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by

C. L. Merrill, J. A. Pihlainen and R. F. Legget

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THE NEW AKLAVIK

Search for the Site

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This paper was presented to the Ottawa Branch of The Engineering Institute of Canada on September 18, 1956; to the Montreal Branch on March 20, 1957; and to the Cornwall Branch on April 17, 1957.

AKLAVIK, the main settlement of Northwestern Canada, is located in the delta of the Mackenzie River about 68°N. (Fig. 1). This places it in approximately the same relation to the Arctic Circle as Fairbanks in Alaska (65°N), Reykjavik in Iceland (64°N), Narvik in Norway (68°N) and Murmansk in the USSR (69°N). Compared to these other cities, Aklavik is a relatively small place with a permanent population of about 400, which increases to possibly 1500 during the short summer season when Indians and Eskimo come to visit the settlement. Despite this it is the most important Canadian outpost north of the Arctic Circle, and it will almost certainly steadily increase in importance with the development of the Canadian North.

The decision of the Government of Canada in 1953 to move the entire settlement to a new site is a matter of importance to all Canadians. This was the first step in a development in connection with a town which is almost without precedent, apart from such special operations as the move of some mining communities (notably Sherridon to Lynn Lake) and the current work in relocating some of the municipalities on the Canadian side of the St. Lawrence River. The decision to make the move was taken only after the most exhaustive studies. The selection of a new site was correspondingly made only after a most thorough investigation. It is the purpose of this paper to explain briefly the reasons for the move of Aklavik, the requirements for the new site, and the means employed in carrying out the field survey work which eventually resulted in the selection of a new location for this northern outpost.

The start of Aklavik can be dated as recently as 1912 when a small fur trading post was established. In 1919 the famous Anglican Mission was started. The R.C.M.P. established a detachment at Aklavik in 1922 and the first building of the signal station of the Royal Canadian Corps of Signals was built in 1925. The Roman Catholic Mission was started in 1926 and in this same year the adjacent post of the Hudson's Bay Company (on the Pokiak Channel) was relocated. By 1931 population of the settlement and the surrounding area had reached about 400. Today the population of the town and the surrounding delta country exceeds 2000, of whom about 30% are white, 20% Indian and 50% Eskimo; many of the Indian and Eskimo children live in the schools operated by the two churches.

In addition to being the location of the agencies already noted, the town is an important administrative centre for the Department of Northern Affairs and National Resources which is responsible for the administration of the Northwest Territories. More recent establishments have included a Department of Transport radiosonde station and a naval signal station. The town is supplied with electric power by a local power company and is served by two river transportation companies. A scheduled mail and freight air service from Edmonton is operated by Pacific Western Airlines.

The Mackenzie Delta

Aklavik owes its strategic location to the fact that it is on one of the main navigation channels in the delta of the Mackenzie River (Fig. 2). This is one of the greatest rivers of the world, eighth in order of magnitude based on discharge, eleventh in the size of its drainage area and so about 50% larger than the St. Lawrence. The Mackenzie System is navigable by shallow draft boats for 1600 miles from rail head on the Clearwater River at Waterways, Alberta, to the Arctic Ocean, with only one break—the 12-mile stretch of rapids on the Slave River between Fort Fitzgerald and Fort Smith at the northern boundary of Alberta. River transport is therefore operated in two stages on the upper and lower sections of the river system.

Because of the great load of sediment which the river carries, its delta is spectacular (Fig. 3). It is one of the most remarkable physiographic features of Canada, but because of its location it is not as well known as some other major river deltas of the world, even though it is the twelfth largest. From Point Separation, where the delta properly starts, it is approximately 150 miles to the Arctic Ocean. Unlike other deltas it is confined—on the west by the Richardson Mountains and on the east by the Caribou Hills and other high land that is a result of glacial action. Its maximum width is about 50 miles. Of this immense area about one half is water in the form of meandering channels and backwaters, small ponds, and many cut-off *(oxbow)* lakes.

The level area of the delta is nowhere more than from 10 to 15 ft. above normal river level, and much of the area is flooded during high water in the spring. Such land as there is appears generally to consist of silt covered by the inevitable muskeg growth so typical of the North. This makes an ideal area for the breeding of muskrat and the delta is well known as a muskrat hunting area. In the 5,275 square miles of the delta there are over 900 people dependent on trapping. Income from muskrat furs has been declining during recent years and this is creating a local problem. This is only one of the many problems regarding the future of Aklavik, however, which have had to be faced by those responsible for its administration.

