THE COSTS AND BENEFITS OF ENVIRONMENTALLY SOUND PLANNING PRACTICES

Planning
Collaborative
Inc.

PART V REPORT

THE COSTS AND BENEFITS

OF

ENVIRONMENTALLY SOUND PLANNING PRACTICES

A Report to

Central Mortgage and Housing Corporation

National Office, Ottawa

Prepared by:

Planning Collaborative Inc.

The Environmental Applications Group Ltd.

Toronto, March, 1979

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31 March, 1979

Mr. David Crenna
Policy Development Division
National Office
Central Mortgage and Housing Corporation
Montreal Road
OTTAWA, Ontario
K1A 0P6

Dear Mr. Crenna:

Re: Final Report
Costs and Benefits of Environmentally Sound Planning Practices

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We enclose 10 copies of the Final Report for the above study, together with the original manuscript.

The project has benefitted from the comments and assistance of many persons, whose contributions are gratefully acknowledged. We have enjoyed working on this assignment, and trust that the results will be both productive and useful for all those who are concerned with improving the quality of the urban environment in Canada.

Yours sincerely,

PLANNING COLLABORATIVE INC.

Thomas E. Martin

Thomas E. Martin, MRAIC, MCIP
President

TEM:js
encl.

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TABLE OF CONTENTS

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A. INTRODUCTION

"In nature, everything is connected to everything else."

Biologists have long noted that nature's web is a mass of cycles within cycles, and chains of interlocking and interdependent relationships. In instances where these relationships are not fully considered or understood, human interventions may be detrimental to natural systems.

There are many examples of problems created by development practices which do not complement the natural environment, or make the best use of site potentials. The costs of such interventions can be described both in terms of loss or damage to the environmental components themselves - water, air, soil, vegetation; and in terms of on-site and off-site development costs and operating costs for transportation, energy, and municipal services. Such costs are borne in varying degrees by inidividual homeowners, developers and contractors, and government authorities. However, in a climate of economic restraint, all of these groups are less willing to bear the expense of living with, or mitigating, the results of insensitive development. Nor can the natural environment indefinitely sustain losses in quality or productivity.

The objective of "environmental planning" is to ensure that development does not harm natural systems, and the pages that follow describe a set of emerging environmentally sensitive planning and development practices which have been effective in residential development projects across Canada and the United States. The report highlights the usefulness of these practices in dealing with typically encountered environmental conditions and process, particularly in terms of their economic costs and benefits to the development industry. Responses are also developed for some of the very specific environmental conditions encountered in different "ecological planning regions" across Canada.

There are no formal cost-benefit analyses in the report. These are effective only for specific projects, and the technique itself is extremely sensitive to the discount (interest) rate used to compare alternatives. In addition, many environmental and social costs and benefits are not quantifiable or expressable in universally accepted terms.

The reader is also cautioned that the "natural environment" is only one of the environments or contexts (others being social, economic, and political) in which development takes place. This report is therefore necessarily selective in illustrating only certain environmental conditions and development practices. Professional advice should be sought when dealing with the particular conditions of a specific site or project.

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B. SUMMARY: THE ENVIRONMENTAL PERSPECTIVE

Environmentally sensitive planning and development emphasizes the application of ecological principles and information to urban development, and is one mechanism for harmonizing and making compatible, the interrelationships between urban development and thos characteristics of the land which are of critical importance for human use and well-being.

Such ecological or environmental concerns can be introduced and integrated into the development process in two ways:

1. within the planning process; that is, by expanding the capability to deal with ecological information;

2. within the development project;in adaptations and responses to specific environmental conditions, both while the project is under construction, once it is completed and in use.

The importance of the first area – that is, the integration of ecological information into the planning process, derives from recurring problems such as development in inappropriate areas (for example, unstable or flood-prone sites), unsuitable forms of development (such as rural (non-farm) residential) which result in high servicing costs or health hazards, and the mismanagement of land resources. Examples of the latter include the loss of non-renewable resources, resulting from the urbanization of prime agricultural lands, wetlands, and gravel deposits; the pollution of soil and water; and the competition among different land uses (such as wildlife refuges vs. oil and gas exploration, or residential development.).

Environmental degradation has often been particularly severe in Canada's northern resource communities, with damage to tundra, sensitive vegetation, and thin soil mantles, as well as severe drainage and sewage disposal problems.

Each of these issues rarely affects only one land resource; often several are impacted at one time. For example, a wetland which becomes the site for landfill and development can also mean the loss of a unique vegetation community, a waterfowl habitat, an educational site, and a natural holding area for surface runoff.

To deal with such complex and interrelated ecological issues, Wiken (1978) has suggested that the linkages between development and the land environment be highlighted in the planning process:

> "The properties associated with any given parcel of land imparts certain limitations and opportunities for its use. This applies to both human activities such as obtaining agricultural crops or stable building sites and to non-human activities such as maintaining natural waterfowl habitats or wilderness reserves. Once this land versus activity relationship is understood, this knowledge can

> assist in determining compatible and rational use of the land. This notion has broadened the traditional conceptual models for comprehensive land planning. Besides calling for a firm grasp of social, economic, judicial, and political factors, many current models stress that planning decisions should also account for environmental factors."

Thus, the "environmental" component of the development planning process can present ecological information in ways which enable more informed land use deicsions to be made; in particular, highlighting the value of the environmental resources affected by development.

At a broad conceptual planning level, the mapping of environmental factors is used primarily for determining suitable locations for development. This "general constraint mapping" is particularly important in certain regions of Canada such as the Boreal Forest/Canadian Shield, where the number and quality of development sites are severely limited. A comprehensive analysis of geotechnical conditions may be necessary to avoid excessive construction costs and future problems such as foundation settlement and frost heave.

This basic level of analysis concentrates on geotechnical factors (for example, soil type, drainage, bearing, slope, permeability, etc.) which affect engineering and foundation costs. With municipal cost/revenue data added, this kind of analysis can be used to cost and compare alternative patterns of growth for urban areas, in terms of their public servicing costs (as has been done in Thunder Bay).

For a broader perspective, biotic (living) components of the land (such as wildlife, vegetation, and aquatic resources) and cultural (human) resources such as archaeological sites and historic buildings, are analysed as well as the abiotic (non-living) components. This ensures that the significant components of the landscape are retained, and other lands, more suitable for development, are those actually developed.

The Resources Analysis Branch of the British Columbia Ministry of the Environment has extended the interpretation of ecological information to develop suitability ratings both for non-urban uses such as forestry, agriculture recreation, and wildlife, and for urban activities such as low buildings with and without basements, landfill, roads and parking, playground and recreational facilities.

A further elaboration, Development Impact Zoning, assesses the overall impacts of a development project, including its effects on natural systems, public services, and municipal finances, against benefits such as taxes and social mix. The mix and form of the development can be related not only to the natural carrying capacity of the site, but also to the community's social, cultural, and financial context.

The costs of including ecological (biophysical) information in the development planning process are relatively modest (from $2.50 to $10.00/ha at a map scale of 1:25,000, depending on the degree of interpretation), although the normal process may be lengthened somewhat by this analysis phase. However, the payoffs in benefits such as the avoidance of major difficulties (for example, flood damage or land slippage) and the value of environmental resources which are retained from development, are substantial. (As an example, benefit/cost ratios of 100:1 or more have been reported for large scale urban soil surveys in the United States. (Case Study)).

The importance of the second area, development and construction practices which respond to specific environmental conditions, comes into play after the appropriate locations for development have been determined. These adaptations focus on ensuring a compatible "fit" between the project and its environmental context, so as to:

- mitigate potentially negative impacts
- save on development costs (both capital and operating)
- improve project amenity.

The essence of "ecological" site development is to do as little to the land as possible, retaining existing vegetation and drainage patterns for project benefit. Working with the terrain in siting housing and roads can minimize cut and fill excavation costs, as well as future hazards such as erosion or land slippage. The difference between good and marginal terrain conditions can be as much as 100% for subdivision (servicing, roads, and grading) costs. Other terrain adaptations use the insulating and sheltering qualities of the earth for energy conservation and summer cooling.

Another set of development practices deals with storm water and the runoff problems created by development and increased impervious surfaces. A number of innovative practices have been developed, each suitable for different climatic, terrain, and soil conditions, but basically they all work to approximate the pre-development water flow ("hydrograph") characteristics as closely as possible. This is done by maximizing the infiltration of water into the soil, and intercepting and directing runoff; by holding it on-site temporarily or permanently, as appropriate.

Storm water management techniques, when applied on a project by project basis and co-ordinated over a regional watershed, have great potential for reducing on-site development costs, and creating new amenity features such as recreational lakes, around which projects can be designed and marketed. Recent American and Canadian studies indicate that the use of natural storm water drainage together with modified engineering standards could save as much as $1,000 to $2,000/unit over conventional development practices. The potential savings on downstream watercourse construction (such as dams, impoundments, and stream channelization) are even more significant.

Development adaptations to climate are receiving increased interest due to concerns about energy conservation. Significant energy savings (as high as 10 to 15%) appear to be possible by the sensitive handling of building orientation and design to maximize solar insolation, minimize heat losses and wind effects, and by the use of vegetation for micro-climatic shelter (so-called "passive solar design").

Vegetation as well has a role in erosion and drainage control, in reducing wind velocities and snowdrifting, and can add significantly to a project's amenity and sales appeal, particularly if existing mature trees are retained wherever possible. Projects in which tree identification andvegetation preservation have been practiced during construction have received payoffs in increased lot prices (as high as $500 to $2,000), and reduced landscaping costs (as much as $\$2.00/m^2$).

Another area of environmental planning and development gives special attention to Construction Practices, since it is at this time when much erosion, sedimentation, and loss of topsoil can occur. In fact, construction sites have a higher potential for causing erosion than virtually any other major land activity. Measures to maintain vegetation, minimize earthmoving and soil exposure, can be useful as well as specific techniques to retain, divert, or slow the runoff which does occur from a construction site.

The costs of these practices are more than compensated by savings on the repair of gullying and erosion damage, and the loss of topsoil from the construction site.

Another developing area of environmental management deals with Environmentally Sensitive Areas such as streams, wetlands and recharge areas, woodlands and hillsides, and shorelines. Very often such areas are difficult or costly to build on in any case, but it is not generally realized that they also serve vital functions such as the removal of pollutants or moderation of floods, which are rather expensive to provide if natural functions are interrupted.

The equilibrium of steep slopes can be easily upset by construction, resulting in property damage and losses from soil erosion and land slippage. Also, hillsides (such as the foothills around Calgary) often constitute one of a city's major scenic resources, which can be destroyed by indiscriminate development.

Most such areas should be identified and witheld from development as a result of the planning process. While there are costs with such policies; in development rights foregone, and ongoing protection and maintenance costs, these are generally outweighed by benefits such as watershed protection, avoidance of excessive construction and servicing costs (if development were to be permitted on Environmentally Sensitive Areas), and the educational, touristic, and recreational values of the resources themselves.

In spite of the demonstrated potential of environmentally sound planning and development practices, there are still many constraints to their implementation in Canada. These include concerns in the development industry about the costs of environmental approvals, the costs of the practices themselves, and the loss of development potential if environmental resources are retained and not developed; the insistence of local authorities on overly restrictive planning and engineering standards which preclude innovation; and consumer resistance to natural "unfinished" site development and non-traditional housing design. These can be addressed by a number of means: such as information (for example, manuals on environmentally appropriate practices, and their costs and benefits), by institutional changes (for example, innovative zoning, performance-oriented standards, and agency co-ordination), and by marketing which stresses to housing consumers, the merits of a lower cost, higher quality, ecologically compatible, urban environment. Hopefully this report will be one of the steps in the process of overcoming these constraints.

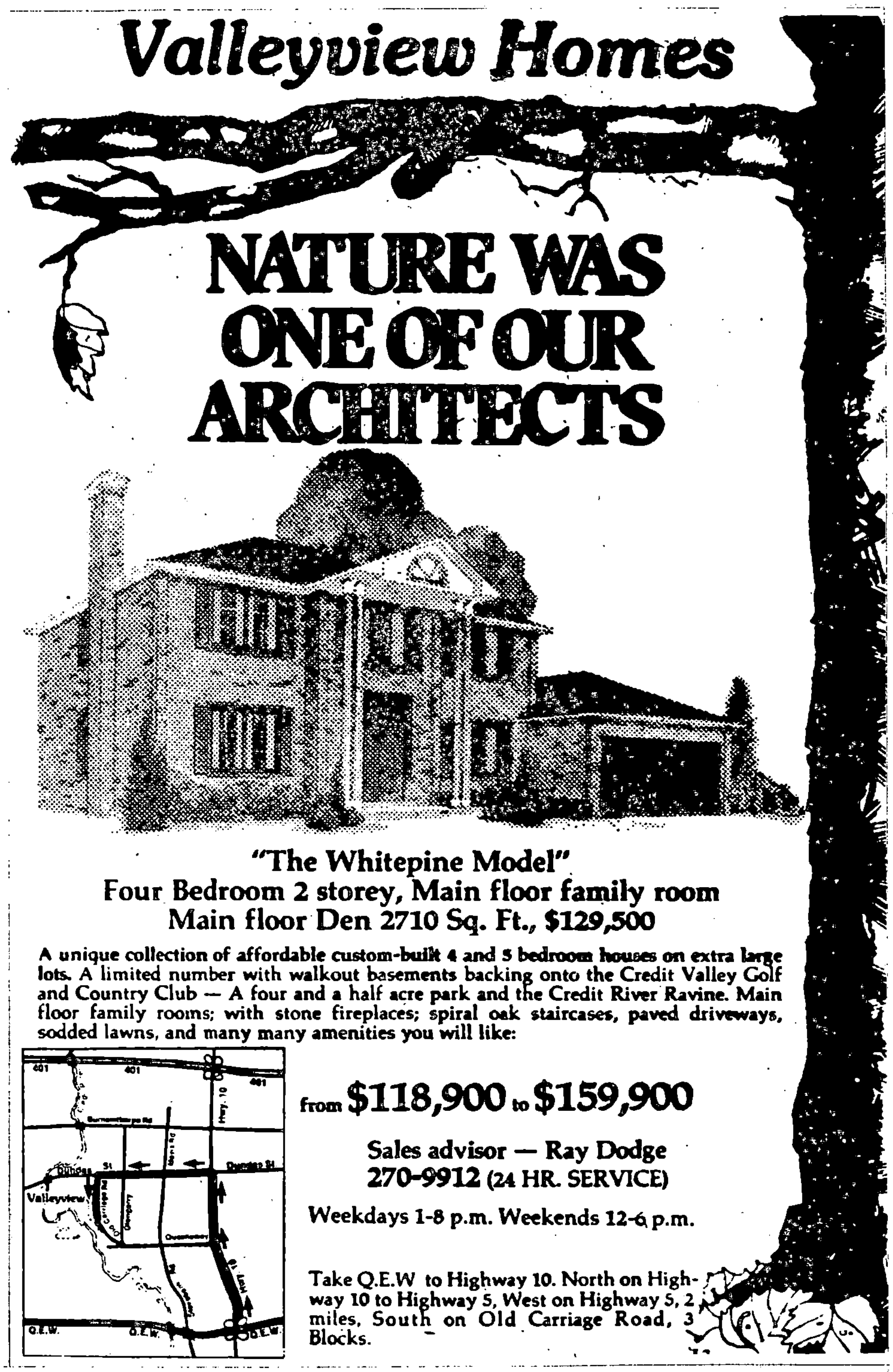


Figure 1: The Right Slogans, but the Wrong Ideas.

C. THE PLANNING PROCESS

Planning in any field is an anticipatory activity in which the potential consequences or impacts of a decision are assessed beforehand, so as to determine which is the most beneficial course of action to undertake. The range of environmental factors being considered in development planning has been steadily expanding in recent years. This is partly the result of increasing public awareness that human settlements are both affected by environmental resources such as land, water, air, flora and fauna, and in turn exert major impacts on these same resources. When these effects or impacts are adverse, problems ranging from basement flooding to air and water pollution, and human suffering or loss of life, can occur. Correcting such problems after land has been committed to development can be extremely difficult or costly, while anticipating and dealing with potential environmental impacts within the planning process is generally very economical and cost-effective.

Post-war development projects in which the characteristics of the natural environmental context have not been considered, have often resulted in severe problems and damage to property, resources, and human activities. Some of these are:

- Development on unstable or flood-prone lands

  Ontario: In 1954, Hurricane Hazel caused more than $75,000,000 in property damages, and more than 80 deaths, in and around Metropolitan Toronto, much of it in the Humber River valley floodplain where housing had been permitted. Much of downtown Galt (Cambridge) is built on the Grand River floodplain, and a 1974 flood caused more than $7,000,000 in damages to structures (not including business losses in addition).

  Throughout Ontario, about 6 to 7% of the total land area in urban municipalities of more than 5,000 population is presently considered floodplain, and approximately 1/3 of this urban floodplain is developed. (Ontario Ministry of Natural Resources, 1977) Potential damages in a developed residential area without floodplain zoning or protection could range as high as $44,000/ha in a flood as strong as Hurricane Hazel.

  Parts of Vanier, a community adjacent to Ottawa, have been built on an extensive peat bog, with severe foundation settlement problems common throughout the area.

  Quebec: In St. Jean Vianney, a 1971 landslide in the town resulted in the destruction of 43 buildings and the loss of 31 lives.

  New Brunswick: A 1973 spring flood in the St. John River basin caused property damage totalling more than $11,000,000. A major reason for this level of flood damage was the gradual encroachment of urban development into floodplain lands.

- Rural residential development

Many urban centres in Canada (notably Winnipeg, Calgary, and Toronto) have widespread and scattered estate residential development on 1 to 5 ha lots at distances 30 to 50 km out from the city centres. While this rural non-farm population is small in numbers, it is one of the fastest growing population sectors in Canada. The effects of such development are two-fold:

Loss of resource lands

Canada permanently loses more than 17 250 ha (Manning & McQuaig, 1977) of high capability agricultural lands to development or to the limbo between agriculture and development, each year. The problem was particularly acute in British Columbia, with the loss of 3 900 ha of farmland annually, until the passage of the Land Commission Act in 1973.

In southwestern Ontario, the municipalities of St. Catherines and Niagara Falls are attempting to extend their urban boundaries, potentially resulting in the loss of 3 050 ha of unique tender fruit lands, together with another 6 275 ha of general farmlands.

While the loss of 17 250 ha may not seem large in comparison with Canada's productive agricultural land reserves of 119 000 000 ha of land having agricutural potential (69 000 000 of which are currently farmed), more than 53.5% of Canada's Class 1 agricultural lands are within an 80 km radius of the country's 22 largest urban centres, and are therefore particularly vulnerable. These urban-related fringe areas also contain 28.6% of Canada's Class 2 lands and nearly 20% of its Class 3 lands (Manning & McQuaig, 1977).

