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OLD CROW
WATER SUPPLY STUDY

Prepared For

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LETTER OF TRANSMITTAL

5 December 1979
File: 1060-22-1-1

Department of Highways and Public Works
Government of Yukon
Box 2703
WHITEHORSE, Yukon
Y1A 2C6

Attention: Mr. J. Cormie, P. Eng.
Municipal Engineer

Reference: Old Crow Water Supply Report

Dear Sir:

We submit herewith our final report on the above project. The recommendations contained herein are based on our site evaluations carried out during our trip to Old Crow in July, on the engineering analysis of the selected alternatives and the Yukon Territories Government review of the draft report.

We look forward to discussing the results of this study with you at your convenience and offering any assistance possible in implementing the program recommended in the report.

Yours very truly,

STANLEY ASSOCIATES ENGINEERING LTD.

E.I. Shillington, P. Eng.
Project Manager

N.J. Nuttall, P. Eng.
Yukon Area Manager

EIS/NJN/ds
Enclosure

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ACKNOWLEDGEMENT

We acknowledge with gratitude, the assistance and guidance from the Yukon Territorial Government, Department of Highways and Public Works and in particular Mr. J. Cormie, P. Eng. and Mr. J. Grainger, P. Eng.

The study team for Stanley Associates Engineering was headed by Mr. E. Shillington, Project Manager with support from Mr. E. Kroeker, P. Eng., Mr. O. L. Shaw, P. Eng. and Mr. W. Kiefer, P. Eng.

SECTION 1

INTRODUCTION

1.1 SCOPE OF STUDY

The community of Old Crow, located at the junction of the Porcupine and Old Crow Rivers about 120 km above the Arctic Circle, does not have, at the present time, a reliable community potable water supply. Although several facilities in the community including the RCMP detachment, nursing station and the school have an intake, pumping, disinfection and storage facilities, most members of the community carry water in buckets from the Porcupine River or have it delivered in 45 (200 litre) gallon drums.

The scope of this study include the following:

1) To assess the potential for providing a reliable water supply for the community of Old Crow and to provide the conceptual design and cost estimates for alternative solutions.

2) To assess the relative merits and costs associated with the distribution of water to community users and to make recommendations.

1.2 AUTHORIZATION

This study was formally authorized by Mr. J.A. Cormie, P. Eng., Municipal Engineer, Department of Highways and Public Works, Government of Yukon (YTG) in a letter dated October 6, 1978.

1.3 TERMS OF REFERENCE

The primary object of this study was to determine and analyze options available for long term water supply systems and limited distribution systems to determine costs of these options.

1.4 STUDY APPROACH

This report contains the results of a water supply and distribution assessment study for the comunity of Old Crow. The results and recommendations have been based on a review of existing published information, from a site trip to Old Crow during July 30 and 31, 1979, and a review of current state-of-the-art technology. Water supply alternatives which have been considered include the following:

1) Porcupine River adjacent to the community of Old Crow
2) Old Crow River upstream of the community
3) groundwater
4) unnamed lake situated approximately 600 metres north from Old Crow.

Each of these alternatives is evaluated on the basis of the unique constraints imposed by the location of the town. A conceptual design for a system of water withdrawal from the Porcupine River has been included.

A subjective and objective analysis of water distribution alternatives is also provided. Alternatives considered range from "self-haul" from a centrally located pumphouse to underground piping.

SECTION 2

BASIC DATA AND DESIGN CRITERIA

2.1 STUDY AREA AND LAND USE

The community of Old Crow has a rather extensive history. Archaeological evidence suggests that people have been living in the Old Crow flats area for 30,000 years and the site of present day Old Crow has long been a focal point for gatherings because it is near the major caribou crossings and has always been a good fishing and trapping area. All weather access to the community is by air with alternative access by boat in the summer months. Refer to Figure 2.1.

The buildings that make up the physical village are strung out almost one kilometer along the right bank of the Porcupine River just downstream from the tributary Old Crow River. All are within 120 metres of the water's edge. The site is flat with slightly lower land situated behind the houses while the river bank is approximately 6 metres above normal water level. In front of the town the descent to the river is over a steep bank that is maintained in an unstable condition by the current of the river as it flows to the outside of the bend on which Old Crow was built.

There are approximately 75 major buildings in the settlement consisting mostly of log houses, and government buildings such as the school teacherage, RCMP, nursing station, government garage and post office. Service buildings include a co-operative store, community hall, band office, and air terminal building. There are two churches with associated domestic buildings. At almost every house there are one or more adjacent buildings such as caches, smokehouses, tent frames, sheds and privies.

2.2 POPULATION PROJECTIONS

Future population projections for a community such as Old Crow are tenuous since the establishment of economic activities could radically alter any predictions.

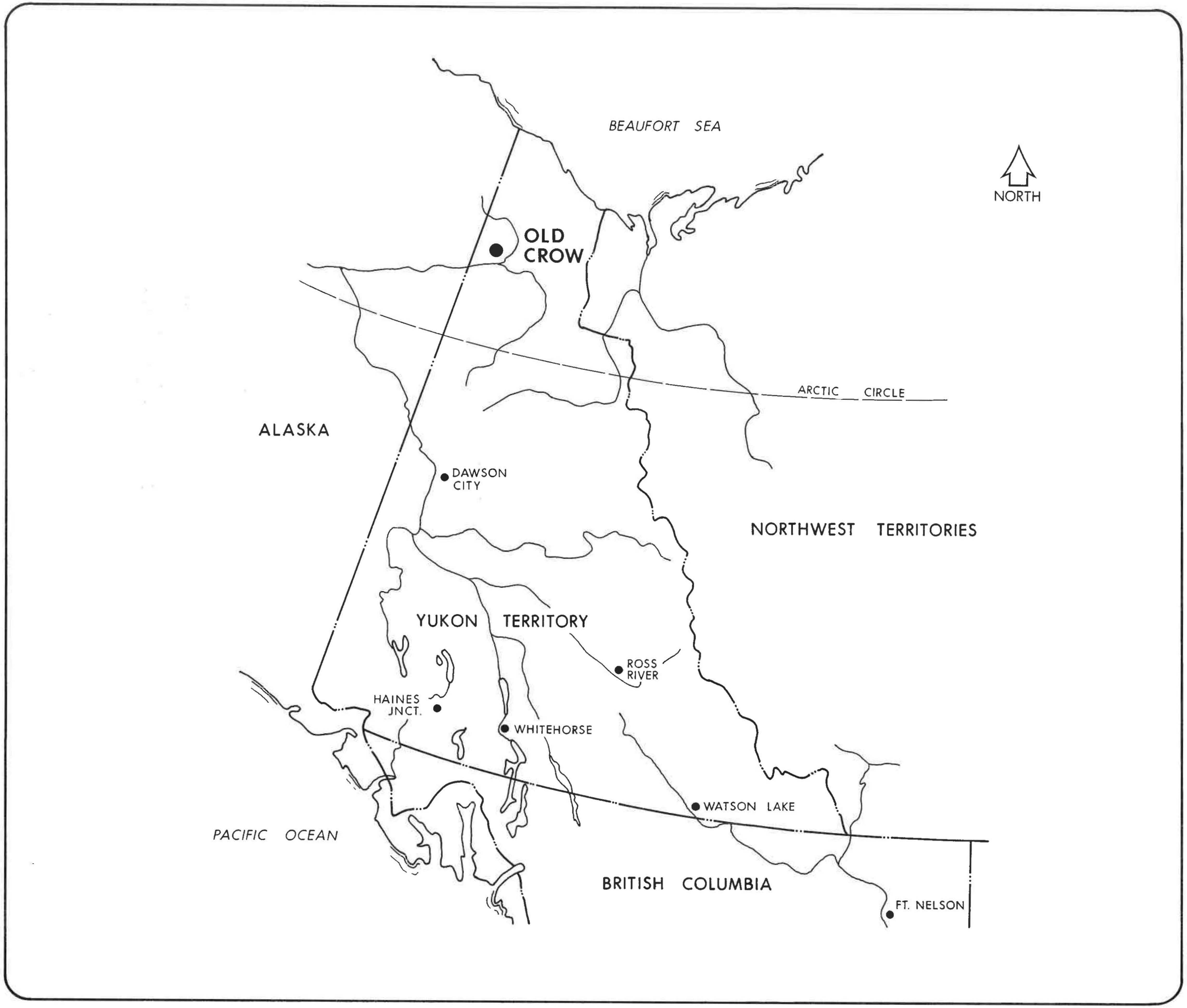

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figure 2.1

Location Plan for Old Crow

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Also, the establishment of a higher level of basic services could reverse the apparent flow of people away from the community and attract new dwellers. Nevertheless, for the purposes of planning utility systems a projection is required.

The population of Old Crow has been very stable over the past years as shown in Table 2.1 below:

Table 2.1 - Population Records

	Source	Year	Population
i)	Yukon Housing Corporation	1978	205
ii)	Economic Research	1977	197
	Economic Research	1979	210
iii)	Yukon Health Care	1977	183
		1978	202

Based on the above records and our experience in other communities we expect that the population to be stable unless gas or oil pipelines through this region become a reality. Therefore the design of the water supply system should be based on a maximum population of 250 persons which will give some future flexibility. Also, for economic comparisons of alternative water supply systems only a design life of 20 years will be used.

2.3 WATER DEMANDS

In order to estimate future water demands, an analysis of existing water usage in communities similar to Old Crow and a literature search was undertaken.

Water supply projections are based on the two methods of water distribution systems; mainly, truck hauled systems and a piped system. As outlined in Section 5, Water Distribution, a piped system proved to be impractical in Old Crow, therefore the water supply design criteria provided is only for a truck hauled system.

The following criteria were used to assess the water supply and servicing requirements based on a truck hauled system:

1) An average daily consumption of 90 litres per person

2) There are no requirements for maximum day or peak hourly demands

3) Total daily usage for 250 persons is 22,500 litres

4) Demands for the individual buildings such as the R.C.M P., teacherage and nursing station which will have a pressure pipe is 25 litres/min.

5) Fire flow storage requirement would be provided to accommodate sufficient reserve for the fire truck to fight a residential fire or for a fire flow to be directed from the pumphouse. We have calculated that a 10,000 litre storage tank would be adequate.

6) The supply line to the school was sized for useage only, no fire flow, and this was based on 45 litres/min.

2 4 SUBJECTIVE ANALYSIS

In formulating solution alternatives the following constraints were addressed:

1) a low level of community municipal services currently exists,

2) climatic limitations imposed by ground permafrost and severe temperature variations from winter to summer,

3) the relatively low population,

4) access isolation,

5) lack of diversified economic base,

6) the scattered distribution of buildings.