Reasons for the Move of Aklavik

The entire delta area is perennially frozen so that the ground consists of material that can be described by the popular name *permafrost.* This condition indicates that the temperature of the ground for an appreciable distance beneath the surface (possibly 1000 ft.) is below freezing temperature, apart from the upper few inches which may thaw during the heat of summer. The soil on which Aklavik rests is an organic silt with a very high natural moisture content. Subsurface investigations for the formation of a new school, which were carried out in 1953, showed that about 60% by volume of the frozen fine-grained soil consisted of ice. If, therefore, the old town site were further developed with a further clearing of the muskeg cover and the installation of heated buildings, ground subsidence would occur with serious results.

The old town site is located on a bend in one of the navigation channels. The entire area adjacent to this site is flat and drainage has always been a particularly difficult problem. One feature of the area is stagnant pools of water formed by the melting of permafrost. Subsurface drainage is impossible and the ditches that are dug for surface drainage tend to complicate the drainage problem by causing still more thawing of the permafrost.

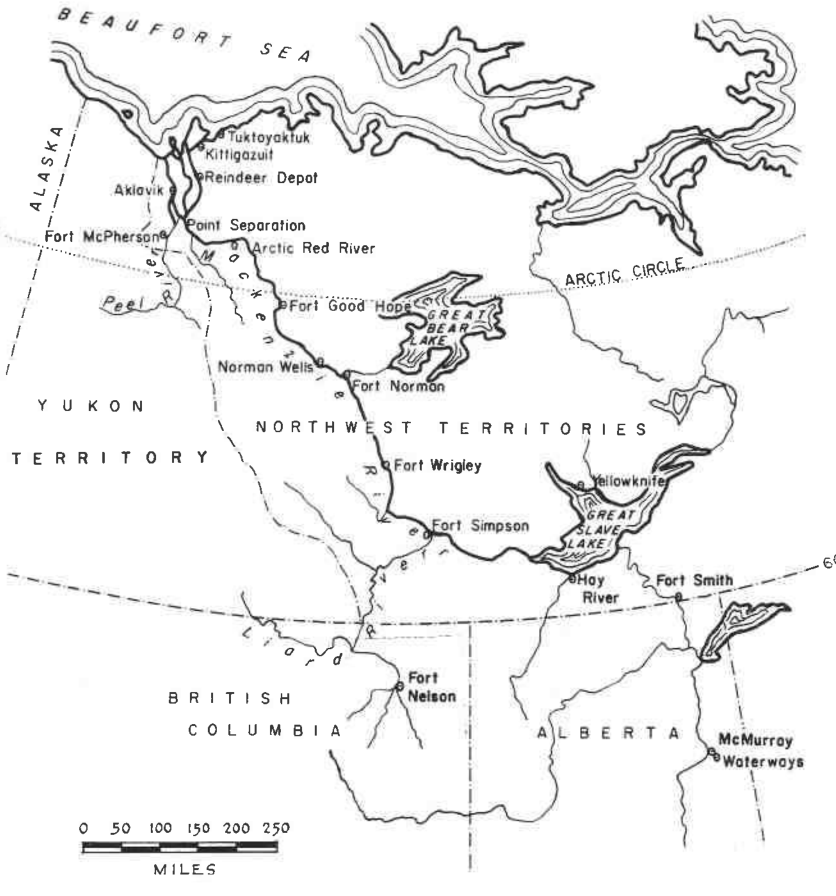
Because of the subsurface conditions, the laying of sewers or watermains beneath the surface would similarly create serious problems. To locate them above ground level and then to connect them to existing buildings would be costly and unsatisfactory for the existing town conditions.

The area used for the town is hemmed in by the bend of the river and by swamps and ponds. There is, therefore, no practical way for the town to expand, and expansion is vital if Aklavik is to fulfil its role as the centre of administration for northwest Canada. Not only is the present site restricted but it is even getting smaller because for some time the river bank has been eroding badly near the Roman Catholic Mission. Works to stop this natural action have been estimated to cost several million dollars and their success would be questionable.