These losses are even more amplified than the straight conversion of agricultural lands to other uses would indicate: one study (Winnipeg Region Study Committee, 1974) noted that a rural non-farm residential density of only 3.5 residences/km^2 starts to interfere with, and fragment agricultural production units, in a region whose area is 80% in high capability agricultural lands.

Servicing difficulties and costs

One analysis (Lombard North Group, 1975) of rural residential development north east of Winnipeg indicated severe difficulties with septic tank failures, groundwater pollution, poor drainage, and high servicing costs. For example, electrical service costs, telephone service, water, sewer, and fire insurance costs were up to $500/lot/year higher than in Winnipeg.

The costs to rural townships with small populations and large land areas to service scattered non-farm development have, in some cases, completely outstripped the resulting tax increases. Over 60% of the municipal budgets for some small communities with substantial amounts of estate residential development west of Calgary, goes to road-related costs such as snow removal, road maintenance, and school bussing. Per capita public works expenditures in some rural townships are more than 7 times those in Calgary; operating expenses more than double (Calgary Regional Planning Commission, 1976).

- Resource Communities

  The development of northern resource communities in Canada has frequently been carried out without regard for the fragile ecologies and harsh climatic settings in which many of them must be located. The potential for environmental degradation is particularly severe: thin soil mantles are sensitive and susceptible to damage, vegetation is hampered by short growing seasons and long winters, drainage and sewage disposal are often hindered by rock, muskeg, and permafrost.

Such problems serve to re-iterate again and again, that recent settlement planning has often failed both to respect natural environmental resources or to develop community forms compatible with their environmental settings. Considering the diversity and complexity of these difficulties, it is clear that development planning must be carried out in a more comprehensive and holistic manner than it has in the recent past. In particular, the need for ecological inputs in planning, especially an integrative approach which builds on many disciplines, has been recognized by several authors (Hills, 1974 and Dorney, 1977). Wiken (1978) has summarized these inputs in a planning flowchart (Figure 2) which emphasizes the ecological dimension, but does not suggest that other inputs to the process are any less important.

For the land developer, the primary purpose and value of ecological inputs to the planning process lies in determining environmentally appropriate locations for development. As mentioned above, this has two aspects: avoiding major development problems, and protecting significant or sensitive environmental resources.

While Figure 2 represents the full range and potential complexity of ecological inputs, there can be varying degrees of sophistication or detail in environmental assessment, depending on the severity of environmental condition, or the size of the proposed development. These degrees can be represented as levels of increasing analysis or interpretation of an environmental data base:

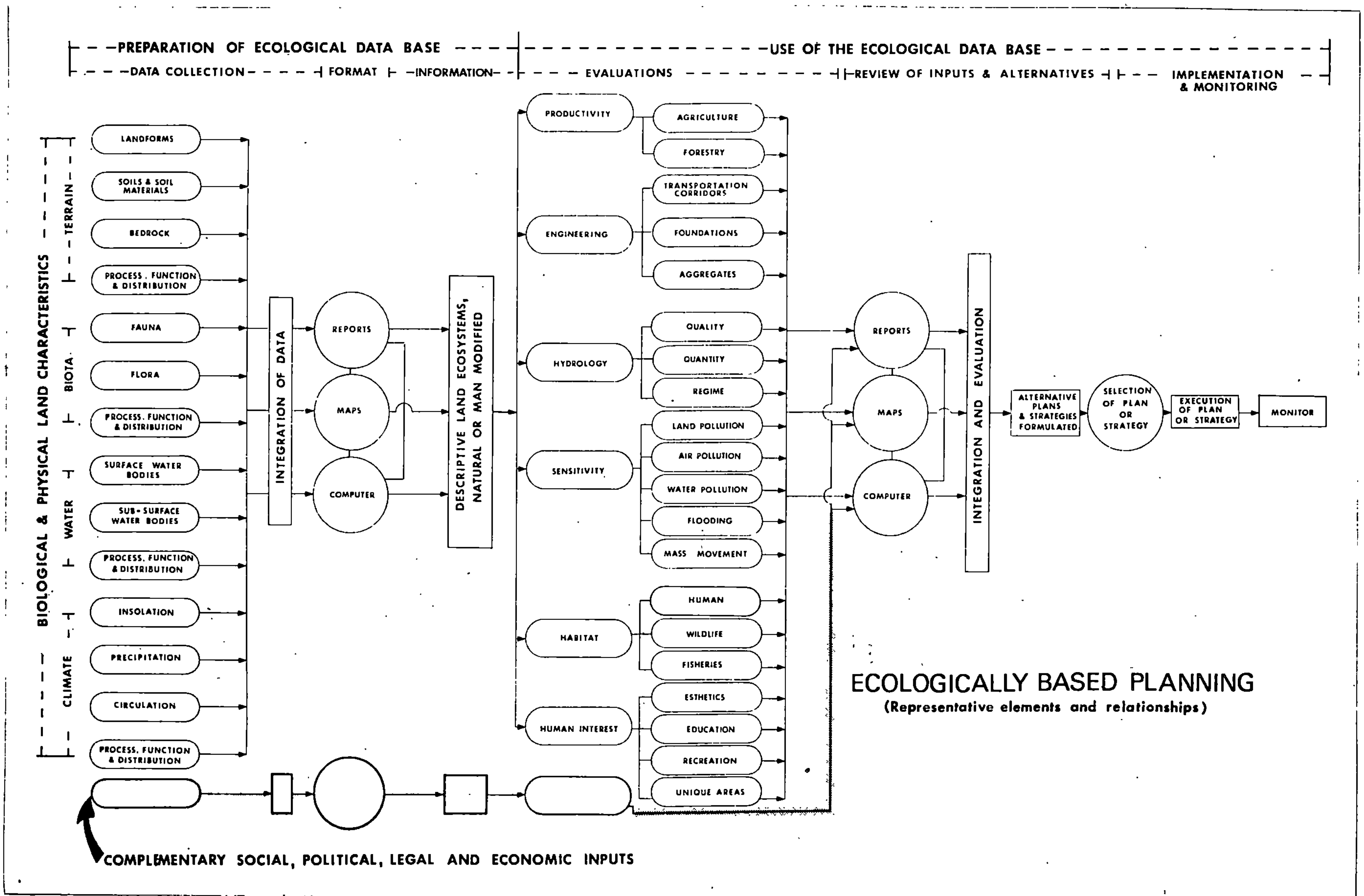
- Level 1: General Constraint Mapping
  (no-build zones: hazard and unstable lands, floodplains, etc.; geotechnical considerations for construction and services)

- Level 2: Constraint ("ABC") Mapping
  (abiotic, biotic, and cultural determinants to define a "development envelope")

- Level 3: Comprehensive Suitability Mapping
  (for a variety of urban uses and environmental conditions)

- Level 4: Development Impact Zoning
  (Relates the scale and form of a development project to the capabilities of the land, people, and financial resources in a community)

Figure 2
Source: Wiken (1978)



Level 1: General Constraint Mapping

While most developers and planners are familiar with soil surveys, there is relatively little experience in Canada with more complex geotechnical analyses covering a large developing urban region. One example of a geotechnical terrain analysis for a large area was completed recently in Thunder Bay, where much of the surrounding region has severe physical constraints to development, common to Boreal Forest/Canadian Shield conditions. These include:

- shallow bedrock
- high ground water table
- slope instability
- excavation difficulty
- low foundation bearing
- erosion potential.

The first level of analysis (costing approximately $1.00/ha) identified constraints for planning (Figure 3) including bedrock (exposed or shallow cover) and drainage; and constraints for services, including bedrock (high costs), muskeg (high to moderate cost premiums), dewatering (moderate cost premiums) and soil with some rock as boulders or outcroppings (low to moderate cost premiums). Mineral soils with no rock were assessed as having normal servicing costs.

A second more detailed level of analysis (costing approximately $14.00/ha) rated each characteristic for development, scaled as directly (linearly) as possible to costs (0 = minor or no constraint, to 9 = severe constraint). The mapping of cost or difficulty constraints for each terrain factor could then be related to the requirements of any proposed activity (for example: apartments require high bearing capacity for deep footings; other uses may need less bearing capacity for shallow footings). Activities with high land values can afford to pay more to overcome terrain conditions, and are not necessarily excluded from an area by virtue of the conditions per se.

Foundation costs are only a small percentage of total development costs (usually less than 5%) and therefore it takes really significant cost increases or decreases in this area to affect overall project costs. However, for underground services, both on-site and off-site, terrain conditions can have a very major influence on costs, particularly through peat, sand, or clay soils.

This work has since been elaborated in a series of cost-revenue analyses (City of Thunder Bay, 1978) by local municipal officials. In one such study, a growth option which extended development by incremental subdivis-

Corporation Of City Of Thunder Bay

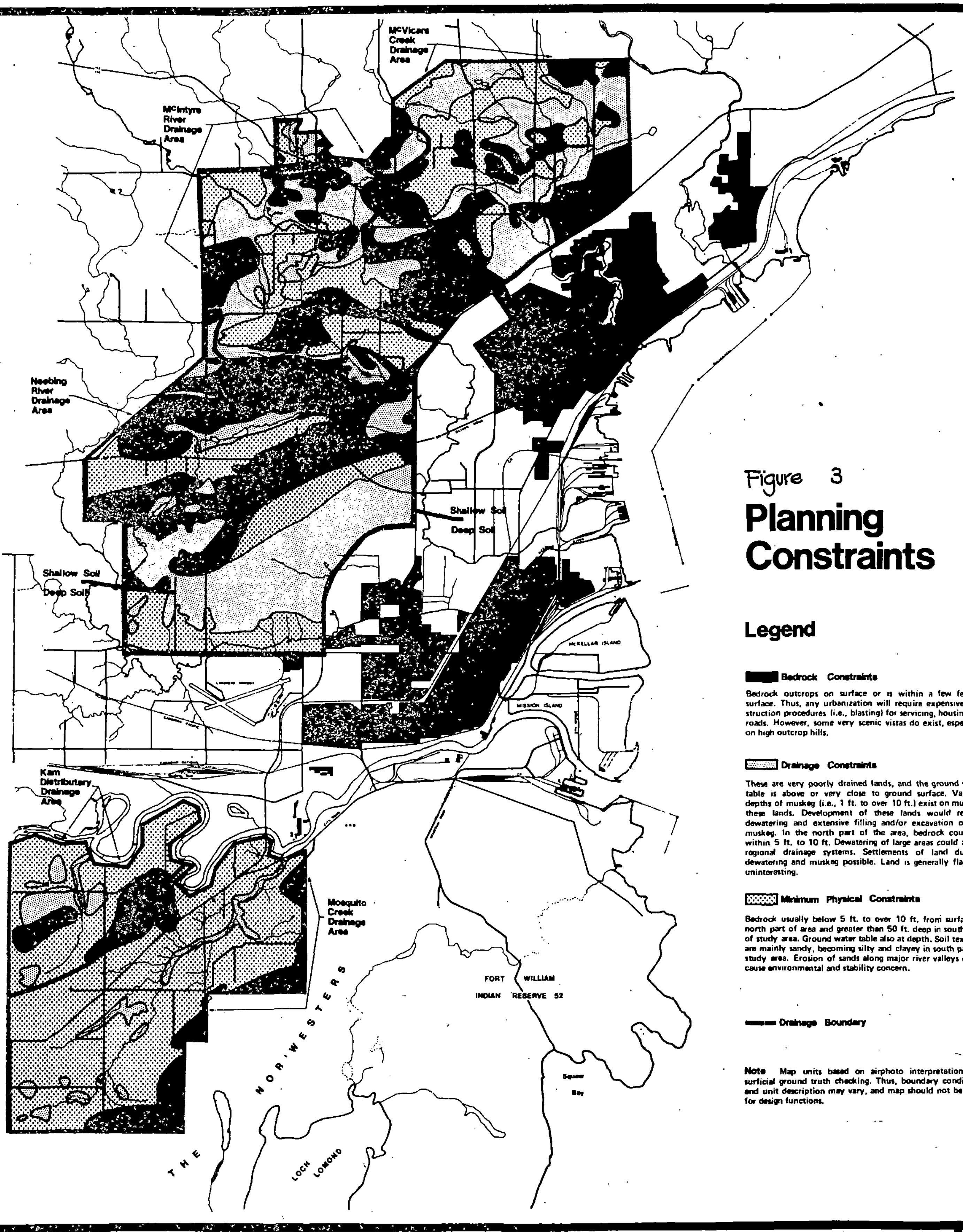


Figure 3

Planning Constraints

Legend

Bedrock Constraints

Bedrock outcrops on surface or is within a few feet of surface. Thus, any urbanization will require expensive construction procedures (i.e., blasting) for servicing, housing and roads. However, some very scenic vistas do exist, especially on high outcrop hills.

Drainage Constraints

These are very poorly drained lands, and the ground water table is above or very close to ground surface. Variable depths of muskeg (i.e., 1 ft. to over 10 ft.) exist on much of these lands. Development of these lands would require dewatering and extensive filling and/or excavation of the muskeg. In the north part of the area, bedrock could be within 5 ft. to 10 ft. Dewatering of large areas could affect regional drainage systems. Settlements of land due to dewatering and muskeg possible. Land is generally flat and uninteresting.

Minimum Physical Constraints

Bedrock usually below 5 ft. to over 10 ft. from surface in north part of area and greater than 50 ft. deep in south part of study area. Ground water table also at depth. Soil textures are mainly sandy, becoming silty and clayey in south part of study area. Erosion of sands along major river valleys could cause environmental and stability concern.

Drainage Boundary

Note Map units based on airphoto interpretation and surficial ground truth checking. Thus, boundary conditions and unit description may vary, and map should not be used for design functions.

ions on the fringes of the city, much of it over poor terrain conditions and requiring major additions to existing trunk services, was found to cost $15 to $20 million more in long term infrastructure costs, over an option which directed growth to Parkdale, an outlying area of 610 ha, with good terrain conditions. The City Council recently approved development of the Parkdale area, even though some major front-end servicing costs have to be absorbed in the early stages of development.

Level 2: Constraint ("ABC") Mapping

This form of biophysical land surveys differs from more general constraint mapping in terms of the broader number of factors included in the analysis, rather than in the degree of interpretation given to the data. Analyses of this kind have been done for both the North Pickering and Townsend new community projects in southern Ontario, as inputs to conceptual land use planning. The biophysical land survey for Townsend, termed "ABC" Mapping by its author (Dorney, 1978) includes:

- Abiotic Constraints (non-living) such as hazard lands and floodplains, areas of poor drainage, high water table, and shallow overburden (Figure 4 illustrates one such map from the Townsend project).
- Biotic Constraints such as water quality, woodlots, wildlife and aquatic resources
- Cultural and Historical Constraints such as archaeological sites and historical buildings.

These factors are then combined into a Development Envelope (Figure 5) which indicates not only the best areas for development, but also areas to be protected (such as woodlots), as well as watershed and floodplain boundaries.

The benefits of this kind of analysis are that it identifies the most easily developed lands with minimal cost premiums to the developer, identifies potential economic resources such as sand and gravel, avoids site hazard lands with accompanying structural cost premiums, repairs, and failures often associated with development on such lands, and retains the agricultural production base (as in both North Pickering and Townsend).

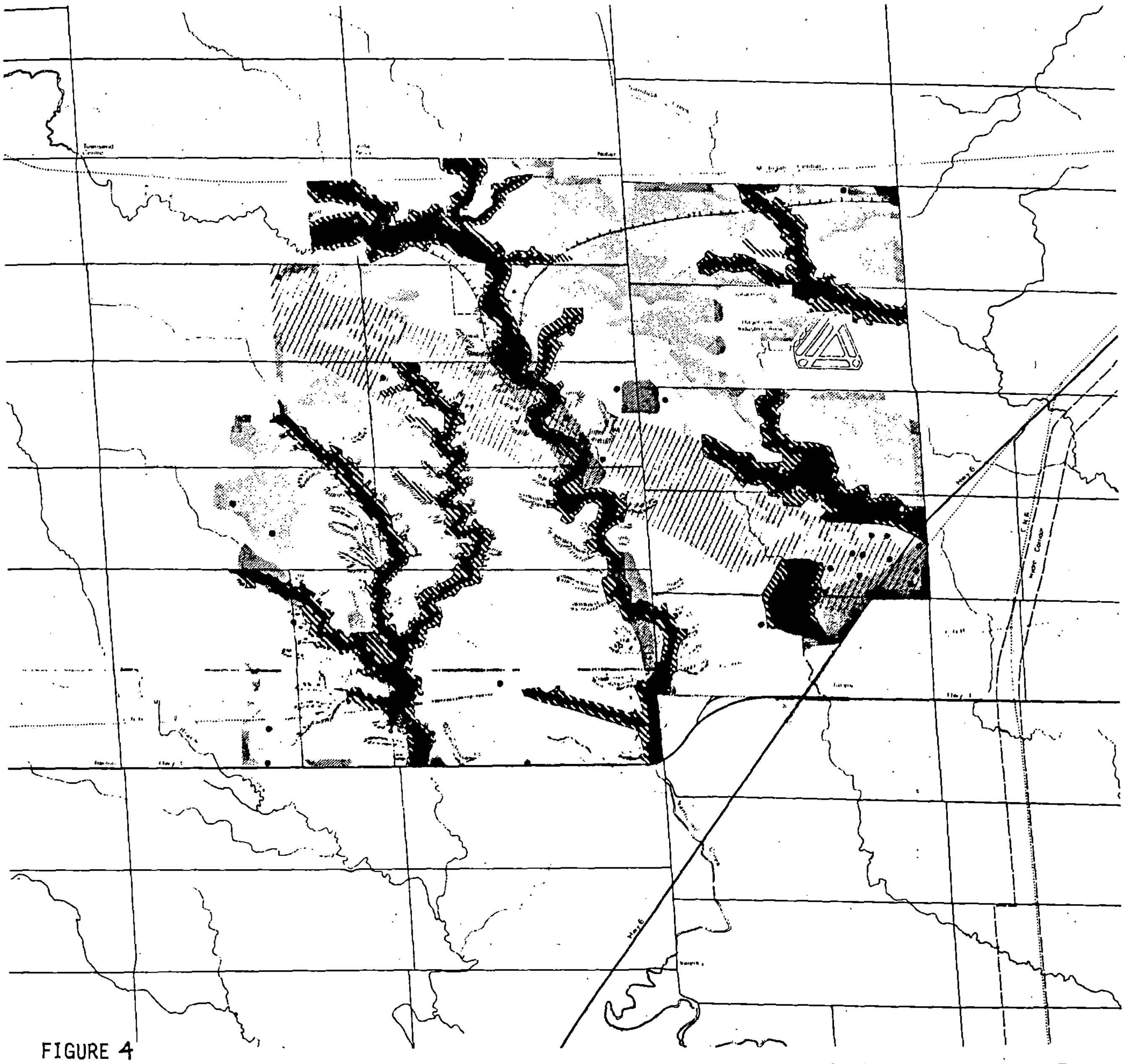


FIGURE 4

Abiotic Constraints for Development

- Flood Plain (Incomplete Data)
- Fill Line (Incomplete Data)
- Shallow Overburden (Less than 5m. to Bedrock)
- Poorly Drained Soils (>50% of Area)
- Steep Slopes (More than 9%)
- Other Areas Liable to Seasonal Flooding
- Zone of Possible Bedrock Sinks
- Gypsum Bearing Formation <30m. from Surface
- Gas Wells
- Poorly Drained Soils (20% to 50% of Area)