It is felt that any solutions to the water supply problem should give foremost consideration to the provision of a reliable potable water supply. Secondly, careful attention should be paid to the community's sense of self reliance. This factor is especially important since the community is relatively isolated from major supply centres for technical staff and expertise. Thirdly, proper regard should be paid to the social and cultural milieu of the community. From an economic and operating and maintenance point of view such a system in locations similar to Old Crow is not always appropriate.

SECTION 3

WATER SUPPLY

3.1 GENERAL

Water supply investigations for northern communities in areas of continuous permafrost generally consider the same types of water sources as those considered in temperate region studies. Surface water options are usually restricted to large rivers and large lakes since ice cover effectively eliminates smaller creeks and smaller lakes. Many freeze completely or to an extent that an adequate supply of water is not available. Subsurface water (groundwater) may be an option if permafrost conditions are such as to allow saturated thaw zones.

The following section discusses the surface water and groundwater resources of the Old Crow area within the context of their supply suitability and potential as well as the existing water supply. Refer to Figure 3.1.

3.2 EXISTING WATER SUPPLY AND DISTRIBUTION

As mentioned earlier, water supply for the community is currently derived from the Porcupine River. Although the quantity is adequate, quality of the supply is frequently less than desirable even by minimum drinking water standards. In the spring and summer the river has a sediment load that is enough to render the stream quite opaque. Problems of water quality also arise when the river is used as a vehicle for the removal of wastes, as been observed by the debris along the river shore.

Results of a September 1978 water quality survey by the Environmental Health Division, Health and Welfare Canada indicated that contamination of an intestinal nature was entering the Porcupine River from an unknown source. Six water samples collected in the vicinity of Old Crow and 32 km upstream on the Porcupine River each had faecal coliforms present in concentrations ranging from one to six

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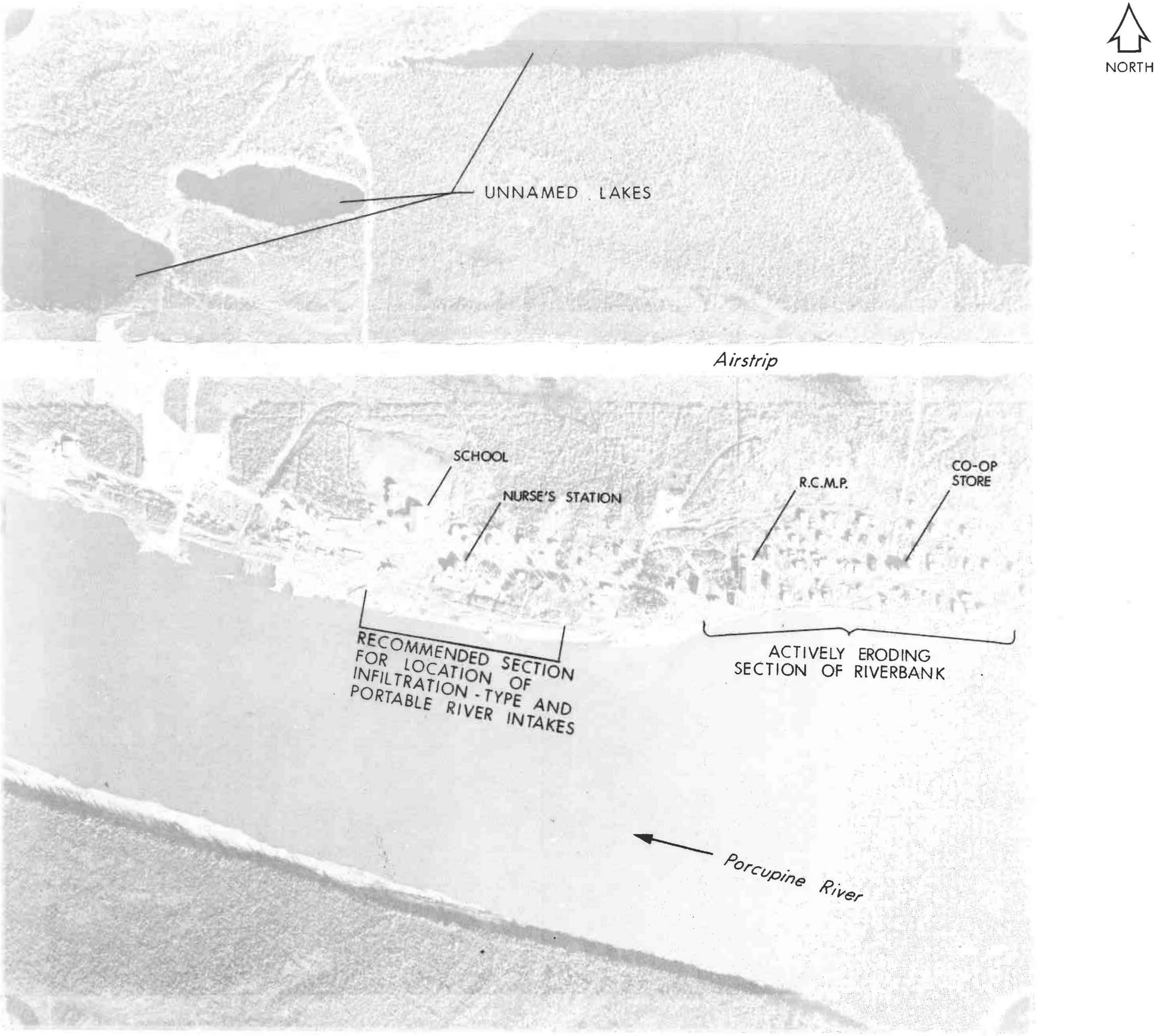

figure 3.1

Water Supply Sites

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colonies per 100 ml. Unless treated prior to use, water of this quality is deemed "unsafe" for human consumption. A water sample collected during April, 1979 again indicated the presence of significant coliform bacteria although faecal coliforms were not detected. The information indicates that from a public health standpoint an upgrading of the present water supply is required.

At the present time, water distribution in Old Crow is carried out in several ways. The nursing station, school and RCMP detachment have separate water systems from the river. These are portable systems used during periods of good water. Water is withdrawn from the river during periods of low turbidity and stored in indoor tanks. Water distribution to the remainder of the community is done either by "self-haul" or "community haul". During the summer, "self-haul" is accomplished by using 22 litre buckets which are carried by hand or by yoke. During the winter months water is drawn from a hole in the ice and hauled by hand or with the use of snowmobiles. The "community haul" method is currently done by the co-operative store by using a tractor and wagon to haul a small water tank at a cost of $3.00 per barrel or approximately $0.013 per litre ($0.06 per gallon). The water is stored in the homes in 225 litre barrels which have been supplied by the Territorial Government.

In 1978 the Federal Government Department of Indian and Inuit Affairs constructed a pumphouse consisting of a pressure tank, chlorination unit and 3,000 litre holding tank. A submersible pump was placed in the river with a heated line, insulated with styrofoam, running between the pump and the pumphouse. Because of malfunctions, however, the intake line froze and was broken by the river ice during spring break-up. The pump was also destroyed by spring break-up. At the present time, this system has not been repaired.

3.3 SURFACE WATER SUPPLY

The Hydrological Atlas of Canada published by Fisheries and Environment Canada contains maps which summarizes freeze up and break up phenomenon for regions within Canada. From interpolation of these maps it was found that the mean date for freeze up of rivers and lakes in the Old Crow area is October 15. The mean date for rivers to be clear of ice is May 21 and the mean date given for lakes to be clear of ice is June 21. It is recognized that these represent general dates only; however, they are presented here to provide appreciation of the Old Crow climate. This Atlas further lists the mean January daily air temperature to be -32.5 degrees Celsius and annual snowfall to be approximately 120 cm. Local residents have confirmed a maximum ice thickness in the range of 150 to 200 cm.

Surface water resources in the vicinity of Old Crow include the Porcupine River, the Old Crow River and a small unnamed lake situated 600 metres north of the community. Refer to Photo A. A field reconnaissance was made in July to assess these alternatives for their suitability as practical water sources.

3.3.1 The Porcupine River

The Porcupine River drains a large portion of the northern Yukon westward into Alaska where it eventually flows into the Yukon River at Fort Yukon, Alaska. The headwaters of the Porcupine River are in the British Mountains to the north, the Richardson Mountains to the east and the Ogilvie Mountains to the south. Notable tributaries include the Bell, Eagle, Rock, Whitestone, Miner and Old Crow Rivers.

Water Survey of Canada (WSC) have operated a hydrometry station, No. 09FD001, near the community of Old Crow on the Porcupine River since 1961. The drainage area above this station is 55400 sq. km. From inspecting these records it was found that typically the highest annual flows occur in May or June and the lowest annual flows occur in March or April. The maximum daily flow record was 6711 m^3/sec occurring on June 4, 1964 and the minimum daily flow on record was 11 m^3/sec occurring on April 3, 1975. In view of the community's water requirement being so low it is evident that the volumetric supply potential of the Porcupine River is guaranteed.

The bed material of the Porcupine River consists of coarse gravels to 10 cm cobbles and as such is subject to shifting and scour at high flows (see photos B and C). Adjacent to the community, the bank of the river has been eroding rapidly (for some 500 m of length) in recent years, as shown in Photo D. Efforts to control this lateral migration and protect the buildings near the bank have been initiated during the summers of 1974 and 1975 by the Yukon Territory Government and continued in the summer of 1979. An unprotected gravel embankment has been placed along

Photo A - Viewing northwest towards the Old Crow settlement. Note that the community is located on a historic floodplain of the Porcupine River.

Photo B - Viewing upstream along the bank of the Porcupine River adjacent to the Old Crow settlement. Note the sorting of bed material and the scour conditions at the right of the photograph.

Photo C - Viewing typical bed material along the bank of the Porcupine River at Old Crow. Sizes range from sand and gravel to cobbles.

Photo D - Viewing upstream along the actively eroding section of bank of the Porcupine River at Old Crow. Surface velocities measured at this location during July 1979 reconnaissance neared 1.7 m/s.

some 120 m of the eroding reach. It is our understanding that this program will continue during the summer of 1980. This remedial action to control bank erosion will require maintenance as portions of the unprotected embankment will be lost during high flows. Any intake facility along the Porcupine River would not be sited along this eroding reach for these reasons.

The Porcupine River has high silt concentrations during the annual freshet and to a lesser extent during summer rainstorm periods when flows are similarly high.