Finally, if Aklavik is to serve properly the expanding needs of the North, it is essential that it should have available to it an airport that could be used throughout the year. Now each year, during the break-up period in the spring and the freeze-up period in the fall, the town is cut off from all flying services. Attempts have been made to construct an airstrip adjacent to the present town but the subsurface conditions are such that this has proved impracticable. A small strip for very light planes does exist, but only with the expenditure of vast sums of money could a major airstrip be developed.

These were the main factors that had to be considered with regard to the future of Aklavik as an expanding community of the North. Confirmation by detailed soil testing of what had been suspected about subsurface soil conditions finally showed the need for over-all consideration of the entire problem. It was this study that finally led to the decision that the only possible solution was to find a new site for the town.

Fig. 1. The Mackenzie Waterway.



Requirements for the New Site

Before any work could be done in attempting to locate a new site a clear picture had to be developed of the requirements that any such site would have to meet. These could then provide the guide posts for those who were to conduct the actual survey.

The essential factors for any new town site were determined as follows:

(a) the site must be suitable from economic and social points of view;

(b) the site should be suitable for the installation of permanent sewer and water systems, building foundations, and roads;

(c) the site should be on, or very close to, a good navigation channel within the delta;

(d) the site must have reasonably close to it a suitable area for the construction of a permanent first-class air field;

(e) there should be, within economical distance, a suitable public water supply.

The following were regarded as highly desirable features but were not quite so important as those already listed:

(f) the site should provide for economical and convenient disposal of sewerage;

(g) it would be convenient if there were a good supply of gravel and sand nearby for building purposes;

(h) from the navigation point of view it would be desirable if the wharf facilities could be used as a trans-shipment point for freight from river vessels to sea-going vessels which could sail out into the Arctic Ocean.

Finally, the following three factors had to be kept in view as desirable but in no way essential:

(i) availability of a good wood supply;

(j) availability of coal for heating purposes, and

(k) if possible, availability of water power which could be used for the generation of power for public supply.

Organization of the Survey Team

In January, 1954, when the requirements for the new site were specified, the agencies to be represented on the survey team were selected. These agencies were the Department of National Health and Welfare, the National Research Council (Division of Building Research), the Department of Northern Affairs and National Resources, the Department of Mines and Technical Surveys, the Department of Public Works, and the Department of Transport. To the Department of Northern Affairs was assigned the task of placing a team on the ground by March 15, 1954. The survey was to extend through late winter, spring, and summer and the team was to report its findings by August 1, 1954.

The personnel included men trained in the social and physical aspects of the geographic, geologic, and engineering sciences. (See Appendix A for members of the team.) Each agency had responsibilities in the Aklavik area. The Department of Northern Affairs, with the primary administrative responsibility, provided the project manager, C. L. Merrill.

In the few weeks during which the team was recruited, winter clothing, rations, camping and surveying equipment were obtained and, when necessary, shipped to Aklavik. During the winter the only means of getting in supplies was by air. At the same time, relevant information was obtained from reports of earlier expeditions and from representatives of the Royal Canadian Mounted Police and other organizations in Ottawa. Studies of air photographs, already initiated at the National Research Council, were continued in Ottawa until the time of departure of the team, and thereafter in the field.