Source: Dillon, MNR, ESP and Dr. Chesworth

100 Hectares | 100 Acres

1 KM

1 MI

Date Sept. 76

TOWNSEND

COMMUNITY DEVELOPMENT PROGRAM

Ministry of Housing

Ontario

Source: Llewelyn-Davies Weeks Ltd. et al., 1976

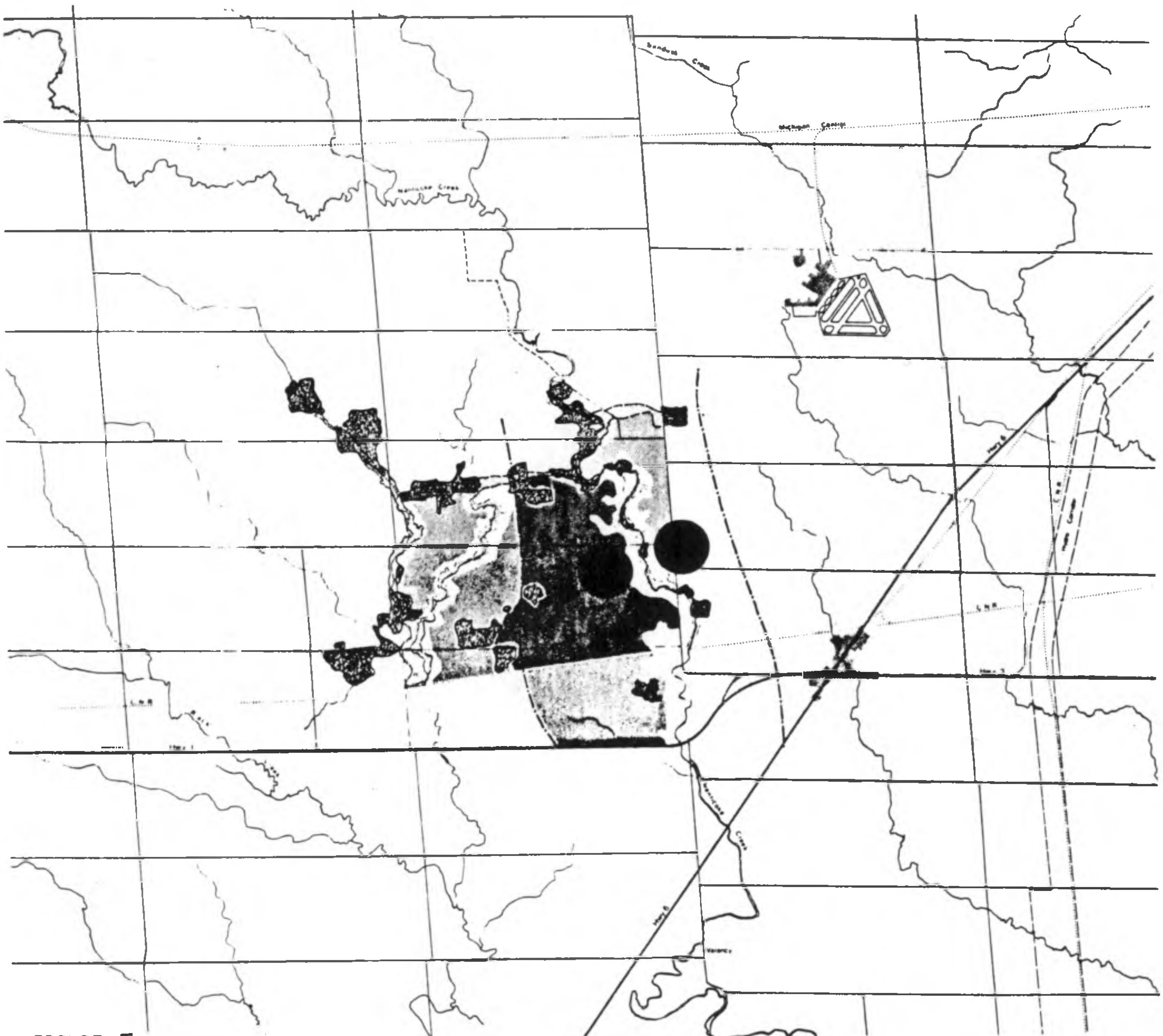


FIGURE 5

Recommended Development Envelope

Phase 1: 20000 Population (1986)

- Confirmed Areas for Development
- Possible Areas Requiring Study
- Possible Locations for Regional Centre
- Flood Plain with Fill Line
- Woodlots
- Watershed Boundary

100 Hectares
100 Acres
1 KM
1 MI

Date April 78

TOWNSEND

COMMUNITY DEVELOPMENT PROGRAM

Source: Llewelyn-Davies Weeks Ltd. et al., 1976

Level 3: Comprehensive Suitability Mapping

A further level of detail and interpretation is added by comprehensive suitability mapping, the use of which has been pioneered by the Resource Analysis Branch of the British Columbia Ministry of the Environment, for various projects in the interior of the Province, such as townsite selection for the North East and South East Coal developments, or the Lower Arrow Lakes Resettlement Plan (occasioned by the flooding of settlement areas by the Mica Creek dam - Figure 6). (Resource Analysis Branch, 1977)

The three- part analysis includes:

(1) An initial screening of suitable sites from the sector under study, based on generalized criteria. These include climate, location, elevation, access, availability of land, and overall topography.

(2) From a small set of suitable areas, more detailed terrain data is collected, including:

- geotechnical analysis (soils, depth to bedrock and water table, texture, drainage, slope, etc.)
- related factors such as micro-climate, vegetation, wildlife, recreation, heritage, visual and aquatic resources.

(3) A set of interpretations for selected urban uses such as

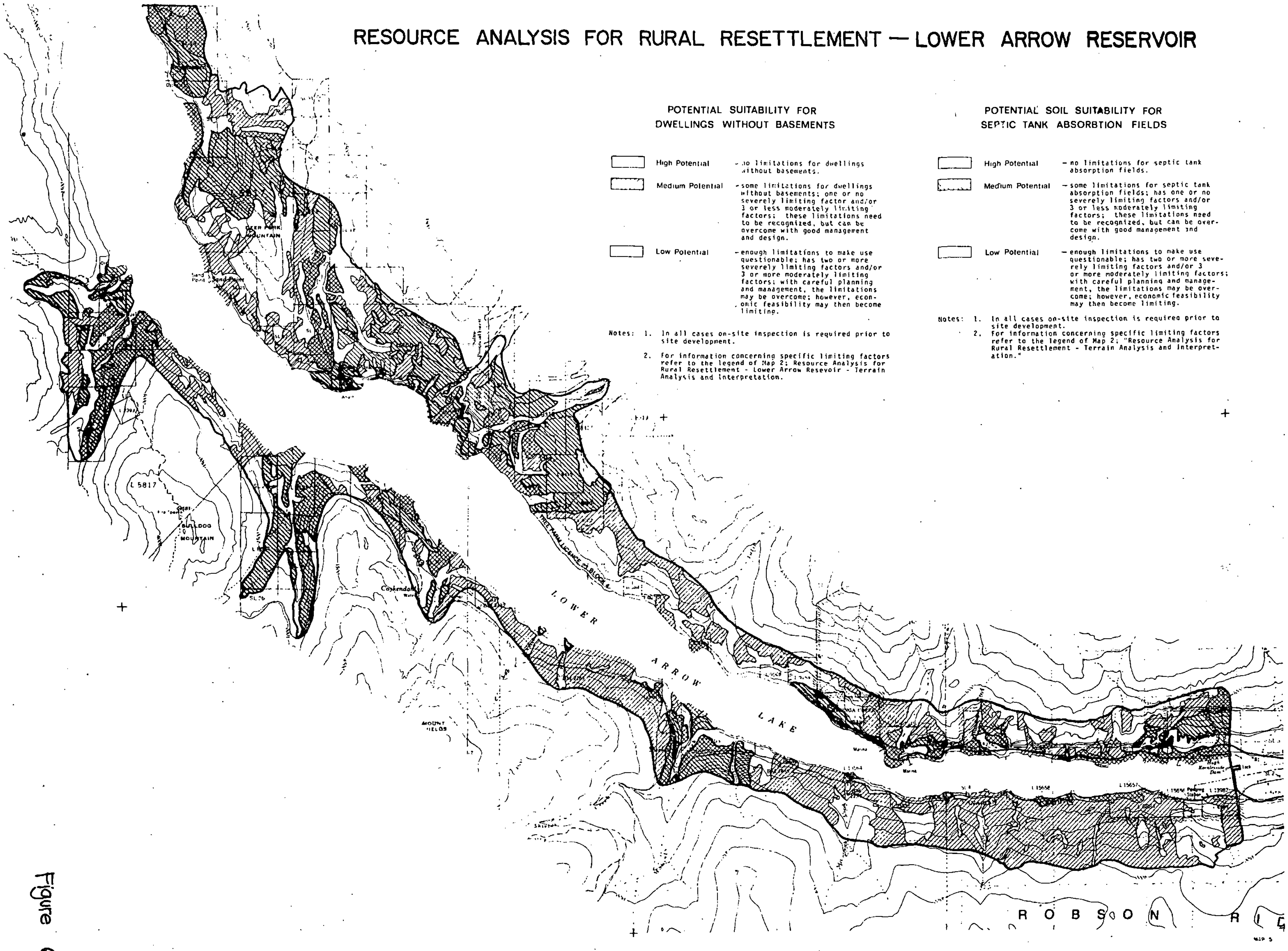
- low buildings with and without basements
- septic tile beds
- roads and parking
- sanitary landfill
- reservoirs and sewage lagoons
- playgrounds and recreational facilities;

for the use of materials for top soil; sand and gravel for construction; and for soil erosion and mass movement.

In some cases, interpretations have also been done for wildlife, forestry, agriculture, and recreation, with the overlapping maps indicating potential management opportunities, or development vs. resource conflicts.

The "high medium low" suitability interpretations (Figure 7) have inherent cost implications, but these must be verified with on-site visits and testing. Basically then, this is a "fail-safe" level of analysis, intended to avoid serious development problems such as land slippage or drainage, or resource conflicts.

RESOURCE ANALYSIS FOR RURAL RESETTLEMENT — LOWER ARROW RESERVOIR



POTENTIAL SUITABILITY FOR DWELLINGS WITHOUT BASEMENTS

- **High Potential** – no limitations for dwellings without basements.
- **Medium Potential** – some limitations for dwellings without basements; one or no severely limiting factor and/or 3 or less moderately limiting factors; these limitations need to be recognized, but can be overcome with good management and design.
- **Low Potential** – enough limitations to make use questionable; has two or more severely limiting factors and/or 3 or more moderately limiting factors; with careful planning and management, the limitations may be overcome; however, economic feasibility may then become limiting.

Notes:
1. In all cases on-site inspection is required prior to site development.
2. For information concerning specific limiting factors refer to the legend of Map 2; Resource Analysis for Rural Resettlement - Lower Arrow Resevoir - Terrain Analysis and Interpretation.

POTENTIAL SOIL SUITABILITY FOR SEPTIC TANK ABSORBTION FIELDS

- **High Potential** – no limitations for septic tank absorption fields.
- **Medium Potential** – some limitations for septic tank absorption fields; has one or no severely limiting factors and/or 3 or less moderately limiting factors; these limitations need to be recognized, but can be overcome with good management and design.
- **Low Potential** – enough limitations to make use questionable; has two or more severely limiting factors and/or 3 or more moderately limiting factors; with careful planning and management, the limitations may be overcome; however, economic feasibility may then become limiting.

Notes:
1. In all cases on-site inspection is required prior to site development.
2. For information concerning specific limiting factors refer to the legend of Map 2; "Resource Analysis for Rural Resettlement - Terrain Analysis and Interpretation."

Figure 6

Figure 7

****The <u>HIGH MEDIUM LOW SYSTEM</u>. Used to Rate Terrain Units for Various Interpretations Related to Urban Suitability Potential

LIMITING FACTORS

1) high water table
2) flood hazard
3) perviousness (rapid or slow) class
4) soil drainage class
5) slope
6) stoniness (10 inches +)
7) rockiness class
8) textural limitation
9) frost heave susceptability
10) shallow depth to bedrock or impervious layer
11) unsuitable overburden
12) ground water contamination hazard
13) surface soil erosion hazard
14) mass movement hazard (including snow avalanches)
15) clay characteristics
16) salinity
17) organic matter content
18) deposit depth
19) soil reaction (pH)
20) thickness of Ah horizon
21) possible shrink swell potential
22) bedrock type
23) coarse fragment content (3 to 10 inches)
24) evidence of previous slope and surface instability

H HIGH POTENTIAL - no limitations for the specific use interpretation.

$M_{\#}^{\#}$ MEDIUM POTENTIAL
- severe Limiting Factor #, 1 or none (super-scripted).
- some limitations for the specific use interpretations; these limitations need to be recognized, but can be overcome with good management and design.
- moderate Limiting Factor #, 3 or less (subscripted).

$L_{\#}^{\#}$ LOW POTENTIAL
- severely Limiting Factor #, 2 or more alone (super-scripted)
- enough limitations to make use questionable. However, with careful planning and management, the limitations may be overcome, but economic feasibility may then become limiting.
- moderate Limiting Factor #, 3 or more alone (sub-scripted).

EXAMPLE: $L_2^{5,4}$ This represents a terrain unit having a selected use severely limited by slope and drainage, and having moderate limitations due to flood hazard.

Whether a Limiting Factor is considered Moderate or Severe for a selected interpretation is based largely on specific criteria given in the report, which is based on U.S. Department of Agriculture publication <u>Guide to Interpreting Engineering Uses of Soils</u>.

As not all Limiting Factors can be equated, some are given more weight for specific interpretations. This can either increase or decrease potential use for the unit.

Suitability interpretations are more flexible than constraint analysis since the ratings allow some leeway in land use allocation: uses with high land values may be able to pay to overcome terrain limitations. However, the "Low Potential" rating acts as a constraint since it virtually precludes most development uses. Often suitability for roads or services is more critical than suitability for buildings; roads are constrained by slopes or the availability of aggregates, services by the depth to bedrock or water table (both instances in which there may be economical building design solutions).

A more complex study, also by the Resource Analysis Branch, elaborates on site selection factors for a resource community of 5,500 to 10,000 population (depending on the amount of coal to be extracted) in North East British Columbia (British Columbia Government, 1977). Critical factors in the site selection included:

- commuting distance to mine sites*
- centrality in the region; access to transportation corridors*
- adequate land for urban purposes (8 km^2 +)*
- closeness to airport site
- water supply and sewage treatment costs (capital and operating) for housing and mining
- biophysical features (climate, fire hazard potential, vegetation cover & aesthetics, local outdoor recreational opportunities)
- impacts on fisheries and wildlife
- availability of resource materials (especially gravel) for construction
- siting, slope, aspect, sunlight exposure
- elevation constraint (not greater than 1 000 m)
- inversion avoidance
- well-drained, non-organic soils
- water supply and receiving water for sewage disposal
- horizontal separation of townsite and coal mining operations.

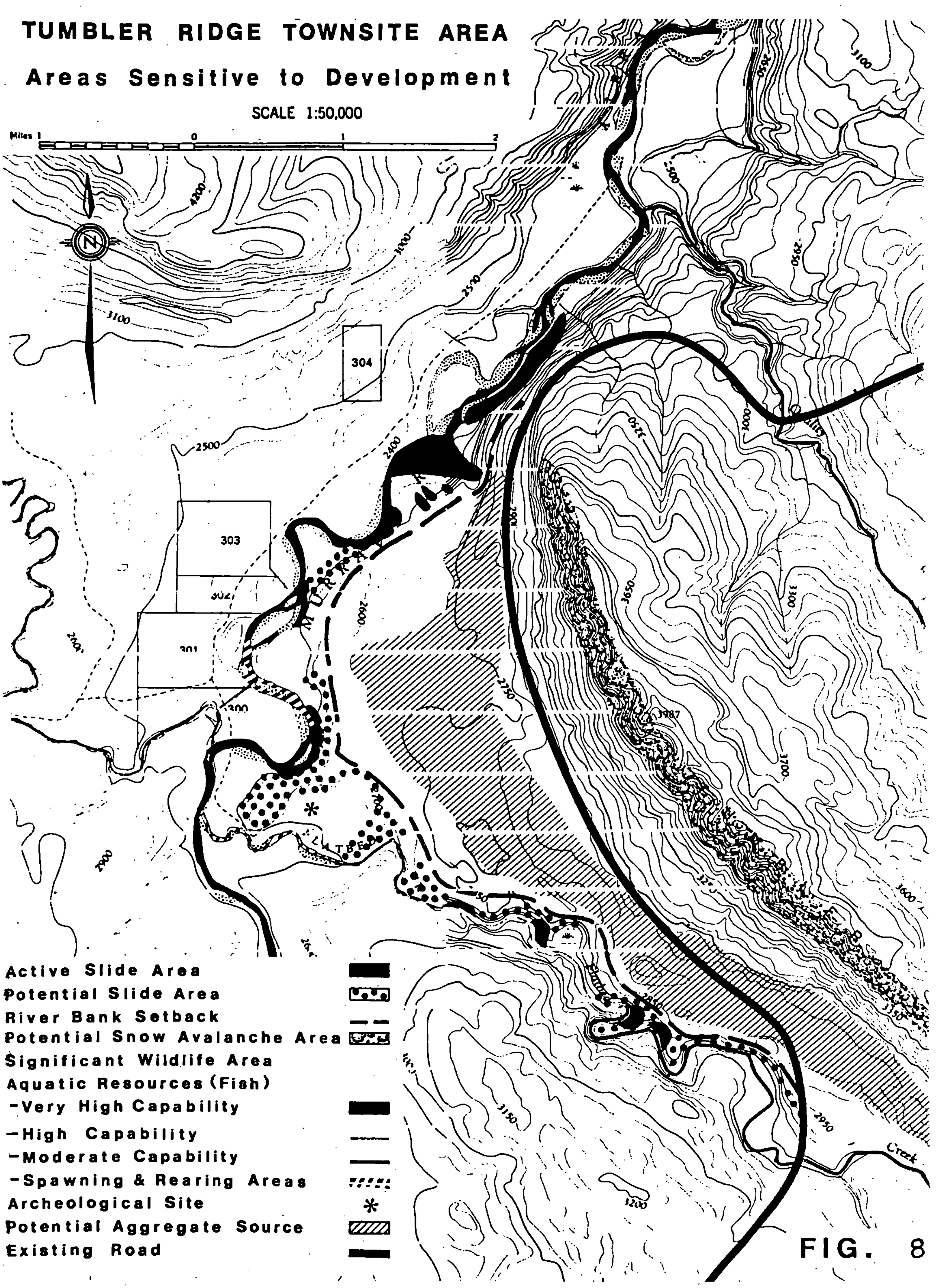
Major sites were examined in terms of land sensitivities, terrain suitabilities for development, community design and resource opportunities. The development costs (capital and operating costs for community infrastructure) and commuting costs for each alternative site were also compared. The report is an excellent example of the site selection process for an isolated resource community, using complex factors, but organizing and arraying them for decision-making purposes in a simple format. (Figure 8).

