THE DELPHI TECHNIQUE:

A SITE SELECTION METHODOLOGY

FOR URBAN DEVELOPMENTS

IN NORTHERN ENVIRONMENTS

Submitted by

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In Partial Fulfillment Of The Requirements

For The Degree Of

Master of City Planning

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BY

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A dissertation submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements of the degree of

MASTER OF CITY PLANNING

"The basic task of ecology is not to tinker with technology, but to create an awareness and understanding among policy makers to the vital necessity to slow down the rush towards environmental disaster and the progressive destruction of the earth's irreplacable resources. This concept of making rational use of the earth's resources is often referred to as conservation. Some confusion exists as to the relationship between ecology and conservation--ecology is a science, conservation an art; ecology supplies the facts, conservation the philosophy."

James Woodford, 1972.

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CHAPTER I

INTRODUCTION

> "Unless Canadians are successful in developing attractive communities that are able to provide all the services and amenities to the residents that are being enjoyed by their counterparts residing in southern areas, the future of our resource industries in the north are in considerable jeopardy of failure."
>
> -A. E. Moss (1975).

I. THE OBJECTIVE

In an age when there is great concern for depleting natural resources there is the growing dependency upon development of the Canadian North, still largely virgin territory rich in raw materials.

Future development in the North is to a great extent based upon the assumption that the present energy crisis will continue to deplete many of our natural resources e.g., minerals, timber, natural gas, oil etc. Based upon this assumption the following postulates are put forth.

(1) Further depletion of these resources will cause a northward expansion of associated industries in order that known northern reserves may be tapped. Additionally there will be an increase in activity in the northland for discovery of other deposits.*

(2) This activity in the Canadian North will warrant the construction of New Towns to provide the services to resource communities which for the most part will be industrial towns existing to a large extent in isolation from similar towns or larger centres.

(3) Because of the isolation factor the new towns will not function as regional centres (with perhaps a few exceptions as a community expands over a long period of time). Rather they will be largely independent--

*The controversial MacKenzie Valley Pipe Line is sighted as an example.

there only for the purpose of extracting natural resource and dependent for supplies from larger centres in the south.*

(4) Inhabitants of northern communities will serve industries dependent upon a high degree of technology. Therefore many of those who become members of the community will be highly skilled and educated. Moreso than has been necessary in the past. The community will cater to a cross section of the population but the population as a whole will demand a better life style and standard of living than those who inhabited northern communities 15 or 20 years ago. (Jackson and Poushinsky, 1971).

(5) Past practices, so far as industrial towns are concerned have shown that the prime motivators in the community have been largely economic in nature. There has been little regard for the natural environment. (Moss, 1975).

(6) If such practices are carried into future northern communities the consequences can be easily forecast. Northern environments are more susceptible to environmental damage and recovery time is greater than it is in more southerly communities. Failure to take into consideration critical environmental factors could result in tremendous detremental consequences for the natural environment.

With the increasing need for northern development comes the increasing concern for the impact new communities will have upon the natural environment. We have long been aware of the problems of pollution created in existing urban centres.** We are also aware of the fact that the problems are not a localized phenomenon centered

*The implication is not necessarily that the communities will be single enterprise; the major industry will likely be natural resource oriented.

**It is noteworthy that the effects of pollution from the mining operation in the vicinity of Sudbury, Ontario have been so devastating that the surrounding natural environment now resembles a lunar landscape. For this very reason the National Aeronautics and Space Administration (NASA) chose this area as a training and testing ground for men and equipment which were to be associated with the Apollo moon missions.

around large urban areas, rather they have been transferred into the environmental ecosystems and have reached a global scale. (Carson, 1962; Commoner, 1972; Ward and Dubois, 1972). Northern environments are fragile in the sense that while the plants themselves may be more hardier than their species in more southerly regions, and therefore more suited to harsh climatic conditions, their recovery time, due to the harsh environment, is greatly increased (Dunbar, 1973). Erosion of soil also occurs much more readily once the surface cover has been removed. Climatic conditions are more severe. Consequently the environmental impact is much quicker and more devastating (Johns, 1973).

New towns are being developed to provide the necessary facilities and services required as mining claims go into production, timber reserves opened, hydro generating stations built across the northern rivers, and oil and natural gas are piped to urban Canada and the United States from the remote northland.

Mistakes have been made which are most difficult if not impossible to rectify. However we can learn from past error and take steps not to repeat them in the future.

<u>The objective of this thesis is to define the manner in which a decision making process, the Delphi Technique, may be adapted to the process of selecting a specific geographic townsite from among a number of given alternative locations in northern environments</u>. Because of the nature of the technique, to be defined in a later chapter, it is hoped that its implementation in a site selection process has the potential of reducing the negative effects of environmental impact generated by man's interference with the natural environment.

II. NORTHERN URBAN AREAS: A DEFINITION

In the conventional sense the North may be thought of in terms of obscure concepts relating to those lands and territories which lie within the boundaries of arctic and subarctic regions. Alternatively it may include only that area which lies north of the 53rd parallel or perhaps regions to the north of the most southern limit of the discontinuous permafrost zone. Further, the North may be defined as all territory lying northward of the agricultural zone including regions of boreal forest. With the exception of the 53rd parallel, the boundaries that would encompass the North (in the context of the foregoing definitions) are not at all well defined and are anything but congruent.

Rather than attempt to define the northern region of this country in geographical or climatical terms, it is perhaps more feasible for the purposes of this thesis to concern ourselves with the characteristics of the communities with which we are attempting to deal. From this viewpoint a northern community may be independent of a specific geographical location or climatic conditions but as a requisite for definition may exhibit the following characteristics:

- the community may be relatively isolated in terms of accessibility i.e., it is not likely to be located on or in close proximity to a major transportation corridor; it may exist at the terminus of a transportation route created solely for access to the community. (Such routes may be extended over time to link new communities as they develop.)

- the community is not likely to engage in or be dependent for its existence upon agricultural production.

- the community will in all probability be natural resources based i.e., the prime purpose for its

> location will be as a direct result of a base industry involved in mining, timber, fishing, natural gas and oil extraction or hydro-electric power.*

Figure I.1 indicates the approximate area which may be encompassed by the term "north" in consideration of the foregoing characteristics. The dotted line is not intended to define the absolute southern limit of northern territories, rather its function is to provide some indication as to the geographic area relevant to the major concerns of this thesis.

III. THE NECESSITY OF POSITIVE PLANNING IN NORTHERN DEVELOPMENTS

Man as a technological animal has many qualities and characteristics which enable him to adapt to most any environment over short or extended periods of time. However this adaptability provides no guarantee that man will remain in a hostile environment.

With the exception of a select minority, few have accepted the unhospitable climate of Canada's Northland and even fewer have elected to stay. Those who did were the pioneers of Canada's future in the North. Their determination and perseverence provided the foundation upon which many northern settlements were built. These settlements were often an uncontrolled growth of shacks and tents (Figure I.2). The shacks and tents slowly gave way to structures of a more permanent nature. Towns emerged, cities were built and industry flourished to extract our natural resources.

*This does not by necessity exclude military installations or towns which have grown up around communication, radar, or weather station installations.

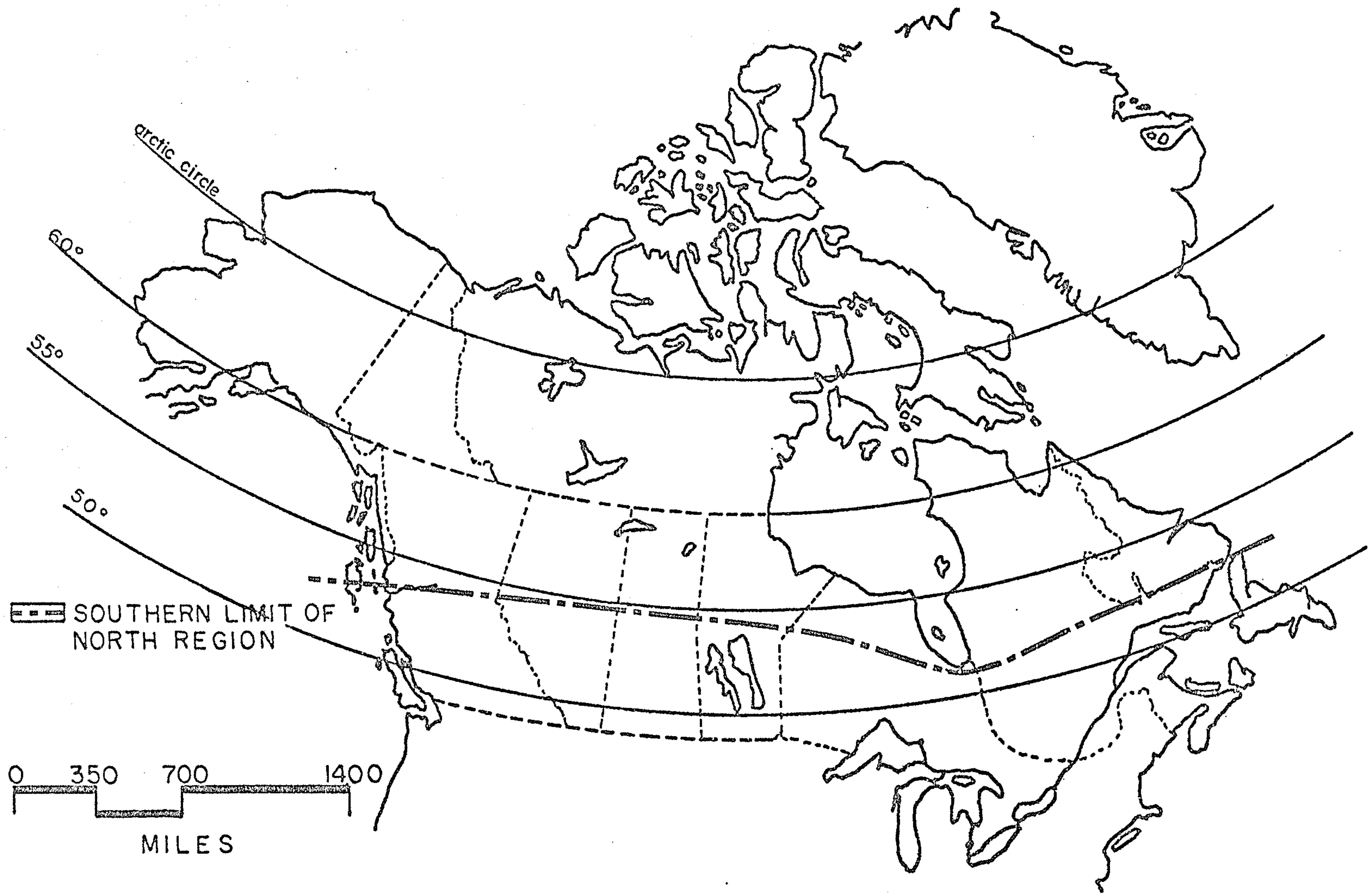


Fig. I. 1 Approximate "Northern" Regions

Fig. I. 2. Uncontrolled Development Around the Mine Shaft.

Source: Siemens, L.B. Single-Enterprise Community Studies in Northern Canada, Series 5: Occasional Paper No. 7, Center for Settlement Studies, University of Manitoba, 1973, p. 5.

There are a variety of problems encountered in the planning processes of any community but problems are increased in number and often compounded for a town which is to function as a service centre for an isolated resource community.

In the majority of cases, with some exceptions, new towns in the north will be built from scratch rather than rejuvinate older existing communities. For this reason the towns must cater to the needs of those who will develop and sustain the industry, namely the workmen and the professional administrators and technologists responsible for the overall operation; the people employed by the supportive non-basic industries which will follow and; those essential for community health, education and protection. These people along with their families must be willing to leave their homes in the south and become part of a new frontier. If they are to put down roots and build a new community which will endure the people must be offered amenities at least comparable to those which were left behind and preferably better (Moss, 1975).

The community, regardless of location may be thought of as being comprised of three integrated elements: the natural environment; that environment which is built or man-made, and the populace which inhabit the community.

The planning processes which involve urban development are concerned with the manner in which the integration of the elements can best be achieved to promote, or instill in the people, a social cohesiveness and sense of community identity which will enhance community living and a desire to remain in the community. To accomplish this end it becomes imperative that amenities be provided in terms of an aesthetic living environment coupled with financial opportunity (i.e., job opportunity and security) together with those facilities necessary to support the daily activities and social requirements of the inhabitants. These amenities may include such facilities as adequate shopping, recreation, education, health needs (i.e., medical, dental, social services, etc.) as well as housing facilities.

Because of the isolation factor characteristic of many northern urban developments the amenities play a more sensitive role in maintaining the community. When northern communities lack sufficient amenities people become dissatisfied with their environment* and look to greener pastures (Jackson and Poushinsky, 1971, pp. 42-43, pp. 100-101).

The aesthetics of the living environment are derived from both the built and natural environments. Architecture, functional in terms of climate, can be further enhanced by taking advantage of the natural surroundings. Natural vegetation, ground cover, scenic vistas, etc. are all natural tools of the architect. Without them he becomes restricted and it becomes more difficult to create a more pleasant living environment.

The natural environment precedes the other basic community elements yet it has been the case in many instances to ignore the importance of the role played by the natural environment in the planning and development processes of northern communities.

*Environment in this context refers to social and physical amenities, e.g., no job future, high cost of living, poor housing, poor shopping isolation, climate.

The Canadian North is scattered with examples of industrial communities which have developed with greater emphasis on consideration of economic feasibility than on consequences of environmental impact (Moss, 1975). They have not only lost potential aesthetic value but have engaged in the decay and destruction of natural ecosystems through chemical pollution and unnecessary removal of the natural vegetation cover. Much of this could have been avoided had the time been taken to reallocate priorities and apply sensible technology in the proper selection and presentation of potential townsites prior to implementation of development stages (McHarg, 1971).

Many of the problems may have arisen due to failure, not of technology per se, but to recognize the complexities involved when dealing with the natural environment.

Perhaps J.W. Forrester (1971) put it best when he said:

> "The problem is not shortage of data, but rather our inability to perceive the consequences of the information we already possess". (p. 41).

IV. FOUNDATIONS FOR RESEARCH

The foundations of this thesis are built largely upon library research and first hand knowledge acquired by the author through direct contact with planning consultants who are themselves actively engaged in northern community design.

The Delphi Process was developed by the Rand Corporation in the early 1950's as "Project Delphi" through sponsorship by the United States Air Force. Since its inception it has been used as a decision making tool by the military, the government, and industry to assess "the direction of long-range trends*, with special emphasis on science and technology..." (Linstone and Turoff, 1975, p. 10). It has not, to the best of the author's knowledge, been widely applied as a standard procedure in the selection of northern townsites. In fact the only instance the author is aware of where the process has been applied for such a purpose was for the selection of the Lake St. Joseph townsite in northern Ontario.

V. EVALUATION OF THE LAKE ST. JOSEPH PROJECT

Through the application of the Delphi Process to the proposed Lake St. Joseph development it was hoped that some of the problems which had plagued earlier northern urban communities could be alleviated. Of special concern was environmental impact due to the imposition of urban development on what may essentially be a more fragile natural environment than is normally encountered in more southern areas.

Unfortunately, because of circumstances beyond the influence of the designers, this project has not yet been put to a test. The development has not proceeded largely because of economic considerations totally divorced from development criteria and costs of the site per se.

Assessment is therefore made somewhat difficult as the project at this point exists only on paper. However a general evaluation of Delphi as applied to site development will be offered in the concluding chapter.

*Long range was defined as ten to fifty years.

CHAPTER II

THE NEED FOR RE-EVALUATION OF DESIGN CONSIDERATIONS EFFECTING THE PHYSICAL DEVELOPMENT OF NORTHERN URBAN DEVELOPMENTS

No development, no matter how well planned, can totally meet the requirements of the community at large nor can the impact upon the natural environment created by urban development be made totally negligible. Environmental impact can, however, with proper technological application be minimized. Figure II.1 below illustrates a possible relationship between northern urban development, time, environmental impact and ecological technology.

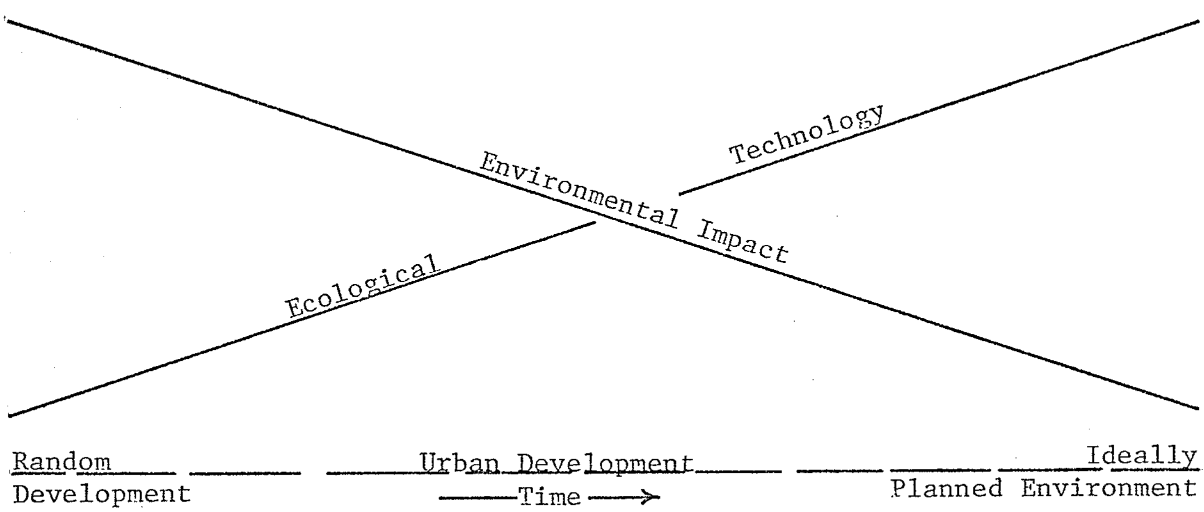


Fig. II. 1. Urban Development and Environmental Impact

The model does not consider economic costs of urban development nor the abstract qualities of a living environment (e.g. quality of life, happiness, etc.) the model is concerned only ecological engineering (e.g., engineering, architecture, biology etc.) for the purposes of environmental control from a purely physical standpoint.