In addition to the representatives

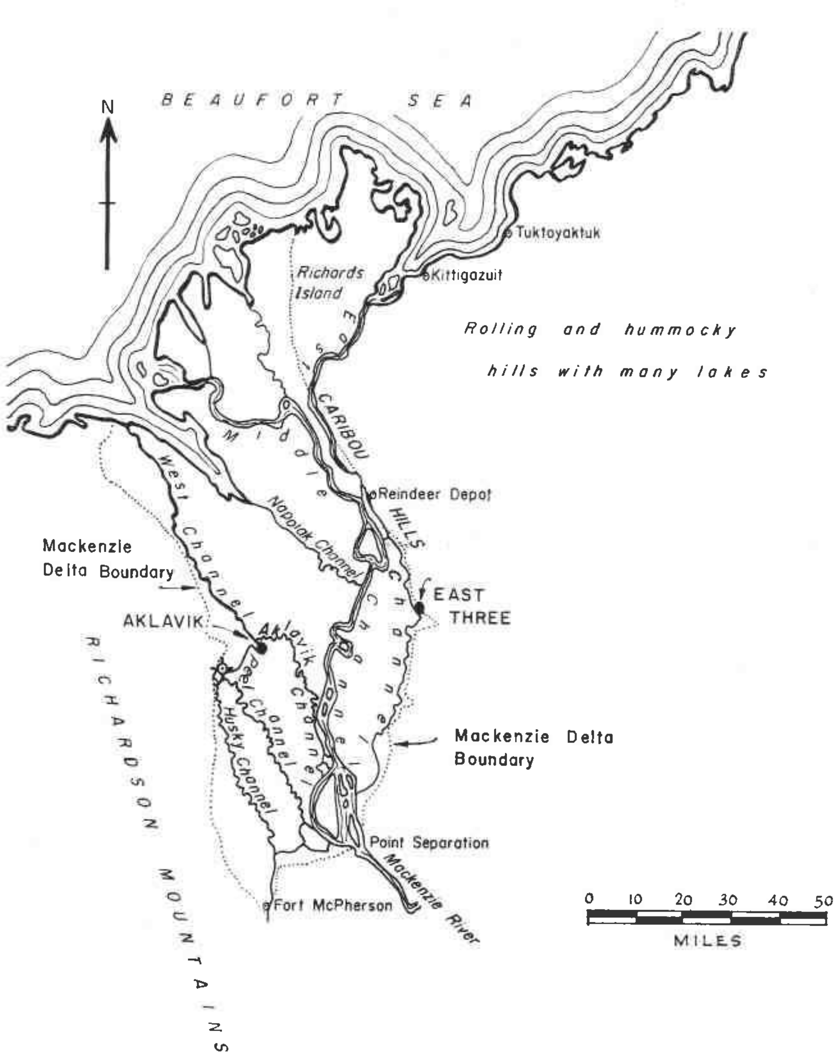


Fig. 2. The Mackenzie River Delta.

already mentioned who were recruited from personnel located at Ottawa and Edmonton, the team was assisted by local departmental representatives "ex officio". The Department of National Defence and the R.C.M.P. unit at Aklavik provided advisory members to the team. Their expert local knowledge proved to be of great value.

The benefit of other local experience was obtained through a Local Advisory Committee. This Committee included representatives from each racial group and from the traders and missions. The first meeting was held before the team established a camp; other meetings were called at intervals as required. In this way, not only was local experience made available to the survey team, but the residents of Aklavik were kept directly advised of the survey's progress.

The Use of Air Photographs

One of the most important early tasks of the survey party was the examination of air photographs covering the entire delta of the Mackenzie River. The techniques of air photo interpretation and identification are increasing in use, especially for the North. The advantages of using air photographs for a preliminary view of the field terrain conditions were appreciated by the survey team. Thus by examining in Ottawa the terrain to be covered by the survey, a preliminary appraisal was made of the problems that would be encountered.

An air photograph records every surface feature to which it is exposed. At first sight this can be confusing since the photograph records these details in many shades of black and white. If, however, the air photographs are viewed stereoscopically (three-dimensionally) the various land forms, and to some extent the variations in the vegetal cover, are soon apparent. After the air photographs are thus examined, similarities in terrain soon become clear. These terrain similarities or *patterns*, as they are most commonly described, are recognized by means of land form, vegetal cover, and photographic tones in a manner similar to the way in which one identifies various acquaintances by their stature and facial features. The land form patterns are then roughly delineated and sampling is carried out in each pattern. If the interest of the observer is the engineering use of soils, the identification of soils in various patterns is attempted. Thus instead of taking soil samples at regular intervals, samples are taken in strategically located positions in the land form and similar soil conditions are assumed for similar patterns. In this way preliminary sampling is greatly reduced.

Using these techniques, members of the survey team, working in the Building Research Centre in Ottawa, carefully examined aerial photographs of the entire area of the Mackenzie Delta. Twelve sites were selected as worthy of detailed study in the field. Their locations were accurately determined and salient features were noted for investigation in the field. The actual saving in time and money which this use of aerial photographs effected cannot be estimated with any accuracy but it is safe to say that, without this preliminary office work, the survey could have been only partially completed in one working season.

Fig. 3. A typical view of the Mackenzie River delta looking west at the Richardson Mountains.

