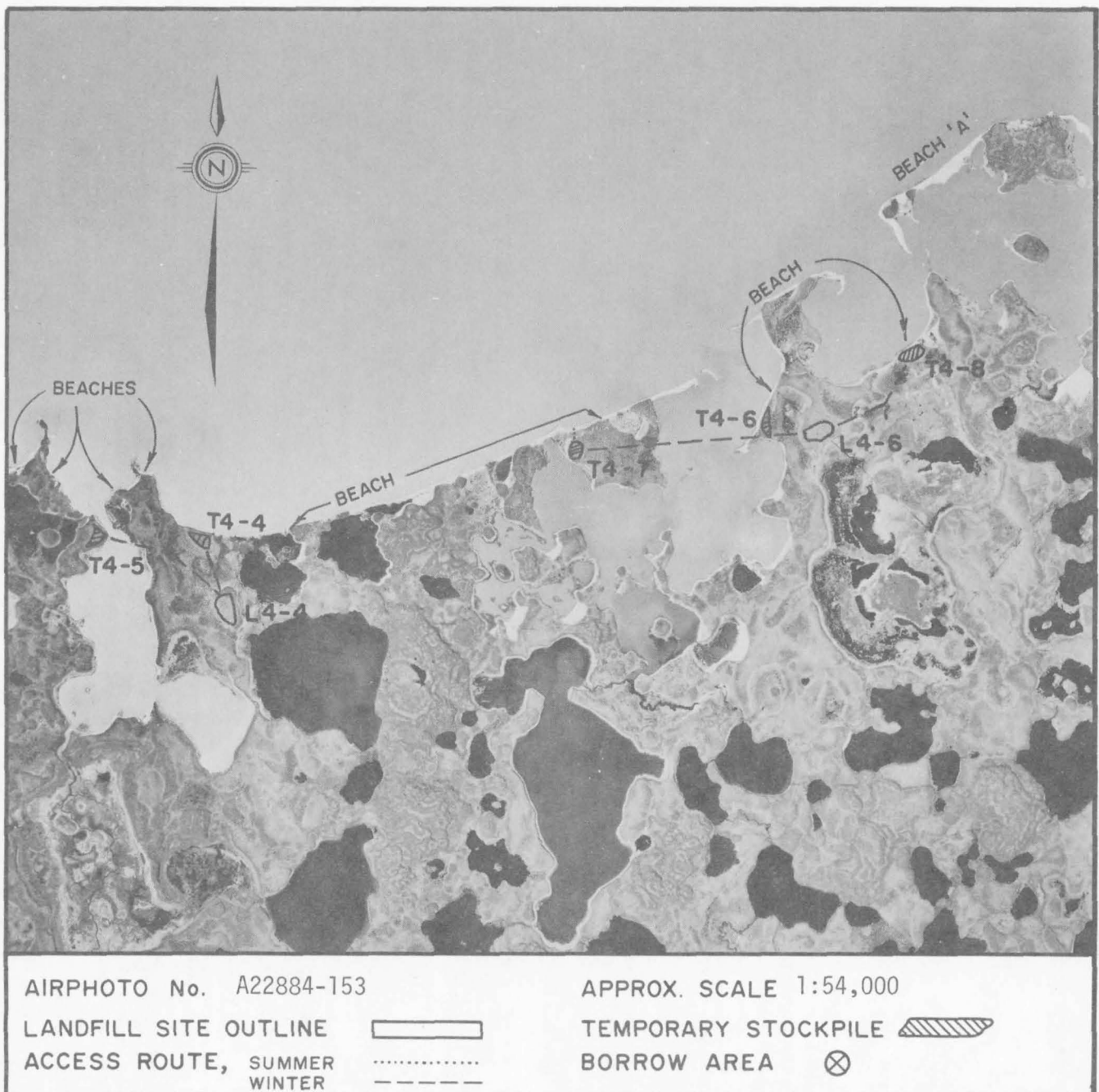
TEMPORARY STOCKPILE: T4-4 and T4-5 have available areas of 10,000 m² each, on same terrain as landfill site.

BEACH: Mixed gravel and sand, 10 m to 50 m wide.

BORROW SOURCE: Use beach material.

ACCESS: 500 m from T4-4 and 1 km from T4-5 (winter) to the landfill site.

DEVELOPMENT: Winter construction of landfill site due to ice content.



LANDFILL SITE L4-6, TEMPORARY STOCKPILES T4-6, T4-7, T4-8

LANDFILL SITE: Available area of 30,000 m² on a well drained lacustrine plain with a medium to high ice content. Some seismic trail damage needs repairing.

TEMPORARY STOCKPILE: T4-6, T4-7, and T4-8 have available areas of 10,000 m², 10,000 m², and 15,000 m² respectively on a lacustrine plain and a medium to high ice content.

BEACH: Gravel and sand, 25 m to 100 m wide.

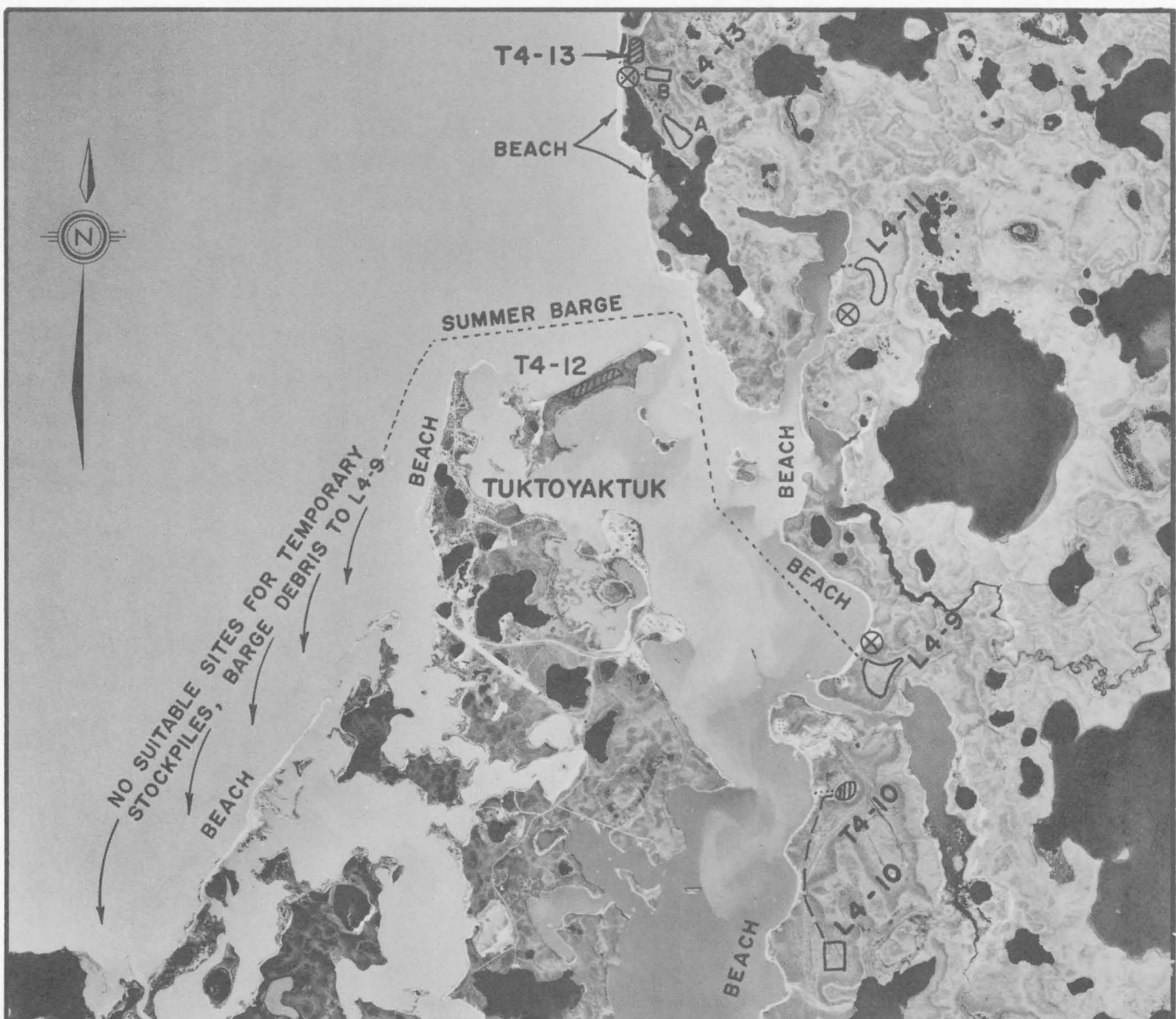
BORROW SOURCE: Use beach material.

ACCESS: 300 m from T4-6, 2 km from T4-7, across the ice, and 1 km from T4-8 on low tundra (winter) to the landfill site.

DEVELOPMENT: Winter construction. Beach "A" has no suitable temporary stockpile. It may be possible to barge debris from there to T4-8 in summer if the water depth permits.

LANDFILL SITE L4-9

- LANDFILL SITE: Available area of 40,000 m² on a sand and gravel terrace with a low ice content, and a 1.6 m silt veneer.
- TEMPORARY STOCKPILE: No suitable sites, none required for summer construction.
- BEACH: Nearest beach is gravel and sand, 50 m wide. Other beaches west of Tuktoyaktuk are gravel and sand, 25 m to 100 m wide.
- BORROW SOURCE: Use beach material. Also borrow sand and gravel at location shown adjacent to L4-9.
- ACCESS: 200 m from nearest beach, 7.5 km by barge from beaches west of Tuktoyaktuk.
- DEVELOPMENT: Summer construction. Low ice content sands and gravels are expected below the 1.6 m silt cover.



AIRPHOTO No. A22884-174

APPROX. SCALE 1:54,000

LANDFILL SITE OUTLINE

ACCESS ROUTE, SUMMER
WINTER

TEMPORARY STOCKPILE



BORROW AREA



LANDFILL SITE L4-10, TEMPORARY STOCKPILE T4-10

LANDFILL SITE: Available area of 30,000 m² on a raised, ice-cored lacustrine plain.

TEMPORARY STOCKPILE: Available area of 15,000 m² on a lower lacustrine plain modified by thermokarst; high ice content.

BEACH: Sand and gravel, 10 m wide.

BORROW SOURCE: Use beach material.

ACCESS: 1.2 km on well drained terrain on existing trails.

DEVELOPMENT: Winter construction of landfill site.

LANDFILL SITE L4-11

LANDFILL SITE: Available area of 35,000 m² on a sand and gravel terrace with up to 1.6 m silt veneer. Low ice content expected in top 6 m.

TEMPORARY STOCKPILE: None required for summer construction.

BEACH: Sand and gravel, 10 m wide.

BORROW SOURCE: Sand and gravel terrace as shown.

ACCESS: Adjacent to beach.

DEVELOPMENT: Check ice content before attempting summer construction.

TEMPORARY STOCKPILE T4-12

TEMPORARY STOCKPILE: Available area of 30,000 m² on glaciofluvial sand and gravel.

BEACH: Sand and gravel.

BORROW SOURCE: Use beach material.

ACCESS: Adjacent to the beach.

TEMPORARY STOCKPILE T4-12 - Continued

DEVELOPMENT: Oiled debris stored at T4-12 could be hauled across the ice for disposal at L4-9, L4-11, or L4-13.

LANDFILL SITE L4-13, TEMPORARY STOCKPILE T4-13

LANDFILL SITE: A and B have available areas of 20,000 m² and 12,000 m² respectively on a low sand terrace with a low ice content.

TEMPORARY STOCKPILE: Available area of 18,000 m² on a low sand terrace with a low ice content.

BEACH: Gravel and sand, 25 - 60 m wide.

BORROW SOURCE: Use beach material and sand from location shown on sand terrace.

ACCESS: 400 m to A and 150 m to B (summer).

DEVELOPMENT: Check ice content to determine suitability for summer construction. B is limited to a design life of 30 years due to coastline recession.

LANDFILL SITE L4-14, TEMPORARY STOCKPILE T4-14

LANDFILL SITE: Available area of 15,000 m² on a lacustrine plain, moderate to high ice content.

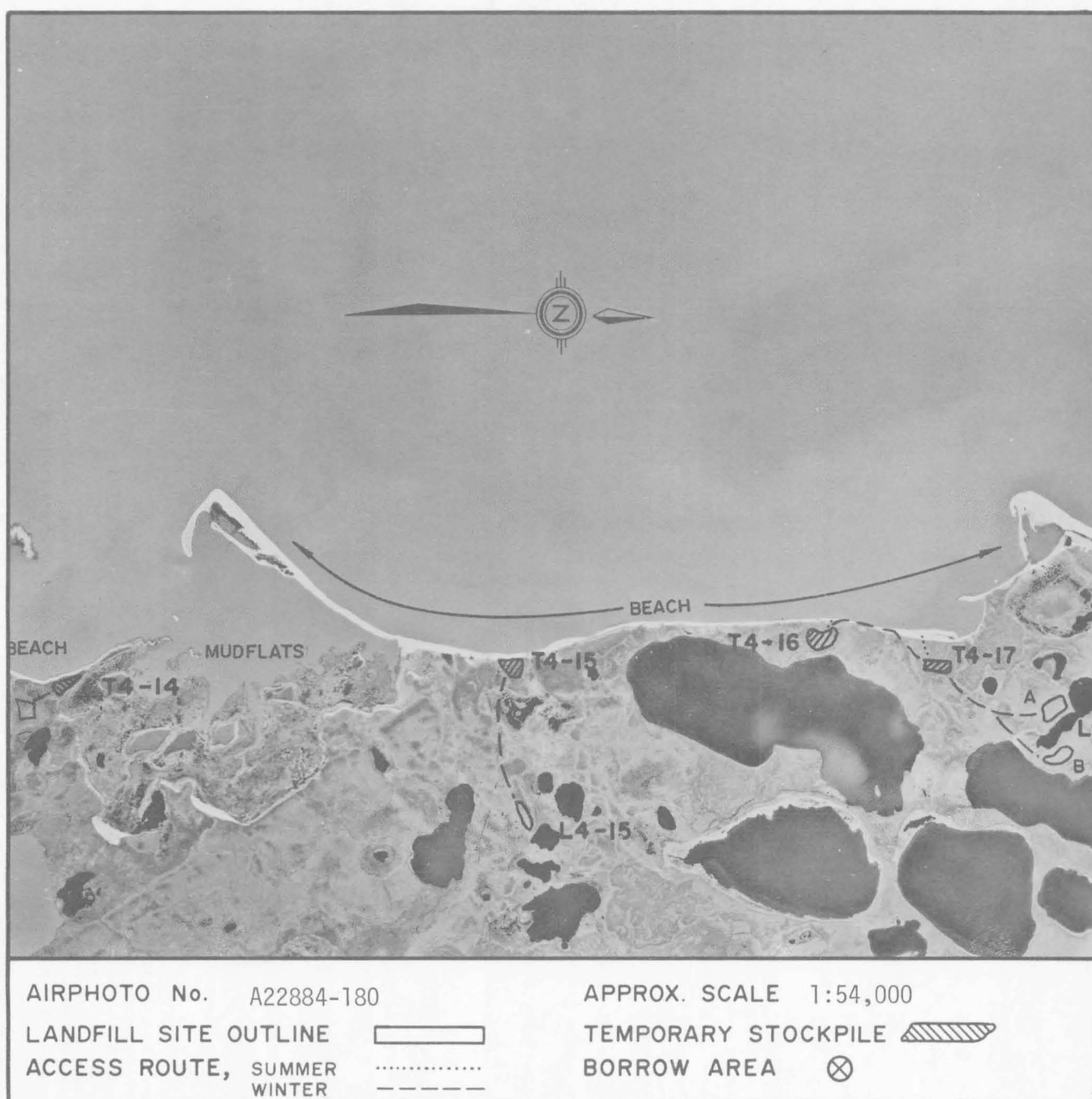
TEMPORARY STOCKPILE: Available area of 10,000 m² on a lacustrine plain.

BEACH: Sand and gravel, 25 m wide.

BORROW SOURCE: Use beach material.

ACCESS: 300 m (winter) from T4-14 to L4-14.

DEVELOPMENT: Winter construction of landfill site.



LANDFILL SITE L4-15, TEMPORARY STOCKPILE T4-15

LANDFILL SITE: Available area of 10,000 m² on a lacustrine plain with a moderate to high ice content.

TEMPORARY STOCKPILE: Available area of 22,000 m² on rolling moraine with a medium to high ice content.

BEACH: Sand and gravel, 50 - 100 m wide, in front of cliffs.

BORROW SOURCE: Use beach material.

ACCESS: 1 km across poorly drained lacustrine plain (winter) to landfill site.

DEVELOPMENT: Winter construction. Removal of the highest beach ridge in front of the mudflats may result in contamination or alteration of the mudflat environment.

LANDFILL SITE L4-17, TEMPORARY STOCKPILES T4-16, T4-17

LANDFILL SITE: A and B have available areas of 22,000 m² and 15,000 m² respectively. A is on a lacustrine plain with medium to high ice content and B is on glaciofluvial sand with a low ice content but containing several ice wedges.

TEMPORARY STOCKPILE: T4-16 has an available area of 20,000 m². T4-17 has an available area of 15,000 m². Both are located on a lacustrine plain with medium to high ice content.

BEACH: Sand and gravel, 50 m wide.

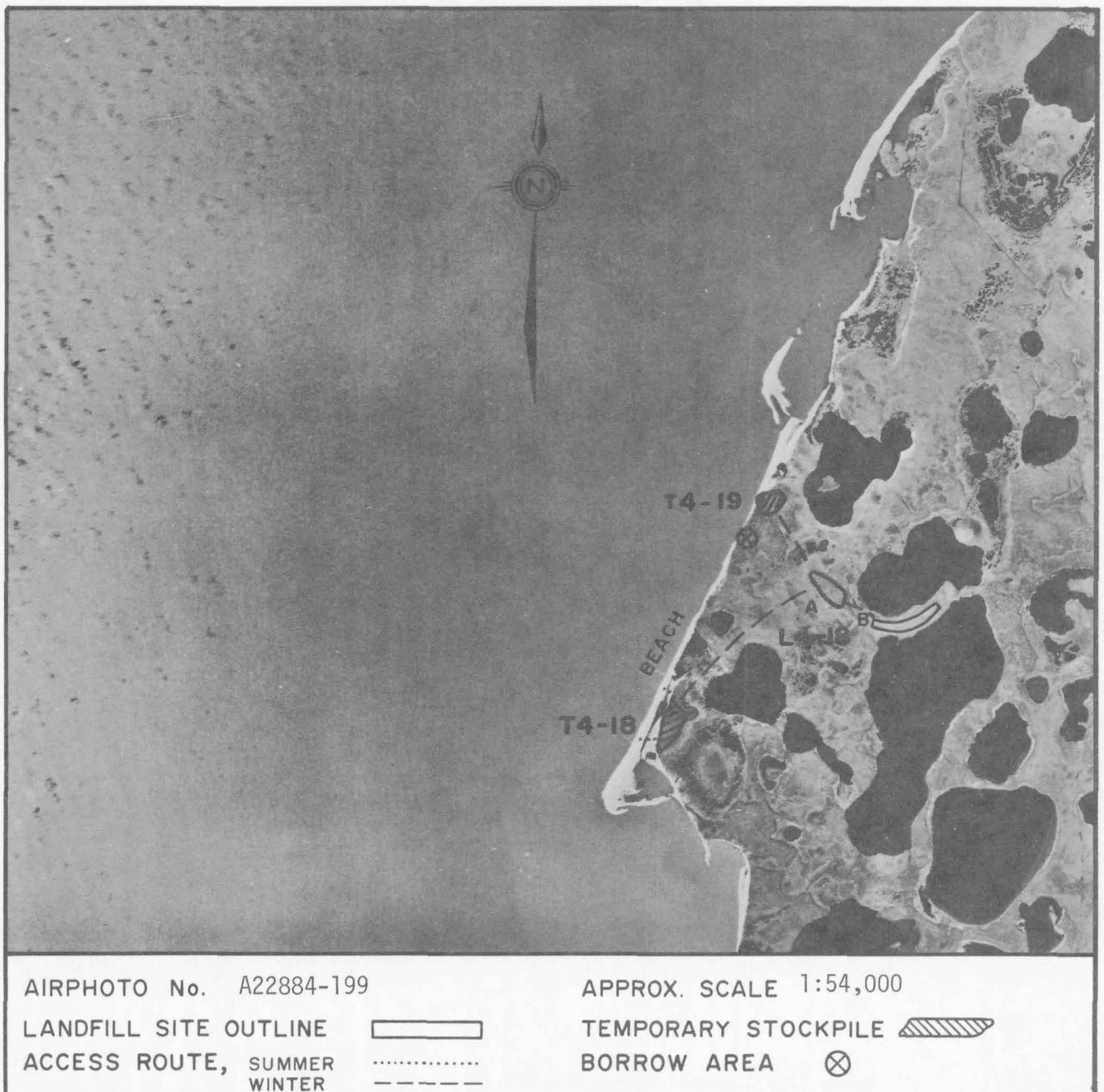
BORROW SOURCE: Use beach sand.

ACCESS: 1 km from T4-17 and 2 km from T4-16 (winter) to the landfill site.

DEVELOPMENT: A would be winter construction. Check ice content of B before attempting summer construction.

LANDFILL SITE L4-18, TEMPORARY STOCKPILES T4-18, T4-19

- LANDFILL SITE: A and B have available areas of $30,000 \text{ m}^2$ and $35,000 \text{ m}^2$ respectively on glaciofluvial sand terraces with a moderate to high ice content and several ice wedges.
- TEMPORARY STOCKPILE: T4-18 and T4-19 have available areas of $30,000 \text{ m}^2$ and $40,000 \text{ m}^2$ respectively. T4-18 is on a glaciofluvial sand terrace with a medium ice content and T4-19 is on a lacustrine plain with a medium ice content.
- BEACH: Sand and some gravel, 50 - 100 m wide.
- BORROW SOURCE: Use beach material or edge of sand terrace as shown.
- ACCESS: 700 m from T4-19 to A, and 1.4 km from T4-18 across some poorly drained terrain to A (winter).
- DEVELOPMENT: Winter construction due to high ice content and ice wedges.



LANDFILL SITE L4-20, TEMPORARY STOCKPILE T4-20

LANDFILL SITE: Available area of 50,000 m² on glaciofluvial sand terrace with a low to moderate ice content.

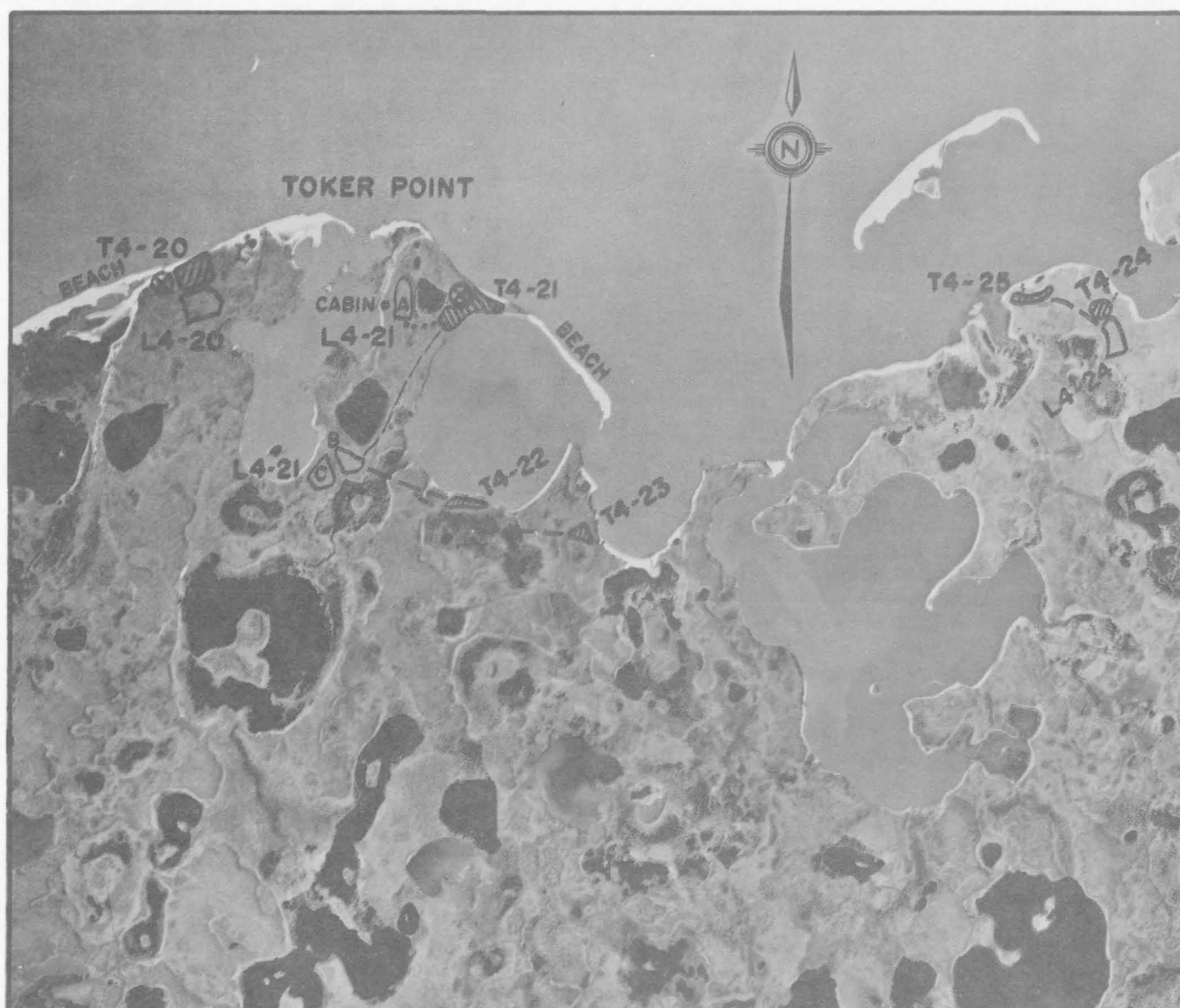
TEMPORARY STOCKPILE: Available area of 50,000 m² on same terrain as landfill site.

BEACH: Sand and some gravel, 100 m wide.

BORROW SOURCE: Use beach material or sand terrace at location shown.

ACCESS: 200 m (summer) from beach to landfill site.

DEVELOPMENT: Check ice contents to determine whether winter or summer construction. Some irregularities in the surface of the landfill site may require dozing before drilling and blasting to provide an even bottom profile in the pit.



AIRPHOTO No. A22884-197

APPROX. SCALE 1:54,000

LANDFILL SITE OUTLINE



TEMPORARY STOCKPILE

ACCESS ROUTE, SUMMER
WINTER

BORROW AREA



LANDFILL SITE L4-21, TEMPORARY STOCKPILE T4-21

LANDFILL SITE: A, B, and C have available areas of 30,000 m², 20,000 m², and 30,000 m² respectively. A is on a glaciofluvial sand terrace with a low ice content and some ice wedges. B and C are on a silty lacustrine plain with a moderate ice content.

TEMPORARY STOCKPILE: If needed, available area of 50,000 m² on glaciofluvial sand with a low ice content.

BEACH: Sand and some gravel, 0 - 80 m wide.

BORROW SOURCE: Use beach material or sand from terrace as shown.

ACCESS: 700 m to A from beach (summer) and 1.2 km to B (winter).

DEVELOPMENT: Ice content of A should be checked to determine if suitable for summer construction. B and C would be winter construction due to their ice contents. A is adjacent to a cabin.

TEMPORARY STOCKPILE T4-22

TEMPORARY STOCKPILE: Available area of 15,000 m² on a lacustrine plain with moderate ice content.

BEACH: Sand, 25 m wide.

BORROW SOURCE: Use beach material.

ACCESS: 700 m to L4-21 (B and C) across wet terrain and ponds (winter).

TEMPORARY STOCKPILE T4-23

TEMPORARY STOCKPILE: Available area of 12,000 m² on a lacustrine plain with moderate ice content.

BEACH: Sand, 0 - 50 m wide.

BORROW SOURCE: Use beach material.

TEMPORARY STOCKPILE T4-23 - Continued

ACCESS: 1.7 km to L4-21 (B and C) across wet terrain and ponds (winter).

LANDFILL SITE L4-24, TEMPORARY STOCKPILES T4-24, T4-25

LANDFILL SITE: Available area of 28,000 m² on a lacustrine plain with moderate ice content.

TEMPORARY STOCKPILE: T4-24 and T4-25 have available areas of 12,000 m² each, on same terrain as landfill site.

BEACH: Sand, 25 - 50 m wide.

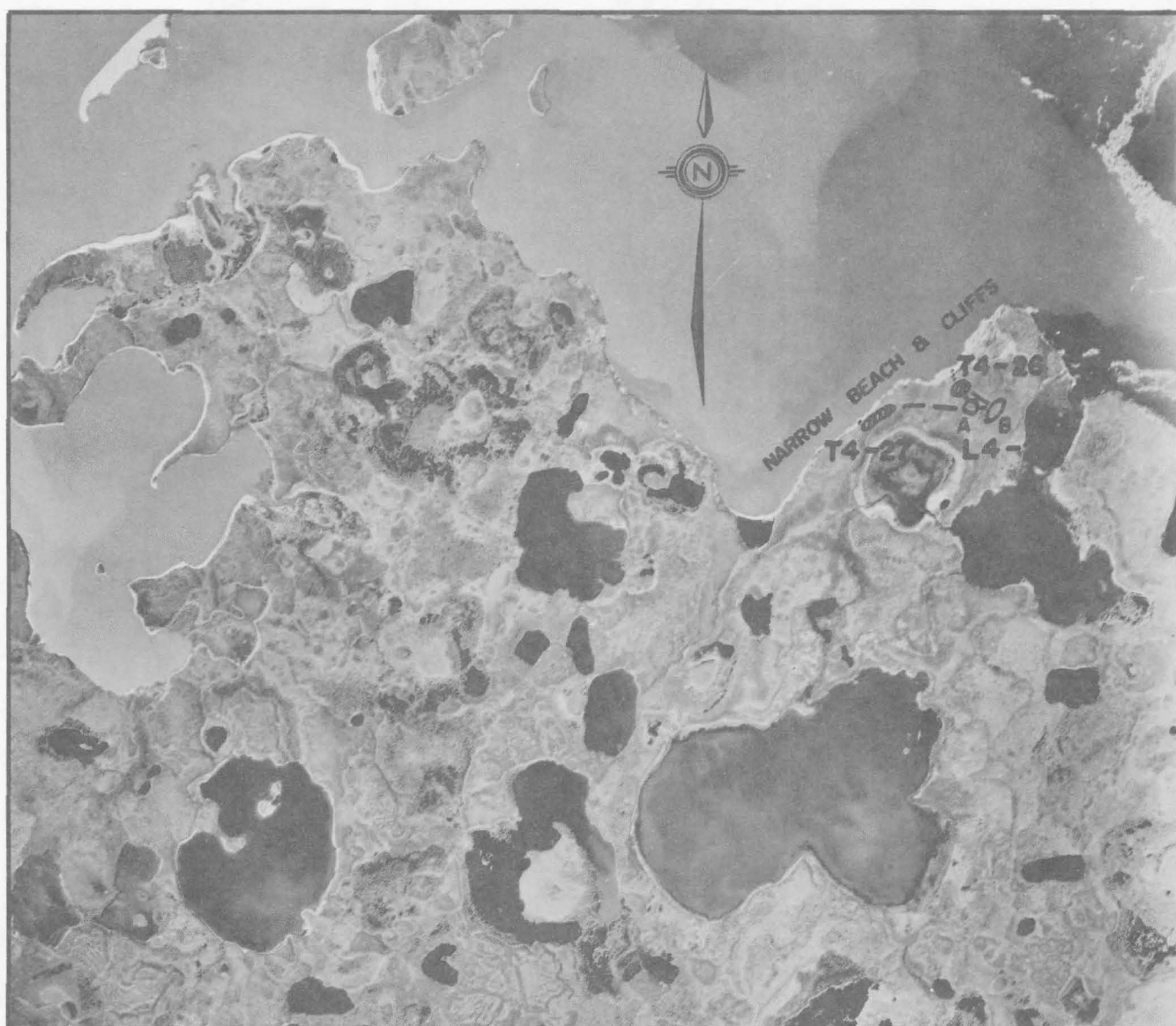
BORROW SOURCE: Use beach sand.

ACCESS: Landfill site L4-24 is adjacent to T4-24 and 500 m from T4-25 (winter).

DEVELOPMENT: Winter construction. During the beach cleanup, the gap in the beach west of T4-25 may have to be filled in with sand.

LANDFILL SITE L4-26, TEMPORARY STOCKPILES T4-26, T4-27

- LANDFILL SITE: Available area of 7,000 m² at A, 10,000 m² at B. Both sites are on a silty lacustrine plain with moderate ice content.
- TEMPORARY STOCKPILE: T4-26 and T4-27 have available areas of 9,000 m² and 12,000 m² respectively on same terrain as landfill site.
- BEACH: Sand beach 10 m wide in front of cliffs.
- BORROW SOURCE: Use beach sand or sand and fines from exposed cliffs.
- ACCESS: 100 m (winter) from T4-26 to A, 500 m (winter) from T4-27 to A, 700 m to B.
- DEVELOPMENT: Winter construction of landfill site. In the event of an oilspill there may not be sufficient clean sand on the beach to meet borrow requirements.



AIRPHOTO No. A22884-196

APPROX. SCALE 1:54,000

LANDFILL SITE OUTLINE



TEMPORARY STOCKPILE

ACCESS ROUTE, SUMMER
WINTER

BORROW AREA



LANDFILL SITE L4-28, TEMPORARY STOCKPILE T4-28

LANDFILL SITE: Available area of 25,000 m² on glaciofluvial sand terrace with a low ice content.

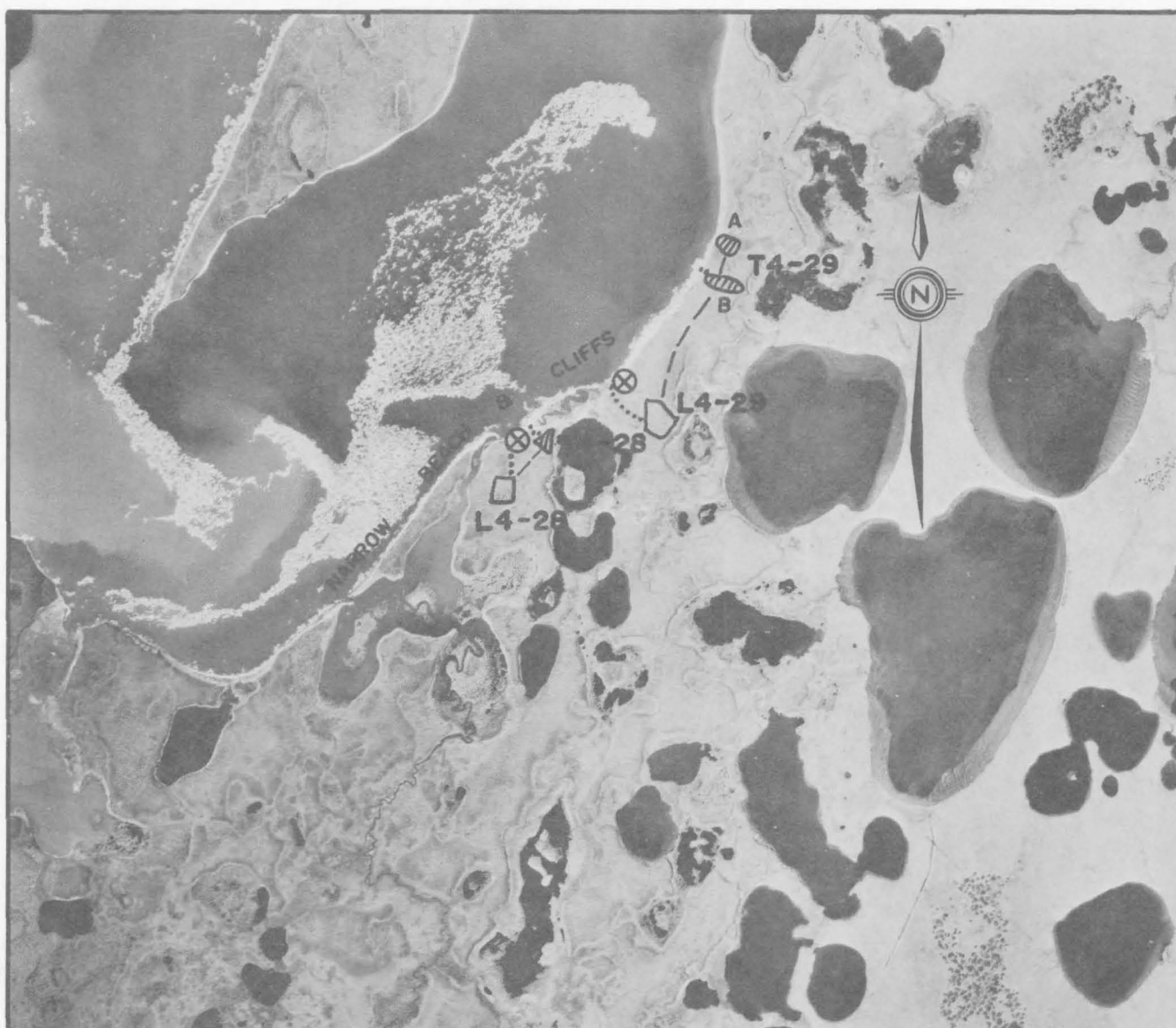
TEMPORARY STOCKPILE: Available area of 12,000 m² on same material as landfill site.

BEACH: Sand, 10 m wide, backed by cliffs.

BORROW SOURCE: Use beach material or sand terraces at location shown.

ACCESS: 300 m from beach (summer) to the landfill site.

DEVELOPMENT: Check ice content before attempting summer construction.



AIRPHOTO No. A22884-194

APPROX. SCALE 1:54,000

LANDFILL SITE OUTLINE



TEMPORARY STOCKPILE

ACCESS ROUTE, SUMMER
WINTER

BORROW AREA



LANDFILL SITE L4-29, TEMPORARY STOCKPILE T4-29

LANDFILL SITE: Available area of 50,000 m² on glaciofluvial sand terrace with a low ice content and some ice wedges.

TEMPORARY STOCKPILE: A and B have available areas of 12,000 m² and 20,000 m² respectively. A is on a lacustrine plain containing silt and clay with a moderate ice content. B is on glaciofluvial sand terrace.

BEACH: Sand, 10 m wide.

BORROW SOURCE: Use sand terrace at location shown, or beach material.

ACCESS: 400 m from beach (summer) and 1 km from T4-29 (winter) to the landfill site.

DEVELOPMENT: Check ice content before attempting summer construction.

LANDFILL SITE L4-30, TEMPORARY STOCKPILES T4-30, T4-31

LANDFILL SITE: Available area of 65,000 m² on an ice cored glaciofluvial sand terrace which contains ice wedges.