Plans were prepared for a new community at the preferred location, Tumbler Ridge, (Case Study), which developed several alternative town configurations and servicing schemes in response to environmental conditions.

TUMBLER RIDGE TOWNSITE AREA

Areas Sensitive to Development

SCALE 1:50,000



Active Slide Area
Potential Slide Area
River Bank Setback
Potential Snow Avalanche Area
Significant Wildlife Area
Aquatic Resources (Fish)
- Very High Capability
- High Capability
- Moderate Capability
- Spawning & Rearing Areas
Archeological Site *
Potential Aggregate Source
Existing Road

FIG. 8

Level 4: Development Impact Zoning

The Development Impact Zoning model extends the use of natural determinants to include their consequences for hydrology and storm runoff, and therefore, for development density and community form (Rahenkamp & Ross, 1976).

Impact zoning deals with 4 key parameters (Figure 9):

- natural determinants
- community growth
- infrastructure
- municipal finances

Development Impact Model

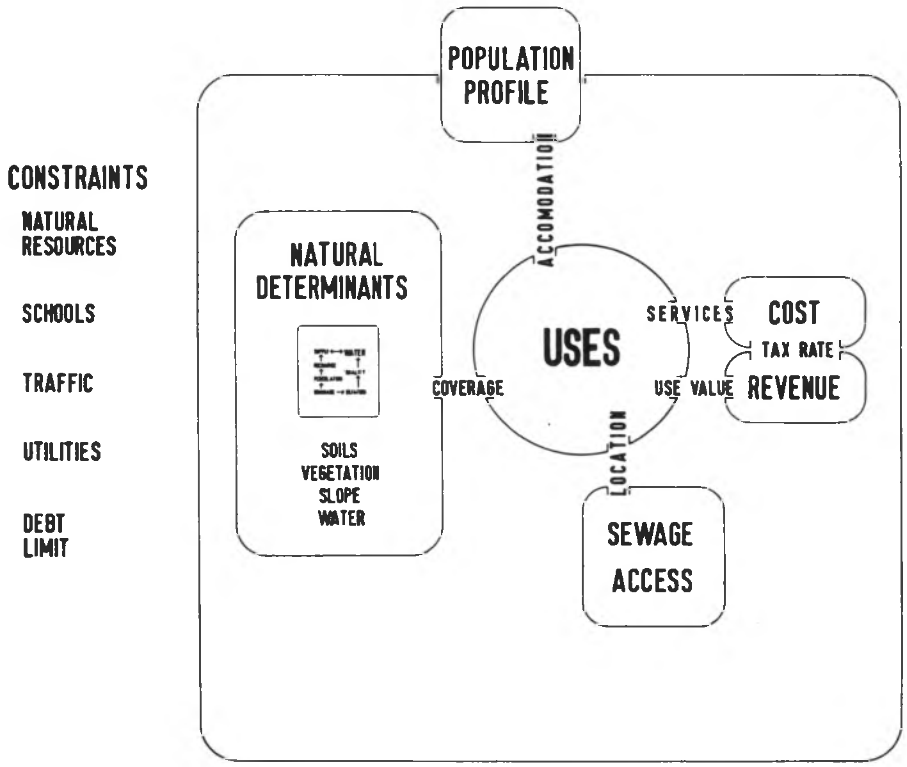


Figure 9: Impact Zoning Model

On the natural determinants side, the model combines ground slopes, soil types, and vegetation, with rainfall and snowfall factors, to create a master map which evaluates runoff and calculates what percentage of each area can be used for hard cover (impervious surfaces) without resorting to man-made runoff controls.

Another series of maps determines flood plain areas and the site's ability to absorb sewage effluent safely. Together, the resulting maps give a clear picture of what coverage and intensity limitations are necessary to preserve the natural environment of the site. A developer can easily find feasible locations for high, medium, and low density development, or see what density is possible on any particular parcel of land.

The community growth sector of the model relates the developer's marketing proposals (housing type and mix) to the community's own growth policy. Where they are incompatible, the model indicates what the additional growth will cost the town (costs which are likely allocated to the developer if he wishes his project to proceed).

The infrastructure component measures the increases in sewage and water supply generated by a project, and whether existing systems have the physical capacity to absorb the increase. This analysis is extended to utilities, roads, schools, and other basic community services as well.

Finally, the financial component compares the project's tax revenues with the municipality's added costs for operating services such as schools, highways, fire, and police, and for capital facilities such as roads, buildings, and infrastructure. If shortfalls are indicated, the developer and town negotiate how much of the added financial burden is to be picked up by the development, or whether the project mix and density should be modified to result in higher revenues or lower costs (for example, education costs can be affected strongly by changes in the housing unit mix).

The Development Impact Zoning model has been primarily adapted for Planned Unit Developments of 30 to 100 ha. (Planned Unit Development is a form of "floating" or negotiated zoning commonly used in the United States for large tracts of undeveloped suburban land, and is not used in Canada). However, many Canadian municipalities have forms of conditional zoning or direct development control which could incorporate such a model. The Impact Zoning model can be used equally by the public sector (in setting performance standards for development) or by the private sector (in determining the environmental and financial impacts of a given development plan). By creating a linakge between the site's natural determinants and carrying capacity, and the development project, the model enables planning responses to be tailored specifically to a town's environmental, social, and financial conditions.

Costs and Benefits

The costs of incorporating biophysical land surveys within the development planning process can vary significantly, depending on factors such as:

- the extent of the land area to be mapped
- the scale at which data is to be collected and analysed
- the purpose of the analysis, and therefore, the amount of interpretation required
- the prior existence of a sufficiently accurate data base.

Figure 10 gives some approximations for the average costs associated with each level of analysis. At either end of the spectrum, some qualifications are important:

- in general constraint mapping, where a large land area is to be searched for feasible development sites, the average costs/ha are not as relevant as the overall budget to be allocated for this purpose (which effectively determines how large an area can be searched). Analysis at this scale is often done by government agencies, which often can borrow from in-house data sources and analysis resources in several departments, at relatively low costs.

- at the scale of the development project, impact zoning and modelling generally costs at least $70 to 100,000 irrespective of project size, because of the relatively fixed costs of computer programs and personnel. Therefore, this level of analysis usually applies to projects in the 100 ha + range, in order to spread such costs over a large land area and as many units as possible. Impact analysis usually results in increases in the development yields, which in turn more than pay for these front-end costs.

An instructive comparison may be made between the two new community projects in southern Ontario, mentioned above: North Pickering and Townsend. In North Pickering, environmental analysis costs at the Concept Plan stage averaged $60/ha over a planning area of 10 000 ha, whereas for Townsend, the costs for a similar analysis at the same stage of planning averaged only $7 to 10/ha over a planning area of 6 000 ha. The reductions in cost came primarily from the realization by the Ministry of Housing that possibly too much environmental data was collected for conceptual planning purposes in North Pickering, and that a simpler and cheaper level of analysis would be acceptable to delineate the major development constraints and opportunities. Thus, biophysical assessment clearly must be directed to defined planning purposes and the proposed development activities, in order to be cost-effective.

These defined purposes and activities can also describe for the user, the expected benefits of biophysical assessment in the development planning process for each proposed application. In Thunder Bay, for example, it was used to define areas with "normal" costs for development and servicing,

Figure 10

ESTIMATED BIOPHYSICAL LAND SURVEY COSTS/HECTARE

Level	Map Scale 1:50,000	1:25,000	1:10,000
1. General Constraint Mapping	$1.00[1]	$2.50 - $5.00	
2. Constraint ("ABC") Mapping		$7.00 - $10.00[2]	$20.00[2]
3. Suitability Mapping	$2.50[3]	$10.00 - $12.50[3]	
4. Development Impact Zoning	n.a.	n.a.	$250 - 750[4] (depends on project size)

Sources

1. City of Thunder Bay Planning Department
2. R.S. Dorney
3. Resource Analysis Branch, British Columbia Ministry of the Environment
4. Rahenkamp, Sachs, Wells & Associates

in a topography pockmarked with potential difficulties for development. The benefits of this analysis are realized both at the level of the individual homeowner (since units can be constructed and marketed to potential buyers at lowest cost and least chance of settlement or similar damage) and also by the public sector, which in this case, faced differences of $15 to 20 million in the capital costs of servicing alternative growth areas.

The benefits of incorporating ecological information and analysis in the development planning process are probably most productively realized in contexts where:

- there are serious environmental constraints to development, directly affecting construction costs or health, safety, and human activity. The expected value of benefits is the costs of damages, failure, or remedial measures, times the probability of their occurrence, This kind of comparison usually results in a benefit/cost ratio strongly in favour of biophysical land analysis. For example, it is very important in northern resource communities to identify areas of permafrost, rock, and muskeg unsuited for development, as well as the scattered eskers and other landforms which are suitable for development.

- there are major resource areas such as agricultural lands, scenic topography, Environmentally Sensitive Areas, etc., which must be defined in order to protect them from development. In such cases benefits can be measured in terms of the intrinsic value of the resource: these may have economic consequences such as production from high capability agricultural lands* as well as less tangible consequences such as the scenic value of mountainous terrain. Even in some agricultural areas, the dollar value of production may not fully represent the true importance of the resource: for example, the Niagara Peninsula is one of the few areas in Canada capable of tender fruit production, an importance going far beyond the monetary returns from particular crops.

The benefits of a sophisticated methodology such as Development Impact Zoning lie primarily in contexts which may have institutional constraints such as restrictive zoning, which prevent the full environmental and economic potential of a site from being realized. Impact modelling has a great effect on planning, both on the development program (project mix, target market and rents, and community facilities) and the development plan (particularly housing form and location, open space, servicing standards, storm drainage, etc.). Therefore, some of the apparently high costs of this technique should be allocated to the detailed planning process. Rahenkamp, Sachs, and Wells quote several Planned Unit Development projects in the United States** in which returns to the developers were in-

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* For example, in St. Andrews municipality north east of Winnipeg, every hectare of agricultural land removed from production by development results in a permanent loss to the Provincial economy of $335.00/yr.

** For example, Narriticon, New Jersey, a Planned Unit Development project of 1,368 units on 69 ha, compared with the permitted single family community of 282 units, resulted in an annual municipal tax surplus of $196,500 and increased returns to the developers by $3,500,000 creased by as much as $2,000,000 to $3,000,000 through a combination of increased overall land values from increased density, and lower construction costs with cluster housing (in comparison with the low density single family housing projects which would have been permitted under the existing zoning). Furthermore, the revised project is often able to balance municipal operating costs with the project's tax revenues, sometimes resulting in a substantial tax surplus. A possible drawback of the Impact Zoning process is its cost ($70 to 100,000) and the time required to negotiate higher densities and site plan changes from the requirements of existing zoning; a process which can take as much as 2 to 6 years. These are delays and costs which only the largest developers can sustain.

S.J. Zayach; "Soil Surveys: Their Value and Use to Communities in Massachusetts", in R.W. Simonson, ed.; Non-Agricultural Applications of Soil Surveys, (New York, Elsevier, 1974)

Millions of dollars have been saved by communities in Massachusetts by using soil survey information to select school sites, control subdivision development, protect community water supplies, and advise developers on sewage disposal systems. Several communities indicated an average benefit:cost ratio of more than 110 to 1 in savings effected by using soil surveys to avoid errors in the use of land (based on 1966 data from 10 communities). These communities reported savings of $1,709,000 from the limited use of soil surveys for a short period (1 to 3 years).

Typical examples of such benefits include:

(1) The Planning Board of one community estimated savings of $500,000 in their school building program by using the appropriate interpretive maps to select school sites. The savings resulted from having a complete inventory of suitable sites which permitted selection and purchase of the sites before land values increased. Additional savings resulted from purchasing the most suitable sites rather than waiting until selection was limited.

(2) A small community along the Atlantic Coast estimated that the savings on the town sewer system will be in excess of $250,000 as a result of using soil survey information. The interpretive map for septic tank disposal alerted the town to the fact that less than 1% of the 6,500 acres in the town had soils suitable for on-site sewage disposal. If 6,000 homeowners had established systems of their own, the disposal systems would not have functioned satisfactorily. This severe financial loss to homeowners was avoided because of the advance knowledge that a municipal sewer system was needed.

The soil maps also indicated that a proposed 102-lot subdivision would endanger the town's water supply. A preliminary investigation and installation of a new well would have cost the town an estimated $2 million.

(3) The soils and related conditions of one town were such that future growth was being planned without a municipal sewer system - only on-site systems were planned for new housing. Soil maps were used to zone the town to allow for adequate on-site sewage disposal. This eliminated the town's need for a $200,000 sewer system which would have been required by a "hit-or-miss: building program.

(4) On the basis of soil surveys, another community determined that a municipal sewer was not needed for a distance of 3.2 km along one road, because the soils had slight limitations for septic tank disposal. the total savings to the community were $105,600.

References: The Planning Process

1. British Columbia Government; Northeast Coal Study: Preliminary Feasibility Report on Townsite Community Development, (Victoria, Feb., 1977)

2. Calgary Regional Planning Commission; Municipal Finances, (Calgary, Report A-9, December, 1976)

3. Dorney, R.S.; "Biophysical and cultural-historic land classification and mapping for Canadian urban and urbanizing land", in Wiken & Ironside, op. cit.

4. Gartner Lee Associates; A Study of the Physical Environment of a Part of Thunder Bay, (Thunder Bay, July, 1974)

5. Hills, G. Angus; "An Integrated Iterative Holistic Approach to Ecosystem Classification", (Ottawa, Environment Canada, 1976)

6. Lombard North Group; St. Andrews Environmental Impact Assessment, (Winnipeg, Manitoba Department of Municipal Affairs, 1975)

7. Manning, E.W. & McQuaig, J.D.; Agricultural Land and Urban Centres, (Ottawa, Environment Canada, July, 1977, Report No. 11)

8. McHarg, Ian; Design with Nature, (Garden City, 1969)

9. Morton, Dodds & Partners; Terrain Suitability Study, Thunder Bay, (Thunder Bay, 1975)

10. Ontario Ministry of Natural Resources; A Discussion Paper on Flood Plain Alternatives in Ontario, (Toronto, August, 1977)

11. Rahenkamp, J. & Ross, A.; "Responsible Land Use Management and the Environmental Assessment Act", OALA Journal, (Vol. 2, No. 3, Dec., 1976, pp. 24-27)

12. Resource Analysis Branch, British Columbia Ministry of the Environment; Lower Arrow Lakes Resource Analysis for Rural Resettlement, (Victoria, August, 1977)

13. Thunder Bay Planning Department; Cost Revenue Analysis, Parkdale Growth Area, (Thunder Bay, August 28, 1978)

14. Wiken, E.B.; Ecologically Based Planning, (Ottawa, Lands Directorate, Environment Canada, 1978)

15. ---- & Ironside, G.R., eds.; Ecological (Biophysical) Land Classification in Urban Areas, (Ottawa, Environment Canada & CMHC, 1976)

16. Winnipeg Region Study Committee; The Nature of Demand for Exurbia Living, (Winnipeg, February, 1974)

D. GENERAL DEVELOPMENT AND MANAGEMENT RESPONSES

Once environmentally suitable locations for development have been determined, the developer and planner must deal with the specific environmental conditions of the developable site "envelope". A number of appropriate site development responses are discussed in this chapter, in terms of environmental components such as terrain, storm water, climate and vegetation, in terms of the construction activity itself, and in terms of particularly sensitive or significant lands, called "Environmentally Sensitive Areas". Chapter E goes on to describe adaptations or responses specific to each of the major Ecological Planning Regions in Canada.

D.1 TERRAIN

Terrain is probably the most basic environmental component which development must respect, since structural loads must be conveyed to earth, services and foundations must be buried underground, and access must be provided between the dwelling and its external land environment. Geotechnical terrain conditions (slope, soils, overburden, etc.) can affect devel opment costs significantly, particularly for foundations and piped utilities (for example, Figure 11). In general, difficult or costly terrain areas can, and should be identified and avoided in the initial planning stages of a project (particularly when building locations are established)

Once suitable geotechnical conditions have been identified for construction, (for example, stable, well-drained soils with firm bearing, moderate slopes, substantial overburden), there are a number of more detailed site development repsonses which can improve the environmental "fit" of the project. These include:

- Aspect

  Moderate, south-facing slopes are preferred to maximize solar insolation to all housing units.

- Shelter

  Land forms can deflect winter winds, therefore leeward (usually south and east) slopes are preferred for housing, windward (usually north and west) slopes are preferred for roads, since snow drifting may be less. (Figure 12)

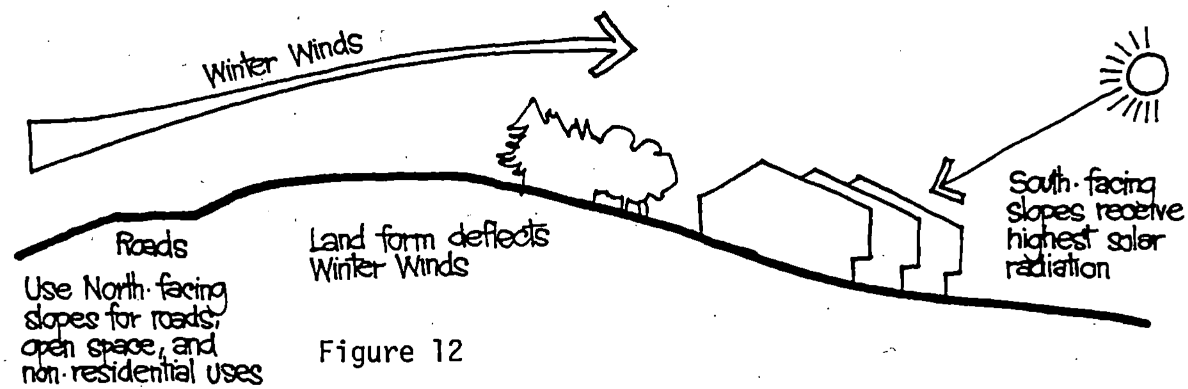


Figure 12

Figure 11

SUBDIVISION COST FACTORS

Terrain Conditions	Slope 0 - 3%	3 - 9%	9 - 15%
• Good Well drained silts, clays, & sands in smooth to gently rolling topography	1.0	1.0	1.1
• Satisfactory Surficial materials with some boulders, fair surface drainage, level to rolling terrain	1.0	1.1	1.1
• Fair Poorly drained silts, clays, gravel, and sand with shallow water table, potential flooding conditions, in level to gently rolling topography	1.6	1.4	1.4
• Marginal Rolling to hilly topography, shallow bedrock, variable drainage conditions	1.9	1.7	1.7

"Subdivision costs" include sanitary sewer collection mains, storm sewers, water distribution mains, water and sanitary connections, pregrading, internal roads, sidewalks, curbs, gutters, and gravelled lanes. Not included: street lighting, underground power, surveys.