The model conceptualizes the progressive stages of urban development in the north from an undesirable random development pattern towards the ideally planned community--the extreme in the opposing direction. Where applied ecological technology is lacking, as it has in many early industrial developments, damage to the natural environment is high. With the progression of time and assuming advances in the environmental sciences (i.e., zoology, biology, engineering, etc.) as well as the application of the technology, damage to the natural environment through urban development should be reduced. The ultimate objective is a Utopia, a completely harmoneous existence between man's built environment and the natural environment onto which he has imposed his demands.

Although the ultimate goal is an ideal, and therefore unattainable state, the logic of the argument would appear to be valid. While we can not achieve the ideal end, we do possess sufficient technological knowledge which, if applied, would consideraly reduce the negative* effects of environmental impact (i.e., the unnecessary destruction of the natural environment) (Commoner, 1972; Forrester, 1971, Grainage, 1976; Johns, 1973; McHarg, 1971; Moss, 1975).

Technological development must, by necessity, be precluded by knowledge based upon a lesser degree of a previous technology. That is to say, with an increase in knowledge (i.e., data base) technological improvement can follow. So it has been with the development of northern communities.

*Positive effects of environmental impact may be thought of in terms of economic gain, both financial and in terms of raw and/or finished products.

For this reason a comparative analysis of the three communities which will be discussed would be difficult to say the least (and possibly invalid) due to the fact the data and the knowledge upon which was formulated the basis for the more modern developments simply did not exist over half a century ago. Even in the short span of time which occurred between the more modern developments concepts changed and technological advances (even though they may have been slight) were gained.

The intent of the ensuing discussion, therefore, is not to draw a detailed comparative analysis between the communities, but rather the intent is to emphasize the progressive changes in development patterns and input into physical designs and design considerations which have occurred over the years.

To illustrate the progression in development of northern communities the author has selected three mining towns in northern Manitoba which developed over different points in time since the turn of the century to the present.

Flin Flon has been used to illustrate those northern communities of a "boom town" era; the communities mushroomed almost overnight in a hodge podge fashion, heedless of the environment--meeting only the basic needs of an industry who's sole purpose was to extract a rich body of ore, and the basic needs of the supporting population.

By the time Thompson was developed technology and environmental knowledge had come a long way from the early days of the boom towns. Thompson was in the beginning, and is presently, much closer to the ideal community of the north than Flin Flon ever was. Thompson was totally pre-planned--Flin Flon was not--Thompson was developed according to engineering and planning standards and limited environmental assessment. However the community developers failed to consider one very important aspect, a carry over from the boom town era--a population explosion. Thompson was never originally designed to cope with this problem and as a consequence the impact of population expanding too rapidly created development problems which should never have occurred had the designers not overlooked the possibility of an expanding northern economy.

The Leaf Rapids community, though developed primarily as a mining center, may be the closest yet designers have come to developing an urban center in the Canadian north which has attempted to meet the needs of industry, the physical needs of the people (especially with consideration of a harsh northern climate) while maintaining much of the natural environment both within and surrounding the development and at the same time, unlike Thompson, allowing for expansion of a population and diversified development.

There are no doubt faults and errors with this development but these will only come to light in time as the community has a chance to develop. In the meantime it appears that factors in development were considered with an eye to the future.

I. FLIN FLON - THE PRODUCT OF A BOOM TOWN ERA

Northern development of any consequence occurred as a result of explosive expansion of the mining industry into the higher latitudes with the discovery of valuable ore deposits.

Because northern mining communities sprang up almost overnight there was little time for planned development and by the time planning was considered the pattern which shaped the community design had already been well established and ensuing planning schemes were either too slow to change the face of the community or were simply economically unfeasible due to decline in the market value of what in many cases to begin with had been marginal grade ore (Hedman et. al. 1974, Moss 1969 & 1975, Pressman 1974).

The pattern of development of northern industrial communities, mining developments in particular, soon became typed. Since little or no planning was involved at the outset tents (Figure II.2) used by exploration crews slowly gave way to more permanent structures clustered around the mine shaft* (Siemens, 1973, p. 5, Hedman et. al 1975, Figure II.3 & II.4).

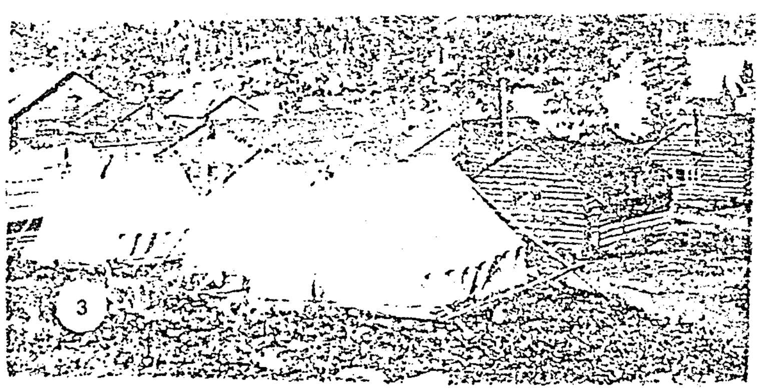


Fig. II.2 Log Cabins Begin to Replace Tents as Residences

Source: Hedman et. al., Flin Flon, 1974, p. 104.

*See Figure I. 2 p. 7 of this thesis.

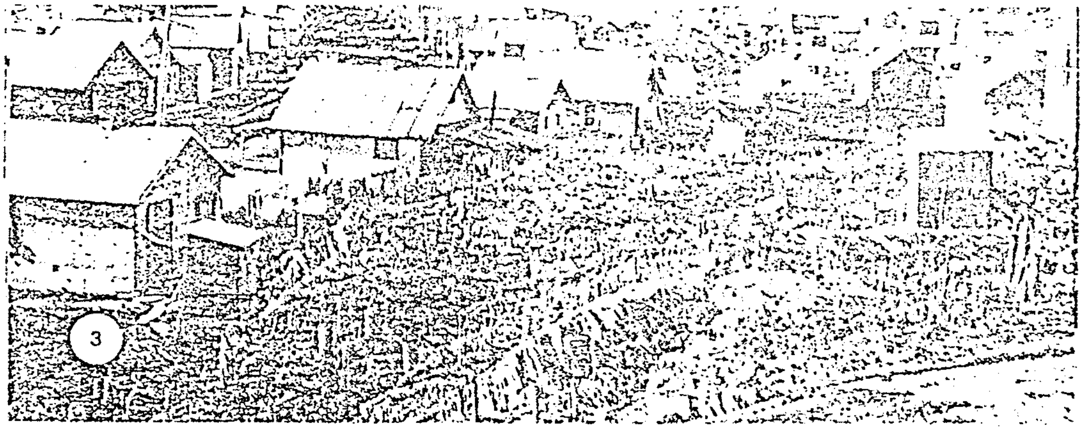


Fig. II. 3. Permanent Housing Built Close To The Mining Operation

Source: Hedman et. al., Flin Flon, 1974, p. 109.

As industrial operations increased buildings too close to the industrial site had to be torn down or moved.

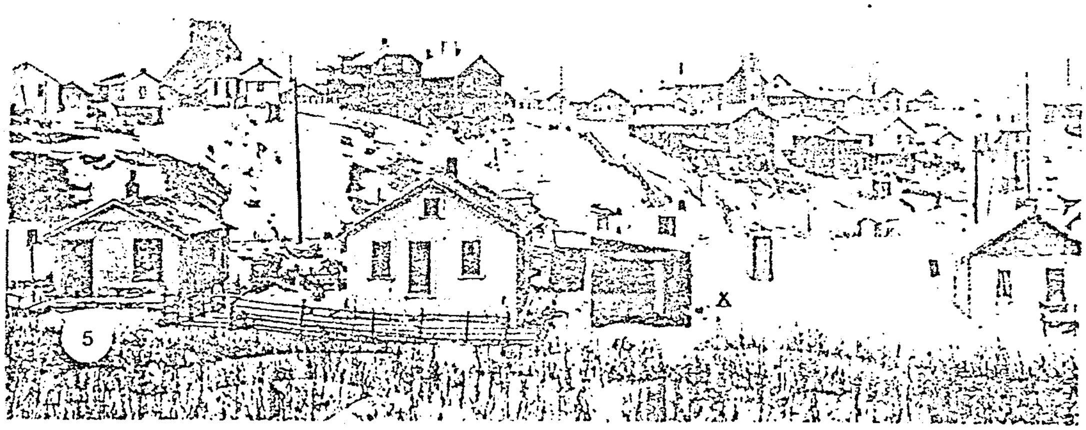


Fig. II. 4. Permanent Development Close To The Mine Shaft

Source: Hedman, et. al., Flin Flon, 1974, p. 358.

Private motorized vehicles were few and there was no need for good roads as horsedrawn vehicles were more practical (Figure II.5), not bogging down in mud or failing to start in subzero weather.

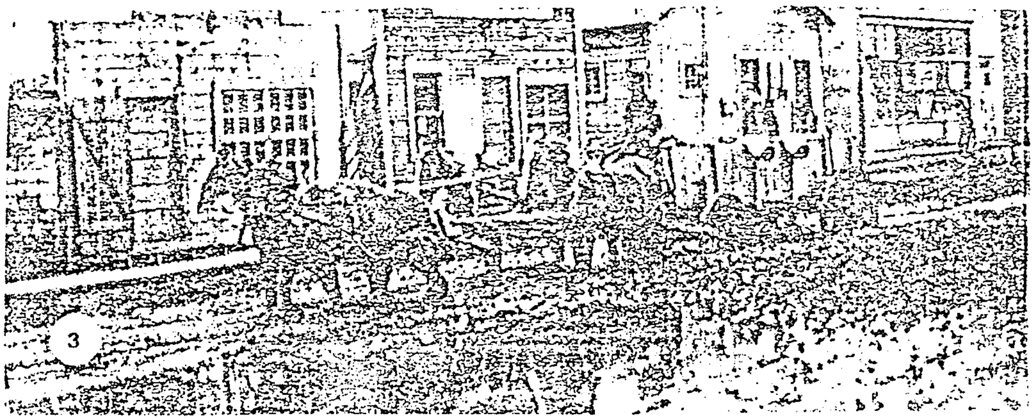


Fig. II. 5. Wagon Up To Its Axles In Muskeg

Source: Hedman et. al., Flin Flon, 1974, p. 109.

The total result was random development characterized by what at times was little more than shacks situated along narrow, winding muddy roads clustered about a mining site which dumpted poisonous chemicals and tailings into local lakes and streams and belching sulphurous fumes from stacks too low to carry smelter smoke safely beyond the townsite (Figure II.6).

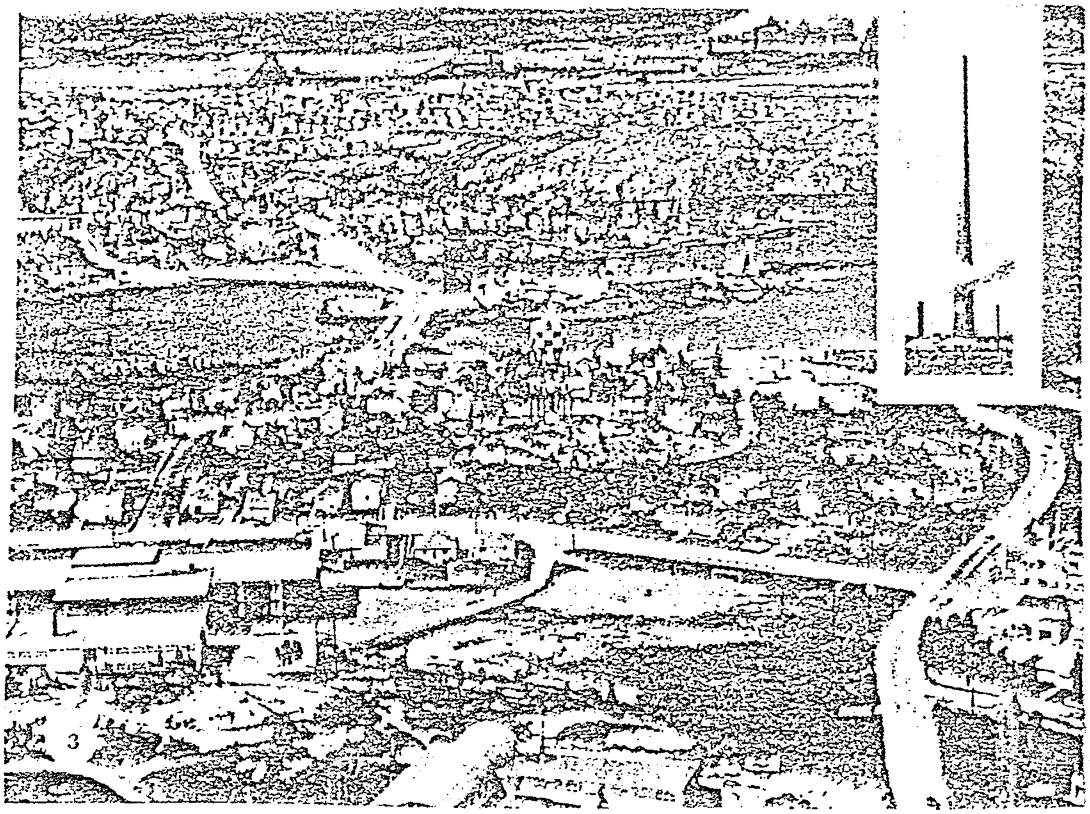


Fig. II. 6. Smelter Smoke Drifitng Over Townsite
(insert shows the new stack recently installed).

Source: Hedman et. al., Flin Flon, 1974, p. 376.

Many of the shacks have since given way to more modern types of housing, though in many instances evidence still remains of inadequate planning and environmental damage (Figures II. 7 & II. 8.)

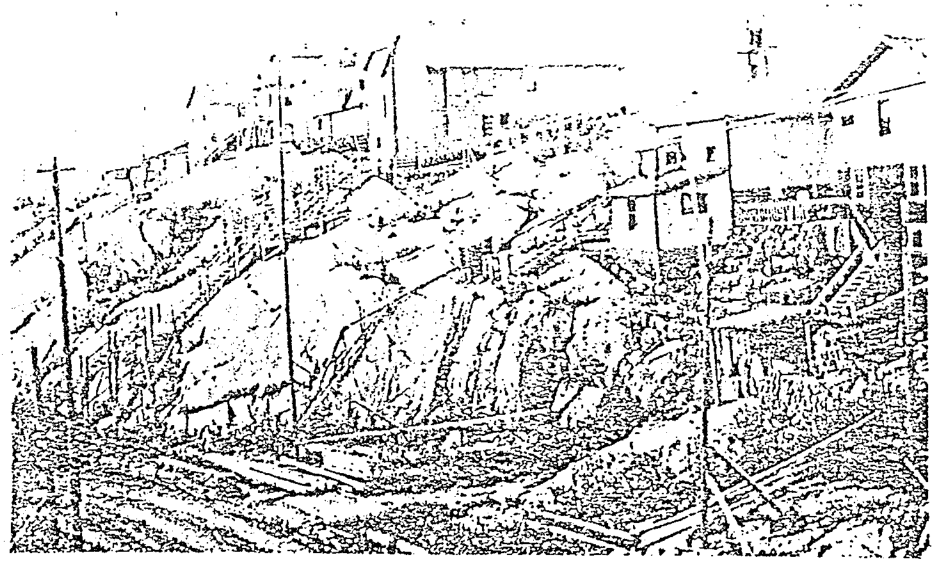


Fig. II. 7. Housing Along A Main Traffic Artery

Source: Hedman, et. al, Flin Flon, 1974, p. 247.

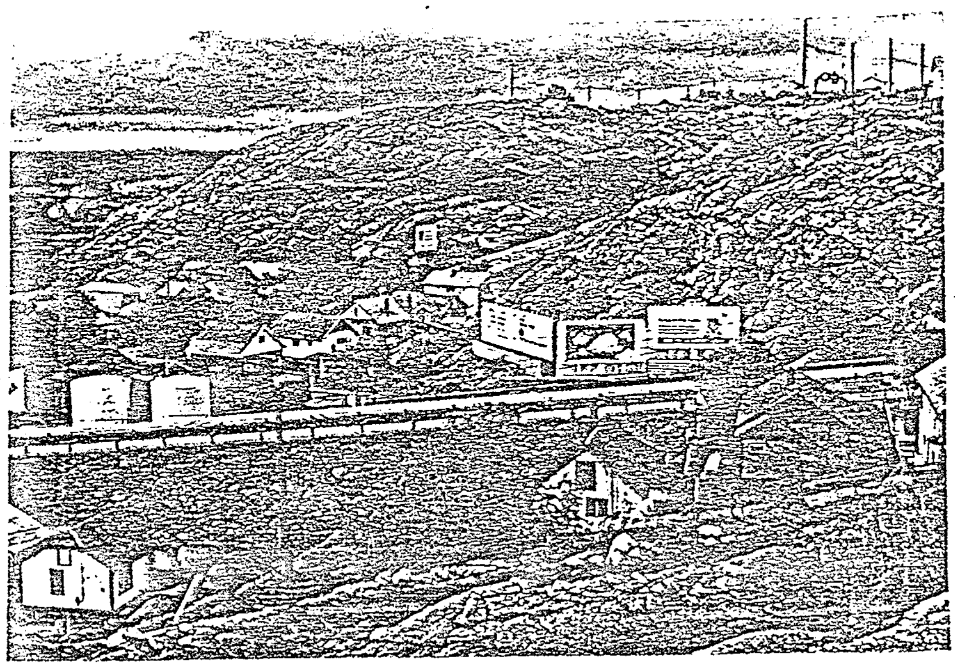


Fig. II. 8. Flin Flon, 1976, Ross Street and Third Avenue.

Source: Courtesy of Underwood McLellan and Associates Ltd., Winnipeg, Manitoba.

It is little wonder that A.E. Moss in his address to the third Northern Resources Conference in 1969 told members of that conference "Gentlemen--I maintain that with few exceptions, today's northern townsites are a disgrace to the mining industry" (p. 3).

II. THOMPSON - THE PRODUCT OF A TOO QUICKLY EXPANDING NORTHERN ECONOMY?

The "few exceptions" referred to by Moss may have been to such pre-planned communities as Thompson, Manitoba which is certainly far beyond the sprawling developments which sprang up in the early 1900's and continued to expand on an indiscriminate basis into the third quarter of the 20th century.

The more modern developments, (e.g. Thompson, Manitoba) were planned from the outset to avoid many of the problems experienced by their predecessors. Design constraints were laid down from the beginning and prior to undertaking the physical design information concerning soil and subsurface material had to be obtained.