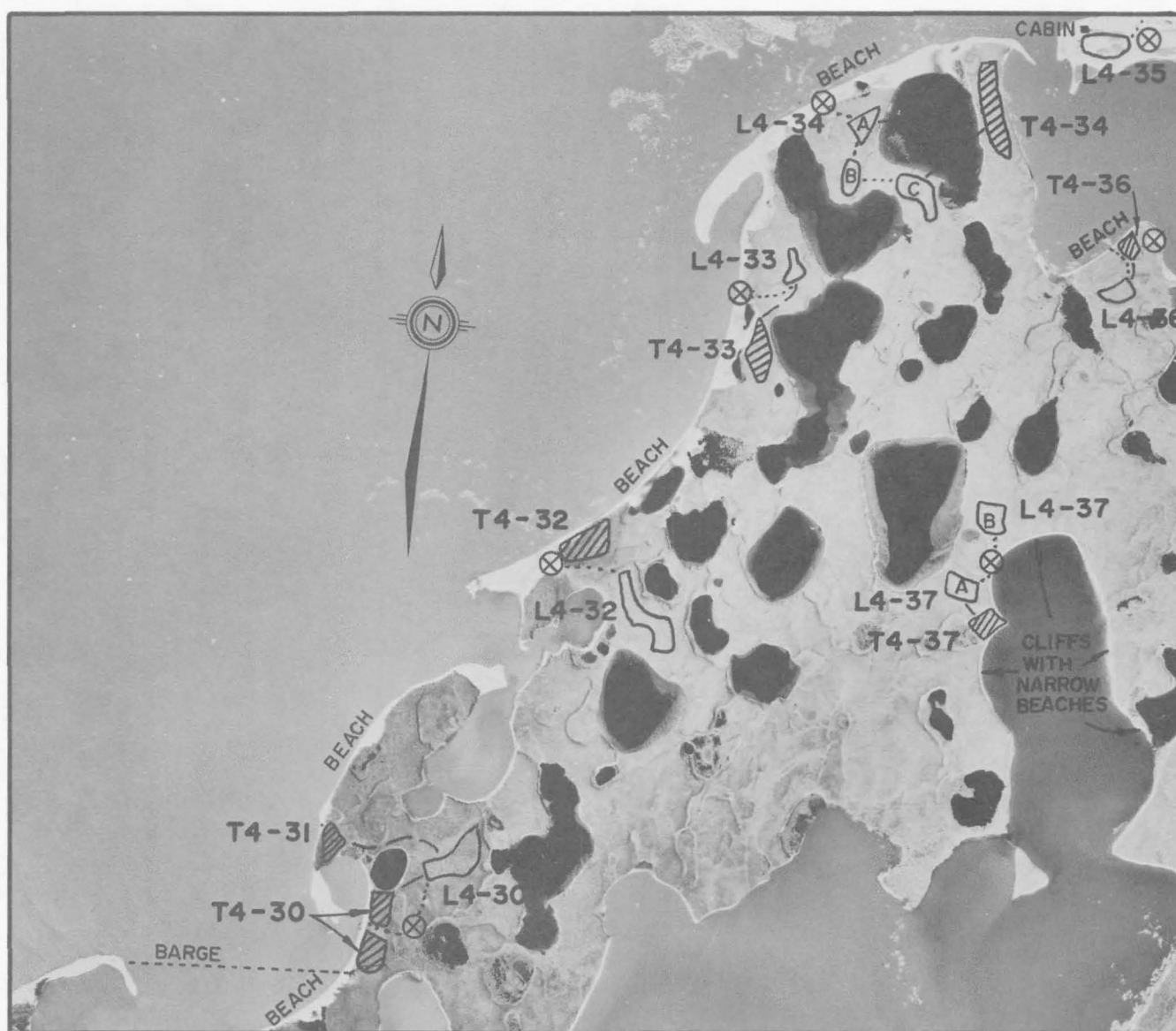
TEMPORARY STOCKPILE: T4-30 has two sites with a total available area of 85,000 m². T4-31 has an available area of 30,000 m².

BEACH: Sand, 50 m wide.

BORROW SOURCE: Use beach material or sand terrace at location shown.

ACCESS: 800 m from beach (summer or winter).

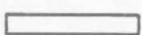
DEVELOPMENT: Check ice content to determine suitability for summer construction. Landfill site and temporary stockpile may have enough storage to barge oiled debris from the offshore spit to the west.



AIRPHOTO No. A22884-205

APPROX. SCALE 1:54,000

LANDFILL SITE OUTLINE



TEMPORARY STOCKPILE



ACCESS ROUTE, SUMMER



BORROW AREA



WINTER



LANDFILL SITE L4-32, TEMPORARY STOCKPILE T4-32

LANDFILL SITE: Available area of 60,000 m² on glaciofluvial sand with a low ice content, but there are several ice wedges.

TEMPORARY STOCKPILE: Available area of 70,000 m² on same terrain as landfill site.

BEACH: Sand, 25 m - 250 m wide.

BORROW SOURCE: Sand terrace at location shown, or beach material.

ACCESS: 500 m across low, wet terrain (summer or winter).

DEVELOPMENT: Check ice content before attempting summer construction of landfill site.

LANDFILL SITE L4-33, TEMPORARY STOCKPILE T4-33

LANDFILL SITE: Available area of 15,000 m² on glaciofluvial sand terrace with a low ice content; several ice wedges.

TEMPORARY STOCKPILE: Available area of 50,000 m² on glaciofluvial sand terrace with a low ice content.

BEACH: Sand, 25 m - 50 m wide.

BORROW SOURCE: Use beach material and sand terrace at location shown.

ACCESS: 400 m (summer or winter).

DEVELOPMENT: Check ice content before attempting summer construction of landfill site.

LANDFILL SITE L4-34, TEMPORARY STOCKPILE T4-34

LANDFILL SITE: A, B, and C have available areas of 25,000 m², 25,000 m², and 45,000 m² respectively on a glaciofluvial sand terrace with a low ice content.

TEMPORARY STOCKPILE: Available area of 75,000 m² on same material as landfill site.

LANDFILL SITE L4-34, TEMPORARY STOCKPILE T4-34 - Continued

BEACH: Sand, 50 - 150 m wide.

BORROW SOURCE: Use beach material or sand terrace at location shown.

ACCESS: 200 m to A, 500 m to B, and 900 m from C (summer). 600 m to 1000 m from T4-34 (winter) to the landfill sites.

DEVELOPMENT: Check ice content to determine suitability of summer construction. If feasible, T4-34 will not be needed. Landfill site has up to 3 m of local relief and may require some levelling before drilling and blasting.

LANDFILL SITE L4-35

LANDFILL SITE: Available area of 45,000 m² on a glaciofluvial sand terrace with a thin wind blown sand veneer.

TEMPORARY STOCKPILE: No suitable sites, none required for summer construction.

BEACH: Sand, 0 - 300 m wide.

BORROW SOURCE: Use beach material or sand terrace at location shown.

ACCESS: 200 m (summer).

DEVELOPMENT: Check ice content to determine if suitable for summer construction. The landfill site has a design life of less than 50 years because it is situated 150 m behind some eroding cliffs. It is also adjacent to a cabin.

LANDFILL SITE L4-36, TEMPORARY STOCKPILE T4-36

LANDFILL SITE: Available area of 20,000 m² on a wind blown sand veneer over glaciofluvial sand with a low ice content.

TEMPORARY STOCKPILE: Available area of 20,000 m² on same terrain as landfill site.

BEACH: Sand, 10 m wide.

LANDFILL SITE L4-36, TEMPORARY STOCKPILE T4-36 - Continued

BORROW SOURCE: Use beach material or sand terrace at location shown.

ACCESS: 250 m (summer or winter).

DEVELOPMENT: Check ice content before attempting summer construction of the landfill site.

LANDFILL SITE L4-37, TEMPORARY STOCKPILE T4-37

LANDFILL SITE: A and B have available areas of 35,000 m² and 40,000 m² respectively on a glaciofluvial sand terrace with a low ice content and several ice wedges.

TEMPORARY STOCKPILE: Available area of 30,000 m² on same terrain as landfill site.

BEACH: Sand beach, 10 m wide in front of cliffs.

BORROW SOURCE: Sand terrace at location shown.

ACCESS: 150 m from beach (summer).

DEVELOPMENT: Check ice content before attempting summer construction of landfill site.

LANDFILL SITE L4-38, TEMPORARY STOCKPILES T4-38, T4-39

LANDFILL SITE: A and B have available areas of 38,000 m² and 25,000 m² on a glaciofluvial sand terrace with a low ice content and several ice wedges.

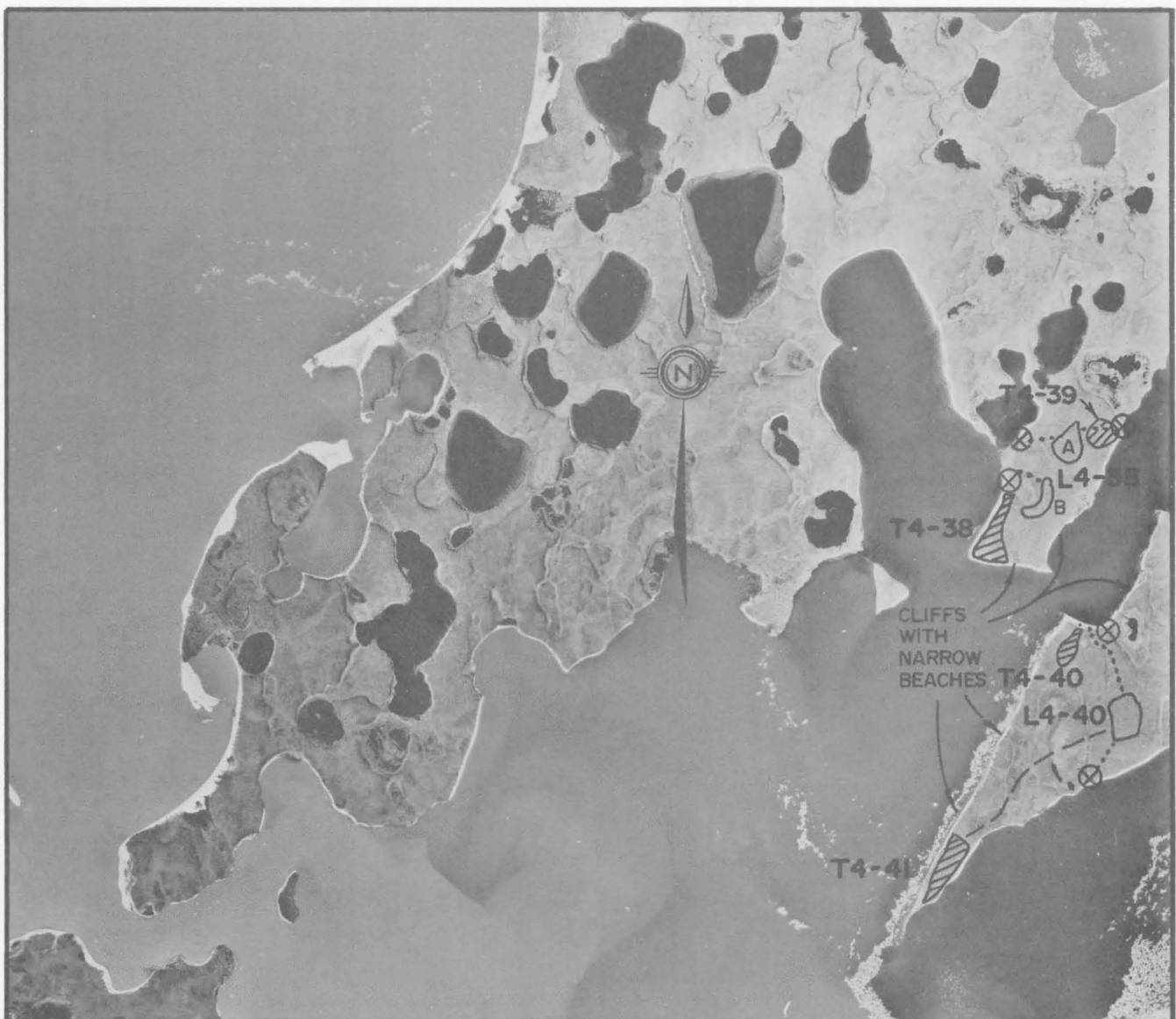
TEMPORARY STOCKPILE: T4-38 and T4-39 have available areas of 50,000 m² and 30,000 m² respectively on same terrain as landfill site.

BEACH: Sand beach, 10 m wide, backed by cliffs.

BORROW SOURCE: Two possible sites near T4-38, as shown on sand terrace. Another possible site near T4-39 as shown.

ACCESS: 300 m from beach to A or B on well drained sandy terrain (summer).

DEVELOPMENT: Check ice content before attempting summer construction of landfill site.



AIRPHOTO No. A22884-205

APPROX. SCALE 1:54,000

LANDFILL SITE OUTLINE



TEMPORARY STOCKPILE

ACCESS ROUTE, SUMMER
WINTER

BORROW AREA



LANDFILL SITE L4-40, TEMPORARY STOCKPILES T4-40, T4-41

LANDFILL SITE: Available area of 50,000 m² on glaciofluvial sand terrace with a low ice content and several ice wedges.

TEMPORARY STOCKPILE: If necessary, T4-40 and T4-41 have available areas of 20,000 m² and 40,000 m² on same terrain as landfill site.

BEACH: Sand beach, 10 m wide, backed by cliffs.

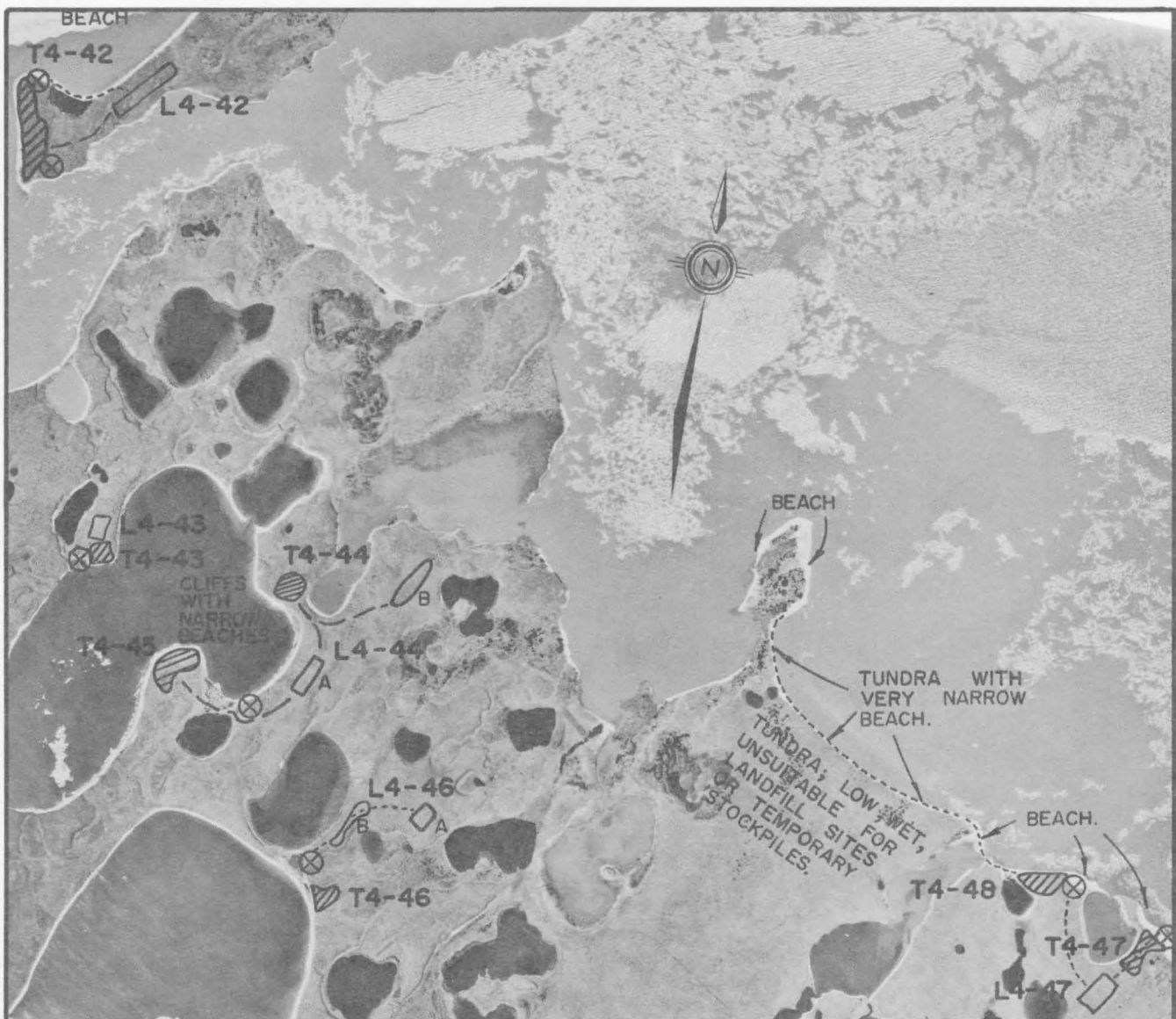
BORROW SOURCE: Sand terrace at locations shown.

ACCESS: 400 m and 600 m to beaches south and north of landfill site (summer). If necessary 1.5 km haul from T4-41 (winter).

DEVELOPMENT: Check ice content before attempting summer construction of landfill site.

LANDFILL SITE L4-42, TEMPORARY STOCKPILE T4-42

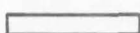
- LANDFILL SITE: Available area of 55,000 m² on a glaciofluvial sand terrace with a low ice content. Up to 3 m of local relief.
- TEMPORARY STOCKPILE: Available area of 85,000 m² on same terrain as landfill site, less local relief.
- BEACH: Sand, 30 m wide; also barrier bar to the north, 250 m wide.
- BORROW SOURCE: Sand terrace at the two locations shown or use beach material.
- ACCESS: 100 m (summer) and 600 m (winter).
- DEVELOPMENT: Check ice content to determine suitability for summer construction. Although the landfill site is closer to the cliffs than the 200 m minimum distance specified in the guidelines, the cliffs are protected by the barrier bar to the north. Therefore, assume a 50 year design life.



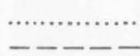
AIRPHOTO No. A22884-207

APPROX. SCALE 1:54,000

LANDFILL SITE OUTLINE



TEMPORARY STOCKPILE

ACCESS ROUTE, SUMMER
WINTER

BORROW AREA



LANDFILL SITE L4-43, TEMPORARY STOCKPILE T4-43

LANDFILL SITE: Available area of 17,000 m² on a glaciofluvial sand terrace with a low ice content and several ice wedges.

TEMPORARY STOCKPILE: Available area of 20,000 m² on same material as landfill site.

BEACH: Sand, beach less than 10 m wide and backed by cliffs.

BORROW SOURCE: Sand terrace at location shown.

ACCESS: 200 m from beach (summer).

DEVELOPMENT: Check ice content to determine suitability for summer construction. Although the landfill site is closer (approx. 100 m) to the cliffs than the 200 m minimum distance specified in the guidelines, the cliffs are in a sheltered bay and erosion rates should be much slower than along the exposed sea coastline. Therefore assume a 50 year design life.

LANDFILL SITE L4-44, TEMPORARY STOCKPILES T4-44, T4-45

LANDFILL SITE: A and B have available areas of 25,000 m² and 40,000 m² on a glaciofluvial sand terrace with low to moderate ice content and several ice wedges. Up to 2 m of ice-rich silt and peat overlies the sand.

TEMPORARY STOCKPILE: T4-44 and T4-45 have available areas of 30,000 m² and 65,000 m² respectively on a glaciofluvial sand terrace.

BEACH: Sand, beach 10 m wide, backed by cliffs.

BORROW SOURCE: Use beach material or sand terrace at location shown.

ACCESS: 400 m to A from T4-44 and 1 km to A from T4-45 (winter).

DEVELOPMENT: Winter construction of landfill site. Site A has a limited design life of approximately 50 years due to proximity of eroding cliffs. Site B does not have this restriction.

LANDFILL SITE L4-46, TEMPORARY STOCKPILE T4-46

LANDFILL SITE: A and B have available areas of 30,000 m² and 20,000 m². A and B are on a glaciofluvial sand terrace with a low ice content. A has ice wedges and a 3% slope.

TEMPORARY STOCKPILE: Available area of 30,000 m² on a glaciofluvial sand terrace with a low ice content.

BEACH: Sand beach, 10 m wide, backed by cliffs.

BORROW SOURCES: Use beach material or sand terrace at location shown.

ACCESS: 1 km from beach on a well drained glaciofluvial sand terrace (summer).

DEVELOPMENT: Check ice content before attempting summer construction. Site A is preferred. Site B has a limited design life of 50 years.

LANDFILL SITE L4-47, TEMPORARY STOCKPILES T4-47, T4-48

LANDFILL SITE: Available area of 40,000 m² on a glaciofluvial sand terrace with low ice content.

TEMPORARY STOCKPILE: T4-47 and T4-48 have available areas of 35,000 m² and 30,000 m² respectively on same terrain as landfill site.

BEACH: Sand, up to 70 m wide.

BORROW SOURCE: Sand terrace at location shown, or use beach material.

ACCESS: 400 m and 800 m from the two beaches (summer).

DEVELOPMENT: Check ice content to determine suitability for summer construction. There is a 25 m gap in the beach that will have to be filled during beach cleanup operations.

LANDFILL SITE L4-49, TEMPORARY STOCKPILE T4-49

LANDFILL SITE: Available area of 35,000 m² on a glaciofluvial sand terrace.

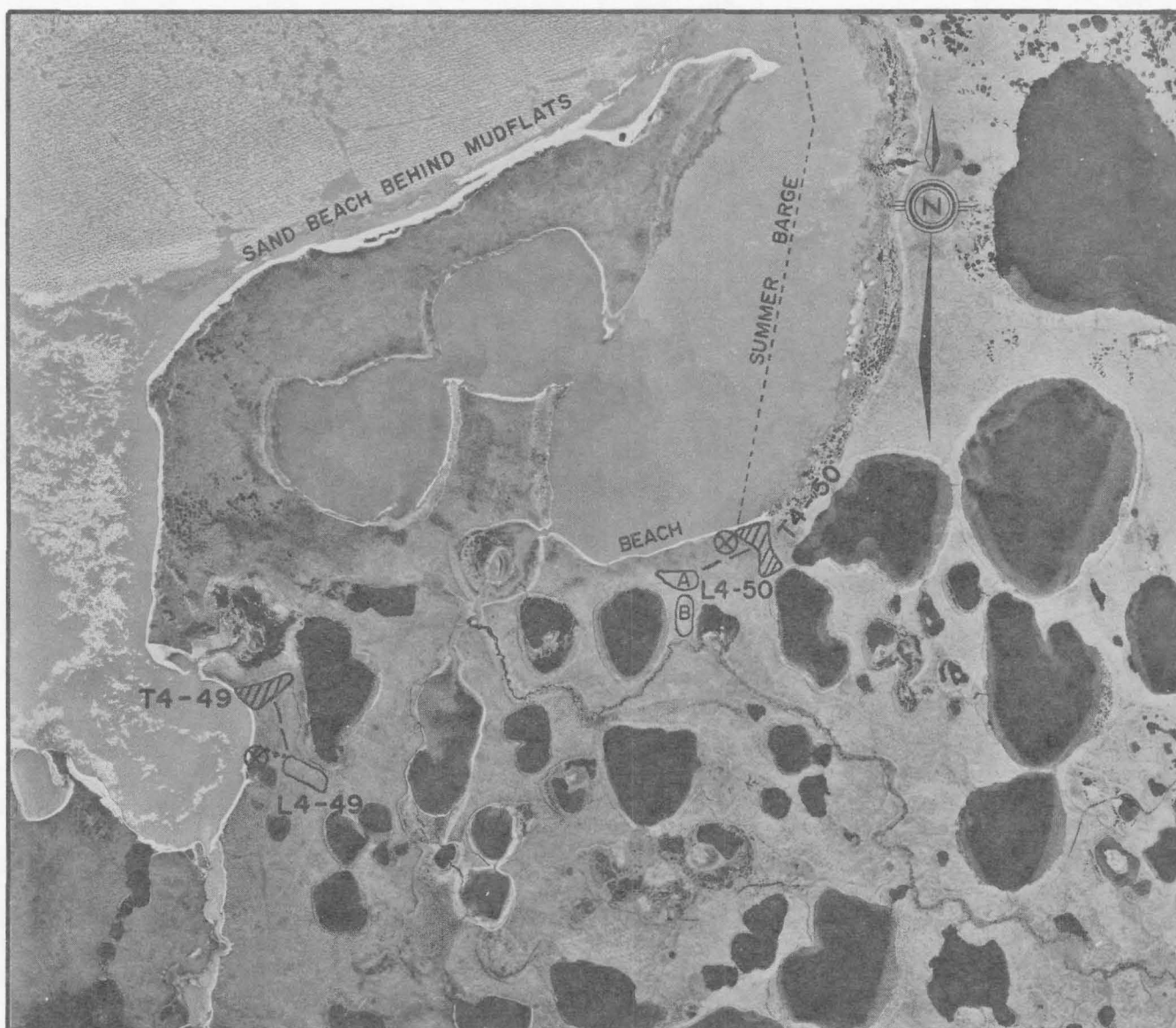
TEMPORARY STOCKPILE: Available area of 45,000 m² on same terrain as landfill site.

BEACH: Sand, 25 m wide.

BORROW SOURCE: Use beach material or sand terrace at location shown.

ACCESS: 300 m (summer) or 400 m (winter).

DEVELOPMENT: Check ice content before attempting summer construction of the landfill site.



AIRPHOTO No. A22884-209

APPROX. SCALE 1:54,000

LANDFILL SITE OUTLINE



TEMPORARY STOCKPILE

ACCESS ROUTE, SUMMER
WINTER

BORROW AREA



LANDFILL SITE L4-50, TEMPORARY STOCKPILE T4-50

LANDFILL SITE: A and B have available areas of 30,000 m² each on a glacio-fluvial sand terrace, with expected moderate to high ice contents.

TEMPORARY STOCKPILE: Available area of 55,000 m² on same terrain as landfill site.

BEACH: Sand, 20 m wide.

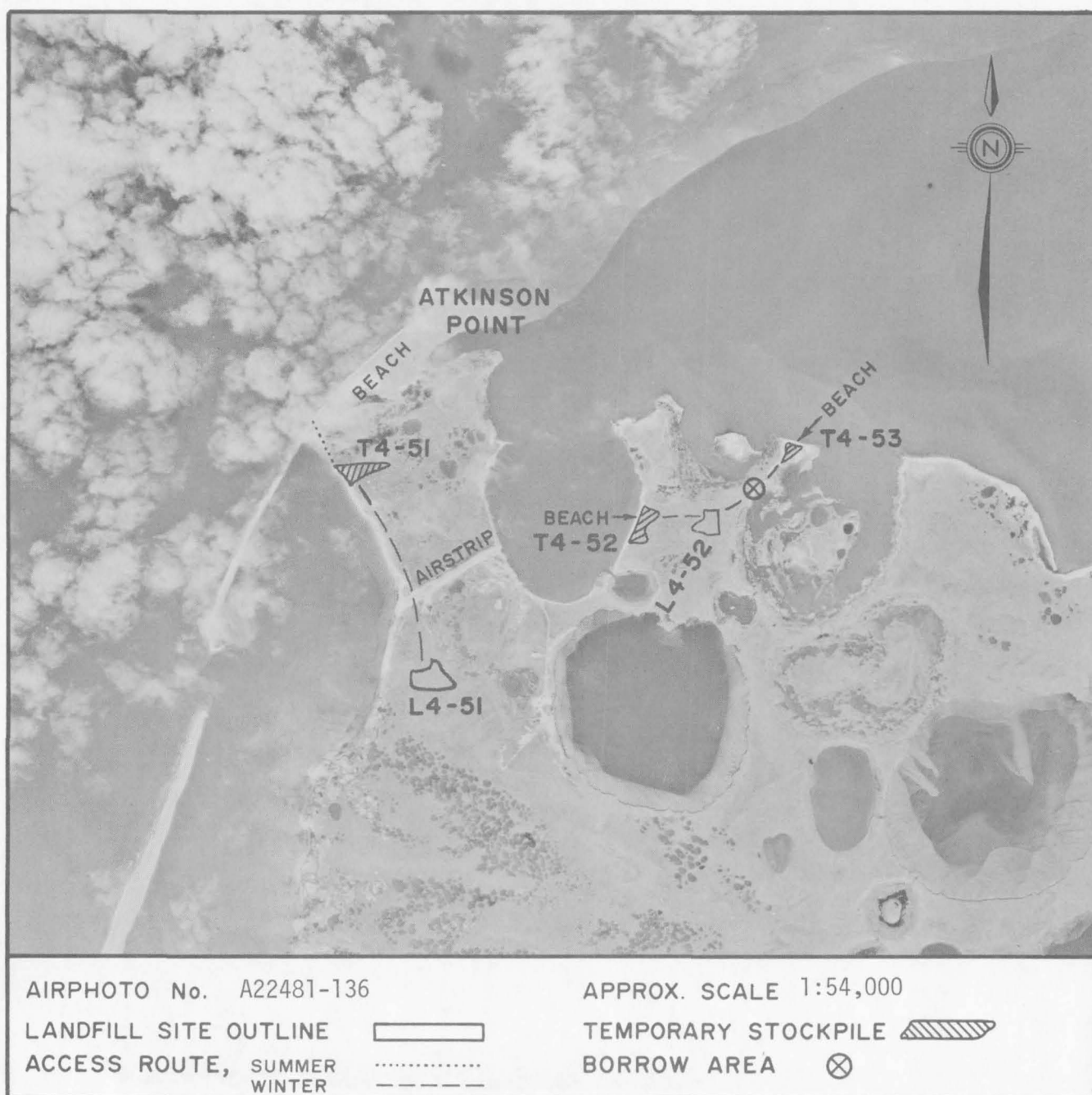
BORROW SOURCE: Use beach material or sand terrace at location shown.

ACCESS: 500 m (winter) from T4-50 to L4-50.

DEVELOPMENT: Winter construction. Summer barge oiled debris from off-shore spit to T4-50 if water depth permits.

LANDFILL SITE L4-51, TEMPORARY STOCKPILE T4-51

- LANDFILL SITE: Available area of 40,000 m² on a glaciofluvial sand terrace with a moderate to high ice content.
- TEMPORARY STOCKPILE: Available area of 35,000 m² on a wet glaciofluvial terrace.
- BEACH: Fine sand, 50 m - 300 m wide.
- BORROW SOURCE: Use beach material.
- ACCESS: 1.6 km on low wet terrain (winter) from T4-51 to L4-51.
- DEVELOPMENT: Winter construction. T4-51 will require protection against storm surges. Because it is a wet area, it will likely require more than the usual quantity of sand borrow for temporary stockpile construction, and cleanup may be difficult.



LANDFILL SITE L4-52, TEMPORARY STOCKPILES T4-52, T4-53

LANDFILL SITE: Available area of 25,000 m² on a glaciofluvial sand terrace with a moderate to high ice content.

TEMPORARY STOCKPILE: T4-52 and T4-53 have available areas of 30,000 m² and 10,000 m² respectively on same terrain as landfill site.

BEACH: Sand, 10 m wide.

BORROW SOURCE: Use beach material or sand terrace at location shown.

ACCESS: 400 m from T4-52 and 700 m from T4-53 (winter) to the landfill site.

DEVELOPMENT: Winter construction of landfill site.

LANDFILL SITE L4-54, TEMPORARY STOCKPILE T4-54

LANDFILL SITE: A and B have available areas of 40,000 m² and 35,000 m² respectively on a wind blown fine sand veneer over glacio-fluvial sand with a moderate ice content.

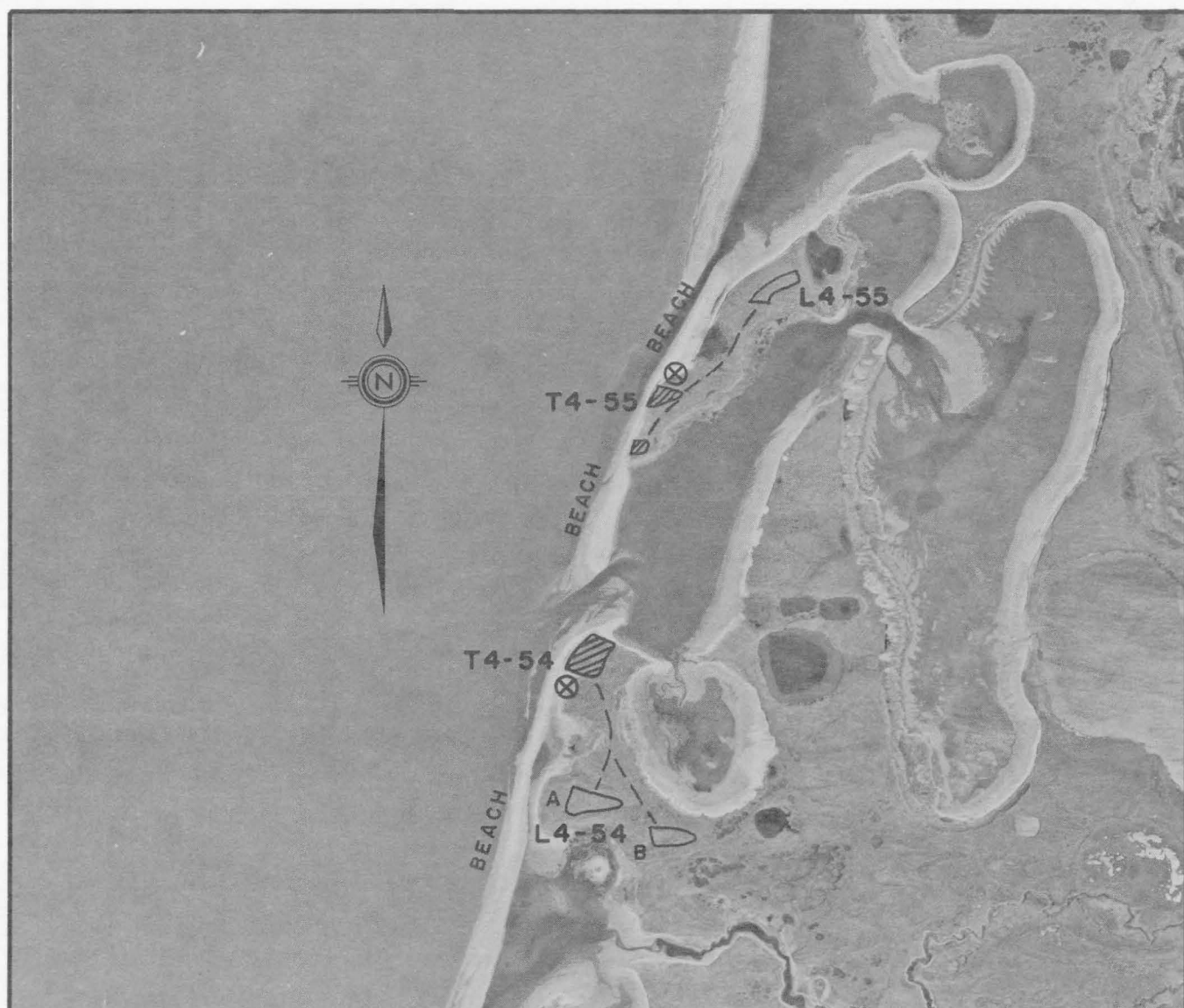
TEMPORARY STOCKPILE: Available area of 65,000 m² on same material as landfill site.

BEACH: Fine sand, 100 m - 200 m wide.

BORROW SOURCE: Use beach material or sand terrace at location shown.

ACCESS: 1 km to A and 1.2 km to B (winter).

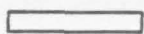
DEVELOPMENT: Winter construction. The landfill site will require wind erosion control measures, such as snow fences, until the revegetation program is successful.



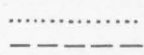
AIRPHOTO No. A22386-93

APPROX. SCALE 1:54,000

LANDFILL SITE OUTLINE



TEMPORARY STOCKPILE

ACCESS ROUTE, SUMMER
WINTER

BORROW AREA



LANDFILL SITE L4-55, TEMPORARY STOCKPILE T4-55

LANDFILL SITE: Available area of 25,000 m² on a wind blown sand veneer over glaciofluvial sand with a moderate to high ice content.

TEMPORARY STOCKPILE: Two sites with available areas of 15,000 m² and 8,000 m² on same terrain as landfill site.

BEACH: Fine sand, 150 m wide.

BORROW SOURCE: Use beach material or sand terrace at location shown.

ACCESS: 1.0 to 1.4 km (winter).

DEVELOPMENT: Winter construction. The landfill site will require wind erosion control measures, such as snow fences, until the revegetation program is successful.

LANDFILL SITE L4-56, TEMPORARY STOCKPILE T4-56

LANDFILL SITE: Available area of 40,000 m² on glaciofluvial sand, with a wind blown sand veneer and a moderate ice content. Irregular surface, local relief up to 3 m.

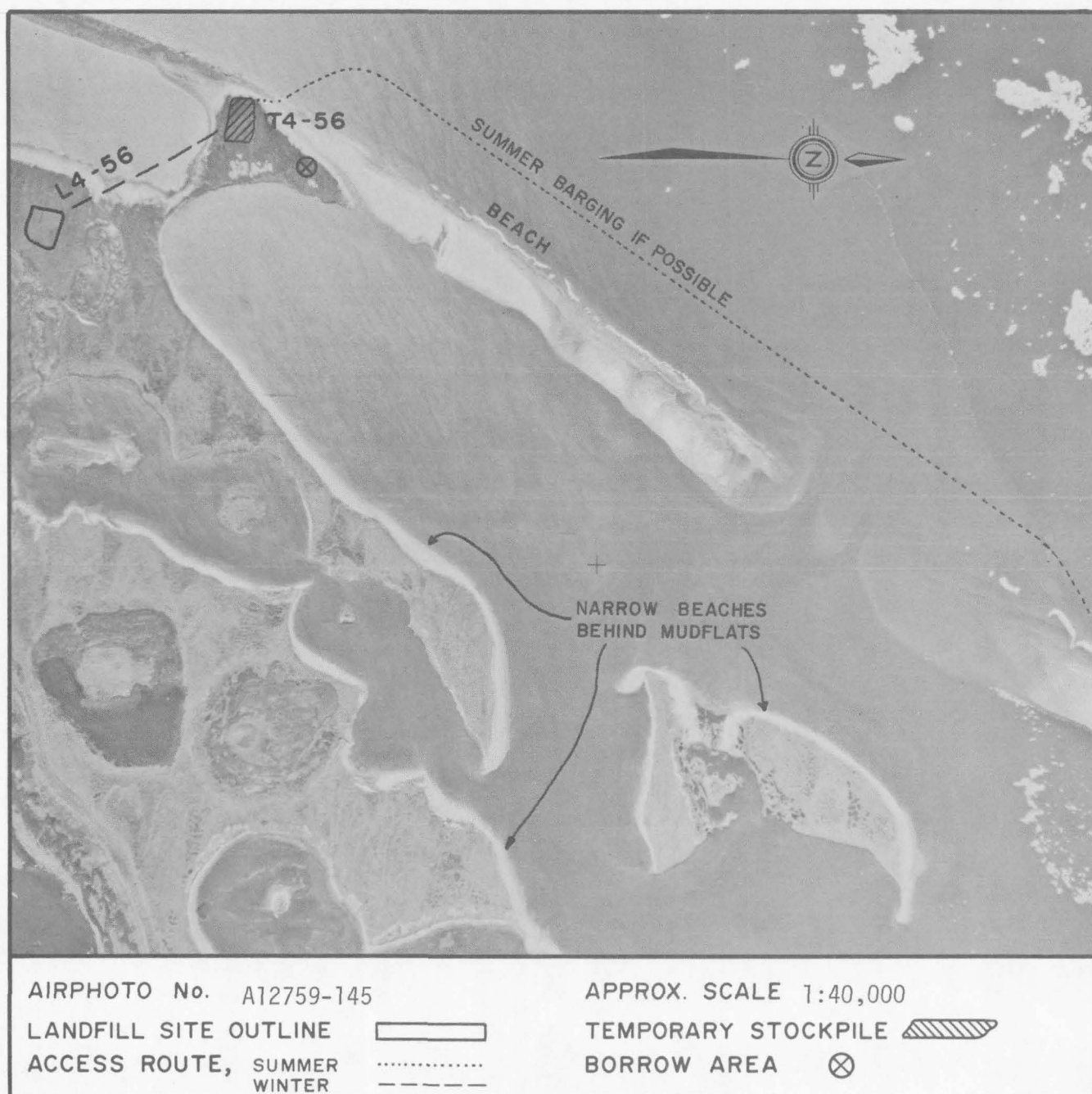
TEMPORARY STOCKPILE: Available area of 40,000 m² on same terrain as landfill site.

BEACH: Fine sand, 200 m - 300 m wide.

BORROW SOURCE: Use beach material or wind blown sand veneer over glaciofluvial sand at location shown.

ACCESS: 1.2 km (winter) from T4-56 to L4-56.