Assumptions: Density 50 persons/ha, population 25,000 (Cost factors not included for slopes greater than 15%)

Source: Calgary Regional Planning Commission; Transportation and Utility Services, (Report A-2, August, 1976)

- <u>Layout</u>

Roads and housing should follow existing contours and grades to avoid costly excavation, cuts and fills, and future erosion problems. (Figure 13).

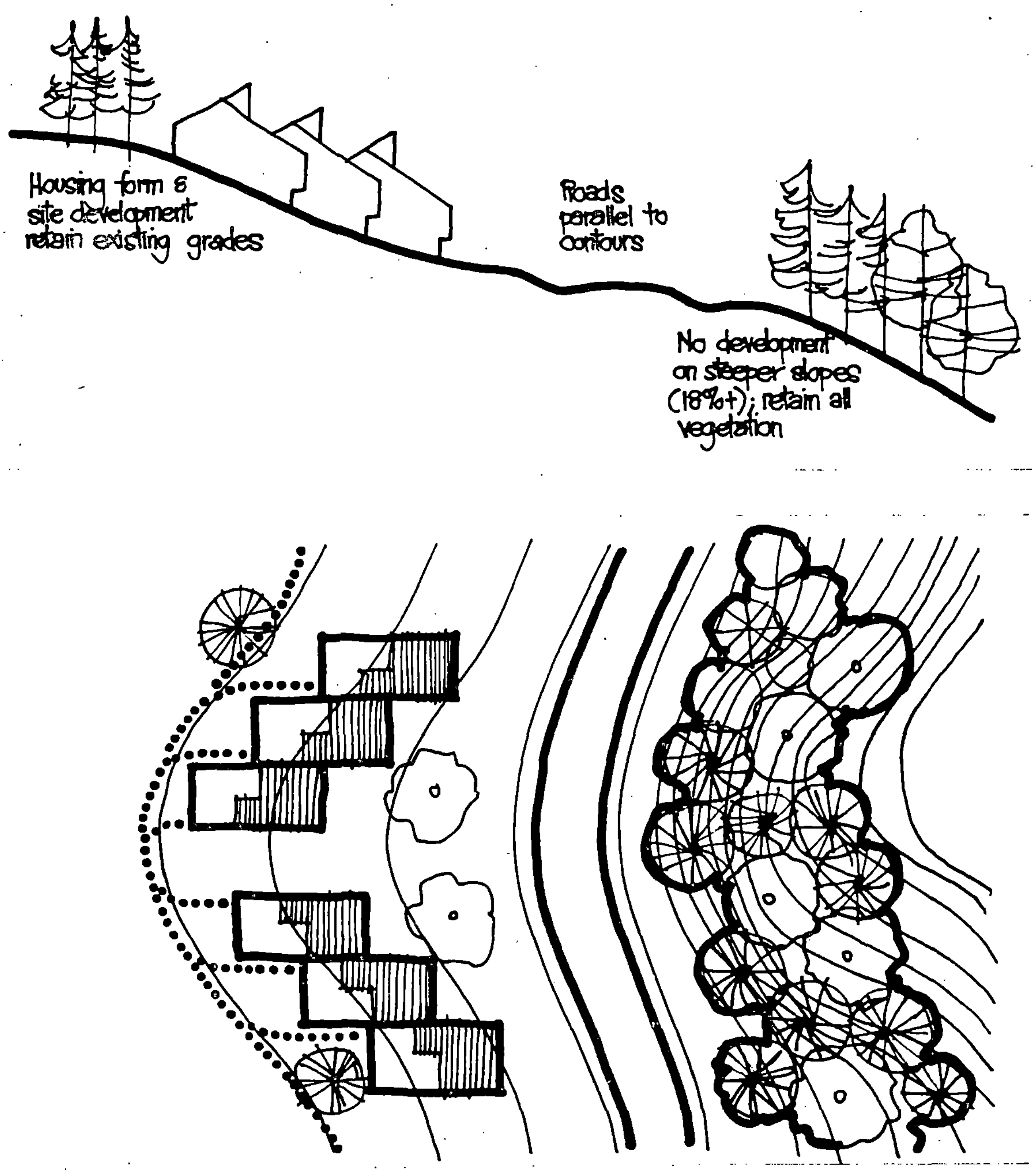


Figure 13

- Insulation

Terrain also provides natural insulation: setting the building into grade aids in energy conservation, since the earth below the frost line is at a constant temperature year round of more than 10°C (except in permafrost regions of Canada). Thus, an earth-sheltered house is cooled in summer and warmed in winter. (Figure 14).

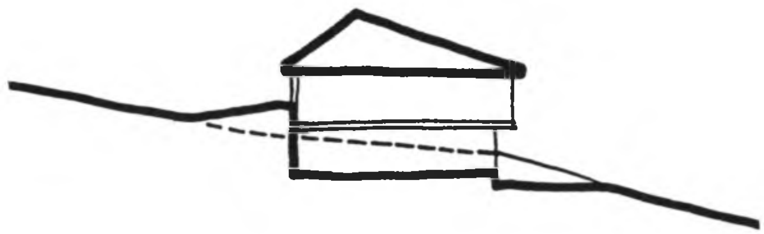


Figure 14: Earth Sheltering

Costs and Benefits

Above all, the essence of "environmentally sensitive" adaptations to terrain conditions is to do as little to the land as possible, avoiding large scale earthmoving, cuts and fills, and other major transformations of the landscape. To do otherwise may be to court disaster: construction and earthmoving on the hills surrounding Los Angeles, California have resulted in landslides, mudflows, and property damage totalling millions of dollars. Much of this damage resulted from excessive terracing of hillsides in order to create flatter housing sites, rather than adjusting housing and site design to sloping conditions.

Avoidance of difficult terrain conditions can have a major effect on lowering site development costs as well as minimizing future problems such as erosion. This is true not only in selecting suitable sites for development, but also within the site itself. While foundation design can often be adapted to relatively severe conditions (provided firm bearing is available) and constitutes only a small percentage of house construction costs, piped services are a major component of site development costs (see Figure 15) and are also less adaptable to terrain variations due to technical constraints. In unfavourable topography, servicing costs could conceivably double over those normally encountered (see Figure 11).

TYPICAL PERCENTAGE DISTRIBUTION—COST COMPONENTS—
TOTAL SELLING PRICE OF A TYPICAL NEW HOUSE IN PEEL
1975

COMPONENTS	PRICE $	PERCENTAGE %
CASH FOR LAND	403	0.5
MORTGAGE	1,363	1.7
MORTGAGE INTEREST	1,157	1.5
SERVICING COST	5,230	6.7
CARRYING COSTS—SERVICING	549	0.7
SURVEY FEES	162	0.2
ENGINEERING/PLANNING	520	0.7
PROPERTY TAXES	632	0.8
LEGAL	300	0.4
ROAD/WATER LEVIES	463	0.6
LOT LEVIES	1,713	2.2
TRANSFER TAX	98	0.1
VALUE INCREASE (MARKUP)	17,337	22.3
MORTGAGE INTEREST	7,700	9.9
PROPERTY TAX	50	0.1
CONSTRUCTION	31,850	40.8
BUILDING PERMITS	96	0.1
TRANSFER TAX	363	0.5
LEGAL FEES	782	1.0
BROKER COMMISSION	1,560	2.0
VALUE INCREASE (MARKUP)	5,599	7.2
TOTAL	77,927	100.0
TOTAL MARKUP	22,936	29.4

Source: 1977 Interim housing policy statement and final report of the Peel Housing task force.

Figure 15

Localized terrain conditions within a site may not always be ideal, requiring that compromises be made. For example, the number of wind-sheltered areas or favourable south-facing slopes may be limited on any site, possibly necessitating some development of more exposed locations or less favourable aspects. However, to the extent that these less favourable areas can be transferred to non-residential uses such as open space, the overall project will generally benefit. The adaptation of housing design and site layouts to minimize grading and excavation cuts and fills is relatively easy and has economic benefits on all but the steepest slopes feasible for development.

The use of excavated soil from foundations to create earth forms for building shelter can reduce winter heat losses and cool the house in summer (in all but permafrost areas). Such a sheltered or "sunken" unit configuration may result in some minor additional waterproofing, drainage, and structural costs.

References: Terrain

1. Calgary Regional Planning Commission; Transportation and Utility Services, (Calgary, Report A-2, August, 1976)

2. Hendler, Bruce; Caring for the Land, (Chicago, ASPO, Report No. 328, 1977)

3. Slosson, J.E.; Engineering Geology - Its Importance in Land Development, (Washington, Urban Land Institute Technical Bulletin No. 63)

4. Wallace, McHarg, Roberts & Todd; Woodlands New Community: An Ecological Plan, (Philadelphia, 1973)

D.2 STORM WATER

Water is another major environmental component which all development must respect. Of course, water is the medium by which liquid wastes are conveyed away from the building, and water supply is essential to the functioning of human activities within the controlled environment of the home.

Development also modifies the external water environment, particularly the drainage of storm water, and movement of water through the earth. In areas which have not been developed, storm water "management" or control is provided by natural means: the various components of the hydrologic cycle (that is, the circulation of water through the earth's environments (depicted in Figure 16)).

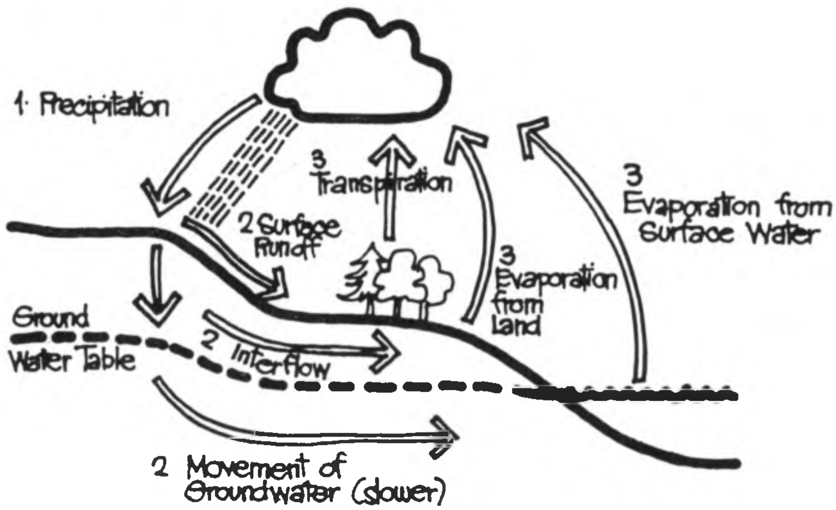


Figure 16: The Hydrologic Cycle

This process is a never-ending cycle consisting of:

1. Precipitation from moisture-laden clouds, in the form of rain or snow

2. Runoff into the receiving systems of streams, lakes, or oceans, by
   - seepage or infiltration to aquifers
   - interflow (underground water movement above the water table)
   - surface runoff

3. Evapo-transpiration: the release of water back to the atmosphere by:
   - evaporation from water areas (streams, wetlands, lakes, etc.)
   - evaporation from land
   - transpiration from vegetation.

Natural drainage systems are constantly changing in response to external forces: streams change course, banks and shorelines erode, water bodies fill with sediment. Natural hazards such as fire or earthquakes can also permanently affect the pattern of a drainage system over a large area.

The Effects of Development

Under most natural conditions (prior to development), on the average 10% of the total amount of precipitation runs off overland, 40% evaporates, and 50% infiltrates into the ground. (Figure 17) This does not apply of course, during winter, when the ground is frozen, or during early spring, which is a time of heavy runoff from snowmelt.

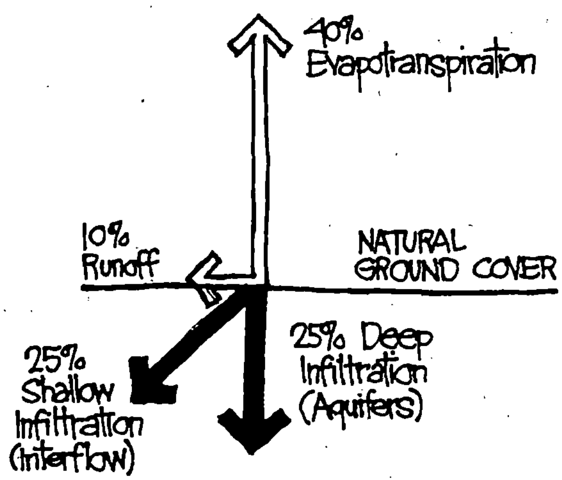


Figure 17

Development activity brings with it the removal of vegetation and earth-moving during construction, increases in the areas of impervious surfaces, and new on-site septic systems. This results in the following effects:

- increases in the volume of storm runoff overland:

  As the ratio of impervious surfaces increases to 10 - 20% (of total land area) runoff in turn doubles to 20% (Figure 18); as the ratio of impervious surfaces to total land area increases to 75 - 100%, runoff can be as much as 5 to 6 times greater than in the natural state. (Figure 19)

- increased sedimentation; reductions in stream water quality

- stream bank erosion

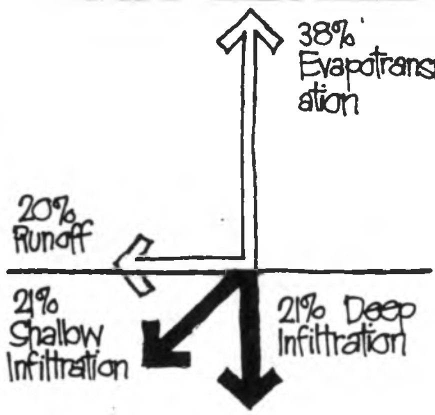


Figure 18: 10-20% Impervious Surfaces

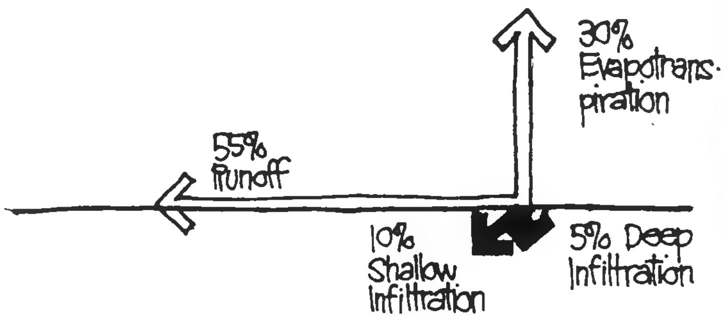


Figure 19: 75-100% Impervious Surfaces

Source for Figures 17, 18, 19: J. Tourbier, 1973

- increases in the speed and peaking of runoff (Figure 20)

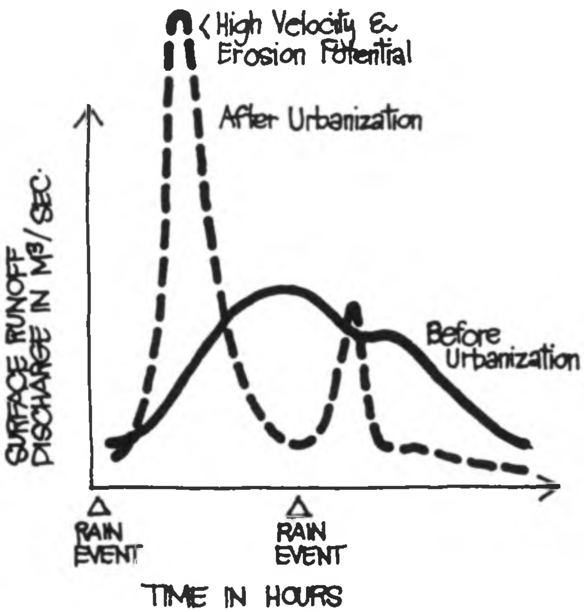


Figure 20: Typical Hydrographs

Modified from Luna Leopold, (1968)

In turn, this can result in several major interrelated problems:

- lowering of ground water reserves because of reduced infiltration
- increased probability of flooding
- increased siltation of water courses, as well as water pollution.

The effects of such problems are further magnified by their interaction (Tourbier, 1973):

- increased runoff from impervious surfaces increases erosion on uncovered land areas, and increased flood volumes cause stream bank erosion. Both result in more sediment.

- silting up of river beds reduces their capacity to carry a flood at a time when floods are getting larger. This results in an enlargement of the flood plain, and heavier flood losses.

- the increase in flood volumes coincides with a decrease in dry weather flow because of reduced infiltration where the ground is covered with buildings and pavement. Streams are often channelized, resulting in faster runoff.

- increasing effluent disposal into streams coincides with a reduction in their capacity to carry effluent during dry weather flows.

Development brings a further need for additional water supplies, yet causes a reduced yield of underground water because of reduced infiltration. Industrial and residential wastes are heavily increased, but streams are less able to dilute the effluent. The resulting ecological effects are that stream environments are often poor, aquatic habitats are jeopardized, and water supplies are uncertain.

Conventional Approaches to Storm Water Management

In developed areas, storm water management has commonly consisted of collecting runoff and discharging it as quickly as possible through a conveyance system of pipes or open ditches to the nearest convenient outfall in a stream, lake, or ocean.

In a typical low density suburban neighbourhood, the system would consist of the following elements (shown graphically in Figure 21):

Lot:	Surface drainage away from the house
	Roof leader to foundation drains
	Foundation drains connection to storm sewer
Road:	Curbs and gutters to catch basins
	Catch basins to storm sewer
Watercourse:	Large diameter storm sewer to outfall
	Stream bank channelization.

Such a system results in the rapid collection and conveyance of surface flows from roads and lots. Surface ponding is rare, and flood damage is minimal under all but the most severe (and infrequent) storm conditions.

However, the emphasis on convenience and safety to the exclusion of other significant factors often has had unfavourable ecological impacts downstream:

- high peak flows and discharge velocities
- lowering of water tables
- increased pollution of receiving streams and lakes due to lawn fertilizers, debris and pollutants from streets and paved areas
- increased danager or damage from flooding.