The Survey: Aerial Reconnaissance

The survey party assembled at Aklavik during March 1954. This early field arrival date was fixed so that observations at potential townsite areas could be made under late winter conditions, during spring break-up, and during the summer season. Spring break-up records for the Mackenzie River delta are virtually non-existent and since this period is critical for any town, a helicopter was chartered for the survey period until well after break-up (Fig. 4). The helicopter was first used to make a winter reconnaissance of the potential site areas selected in Ottawa by the use of air photographs. The original selection of twelve sites was quickly pared down to six since some of the potential sites were obviously unsuitable when examined in the field. During these initial helicopter reconnaissance flights, notes were also made on the depth of snow cover and ice thicknesses of the river channels at the sites.

The helicopter had to be maintained remote from repair facilities, with a staff of only one pilot-mechanic, in air temperatures as low as $-30°F$ (in April 1954). During its service of 73 days, flights were logged on 69 days. (The machine was out of service for one day due to mechanical difficulty and for three days because of unsuitable weather.) A total of 201 sorties was flown for a total of 164 flying hours. Although the three-seat *Hiller* machine could carry the pilot and two passengers, it was found that the pilot and one passenger, usually with some survey or other gear, proved to be more effective in the work. The aircraft had a flying speed of 70 miles per hour and carried sufficient fuel for 3 hours flying with one passenger. All parts of the area under investigation were accessible in less than one hour from one of the base camps established.

Fig. 4. Spring break-up at Aklavik, June 5, 1954.

Field Investigation at Four Sites

The survey was conducted from a series of base camps from which investigations were carried out at each prospective townsite as the season progressed. Base camps were located in turn at four of the possible townsites. The more time-consuming operations, such as topographic and hydrographic studies, and soils investigations, were conducted when the base camp was at, or near, the site of the work. Use of the helicopter, and in summer a fast boat, made it possible to carry out some work at each potential townsite throughout the field season, regardless of the location of the base camp. In the course of field investigations the team was housed in tents. The cook, a driller's assistant, and several labourers were hired locally. The base camp was moved by tractor train, dog team, and by a small barge and scows, all obtained locally, as seasonal conditions dictated.

The first base camp was set up at

a potential site approximately 12 miles southwest of Aklavik. This site was located on the alluvial fans of the Richardson Mountains. The camp was located at the junction of the delta and the fans near the Husky Channel and so was called the Husky Site. The camp was set up during the beginning of April and consisted of two 16 x 16 ft. tents and some other smaller tents. All of the camp equipment was brought to this site by tractor from Aklavik.

Unfortunately the region experienced one of its coldest Aprils on record and this restricted much of the soil sampling. For the first two weeks in camp, the temperature rarely rose above 0°F and went down at night to as low as —30°F. An attempt was made to drill during this interval but the problems of supplying drilling wash water soon forced its abandonment until air temperatures rose above 10°F.

The drilling equipment used was a modified version of a permafrost drill developed by the U.S. Corps of Engineers (Fig. 5). It is essentially similar to a diamond drill using wash water to carry away bit cuttings, but uses a hard metal insert bit (*carballoy*) instead of a diamond bit. A notable feature of the rig is that it is made of lightweight materials and can be broken down into small light components for easy transportation by bush aircraft. The special feature of drilling and sampling in permafrost is not the equipment used but the amount of wash water and the skill with which it is used. If too much wash water is fed to the face of the bit to carry away frozen soil chips, there is a danger of melting and washing away the core, even though a double-tube type of core barrel is used. On the other hand, if too little wash water is used, the frozen soil cuttings soon form a slush with the wash water which can quickly freeze in the core barrel. No rules can be formulated for the amount of wash water to use and the correct amount is best determined in the field.

After the samples were obtained from the drilling, representative split cores were photographed in colour before soil samples were taken. These photographs were invaluable later when the soil test results were available and references were required to the types of frozen soil encountered. The samples were shipped to Norman Wells for routine engineering soil identification tests including determinations of moisture content, grain size, Atterberg limits, and natural densities.