3.3.2 The Old Crow River

The Old Crow River is considered a small stream in comparison with the Porcupine River at the community of Old Crow. WSC operates a hydrometry station at the mouth, No. 09FC001, which drains an area of 8600 sq. km. Data from this station indicates that minimum flows during the winter months are minimal if not zero. This would be the case if the stream is completely frozen as has been reported by local residents in the past.

In as much as the shortest distance from the stream to the center of the community (i.e., school and nurses station) is over 2 km and due to the potential for complete stream freeze-up, this supply source has been ruled out as a feasible alternative.

3.3.3 Small Unnamed Lakes

Approximately 600 m north of the Old Crow community and north of the airstrip, three small lakes or ponds were also investigated. These lakes are remnants of a historic meander scar and are not likely to be more than a few metres deep due to years of sediment laden inflows and organic growth along the shorelines. It is the opinion of some local residents that these lakes freeze to the bottom, although we have no confirmation of this. However, the literature points out that when shallow Arctic lakes develop an ice cover they frequently 'freeze concentrate' impurities below the ice to an extent that the water is no longer of acceptable quality. This condition may exist on these small ponds north of Old Crow if, indeed, they do not completely freeze.

During the July 1979 reconnaissance, it was noted that algae growth existed on the periphery of the lakes. In addition garbage and similar refuse was observed at locations near the lakes, see Photo E. These facts lead to suspicions of unacceptable water quality in the lakes and/or possible contamination from the presence of garbage. Since the volumeric supply potential is also in doubt this alternative is rejected for purposes of this study on Old Crow's community water supply.

3.4 GROUNDWATER SUPPLY

3.4.1 Geology

In the Old Crow Basin, bedrock is overlain by thick, non-glacial sediments which are in turn overlain by glaciolacustrine silts and clays. The community of Old Crow is situated on a terrace of the Porcupine River, which is comprised of fine sand and silt underlain by fluvial gravels.

Results of test drilling program undertaken by the Terrain Sciences Division, Department of Energy, Mines and Resources indicated that the river bank at Old Crow consists of from 3 to 6 metres of sandy silt and silty sand overlying gravel. During the program five testholes were drilled along the banks of the Porcupine River in April, 1973 (testhole locations and lithologs are included in the Appendix). The drill hole logs indicated that the coarse river bed material which is exposed on the bank near the low water continues at approximately the same elevation beneath the finer frozen flood plain deposits. Mr. J. Veillerette, who was in charge of the test drilling program, further indicated in a telephone conversation that one test hole encountered unfrozen gravel at 4.5 metres below surface. The test hole was drilled in April, 1973, approximately 15 metres south-east of the RCMP building. A thermistor cable was set in this test hole and at 5.5 metres from surface the temperatures observed were -3.3°C on November 9, 1973 and -3.8°C on January 25, 1974. A second hole was drilled in this vicinity at the toe of the river bank. The hole was drilled to approximately 1 metre and water was encountered at 0.3 metres below ground level. Permafrost was encountered to the full depth (approximately 6 meters) in the remaining test holes drilled on top of the bank, east and west of the RCMP building.

Photo E - Viewing one of the small unnamed lakes .6 km north of the Old Crow settlement. Note the algae growth around the periphery of the lake and the presence of garbage near the water's edge.

Photo F - Viewing inspection pit along floodplain of Porcupine River south of Nurses Station of Old Crow. Note the nature of the material and the presence of water in the bottom of the hole.

3.4.2 Groundwater Occurrence

Under normal conditions the coarse deposits of fluvial gravels which underlie Old Crow would provide excellent potential for groundwater development. A water well completed in these gravels would be capable of producing fairly substantial quantities of water from bank storage, and induced infiltration from the Porcupine River. However Old Crow is located in a permafrost region which presents problems towards the development of a groundwater supply.

Groundwater is generally obtained from one of the following three zones in permafrost areas:

(a) in the active layer (suprapermafrost)
(b) in thawed areas within the permafrost (intrapermafrost)
(c) beneath the permafrost (subpermafrost)

In the active layer groundwater movement ceases during the winter months, and therefore the supply is seasonal. The subpermafrost zone beneath the permafrost may be as deep as 300 metres in the Old Crow area which essentially eliminates this prospect on the basis that it would not be economical to undertake groundwater exploration and development at this depth. The best prospect for groundwater development at Old Crow would be from the intrapermafrost zone, and in particular from the thaw bulb associated with the Porcupine River. For example, a test drilling program was conducted on the Sagavanirktok River near Prudhoe Bay to identify the extent of the thaw bulb. The drilling was conducted in April, 1969 and consisted of two sections across the river. The results indicated that in April the unfrozen zone was up to 5 metres thick and 60 metres wide. It was further noted that the thaw bulb was below the river extending 10 metres out towards the bank on one side and 20 metres out along the flood plain. Detailed cross sectional drilling has not been carried out at Old Crow; however, in one of the test holes drilled by the Department of Energy, Mines and Resources (Section 3.4.1) unfrozen gravel was encountered at 5.5 metres below surface in the vicinity of the RCMP building.

Because there is no aquifer test information available for Old Crow it is difficult to estimate probable well yields for the fuvial gravels. However in the test hole drilled near the RCMP building a loss of circulation was experienced in the gravels at 4.5 metres, indicating the materials are relatively permeable. Also during our field trip in July, 1979 the material along the flood plain, south of the nurses station was inspected. The material consisted of coarse sand and gravel (up to cobble size) and appeared to be fairly permeable (see Photo F). It should be possible to complete a well in these gravels which would be capable of meeting Old Crow's water requirements.

3.4.3 Groundwater Development

One of the most important considerations in developing a groundwater supply at Old Crow is the availability of construction equipment. Since there is no drilling equipment available, a water well drill would have to be either flown in, or improvised on location. Another alternative would be to use what available excavation equipment there is at Old Crow to dig a large diameter hole, set metal or wooden cribbing and backfill with permeable gravel material. The location of the well would be determined by the nature of the thaw bulb associated with the Porcupine River. It would be preferable to construct the well as close to the river as possible as the size of the thaw bulb will diminish during the winter months. It is also recommended that the well be equipped with a device to protect against freezing during the winter months. Either an electric or a hot water circulation system could be used.

3.5 RECOMMENDED WATER SOURCE

The Porcupine River is the most suitable of the surface water and groundwater options discussed to meet the needs of the Old Crow community. Firstly, the volumetric supply potential of the river is ensured as minimum winter periods flows remain quite substantial. With the other surface water options there are no assurances that a supply would be available year round. Secondly, the piping distance for the insulated line from the water source to the community center is shortest with the Porcupine River option over the two other surface water options. Lastly, the drilling difficulties and high costs associated with groundwater development in areas of continuous permafrost effectively rule out this option when compared to the readily available Porcupine River as a source of supply.

SECTION 4

WATER SUPLY SYSTEM ALTERNATIVE - PORCUPINE RIVER

4.1 GENERAL

As stated in Section 3.4 the recommended water source is the Porcupine River. This section deals with the alternative concepts for providing the means of getting the water to the community.

As discussed in Section 3.3.1, the Porcupine River has an alluvial bed that is subject to shifting and scour action during high flow periods. Further it was described that during those high flow periods much silt is suspended in the river water and some settling must be allowed prior to domestic water usage. Complete ice cover on the river exists for six to seven months of the year and the freeze up and break up processes may extend over several weeks. In selecting the water intake system for Old Crow these river characteristics form an important aspect of the design criteria.

For a long term water supply the two basic types of water intake systems for rivers are the direct water intake situated on the bed of the channel and an infiltration intake buried within the river bed materials. With respect to the community of Old Crow and the Porcupine River, these systems each have certain advantages and disadvantages. Also investigated was the use of a portable water intake.

i) Direct Water Intake

Direct water intakes have the following advantages:

1) large capacity
2) little maintenance required if properly located in the river channel.

They have the following disadvantages:

1) subject to damage from river scour or ice impact and will require protection (i.e. riprap, gabions)
2) relatively high installation cost
3) no filtration of suspended silt
4) trash racks on intake structure are subject to plugging by debris or frazil ice

ii) Infiltration Intakes

Advantages of the infiltration intake include the following:

1) to a certain extent, the structure is removed from the river and thus eliminates potential damage associated with scour and ice impact
2) provide a measure of silt filtration
3) performance not affected as greatly by frazil ice build up
4) may be located outside the active low flow channel

Disadvantages include the following:

1) lower capacity
2) subject to a build up of sediment and difficult to clean (i.e., backflush)

iii) Portable Water Intake

As a third intake alternative, there was investigated a portable intake unit which would float during periods of open water and be situated in the ice during the winter months. This intake would be taken out of service during spring break-up and winter freeze-up.

During these breaking periods a water reservoir of approximately 60 days storage, 675,000 litres, would be required.

Advantages of the portable intake is that costly construction in the river bank and channel is avoided.

Associated with this type of intake are disadvantages as follows:

1) heated water storage is required for the periods of freeze-up and ice break-up
2) no measure of filtration is provided but the turbid periods can be avoided by utilization of the reservoir
3) the intake will require to be set-up and dismantled at least twice a year.

In consideration of the above three intake alternatives only the infiltration intake and the portable intake alternatives warranted further detail engineering and cost consideration.

4.2 INFILTRATION INTAKE ALTERNATIVES

Numerous arrangements and configurations of river infiltration type intakes have been designed with varying degrees of success. In keeping with the infiltration concept two alternative designs are presented in Figures 4.1 and 4.2.

i) Conventional Infiltration Gallery (Figure 4.1)

Figure 4.1 illustrates a conventional infiltration gallery approach with a perforated pipe extending parallel to the Porcupine River and gravity feed back to a large diameter wet well located on the top of the river bank. In Old Crow this conventional approach presents problems both from an operational and construction point of view.

Operation of this system would require that the infiltration gallery be fairly extensive due to the heavy silt loads of the Porcupine River which determines the system life of the gallery. Also the depth of bury of the gallery will have a direct influence on the system. The infiltration gallery would be constructed as close to the main river channel as physically possible. As per any infiltration gallery it is extremely difficult to estimates its useful life.