DEVELOPMENT: Winter construction. The landfill site will require wind erosion control measures, such as snow fences, until the revegetation program is successful. The landfill site and
(continued on next page)

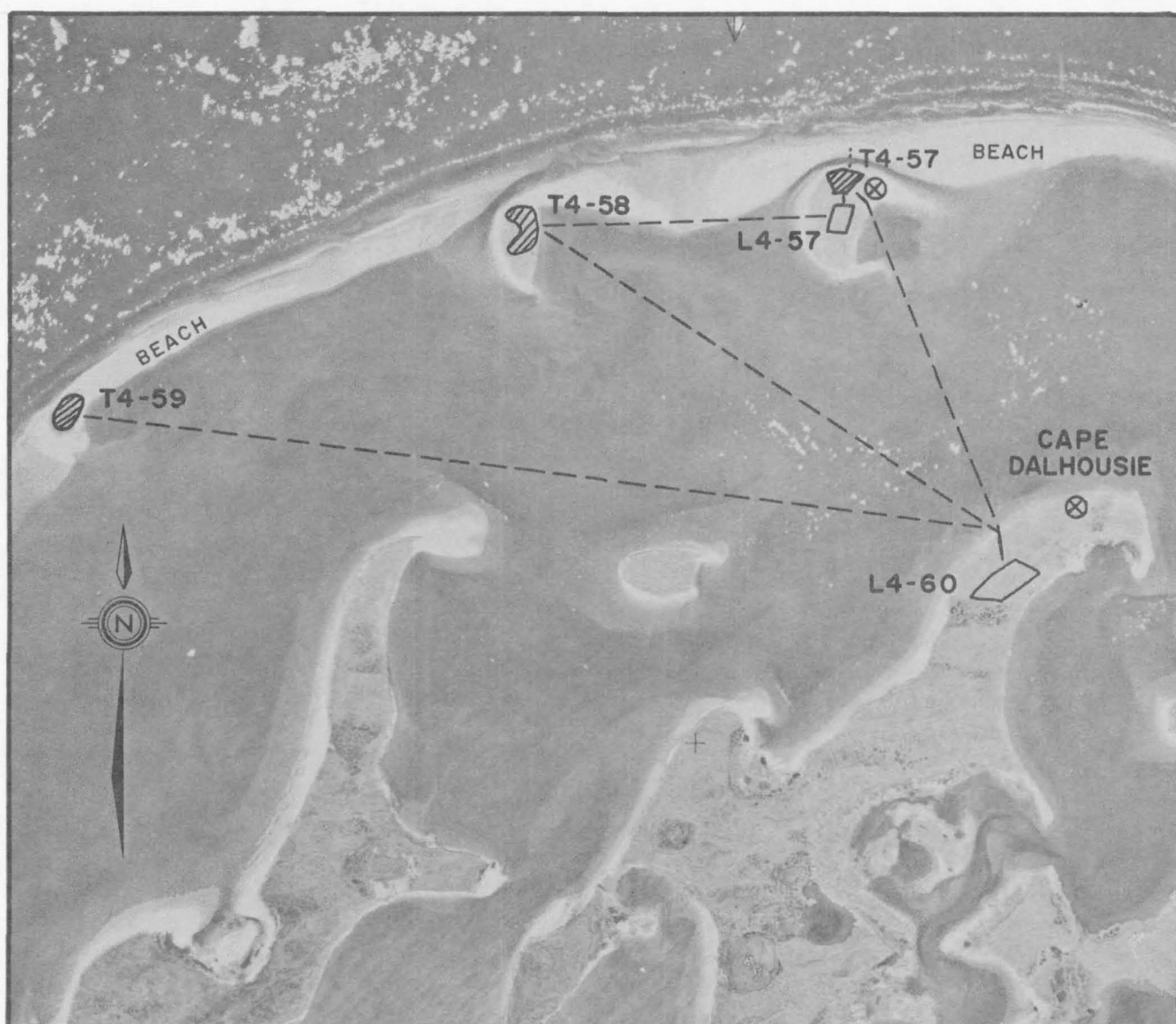


LANDFILL SITE L4-56, TEMPORARY STOCKPILE T4-56 - Continued

DEVELOPMENT: temporary stockpile may also be used to handle oiled debris
(cont'd) from the offshore sandbar to the north if water depth
permits summer barging.

LANDFILL SITE L4-57, TEMPORARY STOCKPILES T4-57, T4-58, T4-59

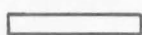
- LANDFILL SITE: Available area of 10,000 m² on a wind blown sand veneer over glaciofluvial sand, with a moderate ice content.
- TEMPORARY STOCKPILE: T4-57, T4-58, and T4-59 have available areas of 12,000 m², 25,000 m², and 20,000 m² respectively on same terrain as landfill site.
- BEACH: Fine sand, 200 m - 400 m wide.
- BORROW SOURCE: Use beach material or sand from location shown.
- ACCESS: Landfill site adjacent to T4-57 and 1.8 km from T4-58 (winter).
- DEVELOPMENT: Winter construction. The landfill site will require wind erosion control measures, such as snow fences, until the revegetation program is successful.



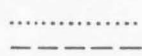
AIRPHOTO No. A12702-411

APPROX. SCALE 1:40,000

LANDFILL SITE OUTLINE



TEMPORARY STOCKPILE

ACCESS ROUTE, SUMMER
WINTER

BORROW AREA



LANDFILL SITE L4-60

LANDFILL SITE: Available area of 40,000 m² on a glaciofluvial sand terrace with wind blown sand veneer, moderate ice content.

TEMPORARY STOCKPILE: See previous comments for T4-57, T4-58, and T4-59.

BEACH: As for T4-57, T4-58, and T4-59.

BORROW SOURCE: Sand borrow at location shown.

ACCESS: 2.5 km from T4-57, 3.4 km from T4-58, 5.8 km from T4-59 across the ice (winter).

DEVELOPMENT: Winter construction. The landfill site will require wind erosion control measures such as snow fences until the revegetation program is successful.

APPENDIX E
AERIAL PHOTOGRAPHS AND DESCRIPTION OF SITES
MAP 5, ESKIMO LAKE

LANDFILL SITE L5-1, TEMPORARY STOCKPILE T5-1

LANDFILL SITE: Available area of 30,000 m² on thermokarst lake basin, variable ice content.

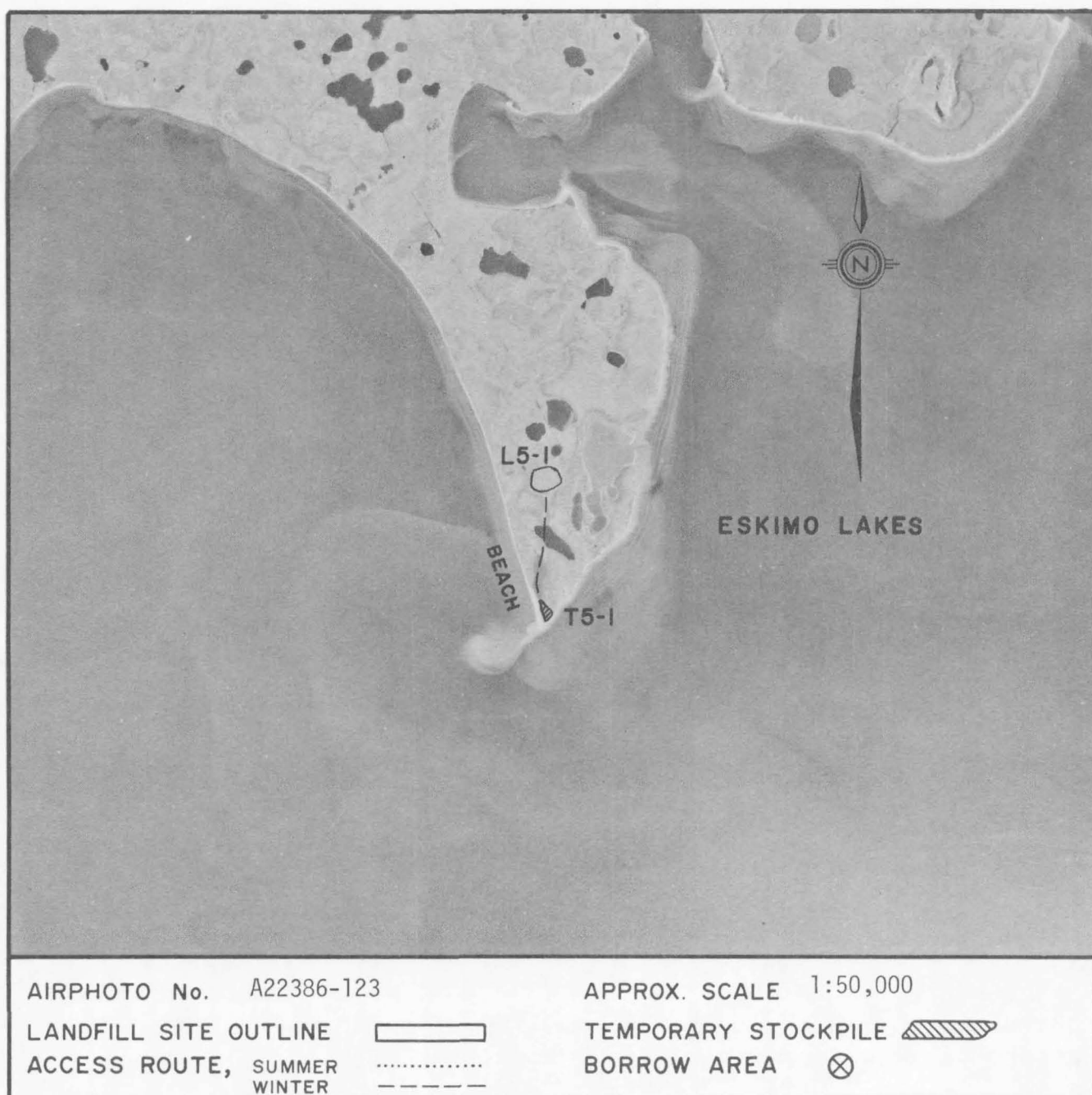
TEMPORARY STOCKPILE: Available area of 5,000 m² on recent lake deposit.

BEACH: Sand, 40 to 50 m wide.

BORROW SOURCE: Use beach sand.

ACCESS: 900 m (winter) from temporary stockpile to landfill site.

DEVELOPMENT: Winter construction of landfill site. The temporary stockpile is not above storm surge levels. It will require some form of protection, e.g., dykes.



LANDFILL SITE L5-2, TEMPORARY STOCKPILES T5-2, T5-3, T5-4

LANDFILL SITE: Available area of 30,000 m² on sand and silt lacustrine plain, moderate ice content.

TEMPORARY STOCKPILE: T5-2, T5-3, and T5-4 have available areas of 22,000 m², 30,000 m², and 20,000 m² respectively on same terrain as the landfill site.

BEACH: Sand, 10 m wide.

BORROW SOURCE: Use beach sand or silt and sand from location shown.

ACCESS: Landfill site is adjacent to T5-2, 500 m from T5-3 (winter) and 1 km from T5-4 (winter).

DEVELOPMENT: Winter construction of landfill site.



AIRPHOTO No. A22386-126

APPROX. SCALE 1:50,000

LANDFILL SITE OUTLINE



TEMPORARY STOCKPILE

ACCESS ROUTE, SUMMER
WINTER

BORROW AREA



LANDFILL SITE L5-6, TEMPORARY STOCKPILES T5-6, T5-5

LANDFILL SITE: Available area of 20,000 m² on sand and silt lacustrine plain, moderate ice content.

TEMPORARY STOCKPILE: T5-5 and T5-6 have available areas of 10,000 m² and 12,000 m² respectively on the same terrain as the landfill site.

BEACH: Sand, 10 to 50 m wide.

BORROW SOURCE: Use beach sand.

ACCESS: 100 m from T5-6 to landfill site (winter), 1.2 km from T5-5 across the ice (winter).

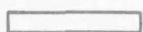
DEVELOPMENT: Winter construction of landfill site.



AIRPHOTO No. A22386-128

APPROX. SCALE 1:50,000

LANDFILL SITE OUTLINE



TEMPORARY STOCKPILE



ACCESS ROUTE, SUMMER



BORROW AREA



WINTER



LANDFILL SITE L5-7, TEMPORARY STOCKPILES T5-7, T5-8

LANDFILL SITE: Available area of 22,000 m² on lacustrine silt and sand, moderate to high ice content.

TEMPORARY STOCKPILE: T5-7 and T5-8 have available areas of 30,000 m² and 20,000 m² respectively on same terrain as landfill site.

BEACH: Sand, 10 m or less in width.

BORROW SOURCE: Use beach sand or sand from borrow location shown near T5-7.

ACCESS: 600 m (winter) from T5-7 to the landfill site, 2 km (winter) from T5-8.

DEVELOPMENT: Winter construction of landfill site.

TEMPORARY STOCKPILE T5-9

TEMPORARY STOCKPILE: Available area of 30,000 m² on silt and sand lacustrine plain, moderate to high ice content.

BEACH: Sand, 10 m wide.

BORROW SOURCE: Use beach sand or sand from the borrow location shown.

ACCESS: Adjacent to beach, 2.7 km winter haul to L5-11 across the ice.

LANDFILL SITE L5-11, TEMPORARY STOCKPILES T5-10, T5-11

LANDFILL SITE: Available area of 30,000 m² on silt and sand lacustrine plain, medium to high ice content.

TEMPORARY STOCKPILE: T5-10 and T5-11 have available areas of 16,000 m² and 16,000 m² respectively on the same terrain as the landfill site.

BEACH: Sand, 10 to 20 m wide.

LANDFILL SITE L5-11, TEMPORARY STOCKPILES T5-10, T5-11 - Continued

BORROW SOURCE: Use beach sand.

ACCESS: 400 m (winter) from T5-10 to the landfill site, 500 m from T5-11.

DEVELOPMENT: Winter construction of landfill site. In the event of an oil spill, there may not be sufficient clean sand on the beach for construction of the temporary stockpiles and landfill site.

LANDFILL SITE L5-12, TEMPORARY STOCKPILES T5-12, T5-13

LANDFILL SITE: Available area of 25,000 m² on silt and sand lacustrine plain, moderate ice content.

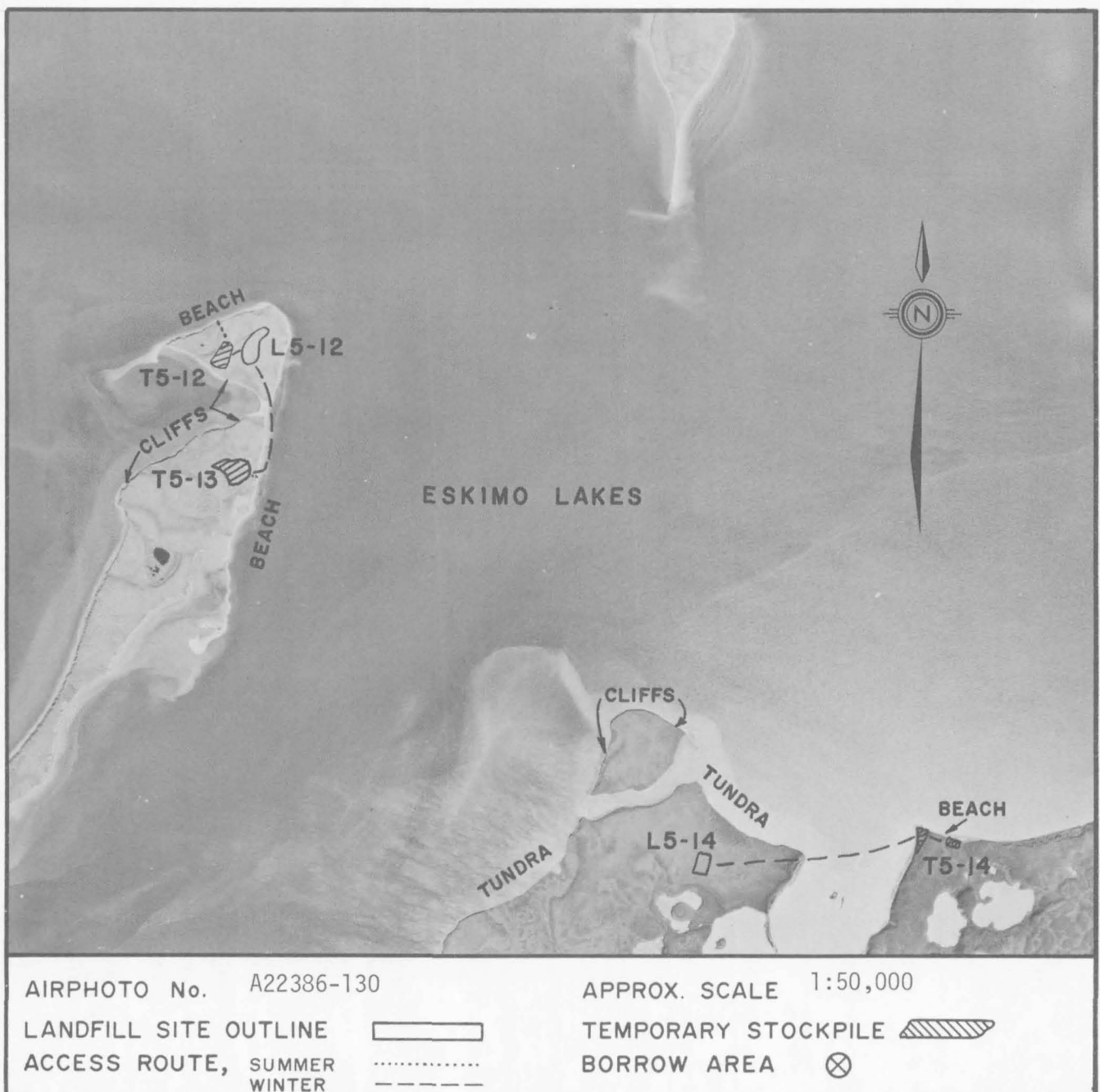
TEMPORARY STOCKPILE: T5-12 and T5-13 have available areas of 20,000 m² and 30,000 m² respectively on same terrain as the landfill site.

BEACH: Sand, 10 - 20 m wide.

BORROW SOURCE: Use beach sand.

ACCESS: 150 m (summer) from beach to T5-12. 100 m (winter) from T5-12 to landfill site, 900 m (winter) from T5-13 across the ice.

DEVELOPMENT: Winter construction of landfill site.



LANDFILL SITE L5-14, TEMPORARY STOCKPILE T5-14

LANDFILL SITE: Available area of 15,000 m² on silt and sand lacustrine plain, medium ice content.

TEMPORARY STOCKPILE: Two areas totalling 20,000 m² available area on hummocky moraine overlying glaciofluvial sand, medium to high ice content.

BEACH: Sand, up to 40 m wide.

BORROW SOURCE: Use beach sand.

ACCESS: 1.7 km (winter) from the temporary stockpile to the landfill site across the ice.

DEVELOPMENT: Winter construction of landfill site.

LANDFILL SITE L5-15, TEMPORARY STOCKPILE T5-15

LANDFILL SITE: Available area of 20,000 m² on silt and sand lacustrine plain, medium ice content.

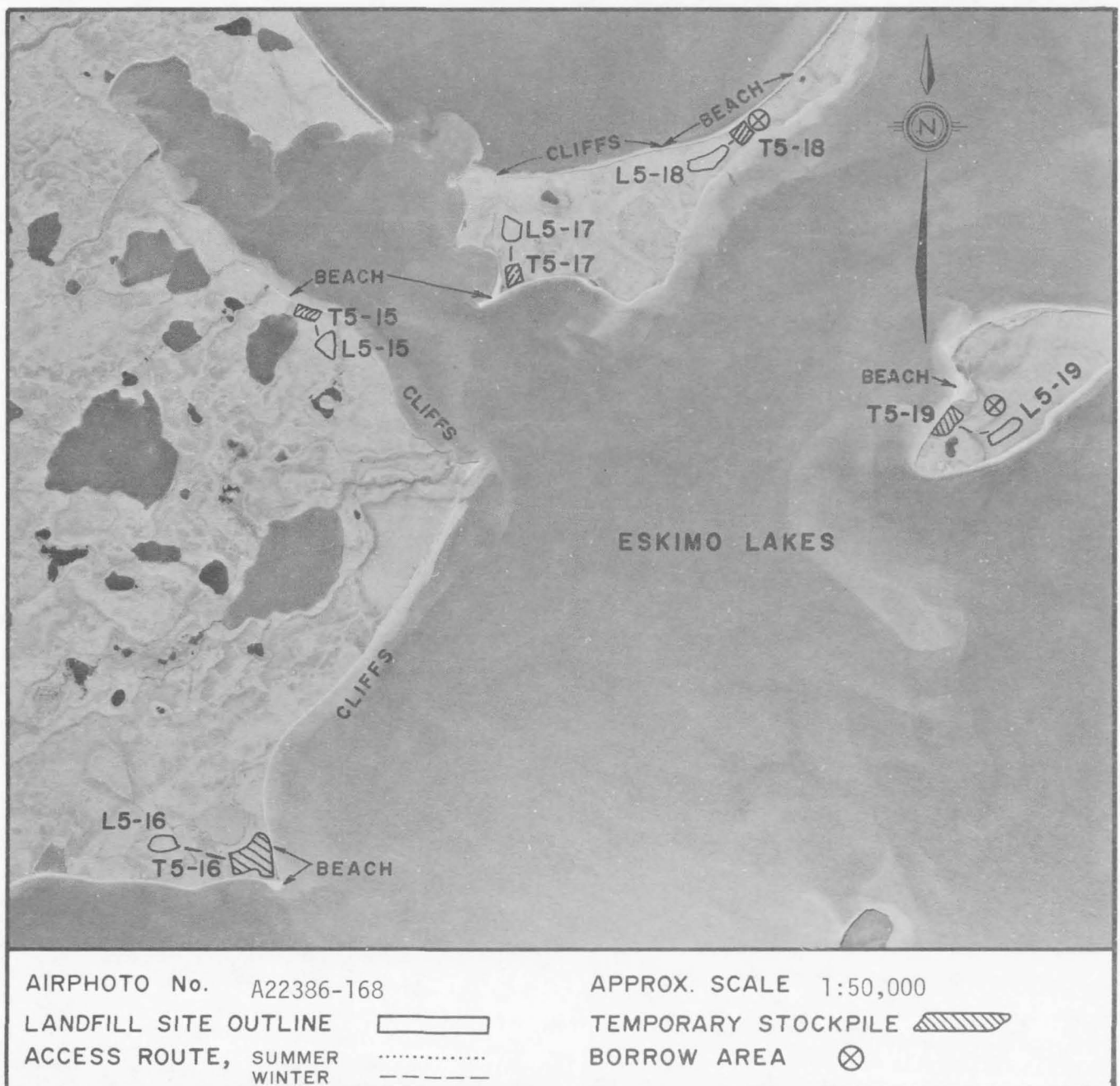
TEMPORARY STOCKPILE: Available area of 18,000 m² on same terrain as landfill site.

BEACH: Sand, 10 m wide.

BORROW SOURCE: Use beach sand.

ACCESS: 150 m (winter) from T5-15 to the landfill site.

DEVELOPMENT: Winter construction of landfill site. In the event of an oil spill, there may not be sufficient clean sand on the beach for construction of the temporary stockpile and landfill site.



LANDFILL SITE L5-16, TEMPORARY STOCKPILE T5-16

LANDFILL SITE: Available area of 20,000 m² on silt and sand lacustrine plain, medium to high ice content.

TEMPORARY STOCKPILE: Available area of 70,000 m² on same terrain as landfill site.

BEACH: Sand, 10 to 75 m wide.

BORROW SOURCE: Use beach sand.

ACCESS: 400 m (winter) from T5-16 to the landfill site.

DEVELOPMENT: Winter construction of landfill site.

LANDFILL SITE L5-17, TEMPORARY STOCKPILE T5-17

LANDFILL SITE: Available area of 22,000 m² on silt and sand lacustrine plain, moderate to high ice content.

TEMPORARY STOCKPILE: Available area of 15,000 m² on same terrain as landfill site.

BEACH: Sand, up to 60 m wide.

BORROW SOURCE: Use beach sand.

ACCESS: 200 m (winter) from T5-17 to the landfill site.

DEVELOPMENT: Winter construction of landfill site.

LANDFILL SITE L5-18, TEMPORARY STOCKPILE T5-18

LANDFILL SITE: Available area of 30,000 m² on a sand terrace, moderate ice content.

TEMPORARY STOCKPILE: Available area of 22,000 m² on same terrain as landfill site.

BEACH: Sand, 10 m wide.

LANDFILL SITE L5-18, TEMPORARY STOCKPILE T5-18 - Continued

BORROW SOURCE: Use beach sand or sand from borrow location shown.
ACCESS: 100 m (winter) from T5-18 to the landfill site.
DEVELOPMENT: Winter construction of landfill site.

LANDFILL SITE L5-19, TEMPORARY STOCKPILE T5-19

LANDFILL SITE: Available area of 22,000 m² on silt and sand terrace, low to medium ice content.
TEMPORARY STOCKPILE: Available area of 25,000 m² on a silty lacustrine plain, moderate to high ice content.
BEACH: Sand, up to 100 m wide.
BORROW SOURCE: Use beach sand or silt and sand at borrow location shown.
ACCESS: 300 m (winter) from T5-19 to the landfill site.
DEVELOPMENT: Winter construction of landfill site.

LANDFILL SITE L5-20, TEMPORARY STOCKPILE T5-20

LANDFILL SITE: Available area of 30,000 m² on silty lacustrine plain, moderate to high ice content.

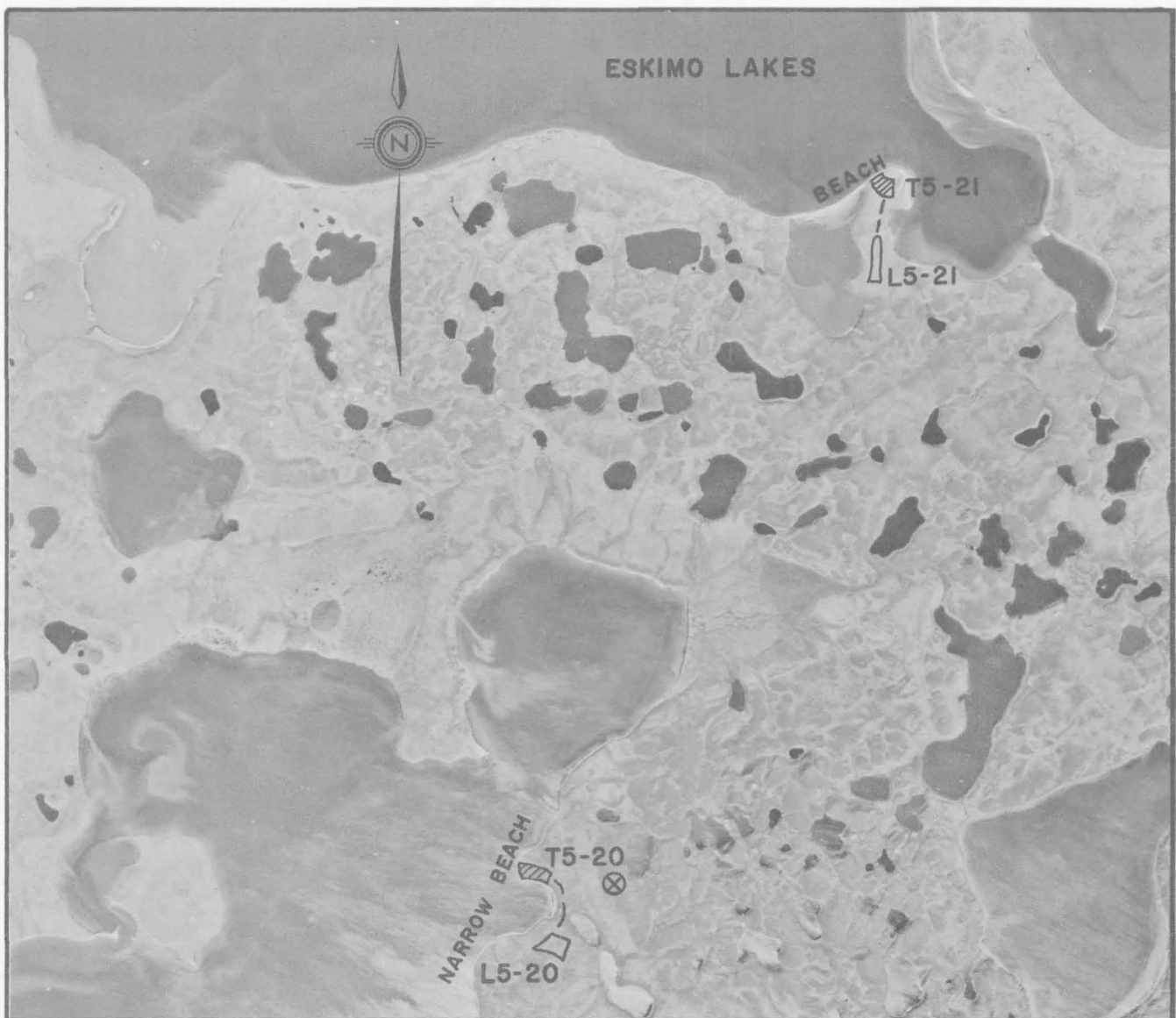
TEMPORARY STOCKPILE: Available area of 25,000 m² on same terrain as landfill site.

BEACH: Sand, 10 m wide.

BORROW SOURCE: Use beach sand or silt and sand from borrow location shown.

ACCESS: 400 m (winter) from T5-20 to landfill site.

DEVELOPMENT: Winter construction of landfill site. In the event of an oil spill, there may not be sufficient clean sand on the beach for construction of the temporary stockpile and landfill site. The borrow location shown will probably be required.



AIRPHOTO No. A22386-165

APPROX. SCALE 1:50,000

LANDFILL SITE OUTLINE



TEMPORARY STOCKPILE

ACCESS ROUTE, SUMMER
WINTER

BORROW AREA



LANDFILL SITE L5-21, TEMPORARY STOCKPILE T5-21

LANDFILL SITE: Available area of 25,000 m² on silt and sand lacustrine plain, moderate ice content.

TEMPORARY STOCKPILE: Available area of 15,000 m² on same terrain as landfill site.

BEACH: Sand, up to 100 m wide.

BORROW SOURCE: Use beach sand.

ACCESS: 300 m (winter) from T5-21 to the landfill site.

DEVELOPMENT: Winter construction of landfill site.

LANDFILL SITE L5-22, TEMPORARY STOCKPILE T5-22

LANDFILL SITE: Available area of 30,000 m² on sand and silt terrace, moderate ice content.

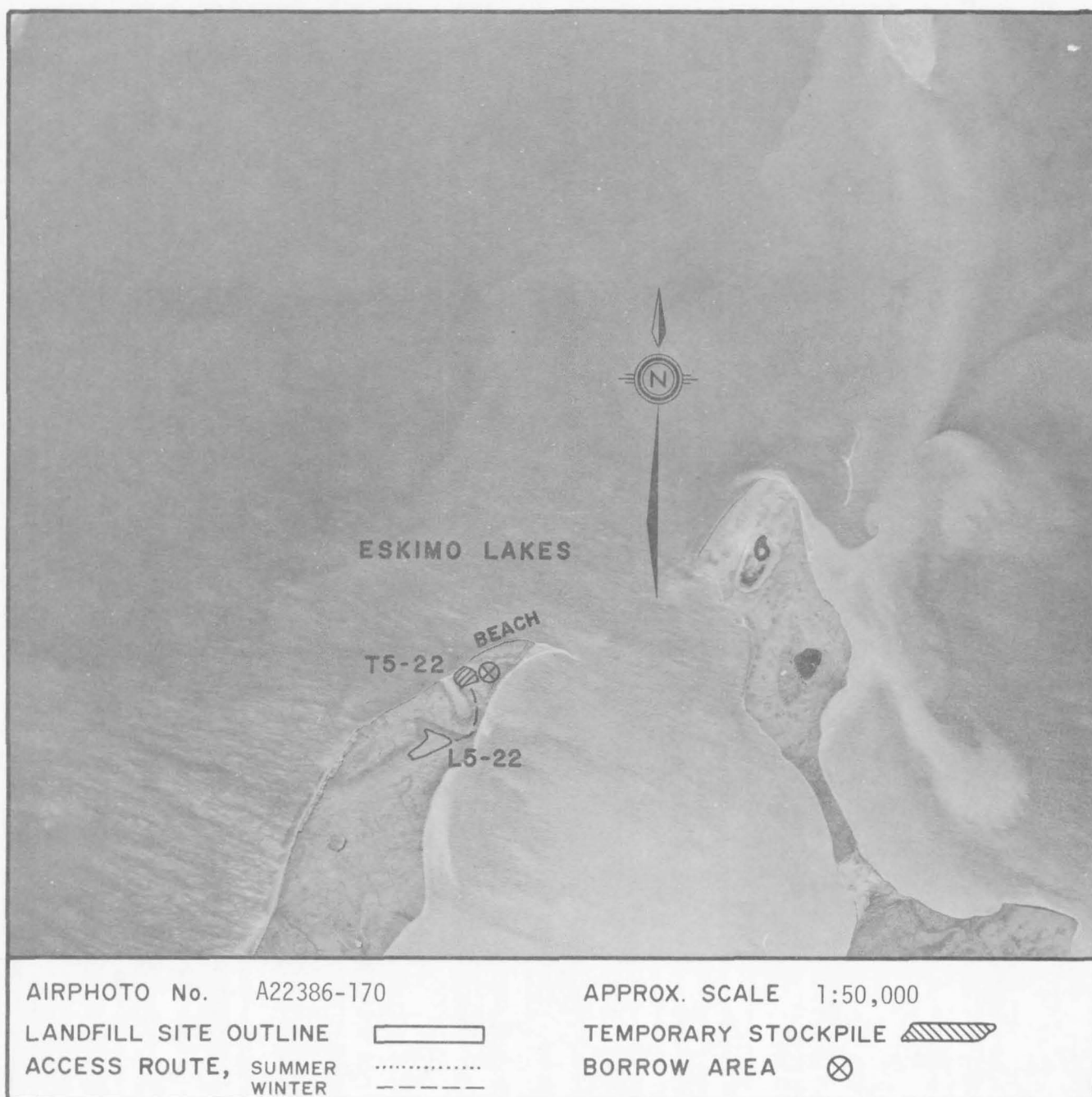
TEMPORARY STOCKPILE: 20,000 m² available area on a silty lacustrine basin, moderate to high ice content.

BEACH: Sand, up to 100 m wide.

BORROW SOURCE: Use beach sand.

ACCESS: 500 m (winter) from T5-22 to the landfill site.

DEVELOPMENT: Winter construction of landfill site.



LANDFILL SITE L5-23, TEMPORARY STOCKPILE T5-23, T5-24

LANDFILL SITE: A and B have available areas of 25,000 m² and 12,000 m² respectively on a silty clay lacustrine plain with moderate to high ice content.

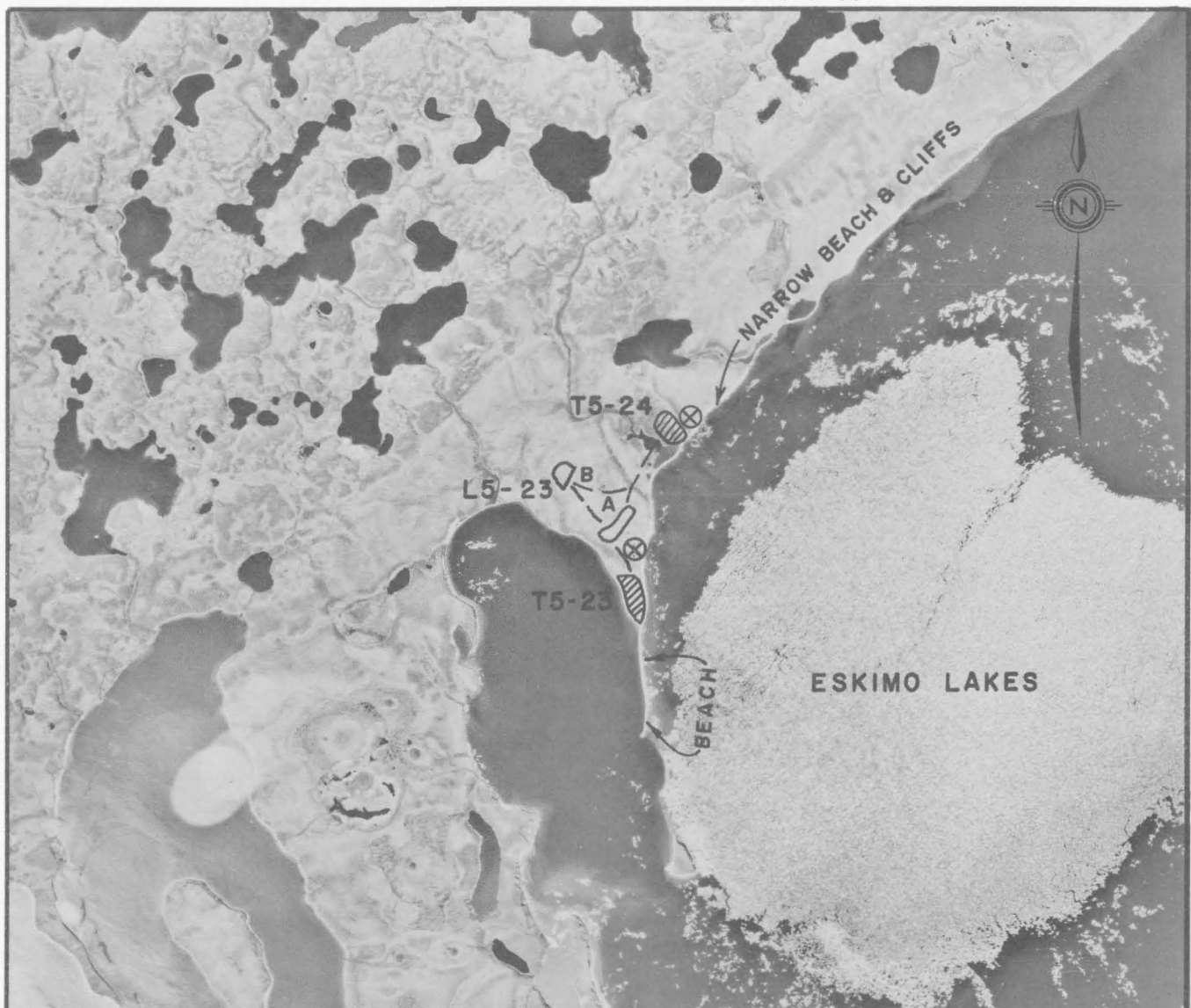
TEMPORARY STOCKPILE: T5-23 and T5-24 have available areas of 40,000 m² and 35,000 m² respectively on lower lacustrine areas with moderate to high ice content.

BEACH: Sand, 10 m wide.

BORROW SOURCE: Use beach sand, supplement with fines and sand from exposed cliffs at the two locations shown.

ACCESS: 300 m and 800 m from T5-23 to A and B (winter).
600 m from T5-24 to A.

DEVELOPMENT: Winter construction of landfill site.



AIRPHOTO No. A22884-132

APPROX. SCALE 1:54,000

LANDFILL SITE OUTLINE



TEMPORARY STOCKPILE

ACCESS ROUTE, SUMMER
WINTER

BORROW AREA



LANDFILL SITE L5-25, TEMPORARY STOCKPILE T5-25

LANDFILL SITE: Available area of 15,000 m² on lacustrine silt with moderate to high ice content.