In addition, conventional storm water drainage design has tended to concentrate on man-made components, without capitalizing on natural elements, particularly those which had an important role in the hydrologic cycle of a drainage basin. This has often resulted in the over-design of piped drainage systems, which when added up, can represent staggering costs for the public sector. For example, the American Public Works Association estimated the capital needs for urban drainage improvements in the U.S.A. at $2.85 billion annually, in 1975. When costs for street and highway drainage ($1.4 billion) and urban flooding costs ($1 billion) are added to this total, direct measurable costs in the U.S.A. exceed $5 billion annually. (Hittman, 1976). Canada's costs would probably approach 10% ($500 million) of this amount.

Recently then, attention has centred on developing drainage practices to avoid and alleviate the negative environmental impacts and damage of conventional practices and to reduce community and project capital, operating, and maintenance costs. Some of these emerging practices are described below.

Alternative Approaches to Storm Water Management

The basic concepts underlying emerging alternative approaches to storm water management are:

- The post-development water flow characteristics (hydrograph) should approximate those existing prior to development, by on-site retention and absorption.
- A balance should be struck among the factors of capital, operating, and maintenance costs, convenience, environmental protection, and damage.

- A greater emphasis on the natural ability of the landscape to absorb and distribute storm water.

- Comprehensive drainage basin master planning in which each site, and natural and man-made components are functionally interrelated.

Drainage design recognizes that the storm water system has two important purposes:

1. control to minimize damage and hazards to human life

2. control to minimize inconvenience or disruption from frequent and less signficant storms.

The latter role, commonly described as the "minor" system function, is designed with the capacity to handle storm water runoff expected to occur normally within an average 1 to 5 year period. However, designers are now recognizing that it is impractical to design the system to handle infrequent major storms (such as Hurricane Hazel) without some inconvenience and minor property damage. The "major" system then, is the route followed by runoff waters when the minor system capacity is exceeded. By careful design, the major system can use roadway or open space easements to convey water to open watercourses, with no damage to private structures (although minor erosion and damage to lawns and vegetation might occur). Modern computational methods can also assist in the design of these systems.

In trying to approximate pre-development water flow characteristics (the so-called "zero increase in runoff" principle), the important concepts designers use in natural storm water drainage are:

- minimization of impervious surfaces in the project to permit greater natural infiltration

- use of the land itself to collect and convey runoff

- physically holding water on the site for gradual release into watersheds or for recycling for productive uses such as irrigation or recreation.

As an example, a natural storm water system for the previous suburban setting, would (depending on variables such as soils and topography) consist of the following elements (see Figure 22):

STORM WATER MANAGEMENT

Figure 21
CONVENTIONAL

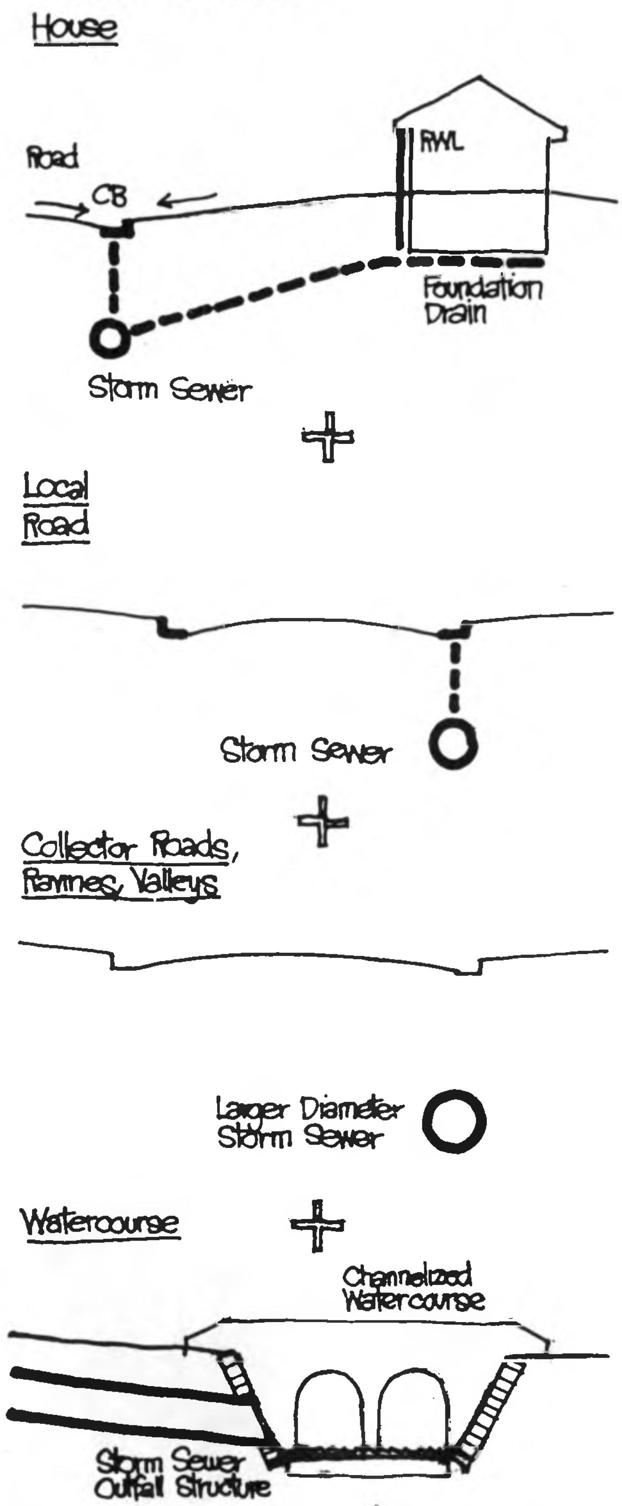
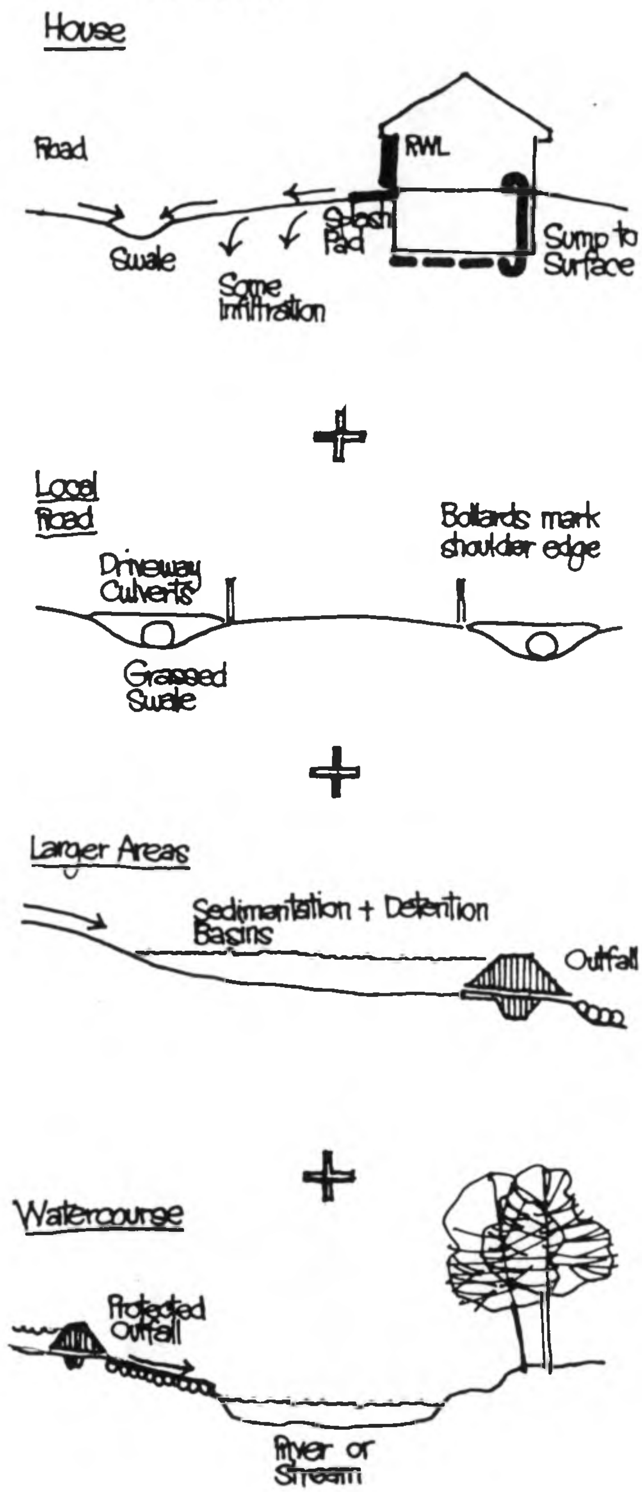


Figure 22
ALTERNATIVE



Lot:	Roof leader to surface splash pads
	Surface drainage to swales
Roads:	No curbs or gutters, drainage to swales
Larger Areas:	Swales to dry detention and sedimentation basins (permanent retention ponds as appropriate)
Watercourse:	Small diameter outfalls (if necessary)
	Unchanged stream banks.

Depending on particular site conditions, the minor system might consist, instead of the above, of "natural" house drainage (to splash pads and swales) with piped roadway drainage (see case study; Barnard et al, 1976), while the major system would be accommodated by detention or retention ponds located in school yards, parks, or parking lots. As land costs and housing densities increase, open space comes at a premium, and it might not always be feasible to accommodate both minor and major systems by surface means which consume land area. Thus, the methods to achieve natural drainage objectives are often used in combination, since the feasibility of their use varies greatly with climate, terrain, land availability, and costs. For example, flat prairie settings such as Winnipeg and Regina may use permanent retention ponds or lakes for above-ground storage; mountainous terrain with limited developable land, as in British Columbia, may require underground storage reservoirs. Figure 23 outlines some of the available techniques, under two broad categories: Infiltration and Storage Systems.

In general, natural drainage can result in substantially improved ecological impacts in contrast with conventional practice:

- reduced peak flow and discharge velocities
- maintenance of water table, with recharge from infiltration
- improved water quality, from the filtration action of the soil to remove pollutants
- reduced flooding danger.

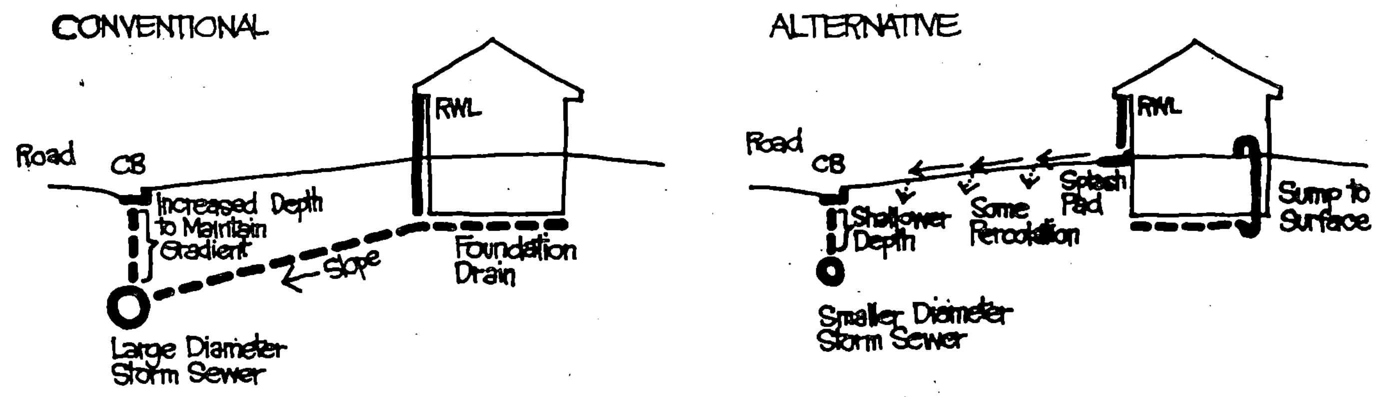
On the other hand, there are several offsetting concerns which must be addressed in the design stages of a project:

- the land area taken up by retention/detention ponds (which it may be possible to incorporate into open space networks)
- maintenance costs to remove leaves and debris from drainageways
- proper design to avoid safety hazards, mosquito breeding, etc.
- occasional inconvenient flooding or streets, parking lots, or open

CASE STUDY: ENGINEERING STANDARDS, STORMWATER MANAGEMENT

P. Barnard et al; Urban Development Standards, (Toronto, Ontario Ministry of Housing, 1976)

Even a simple technique such as disconnecting rain water leaders from the house foundation drains, and permitting them to discharge to splash pads, can result in substantial cost savings, when all of the associated costs such as service connections and storm sewer diameter are examined. This report also costed other minor engineering standards changes such as small reductions in road pavement and right-of-way widths, modified sanitary sewers (smaller diameter, fewer manholes) and sidewalks on one side of the road only.



<u>Higher</u>: roadway

storm sewers (size and depth) depth)

service connections (storm & sanitary)

<u>Lower</u>: lot grading

<u>Higher</u>: lot grading costs

<u>Lower</u>: storm sewers

service connections (sanitary only)

roadway (fewer catch basins)

<u>Difference</u>: ($1,777/unit less (p. F5)

(includes the effects of the other engineering standards mentioned above as well)

Figure 23: Storm Water Management Techniques

(Adapted from Tourbier & Westmacott, 1974)

1. INFILTRATION SYSTEMS

1.1 Extended Gravel Bibs (roadway edges, no curbs or gutters)

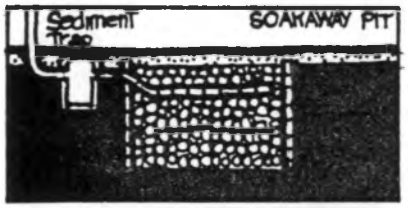
Gravel is extended beyond the normal road surface edge, usually sloping towards a swale. The gravel provides natural infiltration, while the swale receives the excess. Pedestrian walkways can be located on the outside of the swale.

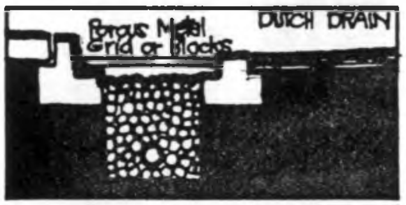
Benefits:
- relatively economical
- reduces road surface runoff volumes
- separates pedestrians from motor vehicles

Liabilities:
- impractical in dense urban contexts

Costs:
- $ /m.

1.2 Dry Wells, Soakaway Pits, Dutch Drains





These pits are usually lined, then filled with a porous material such as clean gravel. They can receive rainwater from roof drains, or surface drainage from a parking lot. The ground water table must be below the bottom of the pit.

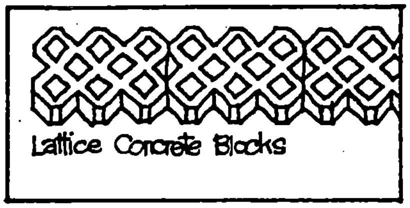
Benefits:
- replenish the groundwater supply, can eliminate the need for storm sewers
- little or no conveyance system is needed to transport runoff, therefore costs are reduced.
- require minimal space

Liabilities:
- impractical in high water tables or impervious soil soil conditions
- danger of groundwater pollution (from road surface contaminants)
- possible basement flooding

Costs:
- Dutch drains (1 m wide x 1 m deep): $50 - $70/m

Figure 23: Storm Water Management Techniques (Continued)

1.3 Porous Pavements



These are paving surfaces such as porous asphalts or "turf stone" (lattice concrete blocks) that permit infiltration of water through or between the material. Porous asphalts are still in the experimental stage particularly in Canada's difficult freeze-thaw conditions. (Surfaces can get clogged as well)

Benefits:
- permit infiltration and ground water recharge
- may eliminate need for runoff conveyance or at least reduce the sizes of piped systems
- lattice blocks are usable for erosion and sedimentation control; excellent appearance when planted.

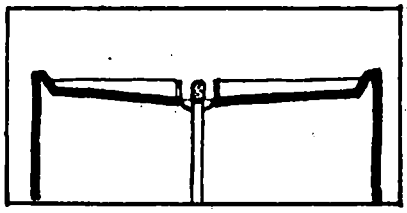
Liabilities:
- can be expensive on a unit cost basis
- porous asphalts are impractical in some parts of Canada due to freezing and breaking of material, also not usable on slopes.

Costs:
- porous asphalts: $6.00/m^2
- lattice blocks: $10.00+/m^2

2. STORAGE SYSTEMS

Unit or Lot Scale

2.1 Roof Top Ponding



Runoff can be delayed from flat roofs by designing them to hold 7-8 cm of water, with slow release to an overflow drain. Runoff checks on sloping roofs may not be practical or useful.

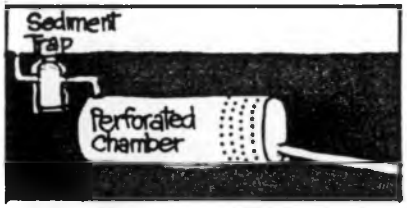
Benefits:
- can be incorporated in individual units as part of the development plan

Liabilities:
- water storage adds to roof loads, and therefore, to construction costs
- limitations on residential flat roofs in many parts of Canada, due to winter snow loads
- breeding area for mosquitoes unless drained within 36 hours
- possible leakage

Costs:
- not detailed.

Figure 23: Storm Water Management Techniques (Continued)

2.2 Subterranean Retention Chambers (Unit or Cluster)



A concrete or galvanized steel vault which receives roof drain or paved area runoff, and allows slow release.

Benefits:
- practical in sloping terrain where there may be insufficient space for detention ponds (for example, shopping centres in West Vancouver)

Liabilities:
- location depedent on soil and sub-strata conditions
- must be below frost level; therefore restricted in many areas
- servicing and maintenance problems (clogging, clean-outs, etc.)

Costs:
-

Development Scale

2.3 Development (Rear Lot) Swales

Swales used for temporary ponding along rear property lines; must be used with mild gradients and suitable sub-soils (no clays or shale)

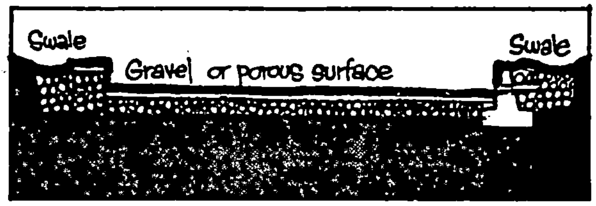
Benefits:
- relatively inexpensive, easily formed of earth

Liabilities:
- impractical in some instances (such as extremely flat land, shallow depth to bedrock, impervious soils)
- inconvenience of temporary ponding

Costs:
- minor (part of final lot grading)

Figure 23: Storm Water Management Techniques (Continued)

2.4 Percolation Ponding/Basins



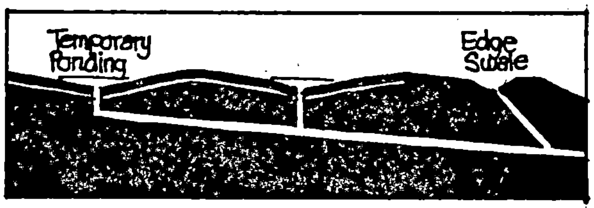
Trenches and basins filled or underlain with sand and gravel to store excess runoff from a large area, and allow it to seep into the ground.