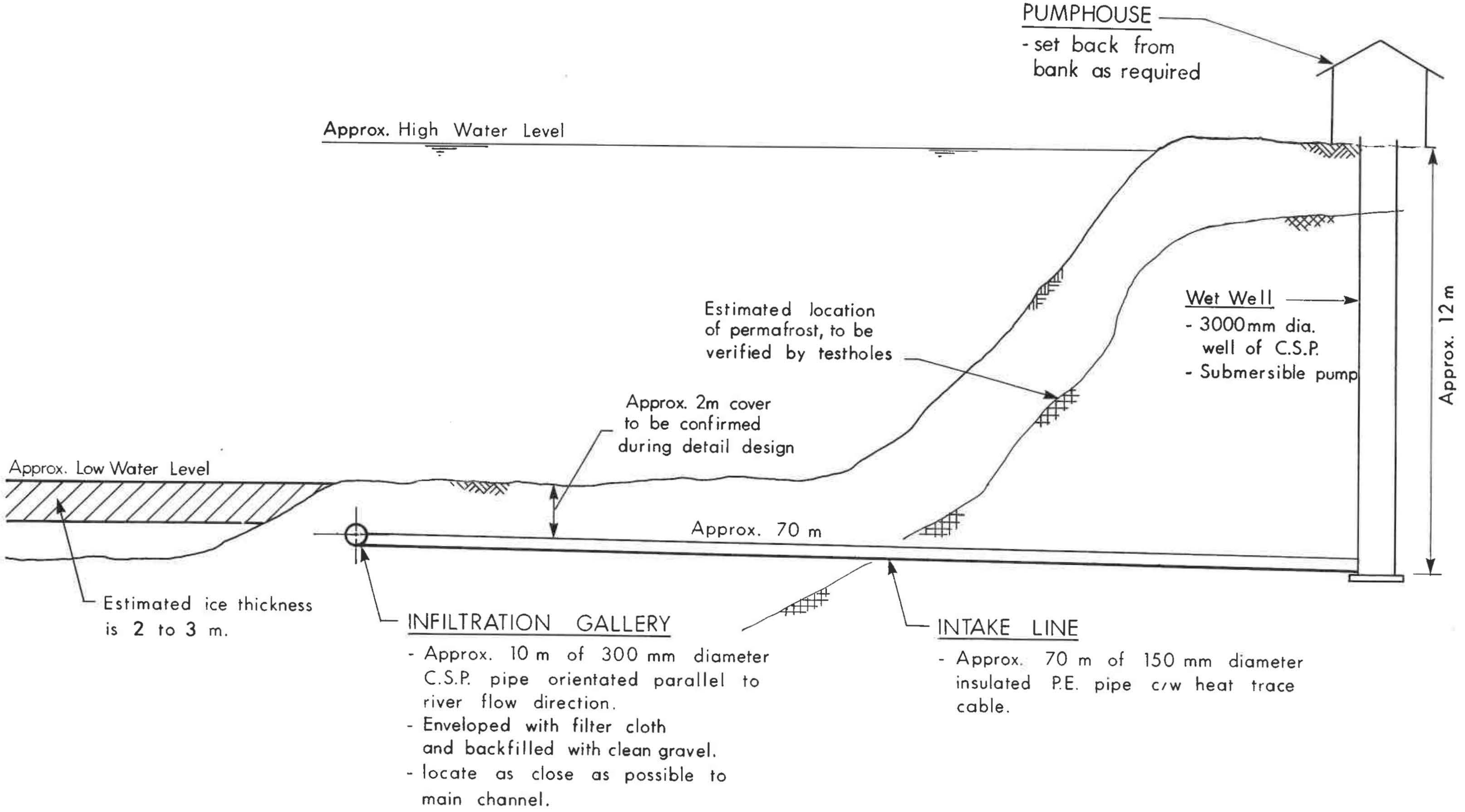

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figure 4.1

Conventional Infiltration Gallery Alternative

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The inlet line will pass through seasonal frost and permafrost zones which will require this line to be insulated and heat traced. If the heating system failed on this line it would be difficult to unthaw but it could be done with a steamer. The wet well would also be required to be heated to prevent freeze up.

Construction of this type of intake would be very expensive due to the required gravity intake line and wet well. The infiltration gallery should be fairly straight forward since it would only be buried to a depth of two (2) metres. The inlet line would be approximately 70 metres in length and be buried two (2) metres in the river bottom and 12 metres in the river bank. The wet well would also be constructed approximately 12 metres in the river bank which is estimated to be partially in the permafrost areas. Large construction equipment is required for this type of work of which none is available in Old Crow.

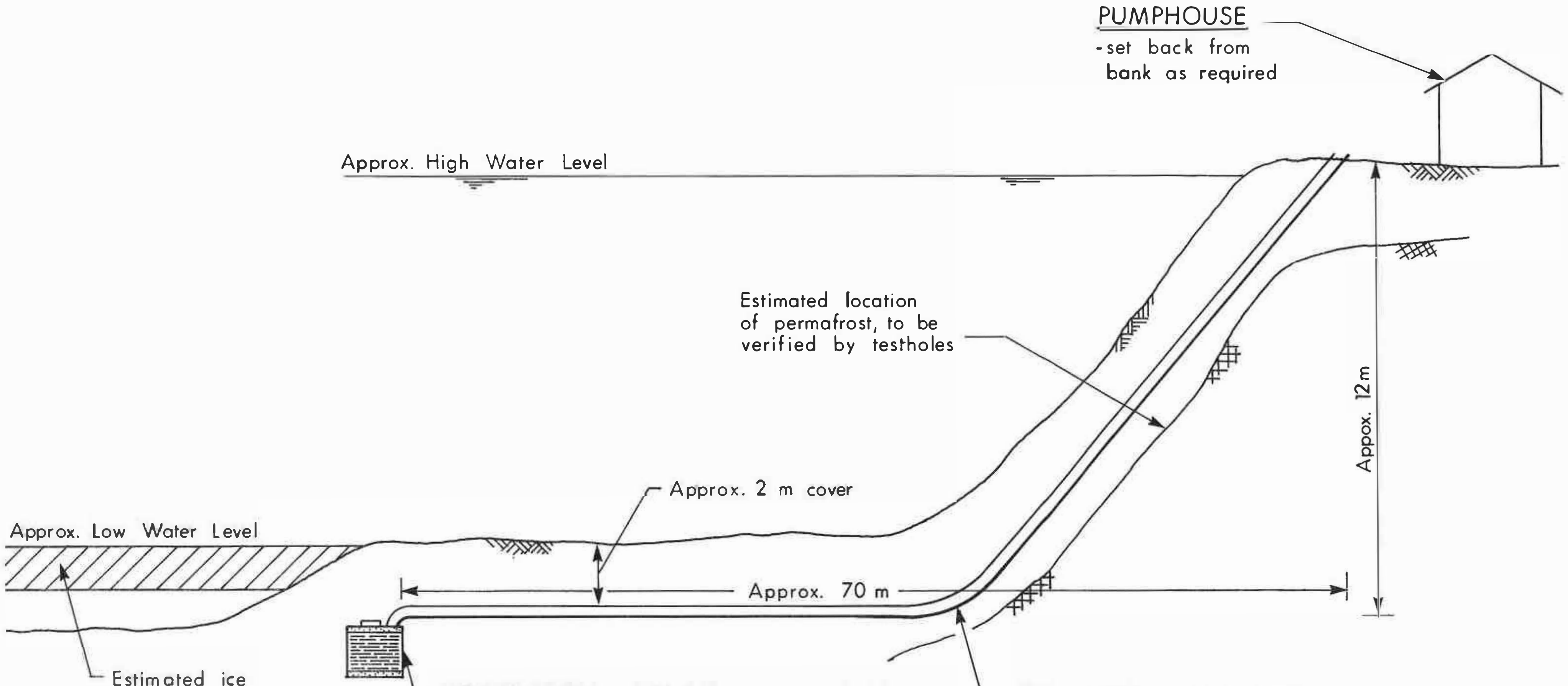
A pumphouse would be provided in this system which includes a 10,000 litre reservoir for fire flows and a chlorination chamber. Small pumps would be installed to provide pressure for truck filling and the fire standpipe.

ii) Infiltration Pump Cell

Figure 4.2 illustrates an innovative system employing two separate 'infiltration cells' equipped with submersible pumps to deliver water directly to a water supply facility located on top of the bank. This type of system does not require a wet well.

This system is much simplier in construction procedure than the conventional system but it also has severe operational constraints.

Operation of the system would include two infiltration cells, buried at least 2 metres deep in the river gravels and located as near the main river channel as possible. These cells should be physically situated to ensure the integrity of one should some damage occur at the other. The final positioning of each in the river gravels should be in light of silt depositional patterns and rivershed scour activity. A competent river engineer should be involved in site selection and a detailed hydrographic survey is a prerequisite to final design. Each of the infiltration wells would have two small submersible pumps with one in each cell pumping



INFILTRATION CELL (2 recommended)

- Two submersible pumps in each cell.
- 2 m diameter 'perforated' C.S.P.
- Concrete base and concrete top with access hatch.
- Enveloped with filter cloth and backfilled with clean gravel.
- Locate as close as possible to main channel.
- Connect the two cells together by perforated pipe.

INSULATED INLET LINE

- Polyurethane insulation with electric heat cable.
- One line common to both infiltration cells or seperate lines. Dependent on seperation of wells.

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figure 4.2

Infiltration Pump Cell Alternative

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continuously to a storage tank located on the river bank. The two wells could be connected together by a perforated line to enhance system operation. The supply line would be an insulated heat traced line buried at approximately 1.5 to 2 metres in the river bed and river bank. During detail design operational aspects of these wells would be throughly considered prior to finalization of the well design.

The pumps would be servicable only during that part of the year when the river is the lowest. Also, the infiltration cell capacity is entirely dependent on the permeability of the riverbed material.

Construction of this system would not require any specialized equipment. The infiltrate cells and supply line would be required to be deep enough to avoid scouring of the river.

The pumphouse for this system would be similar to the conventional infiltration gallery pumphouse.