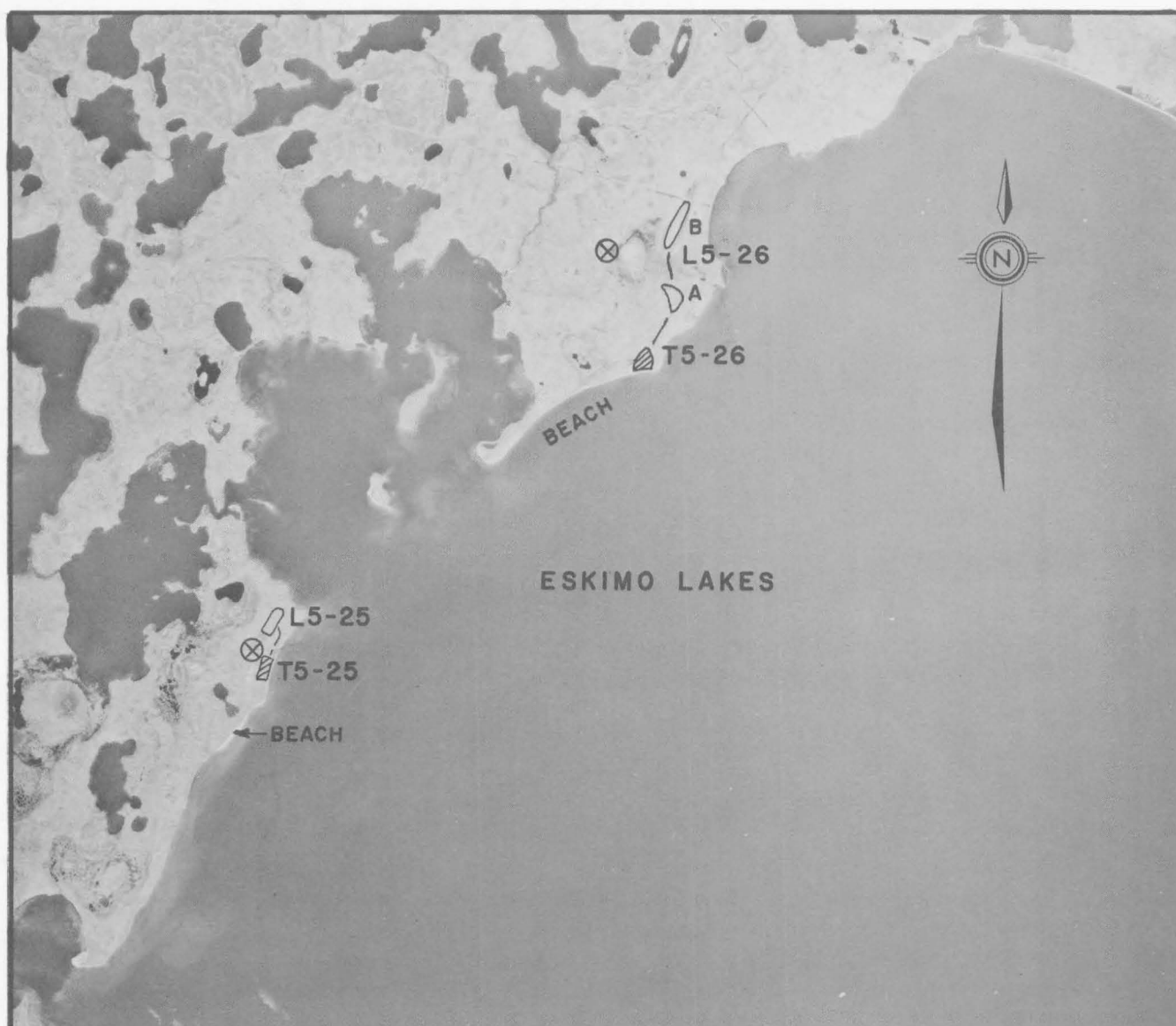
TEMPORARY STOCKPILE: Available area of 12,000 m² on same terrain as landfill site.

BEACH: Sand, minor gravel, up to 20 m wide.

BORROW SOURCE: Use beach sand or sand and gravel from borrow location shown.

ACCESS: 200 m (winter) from T5-25 to the landfill site.

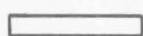
DEVELOPMENT: Winter construction of landfill site.



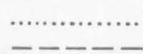
AIRPHOTO No. A22884-120

APPROX. SCALE 1:54,000

LANDFILL SITE OUTLINE



TEMPORARY STOCKPILE

ACCESS ROUTE, SUMMER
WINTER

BORROW AREA



LANDFILL SITE L5-26, TEMPORARY STOCKPILE T5-26

LANDFILL SITE: A and B have available areas of 20,000 m² and 15,000 m² respectively on lacustrine silt and sand with moderate to high ice content.

TEMPORARY STOCKPILE: Available area of 22,000 m² on same terrain as landfill site.

BEACH: Sand, up to 10 m wide.

BORROW SOURCE: Use beach sand or sand and gravel from the borrow location shown.

ACCESS: 300 m (winter) to A from the temporary stockpile, 800 m to B.

DEVELOPMENT: Winter construction of landfill site. In the event of an oil spill, there may not be sufficient clean sand on the beach to meet borrow requirements. Development of the borrow location shown will probably be necessary.

LANDFILL SITE L5-27, TEMPORARY STOCKPILES T5-27, T5-28

LANDFILL SITE: Available area of 15,000 m² on ice cored moraine overlying glaciofluvial sand with high ice content.

TEMPORARY STOCKPILE: T5-27 and T5-28 have available areas of 20,000 m² and 15,000 m² respectively on lacustrine silt with high ice content.

BEACH: Sand, 10 m wide.

BORROW SOURCE: Use beach sand.

ACCESS: 1.1 km from T5-27 to landfill site (winter), 800 m from T5-28.

DEVELOPMENT: Winter construction of landfill site. In the event of an oil spill, there may not be sufficient clean sand on the beach to meet borrow requirements.



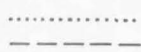
AIRPHOTO No. A22884-122

APPROX. SCALE 1:54,000

LANDFILL SITE OUTLINE



TEMPORARY STOCKPILE

ACCESS ROUTE, SUMMER
WINTER

BORROW AREA



LANDFILL SITE L5-29, TEMPORARY STOCKPILE T5-29

LANDFILL SITE: Available area of 25,000 m² on glaciofluvial sand with a moraine veneer, high ice content.

TEMPORARY STOCKPILE: Available area of 45,000 m² on lacustrine silt, moderate to high ice content.

BEACH: Sand beach, 10 m wide in front of cliffs.

BORROW SOURCE: Use beach sand.

ACCESS: 100 m from T5-29 to the landfill site.

DEVELOPMENT: Winter construction of landfill site. In the event of an oil spill, there may not be sufficient clean sand on the beach to meet borrow requirements.

LANDFILL SITE L5-30, TEMPORARY STOCKPILE T5-30

LANDFILL SITE: Available area of 40,000 m² on a sand terrace, low to moderate ice content but ice-cored at depth.

TEMPORARY STOCKPILE: Available area of 10,000 m² on lacustrine silt with moderate to high ice content.

BEACH: Sand beach, 10 m wide, in front of cliffs.

BORROW SOURCE: Use beach sand or sand from two locations shown.

ACCESS: 900 m (summer or winter) to landfill site across well drained terrain.

DEVELOPMENT: Check ice content in upper 6 m before attempting summer construction of the landfill site.

LANDFILL SITE L5-31, TEMPORARY STOCKPILE T5-31

LANDFILL SITE: Available area of 15,000 m² on lacustrine silt and sand, moderate ice content.

LANDFILL SITE L5-31, TEMPORARY STOCKPILE T5-31 - Continued

TEMPORARY STOCKPILE: Available area of 8,000 m² on same terrain as landfill site.

BEACH: Sand, 25 m wide.

BORROW SOURCE: Use beach sand or sand from the borrow location shown.

ACCESS: 500 m (winter) from T5-31 to the landfill site.

DEVELOPMENT: Winter construction of landfill site.

LANDFILL SITE L5-32

LANDFILL SITE: Available area of 12,000 m² on a sand terrace with low ice content.

TEMPORARY STOCKPILE: No site available, none required for summer construction.

BEACH: Sand, 20 m wide.

BORROW SOURCE: Use beach sand, or sand from borrow location shown.

ACCESS: 300 m (summer) from the beach to the landfill site (through the borrow area).

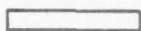
DEVELOPMENT: Summer construction of the landfill site is possible. The site has a design life of only 50 years due to eroding cliffs.



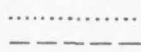
AIRPHOTO No. A22884-124

APPROX. SCALE 1:54,000

LANDFILL SITE OUTLINE



TEMPORARY STOCKPILE

ACCESS ROUTE, SUMMER
WINTER

BORROW AREA



LANDFILL SITE L5-33, TEMPORARY STOCKPILE T5-33

LANDFILL SITE: Available area of 10,000 m² on a sand terrace with low ice content.

TEMPORARY STOCKPILE: Available area of 40,000 m² on same terrain as landfill site.

BEACH: Sand, 10 m wide.

BORROW SOURCE: Use beach sand, or sand from the two locations shown on sand terraces.

ACCESS: 1.4 km (winter) across the ice from T5-33 to landfill site.

DEVELOPMENT: Winter construction of landfill site due to poor access.

LANDFILL SITE L5-34

LANDFILL SITE: Available area of 12,000 m² on a sand terrace with low ice content.

TEMPORARY STOCKPILE: No site available, none required for summer construction.

BEACH: Sand spit, up to 30 m wide.

BORROW SOURCE: Use beach sand, or sand from borrow location shown.

ACCESS: 350 m (summer) from the beach to the landfill site.

DEVELOPMENT: Summer construction of the landfill site is possible. The site is close to stable cliffs, and although the cliffs are not actively eroding at the present time, erosion could become active in the future. Assume a design life of 50 years for L5-34.

LANDFILL SITE L5-35, TEMPORARY STOCKPILES T5-35, T5-36

LANDFILL SITE: Available area of 35,000 m² on a sand terrace. The terrace is ice cored, but the ice content in the top 6 m is probably low.

LANDFILL SITE L5-35, TEMPORARY STOCKPILES T5-35, T5-36 - Continued

TEMPORARY STOCKPILE: T5-35 has available area of 20,000 m² on lacustrine silt. T5-36 has available area of 80,000 m² or more on same terrain as landfill site.

BEACH: Sand beach, 10 m wide, in front of cliffs.

BORROW SOURCE: Use beach sand, or sand from 2 borrow locations shown.

ACCESS: 500 m (summer) from the beach to the landfill site.

DEVELOPMENT: Check ice content in top 6 m before attempting summer construction of the landfill site.

LANDFILL SITE L5-37, TEMPORARY STOCKPILE T5-37

LANDFILL SITE: Available area of 12,000 m² on lacustrine silt with moderate to high ice content.

TEMPORARY STOCKPILE: Available area of 25,000 m² on same terrain as landfill site.

BEACH: Sand beach, 10 m wide, in front of cliffs.

BORROW SOURCE: Use beach sand, or sand and fines from borrow location shown.

ACCESS: 1 km (winter) from T5-37 to the landfill site.

DEVELOPMENT: Winter construction of landfill site.

LANDFILL SITE L5-38, TEMPORARY STOCKPILE T5-38

LANDFILL SITE: Available area of 17,000 m² on lacustrine silt with moderate to high ice content.

TEMPORARY STOCKPILE: Available area of 35,000 m² on the same terrain as the landfill site.

LANDFILL SITE L5-38, TEMPORARY STOCKPILE T5-38 - Continued

BEACH: Sand beach, 10 m wide, in front of cliffs.

BORROW SOURCE: Use beach sand, or sand and fines from borrow location shown.

ACCESS: 100 m (winter) from T5-38 to the landfill site.

DEVELOPMENT: Winter construction of landfill site.

LANDFILL SITE L5-39, TEMPORARY STOCKPILE T5-39

LANDFILL SITE: Available area of 12,000 m² on lacustrine silt with moderate to high ice content.

TEMPORARY STOCKPILE: Available area of 12,000 m² on same terrain as landfill site.

BEACH: Sand, 10 m wide.

BORROW SOURCE: Use beach sand. In the event of an oil spill, there may not be sufficient clean sand on the beach to meet borrow requirements.

ACCESS: 200 m (winter) from T5-39 to the landfill site.

DEVELOPMENT: Winter construction of landfill site.

LANDFILL SITE L5-40, TEMPORARY STOCKPILE T5-40

LANDFILL SITE: Available area of 15,000 m² on lacustrine silt with medium to high ice content.

TEMPORARY STOCKPILE: Available area of 20,000 m² on same terrain as landfill site.

BEACH: Sand, 10 m wide.

BORROW SOURCE: Use beach sand. In the event of an oil spill, there may not be sufficient clean sand on the beach to meet borrow requirements.

ACCESS: 100 m (winter) from T5-40 to the landfill site.

DEVELOPMENT: Winter construction of the landfill site.

LANDFILL SITE L5-41, TEMPORARY STOCKPILE T5-41

LANDFILL SITE: Available area of 10,000 m² on glaciofluvial sand with a moraine veneer, medium to high ice content.

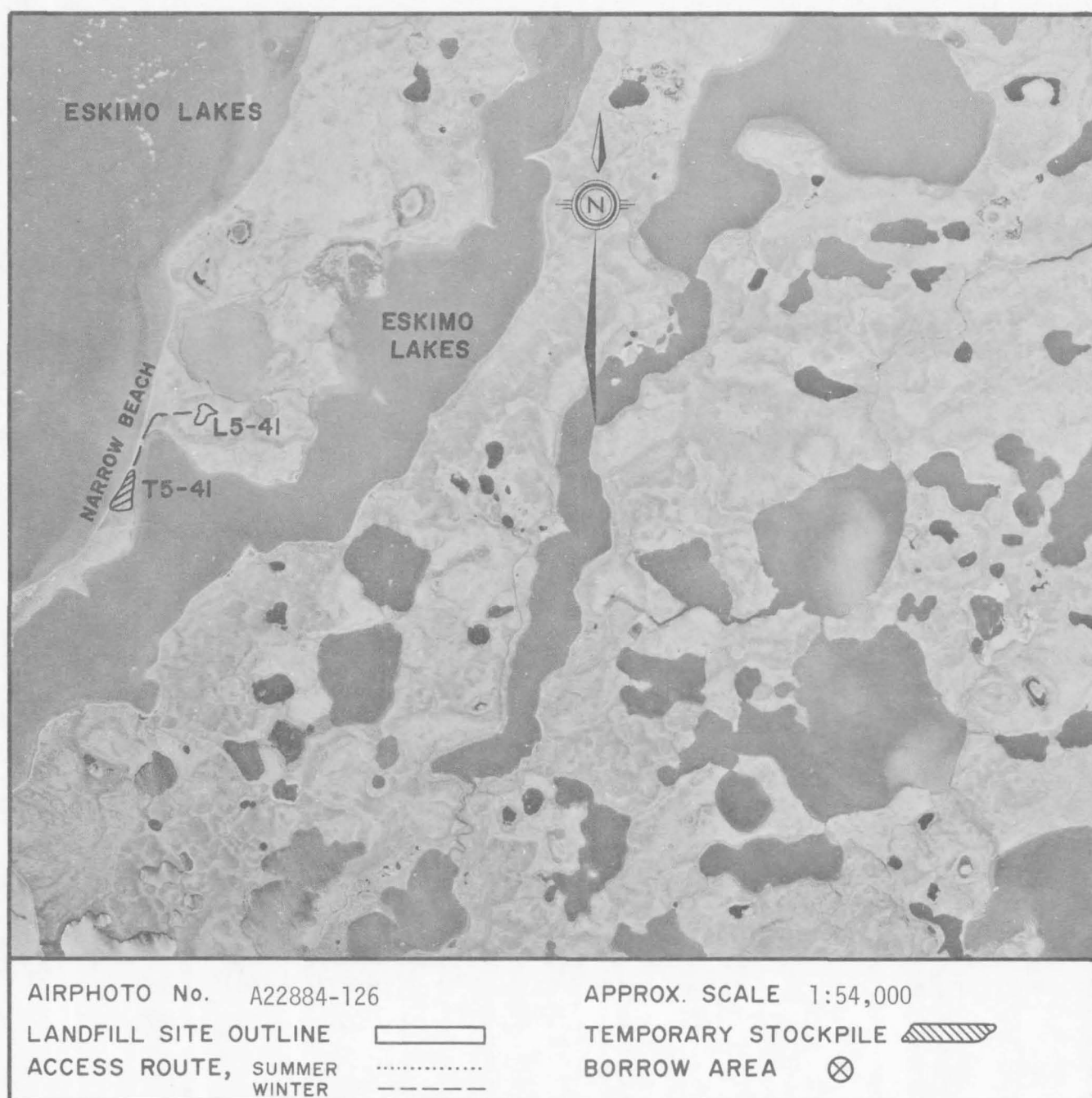
TEMPORARY STOCKPILE: Available area of 30,000 m² on lacustrine silt and sand, moderate ice content.

BEACH: Sand, 10 m wide.

BORROW SOURCE: Use beach sand, supplement with fines from exposed cliffs. In the event of an oil spill, there may not be sufficient clean sand on the beach to meet borrow requirements.

ACCESS: 800 m (winter) from T5-41 to the landfill site.

DEVELOPMENT: Winter construction of landfill site.



LANDFILL SITE L5-42, TEMPORARY STOCKPILE T5-42

LANDFILL SITE: Available area of 40,000 m² on a sand terrace, low ice content, but expect massive ice at depth.

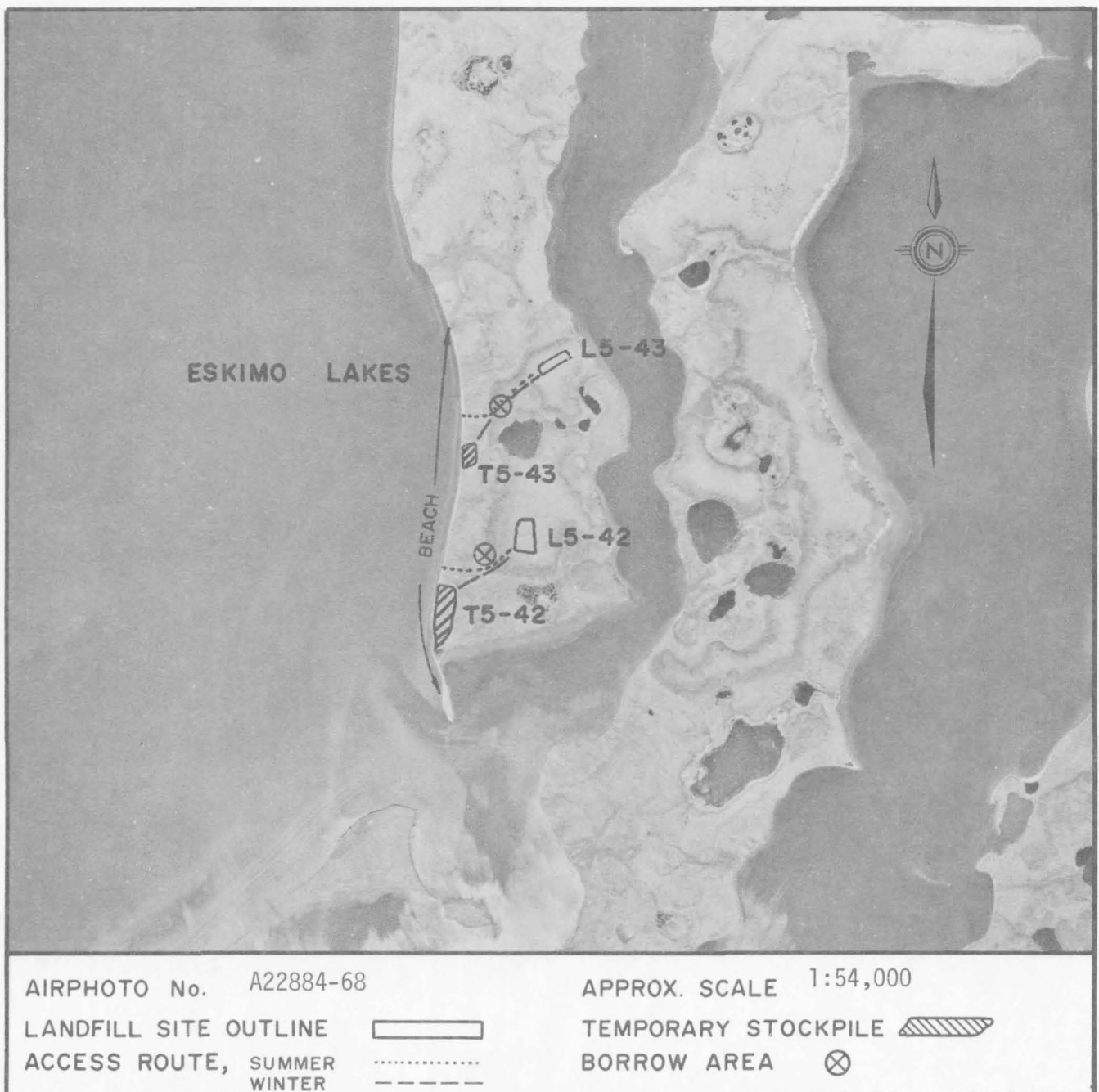
TEMPORARY STOCKPILE: Available area of 50,000 m² on lacustrine silt, moderate to high ice content.

BEACH: Sand, 20 to 50 m wide.

BORROW SOURCE: Use beach sand, or sand from borrow location shown on sand terrace.

ACCESS: 700 m (summer or winter) to landfill site, of which 350 m is well drained terrain. The other 350 m is low tundra.

DEVELOPMENT: Check ice content in top 6 m before attempting summer construction of landfill site.



LANDFILL SITE L5-43, TEMPORARY STOCKPILE T5-43

LANDFILL SITE: Available area of 20,000 m² on a sand terrace, low ice content, but expect massive ice at depth.

TEMPORARY STOCKPILE: Available area of 15,000 m² on lacustrine silt, moderate to high ice content.

BEACH: Sand, 10 to 20 m wide.

BORROW SOURCE: Use beach sand or sand from borrow locations shown on the sand terrace.

ACCESS: 800 m (summer or winter) to the landfill site, of which 250 m is on low tundra.

DEVELOPMENT: Check ice content in top 6 m before attempting summer construction of landfill site.

LANDFILL SITE L5-44

LANDFILL SITE: Available area of 20,000 m² on a sand terrace. The terrace is ice-cored at depth but the ice content of the top 6 m is probably low.

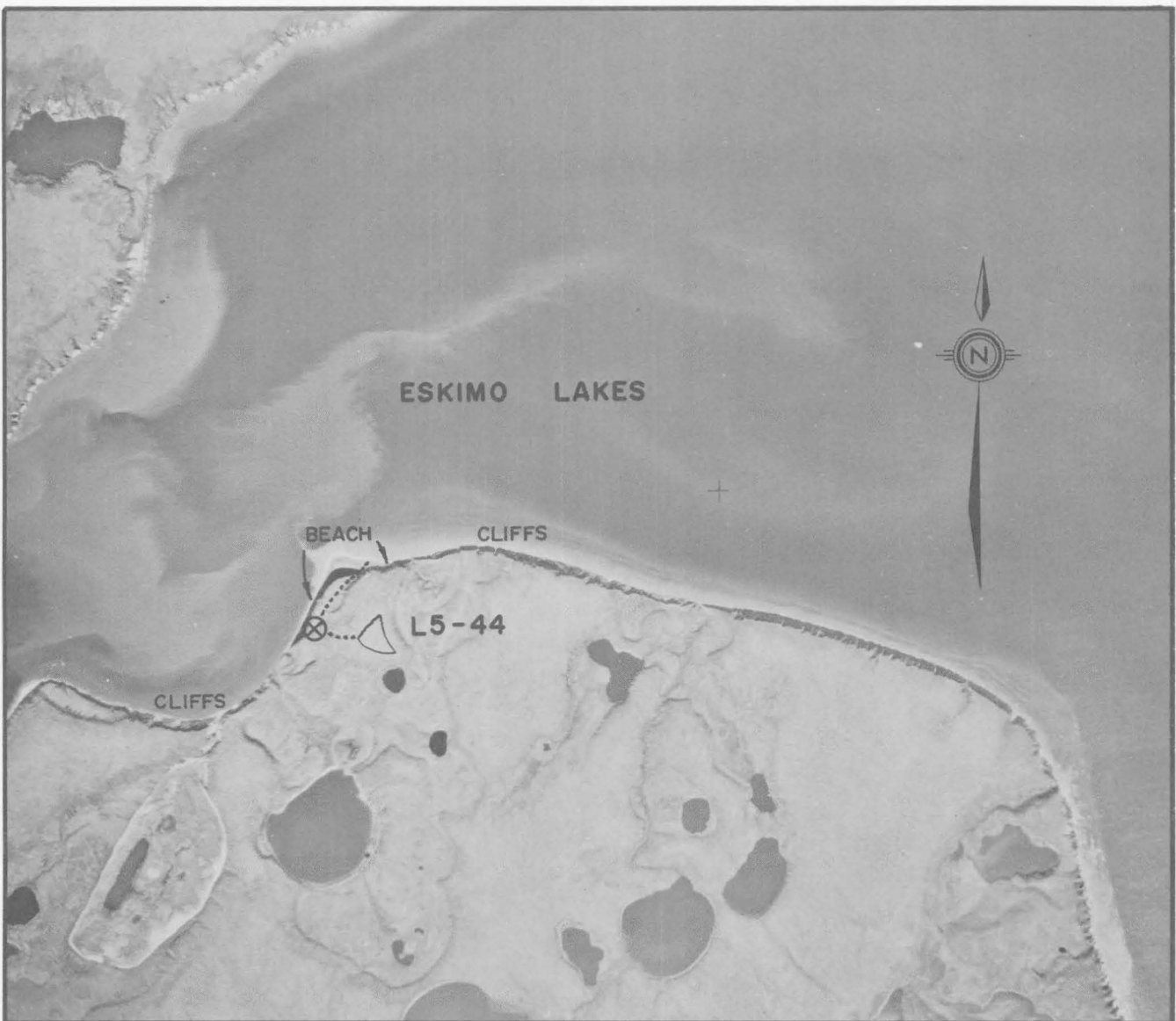
TEMPORARY STOCKPILE: No site available, none required for summer construction.

BEACH: Sand, 40 m wide.

BORROW SOURCE: Use beach sand or sand from borrow location shown on the sand terrace.

ACCESS: 700 m (summer) from beach to landfill site, up a moderately steep slope.

DEVELOPMENT: Check ice content of top 6 m before attempting summer construction of landfill site.



AIRPHOTO No. A12918-114

APPROX. SCALE 1:40,000

LANDFILL SITE OUTLINE



TEMPORARY STOCKPILE

ACCESS ROUTE, SUMMER
WINTER

BORROW AREA



LANDFILL SITE L5-45, TEMPORARY STOCKPILE T5-45

LANDFILL SITE: Available area of 20,000 m² on a sand and gravel raised beach, low ice content.

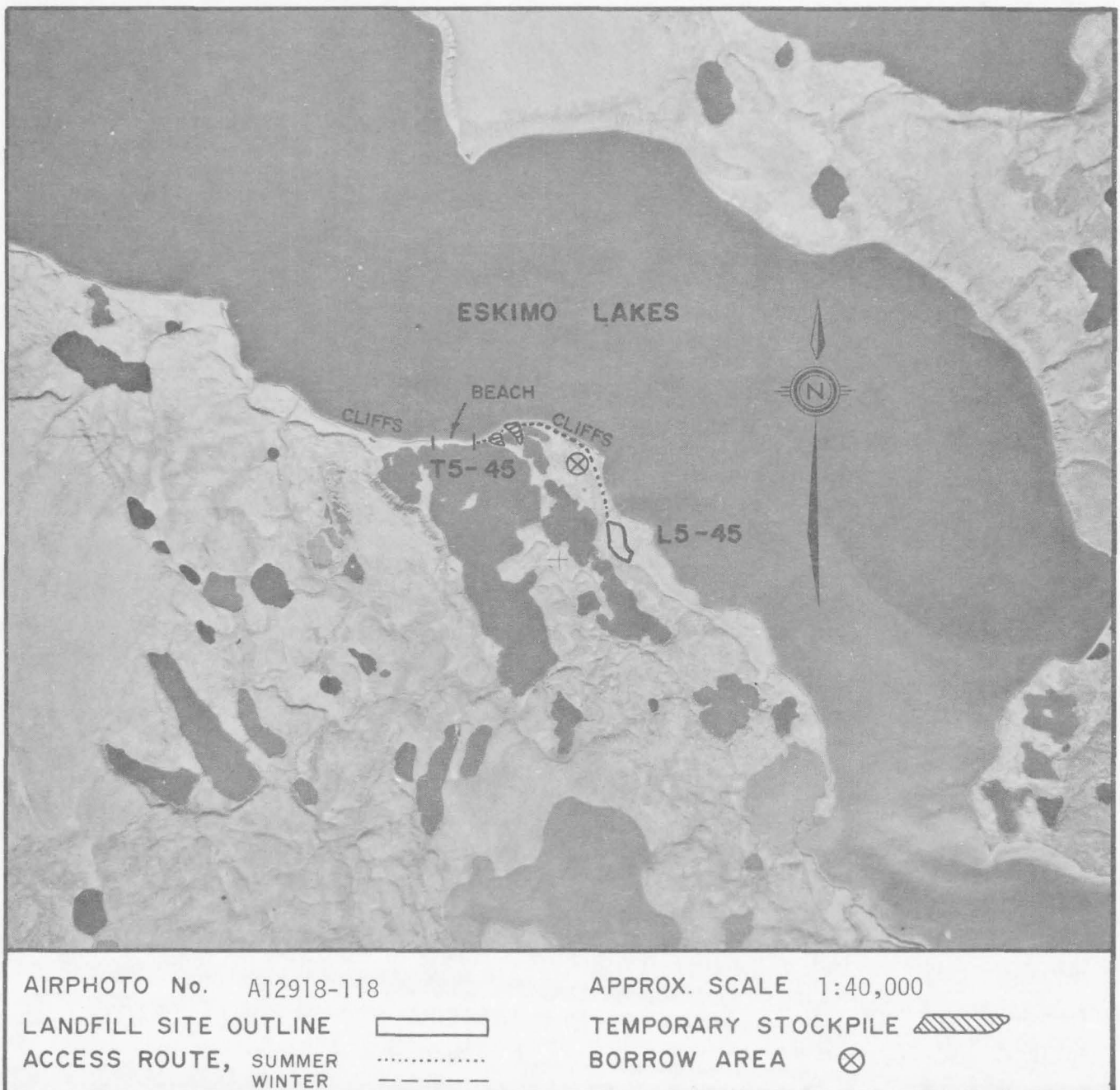
TEMPORARY STOCKPILE: Two areas totalling 12,000 m² on a sand and gravel raised beach.

BEACH: Gravel and sand, 10 m wide.

BORROW SOURCE: Use gravel and sand at borrow location shown.

ACCESS: 1.2 km (summer) from beach to landfill site along well drained sand and gravel.

DEVELOPMENT: Summer construction of landfill site is possible. Removal of the beach in front of the lagoon could result in contamination or alteration of the lagoon environment.



LANDFILL SITE L5-46, TEMPORARY STOCKPILES T5-46, T5-47

LANDFILL SITE:

A has an available area of $30,000 \text{ m}^2$ on a gravel terrace. The terrace is ice-cored, but the top 6 m probably has low ice content. B has an available area of $20,000 \text{ m}^2$ on a gravel terrace overlain by moraine, moderate to high ice content.

TEMPORARY STOCKPILE: T5-46 and T5-47 have available areas of $15,000 \text{ m}^2$ and $40,000 \text{ m}^2$ respectively on low sand terraces with low ice content.

BEACH:

Gravel and sand, 10 to 40 m wide.

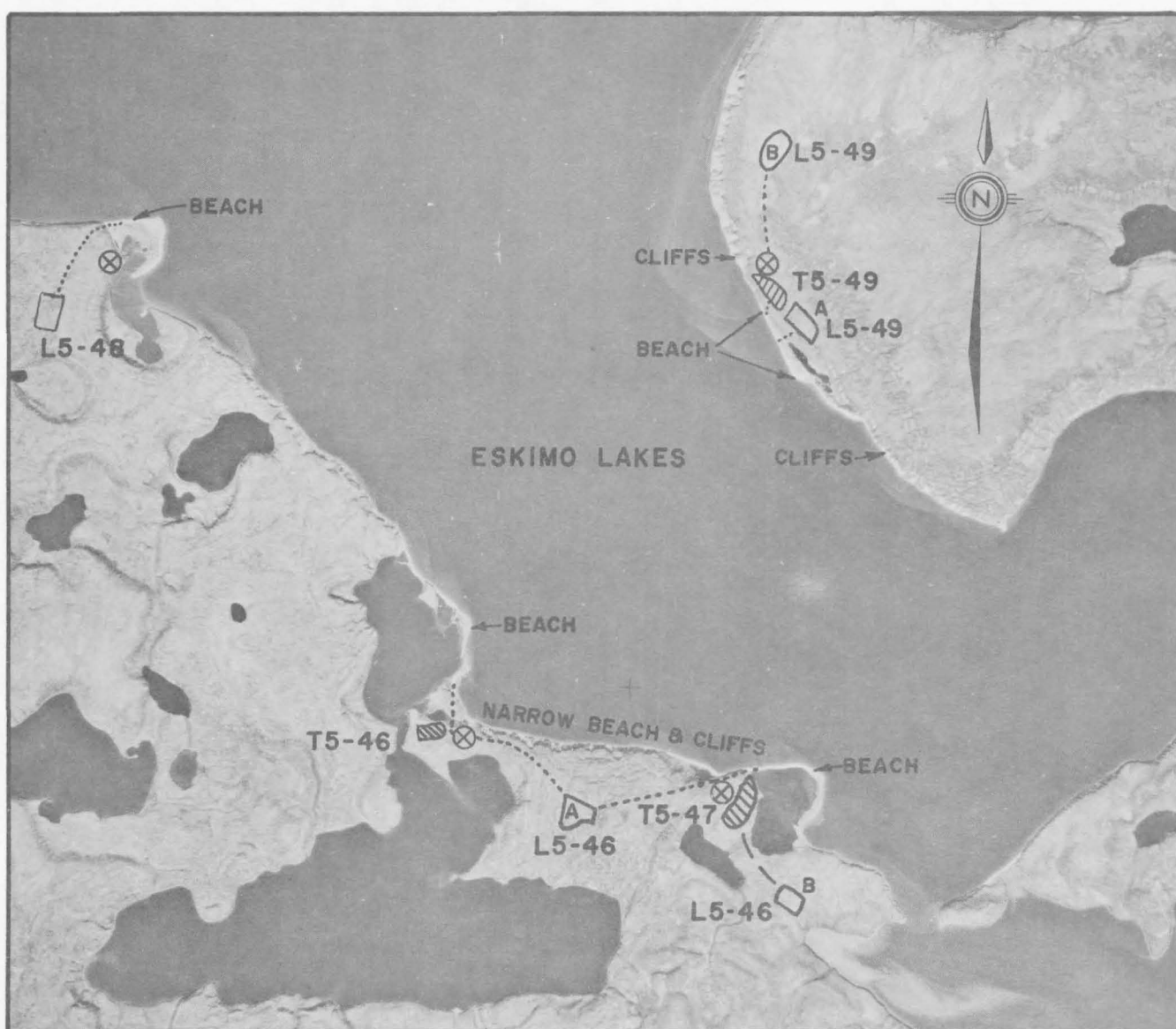
BORROW SOURCE:

Use gravel and sand at the two locations shown.

ACCESS:

500 to 600 m (summer) to A from the beach, 400 m (winter) to B from T5-47.

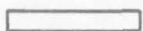
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AIRPHOTO No. A12902-100

APPROX. SCALE 1:40,000

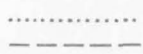
LANDFILL SITE OUTLINE



TEMPORARY STOCKPILE



ACCESS ROUTE, SUMMER
WINTER



BORROW AREA



LANDFILL SITE L5-46, TEMPORARY STOCKPILES T5-46, T5-47 - Continued

DEVELOPMENT: A could be summer construction, B would be winter construction. Removal of the beaches in front of the lagoons may result in contamination or alteration of the lagoon environment.

LANDFILL SITE L5-48

LANDFILL SITE: Available area of 45,000 m² on a gravel and sand terrace. The terrace is ice-cored at depth but the top 6 m probably has a low ice content.

TEMPORARY STOCKPILE: No site available, none required for summer construction.

BEACH: Gravel and sand, up to 80 m wide.

BORROW SOURCE: Use beach material or gravel and sand from borrow location shown.

ACCESS: 600 m (summer) from beach to landfill site on gravel and sand terrace. The slope from the beach is steep and may require construction of a ramp for access.

DEVELOPMENT: Check ice content in top 6 m before attempting summer construction of landfill site.

LANDFILL SITE L5-49, TEMPORARY STOCKPILE T5-49

LANDFILL SITE: A and B have available areas of 20,000 m² and 30,000 m² respectively. A is on a low sand and gravel terrace, B is on a higher terrace that is ice-cored.

TEMPORARY STOCKPILE: Available area of 20,000 m² on same terrain as A.

BEACH: Gravel and sand, up to 75 m wide.

BORROW SOURCE: Use beach material or sand and gravel from borrow location shown.

LANDFILL SITE L5-49, TEMPORARY STOCKPILE T5-49 - Continued

ACCESS: 100 m from beach to A (summer), 900 m to B up a steep slope (summer or winter).

DEVELOPMENT: Summer construction may be possible at A, less likely at B. Check ice content in top 6 m before attempting summer construction.

LANDFILL SITE L5-50, TEMPORARY STOCKPILE T5-50

LANDFILL SITE: Available area of 30,000 m² on a sand and gravel terrace, ice-cored at depth, but probably low ice content in top 6 m.

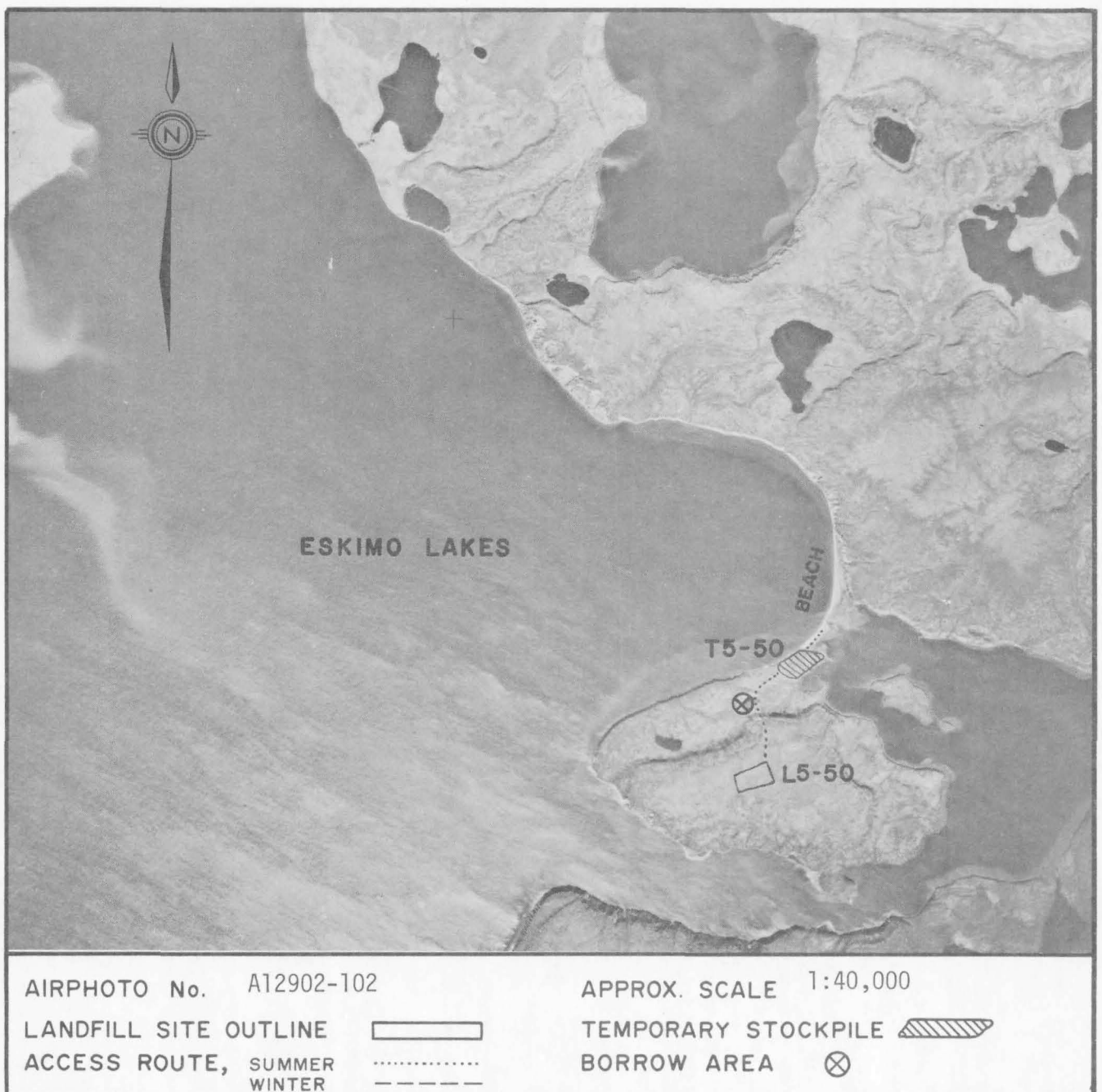
TEMPORARY STOCKPILE: Available area of 30,000 m² on lacustrine sand and silt, moderate ice content.