With respect to the Thompson project, the Province of Manitoba and the International Nickel Company of Canada Limited entered into an agreement to provide:

> "(1).--The establishment of the Local Government District of Mystery Lake, which would affect some nine hundred and seventy-five (975) square miles of relatively virgin lands lying some four hundred (400) miles north of Winnipeg.
>
> (2).--The establishment of the townsite of Thompson, which would be approximately three thousand (3,000) acres in area and lying some two (2) miles distant from the plant site of The International Nickel Company of Canada Limited.
>
> (3).--A sanitary area under the Public Health Act to be established in the townsite of Thompson, thus assuring adequate sanitation control in the first instance.." (Henderson, 1964, p. 1193).

General design factors were introduced and provided for within a general development plan (Fig. II. 8) which would

> "produce a community that the Province of Manitoba, the Company, and its employees will be proud of and enjoy living in, at the same time recognizing the physical characteristics of the area, the difficulties in engineering the required services and building foundations, and certainly the fact that a project of this scope must work within a budget" (Henderson, 1964, p. 1195).

Further additional design requirements provided the following basic features:

"(1).--Major through traffic routes to by-pass townsite development rather than disect it.

(2).--Major traffic collector routes to be limited access in design, with the greater part of the frontage to take the form of buffer zones left in a natural state.

(3).--Pedestrian circulation between dwelling areas, public school and park sites, the shopping center and the civic center to be segregated from vehicular traffic on major and minor collector routes by the development of a system of interior walks and parkways which were to be adequately lighted and maintained.

(4).--The central commercial area and civic center to be in relatively close proximity to all dwelling units, and not more than 1/2 to 3/4 mile distant, if possible.

(5).--The internal street pattern to be made free of through routes by the use of bay, crescent, cul-de-sac and super block layouts.

(6).--Dwelling areas to be so defined as to produce an ultimate population neither too little nor too great to be capable of supporting an elementary school of twelve to sixteen classrooms, such areas to be easily recognizable neighbourhoods.

(7).--The production of a balance of single-family and multiple-family accommodation in each neighbourhood, each so designed and orientated as to avoid any encroachment of one use upon the other, thus allowing harmony of design and function to prevail.

(8).--The multiple-family and hostel areas to be closely related to the central business area. Residential neighbourhood areas to be interrelated and in relatively equal proximity to the high school and major recreation areas.

(9).--Heavy commercial and industrial areas to be served by the major thoroughfare systems, with no opportunity for conflict with the central commercial area or a residential neighbourhood to be remotely possible. No rail facilities were to be brought into the townsite. A heavy industrial area, requiring rail facilities, was to be established at the railhead.

(10).--The hospital, high school and major recreation areas to be readily accessible to major thoroughfare and collector-route traffic.

(11).--The central commercial and civic center area to develop as a focal point of community interest and activity.

(12).--The townsite was to be capable of development in progressive stages, each stage to be more or less complete within itself.

(13).--Ample public park and recreation areas were to be provided." (Henderson, 1964, pp. 1195-1196).

The Burntwood River upstream from the townsite is a source of freshwater supply while effluents from the sewage treatment process and industrial operation are discharged downstream from the townsite. Hydro and telephone lines service the entire community. All lines are buried wherever possible and although there are no back-lanes the utility companies maintain easements along rear lot lines of all properties being serviced by underground lines (Manitoba Department of Industry and Commerce, 1975).

Thompson has been a community which was planned from the very beginning and involving the interests of both the public and private sectors. The community has not proceeded upon nor has it advocated haphazard planning. It offers a full and complete range of commercial services, recreational activities, medical facilities and fire and police protection.

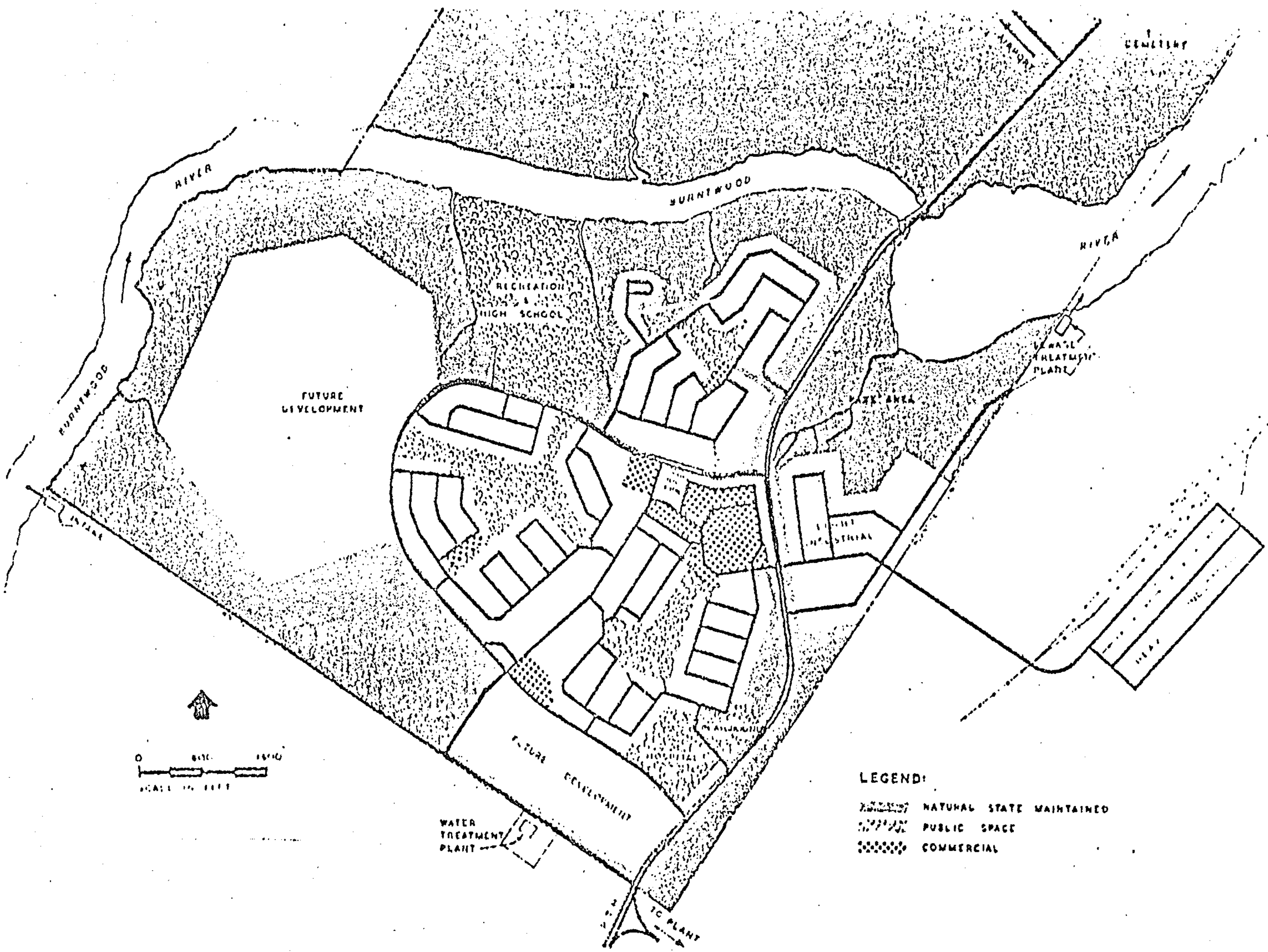


Fig. II. 9. The Development Plan Of The Townsite of Thompson
Source: D.G. Henderson, Community Planning Of The Townsite Of Thompson, 1964, p. 1198.

In addition to these amenities its location is scenic in an environment which is largely virgin territory and it has become a regional center for northern development.

DESPITE THESE ATTRIBUTES THERE IS NO EVIDENCE THAT ANY PARTY EVER ASSOCIATED WITH THE DEVELOPMENT OF THIS COMMUNITY EVER CONSIDERED A COMPREHENSIVE ENVIRONMENTAL IMPACT ANALYSIS PRIOR TO OR DURING TOWNSITE LOCATION AND DEVELOPMENT.

Thompson was originally designed for a maximum population of approximately 12,000 people (Henderson, 1964). However the present population stands in excess of 20,000 (Statistics Canada, 1971).

The major cause of the almost overnight expansion which began in the mid 1960's and has continued to the present was the opening of four new mines in the immediate region of Thompson. The International Nickel Company (Inco) opened a mine at Birchtree, two at Soab Lake and an additional two at Pipe Lake. These were solely ore extraction operations with all processing being carried out at the original mine site in Thompson. Originally Inco did not anticipate such expansion, nor did the community designers allow for expansion, but when the newly discovered ore bodies were brought into production, making the operation at Thompson the second largest if not the largest processing plant in the world in terms of output measured in annual pounds of nickel produced, the town literally boomed and people poured into the community to meet the labour demands.*

*Source: Telephone conversation in July of 1976 with Mr. W.K. Newman, President of the Manitoba Division of International Nickel Company of Canada Limited.

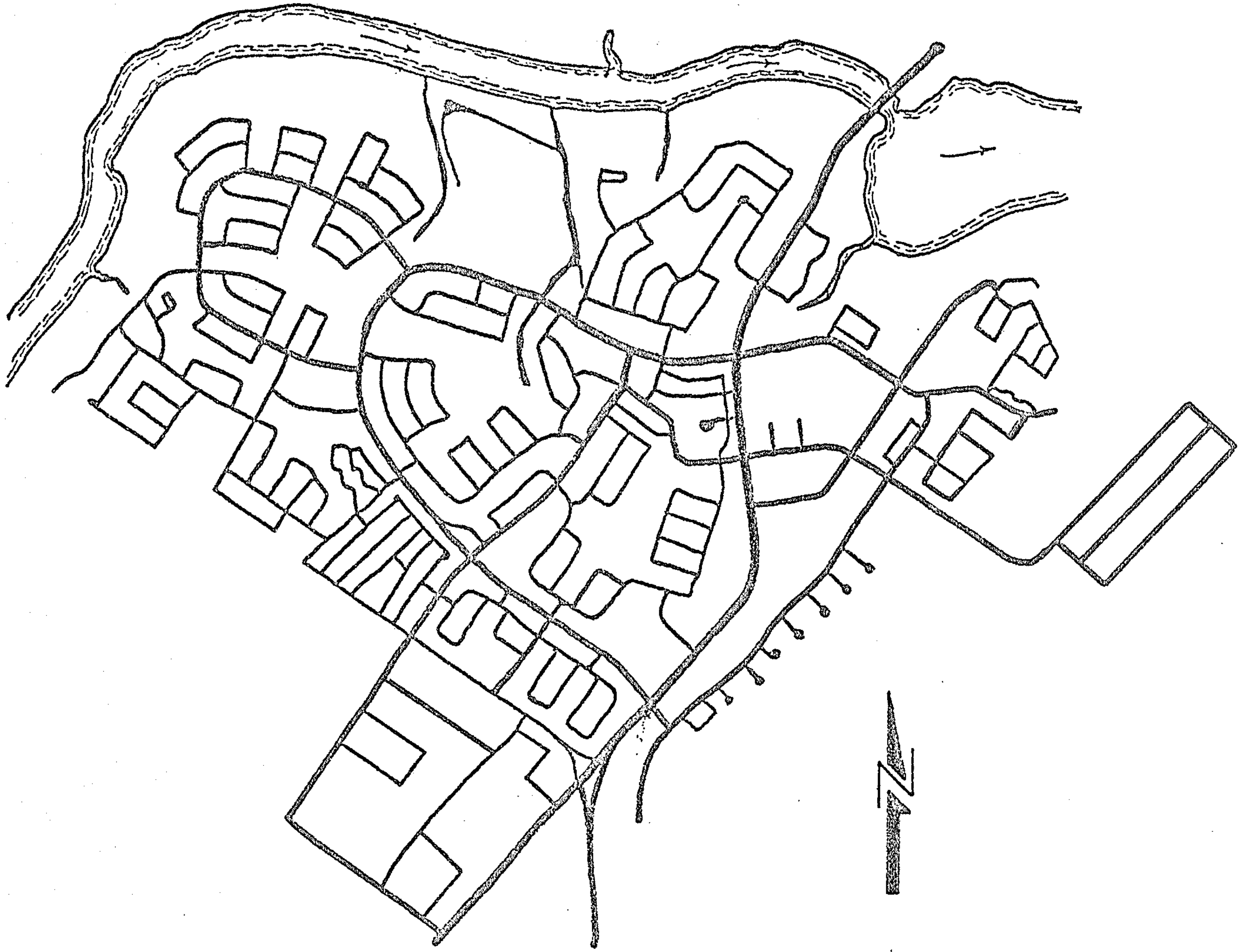


Fig. II. 10. City of Thompson, 1976

Source: Winnipeg Free Press, June 11, 1976, p. 57.

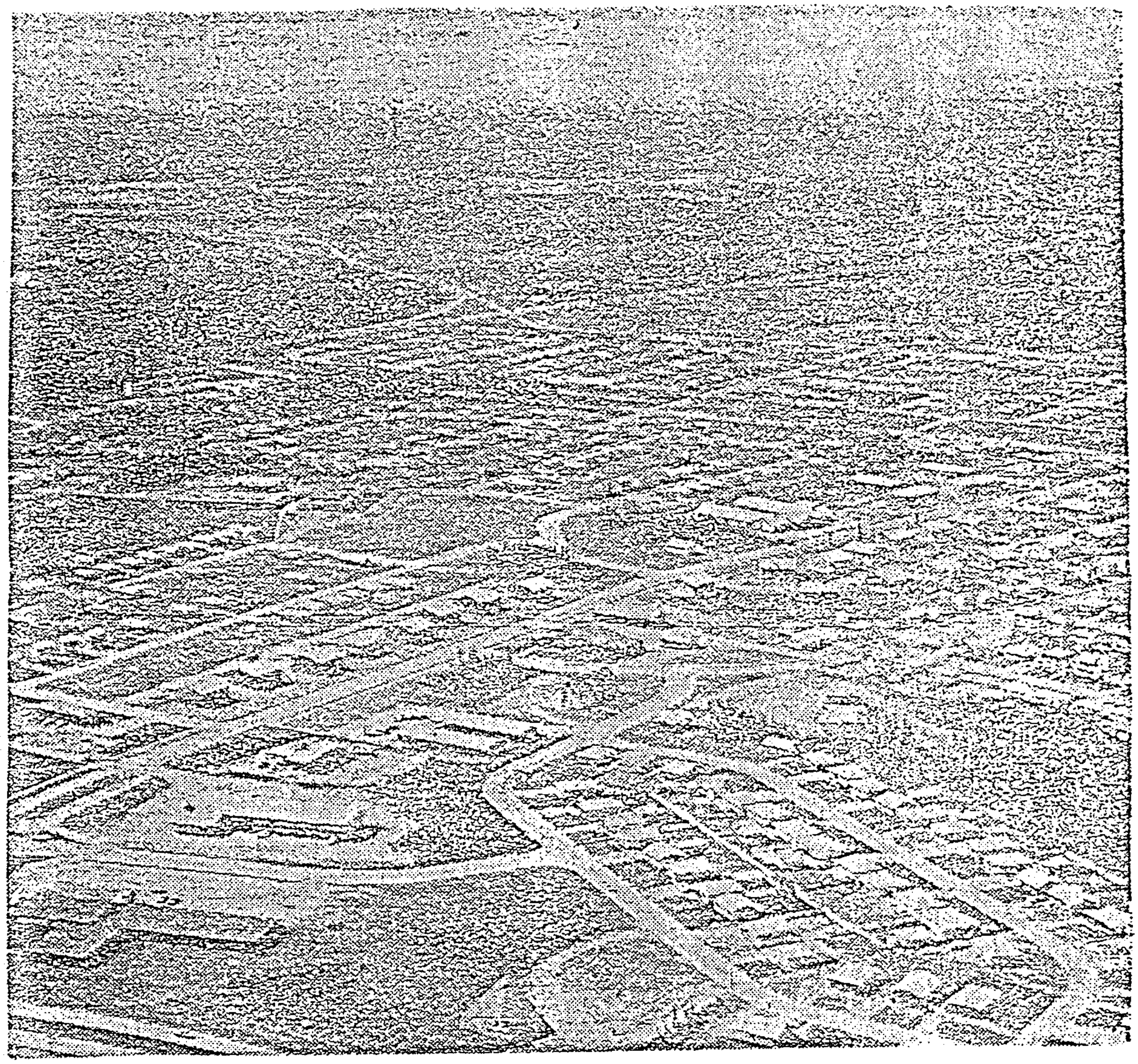


Fig. II. 11. An aerial view of a residential section of Thompson, Manitoba.

Source: Winnipeg Free Press, June 11, 1976, p. 57.

Thompson, in spite of many positive advantages was not designed in a manner which may have better facilitated its multiple functions and expanding population. (Pressman 1974, Engineering and Planning Departments, Underwood McLellan and Associates Limited, Winnipeg, Manitoba, 1975).

While the community of Thompson has perhaps failed in some respects so far as planning criteria are concerned the failure can not be blamed entirely on inadequate planning. Unforeseen circumstances, namely the industrial boom played a large role in creating the present situation.

III. LEAF RAPIDS - DEVELOPMENT WITH AN EYE TO THE FUTURE?

Referring back to Figure II. 1 (page 12), if we somewhat arbitrarily locate the Thompson development approximately at the midpoint of the "urban development" continuum the community of Leaf Rapids, Manitoba might then be located on the continuum at some point slightly in advance in time (and time allowing for technological advance and therefore more towards the ideally planned community) of the point at which the Thompson development is situated.

Leaf Rapids townsite* came about as a result of a discovery of a copper-zinc ore deposit at Ruttan Lake (Figure II. 12) in 1966. With the nearest available work force at Lynn Lake, a mining community some 85 miles to the northwest, it was deemed unfeasible to commute between the new mine site and the town of Lynn Lake. The logical alternative was therefore the construction of an entirely new community in close

*Information sources for this section are drawn from Clarke and Grimes, 1975; Forum, 1976.

proximity to the Ruttan mine location.

Preliminary reconnaissance for site selection and detailed site study included the study of aerial photographs and more detailed data from walking the site and examination of soil data.

The actual mining operation was to be of the open pit type.

Leaf Rapids is a prime example of existing northern communities in which there has been considerable thought given to creating an aesthetic habitable environment while maintaining the identity of the natural environment to a high degree. The following is a detail in point form of criteria and design which has gone into the building of this northern community.

Town Location - 64 miles southeast of Lynn Lake, Manitoba and two miles south of Churchill River Narrows above the Leaf Rapids (Figure II. 12). Region is sub-arctic.