Benefits:
- reduces contaminants entering the ground water system
- recharge of the groundwater supply
- multiple use (recreation, parking, open space)

Liabilities:
- soil limitations: needs deep permeable sub-soil

Costs:
- $6 - $8/m^3 of storage.

2.5 Parking Lot Ponding



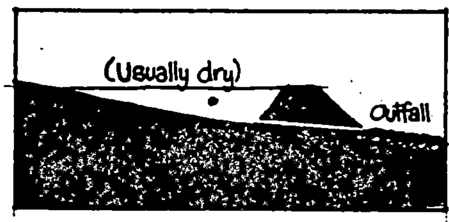
Parking lots are sloped to direct runoff to temporary surface storage areas away from most parking; slow release to bleeder pipes, seepage pits, or swales.

Benefits:
- low cost

Limitations:
- temporary inconvenience to user
- owner dissatisfaction

Costs:
- low

2.6 Detention Basins



Detention basins are small ponds with a dam or release control, receiving runoff from swales. They are intended to increase the time of concentration or reduce the discharge rate from a development. They are usually dry except in times of heavy runoff

Benefits:
- allows significant reductions in piped drainage structures
- will trap solids in the runoff (sediment trap)
- low cost

Liabilities:
- requires periodic cleaning and maintenance
- may be unsightly; possible health/safety hazard
- large land area required for ponding

Figure 23: Storm Water Management Techniques (Continued)

2.7 Retention Ponds

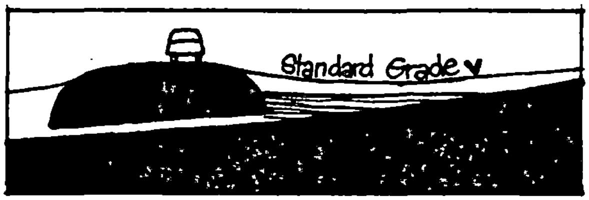
These are permanent water bodies ranging in size from small ponds to large recreational lakes (5 ha+) to receive and retain storm water from a development project. Overflow is released to streams. In contrast with detention basins which are located on permeable soils to maximize infiltration, retention ponds should be located on impermeable soils to maximize retention.

Benefits:
- recreational and visual amenity
- can raise adjacent property values
- multi-purpose

Liabilities:
- safety problems
- periodic maintenance needed to avoid eutrophication and pollution
- varying water levels
- less effective as a storage device than detention basins

Costs:
- \$6 - \$8/m^3 of storage

2.8 Roadway Detention Swales ("Blue-Green" System)



The roadway embankment serves as a runoff water container where streets cross drainageways.

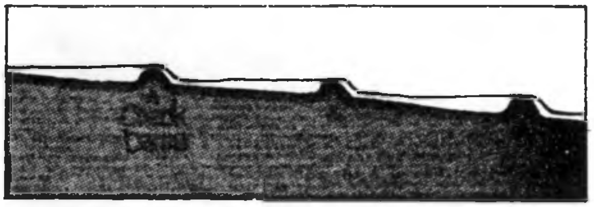
Benefits:
- does not require much additional land in the right-of-way
- low cost

Liabilities:
- bank stability can be a problem
- must avoid overflow onto the roadway, thereby causing a driving hazard

Costs:
- low

Figure 23: Storm Water Management Techniques (Continued)

2.9 Stream Channel Storage



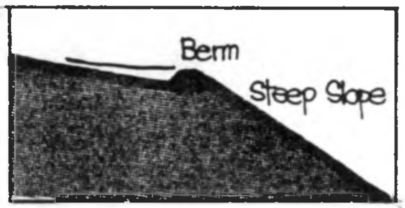
The installation of check-dams along a natural water course or stream channel to slow down the release of storm water downstream

Benefits:
- can be integrated into the open space system
- low cost

Limitations:
- potential erosion and channel stability problems

Costs:
- low

2.10 Diversions



The use of channels and ridges across a sloping land surface to convey water laterally at a slow velocity, discharging into a protected area or outlet channel. The purpose is to spread runoff, and slow down water flow thereby increasing infiltration.

Diversion Berms: ridges at the top of a steep slope to divert runoff away from the slope

Terraces: flat areas or "terraces" on sloping land; constructed along the contour to divert runoff from the slope.

Benefits:
- erosion control, slope protection
- increased flow times and infiltration, decreased volumes of storm runoff

Liabilities:
- may leave ground waterlogged on poorly drained soils

Costs:
- Diversion berms: $4 - $5/m

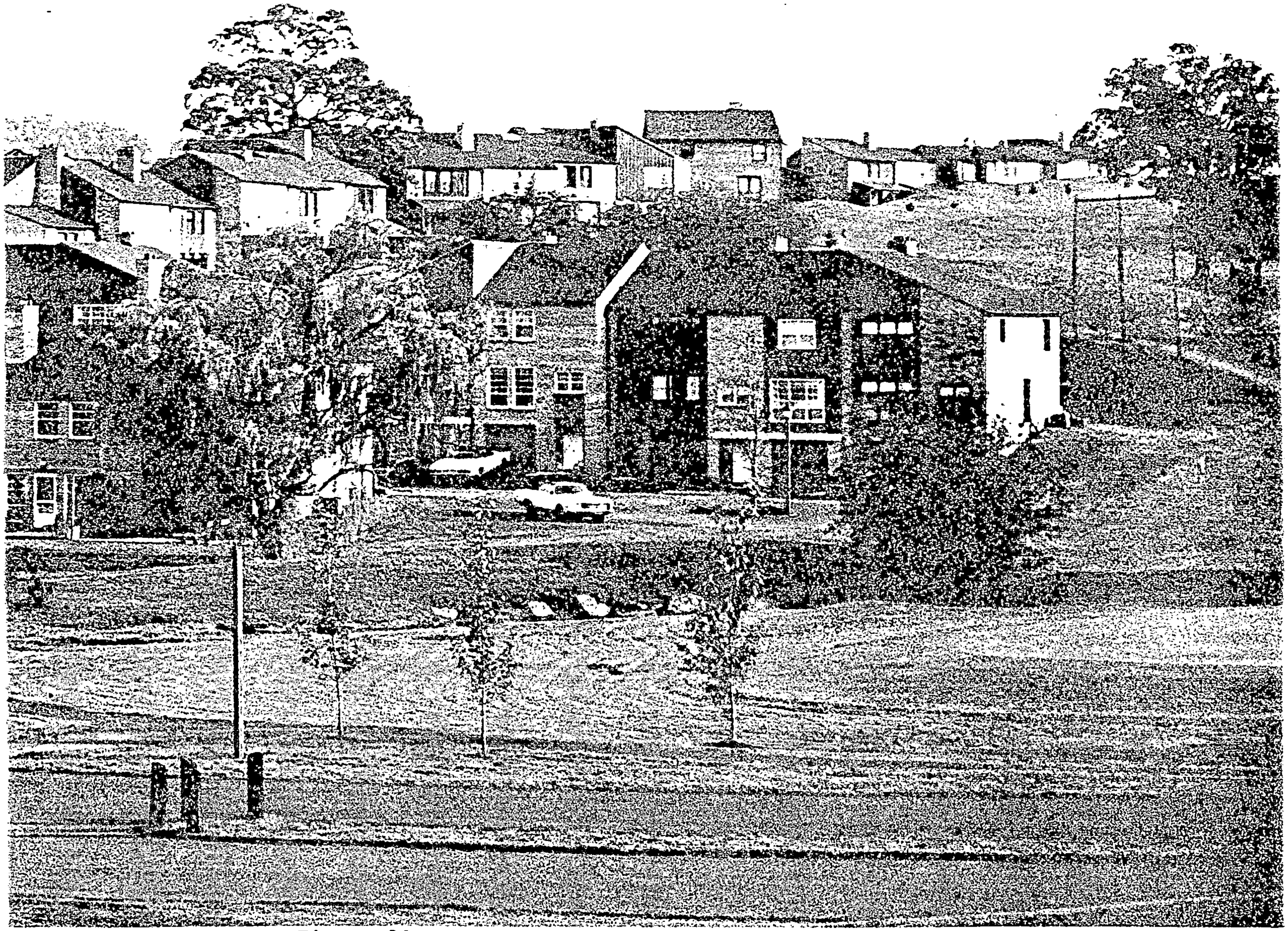
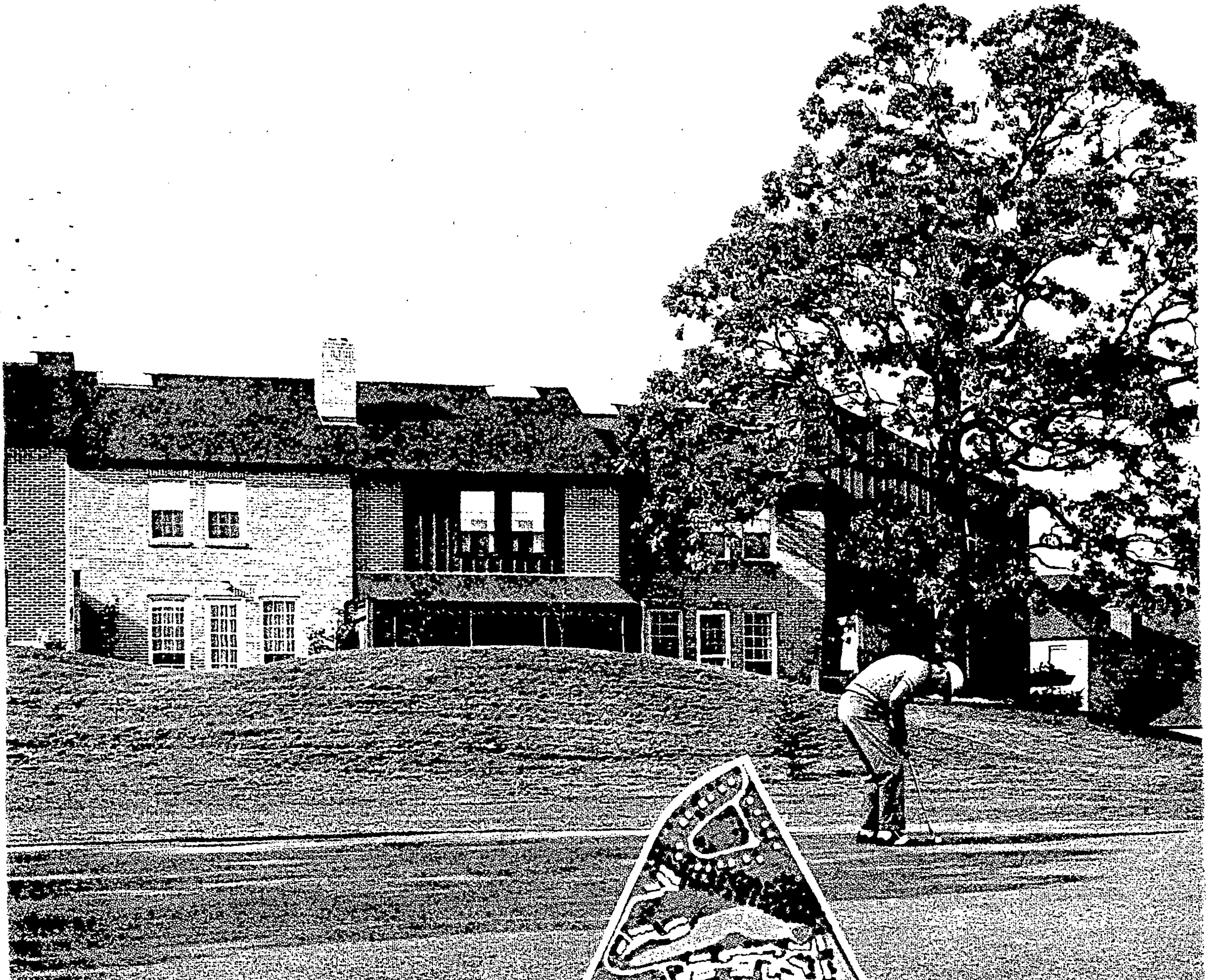
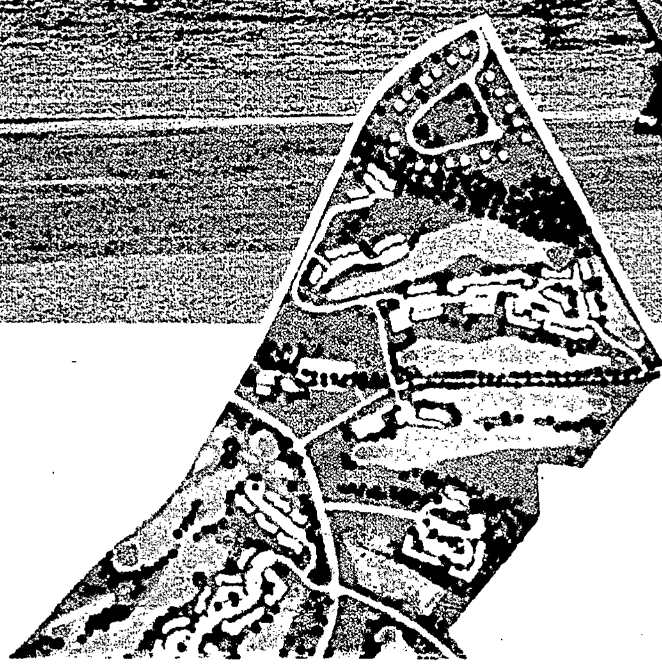


Figure 24

Flying Hills, Pennsylvania (Planners: Rahenkamp, Sachs, Wells & Associates)
A Planned Unit Development of 1 337 units on 123 ha.

This project illustrates the planning principles of natural storm water drainage, cluster housing, and substantial open space (including an 18 hole golf course)





Golf-course orientation is a key amenity; as the site plan at right shows, the majority of Flying Hills' units have views of the 18-hole course, and the others overlook green areas. The first plan presented to township officials had more single-family detached houses and less open space. But the town ruled that the 95-acre golf course could not be counted as open space, so the planners shifted to a greater proportion

greenbelt, more than 50% of the project's 305 acres is actually open space.

Flying Hills' streets have no curbs and gutters, an ecological feature that maintains natural run-off and absorption patterns and makes it unnecessary to have extensive storm drains.

In general, golf holes are built in valleys *(photo, top of facing page)*, while housing follows the site's space easements (under infrequent major storm conditions)

- some additional engineering costs (minor).

Costs and Benefits

Storm water drainage is often combined with revised engineering and planning standards, in those studies which have tried to address comprehensively, the issue of how to lower housing and site development costs. Two important recent studies indicate that capital costs can be reduced with techniques such as cluster housing, natural storm water drainage, and more realistic servicing standards.

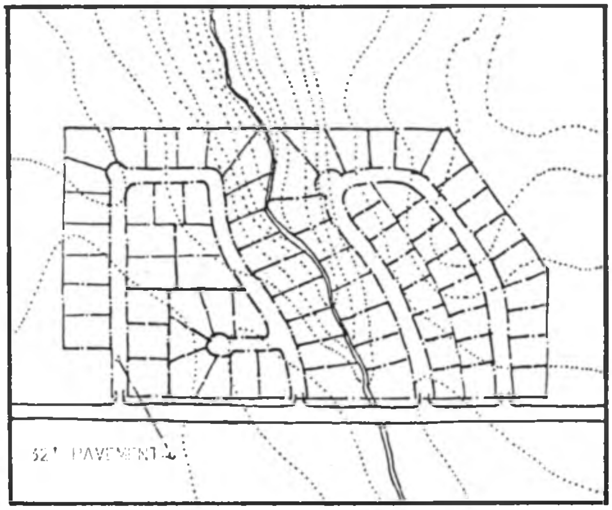
In one American reference (Land Design Research Inc., 1976), cluster and conventional plans were analysed in detail for site development costs on an 80 ha site. Major savings in site development costs (up to $1,000/lot for single family housing) were achievable through practices such as eliminating road curbs and gutters, and using natural drainage swales with retention ponds. The conclusions are applicable to Canada in most instances although U.S. densities are comparatively lower.

Similar conclusions were reached in an Ontario study on urban development standards (Barnard et al, 1976), which found significant savings in reduced engineering standards, although a more significant factor was more rational planning standards (chiefly higher densities). Potential savings amounted to $6,000 to $8,000/lot, with revised engineering standards accounting for $1,770 of this differential. (These included narrower pavement widths, natural house drainage with fewer service connections and catch basins, and smaller diameter storm sewers). Other engineering standards could not be related to environmental conditions except indirectly (for example, reducing road rights of way also reduces impervious surface area, and thus, the size of storm sewers).

One graphic example of the development cost savings possible with cluster housing, and its effects on roads and sewers, is illustrated by Rahenkamp and Ross (1977) (see Figure 25).

In assessing storm water management practices alone, there can be so much variation among local conditions (and therefore the appropriate combination of practices), that it is difficult to give precise estimates of the cost savings of natural drainage systems in comparison with conventional methods, except on a specific case by case basis. In one example where such a comparative analysis was done, Woodlands New Community (Wallace, McHarg, Roberts & Todd, 1973), north west of Houston, Texas, a natural storm water drainage system costing $4,200,000, saved $14,500,000 in capital costs over a conventional storm drainage system costing $18,700,000 (over a development area of 7 200 ha).

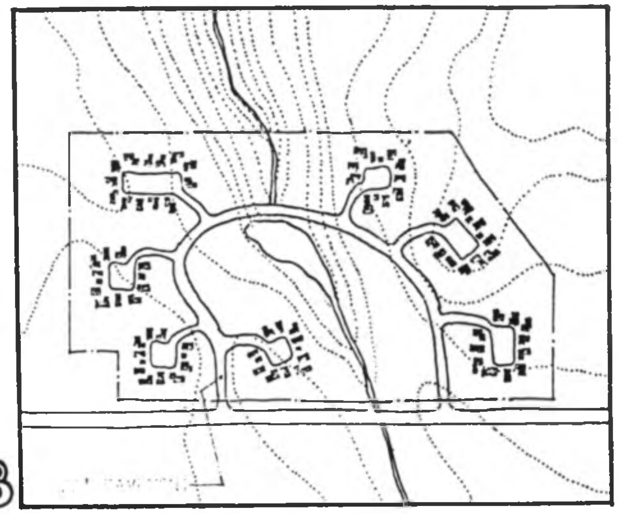
In the Plan for the new resource community of Tumbler Ridge (Case Study) in north-eastern British Columbia, a natural gutter/swale drainage system was estimated to cost as much as $2,140/unit less than a conventional piped system.