BEACH: Gravel and sand, 40 m wide.

BORROW SOURCE: Use beach sand or sand and gravel from borrow location shown.

ACCESS: 800 m (summer) from the beach to the landfill site.

DEVELOPMENT: Summer construction of the landfill site may be possible. Check ice content in top 6 m before attempting summer construction.



LANDFILL SITE L5-51

LANDFILL SITE: Available area of 25,000 m² on a sand and gravel terrace, ice-cored at depth, but probably low ice content in top 6 m.

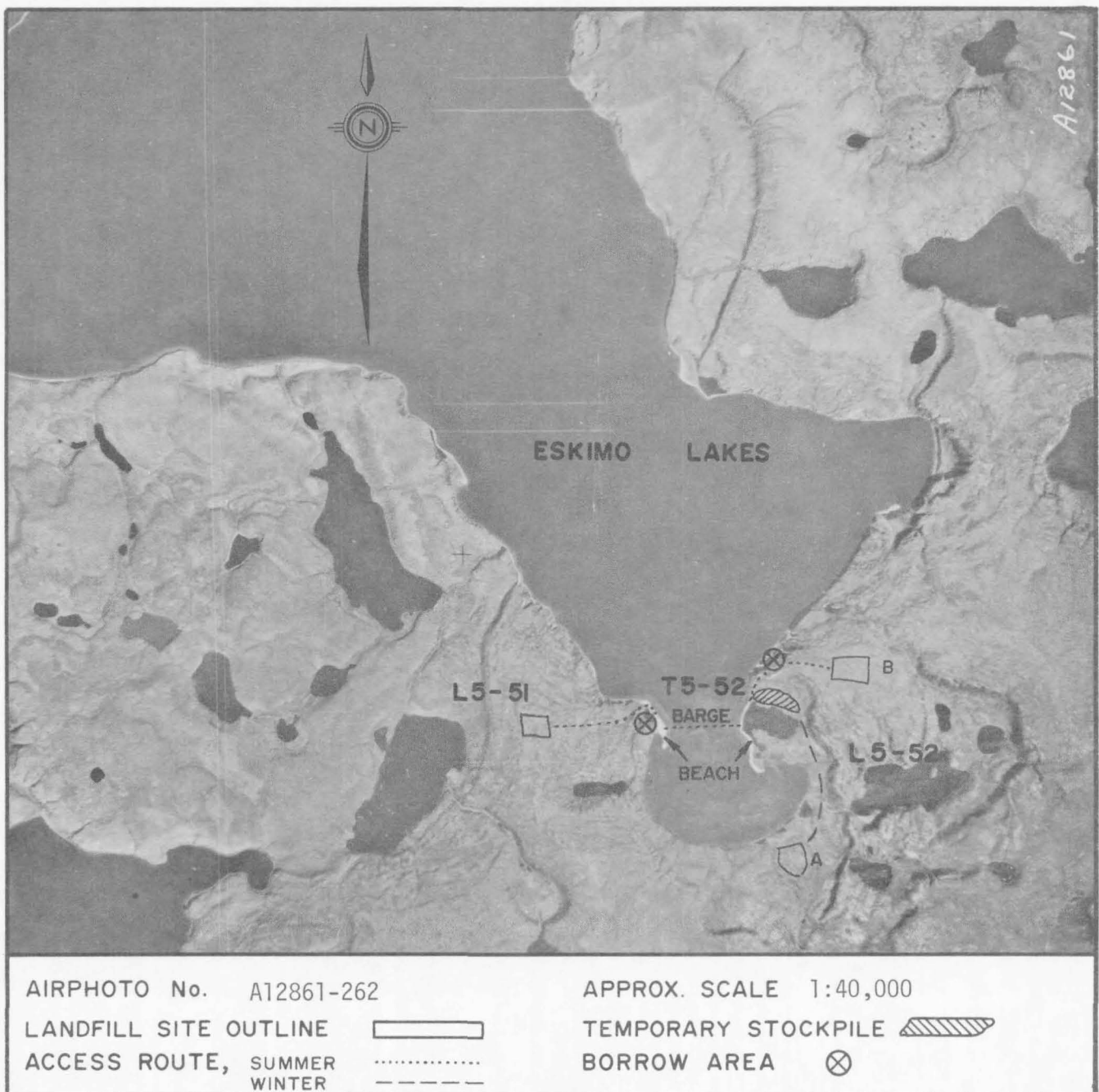
TEMPORARY STOCKPILE: No site available, none required if summer construction.

BEACH: Gravel and sand, 40 m wide.

BORROW SOURCE: Use beach material or sand and gravel from borrow location shown.

ACCESS: 700 m (summer) from beach to landfill site up a steep slope, may require a ramp for access.

DEVELOPMENT: Summer construction of landfill site may be possible. Since the beach is small, and oiled debris volumes would be small, an alternative would be to summer barge the oiled debris to
(Continued on next page)



LANDFILL SITE L5-51 - Continued

DEVELOPMENT: T5-52, a distance of 500 m, and avoid the construction
(Continued) of a ramp on the steep slope leading to L5-51.

LANDFILL SITE L5-52, TEMPORARY STOCKPILE T5-52

LANDFILL SITE: A has an available area of 30,000 m² on lacustrine sand and silt, low to moderate ice content. B has an available area of 40,000 m² on a sand and gravel terrace, ice-cored at depth, but probably low ice content in top 6 m.

TEMPORARY STOCKPILE: Available area of 30,000 m² on same terrain as A.

BEACH: Gravel and sand, 30 m wide.

BORROW SOURCE: Use beach material or sand and gravel from borrow location shown.

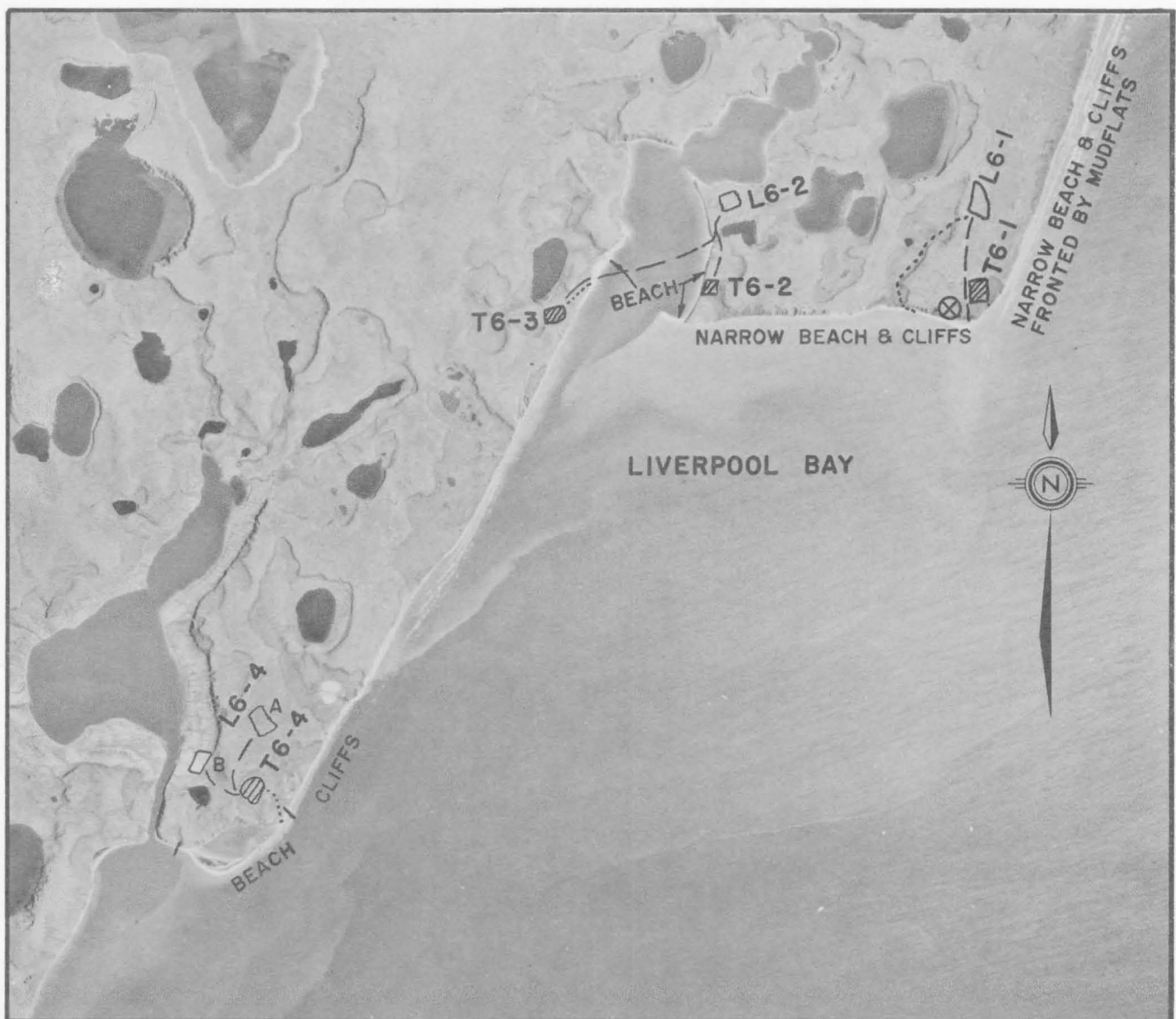
ACCESS: 900 m (winter) from T5-52 to A across level, well drained terrain, 700 m to B up a steep slope (summer or winter).

DEVELOPMENT: A may require winter construction but the ice content should be investigated. Depending on the ice content in the top 6 m, summer construction may be possible at B, but the access route would require construction of a ramp on the steep slope for both summer or winter access.

APPENDIX F
AERIAL PHOTOGRAPHS AND DESCRIPTION OF SITES
MAP 6, LIVERPOOL BAY

LANDFILL SITE L6-1, TEMPORARY STOCKPILE T6-1

- LANDFILL SITE: Available area of 18,000 m² on ice-cored thin morainal deposits overlying glaciofluvial sand. The ice content in the top 6 m is variable.
- TEMPORARY STOCKPILE: Available area of 18,000 m² on same terrain as landfill site.
- BEACH: Sand beach, 50 m wide in front of cliffs.
- BORROW SOURCE: Use beach material or sand from exposed cliffs at location shown.
- ACCESS: 1 km (summer) from beach to landfill site. 500 m (winter) from temporary stockpile to landfill site.
- DEVELOPMENT: Check ice content before attempting summer construction. Temporary stockpile will require a ramp for access to the top of the cliffs.



AIRPHOTO No. A22386-55

APPROX. SCALE 1:50,000

LANDFILL SITE OUTLINE



TEMPORARY STOCKPILE

ACCESS ROUTE, SUMMER
WINTER

BORROW AREA



LANDFILL SITE L6-2, TEMPORARY STOCKPILES T6-2, T6-3

LANDFILL SITE: Available area of 10,000 m² on thin morainal deposits overlying glaciofluvial sand with moderate to high ice content.

TEMPORARY STOCKPILE: T6-2 and T6-3 have available areas of 8,000 m² and 10,000 m² respectively on drained thermokarst lake basins.

BEACH: Sand beach, 5 m to 50 m wide in front of cliffs.

BORROW SOURCE: Use beach material. In the event of an oil spill, there may not be sufficient clean sand available from the beach for construction of a temporary stockpile and landfill site. If necessary, use sand and fines from the exposed cliffs behind the beach.

ACCESS: 500 m (winter) from T6-2 to landfill site, 1.4 km (winter) from T6-3 to landfill site.

DEVELOPMENT: Winter construction of landfill site. A ramp is required at T6-2 in order to gain access to the top of the cliffs.

LANDFILL SITE L6-4, TEMPORARY STOCKPILE T6-4

LANDFILL SITE: A and B have available areas of 20,000 m² and 15,000 m² respectively on a thin, ice-cored morainal deposit overlying glaciofluvial sand with a high ice content. B is on a drained thermokarst lake basin with variable ice content.

TEMPORARY STOCKPILE: Available area of 15,000 m² on a drained thermokarst lake basin with variable ice content.

BEACH: Sand beach, 50 m to 75 m wide.

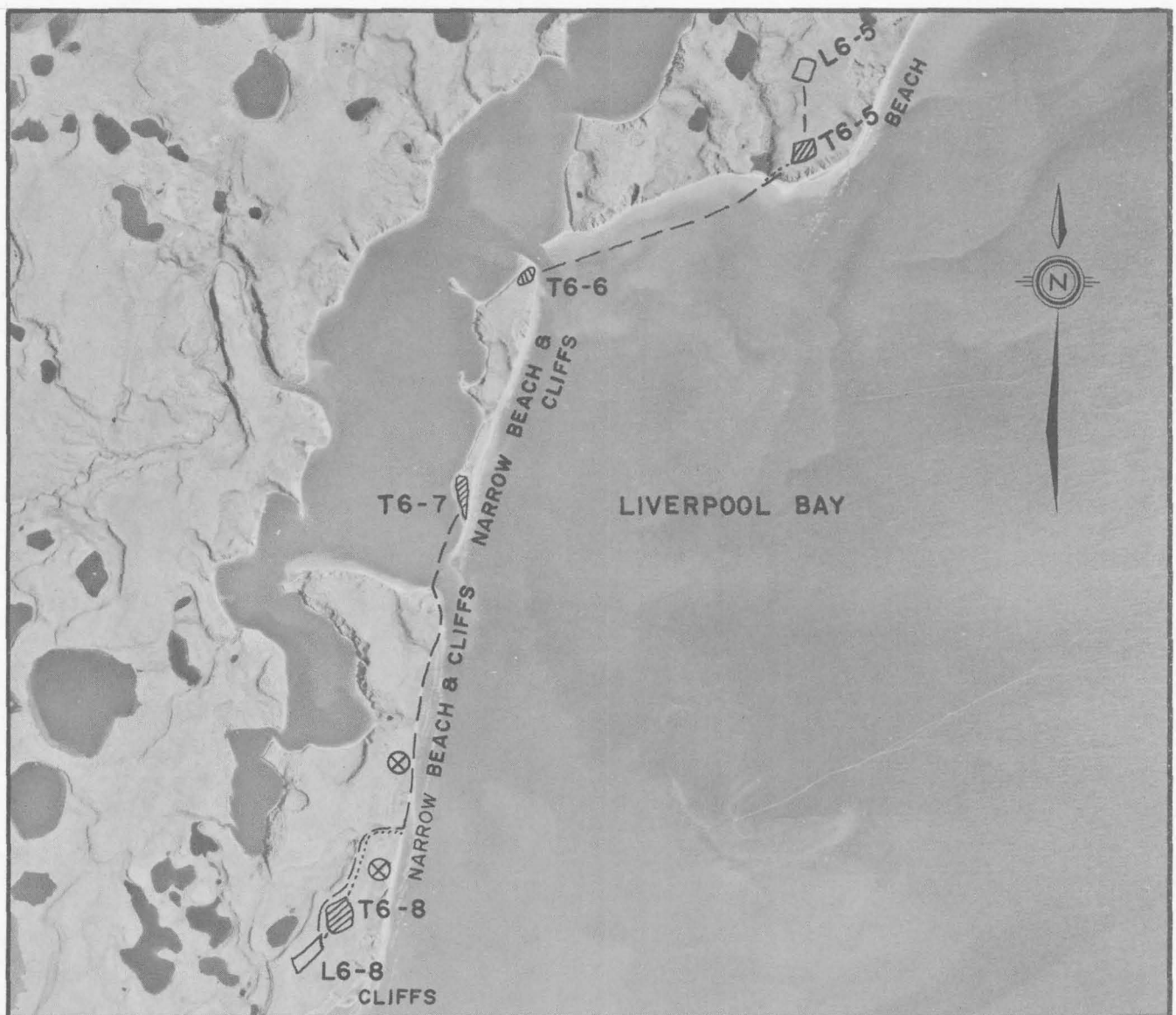
BORROW SOURCE: Use beach material.

ACCESS: 250 m (summer) to temporary stockpile. 400 m (winter) from temporary stockpile to landfill site.

DEVELOPMENT: Winter construction of landfill site. Check the ice contents of A and B and use the site which has the lowest ice content.

LANDFILL SITE L6-5, TEMPORARY STOCKPILE T6-5

- LANDFILL SITE: Available area of 15,000 m² on a thin, ice-cored morainal deposit overlying a glaciofluvial sand terrace with high ice content.
- TEMPORARY STOCKPILE: Available area of 20,000 m² on same terrain as landfill site.
- BEACH: Sand beach, up to 75 m wide, in front of cliffs.
- BORROW SOURCE: Use beach material.
- ACCESS: 200 m (summer) from beach to temporary stockpile, up a steep slope that may require a ramp. 500 m (winter) from temporary stockpile to landfill site.
- DEVELOPMENT: Winter construction of landfill site.



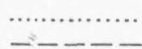
AIRPHOTO No. A22386-26

APPROX. SCALE 1:50,000

LANDFILL SITE OUTLINE



TEMPORARY STOCKPILE

ACCESS ROUTE, SUMMER
WINTER

BORROW AREA



TEMPORARY STOCKPILES T6-6, T6-7

TEMPORARY STOCKPILE: T6-6 and T6-7 have available areas of 8,000 m² and 12,000 m² respectively on a thin ice-cored morainal deposit overlying a glaciofluvial sand terrace with high ice content.

BEACH: Sand beach, 10 m to 20 m wide, in front of cliffs.

BORROW SOURCE: Use beach material.

ACCESS: 3 km (winter) from T6-6 to L6-5 across ice. 3.5 km (winter) to L6-8 from T6-7 across the ice and along the beach.

DEVELOPMENT: In the event of an oil spill, there may not be enough clean sand on the beach for the construction of the temporary stockpiles.

LANDFILL SITE L6-8, TEMPORARY STOCKPILE T6-8

LANDFILL SITE: Available area of 22,000 m² on an ice-cored glaciofluvial sand and gravel terrace. The upper 6 m may have a low ice content.

TEMPORARY STOCKPILE: Available area of 40,000 m² on same terrain as landfill site.

BEACH: Sand beach, up to 50 m wide, in front of cliffs.

BORROW SOURCE: Use beach material or sand from gullies in sand cliffs at two locations shown.

ACCESS: 1.2 km (summer) from beach to landfill site, 700 m (summer) from the temporary stockpile to the beach.

DEVELOPMENT: Since the temporary stockpile is so far from the beach, attempt summer construction of landfill site, but check ice content in the top 6 m before construction.

LANDFILL SITE L6-9

LANDFILL SITE: A and B have available areas of 20,000 m² on an ice-cored glaciofluvial sand terrace. The ice content in the top 6 m may be low.

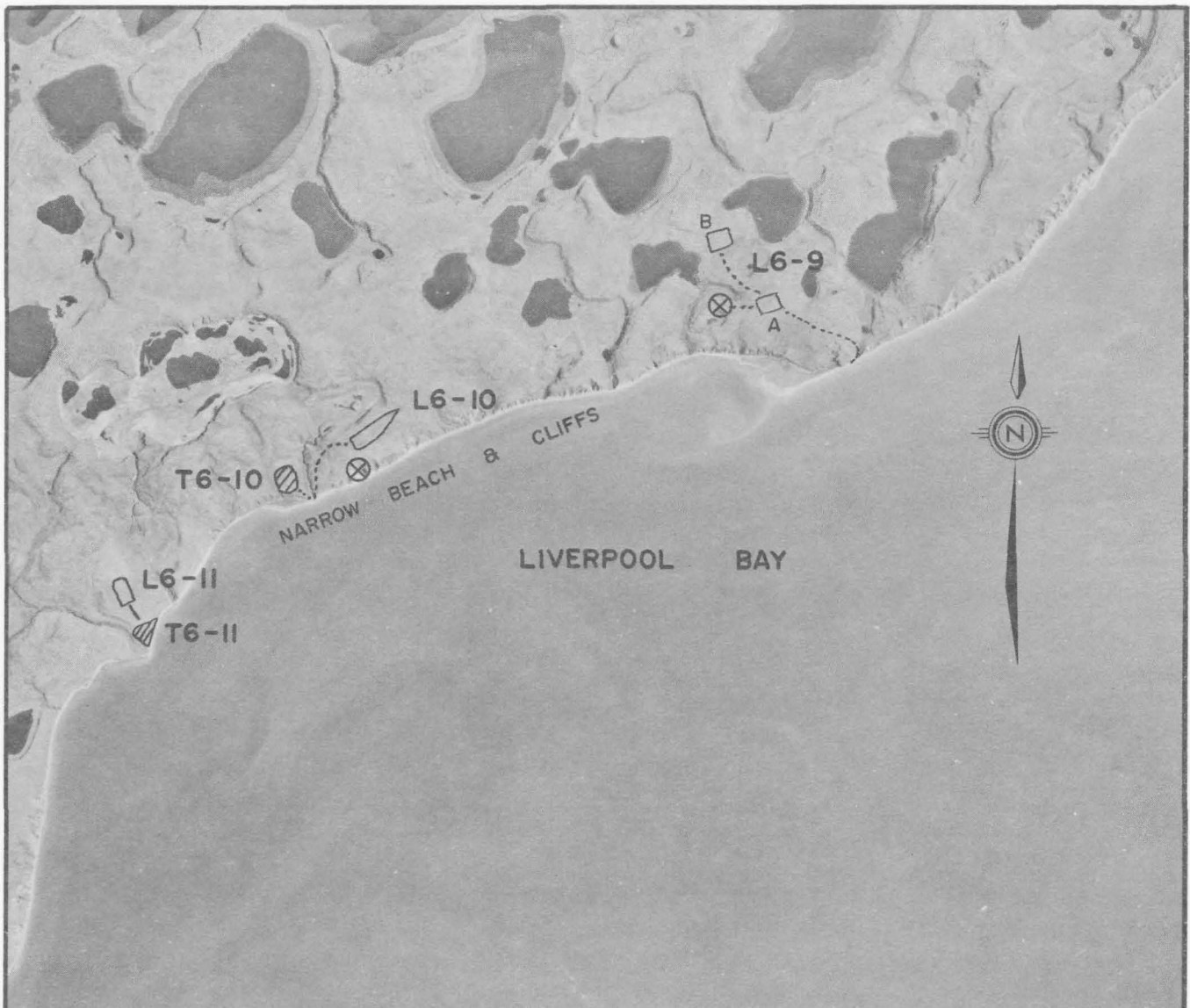
TEMPORARY STOCKPILE: No suitable sites available.

BEACH: Sand beach, up to 40 m wide.

BORROW SOURCE: Use beach material or glaciofluvial sand terrace at location shown.

ACCESS: 800 m (summer) from beach to A, 1.4 km (summer) from beach to B.

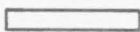
DEVELOPMENT: Check ice content of top 6 m before attempting summer construction of landfill site.



AIRPHOTO No. A22386-13

APPROX. SCALE 1:50,000

LANDFILL SITE OUTLINE



TEMPORARY STOCKPILE

ACCESS ROUTE, SUMMER
WINTER

BORROW AREA



LANDFILL SITE L6-10, TEMPORARY STOCKPILE T6-10

LANDFILL SITE: Available area of 30,000 m² on an ice-cored glaciofluvial sand terrace. The upper 6 m may have a low ice content.

TEMPORARY STOCKPILE: Available area of 30,000 m² on same terrain as landfill site.

BEACH: Sand beach, 5 m to 10 m wide in front of cliffs.

BORROW SOURCE: Use beach material or borrow sand from gully in sand cliffs at location shown.

ACCESS: 500 m (summer) from beach to landfill site on well drained terrain.

DEVELOPMENT: Check ice content in top 6 m of landfill site before attempting summer construction.

LANDFILL SITE L6-11, TEMPORARY STOCKPILE T6-11

LANDFILL SITE: Available area of 20,000 m² on an ice-cored thin morainal deposit overlying a glaciofluvial sand terrace with high ice content.

TEMPORARY STOCKPILE: Available area of 17,000 m² on same terrain as landfill site.

BEACH: Sand beach, 5 m to 10 m wide, in front of cliffs.

BORROW SOURCE: Use beach material.

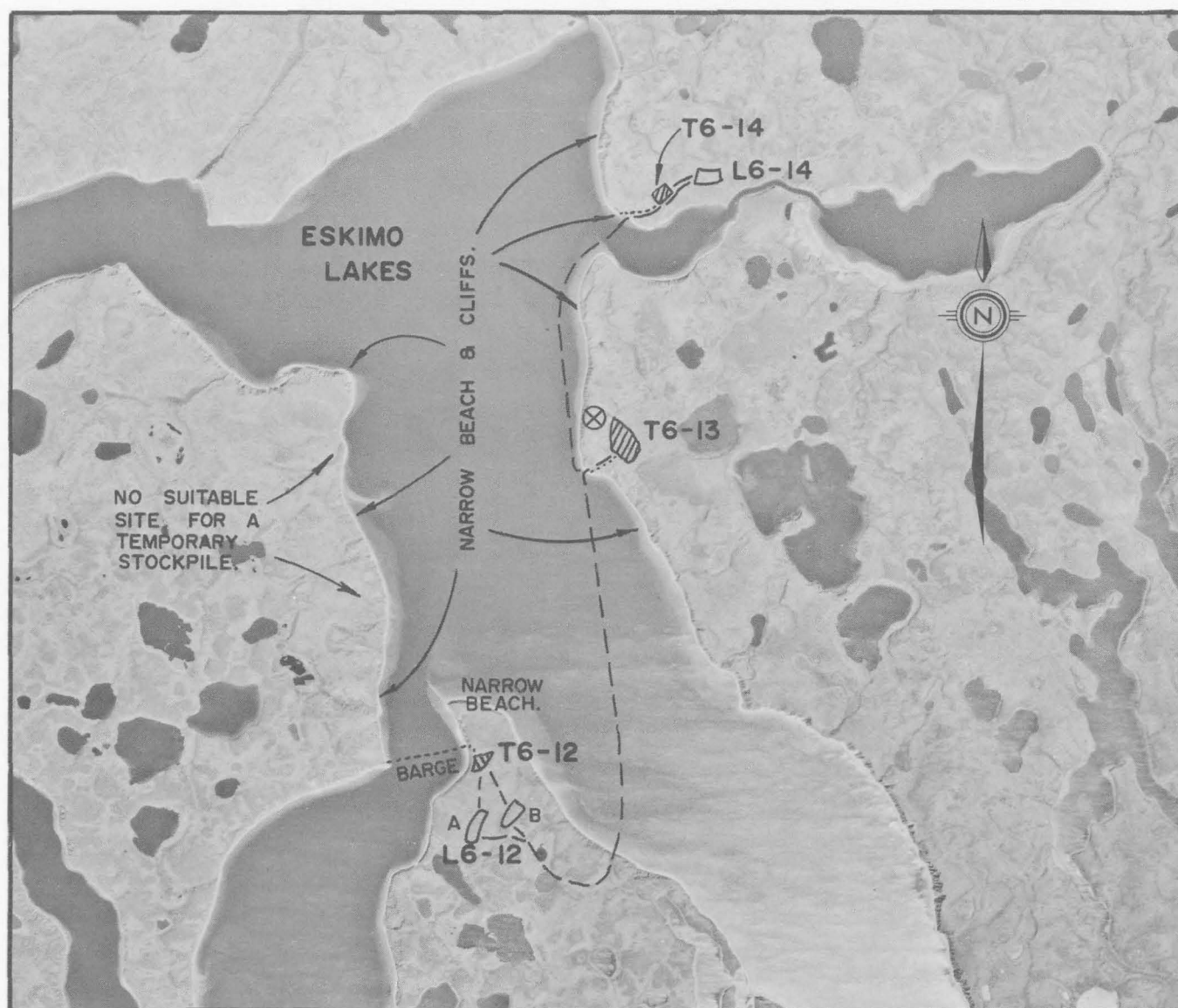
ACCESS: 200 m (winter) from temporary stockpile to landfill site.

DEVELOPMENT: Winter construction of landfill site.

LANDFILL SITE L6-12, TEMPORARY STOCKPILES T6-12, T6-13

- LANDFILL SITE:** A and B have available areas of 20,000 m² and 18,000 m² on a thin ice-cored morainal deposit overlying a glacio-fluvial sand terrace, with moderate to high ice content.
- TEMPORARY STOCKPILE:** T6-12 and T6-13 have available areas of 10,000 m² and 40,000 m² respectively. T6-12 is on same terrain as landfill site. T6-13 is on a drained lake basin containing wet terrain.
- BEACH:** Sand beach, 10 m wide, in front of cliffs.
- BORROW SOURCE:** Use beach material and supplement with fines from exposed cliffs. A sand and gravel source is present adjacent to T6-13.
- ACCESS:** 300 m (winter) from T6-12 to landfill site, 4 km (winter) from T6-13 to L6-12 across the ice.

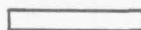
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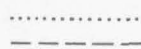
AIRPHOTO No. A22386-104

APPROX. SCALE 1:50,000

LANDFILL SITE OUTLINE



TEMPORARY STOCKPILE

ACCESS ROUTE, SUMMER
WINTER

BORROW AREA



LANDFILL SITE L6-12, TEMPORARY STOCKPILES T6-12, T6-13 - Continued

DEVELOPMENT: Winter construction of landfill site. A ramp will be required for access to T6-12 from the beach due to the steep slope. Some oiled debris from the narrow beach to the northwest may be barged for temporary storage at T6-12 and later disposed at L6-12.

LANDFILL SITE L6-14, TEMPORARY STOCKPILE T6-14

LANDFILL SITE: Available area of 15,000 m² on a thin ice-cored morainal deposit overlying a glaciofluvial sand terrace with medium to high ice content.

TEMPORARY STOCKPILE: Available area of 10,000 m² on same terrain as landfill site.

BEACH: Sand beach, 10 m wide, in front of cliffs.

BORROW SOURCE: Use beach material, supplement with fines and sand from exposed cliffs.

ACCESS: 200 m (summer) to temporary stockpile, 200 m (winter) to landfill site. 2.8 km from T6-13 to landfill site.

DEVELOPMENT: Winter construction of landfill site. In the event of an oil spill, there may not be sufficient clean beach sand available for construction of T6-14 and L6-14.

LANDFILL SITE L6-15, TEMPORARY STOCKPILE T6-15

LANDFILL SITE: A and B have available areas of 25,000 m² and 35,000 m² respectively. A is on a low, wet sand terrace with moderate ice content and several ice wedges. B is on a thin, ice-cored morainal veneer overlying a glaciofluvial sand terrace with moderate to high ice content.

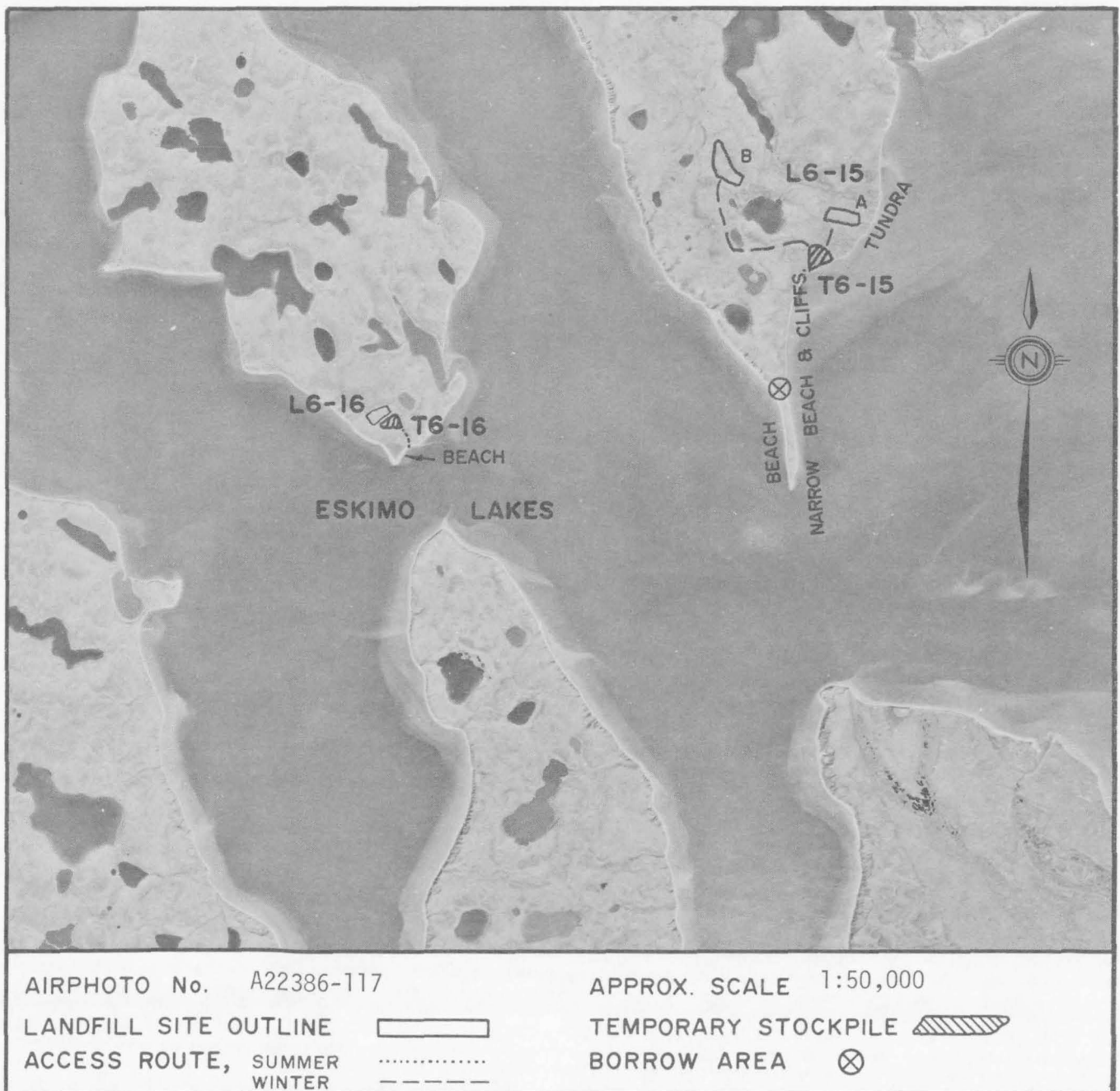
TEMPORARY STOCKPILE: Available area of 25,000 m² on same terrain as A.

BEACH: Sand beach, 10 m wide in front of cliffs.

BORROW SOURCE: Use beach material, or sand terrace at location shown.

ACCESS: 200 m (winter) from temporary stockpile to A, 1.3 km (winter) from temporary stockpile to B.

(Continued on next page)



LANDFILL SITE L6-15, TEMPORARY STOCKPILE T6-15 - Continued

DEVELOPMENT: Winter construction of landfill site. Because of the low, wet terrain, temporary stockpile will require greater quantity of sand than usual and cleanup will be more difficult. Landfill site A is also in wet terrain while site B is well drained.

LANDFILL SITE L6-16, TEMPORARY STOCKPILE T6-16

LANDFILL SITE: Available area of 12,000 m² on a thin, ice-cored morainal deposit overlying a glaciofluvial sand terrace, with moderate to high ice content.

TEMPORARY STOCKPILE: Available area of 8,000 m² on same terrain as landfill site.

BEACH: Sand, 25 m wide.

BORROW SOURCE: Use beach material.

ACCESS: 150 m (summer) to temporary stockpile, landfill site is adjacent to temporary stockpile (winter).

DEVELOPMENT: Winter construction of landfill site.

LANDFILL SITE L6-17, TEMPORARY STOCKPILE T6-17

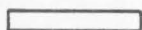
- LANDFILL SITE: A and B have available areas of 30,000 m² and 25,000 m² respectively on a sand and gravel terrace with low ice content.
- TEMPORARY STOCKPILE: If required, 2 sites with available areas of 45,000 m² and 22,000 m² respectively on same terrain as landfill site.
- BEACH: Sand beach, 10 m to 50 m wide.
- BORROW SOURCE: Use beach material or the sand and gravel terrace at location shown.
- ACCESS: 300 m (summer) to A or B from the beach over well drained terrain.
- DEVELOPMENT: Summer construction of landfill site is possible. Site A is preferred because of slightly better drainage.



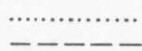
AIRPHOTO No. A22386-180

APPROX. SCALE 1:50,000

LANDFILL SITE OUTLINE



TEMPORARY STOCKPILE

ACCESS ROUTE, SUMMER
WINTER

BORROW AREA



LANDFILL SITE L6-18, TEMPORARY STOCKPILE T6-18

LANDFILL SITE: Available area of 22,000 m² on a sand and gravel terrace with low ice content.

TEMPORARY STOCKPILE: If required, available area of 45,000 m² on same terrain as landfill site.

BEACH: Sand beach, 10 m to 20 m wide in front of cliffs.

BORROW SOURCE: Use beach material or sand and gravel terrace at location shown.

ACCESS: 300 m (summer) from beach to landfill site on well drained terrain.

DEVELOPMENT: Summer construction of landfill site is possible.

TEMPORARY STOCKPILE T6-19

TEMPORARY STOCKPILE: Available area of 25,000 m² on a sand and gravel terrace with low ice content.

BEACH: Sand beach, 10 m wide in front of cliffs.

BORROW SOURCE: Use beach material or sand and gravel terrace at location shown.

ACCESS: Adjacent to beach. 3 km (winter) across the ice to L6-18.

DEVELOPMENT: If L6-18 is summer construction, T6-19 will not be needed.

LANDFILL SITE L6-20, TEMPORARY STOCKPILE T6-20

LANDFILL SITE: Available area of 25,000 m² on a sand terrace with low ice content.

TEMPORARY STOCKPILE: If required, available area of 45,000 m² on same terrain as the landfill site.

LANDFILL SITE L6-20, TEMPORARY STOCKPILE T6-20 - Continued

BEACH: Sand beach, 10 m wide behind mudflats.

BORROW SOURCE: Use beach material or sand terrace at location shown.

ACCESS: Access to the beach is possible along the beach from L6-21 (B), 250 m (summer) from beach to landfill site on well drained terrain.

DEVELOPMENT: Summer construction of landfill site is possible.

LANDFILL SITE L6-21, TEMPORARY STOCKPILE T6-21

LANDFILL SITE: A and B have available areas of 45,000 m² and 12,000 m² respectively on a sand terrace with low ice content.

TEMPORARY STOCKPILE: If required, available area of 60,000 m² on same terrain as landfill site.

BEACH: Sand beach, 10 m to 50 m wide in front of cliffs.

BORROW SOURCE: Use beach material or sand terrace at two locations shown.

ACCESS: 200 m (summer) from beach to landfill site on well drained terrain.

DEVELOPMENT: Summer construction of landfill site is possible.

LANDFILL SITE L6-22, TEMPORARY STOCKPILE T6-22

LANDFILL SITE: Available area of 30,000 m² on a sand and gravel terrace with low ice content.

TEMPORARY STOCKPILE: If required, available area of 25,000 m² on same terrain as landfill site.

LANDFILL SITE L6-22, TEMPORARY STOCKPILE T6-22 - Continued

BEACH: Sand beach, 10 m wide in front of low cliffs.