Design Population - 3,500 with potential of 12,000.

Present Population - 2,300 (December, 1974).

Design Criteria - "to provide for residents of the town a most desireable place in which to live at a cost which they could afford" (Clarke and Grimes, 1975, p. 86).

Site: (Figure II. 13) -

- Serious damage to existing vegetation was to be avoided wherever possible; large areas of trees were to be maintained to avoid damage due to uprooting by wind; a park like atmosphere was to be maintained to the greatest possible degree.

- Areas where rock outcrop was near the surface were to be left undeveloped.

- Poorly drained, muskeg areas and scrub brush were to be developed as a recreation field.

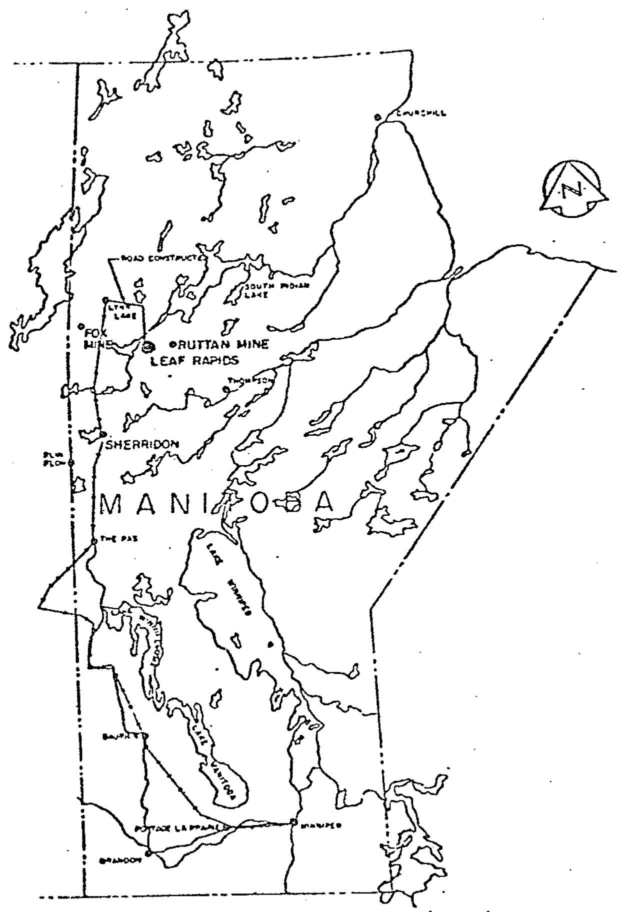


Fig. II. 12. Location Map, Province of Manitoba

Source: Clarke, W.F. Grimes, D.R. "Planning and Construction of Leaf Rapids--A New Town With A New Concept", April, 1975, p. 84.

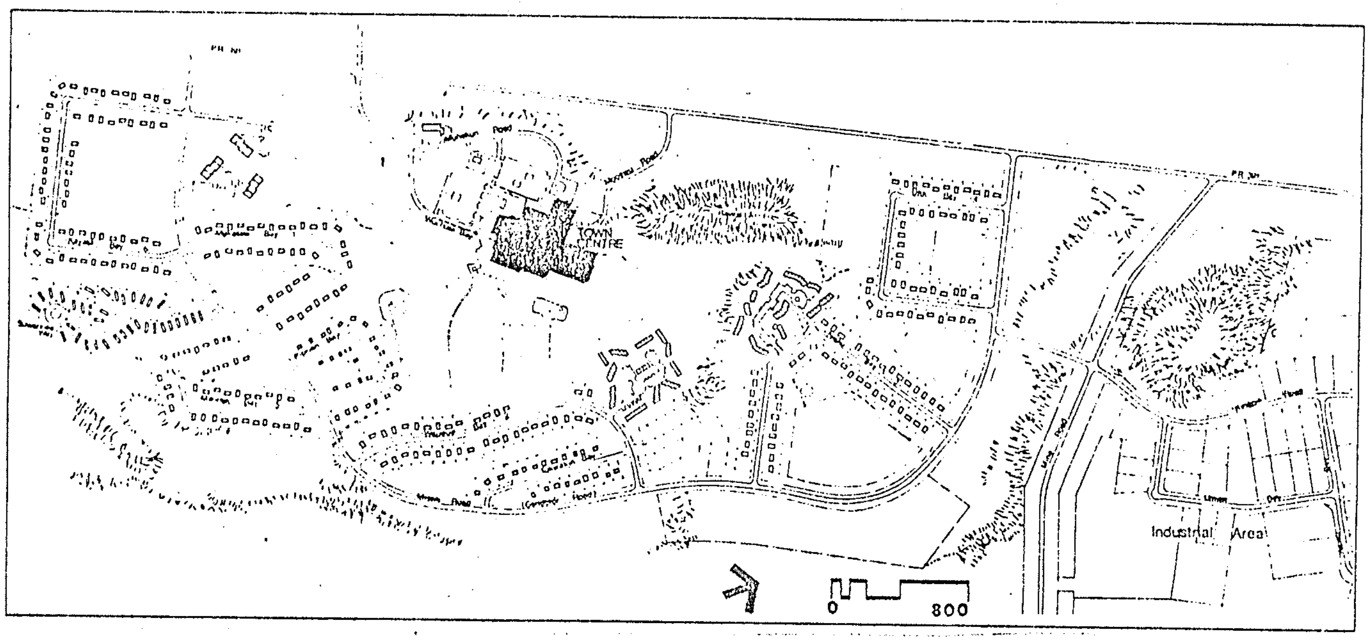


Fig. II. 13. Site Plan

Source: Forum, February, 1976, p. 5.

- Street Pattern:

  (a) Designed to facilitate traffic movement.
  (b) Grid pattern minimizes pressure loss in water distribution system (Figure II. 14).
  (c) Bays facilitate use of a single heated water main which prevents freezing (see also "water system").

- Water System:

  (a) No adequate ground water supply.
  (b) Source of supply is Churchill River; quality of water is such that only chlorination treatment is necessary.
  (c) Problems with low water temperatures, deep frost penetration, low winter ground temperature; therefore water is heated at pumping facility on the river and temperature-actuated valves, pre-set, are used to maintain the water temperature at the end of the system at 34°F. Water is wasted from the terminal ends of the distribution system to prevent freezing. (Figure II. 14.)

- Sewage System:

  (a) Plant is a premanufactured unit for on-site assembly.
  (b) Plant is entirely enclosed to overcome freezing problems and to promote biological action.
  (c) Plant is operated as an extended aeration plant.

- Drainage:

  (a) All sanitary sewers are gravity drained.
  (b) Storm drainage is simplified as all bays drain to the collector road, Mistik Road, where surface ditching carries drainage to natural drainage courses.

Planning

- Housing (planned allocation):

  - 600 single family detached units with an average lot size of 60' x 100'.

  - sufficient multiple units to accommodate 300 family units.

- Services: All services below grade, including hydro and telephone lines.

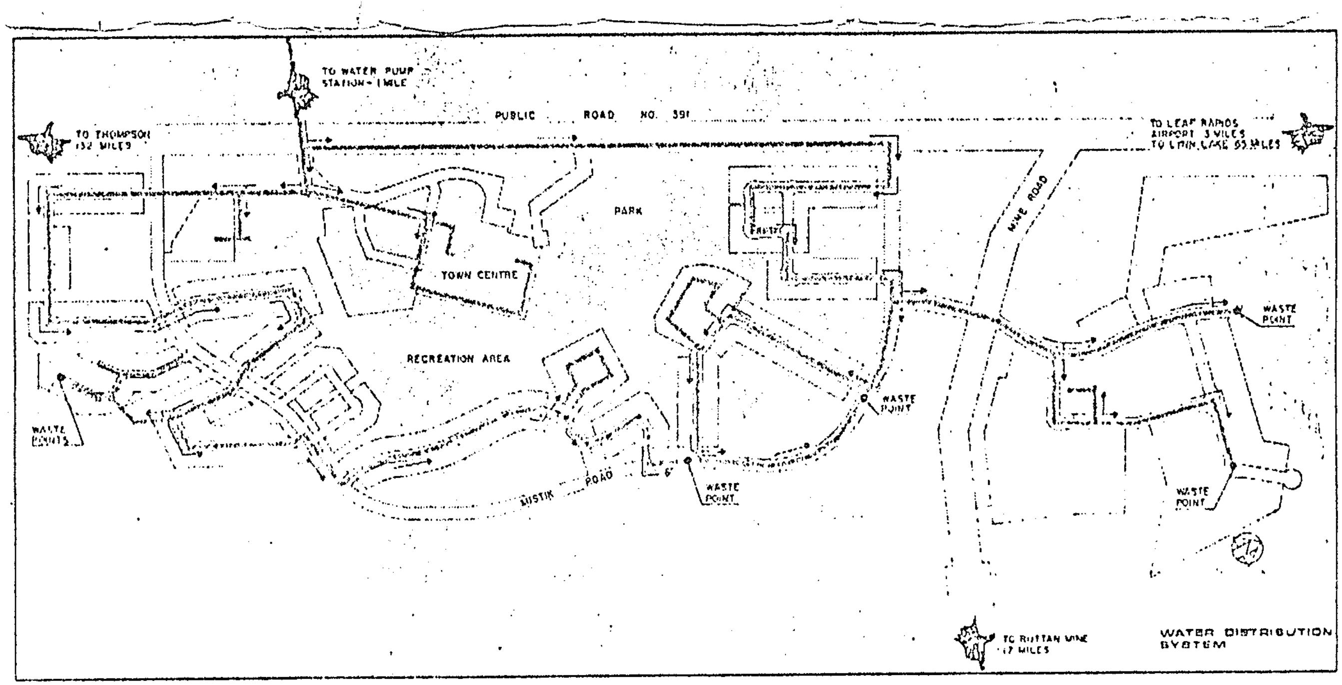


Fig. II. 14. Water Distribution System

Source: Clarke and Grimes, 1975, p. 88.

- Location of Facilities (Figure II. 13).

    (a) Residential areas, commercial areas and recreational facilities are to be located to the south of the mine access road running east-west.
    (b) Heavy commercial and insutrial sites are to be located to the north of the mine access road.

Town Centre*

- Criteria and facilities

    "(1) comfortable access between all town functions, with protection from inclement weather conditions;

    (2) grouping of all functions together to allow and encourage maximum inter-utilization of facilities;

    (3) compact building grouping allowing minimum impact on the site;"

    (Clarke and Grimes, 1975, p. 91).

Figures II. 16 and II. 17 show that the urban development has been molded to fit the natural environment. While this creates an aesthetic quality it has created one problem. Northern bush areas, because of density and isolation of vegetation have been subjected to forest fires which have burned for considerable lengths of time travelling over long distances and destroying thousands of acres of trees.

Urban developments such as Leaf Rapids are highly vulnerable to forest fires because they have been constructed largely in and around large stands of trees. To avoid the potential hazard fire breaks are being broken around the entire perimeter of the town at such a distance to afford adequate protection yet without destroying the visual aesthetic quality of the development (Number Ten Architectural Group).

*Refer to Figures II. 13, II. 14, II. 15, and II. 16.

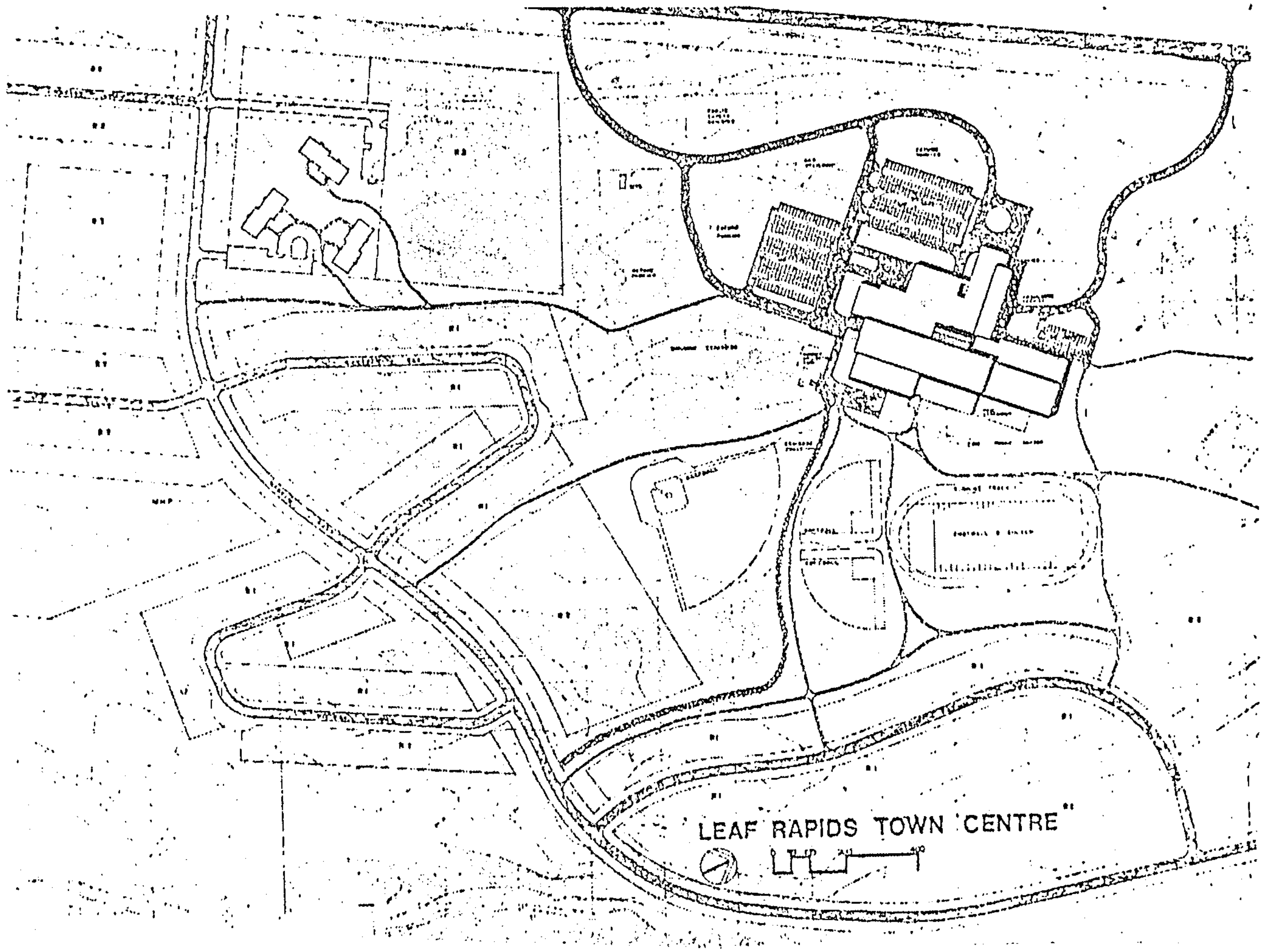


Fig. II. 15. The Area of the Town Centre

Source: Clarke and Grimes, 1975, p. 90.

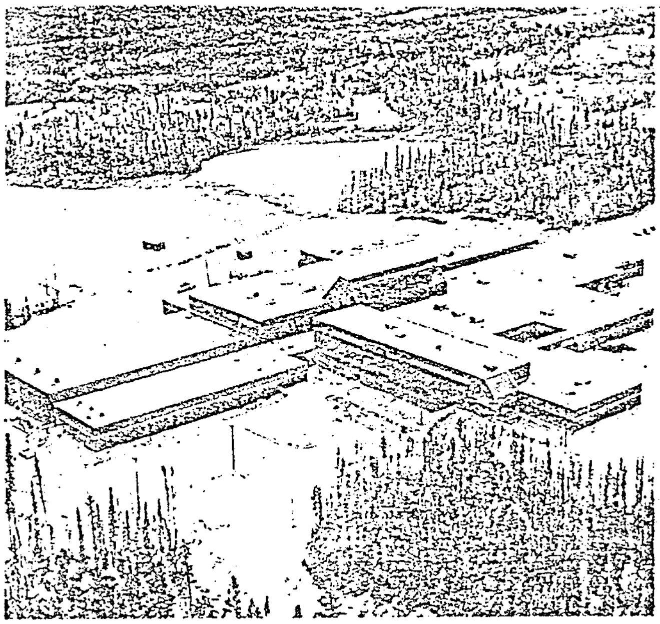


Fig. II. 16. Aerial View of Leaf Rapids in Town Center.

Source: Forum, February, 1976, p. 6.

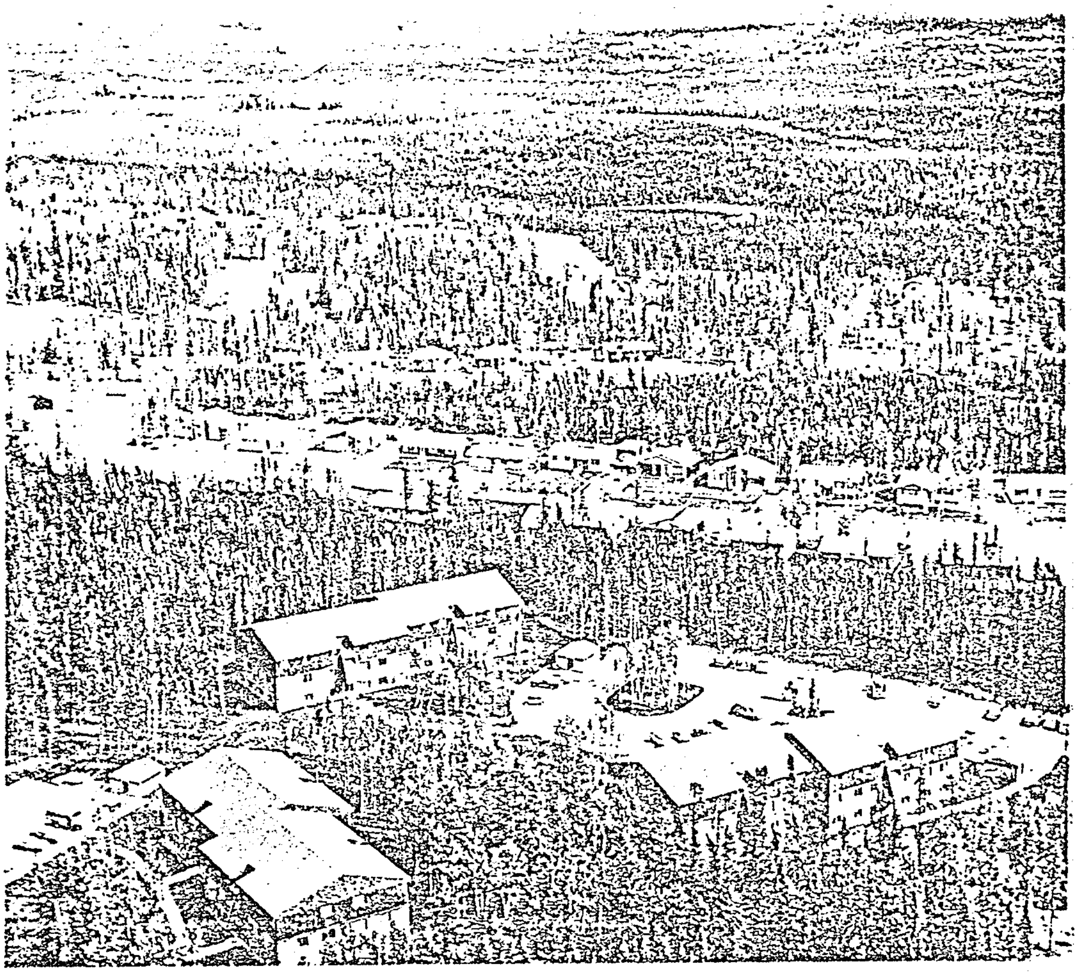


Fig. II. 17. Leaf Rapids, Manitoba

Source: Forum, February, 1976, p. 4.