4.3 PORTABLE INTAKE ALTERNATIVE

A portable intake alternative was included because it allowed the flexibility of avoiding any construction in the river bed and bank. This alternative, refer to Figure 4.3, would include the following:

1. Portable intake unit which would either float on the open water or sit on the ice.

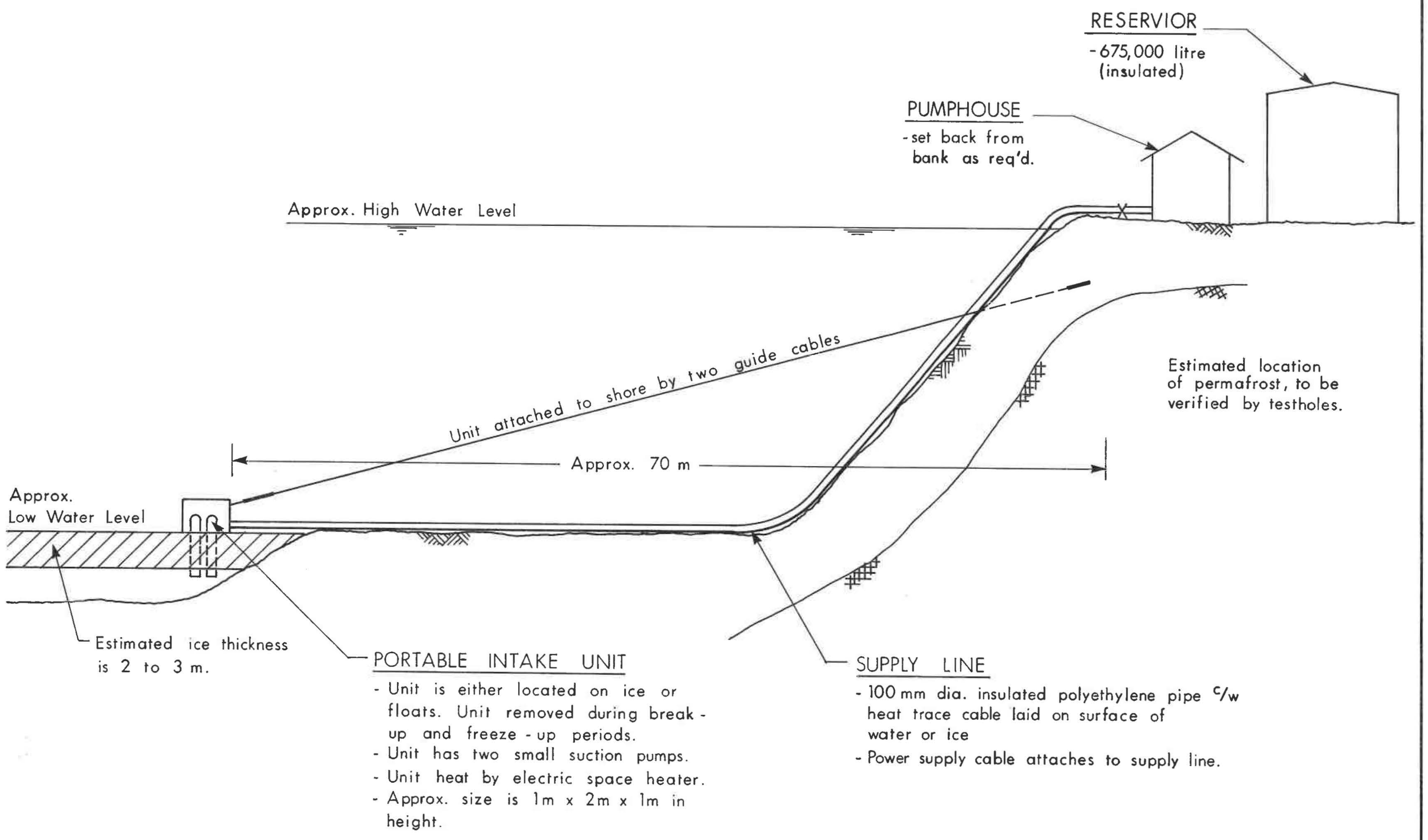
2 Insulated polyethelyene supply line complete with flexible couplers.

3. Pumphouse and reservoir capable of storing 60 days average water consumption; 675,000 litres.

This alternative would allow easy access to the pumps or supply line. The reservoir would be an insulated steel tank located on grade. The pumphouse would contain a recirculation pump from the boiler to keep the water in the reservoir warm and also to pressurize the truck fill operation and fire standpipe.

GOVERNMENT OF THE YUKON

OLD CROW WATER SUPPLY STUDY



RESERVIOR
- 675,000 litre (insulated)

PUMPHOUSE
- set back from bank as req'd.

Estimated location of permafrost, to be verified by testholes.

Estimated ice thickness is 2 to 3 m.

PORTABLE INTAKE UNIT
- Unit is either located on ice or floats. Unit removed during break-up and freeze-up periods.
- Unit has two small suction pumps.
- Unit heat by electric space heater.
- Approx. size is 1m x 2m x 1m in height.

SUPPLY LINE
- 100 mm dia. insulated polyethylene pipe c/w heat trace cable laid on surface of water or ice
- Power supply cable attaches to supply line.

figure 4.3

Portable Intake Alternative

Stanley
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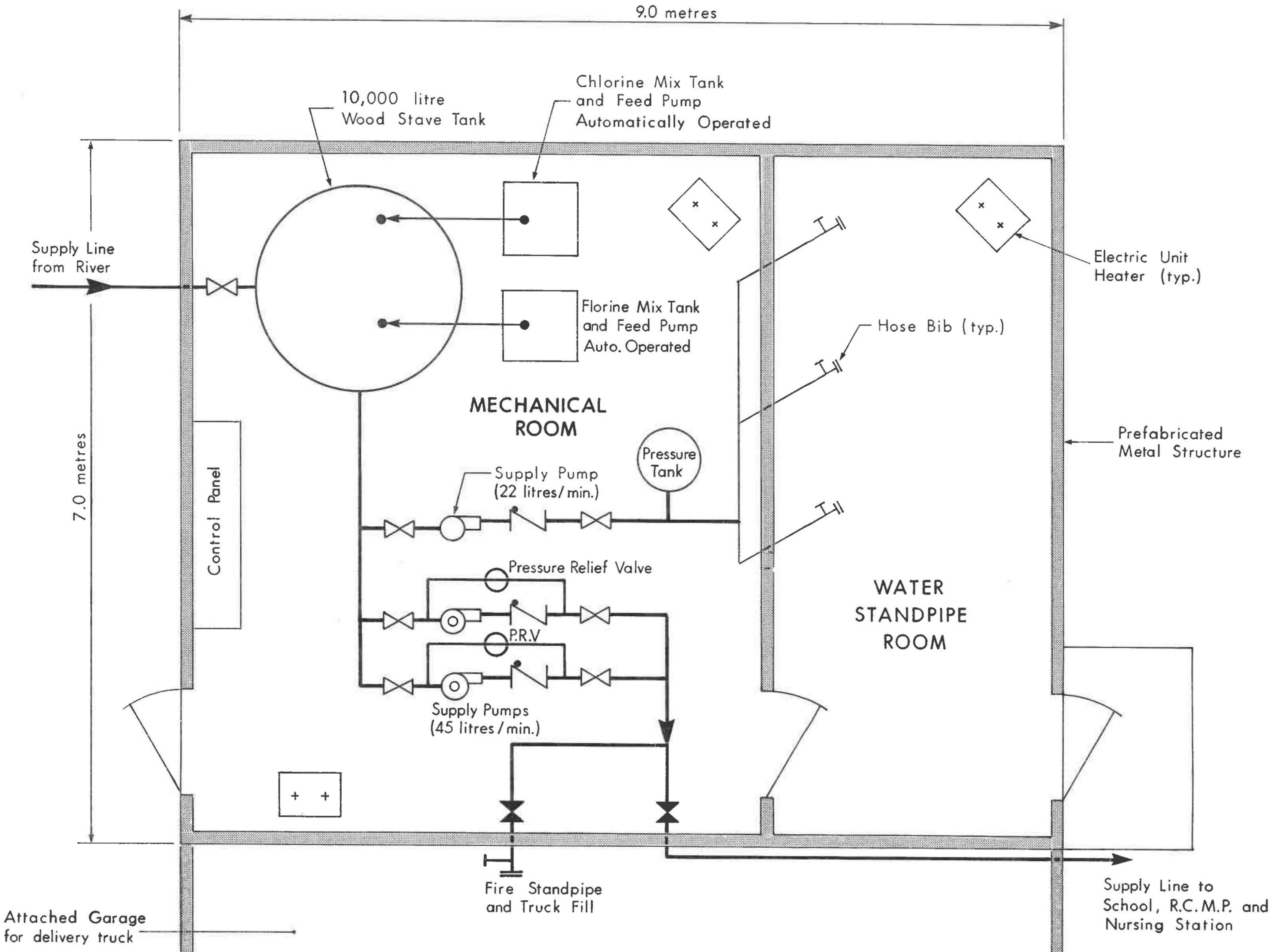
1060-22-1-1



GOVERNMENT OF THE YUKON

OLD CROW
WATER SUPPLY STUDY

figure 4.4

Infiltration Intake Alternatives

Pumphouse Schematic

Stanley

STANLEY ASSOCIATES ENGINEERING LTD.