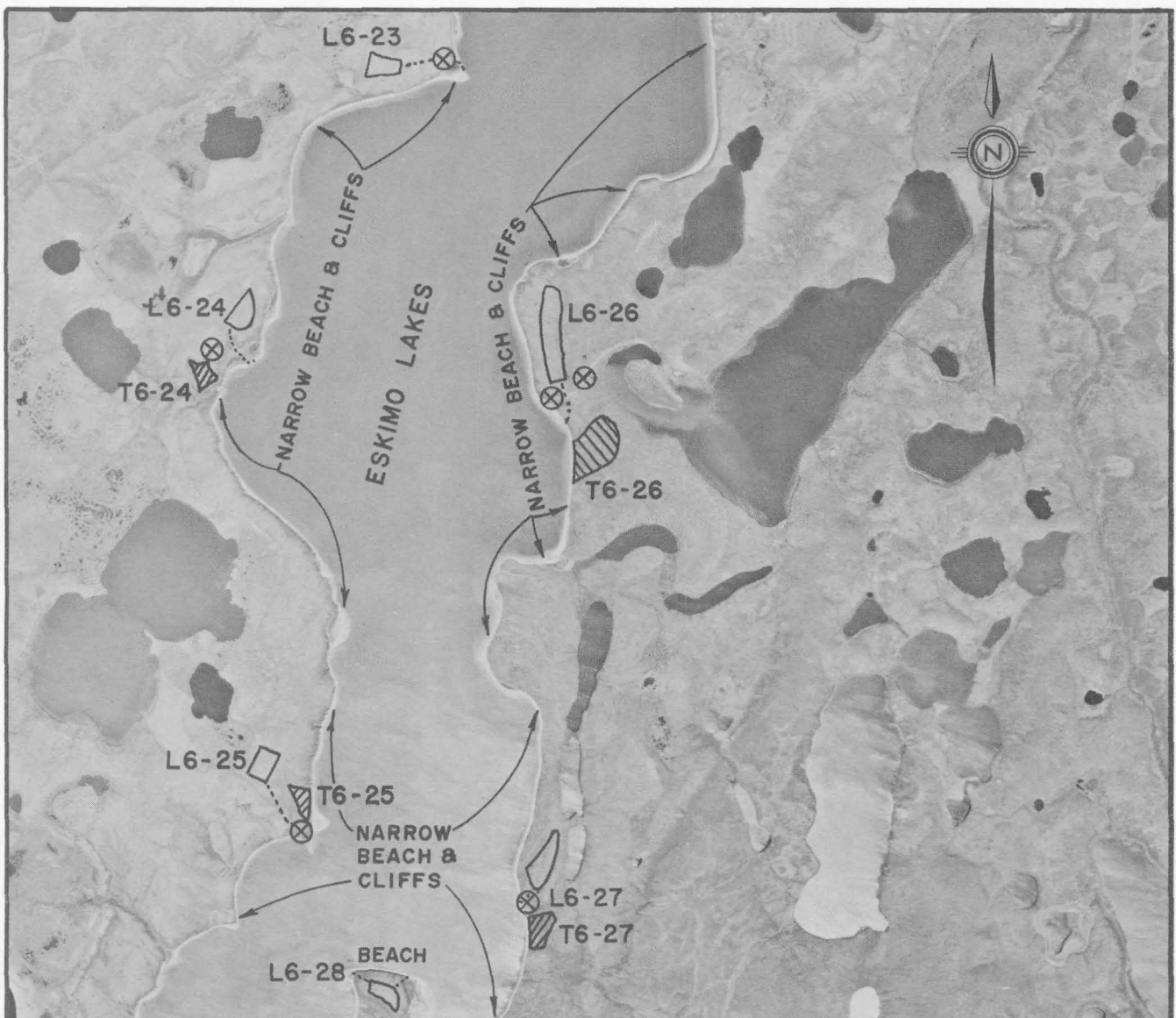
BORROW SOURCE: Use beach material or sand and gravel terrace at two locations shown.

ACCESS: 250 m (summer) from beach to landfill site.

DEVELOPMENT: Summer construction of landfill site is possible.

LANDFILL SITE L6-23

- LANDFILL SITE: Available area of 30,000 m² on a sand and gravel terrace with low ice content.
- TEMPORARY STOCKPILE: None required for summer construction. If necessary, 25,000 m² are available at location of selected borrow area.
- BEACH: Sand beach, 10 m to 50 m wide, in front of low cliffs.
- BORROW SOURCE: Use beach material or sand and gravel terrace at location shown.
- ACCESS: 400 m (summer) from beach to landfill site on well drained terrain.
- DEVELOPMENT: Summer construction of landfill site is possible.



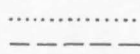
AIRPHOTO No. A22386-199

APPROX. SCALE 1:50,000

LANDFILL SITE OUTLINE



TEMPORARY STOCKPILE

ACCESS ROUTE, SUMMER
WINTER

BORROW AREA



LANDFILL SITE L6-24, TEMPORARY STOCKPILE T6-24

LANDFILL SITE: Available area of 35,000 m² on a sand and gravel terrace with low ice content.

TEMPORARY STOCKPILE: If required, available area of 15,000 m² on same terrain as landfill site.

BEACH: Sand beach, 10 m to 20 m wide, in front of cliffs.

BORROW SOURCE: Use beach material or sand and gravel terrace at location shown.

ACCESS: 300 m (summer) from beach to landfill site on well drained terrain.

DEVELOPMENT: Summer construction of landfill site is possible.

LANDFILL SITE L6-25, TEMPORARY STOCKPILE T6-25

LANDFILL SITE: Available area of 30,000 m² on a sand and gravel terrace with low ice content.

TEMPORARY STOCKPILE: If required, available area of 20,000 m² on same terrain as landfill site.

BEACH: Sand beach, 10 m to 50 m wide, in front of cliffs.

BORROW SOURCE: Use beach material or sand and gravel terrace at location shown.

ACCESS: 600 m (summer) from beach to landfill site on well drained terrain.

DEVELOPMENT: Summer construction of landfill site is possible.

LANDFILL SITE L6-26, TEMPORARY STOCKPILE T6-26

LANDFILL SITE: Available area of 70,000 m² on a sand and gravel terrace with low ice content.

LANDFILL SITE L6-26, TEMPORARY STOCKPILE T6-26 - Continued

TEMPORARY STOCKPILE: If required, available area of 75,000 m² or more on same terrain as landfill site.

BEACH: Sand beach, 10 m wide in front of cliffs.

BORROW SOURCE: Use beach material or sand and gravel terrace at location shown.

ACCESS: 300 m (summer) from beach to landfill site on well drained terrain.

DEVELOPMENT: Summer construction of landfill site is possible.

LANDFILL SITE L6-27, TEMPORARY STOCKPILE T6-27

LANDFILL SITE: Available area of 40,000 m² on a sand and gravel terrace with low ice content.

TEMPORARY STOCKPILE: If required, available area of 35,000 m² on same terrain as landfill site.

BEACH: Sand beach, 10 m to 20 m wide, in front of cliffs.

BORROW SOURCE: Use beach material or sand and gravel terrace at location shown.

ACCESS: 150 m (summer) from beach to landfill site (through the borrow area).

DEVELOPMENT: Summer construction of landfill site is possible.

LANDFILL SITE L6-28

LANDFILL SITE: Available area of 20,000 m² on a sand and gravel terrace with low ice content.

TEMPORARY STOCKPILE: No suitable sites, none required if summer construction.

LANDFILL SITE L6-28 - Continued

BEACH: Sand beach, 10 m to 75 m wide.

BORROW SOURCE: Use beach material.

ACCESS: 150 m (summer) from beach to landfill site.

DEVELOPMENT: Summer construction of landfill site is possible.

APPENDIX G
AERIAL PHOTOGRAPHS AND DESCRIPTION OF SITES
MAP 7, WOOD BAY TO CAPE BATHURST

LANDFILL SITE L7-1, TEMPORARY STOCKPILE T7-1

LANDFILL SITE: Available area of 75,000 m² on a marine silt with a low to moderate ice content.

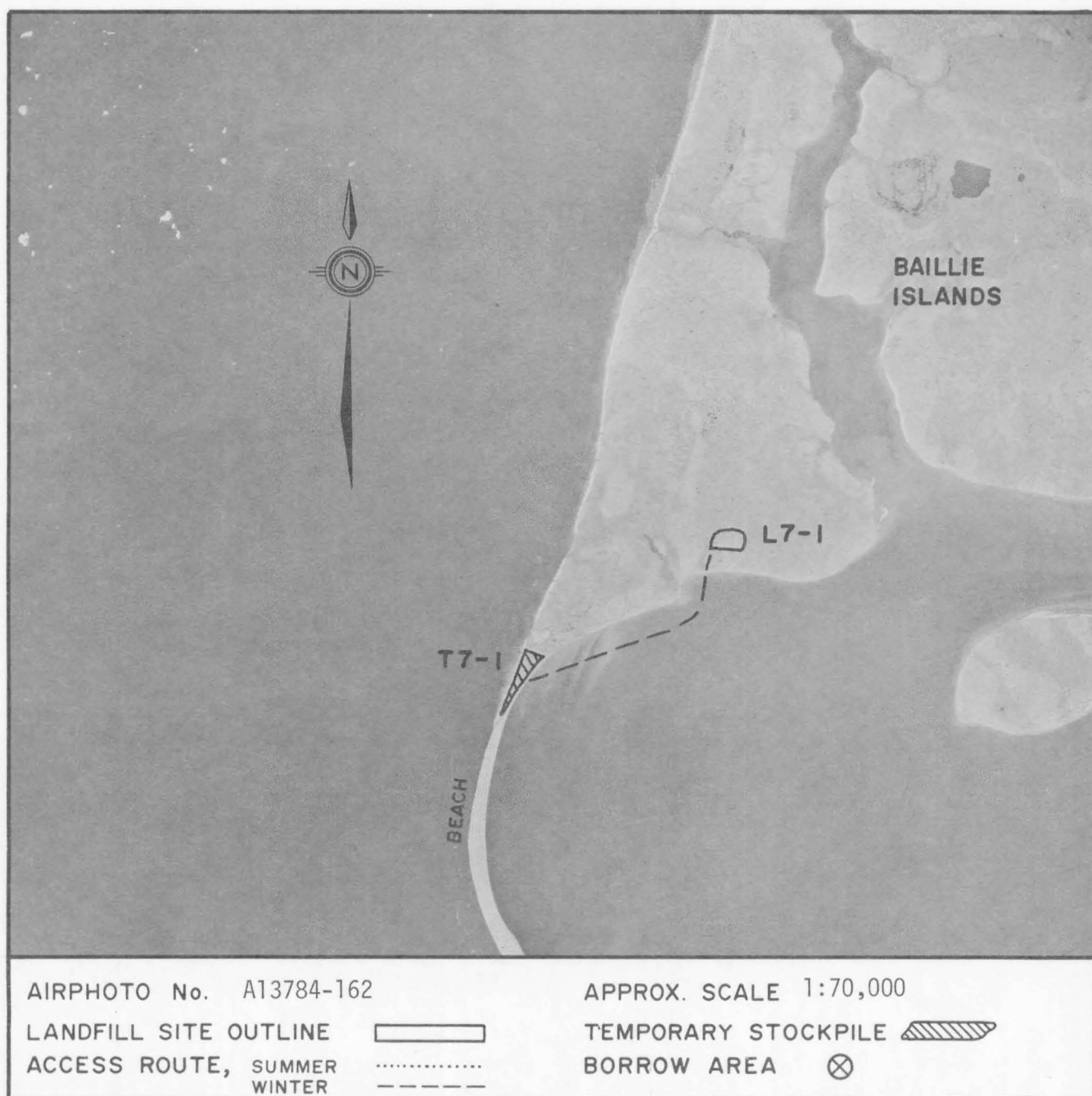
TEMPORARY STOCKPILE: Available area of 50,000 m² on same terrain as landfill site.

BEACH: Sand spit, 200 m wide.

BORROW SOURCE: Use beach material.

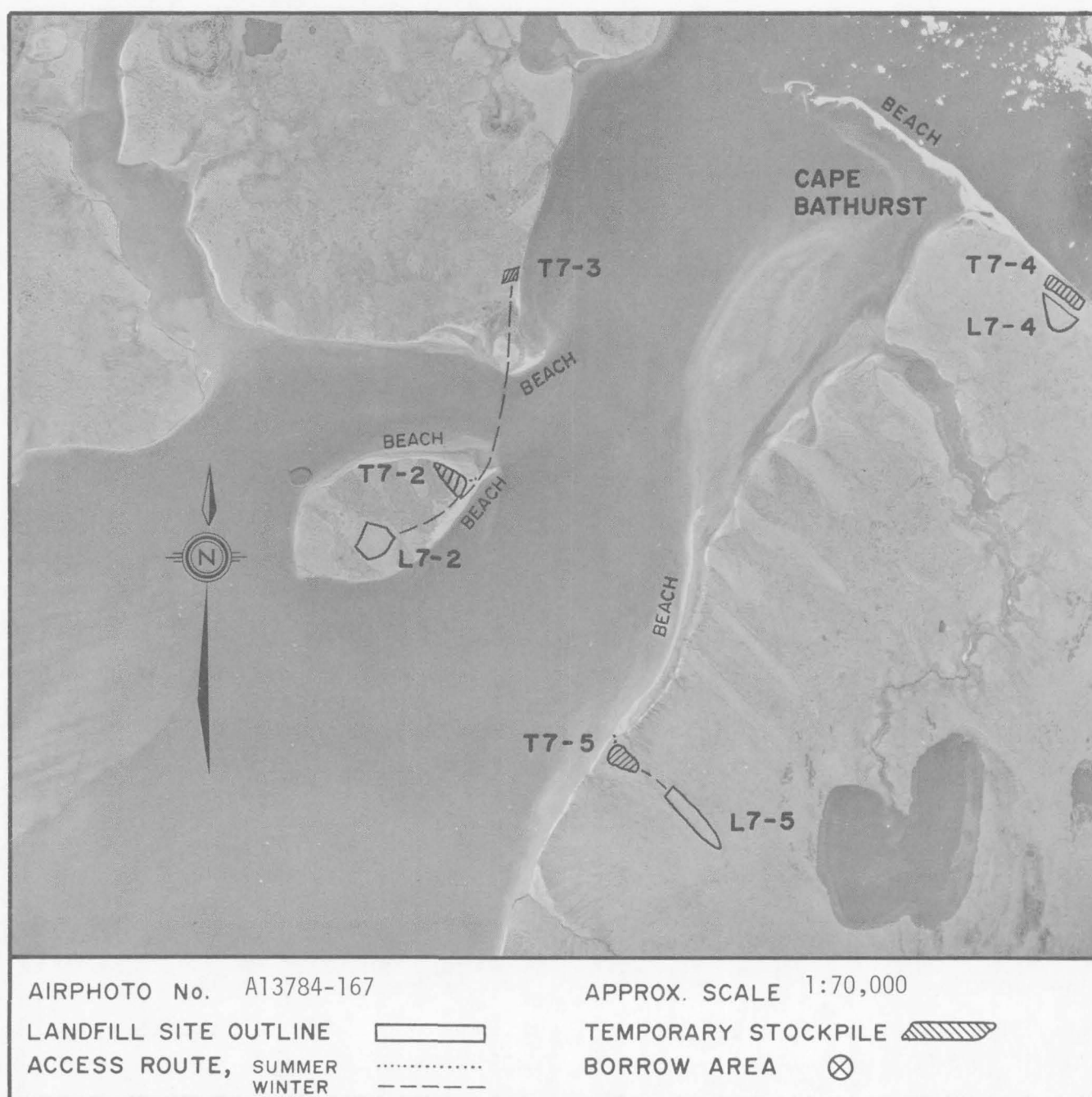
ACCESS: 2.5 km (winter) across the sea ice.

DEVELOPMENT: Winter construction of landfill site.



LANDFILL SITE L7-2, TEMPORARY STOCKPILES T7-2, T7-3

- LANDFILL SITE: Available area of 90,000 m² on a wind blown sand veneer over marine silt, with a low to moderate ice content.
- TEMPORARY STOCKPILE: T7-2 and T7-3 have available areas of 40,000 m² and 25,000 m² respectively. T7-2 is on a wind blown sand veneer over a marine silt. T7-3 is on marine silt.
- BEACH: Sand, up to 50 m wide.
- BORROW SOURCE: Use beach sand.
- ACCESS: 500 m (winter) from T7-2 and 3.5 km from T7-3 across sea ice to the landfill site.
- DEVELOPMENT: Winter construction of landfill site.



LANDFILL SITE L7-4, TEMPORARY STOCKPILE T7-4

LANDFILL SITE: Available area of 80,000 m² on a marine silt with a low to moderate ice content.

TEMPORARY STOCKPILE: Available area of 75,000 m² on same material as landfill site.

BEACH: Sand spit, minor amount of fine gravel, 100 m wide.

BORROW SOURCE: Use beach sand.

ACCESS: Temporary stockpile is adjacent to landfill site. Cliffs in front of temporary stockpile will require an earth fill ramp for access.

DEVELOPMENT: Winter construction of landfill site.

LANDFILL SITE L7-5, TEMPORARY STOCKPILE T7-5

LANDFILL SITE: Available area of 120,000 m² on a wind blown sand veneer over marine silt, with low to moderate ice content.

TEMPORARY STOCKPILE: Available area of 60,000 m² on same terrain as landfill site.

BEACH: Sand spit, up to 75 m wide.

BORROW SOURCE: Use beach sand.

ACCESS: 500 m (winter).

DEVELOPMENT: Winter construction of landfill site.

LANDFILL SITE L7-6, TEMPORARY STOCKPILE T7-6

LANDFILL SITE: Available area of 50,000 m² on a wind blown sand veneer over marine silt, with low to moderate ice content.

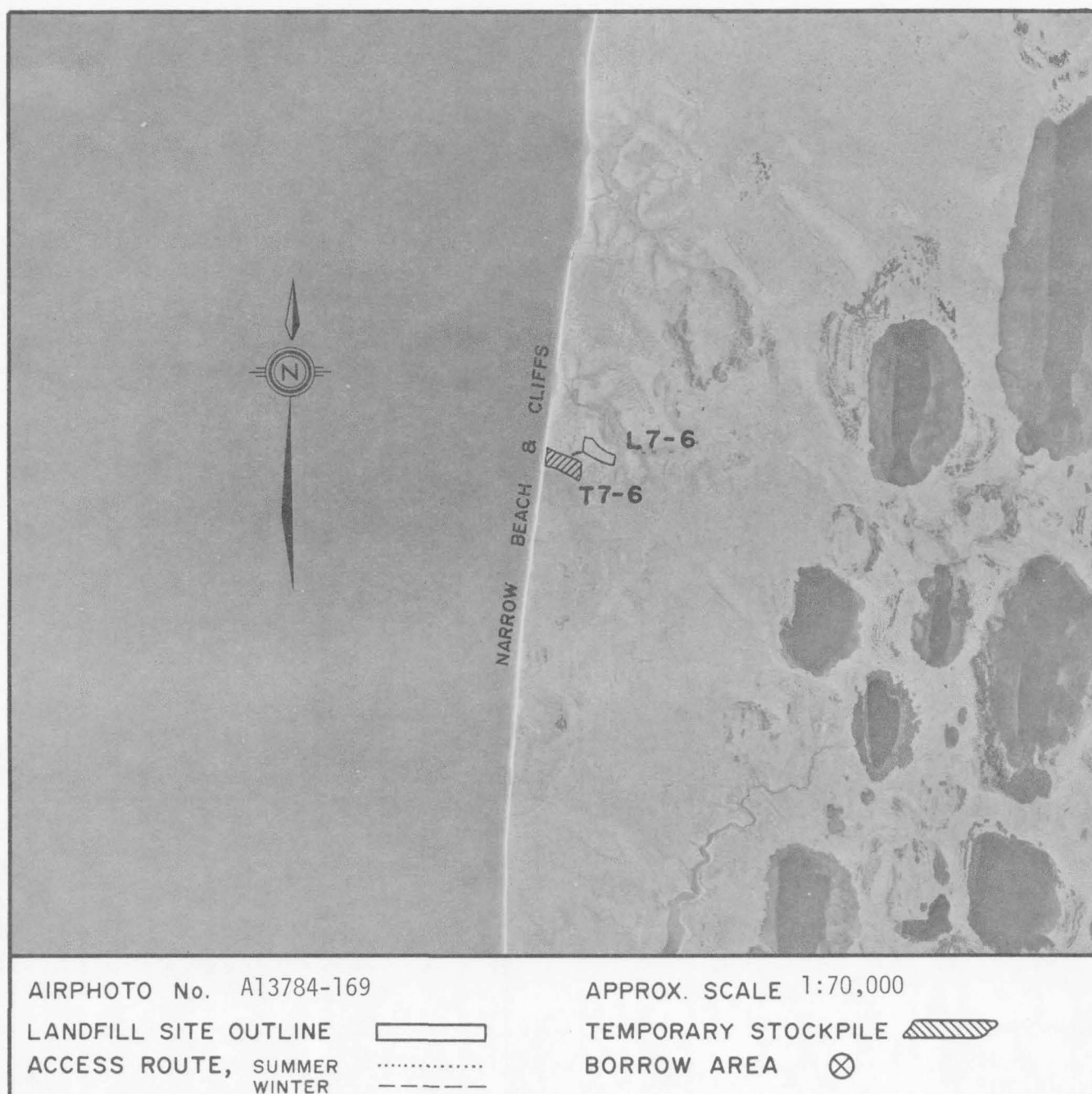
TEMPORARY STOCKPILE: Available area of 80,000 m² on same terrain as landfill site.

BEACH: Sand beach, 25 m wide in front of cliffs.

BORROW SOURCE: Use beach sand.

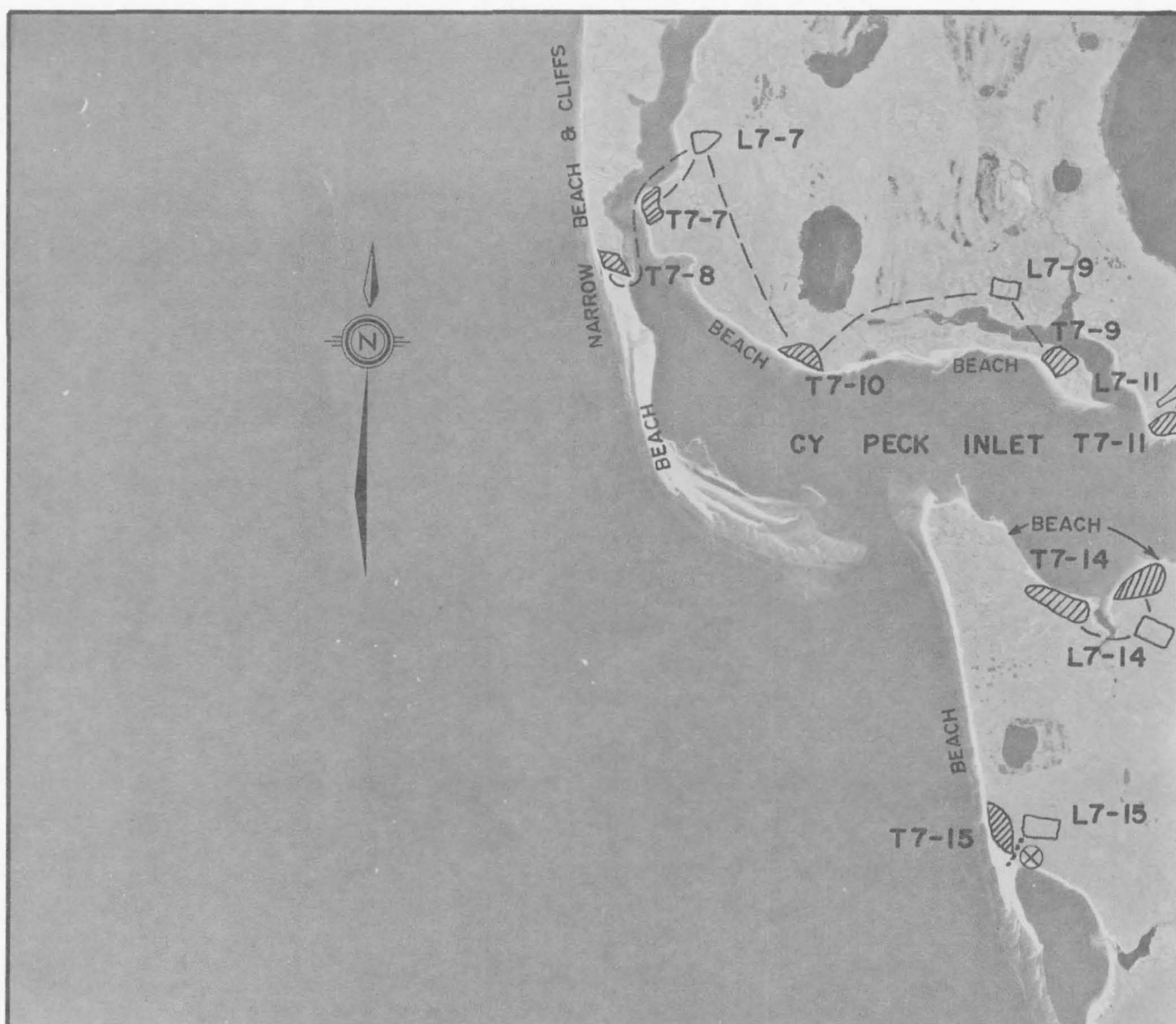
ACCESS: 100 - 200 m (winter). Low cliffs in front of temporary stockpile will require an earth fill ramp for access.

DEVELOPMENT: Winter construction of landfill site.



LANDFILL SITE L7-7, TEMPORARY STOCKPILES T7-7, T7-8

- LANDFILL SITE: Available area of 40,000 m² on marine silt with low to moderate ice content.
- TEMPORARY STOCKPILE: T7-7 and T7-8 have available areas of 50,000 m² and 40,000 m² respectively on same terrain as landfill site.
- BEACH: Sand, 40 m wide in front of T7-7 and 200 - 300 m wide in front of T7-8.
- BORROW SOURCE: Use beach sand.
- ACCESS: 800 m from T7-7 to L7-7, 1.8 km from T7-8 to L7-7 (winter).
Also possible to haul debris 2.2 km from T7-10 to L7-7 (winter).
- DEVELOPMENT: Winter construction of landfill site.



AIRPHOTO No. A13784-171

APPROX. SCALE 1:70,000

LANDFILL SITE OUTLINE



TEMPORARY STOCKPILE

ACCESS ROUTE, SUMMER
ACCESS ROUTE, WINTER

BORROW AREA



LANDFILL SITE L7-9, TEMPORARY STOCKPILES T7-9, T7-10

LANDFILL SITE: Available area of 50,000 m² on a wind blown sand veneer over marine silt with a low to moderate ice content.

TEMPORARY STOCKPILE: T7-9 and T7-10 have available areas of 75,000 m² and 60,000 m² respectively on same terrain as landfill site.

BEACH: Sand, 50 m wide.

BORROW SOURCE: Use beach sand.

ACCESS: 700 m from T7-9, 2 km from T7-10 (winter). Also possible to haul debris 2.2 km from T7-10 (winter) to L7-7.

DEVELOPMENT: Winter construction of landfill site.

LANDFILL SITE L7-11, TEMPORARY STOCKPILE T7-11

LANDFILL SITE: Available area of 40,000 m² on a wind blown sand veneer over marine silt with low to moderate ice content.

TEMPORARY STOCKPILE: Available area of 65,000 m² on same terrain as landfill site.

BEACH: Sand, 50 m wide.

BORROW SOURCE: Use beach sand.

ACCESS: 100 m (winter).

DEVELOPMENT: Winter construction of landfill site.

LANDFILL SITE L7-14, TEMPORARY STOCKPILE T7-14

LANDFILL SITE: Available area of 70,000 m² on a glaciofluvial sand terrace with low to moderate ice content.

TEMPORARY STOCKPILE: Two sites with available areas of 140,000 m² and 120,000 m² on same material as landfill site.

LANDFILL SITE L7-14, TEMPORARY STOCKPILE T7-14 - Continued

BEACH: Sand, 50 m wide.

BORROW SOURCE: Use beach sand.

ACCESS: 200 m and 700 m (winter) from the two temporary stockpiles.

DEVELOPMENT: Winter construction of landfill site may be necessary. Should check ice content to see if summer construction is possible.

LANDFILL SITE L7-15, TEMPORARY STOCKPILE T7-15

LANDFILL SITE: Available area of 75,000 m² on a glaciofluvial sand terrace with low to moderate ice content.

TEMPORARY STOCKPILE: Available area of 75,000 m² on the same terrain as landfill site.

BEACH: Sand, 100 m wide and fronted by mudflats. Access made possible by Cy Peck Inlet.

BORROW SOURCE: Use beach material or sand terrace at location shown.

ACCESS: 100 m from temporary stockpile (winter) or 200 m from beach (summer).

DEVELOPMENT: Check ice content before attempting summer construction of landfill site.

LANDFILL SITE L7-16, TEMPORARY STOCKPILE T7-16

LANDFILL SITE: Available area of 75,000 m² on a glaciofluvial sand terrace with low ice content.

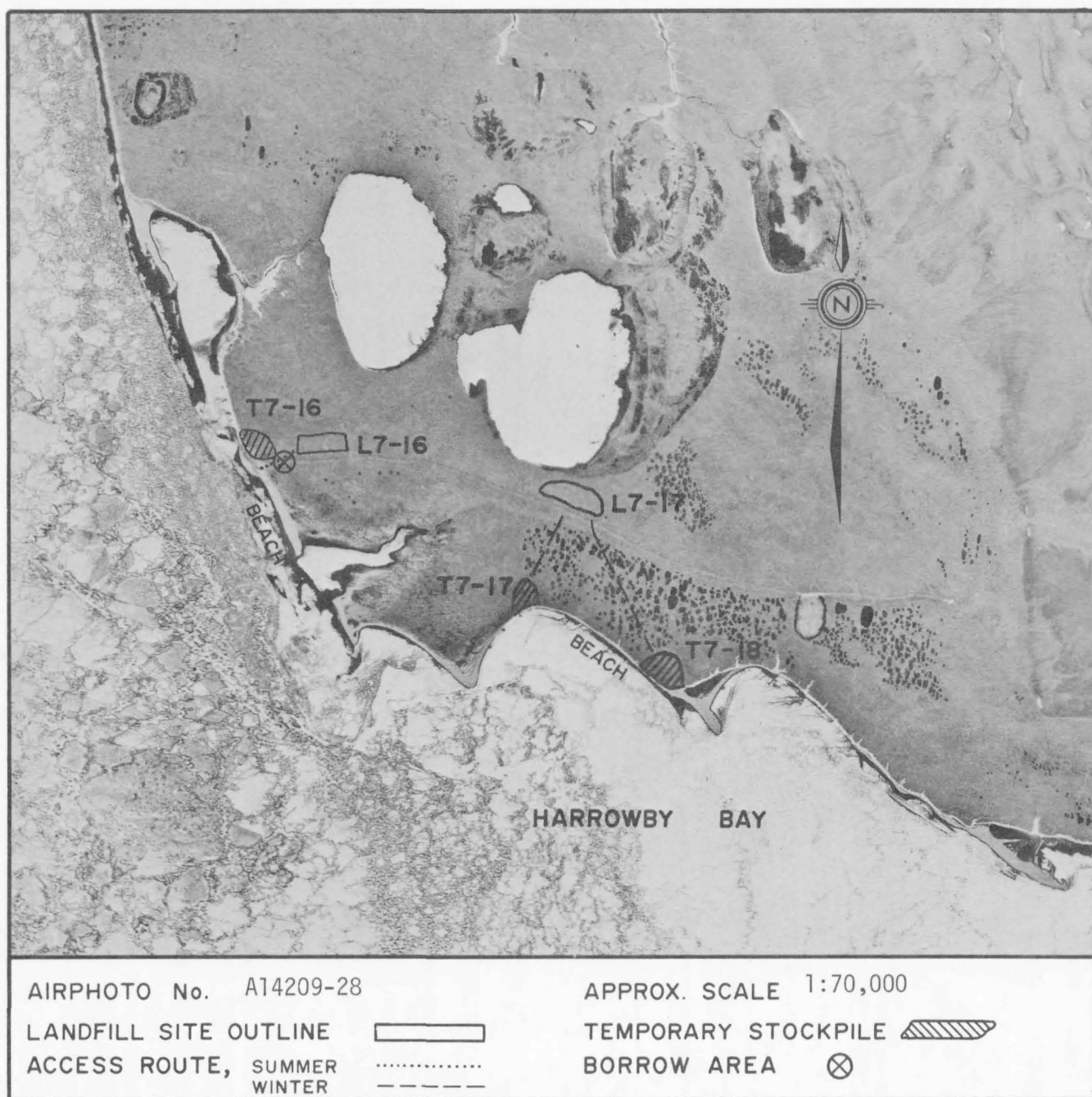
TEMPORARY STOCKPILE: If required, available area of 70,000 m² on same terrain as the landfill site.

BEACH: Sand, 100 m wide.

BORROW SOURCE: Use beach material or sand terrace at location shown.

ACCESS: 500 m from beach (summer).

DEVELOPMENT: Check ice content to determine if landfill site is suitable for summer construction.



LANDFILL SITE L7-17, TEMPORARY STOCKPILES T7-17, T7-18

LANDFILL SITE: Available area of 120,000 m² on a glaciofluvial sand terrace with low ice content.

TEMPORARY STOCKPILE: T7-17 and T7-18 have available areas of 55,000 m² and 90,000 m² on a lower sand terrace with a low to medium ice content.

BEACH: Sand, 50 m to 100 m wide.

BORROW SOURCE: Use beach sand.

ACCESS: 800 m from T7-17 and 1.5 km from T7-18 to the landfill site along wet terrain (winter).

DEVELOPMENT: Winter construction of landfill site due to low wet terrain along access routes.

LANDFILL SITE L7-19, TEMPORARY STOCKPILE T7-19

LANDFILL SITE: Available area of 50,000 m² on a gravel and sand terrace with low ice content.

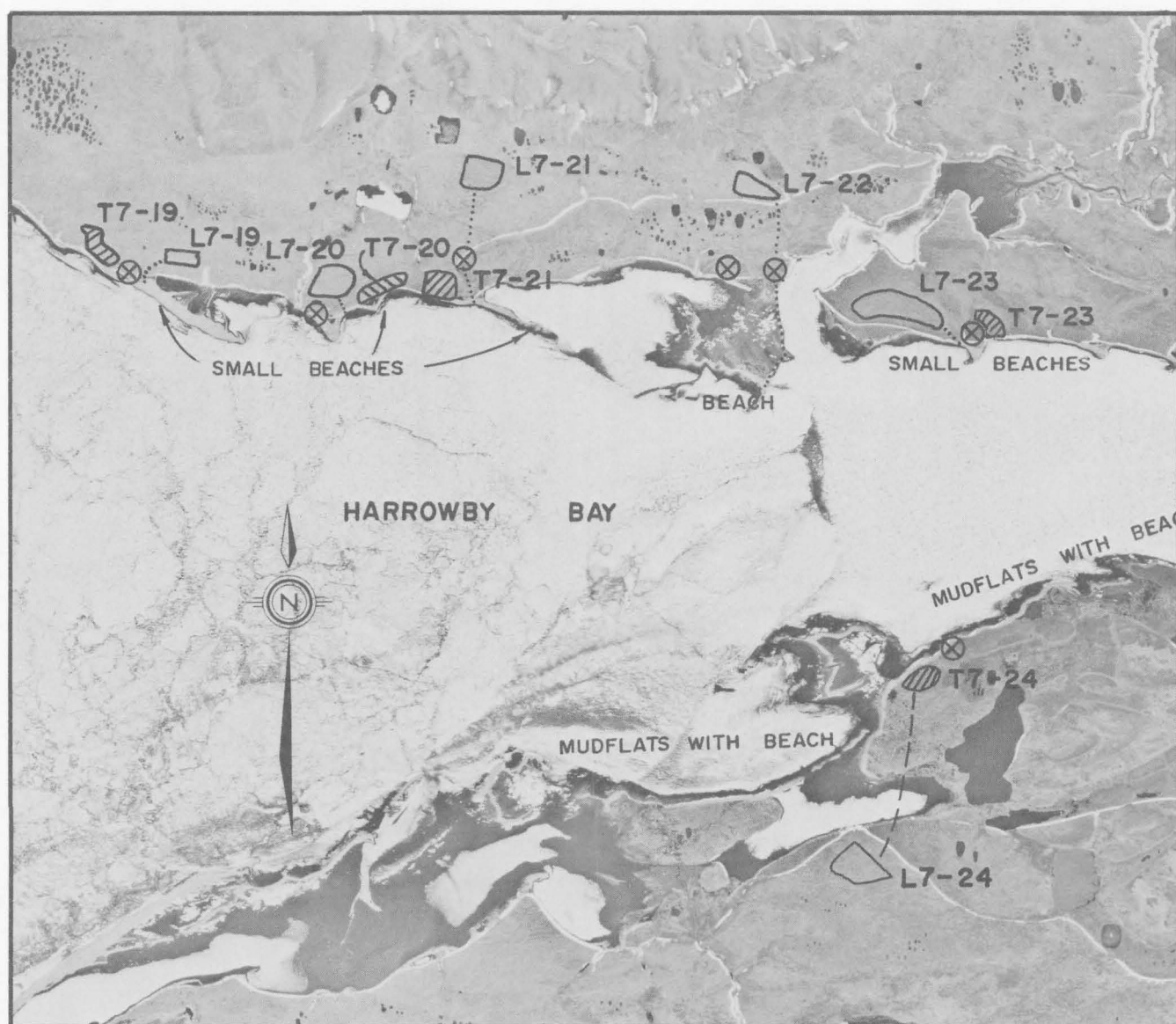
TEMPORARY STOCKPILE: If required, available area of 70,000 m² on a gravel and sand terrace.

BEACH: Gravel and sand, 100 m wide.

BORROW SOURCE: Use beach material, also gravel and sand terrace at location shown.

ACCESS: 300 m (summer) from beach to the landfill site.

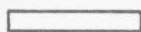
DEVELOPMENT: Check ice content before attempting summer construction of landfill site.



AIRPHOTO No. A14147-117

APPROX. SCALE 1:70,000

LANDFILL SITE OUTLINE



TEMPORARY STOCKPILE

ACCESS ROUTE, SUMMER
WINTER

BORROW AREA



LANDFILL SITE L7-20, TEMPORARY STOCKPILE T7-20

LANDFILL SITE: Available area of 90,000 m² on a gravel and sand terrace with low ice content.

TEMPORARY STOCKPILE: If required, available area of 60,000 m² on same terrain as landfill site.

BEACH: Gravel and sand, up to 100 m wide.

BORROW SOURCE: Use beach material or gravel and sand terrace at location shown.

ACCESS: 200 m (summer) from beach to the landfill site.

DEVELOPMENT: Check ice content before attempting summer construction of landfill site.

LANDFILL SITE L7-21, TEMPORARY STOCKPILE T7-21

LANDFILL SITE: Available area of 160,000 m² on a gravel and sand terrace with low ice content.

TEMPORARY STOCKPILE: If required, available area of 90,000 m² on same terrain as landfill site.

BEACH: Gravel and sand, up to 75 m wide.

BORROW SOURCE: Use beach material or gravel and sand terrace at location shown.

ACCESS: 1 km from beach (summer).

DEVELOPMENT: Check ice content before attempting summer construction of landfill site.

LANDFILL SITE L7-22, TEMPORARY STOCKPILE T7-22

LANDFILL SITE: Available area of 75,000 m² on a gravel and sand terrace with low ice content.

LANDFILL SITE L7-22, TEMPORARY STOCKPILE T7-22 - Continued

TEMPORARY STOCKPILE: No suitable sites, none required for summer construction.

BEACH: Gravel and sand, 50 - 75 m wide.

BORROW SOURCE: Use beach material or gravel and sand terrace at location shown.

ACCESS: 2 km across narrow beach and low gravel and sand terrace.

DEVELOPMENT: Check ice content to determine suitability of landfill site for summer construction.

LANDFILL SITE L7-23, TEMPORARY STOCKPILE T7-23

LANDFILL SITE: Available area of 200,000 m² on a gravel and sand terrace with low ice content.

TEMPORARY STOCKPILE: If required, available area of 30,000 m² on same terrain as landfill site.

BEACH: Gravel and sand, up to 100 m wide.

BORROW SOURCE: Use beach material or gravel and sand terrace at location shown.

ACCESS: 300 m from beach (summer).

DEVELOPMENT: Check ice content to determine suitability of landfill site for summer construction.

LANDFILL SITE L7-24, TEMPORARY STOCKPILE T7-24

LANDFILL SITE: Available area of 160,000 m² on a gravel and sand terrace with low ice content.

TEMPORARY STOCKPILE: Available area of 60,000 m² on a lower sand and gravel terrace with a low to moderate ice content.

LANDFILL SITE L7-24, TEMPORARY STOCKPILE T7-24 - Continued

BEACH: Sand, 50 - 75 m wide and fronted by mudflats. Access to the beach may be possible upriver.

BORROW SOURCE: Use beach material or sand and gravel terrace at location shown.

ACCESS: 2 km across wet terrain and a shallow bay (winter).

DEVELOPMENT: Winter construction of landfill site due to poor access.

LANDFILL SITE L7-25

LANDFILL SITE: A and B have available areas of 65,000 m² and 20,000 m² respectively on an inactive sandy alluvial fan with low ice content.