While Leaf Rapids has no doubt been a positive step in the right direction its conception did not employ available technology to the fullest extent in terms of assessing environmental impact prior to urban development.

David Johns (1973), using Leaf Rapids as an example, illustrated in detail how computer aided design could have been used to assess site vulnerability to environmental impact caused by urban development. Unfortunately this exercise was conducted "after the fact", subsequent to the town's development.

Computer aided design is not new, having application in areas in disciplines not entirely related to planning. What is unique is its application to site development.

The Delphi Process, like computer aided design, is not a new process, having been developed some twenty years ago, its basic principles based upon democratic philosophies of ancient Greece. (i.e., The concept that two heads are often better than one) (Linstone and Turoff 1975). Its application is, however, unique with respect to town planning in northern environments.

The Delphi Process, in this application is the major subject of this thesis and of the following chapter.

CHAPTER III

THE DELPHI PROCESS: A SITE SELECTION METHODOLOGY FOR URBAN DEVELOPMENTS IN NORTHERN ENVIRONMENTS*

I. THE EVOLUTION OF DELPHI

The Delphi Technique (or Process) first began in the early 1950's as a spinoff of defense reserach under "Project Delphi" which was the name given to an United States Airforce sponsored Rand Corporation study. The object of this study was to "obtain the most reliable concensus of opinion of a group of experts...by a series of intensive questionnaires interspersed with controlled opinion feedback". (Linstone and Turoff, 1975, p. 10.)

In 1964 the application of Delphi was expanded to areas outside the defense community. Studies by the Rand Corporation applied Delphi to assess "the direction of long-range trends, with special emphasis on science and technology..." (Linstone and Turoff, 1975, p. 10). "Long-range" was defined as a span of ten to fifty years. The process has since been adapted for use by a variety of agencies utilizing procedures for planning exercises related to education, health, and urban growth.

The purpose of the process as applied to urban development in northern environments is to develop a method of evaluating the signifi-

*Information in this chapter has been largely based upon a report compiled by the consulting firm of Underwood McLellan and Associates Ltd. (Townsite Selection & Environmental Assessment: Lake St. Joseph, Northwestern Ontario, Second Interim Report, January 1976.) Though this might appear as a solitary reference such is not the case. While the report per se has been compiled by The UMA Group, the Delphi Technique as it pertains to site selection, was a product of joint effort by representatives of the UMA Group, Winnipeg, Manitoba; Damas and Moore, Los Angeles California; and The Environmental Applications Group, Toronto, Ontario.

cance of a large volume of data collected during initial phases of the process of selecting a suitable location upon which to build a community.

Hidden biases, concealed preferences and even imperfect knowledge are often major problems in any decision-making procedure. In the Delphi decision-making process, these aspects are made explicit and approached in a systematic way.

II. TWO PROCESSES

Delphi presently exists in two forms the most common being the paper and pencil version or the "Delphi Exercise". This method is somewhat impersonal and does not allow for immediate feedback of respondents.

A small group with specific interests attempts to gain feedback about particular subject matter from a larger respondent group by circulation of questionnaires among the group. The questionnaires are then returned for evaluation. At least one opportunity for a re-evaluation of original answers (based upon total group response) is usually given to the respondent group. The conventional Delphi is therefore "to a degree...a combination of a polling procedure and a conference procedure which attempts to shift a significant portion of the effort needed for individuals to communicate from a larger respondent group to a smaller monitor team" (Linstone and Turoff, 1975, p. 5).

The more modern version, employs a conference of experts gathered together in one location and a computer program to carry out the data analysis of the respondent group input. This newer form, sometimes referred to as a "Delphi Conference", employs a panel of experts as a single respondent group with replacement of the monitor team by a computer. Because the computer data analysis feedback is almost immediate and rather than a single round of re-evaluation, the reduced time factor allows multiple re-evaluation whenever it is deemed necessary.

III. DELPHI PHASES

Before Delphi is undertaken the system requires that the characteristics of the topic under discussion be well defined. Once the topic has been defined and the objectives of the exercise outlined the Delphi Technique undergoes four distinct phases. The first phase is a data input phase in which information in addition to that already known is offered by each expert and which he feels is pertinent to the issue. The second phase involves an attempt to reach a group consensus on issues relative to the objectives of the process. A third phase involves those issues over which there has been significant controversy or disagreement. The reasons for lack of group consensus are explored, dissenting individuals being given opportunities to establish credibility of their viewpoints. (This process may be repeated more than once.) The last phase is one of final evaluation considering all information which has been fed into the discussion. A decision is then reached on the basis of data analysis of final phase evaluation (Linstone & Turoff, 1975, pp. 5-6.)

IV. DELPHI AND SITE SELECTION

The prime objective of this thesis is to adapt the Delphi Technique to the process of site selection in such a manner that the selected site will meet physical design requirements to the greatest degree possible while at the same time minimizing the detrimental effects to the natural environment.

For the purposes of this thesis "site selection" may be defined as the process by which a single geographical location for an urban development is selected from among a number of possible alternative geographical locations.

V. PROFESSIONAL PARTICIPATION AND RESPONSIBILITY

The requirements of the urban community and associated industries in terms of land use and the consequence of potential pollution hazards will be the prime factors in selecting Delphi participants for the purposes of site selection.

At this point it should be noted that the Delphi Technique as illustrated herein has been designed solely for the purposes of site selection (as defined above) and is not meant as an instrument in creating the design per se of the urban development beyond conceptual land use requirements. For this reason the technique is not concerned with the social aspects of design. Social scientists have therefore been excluded from the process. This by no means implies that the social and psychological requirements of potential community inhabitants should not be considered in the process of site development, (i.e., the layout design and construction phases), only that is not necessary during the site selection process itself.

Table III. 1 below suggests those professionals and their responsibilities who conceivably may be involved in the Delphi process.

The list is not meant to be exhaustive as the professions which become involved will depend upon local conditions of specific areas in which sites are to be located.

TABLE III. 1

DELPHI PARTICIPANTS AND THEIR RESPONSIBILITIES

PARTICIPANT	RESPONSIBILITY
1) Statistician	1) Organization of the Delphi Process and Data Analysis. May not act as a direct participant.
2) Planner(s)	2) Ensure proper planning variables and techniques are applied. May also be responsible for project organization and the final report.
3) Engineering	
(a) Mining	3a) Industrial site locations and problems specific to industrial operations as they relate to site selection.
(b) Civil	3b) Supervision of design requirements for infrastructure (i.e. roads and utilities). Areas of expertise in cold climate engineering problems.
(c) Geological	3d) Primarily concerned with pulp and paper industry and logging operations. Advise on what areas suitable for timber cutting and reforrestation programs.
4) Architects	4) Building code requirements for specific building types (for cold climate, aesthetics and functionality) and whether or not areas within sites are capable of supporting (from a stress viewpoint) certain types of buildings (e.g. high rises).
5) Environmentalists - biologists & zoologists	5) Advise on areas of concern relating to effects on environmental impact on the eco-systems of plant and animal communities.

VI. PROJECT SEQUENCE

Before the Delphi Technique can be understood in its relationship to the process of site selection it must be realized that the technique per se, though perhaps most important, is but an integral segment in the overall sequence of events which fall under the total heading of "Site Selection".

Figure III. 1 illustrates a project flow chart outlining the events as they occur in relation to the Delphi Technique and the project as a whole.

Although the main focus of this document is upon the Delphi Technique which will be dealt with in detail under a separate heading a brief outline of the overall project sequence is desirable.

A. Job Initiation

A particular project, of which purpose is to select a suitable location for urban development, is undertaken on a contractual basis between the corporation developing an area and the consulting firm employing expertise essential to competent project development and control.

B. Scope

Prior to enlisting the aid of consultants the corporation will have acquired extraction rights* for removal of a specified natural

*Extraction rights will have been obtained either through lease of Crown land as is often the case in the timber industry, or through mining rights filed under claim.

Fig. III. 1

FLOW CHART OF PROJECT

A. Job Initiation

↓

B. Scope

↓

C. Relevant Disciplines for Selection of Townsites

↓

D. Creation of Discipline Criteria, General Constraints and Appropriate Rating Technique

↓

E. Site Alternatives: Data Collection and Evaluation

↓

F. Revised list of disciplines and criteria for Evaluation of Townsites

↓

G. Rating of Townsites

↓

H. Weighting of Relevant Disciplines (Delphi Technique to be used)

↓

I. Ranking of Sites

Source: The UMA Group, 1976, p. 6.

resource in a specifically defined geographic region. The definition of such a region provides the boundaries for the study area within which a number of alternative townsites may be located, one of which will be selected to serve the developing resource industry.

While there may be as many as a dozen or more potential townsites within the defined confines of the region the potential locations on which the industrial site itself may be located will be limited to one or two or perhaps three depending upon the type of industry and its operation requirements (Estall & Buchanan, 1972).

Figure III. 2 is an illustration of known or "given" factors*, namely, (i) the defined geographic region of study within which the townsite will be selected and ultimately developed, (ii) the potential location of the resource industry.

C. Relevant Disciplines for Selection of Townsite

The specific disciplines involved in any specific process will largely be determined by two major factors (i) the nature (type) of the resource industry in question and its specific requirements and processes, and (ii) the characteristics of the geographic region to which the study is to be applied.

The term "discipline" applies to the individual characteristics of specific sites (e.g., surface geology, vegetation, hydrology etc.) and not to the professions of the participants of the particular decision-making processes.

*Figure III. 2 is a map of a hypothetical geographic region and is intended for illustrative purposes only.

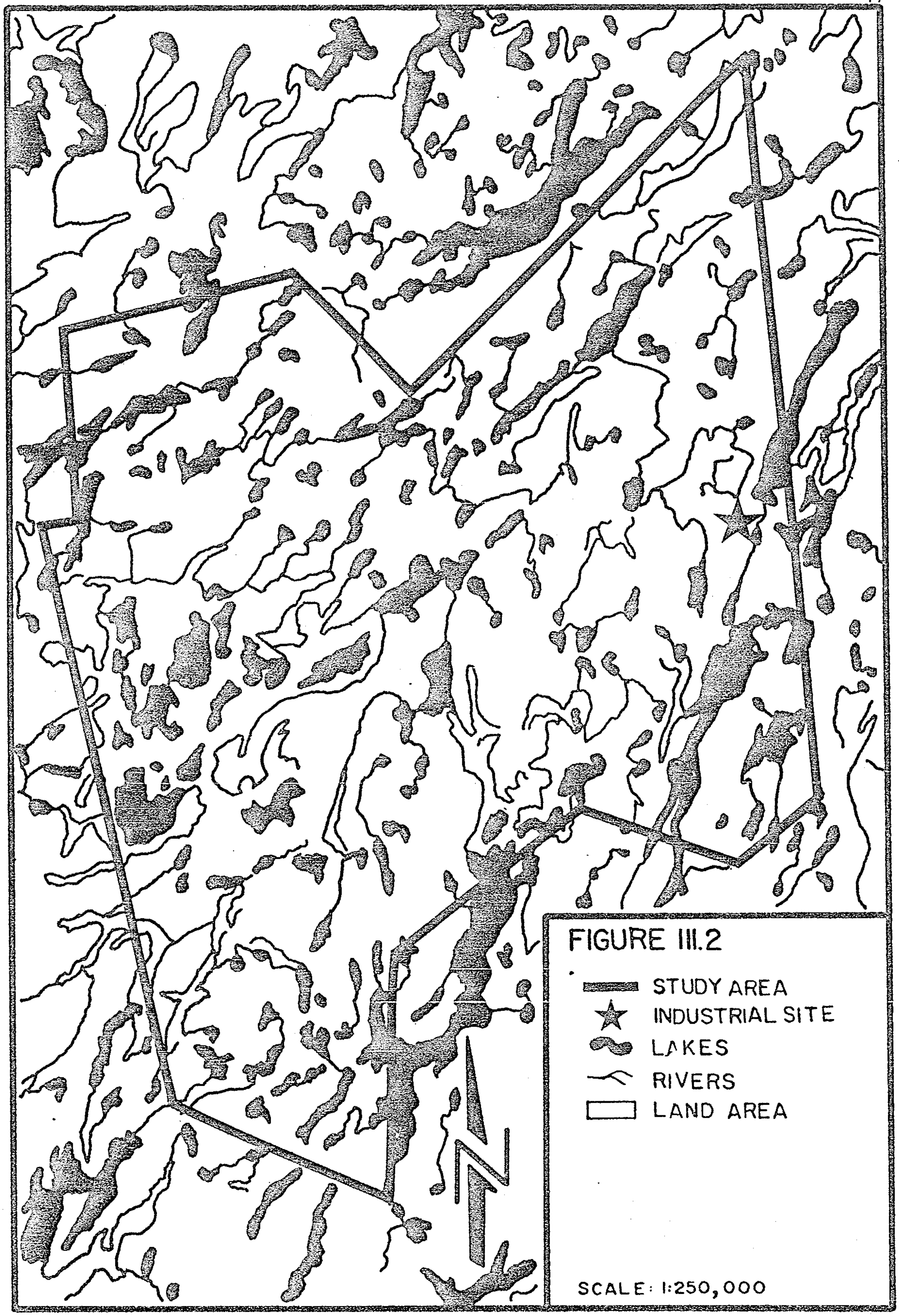


FIGURE III.2
STUDY AREA
INDUSTRIAL SITE
LAKES
RIVERS
LAND AREA
SCALE: 1:250,000

Table III. 2 is a table of disciplines or site characteristics which may be considered as relevant to the site selection process. The list is by no means exhaustive as the components would be expected to vary with type of industry and geographic location. The list is compiled through participant input and group consensus on each item.

TABLE III. 2

SITE DISCIPLINES

Slope	Air Quality
Sun Exposure	Snow Drifting
Surficial Geology	Snow Melt
Proximity to Construction Material	Existing Transportation
Surface Hydrology	Rare and Endangered Species
Groundwater Probability (50%)	Aesthetic Quality
Forest Vegetation	Employment Areas
Water Fowl	Commercial Fishing Potential
Terrestrial Wildlife	Land Ownership
On Top of Mineral Resources	Existing Land Use
Forest Resources	Proximity to Waste Disposal

Source: The UMA Group, 1976, pp. 18-19.

D. Creation of Discipline Criteria, Constraints and Appropriate Rating Technique

While the list of disciplines in Table III. 2 provides a list of items which are to be taken into consideration when discussing the potential of each site for development the list does not provide a breakdown of each item into its component parts which for all intents and purposes becomes the established criteria to be considered for each and every particular townsite.

1. Criteria

Table III. 3 shows the list of disciplines as they are broken down into their components. As in the case of the selection of the disciplines the list of components for each discipline is arrived at in the same manner, i.e., through participant input and group consensus arrived at in two phases:

(i) preliminary meetings of Delphi participants

(ii) fieldwork for studying the selection and evaluation of components.

It should be noted all variables (disciplines) and their respective criteria have two common characteristics:

(i) All pertain only to the physical environment and as such are viewed and analyzed solely with respect to engineering, planning and environmental criteria.

(ii) All are non-economic in nature consequently cost factors of industrial location and site development become non-relevant at this point.

2. General Constraints

Other criteria which will define the study area so far as potential townsites are concerned come under the heading of constraints defined as obvious factors of sufficient magnitude as to restrict locations within the study area for townsite development. These of course will vary depending upon the geographic region under consideration but the following are likely to have a general application over a number of regions:

TABLE III. 3

DISCIPLINE COMPONENTS

COMPONENT

Slope

0-5%
5-10%
10-15%
15-20%
20-25%
25-30%
30 and above

Sun Exposure

North
South
East
West

Surficial Geology

Bedrock Outcrop
Fine Granulars
Coarse Granulars
Tills
Silts and Clays
Organic Terrain (Deep)
Organic Terrain (Shallow)

Proximity to Construction Material

Fine Granulars
Coarse Granulars
Clays/Till
Crushed Rock Sources
Peat/Organic Soil Sources
None

COMPONENT

Surface Hydrology

Lakes
Lakeshore
Swamps
Streams
Floodplain (25y)
Floodplain (100y)
None

Groundwater Table Constraint

0-10 feet
Less than 10 feet

Groundwater Probability (50%)

10 g.p.m. and less
10-50 g.p.m.
Less than 50 g.p.m.