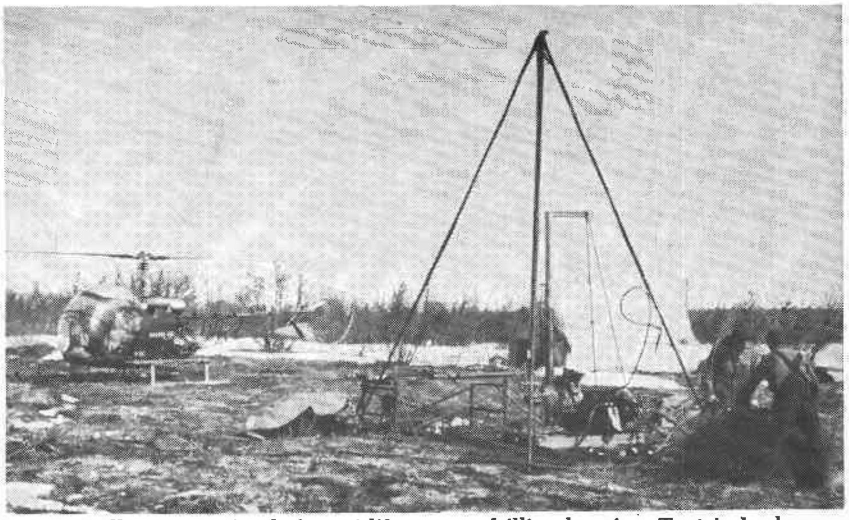


Fig. 5. Drill rig operation before airlift to next drilling location. Tent in background provides shelter for soil sampling and photographing frozen cones.

Break-up observations were started during May. These consisted of establishing observers at the potential townsites to record channel water levels and to assess the damage, if any, caused by the moving ice. During the break-up interval of the delta, daily reconnaissance flights were made with the helicopter and the rate of progress of the moving ice and general water levels was observed.

After break-up, the survey party proceeded to the east side of the delta and carried out terrain studies at two potential sites known as *East Three* and *East Four*. Two more of the east channel sites were eliminated as potential townsites because of their low-lying topography and possible difficulties in reaching them by river transport. After the east channel sites had been investigated, the party completed its investigations at another site on the west channel. This site was purposely left until the end of the survey since snow cover remained at this location until June and made terrain investigations difficult.

After the four finally selected sites had been investigated, the survey completed its field reports. A preliminary appraisal indicated the site known as *East Three* to be the most favourable. Even though a final decision on the new townsite could not be made until the fall of the year, the need for design data from the chosen site was anticipated. Accordingly the month of August and part of September were spent in making a detailed terrain analysis of *East Three* and collecting soil samples for a better understanding of the soils at this site.

Description of New Site: East Three

The central part of the eastern delta flank is predominantly a huge glacial moraine. In the southern part, bedrock is exposed through the glacial deposits; in the northern part, in the latitude of the Reindeer Station, the moraine is built up around the Caribou Hills. *East Three* is located between the areas of bedrock to the south and the Caribou Hills to the north where the East Channel flows along or close to high ground of glacial origin.

The relief of the area is one of flats at varying elevations, gentle undulations separated by shallow swales, rounded knolls, hummocky hills and ridges of varying heights and lengths. To the north are two terraces at elevations of 60 and 150 ft., and to the south a series of elongated smoothly rounded hills (drumlins) aligned in an east-and-west direction, with a swing to the north as the channel is approached. Some of the low-lying areas between the hills are occupied by small lakes.

East Three is drained to the west and northwest by streams which emanate from deep gullies in the high interior upland. The drainage is controlled by the relief, especially in the southern part of the area where the streams flow in parallel courses between the ridges. As a rule the ridges, knolls, and undulations are well drained although some of the relatively lower areas are not.

Spruce and birch are the dominant tree types, with secondary stands of willow and alder. The ground is generally hummocky with a varying cover of moss and shrubs. Birch predominates on the south-facing slopes and on well-drained areas. Spruce predominates on the north-facing slopes; stunted spruce, willow, and alder are found on more poorly drained areas.

Few trees grow on the low flat areas except along stream courses where there are dense thickets of willow and alder.

At *East Three,* frozen ground was encountered in September at depths varying from 6 in. to 4 ft. 3 in. below the ground surface. Surface cover of living organic material is 3 to 9 in. in depth. Soils range from fluvioglacial gravels to glacial till (stoney, silty clays with varying amounts of organic material, with the fine-grained material deposits being of greater extent). The largest deposits of coarse-grained materials (sandy gravels) are found on the northern portion of the site on the lower terrace immediately north of Boot Lake. Granular deposits are also found along the east and north banks of Twin Lake and to a lesser extent on knolls south of Boot Lake. Finer grained soils (stoney silt clays) are found in the ridges and in the lower areas over the rest of the site area.