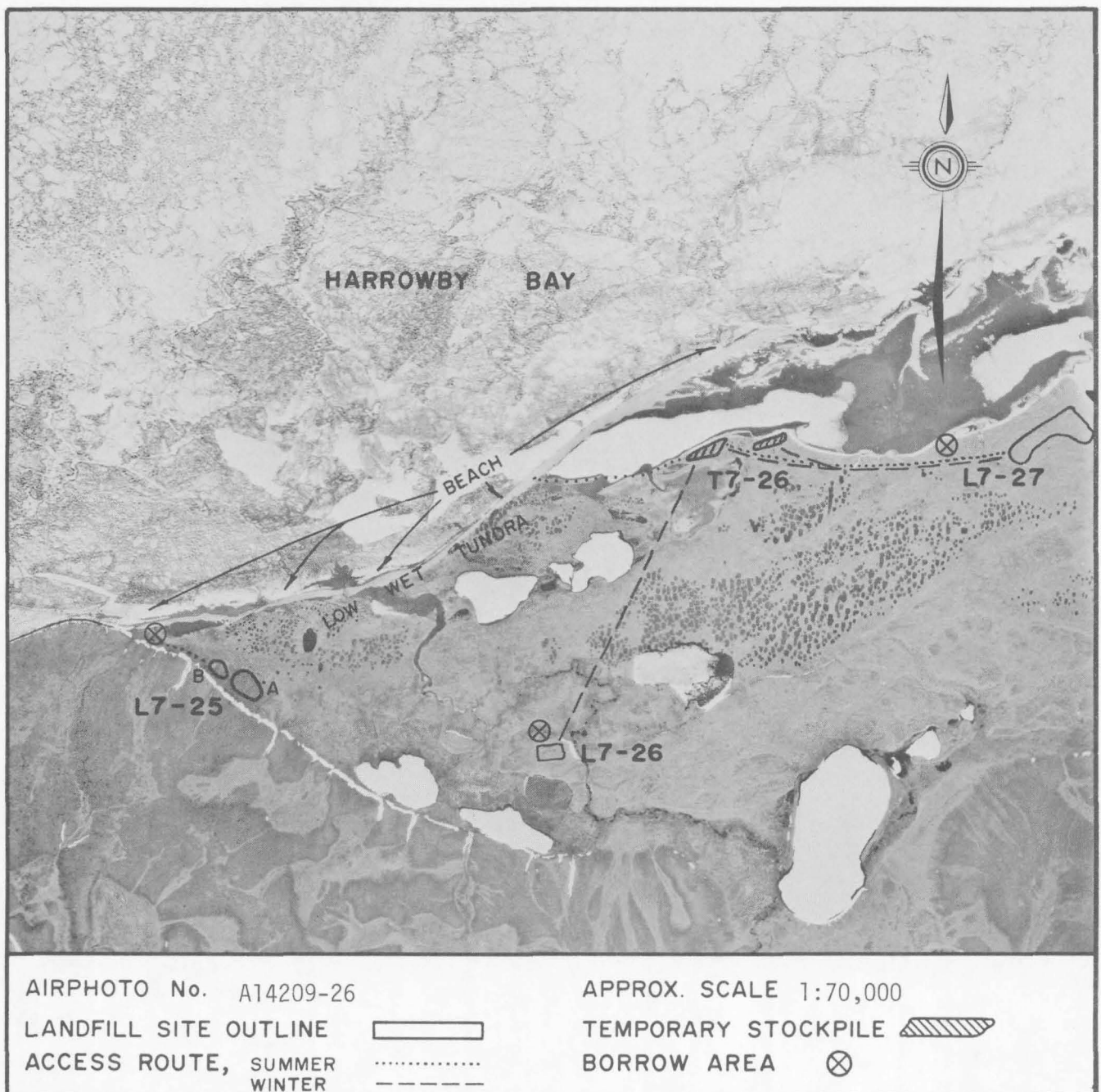
TEMPORARY STOCKPILE: No suitable sites, none required for summer construction.

BEACH: Gravel and sand, 100 m wide.

BORROW SOURCE: Use beach material and sand from the alluvial fan at location shown.

ACCESS: 800 m (summer) from beach to the landfill site.

DEVELOPMENT: Summer construction may be possible. Dykes may have to be constructed around the landfill site to divert surface runoff during rainstorms from the higher area southwest of L7-25.



LANDFILL SITE L7-26, TEMPORARY STOCKPILE T7-26

LANDFILL SITE: Available area of 40,000 m² on a gravel and sand terrace with low ice content.

TEMPORARY STOCKPILE: Available area of 30,000 m² and 20,000 m² on a sand and gravel terrace.

BEACH: Gravel and sand, 100 m wide in front of mudflats and low wet tundra.

BORROW SOURCE: Use beach material or sand and gravel terrace at location shown.

ACCESS: 3.7 km from temporary stockpile (winter) to L7-26. Access to temporary stockpile from beach will require sand fill across the shallow mudflats.

DEVELOPMENT: Winter construction of landfill site due to poor terrain along access route.

LANDFILL SITE L7-27

LANDFILL SITE: Available area of 175,000 m² on a gravel and sand terrace with low ice content.

TEMPORARY STOCKPILE: See comments under Development.

BEACH: Gravel and sand, 100 m wide.

BORROW SOURCE: Use beach sand or gravel and sand terrace at location shown.

ACCESS: 3.5 km from T7-26 to landfill site across gravel and sand terrace (winter or summer).

DEVELOPMENT: L7-27 is an alternative to L7-26 for disposal of oiled debris. Summer construction of landfill site possible if access route from the beach to T7-26 is constructed.

LANDFILL SITE L7-28, TEMPORARY STOCKPILE T7-28

LANDFILL SITE: Available area of 50,000 m² on a glaciofluvial sand and gravel terrace over marine silts, low to moderate ice content.

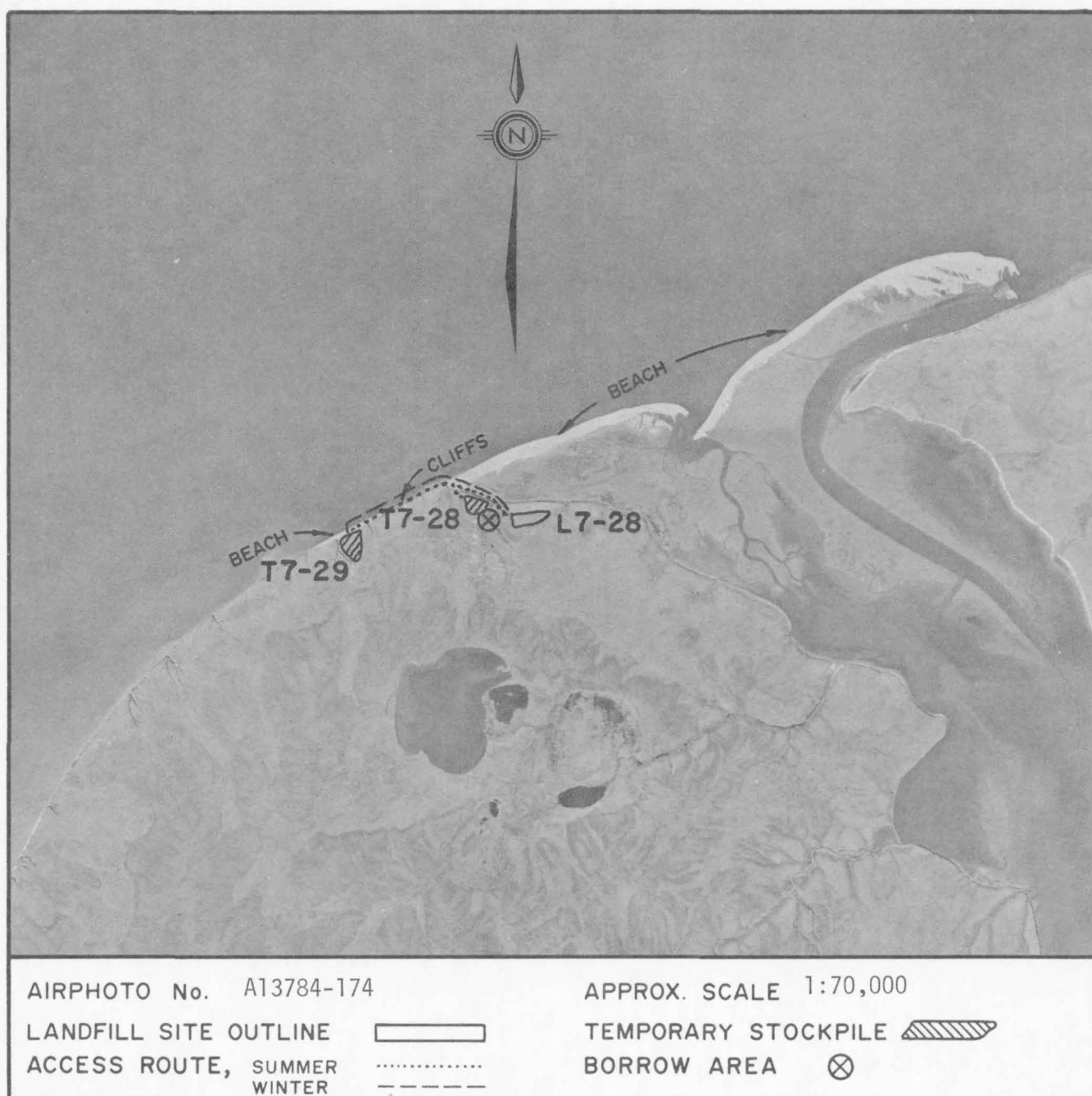
TEMPORARY STOCKPILE: If required, available area of 45,000 m² on same terrain as landfill site.

BEACH: Sand and gravel, 125 m wide.

BORROW SOURCE: Use beach material, or sand and gravel from location shown on sand and gravel terrace.

ACCESS: 700 m from beach (summer).

DEVELOPMENT: Check ice content to determine suitability of landfill site for summer construction.



TEMPORARY STOCKPILE T7-29

TEMPORARY STOCKPILE: Available area of 60,000 m² on marine silts with a low to moderate ice content.

BEACH: Sand, 50 m wide.

BORROW SOURCE: Use beach sand.

ACCESS: 2 km to L7-28 (summer or winter).

DEVELOPMENT: Summer access to L7-28 would require construction of a beach 600 m long in front of the cliffs.

LANDFILL SITE L7-31, TEMPORARY STOCKPILE T7-31

LANDFILL SITE: A and B have available areas of 20,000 m² and 60,000 m² on marine silts with low to moderate ice content.

TEMPORARY STOCKPILE: Available area of 55,000 m² on same terrain as landfill site.

BEACH: Sand, up to 125 m wide.

BORROW SOURCE: Use beach material.

ACCESS: A is adjacent to temporary stockpile, B is 700 m (winter) from T7-31.

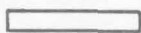
DEVELOPMENT: Winter construction. Landfill site would also have to accommodate oiled debris from T7-30.



AIRPHOTO No. A13784-155

APPROX. SCALE 1:70,000

LANDFILL SITE OUTLINE



TEMPORARY STOCKPILE

ACCESS ROUTE, SUMMER
WINTER

BORROW AREA



TEMPORARY STOCKPILE T7-30

TEMPORARY STOCKPILE: Available area of 60,000 m² on marine silts with low to moderate ice content.

BEACH: Sand beach, 10 m wide, in front of cliffs.

BORROW SOURCE: Use beach material, if enough is available. Can also use silt deposits from the exposed cliffs.

ACCESS: 2 km haul by barge to beach in front of T7-31 (summer) or 3.5 km across sea ice (winter) to L7-31.

DEVELOPMENT: Earth fill ramp required from the beach to the top of the cliffs. Since borrow sources are limited, it may be desirable to summer barge the oiled debris to the beach in front of T7-31.

LANDFILL SITE L7-32, TEMPORARY STOCKPILE T7-32

LANDFILL SITE: A, B, and C have available areas of 45,000 m², 35,000 m² and 35,000 m² respectively on a morainal veneer over marine silts, with a high ice content. Massive ice is expected at depth.

TEMPORARY STOCKPILE: Available area of 90,000 m² on marine silts with a low to moderate ice content.

BEACH: Sand, up to 100 m wide.

BORROW SOURCE: Use beach material or, if necessary, sand and gravel at location shown.

ACCESS: 800 m to A, 1.3 km to B, and 1.5 km to C (winter).

DEVELOPMENT: Winter construction. A is the preferred site, but check for massive ice before construction.

LANDFILL SITE L7-34, TEMPORARY STOCKPILE T7-34

LANDFILL SITE: A and B have available areas of 30,000 m² each, on marine silts with moderate ice content.

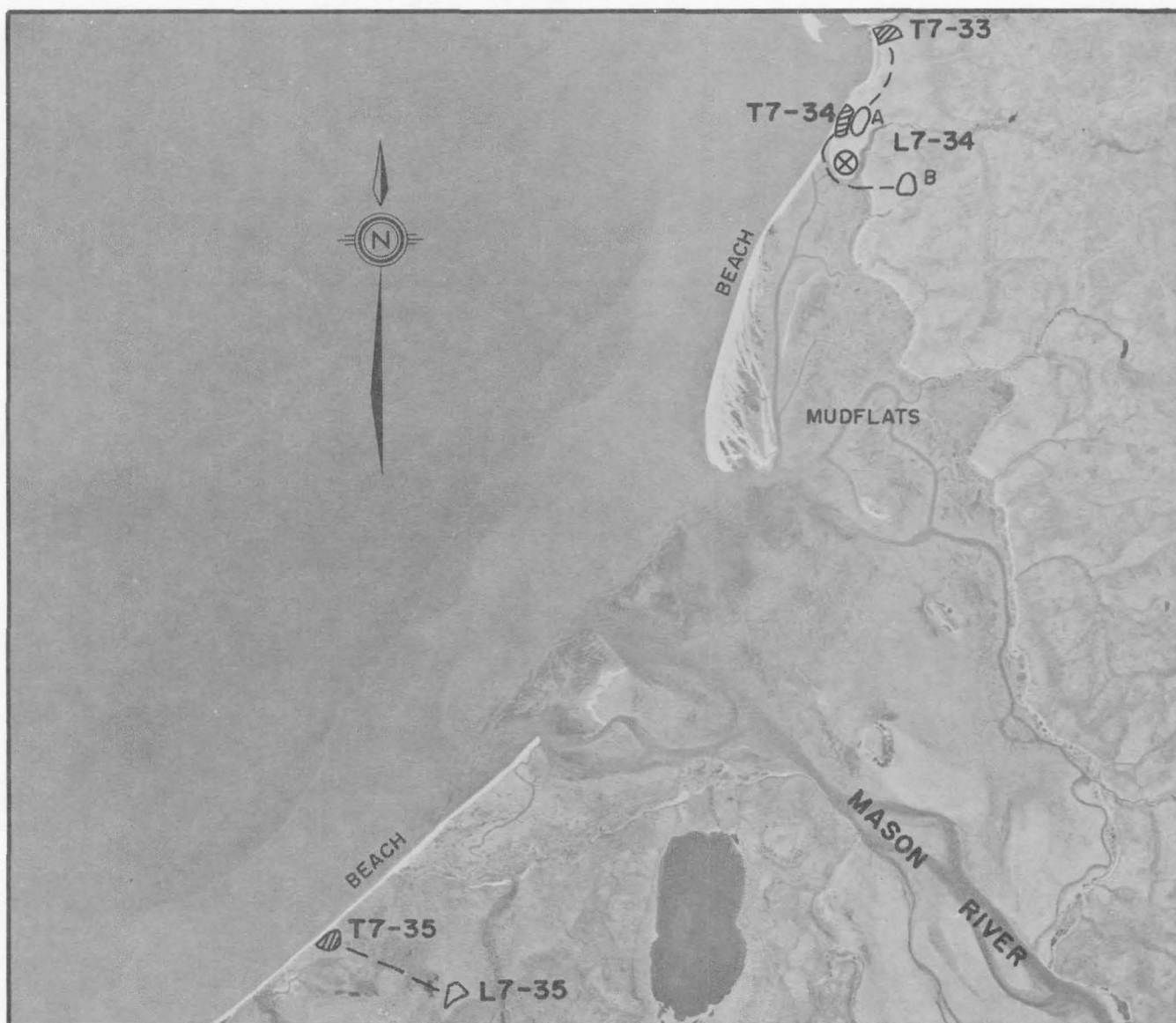
TEMPORARY STOCKPILE: Available area of 35,000 m² on same terrain as landfill site.

BEACH: Sand, 75 m - 100 m wide.

BORROW SOURCE: Use beach material or sand and silt from location shown.

ACCESS: A is adjacent to T7-34, B is 1.3 km (winter) from T7-34.

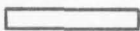
DEVELOPMENT: Winter construction of landfill site.



AIRPHOTO No. A13784-153

APPROX. SCALE 1:70,000

LANDFILL SITE OUTLINE



TEMPORARY STOCKPILE

ACCESS ROUTE, SUMMER
WINTER

BORROW AREA



TEMPORARY STOCKPILE T7-33

TEMPORARY STOCKPILE: Available area of 30,000 m² on marine silts with a moderate ice content.

BEACH: Sand, 75 m wide.

BORROW SOURCE: Use beach material, or sand and silt from location shown near L7-34.

ACCESS: 900 m to L7-34 (A) (winter).

DEVELOPMENT: Would require development only if T7-34 did not have sufficient storage capacity for the beach in front of it.

LANDFILL SITE L7-35, TEMPORARY STOCKPILE T7-35

LANDFILL SITE: Available area of 40,000 m² on a lacustrine plain containing silt with high ice content.

TEMPORARY STOCKPILE: Available area of 35,000 m² on same terrain as landfill site.

BEACH: Sand and gravel, 50 m - 75 m wide.

BORROW SOURCE: Use beach material.

ACCESS: 1.2 km across low, wet tundra (winter) to the landfill site.

DEVELOPMENT: Winter construction. Landfill site may require more than the average amount of borrow if the ice content is very high. Also, dykes may have to be constructed around the landfill site to divert surface runoff during summer rainstorms from the higher area adjacent to L7-35.

LANDFILL SITE L7-36, TEMPORARY STOCKPILES T7-36, T7-37

LANDFILL SITE: A, B, and C have available areas of 12,000 m², 15,000 m², and 10,000 m² respectively on ice cored hummocky moraine with high ice content and numerous ice wedges.

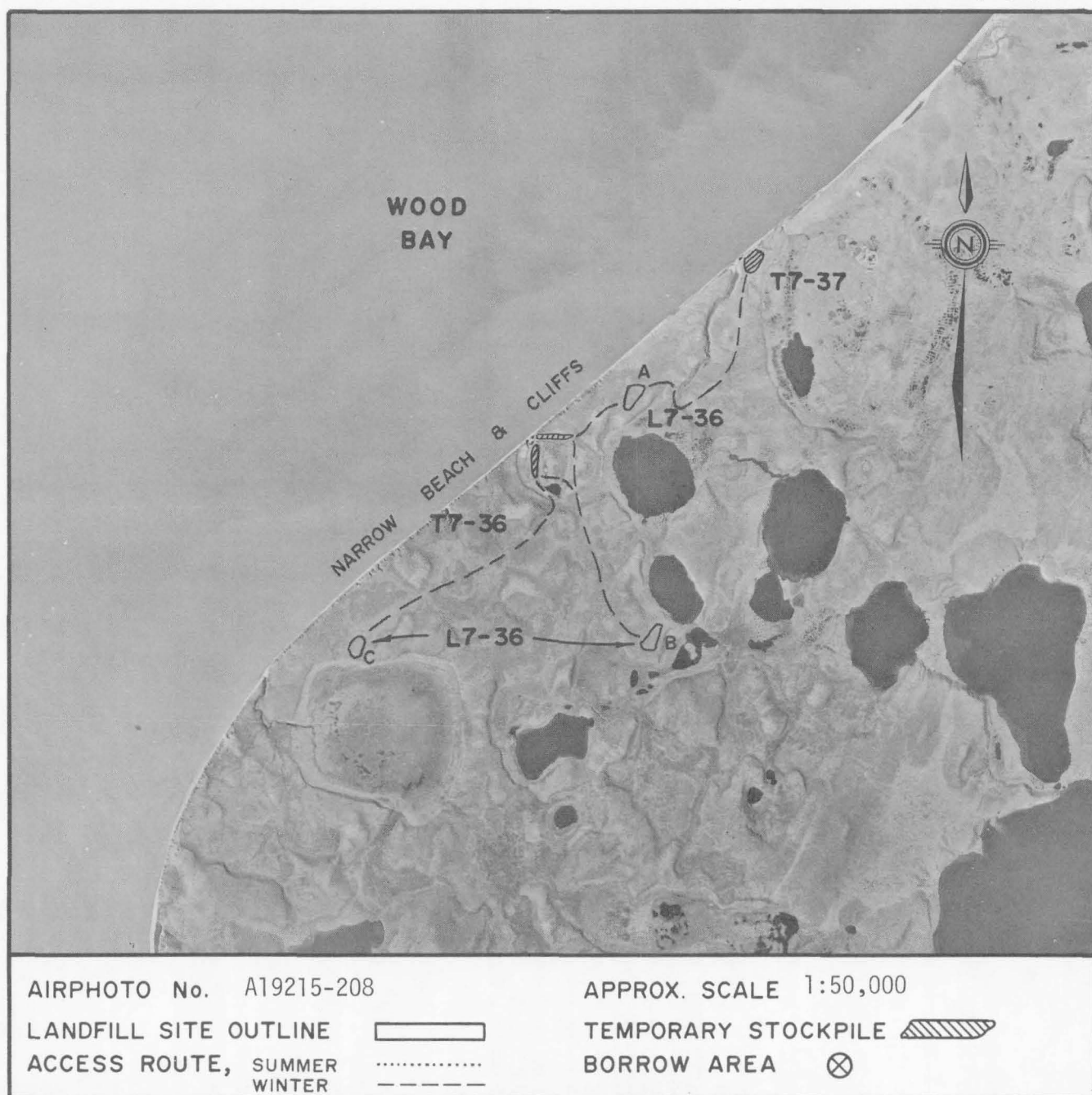
TEMPORARY STOCKPILE: T7-36 has two sites with a total available area of 20,000 m² on a recently drained lacustrine basin. T7-37 has an available area of 15,000 m² on a lacustrine plain with a low ice content.

BEACH: Sand, 10 m wide in front of cliffs.

BORROW SOURCE: Use beach material. In the event of an oil spill, there may not be sufficient uncontaminated sand for borrow due to the narrow width of the beach.

ACCESS: 500 m to A from T7-36 and 1.7 km from T7-37. 2 km to C, and 1.5 km to B (winter) from T7-36.

(continued on next page)

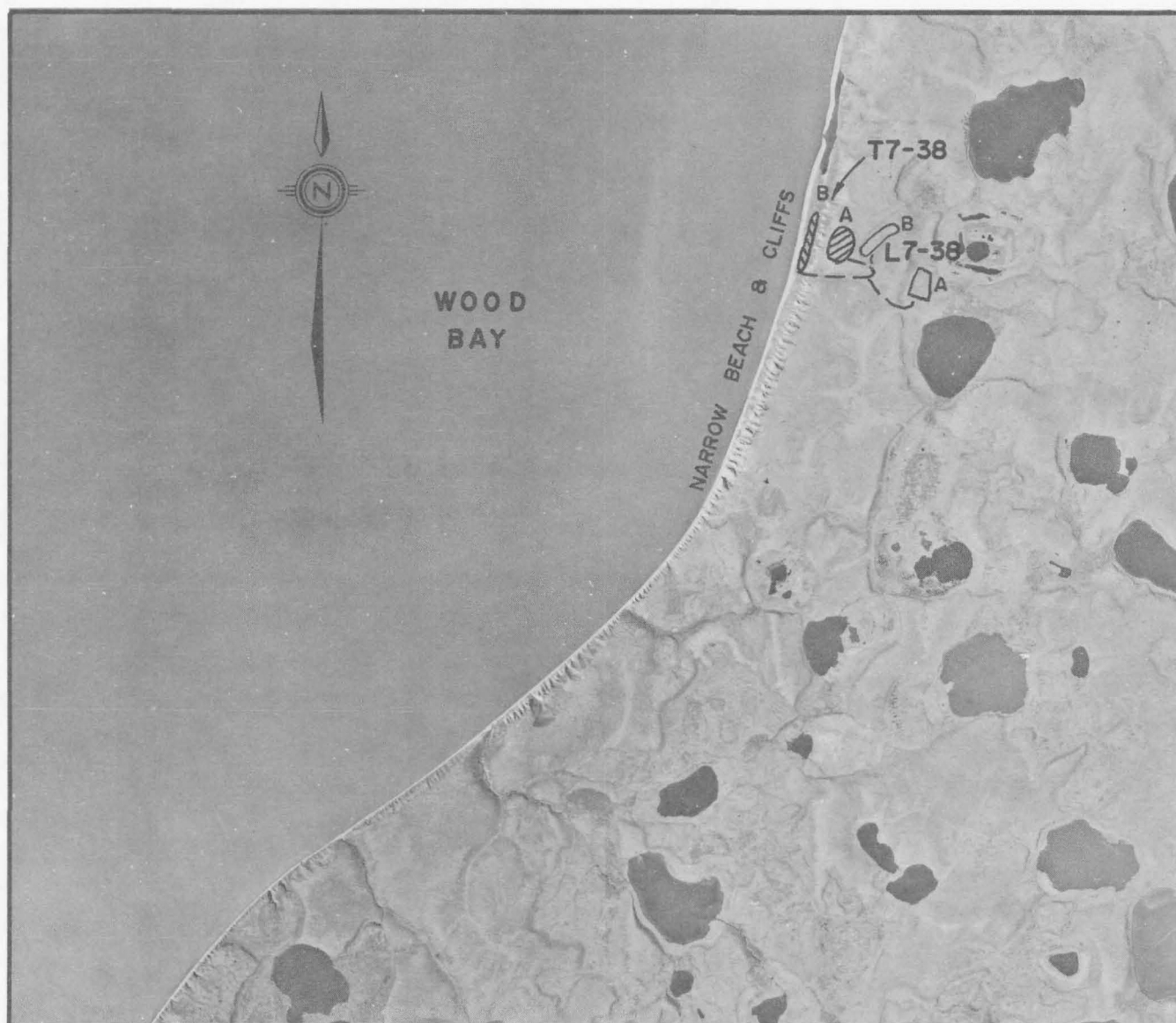


LANDFILL SITE L7-36, TEMPORARY STOCKPILES T7-36, T7-37 - Continued

DEVELOPMENT: Winter construction of landfill site. Field reconnaissance is required to select the site with the lowest ice content in the top 6 m of soil.

LANDFILL SITE L7-38, TEMPORARY STOCKPILE T7-38

- LANDFILL SITE: A and B have available areas of 25,000 m² and 20,000 m² respectively. A is on a silty lacustrine plain with a moderate to high ice content. B is on ice-cored hummocky moraine with a high ice content and numerous ice wedges.
- TEMPORARY STOCKPILE: A and B have available areas of 30,000 m² and 20,000 m² respectively. A is on ice-cored hummocky moraine with a high ice content. B is on a sloping alluvial fan.
- BEACH: Sand, 10 m to 30 m wide in front of cliffs.
- BORROW SOURCE: Use beach material.
- ACCESS: Access to landfill site and temporary stockpile is up a large gully in the cliffs. 600 m from the beach to T7-38 (summer) and 700 m from T7-38 to landfill site A (winter).
(continued on next page)



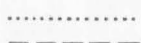
AIRPHOTO No. A19215-173

APPROX. SCALE 1:50,000

LANDFILL SITE OUTLINE



TEMPORARY STOCKPILE

ACCESS ROUTE, SUMMER
WINTER

BORROW AREA

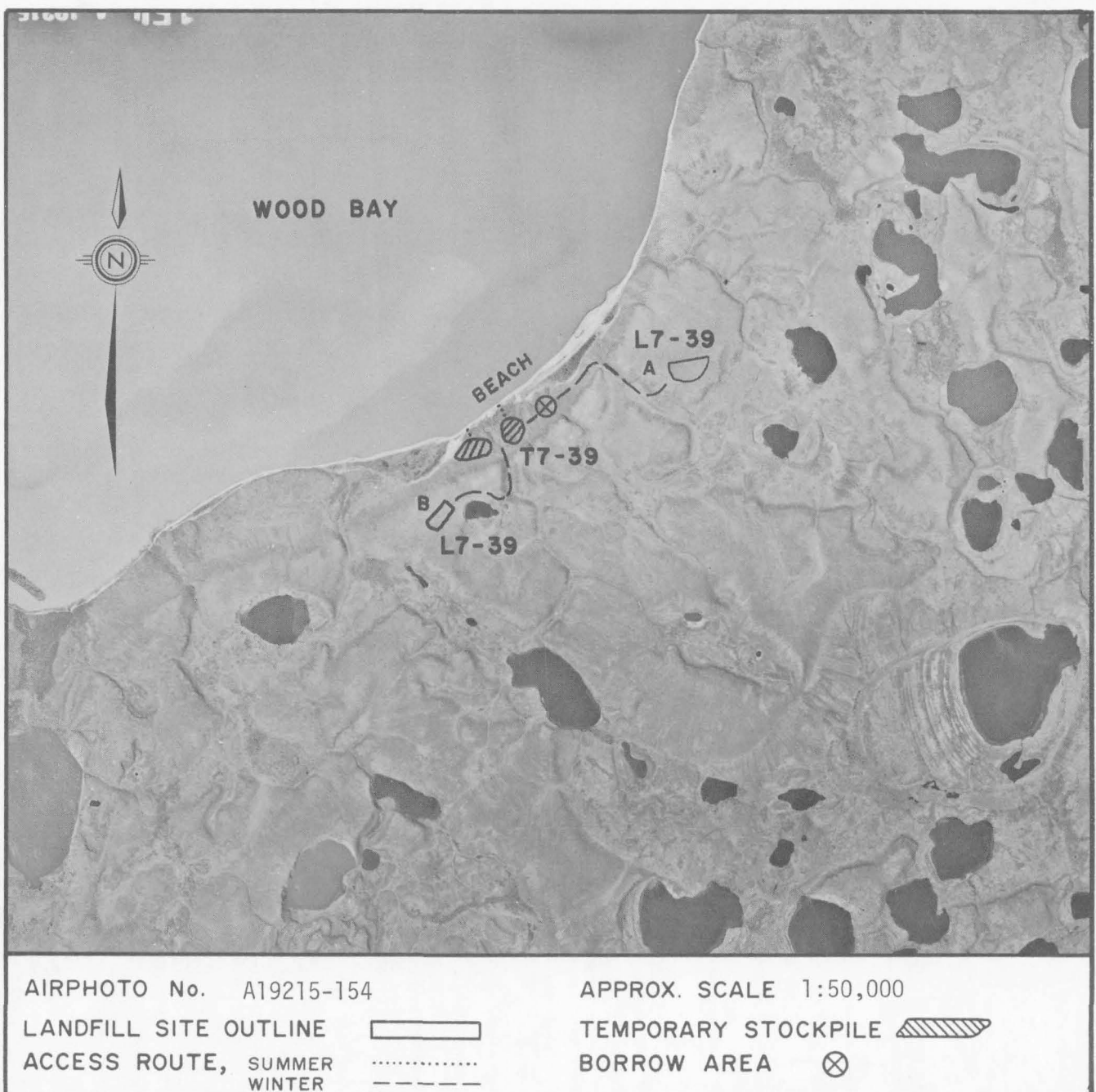


LANDFILL SITE L7-38, TEMPORARY STOCKPILE T7-38 - Continued

DEVELOPMENT: Winter construction. Site reconnaissance required to determine suitability of T7-38 (B) due to steepness of slope.

LANDFILL SITE L7-39, TEMPORARY STOCKPILE T7-39

- LANDFILL SITE: A and B have available areas of 40,000 m² and 22,000 m² respectively on morainal veneer over marine silts, with high ice content.
- TEMPORARY STOCKPILE: Two sites, having available areas of 25,000 m² each, on a glaciofluvial sand terrace with low to moderate ice content.
- BEACH: Sand, up to 100 m wide.
- BORROW SOURCE: Use beach material or sand from alluvial fan at location shown.
- ACCESS: 1.6 km to A and 800 m to B (winter).
- DEVELOPMENT: Winter construction of landfill site.



LANDFILL SITE L7-40, TEMPORARY STOCKPILE T7-40

LANDFILL SITE: Available area of 22,000 m² on ice-cored hummocky moraine with medium to high ice content and ice wedges.

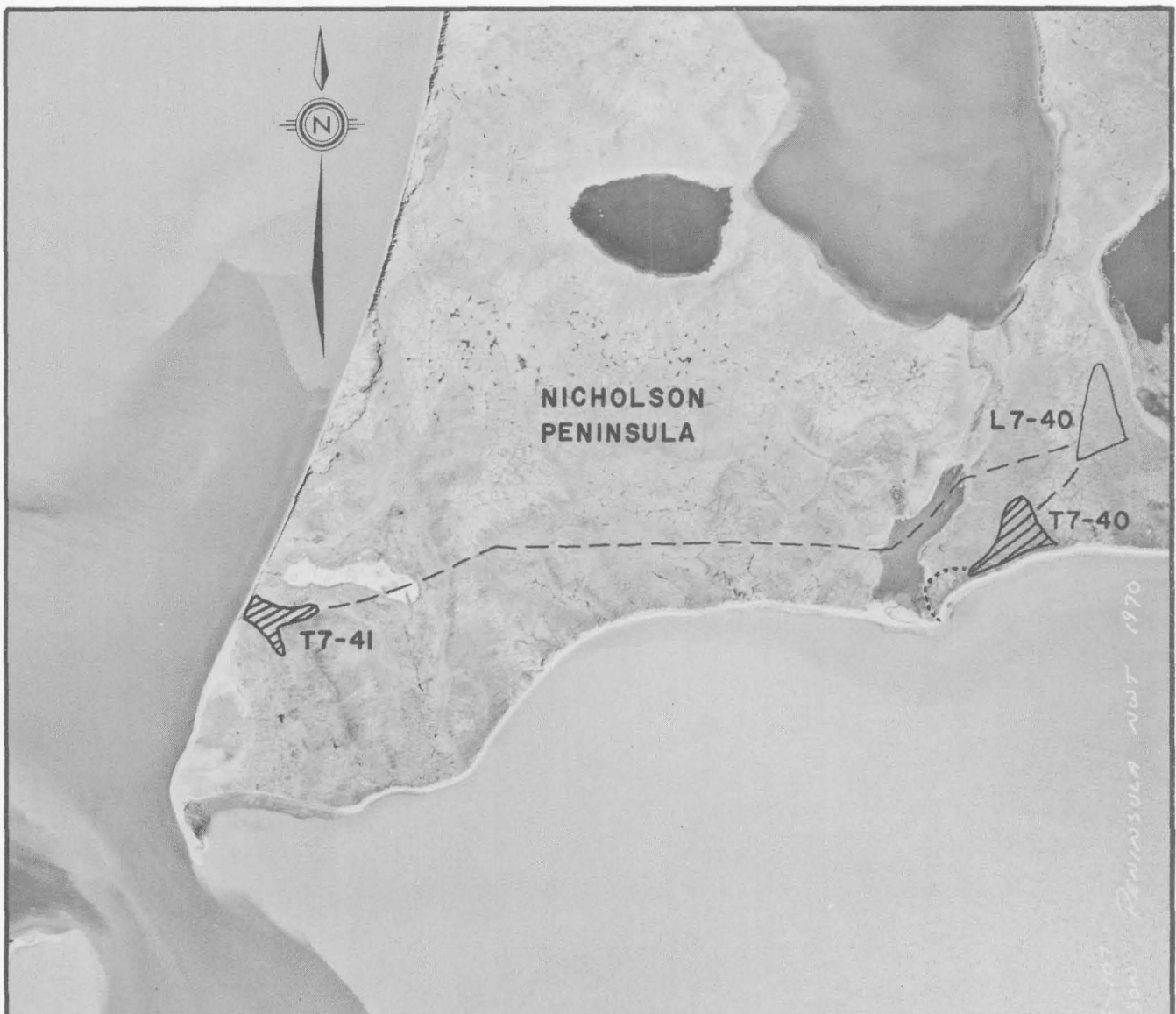
TEMPORARY STOCKPILE: Available area of 25,000 m² on same terrain as landfill site.

BEACH: Sand, 10 m wide in front of cliffs.

BORROW SOURCE: Use beach material.

ACCESS: 250 m from beach to temporary stockpile (summer) and 200 m from temporary stockpile to landfill site (winter).

DEVELOPMENT: Winter construction of landfill site.



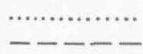
AIRPHOTO No. A21633-107

APPROX. SCALE 1:20,000

LANDFILL SITE OUTLINE



TEMPORARY STOCKPILE

ACCESS ROUTE, SUMMER
WINTER

BORROW AREA



TEMPORARY STOCKPILE T7-41

TEMPORARY STOCKPILE: Available area of 15,000 m² on ice-cored hummocky moraine with high ice content.

BEACH: Sand, 10 m wide in front of cliffs.

BORROW SOURCE: Use beach material.

ACCESS: Adjacent to beach, but requires a ramp for access. 2.5 km to L7-40 (winter).

LANDFILL SITE L7-42, TEMPORARY STOCKPILE T7-42

LANDFILL SITE: Available area of 60,000 m² on ice-cored hummocky moraine with high ice content.

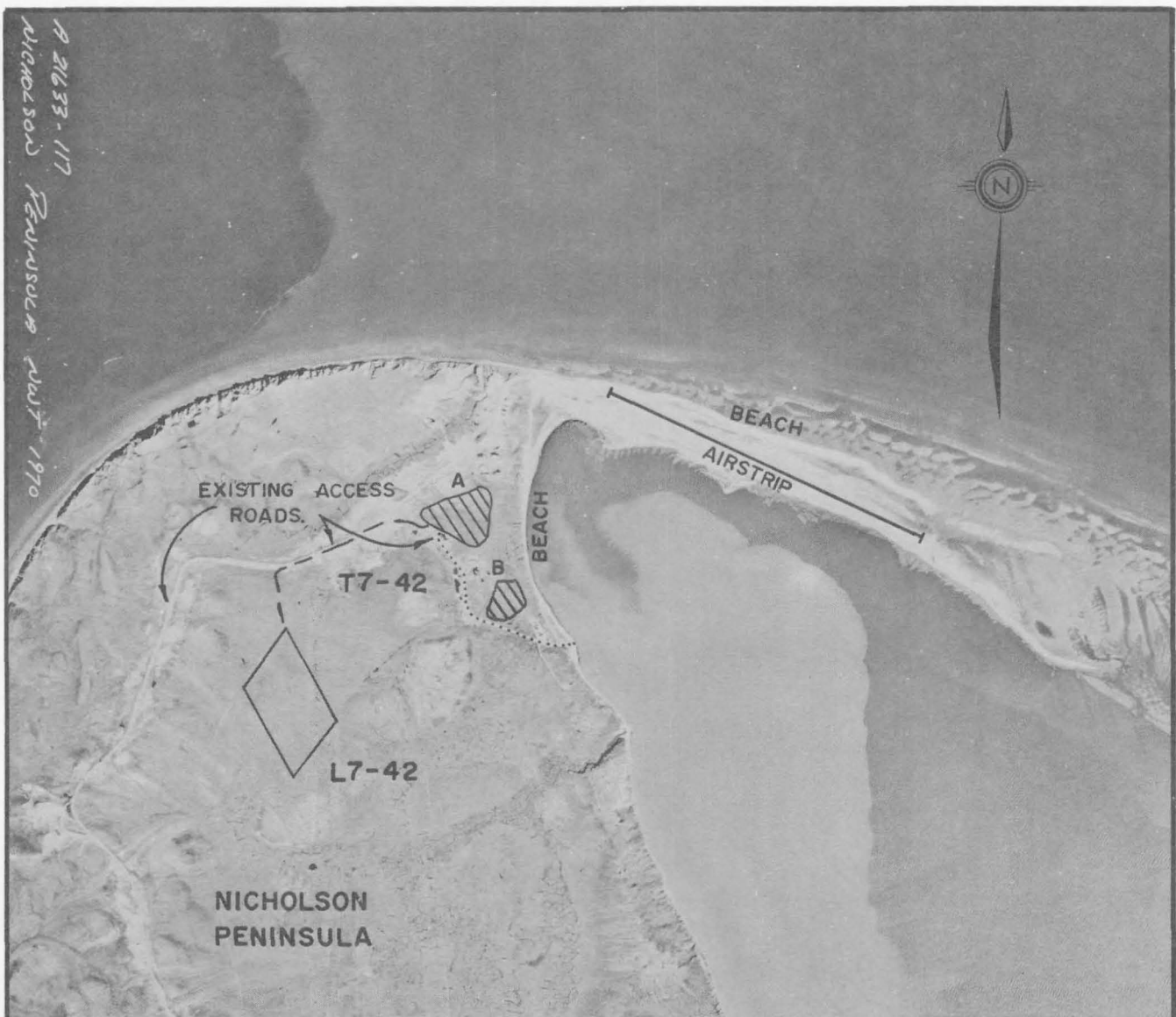
TEMPORARY STOCKPILE: A and B have available areas of 25,000 m² and 10,000 m² on same terrain as landfill site.