Forest Vegetation

Black Spruce
White Spruce
Jack Pine (High Density)
Mature Jack Pine and Other Pine
Aspen, Birch
No Forest Vegetation

Waterfowl

Breeding Area
Staging Area
None

Terrestrial Wildlife

Bears
Moose
Small Fur Bearers

COMPONENT

On Top of Mineral Resources

- Existing Open Pit
- Existing Underground Pit
- Planned Open Pit
- Planned Underground Pit
- Potential Areas (Geological)
- Patented Claim Areas
- Non-Patented Claim Areas
- None

Forest Resources

- Sawmills
- Paper Mills
- Licence Areas
- None

Air Quality

- Pollution Zone
- No Air Pollution

Snow Drifing

- Severe
- Moderate
- Light
- None

Snow Melt

- Slow Melt
- Moderate Melt
- Fast Melt

Existing Transportation

- Road
- Rail
- Airstrip (water)
- Airstrip (land)
- None

COMPONENT

Rare and Endangered Species

- Caribou
- Bald Eagle
- Osprey
- Relict Populations
- Forest Resources Areas
- Wilderness Areas (Defined)
- None

Future Land Use

- Future Forest Cutting
- Future Mining Area
- Future Mill
- None

Aesthetic Quality

- High
- Moderate
- Low

Employment Areas

- Existing
- Future
- None

Commercial Fishing Potential

- High
- Moderate
- Low
- None

Land Ownership

- Crown
- Private
- Patented

COMPONENT

Existing Land Use

- Native Reserve
- Native Settlement
- Native Trapline
- Native Hunting Area
- Native Fishing Area
- Native Wild Rice Area
- Hunting Camp
- Hunting Area
- Fishing Camp
- Fishing Area
- Forest Area
- None

COMPONENT

Proximity to Waste Disposal

- Existing Tailings
- Existing Solid Waste
- Existing Sewage Effluent
- Future Tailings
- Future Solid Waste
- Future Sewage Effluent

Source: Adapted from The UMA Group, January 1976, pp. 20-21.

- Wind direction which could carry atmospheric pollutants from the industrial site.

- Location of water bodies, areas of muskeg and other natural geographic features.

- Travel distance to and from work (usually defined as a maximum of 25 miles due in part to union regulations determining maximum one way travel time and/or distance).

- Location of Indian Reserves as townsite location within such areas is not permissible.

- Wild life sanctuaries and/or habitats of endangered species.

- Townsite location on areas of known mineral potential or on areas of patented claims should be avoided. (The UMA Group, 1976, p. 32.)

3. Rating Technique

Rating refers "to a numerical value assigned to a particular (characteristic) or component under consideration" (The UMA Group, 1976, p. 8). The rating scale (Table III. 4) is derived through professional judgement in such a manner that comparability ensures "the same evaluation procedure be applied to each site" (The UMA Group, 1976, p. 8). Although the ratings are subjective large fluctuations of ratings may be avoided by detailing the decision-making process.

E. Site Alternatives: Data Collection and Evaluation

The selection of alternative sites and the collection and evaluation of data, like the overall project is a stepwise sequential development.

The first step in the procedure is the study of aerial mosaics to provide an overview of the entire study area. In addition to

TABLE III. 4

SUBJECTIVE SCALE

High	H+	9	Medium	M+	6	Low	L+	3
	H	8		M	5		L	2
	H^-	7		M^-	4		L^-	1

a) Condition is poor. There are many problems; some of which cannot be controlled (mitigated)

rating = 1

b) Condition is average to poor. There are many problems, all of which can be controlled, but only at great expense

rating = 3

c) Condition is average. There are a few problems, all of which may be controlled at moderate expense

rating = 4

d) Condition is average to good. There are no problems; however, the area (ecological, social and economic) surrounding the site does not benefit from the construction of the site

rating = 7

e) Condition is good. There are no problems; however, the area surrounding the site benefits (ecological, social and economic) from the development of the site

rating = 9

Source: The UMA Group, 1976, pp. 9-10.

the general constraints listed additional constraining features such as predominant rock outcrop, steep slopes, etc. are plotted on an area base map. Once all known constraints have been defined and located the next step in the sequence is to determine from the mosaics those areas which show some potential for townsite development. Such features may include areas where the slopes are generally less than 10%, with a southern sun exposure, tills or fine granular soils and has a high aesthetic quality in terms of local vegetation and scenery. Thirdly, high level aerial photography* employing a variety of techniques such as infra-red in addition to field reconnaissance define potential sites more specifically. At this point several potential sites may be eliminated. Again the remaining sites are subject to additional aerial and ground reconnaissance by engineering, planning and environmental personnel.

Once the data has been compiled it is evaluated by those participating in the Delphi Technique, many of whom may be involved, but not necessarily, in the original data gathering processes.

F. Revised List of Disciplines and Criteria for Evaluation of Townsites

Once all the information has been gathered and evaluated relative to townsite development there may be items and information

*High level aerial photographs employing a variety of techniques reveals additional data that can not be determined from aerial photographs of the type used in the composing of mosaics.

**While it may be desirable it is not mandatory that Delphi participants have a first hand knowledge of the sites acquired through visitation to the study area, only that they have been provided with sufficient information about the site pertaining to their specific areas of expertise.

which is no longer necessary to consider for one reason or another (e.g., a particular item may have been deleted because it was specific to an original site, which upon closer inspection, was not considered to be suitable for development).

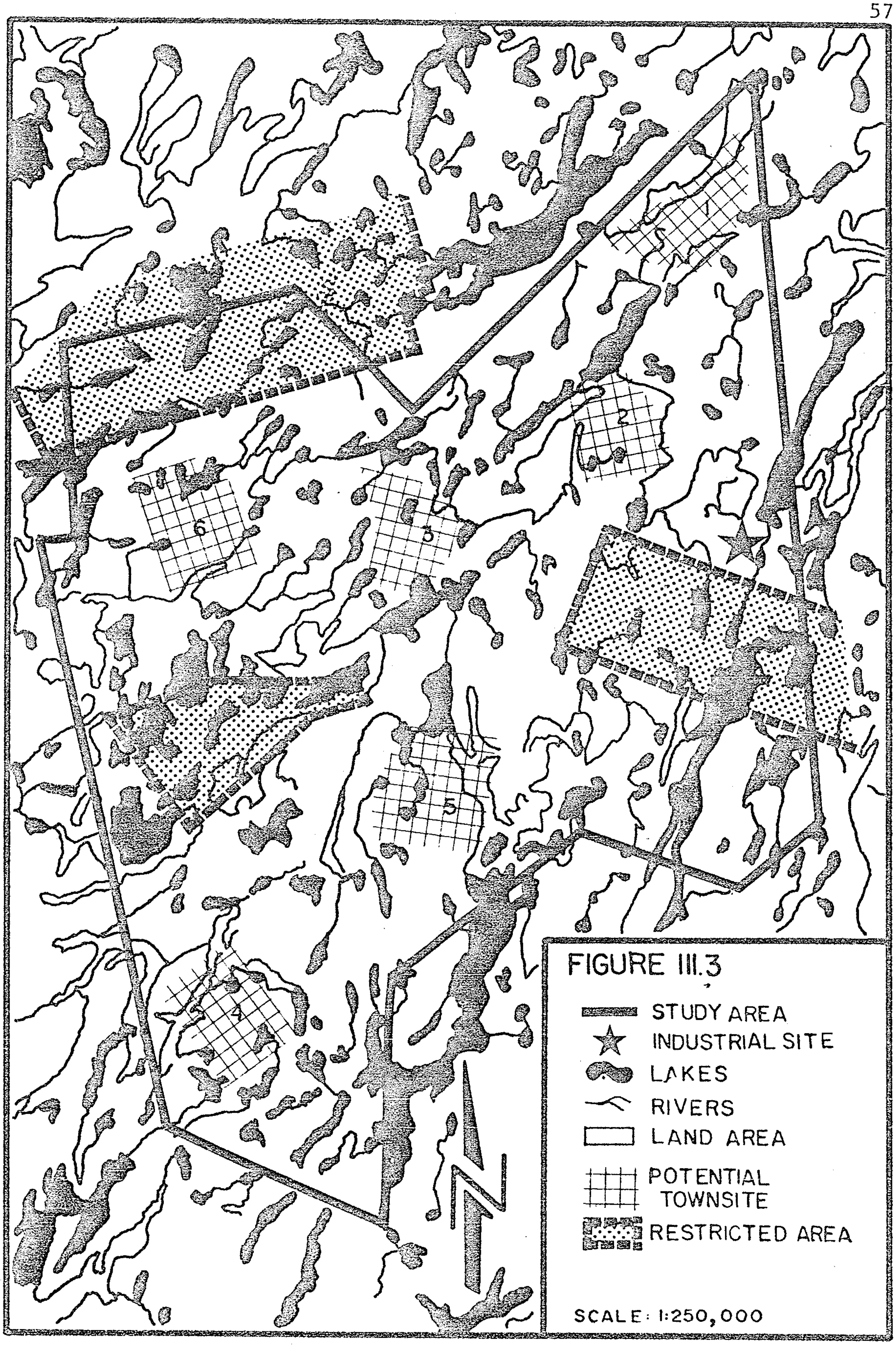
Specific sites are selected on the basis of evaluated data, including the general constraints outlined earlier. Through the process of elimination potential townsite areas are selected for detailed evaluation through application of the Delphi Technique.

For the purpose of this thesis, six such sites will be considered for evaluation on a hypothetical basis.

Figure III. 3 shows the location of the six sites, the industrial site location, restricted areas and the boundaries of the study region. The numbers on the site locations are for identification only and do not imply a rank order of any sort.

VII. THE DELPHI PROCESS

Land use planning is of prime importance in any development and especially so in areas where the balance of nature is extremely sensitive. Site selection for communities in northern areas presents more complex problems and a greater number of considerations than would be warranted in a standard, commonplace development in southern regions. Because of these complexities created by a myriad of variables the Delphi Process has the potential of becoming a viable methodology in the selection of potential sites for urban developments in northern environments.


1
2
3
4
5
6
FIGURE III.3
STUDY AREA
INDUSTRIAL SITE
LAKES
RIVERS
LAND AREA
POTENTIAL TOWNSITE
RESTRICTED AREA
SCALE: 1:250,000

The technique has three features:

> "(1) Anonymous response - opinions of members of the group are obtained by formal questionnaire. (2) Iteration and controlled feedback - interaction is effected by a systematic exercise conducted in several iterations, with carefully controlled feedback between rounds. (3) Statistical group response - the group opinion is defined as an appropriate aggregate of individual opinions on the final round" (Dalkey, 1969, p. v).

The purpose of the employment of the Delphi Technique is northern urban development planning is to evaluate potential townsites which may serve a regional resource-based community* in the interest of "protection of the environment and an assessment of likely effects of a project and ways of mitigating deleterious effects..." (UMA Group, 1976, p. 2).

The process is a weighting and ranking methodology employed in determining relative weights of non-economic factors. It is a stepwise procedure involving decision-making based upon indirect discussion and information feedback with refinement through a panel or committee approach.

The procedure requires experts to draw on their accumulated knowledge to arrive at a consensus regarding certain items. Rather than forecasting future events, the participants are asked to rate the importance of one data type over another.

The evaluation process involves two sets of values:

(a) Importance Ratios: These ratios define the relative degree of importance between data as they relate to a given land use issue. (Example: Are geological considerations more important than ecological sensitivity?)

*Refer to page 1 of the thesis.

(b) Planning Values: These define the relationship between the different data sub-categories within data-groups. (Example: How important are various types of ecological systems?)

Importance Ratios and Planning Values define the weighting structure for aggregating data, weighting being defined as the process assigning a numerical value to each discipline (criteria). This aggregation yields a measurement of the suitability of geographic areas for the planned site, "suitability" being defined as:

> "the capacity of the site in its given condition to produce necessary resource capability combinations for specific land uses..." (Johns 1973, p. 23.).

Further, "capability" represents:

> "...the inherent potential of the combined physiographic features of an area to produce specific goods and services under specified types and intensities of economic and technical controls."

Figure III. 4 is an illustration of the major steps comprising the Delphi Process.

A. Rating of Criteria

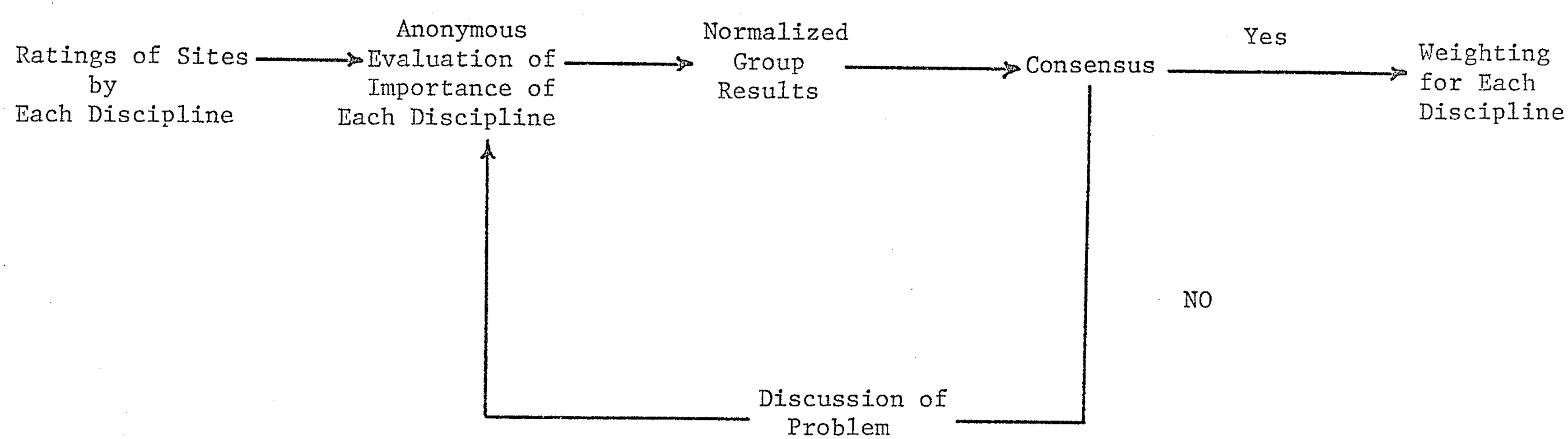
Table III. 3 has provided a breakdown of disciplines (Table III. 2) into component parts.

The first major step in the Delphi Process is to rate the sites (refer to Table III. 4) in terms of their previously established criteria.

Each participant in the process (usually one expert per discipline) is required to rank each of the disciplines involved with respect to some purpose i.e., from highest to lowest and with direct relevance to the environmental impact. (Those disciplines

Fig. III. 4

DELPHI PROCESS



Source: The UMA Group, 1976, p. 16.

which, in the opinion of the participant, have no relevance to environmental impact are ignored.) For example, the following might be one individual's result:

TABLE III. 5

ANONYMOUS DISCIPLINE EVALUATION

Discipline	Rank*	
Land Use	10	Highest
Employment	6	
Rare Species	9	
Air Quality	5	Lowest

*All values are hypothetical and are intended for illustrative purposes only.

Source: The UMA Group, 1976, p. 13.

"Land Use" is therefore most important with "Air Quality" being the least important. The least important discipline is then assigned a value of 1. The remaining disciplines are assigned values according to their importance in relation to townsite selection. To this point the procedure is anonymous. Individual value assignments for all participants are normalized (Table III.6 (A) and the results statistically analysed (Table III. 6 (B). (Note: All data is fictitious and is intended for illustrative purposes only.)

TABLE III. 6

EXAMPLES OF VALUE ASSIGNMENTS

(A) Normalized for reach discipline (single participant)

Discipline	Value	Normalized Values
Land Use	10	38.5
Employment	6	23.1
Rare Species	9	34.6
Air Quality	1	3.8
	26	100

(B) Statistical Analysis for the Group

Discipline	Mean Values	Standard Deviation
Existing Land Use	.82	2.0*
Employment	.76	1.5
Rare Species	.72	0.9
Air Quality	.67	1.2

*Land use shows greatest divergence of participants in the process.

Source: Modified from The UMA Group, 1976, p. 14.

The statistical information is fed back to each expert who then re-evaluates previous estimates in light of known median and quartile values for each concern.

Participants having estimates outside the interquartile range are asked to state the reasons for their estimates thus providing new information to other members of the panel. Through this recycling procedure, the salient features of each concern become identified. The evaluation procedure is reported in succeeding rounds until the value ranges are narrowed so that few values occur outside the inter-quartile range in the last rounds and a mean rating is obtained for each discipline criteria through group consensus.

In view of various sensitivities in an area, a restricted category ($R < .5$) must be introduced into the rating system. The purpose of this is to identify areas which under no circumstances can be used for townsite location. Restricted areas may include elements such as open pit areas, muskeg, lakes, extreme slopes, Indian Reserves, private property, etc. (Refer to Fig. III. 3, p. 54.)

The final result of the rating process may be similar to that illustrated in Table III. 7.

B. Weighted Ratings

Rating of each criteria in itself is not sufficient as the rating is a numerical value applied only to each component part and does not consider the overall general discipline. The systematic use of criteria is necessary to maximize comparability of ratings within a given discipline.

In situations where a common denominator among disciplines is not possible, such comparison must be subjective. The Delphi Process provides a structured method of reaching consensus involving subjective evaluations.