It must be emphasized that the new town will still be founded on permafrost. It would be impossible to find any site in the delta area that was not underlain by perennially frozen material. In the development of the new townsite, therefore, every necessary precaution against disturbing the general permafrost condition will have to be taken. The topographical relief of the new site, however, will facilitate all surface drainage arrangements. The glacial origin of the underlying soils will yield more satisfactory foundation conditions than at the old site, and should provide reasonable supplies of road building material and gravel. At the same time, the glacial character of the local soils almost inevitably means that some massive ground-ice (in the form of *ice-boulders* in the glacial till) is present beneath the site so that some eventual ground subsidence is to be expected.

The site is a beautiful one, especially in summer, and spreads over rolling hills that are enlivened with small lakes. From the site there is a striking view of the low-lying delta to the west. With the careful town planning that is intended for the new settlement, the Aklavik of the future should be as attractive physically as the old Aklavik was disappointing.

Conclusion

Despite all difficulties the survey team completed their main assignment by the scheduled date, their findings pointing to *East Three* as the most desirable site for the new Aklavik. The third author had the privilege of visiting all four sites, in the company of his fellow authors and of other members of the team, in late July 1954. Two weeks later, the sites were visited by the then Minister of Northern Affairs and National Resources and by Mr. R. G. Robertson, his Deputy Minister. This is believed to be one of the first occasions when the Federal Minister responsible for Northern Canada has been able to study in the field, and far to the north of the Arctic Circle, the facts upon which a major policy decision was to be based.

The results of the survey were reported to the Advisory Committee on Northern Development, of which Mr. Robertson is the Chairman. The Committee endorsed the selection of *East Three* as the location for the new Aklavik and on November 18, 1954 the Federal Cabinet, upon the recommendation of the Minister of Northern Affairs and National Resources, officially decided that the town of Aklavik should be moved to this new site. Responsibility for the vast amount of work which the implementing of this decision involved is being shared by the Department of Northern Affairs and National Resources and the Department of Public Works. Preliminary planning has been done; work is actively proceeding at the site. Within a few years the new town will be a reality gracing its fine new location.

The authors are indebted to all the members of the survey team not only for their good work in the field but for demonstrating so well what can be achieved by real team-work in the interests of the awakening North.

Appendix A

the Survey Team

Members	Representing
K. C. Berry	Department of Public Works
R. J. E. Brown	National Research Council (D.B.R.)
G. H. Johnston	National Research Council (D.B.R.)
J. A. Pihlainen	National Research Council (D.B.R.)
J. K. Fraser	Department of Mines and Technical Surveys (Geographical Branch)
E. J. Garrett	Department of Transport
J. W. Grainge	Department of National Health and Welfare
C. L. Merrill (Leader)	Department of Northern Affairs and National Resources

Advisory Members "ex-officio"

Lieut. P. Johnson	Royal Canadian Navy—Aklavik
W. O. D. Allison	Canadian Army (Signals)—Aklavik
Inspector W. G. Fraser	Royal Canadian Mounted Police—Aklavik

Local Aklavik Advisory Committee

Canon R. K. Gibson (Chairman)	Anglican Mission
Father A. Biname, O.M.I. (Secretary)	Roman Catholic Mission
Karl Gardlund	Trappers
Charles Smith	Eskimo
Rev. J. Sitichinli	Loucheux Indians
Inspector W. G. Fraser	Royal Canadian Mounted Police
S. M. Peffer	Local Traders
H. Figgures	Local Traders
F. Carmichael	Territorial Government
L. B. Post	Department of Northern Affairs and National Resources (Local Administration)

Appendix B

Survey Costs

Staff salaries	$13,000
Personnel transport: Ottawa to Aklavik (Return) Edmonton to Aklavik (Return)	3,500
Rations (Purchased locally: 1440 man days at $3 a day)	4,320
Helicopter service	20,000
Labour (local)	2,857
Services (local)	468
Rental of equipment (local)	1,200
Camp fuel, 615 gallons heating oil at $0.26	160
Fuel for boats, 1277 gallons at $0.34	434
Oil for boats, 55 gallons at $2.50	137
Freight for initial camp, 3,000 lb.	3,630
Freight for drill rig*, 2,000 lb.	2,000
	$51,706

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