BEACH: Sand beach, 150 m wide plus a smaller sand beach 10 m wide.

BORROW SOURCE: Use beach material or one of the borrow pits along the access road.

ACCESS: 500 m and 300 m to temporary stockpiles A and B respectively on existing access road (summer). 800 m from A to landfill site (winter).

(continued on next page)



AIRPHOTO No. A21633-117

APPROX. SCALE 1:20,000

LANDFILL SITE OUTLINE



TEMPORARY STOCKPILE



ACCESS ROUTE, SUMMER



BORROW AREA



WINTER



LANDFILL SITE L7-42, TEMPORARY STOCKPILE T7-42 - Continued

DEVELOPMENT: Winter construction of landfill site. The terrain is very sensitive as evidenced by thermokarst and gully erosion on the seismic trails. Ice content of the landfill site is expected to be very high.

LANDFILL SITE L7-43, TEMPORARY STOCKPILES T7-43, T7-44

- LANDFILL SITE: Available area of 30,000 m² on ice-cored hummocky moraine with high ice content.
- TEMPORARY STOCKPILE: T7-43 and T7-44 have available areas of 12,000 m² and 15,000 m² respectively on same terrain as the landfill site.
- BEACH: Sand beach, 10 m to 20 m wide in front of cliffs.
- BORROW SOURCE: Use beach material. In the event of an oil spill, there may not be sufficient clean sand to compensate for the high volume of ice in the landfill site.
- ACCESS: 2.5 km across low wet tundra from both temporary stockpiles (winter).

(continued on next page)



AIRPHOTO No. A21633-120

APPROX. SCALE 1:20,000

LANDFILL SITE OUTLINE



TEMPORARY STOCKPILE

ACCESS ROUTE, SUMMER
WINTER

BORROW AREA



LANDFILL SITE L7-43, TEMPORARY STOCKPILES T7-43, T7-44 - Continued

DEVELOPMENT: Winter construction. Note: This is very sensitive terrain as evidenced by thermokarst and gully erosion on seismic trails. Both temporary stockpiles will require a ramp to the top of the cliffs for access.

TEMPORARY STOCKPILE T7-45

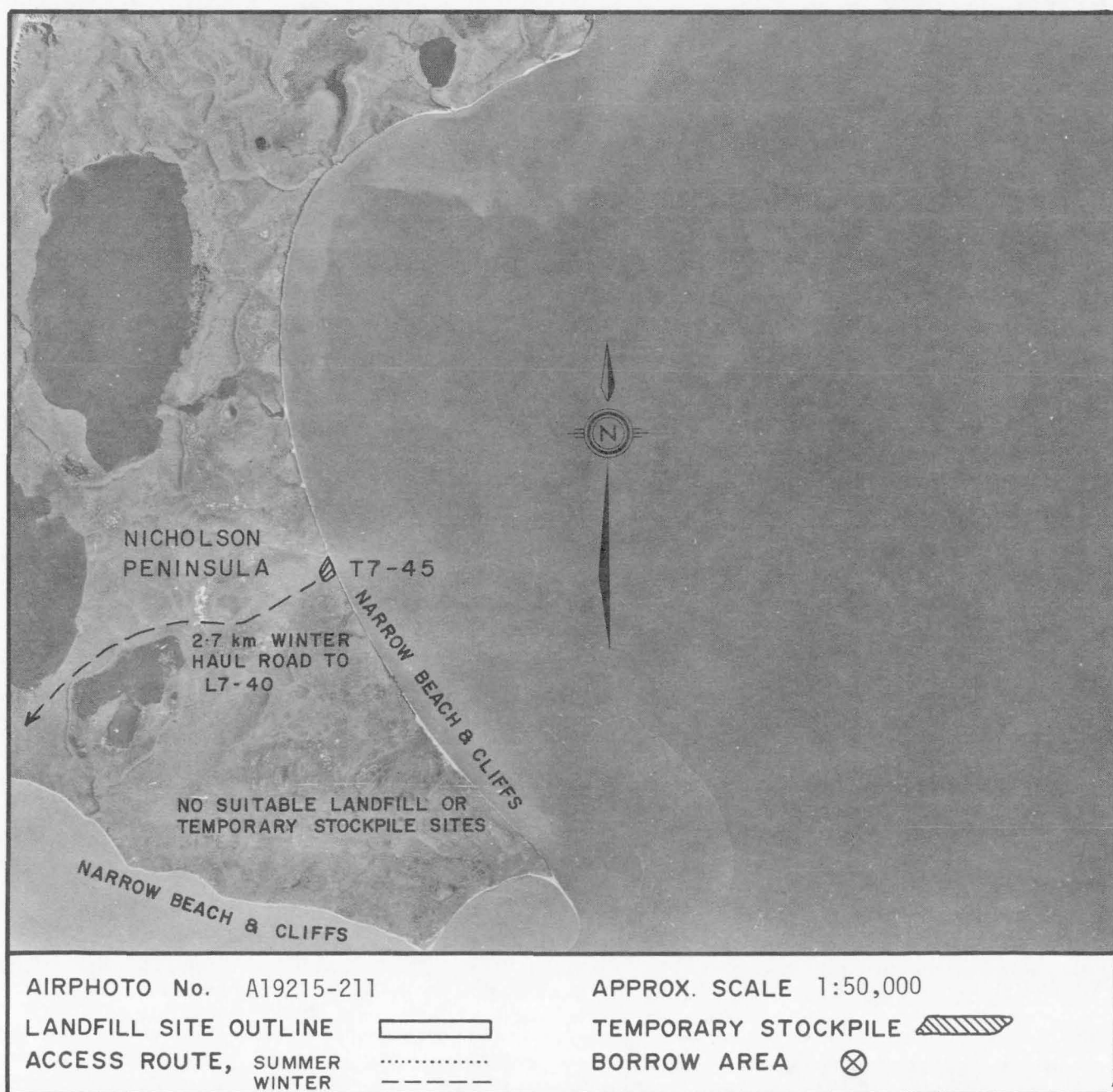
TEMPORARY STOCKPILE: Available area of 15,000 m² on a lacustrine plain containing silt with high ice content.

BEACH: Sand beach, 10 m wide in front of cliffs.

BORROW SOURCE: Use beach material.

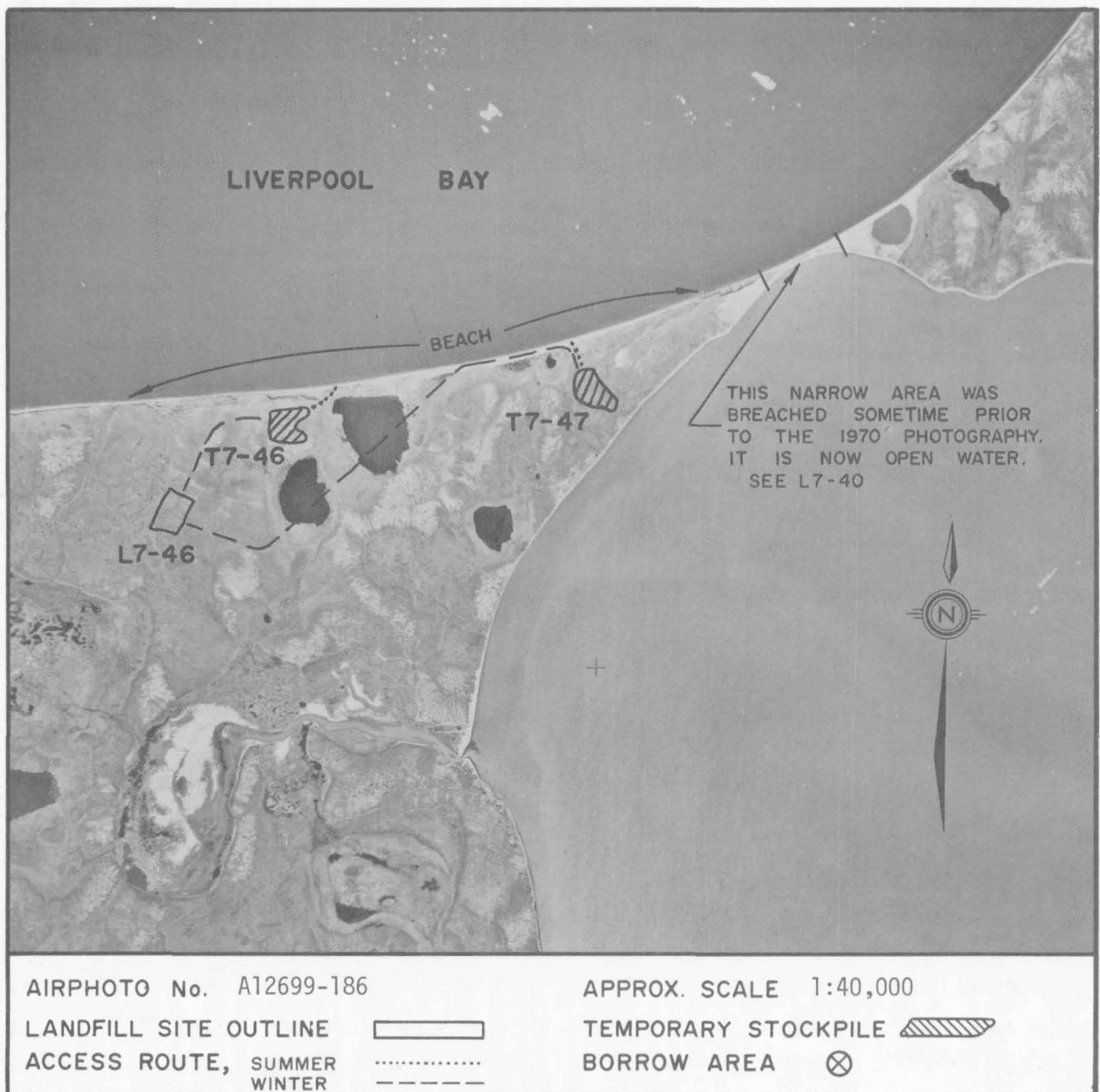
ACCESS: 2.7 km to L7-40 (winter). Will require ramp to the top of the cliffs from the beach.

DEVELOPMENT: In the event of an oil spill, there may not be sufficient clean sand on the beach to construct the ramp and pad for the temporary stockpile.



LANDFILL SITE L7-46, TEMPORARY STOCKPILES T7-46, T7-47

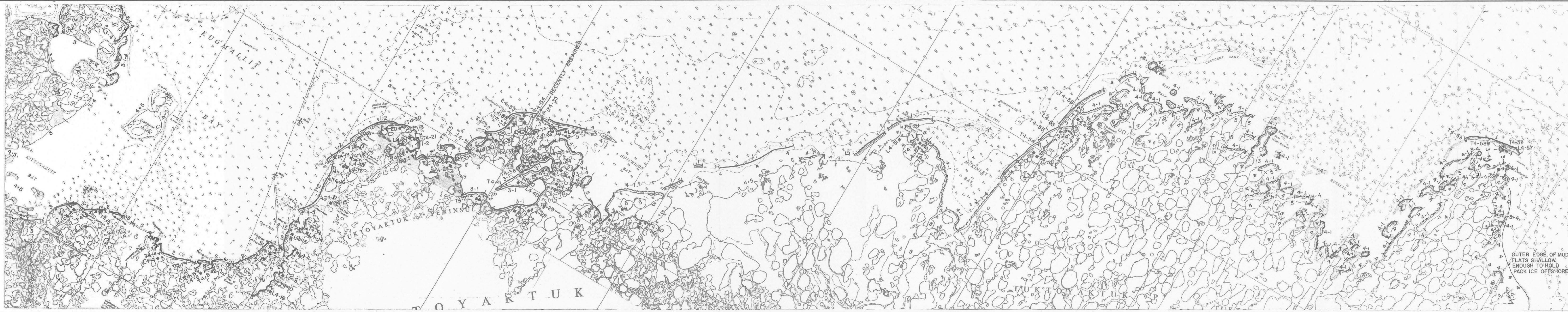
- LANDFILL SITE: Available area of 40,000 m² on ice cored moraine with high ice content.
- TEMPORARY STOCKPILE: T7-46 and T7-47 have available areas of 40,000 m² and 35,000 m² respectively on same terrain as landfill site.
- BEACH: Sand beach, up to 50 m wide.
- BORROW SOURCE: Use beach material, supplement with fines from exposed cliffs.
- ACCESS: 700 m (winter) from T7-46 to the landfill site, 2.8 km (winter) from T7-47 to the landfill site. 200 m (summer) to T7-46 from the beach.
- DEVELOPMENT: Winter construction of landfill site. See L7-40 for more recent photography which shows a breached area.



APPENDIX H

STRIP MAPS

MAP 1	-	YUKON COAST
MAP 2	-	SHALLOW BAY
MAP 3	-	OUTER DELTA
MAP 4	-	TUKTOYAKTUK PENINSULA
MAP 5	-	ESKIMO LAKE
MAP 6	-	LIVERPOOL BAY
MAP 7	-	WOOD BAY TO CAPE BATHURST
MAP 8	-	BEAUFORT SEA COAST, KEY MAP



BEACH UNIT	DESCRIPTION
1	Sand Beach - uniform fine to medium sand. Highest beach ridge may contain fine gravel. Beach width generally 15 m to 200 m, occasionally >300 m.
2	Shingle Beach - generally consists of mixed cobbles, gravel, and sand. Beach width generally 15 m to 200 m.
3	Cliffs - sea cliffs, generally 5 m to 50 m high. Often fronted by a very narrow beach.
4	Mudflats - tidal flats and low-lying river delta flats.
5	Tundra - low-lying tundra areas.
6	Landslide - only exceptionally large landslides are shown on this scale of mapping.
7	Stoping shoreline - caused by severe wind erosion of sand cliffs, no beach.

COMPLEX BEACH UNITS

3-1, 3-2	Cliffs with definable narrow sand beach, cliffs with definable narrow shingle beach. Beach width generally 10 m to 30 m.
3-4	Cliffs fronted by mudflats.
3-1-4	Cliffs fronted by mudflats, but with a 10 m to 30 m sand beach at the base of the cliffs. Beach sand is expected to be thinner than in Units 1 and 2.
4-1	Mudflats with a thin sand beach at the high tide mark. Beach sand is expected to be thinner than in Units 1 and 2.

Note: Where two units are not clearly separable at the scale of mapping, they are shown as a combination unit, e.g. 4+5, 1+2.

Legend:

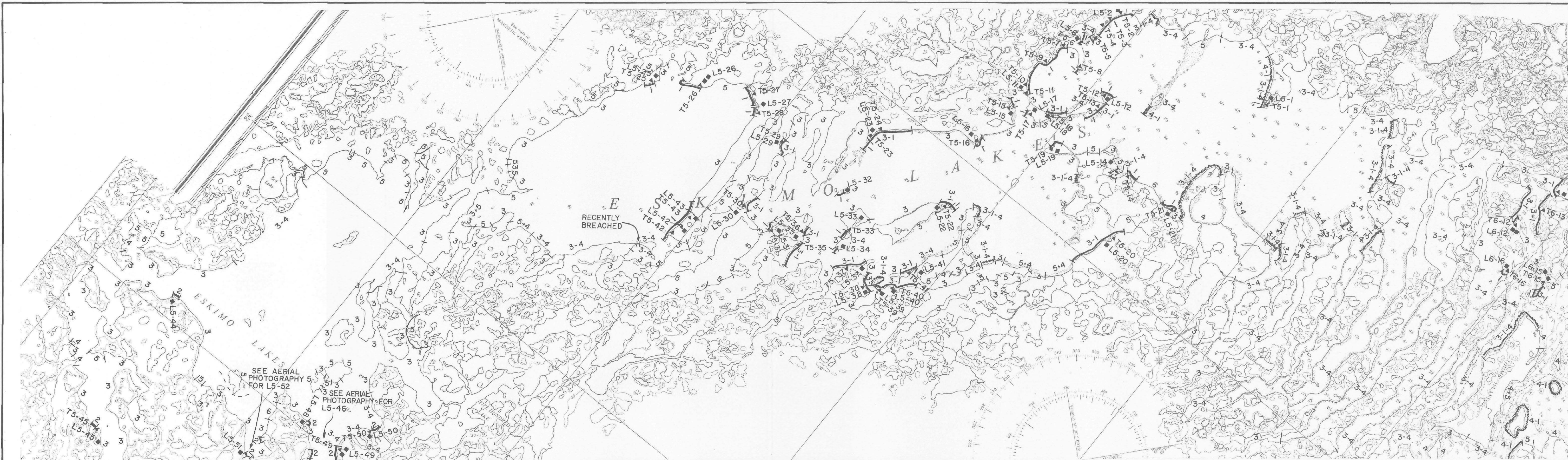
- Sand or shingle beaches - Units 1, 2, 3-1, 3-2.
- Sand beaches developed behind mudflats. Expected to be thinner than the above beaches. Access to the beaches is restricted by mudflats.
- LI-17 Proposed landfill site for disposal of oiled beach debris. Numbers correspond to map and site numbers, respectively.
- ▲ TI-17 Proposed temporary stockpile site. Numbers correspond to map and site numbers, respectively.

0 5 10 Kilometres
0 3 6 miles

OUTER EDGE OF MUD FLATS SHALLOW ENOUGH TO HOLD PACK ICE OFFSHORE

TUKTOYAKTUK PENINSULA
BEAUFORT SEA COASTLINE CLASSIFICATION
AND LOCATION OF PROPOSED LANDFILL DISPOSAL
AND TEMPORARY STORAGE SITES

MAP 4



LEGEND

BEACH UNIT	DESCRIPTION
1	Sand Beach - uniform fine to medium sand. Highest beach ridge may contain fine gravel. Beach width generally 15 m to 200 m, occasionally >300 m.
2	Shingle Beach - generally consists of mixed cobbles, gravel, and sand. Beach width generally 15 m to 200 m.
3	Cliffs - sea cliffs, generally 5 m to 50 m high. Often fronted by a very narrow beach.
4	Mudflats - tidal flats and low-lying river delta flats.
5	Tundra - low-lying tundra areas.
6	Landslide - only exceptionally large landslides are shown on this scale of mapping.
7	Sloping shoreline - caused by severe wind erosion of sand cliffs, no beach.

COMPLEX BEACH UNITS

3-1, 3-2	Cliffs with defineable narrow sand beach, cliffs with defineable narrow shingle beach. Beach width generally 10 m to 30 m.
3-4	Cliffs fronted by mudflats.
3-1-4	Cliffs fronted by mudflats, but with a 10 m to 30 m sand beach at the base of the cliffs. Beach sand is expected to be thinner than in Units 1 and 2.
4-1	Mudflats with a thin sand beach at the high tide mark. Beach sand is expected to be thinner than in Units 1 and 2.

Note: Where two units are not clearly separable at the scale of mapping, they are shown as a combination unit, e.g. 4+5, 1+2.

Sand or shingle beaches - Units 1, 2, 3-1, 3-2.

Sand beaches developed behind mudflats. Expected to be thinner than the above beaches. Access to the beaches is restricted by mudflats.

■ L1-17

Proposed landfill site for disposal of oiled beach debris. Numbers correspond to map and site numbers, respectively.

▲ T1-17

Proposed temporary stockpile site. Numbers correspond to map and site numbers, respectively.

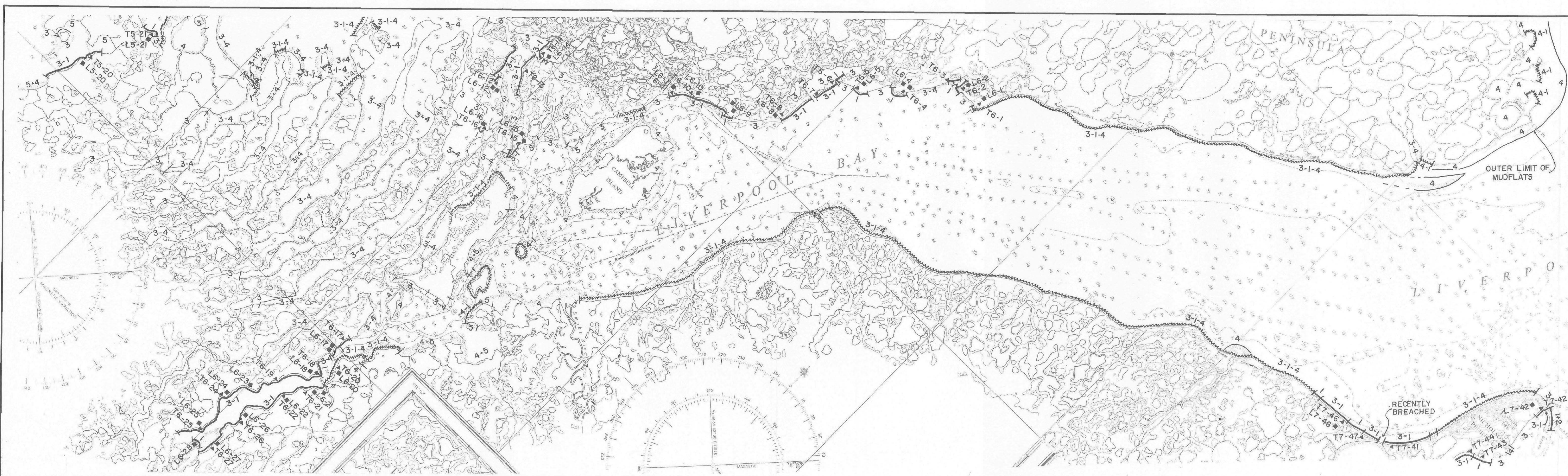
0 5 10 kilometres

0 3 6 miles

ESKIMO LAKES

BEAUFORT SEA COASTLINE CLASSIFICATION
AND LOCATION OF PROPOSED LANDFILL DISPOSAL
AND TEMPORARY STORAGE SITES

MAP 5



LEGEND

BEACH UNIT

DESCRIPTION

1

Sand Beach - uniform fine to medium sand. Highest beach ridge may contain fine gravel. Beach width generally 15 m to 200 m, occasionally >300 m.

2

Shingle Beach - generally consists of mixed cobbles, gravel, and sand. Beach width generally 15 m to 200 m.

3

Cliffs - sea cliffs, generally 5 m to 50 m high. Often fronted by a very narrow beach.

4

Mudflats - tidal flats and low-lying river delta flats.

5

Tundra - low-lying tundra areas.

6

Landslide - only exceptionally large landslides are shown on this scale of mapping.

7

Sloping shoreline - caused by severe wind erosion of sand cliffs, no beach.

COMPLEX BEACH UNITS

3-1, 3-2

Cliffs with defineable narrow sand beach, cliffs with defineable narrow shingle beach. Beach width generally 10 m to 30 m.

3-4

Cliffs fronted by mudflats.

3-1-4

Cliffs fronted by mudflats, but with a 10 m to 30 m sand beach at the base of the cliffs. Beach sand is expected to be thinner than in Units 1 and 2.

4-1

Mudflats with a thin sand beach at the high tide mark. Beach sand is expected to be thinner than in Units 1 and 2.

Note:

Where two units are not clearly separable at the scale of mapping, they are shown as a combination unit, e.g. 4+5, 1+2.

Sand or shingle beaches - Units 1, 2, 3-1, 3-2.

Sand beaches developed behind mudflats. Expected to be thinner than the above beaches. Access to the beaches is restricted by mudflats.

■

LI-17

Proposed landfill site for disposal of oiled beach debris. Numbers correspond to map and site numbers, respectively.

▲

TI-17

Proposed temporary stockpile site. Numbers correspond to map and site numbers, respectively.

0 5 10 kilometres

0 5 6 miles

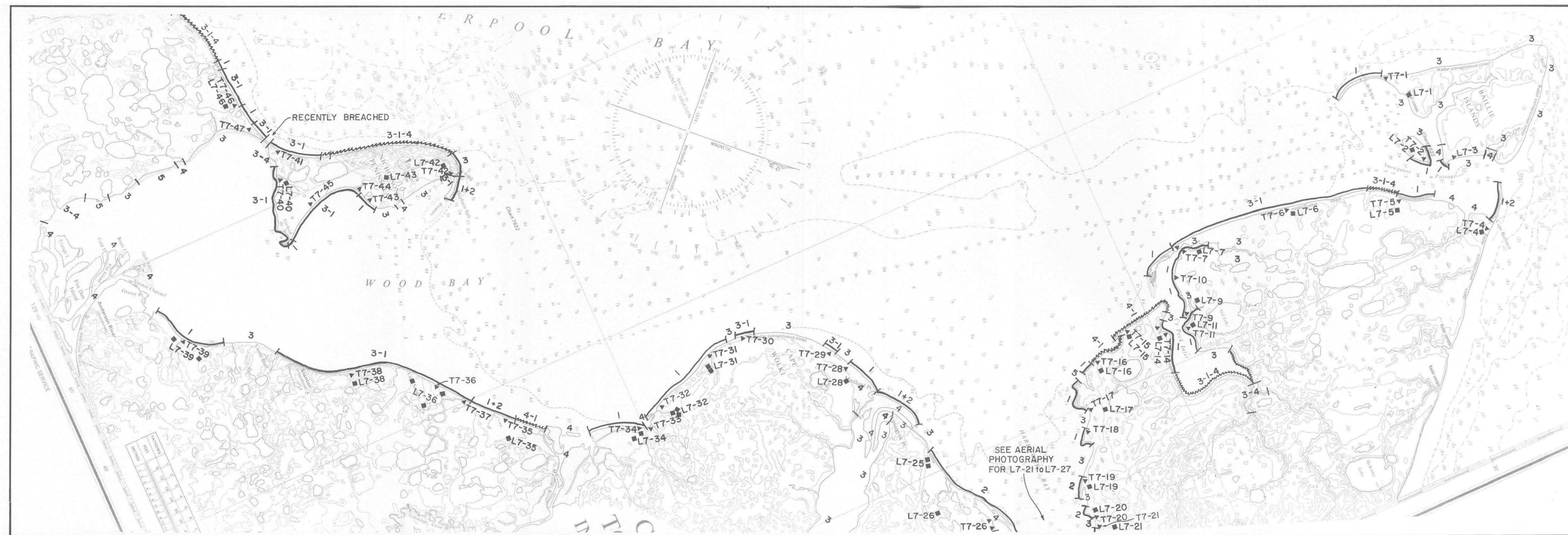
LIVERPOOL BAY

BEAUFORT SEA COASTLINE CLASSIFICATION

AND LOCATION OF PROPOSED LANDFILL DISPOSAL

AND TEMPORARY STORAGE SITES

MAP 6



LEGEND

BEACH UNIT	DESCRIPTION
1	Sand Beach - uniform fine to medium sand. Highest beach ridge may contain fine gravel. Beach width generally 15 m to 200 m, occasionally >300 m.
2	Shingle Beach - generally consists of mixed cobbles, gravel, and sand. Beach width generally 15 m to 200 m.
3	Cliffs - sea cliffs, generally 5 m to 50 m high. Often fronted by a very narrow beach.
4	Mudflats - tidal flats and low-lying river delta flats.
5	Tundra - low-lying tundra areas.
6	Landslide - only exceptionally large landslides are shown on this scale of mapping.
7	Sloping shoreline - caused by severe wind erosion of sand cliffs, no beach.

COMPLEX BEACH UNITS

3-1, 3-2	Cliffs with defineable narrow sand beach, cliffs with defineable narrow shingle beach. Beach width generally 10 m to 30 m.
3-4	Cliffs fronted by mudflats.
3-1-4	Cliffs fronted by mudflats, but with a 10 m to 30 m sand beach at the base of the cliffs. Beach sand is expected to be thinner than in Units 1 and 2.
4-1	Mudflats with a thin sand beach at the high tide mark. Beach sand is expected to be thinner than in Units 1 and 2.

Note: Where two units are not clearly separable at the scale of mapping, they are shown as a combination unit, e.g. 4+5, 1+2.

Sand or shingle beaches - Units 1, 2, 3-1, 3-2.

Sand beaches developed behind mudflats. Expected to be thinner than the above beaches. Access to the beaches is restricted by mudflats.

■ L1-17

Proposed landfill site for disposal of oiled beach debris. Numbers correspond to map and site numbers, respectively.

▲ T1-17

Proposed temporary stockpile site. Numbers correspond to map and site numbers, respectively.

0 5 10 kilometres

0 3 6 miles

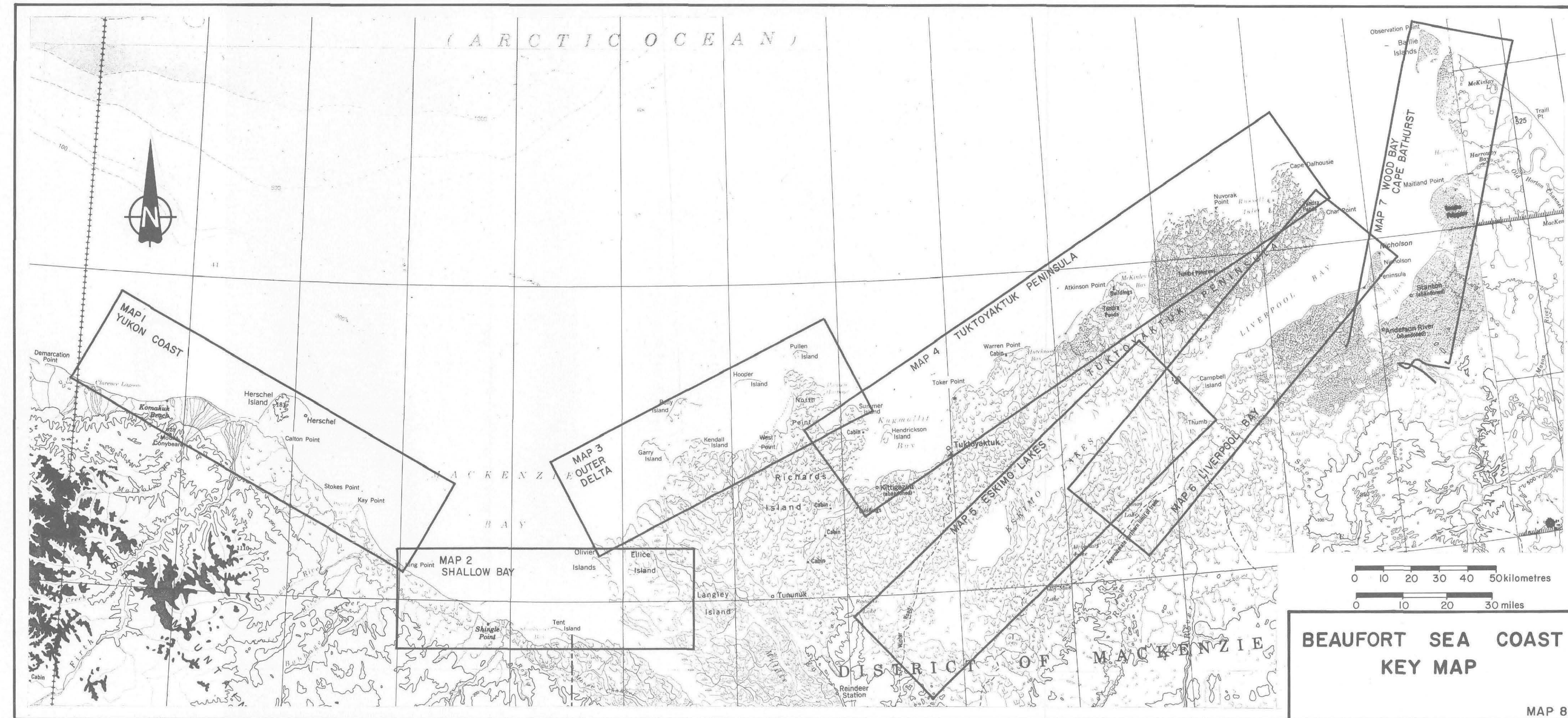
WOOD BAY-CAPE BATHURST

BEAUFORT SEA COASTLINE CLASSIFICATION

AND LOCATION OF PROPOSED LANDFILL DISPOSAL

AND TEMPORARY STORAGE SITES

MAP 7



APPENDIX I

SUMMARY OF COST ASSUMPTIONS AND
EXAMPLE CALCULATION OF COST ESTIMATE

APPENDIX I SUMMARY OF COST ASSUMPTIONS AND EXAMPLE CALCULATION OF COST ESTIMATE

1 DETAILS OF COSTS ESTIMATES

It was not possible within the terms of reference of this study to develop a separate cost for disposal of the oil debris on each beach. There are over 200 potentially cleanable beaches. Many factors, such as summer or winter burial, barging requirements, amount of oil debris to remove from the beach, distance to landfill disposal or temporary storage site, etc., affect the cost. As a result, it was decided to establish a standard size for a beach cleanup (15 000 m³ of oiled debris) and then compare the relative costs of cleaning up this beach. The costs shown in this section provide a reasonable estimate of the relative costs for budgeting purposes for the following four cases:

Case 1.	Summer burial (no barging)	\$2.1 million
Case 2.	Winter burial (no barging)	\$3.2 million
Case 3.	Summer burial (barging)	\$3.8 million
Case 4.	Winter burial (barging)	\$4.6 million

1.1 Landfill Site - Summer Burial Assumptions

- Site consists of a coarse-grained soil deposit with a little fine-grained soil at the surface.
- Volume of the disposal pit is 23 000 m³; area of pit is 40 m by 115 m = 4600 m²; and depth of pit is 5 m (Figure 1).
- Use 3600 m³ of fine-grained soil for cap (Figure 1).
- Use 4000 m³ of clean fill as interlayering material (Figure 1).
- Access road is one km long, 1.3 m high and 8.0 m wide (10 400 m³ of gravel borrow).
- Landfill site is located one km from beach.
- Borrow pit is located 0.5 km from direct line joining landfill site to beach.
- Volume of oiled debris compacted in the pit is the same as the volume cleaned from the beach (1500 m³).
- Average round trip on beach is two km.

1.2 Temporary Storage Assumptions

- Volume of storage pile is 1.25 times 15 000 = 18 750 m³, due to bulking of oiled debris.
- Slope of oiled debris pile is 35° and it is piles to a height of five m.
- Size of the storage area is 50 by 115 m (5750 m²).
- Storage site is covered with 0.3 m of clean fill (1725 m³) as a levelling course.
- Sand dykes around perimeter of site are 1.3 m in height and have a 30° slope (1000 m³).
- Access road from beach to site is 0.1 km in length, 1.3 m high and 8.0 m wide (1040 m³).
- Average round trip on beach is two km.

1.3 Landfill Site - Winter Burial Assumptions

- Volume of debris is 1.2 times 18 750 = 22 500 m³.
- Disposal pit has an area of 5800 m² (40 x 145 m) and is five m deep.
- Snow road thickness is 0.15 m above levelled grade and two km in length.
- Snow pad at landfill site is 0.15 m thick above levelled grade.
- Sand dykes levelled across temporary storage site and then 0.3 m of fine-grained soil placed over top (2000 m³) for revegetation purposes.

1.4 Barging Assumptions

- Average round trip on oiled beach is two km.
- Construct 200 m of earthfill jetty at loading and unloading area.
- Barge oiled debris 30 km.
- Use ocean tug to move barges in deep water and river tug to "loiter" the barges in and out from the jetties.

1.5 General Costing Assumptions

- Work week is seven days; work day is 20 hours; and work shift is 10 hours.
- Efficiency is 75 percent (work hour = 45 minutes).

- Equipment availability is 70 percent.
 - General contingency factor is 15 percent.
 - Alberta Road Builders rates for 1978 used plus 20 percent for northern allowance.
- The prices quoted include costs for the operators.

- Standby equipment charges do not include costs of operators.

1.6 Example Calculation for Summer Burial

The costs shown are estimates for budgeting purposes only.

1.6.1 Summary

Direct Costs	\$1,584,100.00 (Table 3)
Indirect Costs	211,200.00 (Table 4)
Reconnaissance	8,800.00 (Table 5)
Seeding	6,000.00 (Table 6)
<hr/>	
Total	\$1,810,100.00
Contingency 15 percent	271,515.00
<hr/>	
TOTAL	\$2,081,615.00

1.6.2 General

- | | | | |
|-----|-----------------------------------------------------------------------|---|---------------------------------------------------------------------------------------|
| (a) | Mobilization | - | four days (two days at staging area; one day travelling; one day unloading at beach). |
| (b) | Cleanup beach;
construct access
roads; excavate
disposal pit | - | ten days |
| (c) | Fill in disposal
pit; backfill;
seed and cleanup
site | - | eight days |
| (d) | Demobilization | - | four (one day loading; one day travelling;
two days at staging area) |

Total elapsed time is 26 days.

1.6.3 Details

TABLE 3 ESTIMATE OF DIRECT COSTS

Item	Labour, Material or Equipment	Quantity	Daily Unit Rate	Days Required	Cost
1	Cat DS Dozer/Ripper	6	2,000	26	312,000
2	10 yd ³ Tandem Dump Trucks	10	1,000	26	260,000
3	Write Off Low Pressure Tires for Tandem Trucks	10	7,000/truck	-	70,000
4	Cat 966 Front End Loader	1	1,300	26	33,800
5	Cat É12 Motor Grader	2	1,100	26	57,200
6	Cat 825 Compactor	1	1,700	26	44,200
7	Mayhew 1000 Drill Rigs on Nodwell Track Vehicle	5	2,000	26	260,000
8	1000 ton Barge	1	2,000	26	52,000
9	25-30 man Camp Barge	2	2,500	26	130,000
10	Harbormaster (utility craft)	1	500	26	13,000
11	On-Site Tracked Carriers	2	1,000	26	52,000
12	Shallow Draft 4000 hp Tug	1	5,000	10	50,000
13	1500 ton Equipment Barge	1	2,500	10	25,000
14	Geogel Powder	40 000 kg	3.00/kg	-	120,000
15	Industrial Fabric	13 500 m ²	1.85/m ²	-	25,000
16	Replacement Drill Bits	25	700.00	-	17,500
17	Laborers	6	100.00	26	15,600
18	Powdermen Helpers, Mechanics, Foremen	12	150.00	26	46,800
TOTAL					1,584,100

TABLE 4 ESTIMATE OF INDIRECT COSTS

Item	Labour, Services or Equipment	Quantity	Daily Unit Rate	Days Required	Cost
1	Superintendent	1	200	26	5,200
2	Engineer	1	200	26	5,200
3	Surveyor	2	150	26	7,800
4	Helicopter	1	4000	7	28,000
5	Catering	50 men	50	26	65,000
6	Standby Equipment				
	1 - 966 Front End Loader		90,000		
	1 - D8 Dozer/Ripper		150,000		
	2 - Tandem Dump Trucks		80,000		
	1 - 1000 Mayhew Drill Rig		100,000		
	1 - Portable Shop		25,000		
	Misc. Heating Equipment		15,000		
	Misc. Radio Equipment		40,000		
			<u>500,000</u>		
	Write off 20 percent for 26 days				100,000
			TOTAL		<u>211,200</u>

TABLE 5 ESTIMATE OF RECONNAISSANCE COSTS

Item	Labour or Equipment	Quantity	Daily Unit Rate	Days Required	Cost
1	Helicopter	1	4,000	2	8,000
2	Superintendent	1	200	2	400
3	Engineer	1	200	2	400
TOTAL					8,800

TABLE 6 ESTIMATE OF SEEDING COSTS

Item	Labour, Material or Equipment	Quantity	Daily Unit Rate	Days Required	Cost
1	Helicopter	1	4,000	1	4,000
2	Agrologist	1	250	2	500
3	Seed	100 kg	10/kg		1,000
4	Fertilizer	800 kg	0.625/kg		500
TOTAL					6,000