1060-22-1-1

GOVERNMENT OF THE YUKON

OLD CROW
WATER SUPPLY STUDY

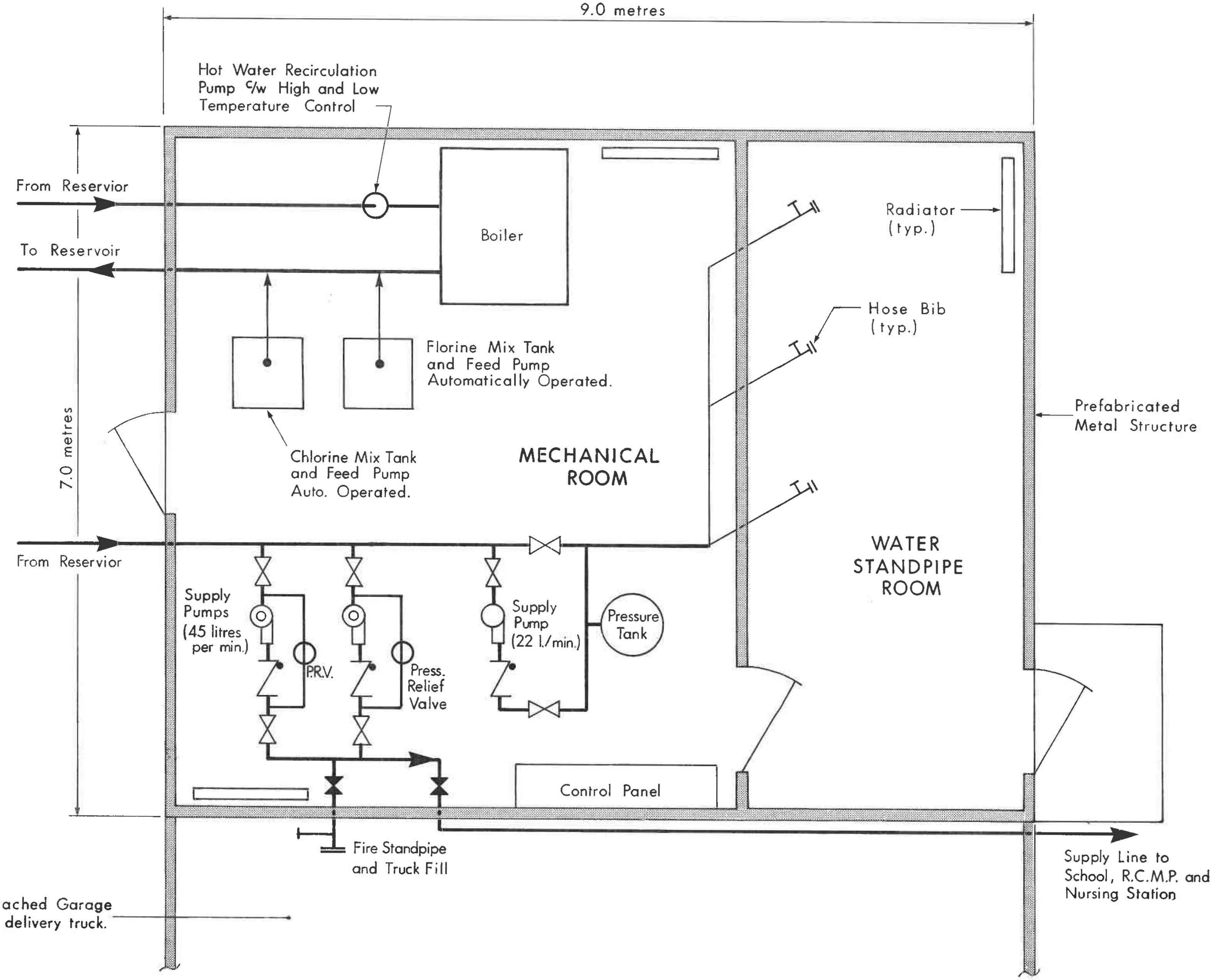


figure 4.5

Portable Intake Alternative Pumphouse Schematic

Stanley
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1060-22-1-1

4.4 CAPITAL COST AND OPERATING AND MAINTENANCE COST ESTIMATES

Capital cost estimates have been provided for each alternative based on costs from existing construction projects and making an allowance for the location of Old Crow. Estimates for operating and maintenance costs are provided. The costs are in 1980 dollars. Tables 4.1 4.2 and 4.3 list these cost estimates.

4.5 RECOMMENDATIONS

The infiltration cell concept appears to provide the greatest potential for a reliable water supply intake from the Porcupine River. Although it has several disadvantages including accessibility for servicing, it appears to offer major operational advantages over an infiltration gallery and portable intake unit. In addition, the estimated capital cost for installation of this alternative is lowest.

We therefore recommend that serious consideration should be given to the installation of an infiltration cell intake from the Porcupine River as illustrated in Figure 4.2. Also, at time of detail design a more indepth cost estimate should be done on the chosen alternative.

Table 4.1 - Capital Costs Estimates and O & M Cost Estimates Conventional Infiltration Gallery

a) Capital Cost Estimates

i)	Infiltration Gallery		$ 8,000
ii)	Intake Line		$ 80,000
iii)	Wet Well		$250,000
iv)	Pumphouse		$100,000
v)	Mechanical and Electrical Equipment, misc.		$ 50,000
vi)	Mobilization		$ 75,000
		Subtotal	$563,000
		Engineering and Contingencies @ 30%	169,000
		Total Capital Cost	$732,000

b) Operating and Maintenance Cost Estimate per annum

i)	Operator		$ 30,000
ii)	Vehicle		$ 5,000
iii)	Power		$ 5,000
iv)	Miscellaneous		$ 7,000
		Total O & M Cost	$ 47,000

Table 4.2 - Capital Cost Estimate and O & M Cost Estimates Infiltration Pumping Cells

a)	Capital Cost Estimate		
i)	Infiltration Cell c/w pumps (2 x $20,000/ea)		$ 40,000
ii)	Supply line c/w electric supply cable		$ 46,000
iii)	Pumphouse		$100,000
iv)	Mechanical and electrical Equipment, misc.		$ 50,000
v)	Mobilization		$ 60,000
		Subtotal	$296,000
		Engineering and Contingencies @ 30%	$ 89,000
		Total Capital Cost	$385,000
b)	Operation and Maintenance Cost Estimate per annum		
i)	Operator		$ 30,000
ii)	Vehicle		$ 5,000
iii)	Power		$ 6,000
iv)	Miscellaneous		$ 7,000
		Total O & M Cost	$ 48,000

Table 4.3 - Capital Cost Estimate and O & M Cost Estimates Portable Intake Alternative

a) Capital Cost Estimate

i)	Portable Intake Unit c/w pumps and support cable	$ 10,000
ii)	Supply line c/w electrical supply cable	$ 23,000
iii)	Insulated Reservoir	$320,500
iv)	Pumphouse	$ 90,000
v)	Mechanical and electrical Equipment, misc.	$ 50,000
vi)	Mobilization	$ 75,000
	Subtotal	$568,500
	Engineering and Contingencies @ 30%	$170,500
	Total Capital Cost	$739,000

b) Operating and Maintenance Cost Estimates per annum

i)	Operator	$ 30,000
ii)	Vehicle	$ 5,000
iii)	Power	$ 7,000
iv)	Fuel cost for heating	$ 8,000
v)	Miscellaneous	$ 7,000
	Total O & M Costs	$ 57,000

YUKON
COMMUNITY AND TRANSPORTATION SERVICES

PROPERTY OF
LANDS BRANCH
LIBRARY

SECTION 5

WATER DISTRIBUTION

5.1 INTRODUCTION

As discussed earlier, water distribution in Old Crow is currently carried out by "self-haul" or community haul methods with several buildings having their own water intake and storage facilities. Whether or not these basic systems should be left as is, or improved upon or if a piped supply should be provided to each building depends on a number of factors including the following:

1) The Yukon Territorial Government has a policy paper Community Assistance Ordinance with respect to funding of municipal services but does not have a policy paper with respect to the type of water or sewer systems to be provided to any individual community.

2) The population of Old Crow appears to be constant and the economic base is stagnant; unless major development such as a pipeline or road develops there will not be any substantial increase in the number of users in the forseeable future.

3) The geographic location of Old Crow presents very real constraints with respect to supplying, installing and maintaining any highly technical water distribution system. Even if it were done, the technical skills required to operate such a system would require specialized training which may not be available in Old Crow at the present.

Alternative distribution methods which have been considered in this study include "self-haul", "community-haul", and piped distribution. This Section summarizes each of these alternatives and provides an economic overview.

5.2 WATER DISTRIBUTION ALTERNATIVES

Table 5.1 summarizes the various "self-haul" alternatives which were considered including the method of operation, and relative advantages and disadvantages. The first method, central pick-up from an unsupervised exterior water point is similar to the pumphouse facility described earlier which has been built in Old Crow by the Department of Indian and Inuit Affairs. Although it was not operating during this past summer becuse of the problems encountered during last winter, it was used quite extensively when it was in operation. The extended failure of that system, however, illustrates the importance of constant supervision. The second alternative is similar to the first except that access to the water supply is limited except upon supervision. There is currently no system like this in Old Crow.

The expanded pumphouse facility which is discussed as the third alternative would provide a multi-use facility which would provide an interior water point but would also include laundry and bathing facilities as well as toilet facilities. The school currently has a version of this system. Close and constant supervision of such a system is absolutely essential.

The "community-haul" system is relatively common in small to intermediate sized northern communities. At the present time a tractor and wagon are used to transport a small water tank for community water delivery in Old Crow. This method is currently very expensive, however, and therefore is not always used by the residents. Old Crow presently has a Chevrolet three (3) ton water truck with a 3,500 litre (750 gal.) stainless steel heated tank. This truck has not been delivering on a regular basis due to mechanical problems, but once it is in working order. it will be capable of serving the communitie's needs.

Piped distribution with the use of utilidors or insulated shallow buried systems are currently used extensively in larger northern communities. The estimated capital and operating and maintenance costs for such a system in Old Crow are very high and it is questionable whether the residents of Old Crow would accept this type of system. It is planned that an insulated shallow buried piped water system would be supplied to the school, R.C.M.P. and the teacherage.

Table 5.1 - Water Distribution Alternatives

TYPE OF SYSTEM	DESCRIPTION	METHOD OF OPERATION	ADVANTAGES	DISADVANTAGES
Alternative 1				
Exterior, unsupervised water point on the outside of a pumphouse facility.	A building containing necessary pumps, piping, valves, heating, chlorination c/w either a water tank or directly connected to water supply. (Similar to existing DINA pumphouse in Old Crow).	Push button or pull a chain to release water into a container. Only maintenance man has access to these locked buildings.	If they contain an interior storage tank several can be located conviently throughout the community at relatively low cost. Reduce hauling distance required therefore the chance of contamination is lessened.	Susceptible to vandalism, because they are unsupervised. Once broken down they are rarely fixed. Supervision tends to be minimal so careful design is required to prevent freeze-up in case of power failure. Back-up system, etc.
Alternative 2				
Interior supervised water point.	Similar to above but water is obtained inside the building.	Ordinary faucet.	Same as above. Allows for more flexibility in design.	Absolutely essential that they are supervised. Larger enclosure is required.
Alternative 3				
Multi-use water supply facility which includes interior supervised water point as well as additional facilities for bathing, laundry and waste disposal.	Can be a combination of services provided: obtain safe water, waste disposal, bathing, laundry or any combination of these.	A safe source of water is provided in a heated, supervised multi-use building.	Safe source of drinking water. Can provide other services that may not otherwise be available: bathing, laundry, sewage disposal.	Because it should be centrally located, it is difficult to locate in a community as spread out as Old Crow is.

ble 5.1 - Water Distribution Alternatives (Continued)

YPE OF SYSTEM	DESCRIPTION	METHOD OF OPERATION	ADVANTAGES	DISADVANTAGES
Alternative 4				
Community Haul System	Water is hauled to individual houses using either a tracked, towed, or wheeled vehicle.	This is very common system often found in places with populations between 50 and 600. Many communities use this in combination with some sort of limited pipe system.	Much safer than any type of self haul system, especially insofar as quantities tend to be larger (200 litres versus 25)	Expensive $3.00/ 200 litres) therefore some people choose not to use it. Doesn't solve the problem of waste disposal
Alternative 5				
Piped distribution	Utilidors and/or underground piped water and sewer system.	Water is heated and chlorinated, piped to point of demand. Sewage is collected treated & discharged to a receiving body.	The ultimate system. Very safe, efficient and economical if the population is there to warrant it.	Very expensive, especially in Old Crow because of remoteness, culture, topography, geography, etc. Lack of trained people to operate. Insufficient population to warrant this system.