TABLE III.7

RATED CRITERIA COMPONENTS FOR SITE DISCIPLINES

COMPONENT		MEAN*	COMPONENT		MEAN*
Slope			**Surface Hydrology**		
0-5%	H	7.8	Lakes	R	0.2
5-10%	H	7.8	Lakeshore	H+	8.4
10-15%	M+	5.9	Swamps	L-	0.5
15-20%	L+	3.2	Streams	M+	6.3
20-25%	L-	0.6	Floodplain (25y)	L	1.5
25-30	R	0	Floodplain (100y)	L+	3.1
30 and above	R	0	None	M-	3.5
Sun Exposure			**Groundwater Table Constraint**		
North	L	1.5	0-10 feet	L	1.6
South	H	7.8	Less than 10 feet	H	7.8
East	M	4.4			
West	M	5.0	**Groundwater Probability (50%)**		
Surficial Geology			10 g.p.m. and less	L	1.7
			10-50 g.p.m.	M	4.3
Bedrock Outcrop	L-	1.0	Less than 50 g.p.m.	H	7.6
Fine Granulars	H-	6.4			
Coarse Granulars	M+	5.4	**Forest Vegetation**		
Tills	H-	6.5			
Silts and Clays	M	5.0	Black Spruce	L+	2.9
Organic Terrain (Deep)	L	1.0	White Spruce	M	5.3
Organic Terrain (Shallow)	L+	2.3	Jack Pine (High Density)	M	4.8
Proximity to Construction Material			Mature Jack Pine and Other Pine	M+	6.0
			Aspen, Birch	H-	6.6
Fine Granulars	M+	6.0	No Forest Vegetation	L	1.6
Coarse Granulars	H	7.5			
Clays/Till	M+	6.0	**Waterfowl**		
Crushed Rock Sources	M	4.9			
Peat/Organic Soil Sources	M	4.0	Breeding Area	L-	1.2
None	L+	2.8	Staging Area	L-	1.0
			None	H	7.6
			Terrestrial Wildlife		
			Bears	M-	3.8
			Moose	L+	3.0
			Small Fur Bearers	L+	2.9

COMPONENT		MEAN*
On Top of Mineral Resources		
Existing Open Pit	R	0.1
Existing Underground Pit	L^-	1.0
Planned Open Pit	R	0.1
Planned Underground Pit	L^-	1.1
Potential Areas (Geological)	L	1.4
Patented Claim Areas	L+	2.6
Non-Patented Claim Areas	M^-	4.2
None	H+	8.7
Forest Resources		
Sawmills	M	4.8
Paper Mills	L+	2.5
Licence Areas	M^-	3.7
None	M+	6.2
Air Quality		
Pollution Zone	L^-	0.6
No Air Pollution	H+	8.7
Snow Drifting		
Severe	L	2.0
Moderate	M+	5.8
Light	H^-	6.8
None	M	5.1
Snow Melt		
Slow Melt	L+	3.1
Moderate Melt	M+	5.4
Fast Melt	M^-	4.3
Existing Transportation		
Road	H^-	7.2
Rail	H^-	6.7
Airstrip (water)	H	7.7
Airstrip (land)	H^-	7.3
None	L	1.5

COMPONENT		MEAN*
Rare and Endangered Species		
Caribou	M	5.3
Bald Eagle	L^-	0.4
Osprey	L^-	1.2
Relict Populations	L^-	1.2
Forest Resources Areas	L^-	1.0
Wilderness Areas (Defined)	L^-	1.0
None	H+	8.6
Future Land Use		
Future Forest Cutting	L+	3.3
Future Mining Area	L^-	1.3
Future Mill	M^-	3.6
None		
Aesthetic Quality		
High	H	8.2
Moderate	M	5.0
Low	L	1.9
Employment Areas		
Existing	M+	5.7
Future	H+	8.4
None	L	1.0
Commercial Fishing Potential		
High	L+	2.8
Moderate	M^-	2.8
Low	M+	5.5
None	H^-	6.7
Land Ownership		
Crown	H	8.3
Private	M^-	4.1
Patented	M^-	4.1

COMPONENT		MEAN*
Existing Land Use		
Native Reserve	R	0
Native Settlement	L-	0.4
Native Trapline	L	2.1
Native Hunting Area	L+	2.8
Native Fishing Area	L+	2.6
Native Wild Rice Area	L-	0.5
Hunting Camp	M	4.8
Hunting Area	M	4.6
Fishing Camp	M	5.0
Fishing Area	M	5.0
Forest Area	M	5.2
None	H	8.2

COMPONENT		MEAN*
Proximity to Waste Disposal		
Existing Tailings	L	1.4
Existing Solid Waste	L+	2.5
Existing Sewage Effluent	L	1.6
Future Tailings	L-	0.7
Future Solid Waste	M-	4.0
Future Sewage Effluent	M	4.6

H - High
M - Medium
L - Low
R - Restricted Category

*All values are for illustrative purposes only and are not intended as actual data.

Source: Modified from The UMA Group, 1976, pp. 20-21.

The weight may be defined as a numerical value applied to each discipline as whole, not considering its component parts. The process is similar to that of the rating process and the subjective scale (Table III. 4) may also be applied.

Weighted rating is the product of the weighting and the rating. For example a participant examines the site, considering southern sun exposure which he feels is extremely desirable. He therefore gives it a rated value of 7.8 (Table III. 7). However he knows the site condition is only average and must therefore apply a weighted value of 4 (Table III. 4). The weighted rating for a southern exposure on this site is (7.8) (4) = 31.2. The process is repeated for each component being examined in the discipline. The total weighted rating is the sum of the individual weighted ratings. i.e.,

$$\text{Total Weighted Rating} = \sum_{i=1}^{n} R_i W_i$$

where n - number of components in the discipline

R_i = rating for component i

W_i = weighting for component i

Source: The UMA Group, 1976, pp. 11-12.

At best the system is a tool which must be used properly and therefore, if the system does not, in professional judgement, reflect the unique situation of a site, the participant remains responsible for altering the rating system until the system is as effective as humanly possible. In other words, the technique does not release the professional from responsibility for decisions made.

C. Discipline Evaluation

Components favoured for townsite development are selected from among the disciplines and which have a minimum established rating i.e., greater than 6.5* (Table III.7). For example, the maximum slope deemed desirable for development is 10% (rating 7.8), a southern sun exposure is preferable (rating 7.8), fine granular soil (rating 6.5) and tills rating (6.6) are preferred, and so on down the list.

Having selected components which fall above the minimum rating, the list may be further refined through dichotomization into "planning and engineering" and "environmental" disciplines (Table III.8). The analysis procedure is identical for each set of considerations, however, the planning and engineering concerns will be employed as an example.

Discipline evaluation is obtained through the processes of numerical value assignments as part of the rating process earlier described. Participants average comparative weights and mean weights for each discipline as shown in Table III.9.

To this point Delphi has been utilized to evaluate disciplines based upon engineering, planning and environmental criteria. The variance in numerical values (refer to Table III. 9) is an indication of those disciplines which bear a degree of relative importance in comparison of sites. Using this data to determine the ranking of engineering and planning disciplines the rank order is shown in Table III. 10.

*This minimum value is arbitrarily set after all values have been considered and group consensus has been reached upon acceptable minimum standards for a specific situation.

TABLE III. 8

DICHOTOMIZATION OF DISCIPLINES

PLANNING & ENGINEERING	ENVIRONMENTAL
Existing Land Use	Rare and Endangered Species
Surface Hydrology	Air Quality
Employment Areas	Forest Resources
Slope	Forest Vegetation
Surface Geology	Waterfowl
Existing Transportation	Terrestrial Wildlife
Future Land Use	Commercial Fishing Potential
Construction Materials	Climatic
Mineral Resources	
Aesthetic Quality	
Groundwater Table	
Land Ownership	
Groundwater	

Source: The UMA Group, 1976. pp. 34 & 52.

TABLE III. 9

DISCIPLINE EVALUATION*

Discipline	Mean Weights	Participant's Average Comparative Weights							
		1	2	3	4	5	6	7	8
Slope	.73	.53	.86	.61	.63	.67	1.22	.70	.60
Sun Exposure	.36	.23	.35	.31	.23	.49	.42	.48	.37
Surface Geology	.73	.72	.66	.61	.63	.67	.95	.70	.89
Construction Material	.68	.62	.66	.79	.47	.84	.55	.81	.70
Mineral Resources	.61	.43	.35	.88	.63	.67	.68	.48	.78
Surface Hydrology	.74	.72	.86	.51	.71	.75	.82	.70	.83
Groundwater Table	.58	.53	.76	.42	.47	.49	.55	.81	.61
Groundwater 50% Prob.	.47	.34	.46	.42	.63	.49	.28	.59	.57
Forest Vegetation	.51	.72	.35	.42	.39	.49	.55	.59	.53
Waterfowl	.46	.62	.35	.51	.63	.41	.42	.37	.39
Terrestrial Wildlife	.39	.48	.35	.17	.79	.41	.28	.26	.34
Rare and Endangered Species	.72	1.09	.66	.88	1.03	.49	.55	.48	.55
Forest Resources	.49	.43	.46	.88	0	.49	.42	.59	.68
Air Quality	.67	.72	.76	.61	.55	.67	.68	.70	.63
Snow Drift	.33	0	.56	.33	.23	.32	.42	.48	.33
Snow Melt	.18	0	.25	.24	0	.32	0	.37	.28
Existing Transportation	.71	.77	.56	.51	.79	.67	.82	.59	.93
Existing Land Use	.82	1.10	.46	.88	1.03	.93	.68	.48	.97
Future Land Use	.65	.43	.86	.70	.95	.67	.42	.48	.70
Aesthetic Quality	.63	.62	.97	.61	.39	.58	.68	.59	.56
Employment Areas	.76	.72	.35	.88	.87	1.01	.55	.81	.86
Commercial Fishing Potential	.35	.48	.35	.47	.23	.32	.42	.26	.29
Land Ownership	.47	.34	.46	.33	.39	.41	.42	.70	.71
Waste Disposal	.66	.72	.86	.78	.63	.32	.68	.59	.71

*All Values Are Hypothetical

Source: Modified from the UMA Group, 1976. p. 34.

TABLE III. 10

ENGINEERING & PLANNING DISCIPLINE RANKING

Discipline	Mean Weight	Normalized Weighting	Rank	Assigned Weight
1. Existing Land Use	.82	10.3	10	7
2. Employment Areas	.76	9.6	9	6
3. Surface Hydrology	.74	9.3	8	6
4. Slope	.73	9.2	7	6
5. Surface Geology	.73	9.2	7	6
6. Existing Transportation	.71	8.9	6	6
7. Construction Materials	.68	8.5	5	5
8. Future Land Use	.65	8.2	4	5
9. Mineral Resources	.61	7.7	3	4
10. Groundwater Table	.58	7.3	2	3
11. Land Ownership	.47	5.9	1	2
1]. Groundwater	.47	5.9	1	1
	7.95	100		

Source: Modified from The UMA Group, 1976, p. 34

D. Site Selection

The weighted rating procedure as outlined previously is applied to the process of site selection. Each site is rated on a scale of 1 to 9 for each discipline. Mean weighted values are normalized (Table III. 10) for each discipline and to each discipline a weight is assigned, the value of which is based upon group consensus (and rank order) as to relative discipline importance. The assigned weight reflects the contribution of the disciplines to overall engineering and planning evaluations. The weighted rating for each discipline for each site is then obtained using the normalized weighted value which is based upon the assigned weight. To obtain the ordination of the site the weighted rated values for each site are totalled, the higher values indicating the greatest suitability for townsite development. Table III. 11 indicates the results of the ordination process as applied to the 6 hypothetical sites designated in the beginning of this chapter.

From the weighted ratings it can be seen the range extends from 328 at the low end of the scale to a value of 628 at the high range of the scale (possible range 100 - 900).

The reliability of the ratings may be tested by drawing fewer disciplines (e.g., 4 or 5 out of the total 12) at random and applying the identical rating procedure. If an almost identical order of ranking occurs it may be assumed the data base is sufficiently reliable (The UMA Group 1976, p. 38-39).

TABLE III. 11

SITE ORDINATION

Discipline	Assigned Weight	Normalized Weighting		Alternative Site Ratings 1	2	3	4	5	6
1. Existing Land Use	7	12.3	x	3	3	5	5	6	2
2. Surface Hydrology	6	10.5	x	4	4	4	4	4	4
3. Employment Areas	6	10.5	x	3	4	4	3	7	5
4. Slope	6	10.5	x	4	4	7	4	6	7
5. Surface Geology	6	10.5	x	2	3	1	3	8	8
6. Existing Transportation	6	10.5	x	6	3	3	3	7	6
7. Future Land Use	5	8.8	x	2	3	3	2	6	3
8. Construction Materials	5	8.8	x	3	3	1	3	8	8
9. Mining Resources	4	7.0	x	4	4	4	4	4	6
10. Groundwater Table	3	5.3	x	1	4	4	3	7	5
11. Landownership	2	3.5	x	3	3	7	3	7	7
12. Groundwater	1	1.8	x	2	4	1	6	3	1
TOTALS	57	100.0		328*	346	376	350	628	536

*Values Rounded to Nearest Whole Number
Source: Modified from The UMA Group, 1976, p. 37.

Table III. 12 below illustrates the random check.

TABLE III. 12

ORDINATION BASED UPON RANDOMLY SELECTED DISCIPLINES

Discipline	Assigned Weight	Normalized Weighting		Alternative Site Ratings 1	2	3	4	5	6
Existing Land Use	7	25.0	x	3	3	5	5	6	2
Slope	6	21.4	x	4	4	7	4	6	7
Surface Geology	6	21.4	x	2	3	1	3	8	8
Construction Materials	5	17.9	x	3	3	1	3	8	8
Mining Resources	4	14.3	x	4	4	4	4	4	4
TOTALS	28	100.0		314*	336	371	336	650	600

*Values Rounded to the Nearest Whole Number.

Source: Modified from The UMA Group, 1976, p. 39.

Table III. 13 indicates the ordination of the six sites based upon data from Tables III. 11 and III. 12.

TABLE III. 13

SITE ORDINATION COMPARISON

Table III. 11 Sites	Table III. 12 (Random Check) Sites
5	5
6	6
3	4
4	3
2	2
1	1

Based upon the foregoing procedure site #5 is the most suitable for location of a townsite from an engineering and planning viewpoint. However the environmental evaluation must be considered if the process is to have any meaning so far as site selection is concerned in areas extremely sensitive to environmental impact.

To complete the process the environmental ranking is evaluated against the engineering and planning considerations. On this basis sites may fall into one of three categories: (1) sites favoured on ecological grounds; those having few environmental constraints; (2) sites favoured on ecological grounds but have some environmental constraints which could be mitigated by planning or design options; (3) sites which should be eliminated as possible townsites on the basis of environmental grounds unless planning or engineering aspects are so favourable as to offset the severe environmental constraints (The UMA Group, 1976, p. 49).

The categories into which each site falls can be determined by considering the total weighted ratings. The higher this value the more favourable the townsite location. However the number and type of constraints considered for each townsite must be considered as well. A site containing a number (e.g., 4-5) first order constraints (value 1) will not prove suitable for townsite location even though the rated weighting may place it in the second category. Such first order constraints may reflect known breeding habitat for rare and endangered animals, wildlife reserves, commercial fisheries, etc.

The process of site selection must therefore involve the human element of judgement, weighing the advantages and disadvantages of each potential site location in light of environmental and engineering constraints.

The advantages and disadvantages of each site are outlined in consideration of environmental and planning constraints and economic costs of development are analysed.

The final decision as to what site is selected is strictly a subjective decision in the sense that the selection will depend on what best suits the requirements of the entity responsible for the development of the site (e.g., a mining company and/or a Provincial Government). Trade offs will be made between environmental considerations, planning and engineering concerns and economic costs. The decision is a human function and is based upon knowledge of each site.

There is no guarantee that the final decision will be the "best" solution. The Delphi Process is simply a tool to supply information that would otherwise not come to light. It is an aide to decision-making; not the decision-maker per se.

CHAPTER IV

CONCLUDING REMARKS

Perhaps the most controversial environmental impact document of this decade, if not this century, has been the Berger Commission Report on the development of a proposed gas pipeline through Alaska and the Canadian North. Its implications are that if we do not heed the harsh lessons hopefully learned in the past concerning development in fragile northern environments the consequences may be an environmental disaster from which it would take centuries to recover.

The report, though its purpose and frame of reference were specific, echos the voice of environmentalists for decades past. Often there has been the lack of concern, lack of knowledge, lack of technology. Too often the result was a deplorable urban development thrust upon a fragile natural environment incapable of withstanding the impact.

I. EARLY RESOURCE COMMUNITIES

Perhaps nowhere to a greater degree were the consequences of this state reflected than in the early resource communities in the North. The early part of this century saw many boom town resource communities spring up in a haphazard fashion, heedless of environmental consequences. Such communities would become permanent, setting a pattern of development which exists to the present, while others were destined to become ghost towns as ore bodies became depleted or uneconomical to mine.

Of those communities which did survive perhaps the mining town of Flin Flon in northern Manitoba mirrors the remnants of the pioneer era when the only concern was to get the ore out of the ground, process it, market it, and let the town and natural environment take care of themselves.

The town, like many of its kind, had its beginnings in tents and shacks clustered around the head frame. Structures of a more permanent nature gradually replaced the earlier shelters but even these were spread at random over the landscape. Roads in many cases were constructed to serve what was little more than shacks erected on outcrops of shear rock and so the town took on a shape and form which exists to the present (refer to Figures II. 2 through II. 8, Chapter II).

To make matters worse the fumes from a smelter smoke stack constructed too low drifted over the community destroying vegetation and making gardens almost non-existent*.

The situation, from an environmental viewpoint, did not change drastically until approximately the mid 1950's when environmentalists began to realize natural resources were finite and conservation and resource management were becoming increasingly necessary. Attitudes about conservation were changing all over North America and some of these attitudes were beginning to be reflected in new town design in the north.

II. NEW TOWN DESIGN IN THE NORTH

Thompson, Manitoba** was certainly not the first community

*The author was a resident of that community for ten years. There were days when one could almost taste the sulphur fumes.

**The author spent three years in Thompson both as a student in high school and as an employee of the mining company.

of its type to be designed for a northern environment but it is not likely a deviation from other northern developments of the late 1950's and early 1960's.

The planned community was designed to minimize the effects of the mining industry which was not only buffered from the townsite by a mile of vegetation but was downwind as well thereby eliminating the effects of smelter smoke drifting over the town. In addition the smoke stack rose nearly a thousand feet into the air allowing superheated smoke to be dissipated in the upper atmosphere.

The townsite itself was designed with a commercial core accessible to a large degree only by a series of traffic loops. Services were all underground and there were no back lanes.

This latter aspect coupled with the design of the traffic loops proved to be a design fault when the community underwent an increase in traffic volume due to an unforeseen population explosion.

The loop system, absence of rear lanes and few connecting sidewalks forced both vehicle and pedestrian traffic to move over increased distances to a destination which if one could have travelled to in a straight line would have involved half the travel time. This created unpleasant conditions especially in the severity of a northern winter.

Though the site itself was selected after studies of vegetation, soil stability, water pollution, and geological surveys were conducted, the town was built in a location which would restrict expansion. The Burntwood River provided what was essentially north and west boundaries, with marshland on the southwest and the minesite on the southeast defining other limitations to expansion. However limited expansion of the site did occur to accommodate the population but the loop system of traffic arteries was maintained.

The overall result was a congested downtown core with difficult access. Other shopping areas had to be constructed but as they were not a part of the original development scheme space upon which to locate them became a problem and they may not have been located to the best advantage of the community they served.

Isolation is a factor to cope with in many northern developments and Thompson was no exception. Prior to construction of the highway the only means of access to the community was by air or rail. The airport was located approximately three miles beyond the town limits to minimize noise from low flying air traffic on runway approaches. Similarly the railway station was located approximately a mile and a half from the townsite for some reason unknown to the author. The result was that by whatever route one entered the community upon arrival one could not help but notice the vast expanse of wilderness and immediate sense of isolation. Perhaps some of the sense of isolation, at least initially, could have been reduced if the major transportation systems, the railroad in particular, had been integrated to a greater degree with the community.

Whatever the criticisms of this particular development, one who has experienced living in both Flin Flon and Thompson can not help but appreciate the attitudes, planning and effort that went into the development of Thompson in a serious attempt to ensure the deplorable environmental errors common to so many northern resource communities would not be repeated.

III. AN APPROACH TO THE FUTURE

The Leaf Rapids Development, being the most recent of the communities under discussion appears to have taken the lessons learned in Thompson one step further.