In summary, the relative merits of each of the alternatives is not only a function of costs but also of reliability and supervision requirements. The failure rate of self-haul watering points have historically been relatively high due to vandalism, freeze-ups, poor design, and lack of supervision and management. Unsupervised watering points tend to become unsanitary and quickly non-operational. Community haul or trucked water systems usually ensure a more positive means of supplying housing units on a regular basis with safe clean water. The construction of a multi-use water supply facility would serve to combine the benefits of several alternatives while also making provision for better community hygiene.

5.3 ECONOMIC ANALYSIS

The minimum requirements for upgrading the present water supply include provision for an intake line and pumphouse with a water loading point and small diameter insulated supply lines to the school, R.C M.P. building and nursing station. The pumphouse facility was discussed in Section 4. It would include pumping, chlorination equipment and a storage tank to provide fire flows.

The provision of a multi-use facility would require the installation of equipment additional to that required for the first alternative. The estimated additional capital cost for a multi-use facility is $273,000 which can be broken down as follows:

1)	Building (9 m x 12 m) (additional to area required for alternative 1)	$100,000
2)	Mechanical and electrical (additional to pumping, chlorination and storage)	$ 80,000
	Subtotal	$210,000
	Contingencies @ 30%	63,000
	Total	$273,000

The provision of a complete piped distribution system would require the installation of an underground piping system or a utility and a pumphouse with equipment similar to that previously discussed. The estimated capital cost for installation of a complete distribution piping system was not undertaken since it was only looked at in an overview.

However, the capital cost to provide polyethylene insulated small diameter supply lines to the school, R.C M P. building and nursing station is as follows:

i)	School (135 metres of 75 mm diameter)	$ 25,200
ii)	Nursing Station (15 metres of 50 mm dia.)	5,500
iii)	R.C.M P. Building (425 metres of 50 mm dia.)	70,000
	Subtotal	$100,700
	Contingencies and Engineering @ 30%	30,300
	TOTAL	$131,000

The above cost estimate includes valves, bleeders and building connection. The piped systems would be buried approximately 600 mm in the ground and be electrically heat traced. The trench would be designed to minimize frost heave.

The construction of piped system could cause additional servicing problems due to sewage disposal, interior plumbing and increased consumption problems for the areas served.

Although the provision of a complete piped distribution system would provide maximum insurance of a "safe" water supply to each dwelling, considerable cost is involved in implementing such a system. Secondly, provison of piped distribution increases the complexity of the water supply system thereby increasing the chances of break-down and failure of such a system. Lastly, acceptance of a piped distribution system would be dependent on the community themselves.

5.4 RECOMMENDATIONS

The minimum upgrading requirements for a water distribution system in Old Crow include construction of an intake line and pumphouse as discussed in Section 4.0. The water supply truck should be insulated to prevent freezing and made operational. Although the provision of a complete piped distribution does not appear to be warranted, serious consideration should be given to the construction of a pumphouse and multi-use facility in the future. Supply lines to buildings designated to require a reliable water supply should be considered since there is capacity in the pumphouse for this purpose. No budget figures have been presented for sewage disposal in these buildings due to the proposed hookups and this potential problem should be addressed when the servicing descision is made.

Consideration should also be given in the future to make provision for one or more watering points conveniently located within the community, such as near the R.C.M.P. connection, if a line was to be constructed to that point.

SECTION 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSION

From our review of the system and development of capital and operation and maintenance cost estimates, the following conclusion can be drawn:

1) The water source be from the Porcupine River.

2) That the economic solutions for a long term water supply is from the Porcupine River by means of an infiltrate pump cells.

3) The water distribution system be upgraded by providing a better water haul method.

6.2 RECOMMENDATION

The following recommendations result from the conclusions:

1) Infiltrate pump cells and pumphouse be constructed for an approximate cost of $385,000. These costs should be reviewed during the detailed design stage for a more accurate budget preparation.

2) The water distribution be upgraded by insulating the present water truck and making it operational.

3) Future consideration should be given to the construciton of a multi-use facility which is fully supervised. The desirability of such a system should be determined through community consultations.

4) Piped water supply should be provided to the school. Other buildings could be connected if the need for a reliable water supply is established.

5) During detail design of the water supply system a review of the sewerage system be undertaken to ensure the safety of the individual water storage requirements.

Health and Welfare Canada
Sante et Bien-être social Canada

2.170 - 15/1060-20-1

Jack Cormie.

Your file Votre référence

Our file Notre référence

S-1 TW
M-1 LDI for info.

Environmental Health Division
#2 Hospital Road
Whitehorse, Yukon
Y1A 3H8

October 2, 1978

Mr. C. Kent
Local Government Advisor
Indian and Inuit Affairs
Box 4100
Whitehorse, Yukon

Dear Mr. Kent:

RE: SANITARY SURVEY - COMMUNITY OF
OLD CROW, YUKON TERRITORY - SEPTEMBER 16/78

At the request of Dr. D.C.Dimitroff the above mentioned survey was conducted by the undersigned for Public Health purposes.

The following water results indicate that contamination of an intestinal nature is entering the Porcupine River from an unknown source making the water "unsafe" for human consumption. Sample points can be determined on the enclosed list.

The results are as follows:

LOCATION	TOTAL COLIFORM	FAECAL COLIFORM	STANDARD PLATE COUNT
# 1	69	1	+3000
# 2	58	6	+3000
# 3	BOTTLE BROKEN		
# 4 (Raw Sewage)	2400+	540	300,000
# 5 (Raw Sewage)	1600	49	300,000
# 6	72	2	+3000
# 7	38	1	+3000

LOCATION		TOTAL COLIFORM	FAECAL COLIFORM	STANDARD PLATE COUNT
# 8	Crow River Inlet	2	1	+3000
# 9	Approx. 20 miles Upstream	61	3	+3000

Any one of the following steps must be taken to ensure a safe drinking water supply for the Community of Old Crow:

1. Boil the drinking water for 10 minutes prior to use.
2. Chlorinate at a concentration of 8 drops of domestic bleach for each gallon of drinking water and allow to stand for 15 minutes before use.
3. Installation of a properly constructed well with a chlorinator.

During my inspections and testing I noted that a new well was being constructed. This was being done without my prior knowledge. However, this is a big step in the right direction and we do approve of its installation.

Due to the above mentioned results, this office feels that an automatic chlorinating device must be installed on this new water system at least until the raw water results are satisfactory.

Inspection of the garbage dump indicates that insufficient back-filling is being conducted. Fill should be stock piled over the summer so that the dump can be covered periodically over the winter. At present the dump is open to flies and animals making it entirely unsatisfactory.

Samples # 4 and 5 are of raw sewage from the sewage lagoon. These results are normal for raw sewage.

It is important that these items be placed on the top of the lists of priorities to ensure the Public Health safety of the people of Old Crow. Any comments from you or suggestions toward a satisfactory end are most welcome.

Yours truly,

Grant M. Lundy, C.P.H.I(C)
ENvironmental Health Officer

GML:jkm

cc: Dr. D.C.Dimitroff, PMO

Mrs. J. Merriweather
NIC, Old Crow

Chief John Joe Kay
Old Crow

Mr. B. McAlpine
Indian/Northern Affairs

Mr. J. Cormie
Municipal Engineering

Colin Wykes
Environment Protection Serv.

Mr. McAlwain
Indian/Northern
Affairs

SAMPLE LOCATIONS

# 1	Porcupine River opposite Band Office
# 2	Old Crow River by-pass at end of run way
# 3	Porcupine River at end of town
# 4	Raw sewage (sewage lagoon)
# 5	Raw sewage (sewage lagoon)
# 6	Porcupine River directly opposite Northward Office
# 7	Porcupine River opposite Nursing Station
# 8	Old Crow River at entrance to Porcupine River
# 9	Porcupine River near Berry Creek

cc SAEL, Whitehorse.

Department of Energy, Mines and Resources
Ministère de l'Énergie, des Mines et des Ressources

CANADA

Geological Survey of Canada
Commission géologique du Canada

File Number
Nº à rappeler

Terrain Sciences Division,
3303 33 St. N.W.,
Calgary, Alberta, T2L 2A7.

June 14, 1973

450-6-4

03877

A

Dr. S. B. Hollingshead,
Comptroller Water Rights,
Room 211, Federal Building,
Whitehorse, Yukon.

Dear Dr. Hollingshead:

Included is a description of five holes (consider ocww2 and ocww10 as one hole) drilled on the bank of the Porcupine in Old Crow at the beginning of April 1973.

Drilling equipment consisted of a light diamond drill (Winkie) using BXL size core barrels and diesel fuel (stove oil) as drilling fluid; this drill has been adapted to helicopter operations. Core recovery was excellent in fine grained sediments and moderately stony deposits. Although recovery in gravel was generally possible, the ice structure was often destroyed and in some cases the ice was washed away from the core by the drilling fluid. Because of this condition, moisture content data on gravel cores are less reliable than those on fine grained soils.

Large snow accumulation at the foot of the bank made it difficult to drill at those locations. Hole ocww17 was drilled near river ice. Unfrozen sand and gravel was encountered close to the surface. The hole was stopped on account of flooding.

A capping of organic silt with isolated sand beds overlying gravel is characteristic of holes ocww10, 18, 19, 20. This capping varies in thickness from 5.80 meters at ocww10 to 3.08 meters at ocww20. It is everywhere very ice-rich.

A thermistor cable was permanently installed at ocww18 to monitor ground temperatures, readings will be taken this summer.

According to arrangements made between Dr. Hughes and yourself, I include the chartering bill from Northward Airlines Ltd. to be paid directly to them.

Laboratory analysis of samples is presently underway for grain-size, organic content and Atterberg limits. If you wish more detailed results, those could be made available to you in a few weeks.

Yours truly,

Jean Veillette

JV'lf

Jean Veillette

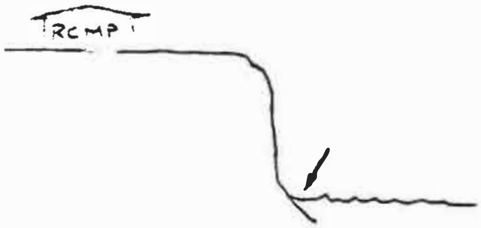
HOLE LOCATIONS

OCWW2 - OCWW10

ON SLASH IN CLUMP OF TREES EAST OF YUKON TERRITORIAL SHOP-GARAGE. APPROX. 50' EAST OF BUILDING. OCWW2 - MARCH 26 OCWW10 - MARCH 24

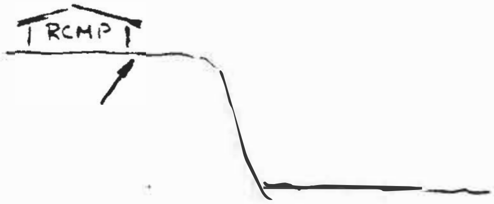
OCWW 17

AT FOOT OF RIVER BANK SOUTH OF RCMP OFFICE.



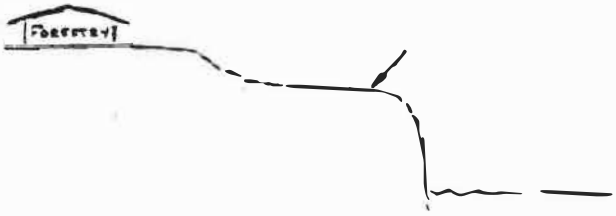
OCWW18

50' SOUTH EAST OF RCMP and 50' NORH OF RIVER



OCWW19

TOP OF BANK SOUTH OF FORESTRY BLDG.



OCWW20

APPROX. 50' NORTH OF OCWW19

COLOR

DRY - some cores had little or no melting take place, especially applicable when the weather was very cold.

WET - core had either melted sufficiently or water was applied.

FRESH - all core was split in two in order to aid the examination.

Unless otherwise specified the color given for the sample refers to the fresh color.

"GRAIN SIZE" AS USED IN CORE LOGS

VERY FINE SAND	≈ 1/16 - 1/8 mm
FINE SAND	≈ 1/8 - 1/4 mm
MEDIUM SAND	≈ 1/4 - 1/2 mm
COARSE SAND	≈ 1/2 - 2 mm
PEBBLES	≈ 2 mm - 64 mm

EPTH	SAMPLE DESCRIPTION	ICE DESCRIPTION	WATER CONTENT
	Meters → cm.?		
0	olive grey silt with abundant large + small organic fragments. chunks of peat	large amt of inclusive ice	237
20			
24	light grey + light brn (dry). med brn + ol grey (wet) silt + fine sand. relatively abundant organic frags.	generally horizontal, very thin stringers well banded non visible ice	71
30			
40			
41			
50	lt olive grey (dry), med olive grey (wet) silt. wood fragments	same as 24-41 except the ice tends to become inclusive downwards	67
60			
70			50
79			
80	clayey silt	fine horizontal stringers	
81			
90	beds of medium brown (wet) grey brn (dry) silt alternating with beds of ol. brn clay rich silt about 5-10 cm. thick		
100		generally horizontal, v. fine stringers in clay rich interbeds	57
110			
120	wood fragments intermittantly	mainly inclusive ice in the silt rich interbeds	
130			
140			
150			57
160			
170			
180			
190			
195			
200			

PTH M	SAMPLE DESCRIPTION	ICE DESCRIPTION	WATER CONTEN
	Meters		
-150			
195			
-200			35
	buff + light grey brn (dry) lt-med	some very thin lenses	31
	brn (fresh) sandy silt.	and some inclusive	30
	silt rich + sand rich interbeds.		
	some of the interbeds are X-bedded.	ice	50
-300	thin lenses of clay, organic rich	not much visible ice	39
	silts and v f sands. some		
	organic fragments. amount of		
	silt seems to increase downwards.		
			46
3[illegible]			
-400	light - med olive brown (fresh)	silt unit has abundant	51
	silt interbedded with a	horizontal clear ice	63
	unit of silty sand that contains	stringers.	47
	a few silt lenses	sandy unit has fewer	
	some small organic fragments	stringers + some inclusive	
-500	a small amount of coarse sand.		30
5[illegible]	med brn (fresh) sandy silt	some inclusions	25
5[illegible]	downward: coarse -> med -> coarse sand	non visible	28
550			
-600			
	gravel:		
	fine sand -> pebbles ≤ 5cm.	non visible	5
-700			

0-WN17

TH M	SAMPLE DESCRIPTION	ICE DESCRIPTION	WATER CONTEN
	Meters		
	unfrozen sand + gravel	—	—
20	drilling suspended due to flooding.		

CM	SAMPLE DESCRIPTION	ICE DESCRIPTION	WATER CONTE
	dk brn-black org silt, very abundant org frags	inclusive	85
5	med ol grey silt, larger but fewer org frags.	inclusive	85
10 11	med brn fine grained organic silt	inclusive + [illegible] visible	
14	same as 5-11		57
20	same as 11-14		57
22 30	same as 5-11		49
40			
46 50 60	light-med olive brn silty vf + f sand rare organic fragments	some inclusive	34
65 70	med brn - med ol. brn silty sand same as 46-65		34
75 80 90 100 110 120	med olive brn sandy silt. a few thin organic rich lenses some large + med sized org. frags. a couple of medium grey sandy. silt layers; slightly contorted.	a few thin stringers + inclusions	58
124 130 140	med brn sandy silt. a few large organic fragments. Thin (1mm) lenses of darker brn vf. sand. abundant small org frags	a couple of thin stringers	55
-2 150	med ol brn sandy silt large + med org. frags.		
160 170 180	medium ol brn sandy silt 2 beds (5cm each) of lt-med brn silty sand quite abundant small org frags.	a few stringers + some inclusive ice.	53
190			59
200			

CONT'D

PTH M	SAMPLE DESCRIPTION	ICE DESCRIPTION	WATER CONTENT
-220	med brn silty sand a few small pebbles (≤ 4cm) and coarse sands	some inclusive ice	50
-230			
238 -240	med-dk ol brn slightly sandy silt probably <u>not</u> in situ		54
248 -250	med ol brn silty sand. some 1mm vf + f sand lenses	some v. fine stringers near top	54
-260 264			
-270	med brn sandy silt quite abundant organic frags.	some inclusive ice	49
-280 28?	interbedded layers of org. rich silty sand organic rich sandy silts, of brn sandy silt, yellowish sand w/some silt. beds 0.5-2cm thick	non visible	49
-290			
-300	light colored vf-med sand w/some silt. organic rich lenses. one med brn sand silt lens (295-300)	v. little visible ice	39
-310			
-320 322			
-330	med brn silty sand some org. frags	only visible ice is one vertical vein	42
-340 339	lt colored vf-med sand a few org frags in top 5mm	no visible ice	42
343			
-350			
-360	med brn sandy silt (silty sand?)	some inclusive ice	43
-370			
377			
-380	med brn silty sand with thin lenses of org rich sand + silt	no visible ice	42
383	same as 343-377	some inclusive ice	42
-390 389	interbedded (some X-beds) silty sand, sandy silt, medium sand, & thin org. rich sands. some org. frags.	no visible ice.	42
-400 398	med brn sandy silt. quite abundant organic frags - the larger ones ice filled	some inclusive.	42
-410			
-.3			

CONT'D

CM	SAMPLE DESCRIPTION	ICE DESCRIPTION	WATER CONTI
413			
420	lt. brown silty sand some organic fragments.	no visible ice	42
427			
430	med. ol brn sandy silt. rel abundant organics	some inclusive ice	42
435			
440	med ol brn silty sand beds about 2cm thick, interbedded w/ dk org rich silty sand beds (≈ 1cm)	little visible ice	42
450	gravel : silt → pebbles	no free H_2O when drilled.	
460			

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EPTH CM	SAMPLE DESCRIPTION	ICE DESCRIPTION	WATER CONTEN
-10 17	lt brn silt abundant fibrous organic matter	no visible ice	22
-20 -30 -40 4.	med - dark brn sandy silt abundant organic fragments	no visible ice.	27
-50 -60 -70 -80 82	med brn fine sandy silt 5 organic, sand rich layers (.5-1cm) one lt brn vf+f sand layer 4cm thick	some v. fine short stringers + some inclusive ice	51
-90 -100 10.	med brn silty sand with thin darker brn sandy silt lenses organic frags.	some inclusive	44
-10 1.	lt brn silty sand some small organic fibres + frags	no visible ice	88
-20 -30 13.	gray vf → coarse sand.	pebble size chunks of inclusive ice ≤ 2cm.	
-40 -50 155	med - dk brn silt small amount of fine sands.	abundant, very thin, short, random stringers	41
-60 -70 -80 -90 -200	lt - med brn sandy silt (or silty sand?) some fine + a few large org. frags. some fine org, rich sand lenses (0 5cm)	no visible ice	48

CONT'D

CM	SAMPLE DESCRIPTION	ICE DESCRIPTION	WATER CONTE
210	continuation of 158-200		
220			
225			
230			
240	lt-med brn silty sand probably same as 158-225	no visible ice	
250			37
260			
270			
274	lt brn vf-med silty sand (eg 20-80%)	no visible ice	39
278 280	lt d brn silty sand interbedded with darker org rich silty sand	no visible ice	39
290 288			
300	lt-med d brn silty sand. thin (1-3mm) lenses of organic rich silt + sand; separated by cross beds of the main sediment in some cases. abundant small organics	no visible ice	45
310			
320			
330			
340			47
344	lt brn silty sand (vf-med) eg 20-80%	no visible ice	
350 348	med d brn sandy silt a couple of sand rich lenses (1-2 mm)	no visible ice	
360 357	med brn silty vf + f sand. a few coarser grains near bottom. 2 - 1cm thick organic rich lenses.	no visible ice	
370			39
374 376	vf sand → pebbles ≤ 2cm.	no visible.	
380	vf sand → coarse sand	no visible	31
390			
394			
400	gravel.		6

EPTH	SAMPLE DESCRIPTION	ICE DESCRIPTION	WATER CONTE
	dk brn silt. abundant twigs, moss etc	no visible	45
5	lt. med brn silt. abundant large + small organic fragments. some sand	some inclusive ice.	25
22	med brn sandy silt some organic fibres	a couple of vertical stringers some inclusive ice	29 39
	lt. med olive brn sandy silt	no visible ice	
67	lt. med brn (w/ some reddish oxide staining) sandy silt	some thin random stringers.	40.
[illegible]	lt. med brn silty sand. beds slumped ≈ 40° some small org. frags near top	some inclusions	43
	med. brn sandy silt couple of large org frags.	some very fine stringers and inclusions	44
[illegible]	med brn silty sand (45.55?) a few small org frags.	some inclusions	36
65	silt → v. coarse sand.	no visible ice	
177	med ol brn silty sand fine organics	no visible ice.	28.
[illegible]			

CM	SAMPLE DESCRIPTION	ICE DESCRIPTION	WATER CONTE
199			
-200	med brn sandy silt.		
	some small organic fragments	some inclusive ice	
-210	and 2 larger ones		
	couple of 1cm slumped sand lenses		35
-220	couple of silty sand lenses		
-230			
-240			
243	silt → coarse sand	no visible	
248 -250			
-260	med brn silty sand vf → coarse		32
-270	thin lenses rich in fine organics	some inclusions ice	
	a few pebbles near base		
-280			50
-290			
-300			
308			
-310	gravel		13