Leaf Rapids while compact in physical design with its multi-purpose commercial core essentially under one roof to facilitate protection from the elements merges with the natural environment. Figures II. 16 and II. 17 (Chapter II) shows a downtown core infiltrated by greenery from a natural environment creating a somewhat park-like atmosphere rather than what could have been a sterile urban environment open to the mercy of a hard winter.

Engineering design techniques for underground utilities ensured a minimum of problems developing from freezing water lines and water pollution.

The architecture of the commercial core has succeeded in creating an aesthetic indoor environment, multi-purpose in use (e.g., hotel can double as a hostpital in case of emergency).

Because the town is not yet large and has been designed to facilitate pedestrain and vehicle traffic flow to a far greater degree than the Thompson design, travel distances from place of residence to the commercial core are not excessive relative to climatic conditions.

Physical expansion of the townsite is possible should the situation dictate as there are no natural physical boundaries to restrict expansion other than the clearing of vegetation.

Whether or not Leaf Rapids will suffer ill effects of environmental impact remains to be seen. Johns (1973) points out the absence of a thorough environmental impact assessment prior to townsite selection. At this point in time the community is too new to thoroughly evaluate the pros and cons of the site selection and only with time will the results become evident.

IV. EVALUATION OF THE LAKE ST. JOSEPH PROJECT

Lake St. Joseph has been designed as what might be described as a "model" community in a northern environment. The success or failure of the development may conceivably be, in the final analysis, attributable to the adaptation and application of the Delphi Process to the initial stages of design. Unfortunately such an evaluation both of the community and the process per se will have to wait.

Extrinsic circumstances have led not to the shelving of the project, but to the indeterminate delay in development. To be brief and somewhat simplistic, taconite (low grade iron ore) is presently available in abundance and readily accessible in the Masebi Range in Minnesota and is less expensive to mine, than the richer deposits at Lake St. Joseph. However, additional factors further complicate this matter. The Canadian Pacific Railway has control of 50 percent of the potential development at Lake St. Joseph. The C.P.R. also owns the mills at the Lakehead where the ore would be processed, the trackage over which the raw and refined products would be shipped and the end users of the iron such as Dominion Bridge. In effect the CPR has a monopoly with legal sanction under Canadian law.

Because of the less expensive taconite ore being mined in Minnesota the Lake St. Joseph development can not economically compete. Even in the event that ore could be extracted and refined on a competitive basis neither the refined product or finished material could be sold in the United States because of the Sherman Anti-Trust Laws which prevent formulation and/or operation of monopolies in that country.

The Province of Ontario now requires environmental impact statements to be formulated prior to the operation of any industry which may have the potential of creating hazards to the natural environment. In light of this, the problems of operating competitively with U.S. operations, the U.S. anti-trust laws and the fact that the C.P.R. owns and operates more economically, iron ore mines of comparative grade with the Lake St. Joseph deposits, in South America, Australia, and Mexico the Lake St. Joseph development will remain as a proposal until such time as the Canadian Pacific Railway feels the necessity of developing the mining operation there*.

V. APPROACHES TO DECISION-MAKING

Decision-making for the purposes herein may be defined as the process by which individuals, either singularly or collectively, arrive at a conclusion to a predetermined problem. Obviously one can not,

*The information obtained in an interview with Mr. Brophy, Area Planner, Underwood McLellan and Associates Limited, August 22, 1977.

within reason, evaluate each and every model or analyze each piece of literature ever written on the subject. Rather it is more appropriate for the purposes of this thesis to draw general comparisons between the Delphi Technique and other approaches to decision-making rather than to specific types and models.

For the purposes of this discussion approaches to decision-making have been limited to one or a combination of the following:

(1) Decision by a single individual based upon his experience and knowledge.

(2) Group discussion (a group for the purposes herein being two or more individuals) in which knowledge is pooled in an attempt to limit error and arrive at some degree of consensus.

(3) Computer Analysis involving a machine being pre-programmed to analyze given data in a logical sequence to a final conclusion. Information input of course must be achieved by either (1) or (2) of the above.

A. Decision By A Single Individual

For some purposes and depending upon the situation this may be a perfectly acceptable means of dealing with a specific problem at hand. It is not, however, acceptable in dealing with multi-faceted, highly complex problems such as environmental impact assessments. The single human being simply is not likely capable of acquiring, understanding, storing, and analyzing all relevant data relating to highly complex problems, while arriving at judgment free from personal biases and error due to insufficient knowledge and data. The more complex the problem the less desirable it may become to employ a single person to make a decision where the solution may have a wide spread detrimental effect.*

There is also the possibility of valid contradictory expert opinion.

B. Group Decision-Making

Group decision-making, of which the particular adaptation of the Delphi Technique** employed in this thesis is a part, is potentially superior to decision-making by a single individual insofar as decisions to problems of a more complex nature are concerned.

1. Groups Other Than Delphi

The basic concept employed in group decision-making is that two heads are better than one.

The reliability of the group decision depends to a large extent upon the degree of expertise of group members. However, on the assumption that members of the panel or group are acknowledged experts,

*In terms of a complex problem being solved by a single individual the argument here is that what must be considered is the final solution and its potential effect upon an entire population. For instance, one could spend ten years arriving at a solution to a complex mathematical formula the answer to which may be purely academic. However in instances where such a formula may be the computation for a decision as to whether or not to employ an element potentially harmful to an environment, and that decision must be reached within a relatively short time period, a single individual, without the aid of pre-programmed knowledge i.e., the employment of a computer, could not be expected to arrive at the correct solution. In such a case the probability of making the wrong judgement would likely increase with the number of criteria to be considered.

**The aspects of Delphi as applied to this document will be dealt with under a separate heading.

there still exists a possibility that an erroneous decision may be made, though the probability would likely decrease with an increase in the number of panelists (to a manageable limited - e.g., 10-12) while maintaining the same degree of problem complexity.

An element of discussion groups is that there is often no statistical control of information input or data feedback. Group consensus may be forced by one or two individuals who are more eloquent, loquacious, or simply shout louder than other group members.

If group discussion is to proceed in an orderly fashion to achieve a desired goal group leadership is essential. Regardless of the method of deciding who should lead the group there always exists the inherent danger that the leader may unintentionally bias group opinion through enforcement of his authority.

Lack of statistical feedback and built in biases may result in the group not adequately discussing specific aspects of the problem and/or overemphasizing matters which may not be relatively important issues. It is not recommended, therefore, that such groups be organized to deal with multi-faceted, complex problems especially where such problems concern potentially dangerous environmental impact.

2. Conventional Delphi and Questionnaire Surveys

The one big problem facing the conventional Delphi process and similar methods of data gathering and analysis involving survey questionnaires is the problem of interpretation.

Allowing for the fact that a pre-test may be able to determine the reliability of the questions per se it is almost impossible to ensure that each individual responding to a particular question will interpret that question in exactly the same way. Perhaps an even greater problem in interpretation may occur concerning statistical analysis (particularly in the case of open ended questions) of the questionnaires. The data, without opportunity for feedback, discussion and response by respondents, becomes a collection of individual opinions subjected to analysis by a single individual who may inadvertently manipulate the data. Admittedly such manipulation may be controlled to a greater degree by employment of closed-end questions. This type of question, however, is not suited to complex issues requiring a high degree of discussion.

3. Employment of Computer Analysis in Decision-Making

Computer analysis should not be categorized or classified as "Group Decision-Making" per se. Computers are simply tools, programmed to analyze input data in a specific manner. They are not intended in the decision-making process to provide the ultimate answer; data feedback is intended only as information on which the decision of the individual or group may be based.

4. The Delphi Technique

The prime component in environmental relationships is the natural environment for it is the starting point and to a large extent the determining factor shaping what is to follow. Past development practices in northern communities have shown little concern for the welfare of the Canadian north. The environment has been polluted in a number of manners from a variety of sources and unless we learn to manage the natural environment we will continue its destruction and along with it one of the key elements essential to northern community living.

Community environments and particularly those associated with northern living create complexities which can not possibly be understood by a single individual and dealt with effectively. Planning is a process which requires specific inputs from knowledgeable individuals. If this information is to be properly applied with the intention of creating improved community environments, advanced and sophisticated processing methods will have to be employed. Environments are suited to an individual's needs and desires and not all people can live in all environments and so it is with northern communities. No matter how attractive a northern community is made in terms of physical design there will always be those who simply do not desire to live in the north, because northern living in any form does not meet their daily needs and desires. In the opinion of the author people living in northern environments or people who would be attracted to such environments have similar daily requirements. They may not enjoy the rat race of concentrated urban living and therefore seek a life style which offers a slower pace, where they can get out and enjoy nature, or hunt, fish, go boating or whatever. They may become tired of the social structure, status and demands common of larger centers in southern regions and may prefer a community in which social status is not of any great consequence and people are more open and friendly. Whatever the reason, they will choose a northern community because it offers them the type of environment they find satisfying.

Additionally there are those who would live in the north almost regardless of physical aesthetics and amenities.

Because of these differences, criteria for townsite selection will undoubtedly vary according to the specifics of location, reason for development and the needs of the community inhabitants.

It may be noted that the decision tools can be the key factor in the planning process. Because of the capabilities and versatility of these tools they are of unmeasureable help in determining the specific criteria which must be considered for a specific development. However their limitations must be recognized in the fact that they are not intended nor were they designed for the purpose of generating the ultimate plan. They are simply decision-making tools which are subjective to the extent that they depend for their input upon human judgement based on specific knowledge and opinions. The final decision is and must be left to human judgement and reason.

Such planning techniques provide no guarantee that the decisions made will be the "best" or "correct" ones.

Future northern communities will depend for their survival upon a host of people with specialized knowledge and with different interests and backgrounds. The question of success in northern development lies in the ability of these people to provide communities with amenities, building types and systems as yet unrealized in northern development and which will exist in harmony with the natural environment. Mistakes have been made even in most recent years but we must learn from our mistakes and proceed with the thought in mind that future communities will be as pleasing and comfortable and inviting as technology will allow.

a. Advantages of the Delphi Technique

The Delphi Technique employed in the planning process is intended to reduce the risk of rejecting important criteria and increase the probability that additional factors will be considered which might not otherwise come to the attention of those involved in the decision-making process.

The mechanics of establishing initial criteria for discussion are varied but the common denominator is that these criteria are established by multiple expert opinion rather than by a single individual. Multiple expert opinion also has the advantage in that it determines the degree and relevance of a particular datum in relationship to total requirements through computer analyzed feedback.

Computer feedback is to all intents and purposes, immediate, and not usually common to other approaches in decision-making. Feedback of this nature allows for subsequent discussion on matters which appear to be deviant opinions. The opinions, though deviant, may not necessarily be irrelevant, and continuing discussion on these matters allows for consideration of data which at first glance may not have appeared to be important but which after further analysis may prove worthy of consideration.

Unlike more "conventional" groups the Delphi Process employing computer analysis and feedback does not require a group leader. Criteria for discussion are established during initial discussion stages with in depth consideration during subsequent discussion stages. There is therefore no leader to force his authority or arbitrate disagreement between group members and thus bias group consensus. All that is required is simply a person to gather information, feed it into the computer and report information to the group which embarks upon further discussion based upon the data analysis.

Anonymous written responses during the course of the first round eliminates influence of an individual's response by other members of the group. In this manner there is some assurance that opinions expressed are of an individual nature based upon an individual's personal knowledge and background, and not partially the result of some other opinion.

During subsequent rounds of open discussion there is the opportunity for panelists to exchange ideas and opinions. Group discussion therefore becomes a learning experience for each member and an opportunity to hear and evaluate the opinion of others.

Given the opportunity to establish criteria, express a personal evaluation of that criteria, and involvement in group discussion group consensus will emerge through convergence of opinion rather than be arrived at through intentional or unintentional manipulation of statistical data by a single individual be he acting on his own behalf or that of a group from which he has drawn opinions.

b. Limitations of the Delphi Technique and Possible Solutions

The most obvious limitations of this type of Delphi application are (1) the possibility of inadequate* (not necessarily

*meaning insufficient in number and scope.

unreliable) questions in the first and subsequent rounds and (2) the problem of choosing experts.

Perhaps it is better to deal with the latter problem first as the choice of experts may conceivably affect, if not the number of criteria, the nature of the criteria established.

There is some danger in allowing the project co-ordinator* to select the panel of experts in that there is the potential of biasing the panel through selecting or not selecting members on the co-ordinators opinion of merit of an individual's knowledge and experience. There is also the possibility that potential members may be overlooked simply because they are unknown to the co-ordinator. There is also the possibility of a panelist being eliminated because of a personality clash between himself and the co-ordinator.

In order to avoid this type of biasing it would be more appropriate for the co-ordinator to select a number of experts in varied disciplines relevant to the problem, explain the nature and purpose of Delphi, and ask them for their recommendations as to panel members. The final selection, would of course remain the responsibility of the project co-ordinator, and although there is still a risk of bias, the risk would be reduced considerably.

Further, it may be noted that it is not necessary to select the panel of experts from the tranditional pool of practicing professionals and classic academics. In fact it would be advantageous to include knowledgeable laymen with first hand experience in a particular

*The project co-ordinator at no time actively participates in discussions and therefore is in no manner conceived as a group leader.

subject field.

Once the panelists have been selected there is the problem as to how to determine initial criteria. Again this should not solely be at the discretion of the project co-ordinator, although criteria may be suggested on the basis of his background, experience, and library research.

There are a number of possible methods which may be employed to select initial criteria.

- by panelist themselves in a pre-Delphi discussion
- by panelists during the first round of the Delphi Process per se
- by experts in the role of consultants but not participating directly in group discussion
- by a combination of the above.

Depending upon the problem at hand, a combination may be the most likely method as it offers the widest range possible of obtaining criteria thereby reducing the risk of overlooking important data.

There is the problem, as there is with any group, that there may be a forced consensus due to one or more group members influencing the rest of the group for reasons previously discussed. Although there is this recognized risk it may be somewhat reduced by employing more than one expert from each discipline on the panel. The opinion of the other expert could then be consulted as to whether or not the opinion being voiced is valid.

This latter aspect of including a number of participants from each discipline in the group would also reduce the risk of bias due to attrition of selected group members not being able to attend the discussion.

One of the basic reasons for group attrition may be due to the fact that group participants often have demanding responsibilities and if not properly compensated for their costly time and expenses are not willing to participate in the discussions.

Depending upon the objectives of a particular Delphi application there will be some questions as to whether or not the costs warrant its employment. Costs can not be really discussed here in that there will be no uniformity between one application and another. Determinants of costs will depend greatly upon the number of panelists selected, their discipline, their experience, travelling distance and duration of the discussions. Delphi should not be considered for purposes where costs of application far exceed any benefits to be gained. However, where there is a question as to far reaching implications and unknown effects of processes still not fully understood the application of the Delphi Technique could well be worth the money spent.

The Delphi Technique is not without its inherent biases and technical problems and it is in no respect intended as the final solution. Regardless of decisions reached, human judgement and common sense must prevail without which there would be little justification in attempting to reach a practical compromise to the problems.

In the application of the Delphi Technique to environmental problems perhaps all we can expect is compromise as solutions may be non-existent or so impractical their implementation would be totally an impossibility.

VI: RECOMMENDATIONS

Of major concern to this thesis has been the effects of impact of urban development upon northern natural environments and the potential of a modified Delphi Technique in minimizing some of the undesirable effects of that impact.

Over the course of the last few decades man has become increasingly aware of the consequences of tampering with and altering the natural environment. In some instances the effects have been immediately visible and some damage repairable. However, environmental impact on a large scale, such as that which occurs as a result of urban development in fragile environments, is likely to be severe with long lasting and often unknown side effects if care is not taken to minimize the impact wherever possible.

The employment of Delphi in the final analysis may prove to be insufficient and inefficient as a data analyzing tool, especially in light of the increasing sophistication of computer technology. Whatever the tool used in the process of analysis there must be recognition of the requirements of the natural environment to survive and the awareness of man's dependency upon that very environment for his own survival.

In conclusion, the following general recommendations may be considered in the process of future development in the Canadian Northland:

A. Primary Recommendations

(1) Consideration be given to the employment of a sophisticated data analyzing tool capable of processing all known facts relevant to the problem.

(2) All known sources of relevant data be thoroughly explored during the data gathering phase and methods be derived to expand the data base wherever feasible.

(3) In instances where the analyzing tool being employed involves human judgement* the decision-makers come from a sufficient number of varied disciplines to adequately deal with the data at hand, allowing for attrition of participants.

(4) Aspects of the natural environment considered must also include wildlife and their requirements as well as the physical features such as vegetation, rock, outcrop, soil stability, etc. This would necessitate an examination and consideration of eco-systems including climatic effects.

(5) Communities be planned to allow for future expansion. Expansion should be limited, however, to a point where it is expected that additional growth of the community would seriously damage the natural environment. The alternative would therefore be a limited growth policy favouring several smaller developments over a single large metropolis.

*It is conceivable at some point in the future total analysis and decision-making could be accomplished by a highly sophisticated computer requiring little or no human input.

(6) Consideration be given to the employment of two or more types of decision-making tools in those instances where it is recognized that it would be beneficial and feasible to employ a combination rather than separate methods (e.g., use of a Delphi Technique to establish criteria coupled with computer mapping techniques similar to that suggested by Johns, (1973).

B. Secondary Recommendations

In developing a specific site the following be considered:

(1) As much of the natural vegetation as possible be retained within the immediate townsite so as to give the community a park-like appearance.

(2) A buffer zone of natural vegetation between the townsite and heavy industrial sites should be maintained to provide a visual barrier between the two sites.

(3) The industrial site should be selected prior to selection and location of the townsite.

(4) The townsite should be located such that it receives no ill effects of pollutants from the industrial processes. This usually requires the townsite to be located upwind and upstream from the industrial location.

(5) The townsite should be located in such a manner as to maximize the potential of scenic vistas. Rolling terrain, local lakes and rivers, and natural vegetation can do much to enhance the aesthetic value of the community.

(6) The infrastructure (roads and utility installations) should be designed keeping in mind local climatic conditions. Road layouts should maximize traffic flow and minimize travel time and distance.

(7) The architecture of both residential and commercial units should maximize the living and working environment to the greatest degree possible in consideration of the isolation and the climate.

(8) Wherever feasible major transportation routes and systems serving the community from other regions should be integrated with the community. This would provide a visual link with the outside and hopefully thereby reduce the sense of isolation.

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*The supplementary readings are intended as a source of additional relevant information but do not appear as direct references in the thesis text.