1

CONVENTIONAL LOTTING SCHEME

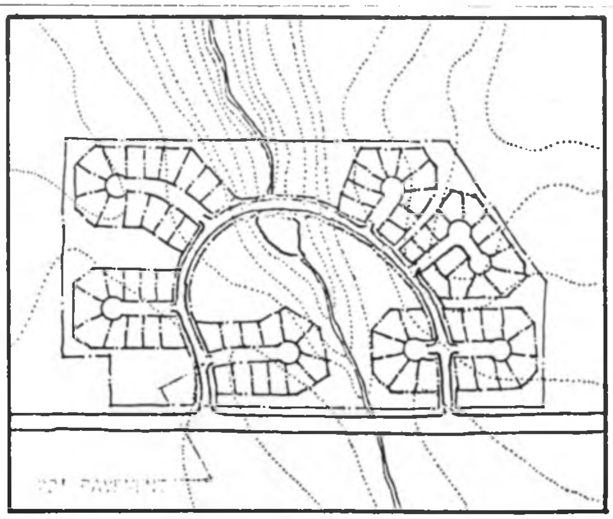
Site Size	42 acres
Number of Units	75
Density	1.8 du/ac
Average Lot Size	15,000 sq. ft.
Percentage of Site Requiring Grading/Clearing	90%
Amount of Open Space	0%
Road Costs (3,750 ft. @ $75.)	$281,250
Water and Sewer Costs (3,750 ft. @ $50.)	$187,500
Total	$468,750



3

CLUSTER HOUSES

Site Size	42 acres
Number of Units	75
Density	1.8 du/ac
Average Lot Size	2,500 sq. ft.
Percentage of Site Requiring Clearing/Grading	40%
Amount of Open Space	40%
Road Costs (2,000 ft. @ $75.)	$150,000
Water and Sewer Costs (2,650 ft. @ $50)	$132,500
Total	$282,500
Cost Reduction from Conventional Scheme	50%



2

CUL-DE-SAC CLUSTERS

Site Size	42 acres
Number of Units	75
Density	1.8 du/ac
Average Lot Size	5,500 sq. ft.
Percentage of Site Requiring Clearing/Grading	50%
Amount of Open Space	35%
Road Costs (3,250 ft. @ $75.)	$243,750
Water and Sewer Costs (2,650 ft. @ $50.)	$132,500
Total	$376,250
Cost Reduction from Conventional Scheme	20%

Figure 25

Source: A. Ross, J. Rahenkamp; "Cluster Housing", Input, (Real Estate Institute of British Columbia, October, 1977)

Thiel (1976) in his study of U.S. and Canadian development projects noted that there were no installations of "zero increase in runoff" systems which were more expensive than conventional storm water systems, and in most cases very substantial savings were realized.

In other instances, the capital costs of a major retention pond or lake, if marketed as a project amenity, can be recovered from higher prices for lots in the immediate vicinity. For example, the $750,000 cost of Lake Aquitaine (although not planned strictly as a retention facility) in the new community of Meadowvale, west of Metropolitan Toronto, is being recovered from higher lot prices. Similar experience has been reported in Winnipeg and Calgary, where recreational lake frontage lots are selling for as much as $10,000 higher than comparable non-frontage suburban lots in the same project*. (see Figure 26).

Thiel also notes several instances of projects which could not have been developed because of capacity restrictions in the receiving streams, but which were allowed to proceed with "zero increase in runoff" drainage concepts.

To achieve natural drainage objectives, drainage design should be integrated into the overall development planning process, through other supporting practices such as:

- roadway design eliminating curbs and gutters where feasible (shoulders must be provided to prevent pavement edge unravelling, together with markers or bollards for snow plowing)
- incorporation of storm water drainageways into open space systems
- retention of existing trees and vegetation to the greatest extent possible
- housing density and design to minimize lot coverage by buildings, or to scale coverage to the absorptive capacities of the soil and terrain.

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* Ivan Lorant; CMHC Environmental Planning Seminar, Don Mills, Ontario, December, 1978

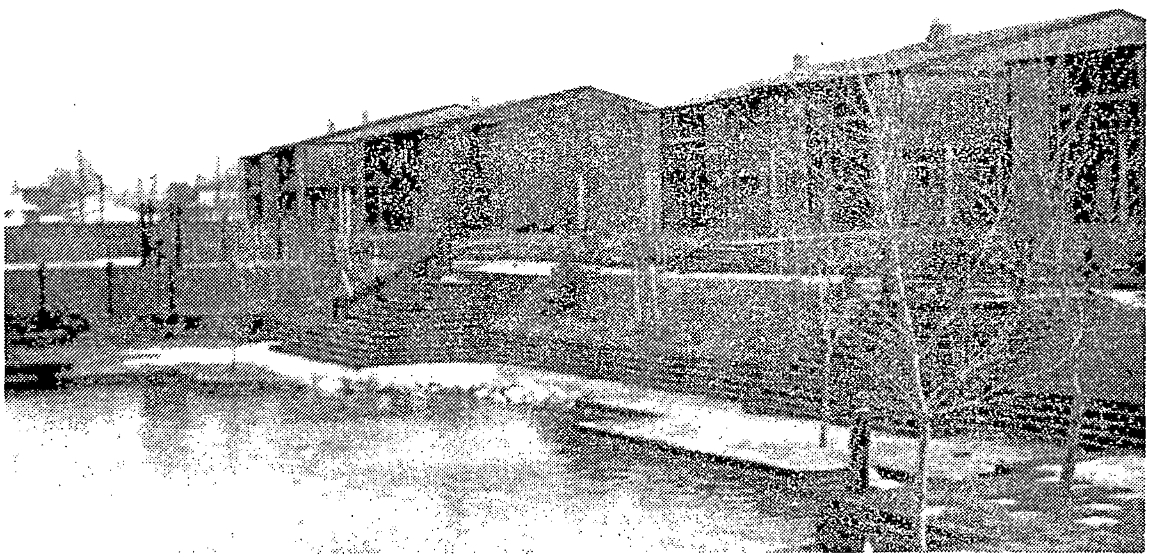


Figure 26: Permanent Retention Ponds in Residential Neighbourhoods, Winnipeg, Manitoba

(Photos: Ivan Lorant, M.M. Dillon Ltd.)

References: Storm Water

1. Barnard, P. et al; Urban Development Standards: A Demonstration of the Potential for Reducing Costs, (Toronto, Ontario Ministry of Housing, March, 1976)

2. M.M. Dillon & James F. MacLaren Ltd.; Flood Plain Criteria and Management Evaluation Study, (Toronto, Ontario Ministry of Natural Resources, 1977)

3. Hittman Associates; Approaches to Storm Water Management, (Columbia, MD, Nov., 1973)

4. Land Design Research Inc.; Cost Effective Site Planning, (Washington, National Association of Home Builders, 1976)

5. Leopold, L.B.; Hydrology for Urban Land Planning, (Washington, D.C., U.S. Department of Agriculture Circ. 544, 1968)

6. Rahenkamp, J.; "Natural Drainage", House & Home, (Dec., 1976)

7. ---- & Ross, A.; "Cluster Housing", Input, (Real Estate Institute of British Columbia, October, 1977)

8. ----, Sachs, Wells & Associates; Comotara: Design Standards, (Wichita, Kansas, April, 1975)

9. Thiel, P.; Zero Increase in Storm Water Runoff, (Toronto, HUDAC, 1976)

10. Tourbier, J.; Water Resources as a Basis for Comprehensive Planning and Development of the Christina River Basin, (newark, Delaware, University of Delaware Water Resources Center, April, 1973)

11. ---- & Westmacott, R.; Water Resources Protection Measures in Land Development: A Handbook, (Newark, etc., April, 1974, NTIS PB-236 049)

12. Urban Land Institute et al; Residential Storm Water Management: Objectives and Principles, (Washington, 1975)

13. Wallace, McHarg, Roberts & Todd; Woodlands New Community: An Ecological Plan, (Philadeplphia, 1973)

14. Wells, R.; "The Power of Water in Planning", Landscape Architecture, (Jan., 1974, pp. 21-26)

D.3 CLIMATE

Development adaptations to climate are fundamentally concerned with the creation of acceptable micro-climates for habitation: maximizing the warming effects of solar radiation in winter, and reducing the chilling effects of winter winds. Of course, the specific adaptations required for human comfort will vary with the seasons, and the climatic zones of Canada (see Chapter E). Much of Canada is in a "cool" or "cool temperate" climatic zone in which heat conservation is the primary concern for 3 of the 4 seasons of the year. While most of the climatically-based concerns in site planning and housing design should be for heat entrapment and retention, summer cooling can usually be provided through sensitive placement of vegetation to modify the external micro-climate of the house, as well as appropriate architectural devices for shading. Climatically-sensitive design has received a great deal of popular interest due to concerns about rapidly increasing space heating costs, and is commonly termed "passive solar" design, in contrast with "active" solar design which uses the "active" technology of collectors and storage devices to utilize solar energy.

Three kinds of responses are available to the physical planner in climatically-sensitive site design for housing:

- Orientation

  A due south or slightly south south-east orientation is preferred for for the long faces of the building since it combines the objectives of maximum solar insolation (particularly in winter when the sun only moves from south-east to south-west) with shelter from winter winds (which are generally from the north or north-west) A slightly east of south orientation is advantageous in that the dwelling receives solar radiation when it is most needed (early morning is generally the coldest period of the day).

  A south south-east orientation can also admit cooling breezes in summer if that is the prevailing wind direction in summer, as it often is. (However, regional wind patterns may be redirected by local topography, vegetation, and buildings, so the characteristics of the site micro-climate must be examined carefully, and housing designed specifically to achieve this objective on each site.)

  Active living spaces should be oriented to the south to take advantage of winter sun. (Figure 27)

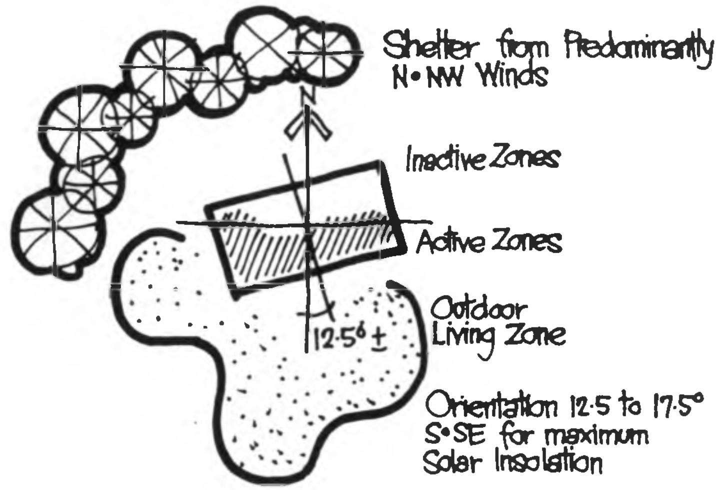


Figure 27: Orientation

These two criteria alone could have a dramatic effect on conventional subdivision plans: streets would be predominantly east-west, therefore houses on the north side of the street would be differently planned for solar orientation from houses on the south side (Figure 20)

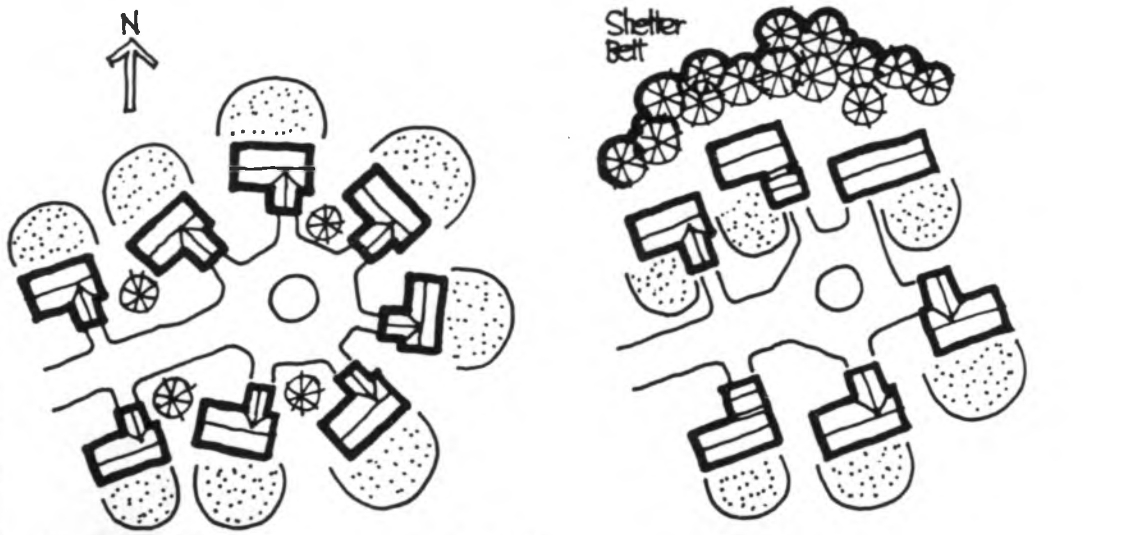
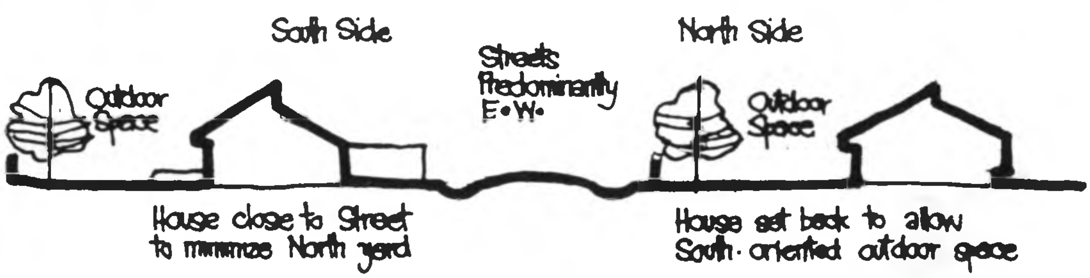


Figure 28



the potential wind funnel effects from a predominantly east-west road orientation should be avoided through tree shelter belts, staggering of units, short cul-de-sacs, and loop roads (Figure 29)

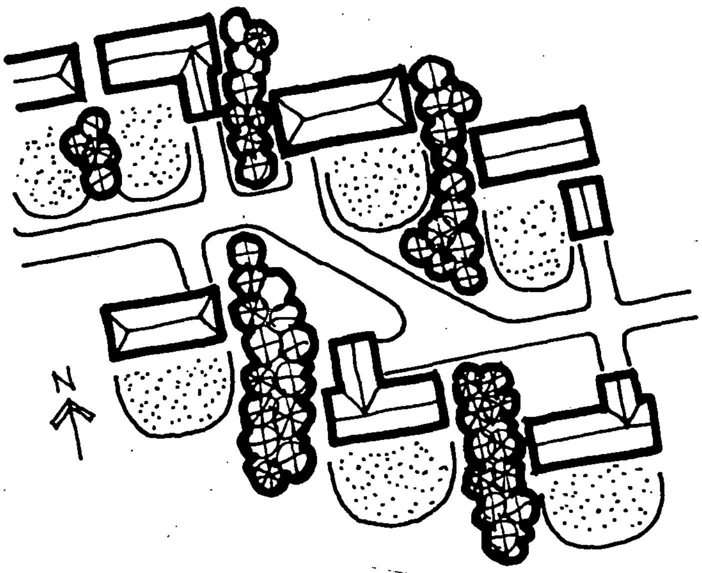


Figure 29

- <u>Location</u>

  Buildings should be set on the lee side of hills, in wind shadow

  Frost pockets in valleys and gullies where cold air can collect, should be avoided as housing sites

  Northern exposures should be protected with evergreens and earth mounds (Figure 30)

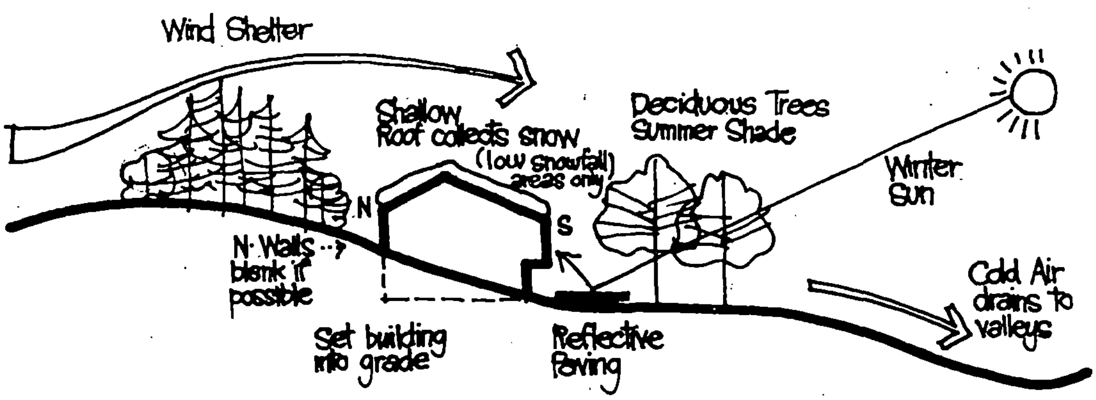


Figure 30

- Housing Form

Glass areas on northern exposures should be avoided since there is no solar radiation to balance the heat losses from the windows. Glass areas should also be minimized on the eastern and western exposures, with the largest glass areas on the south. (Figure 31)

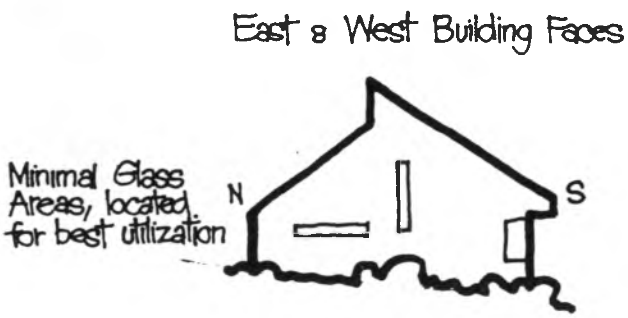


Figure 31

Shallow roofs should be used to retain snow and its insulating qualities (in low to moderate snowfall areas only) (see Figure 30). In high snowfall areas, the criterion becomes reversed: snow shedding action must be encouraged in order to avoid snow build up and structural failure; and high pitch roofs should be used.

Dark building colours can be used to absorb solar radiation in the winter (although sheltering with deciduous trees may be necessary in the summer).

Sun pockets can be created by the siting of buildings, the placing of trees and vegetation, and reflection of the sun. (Figure 32)

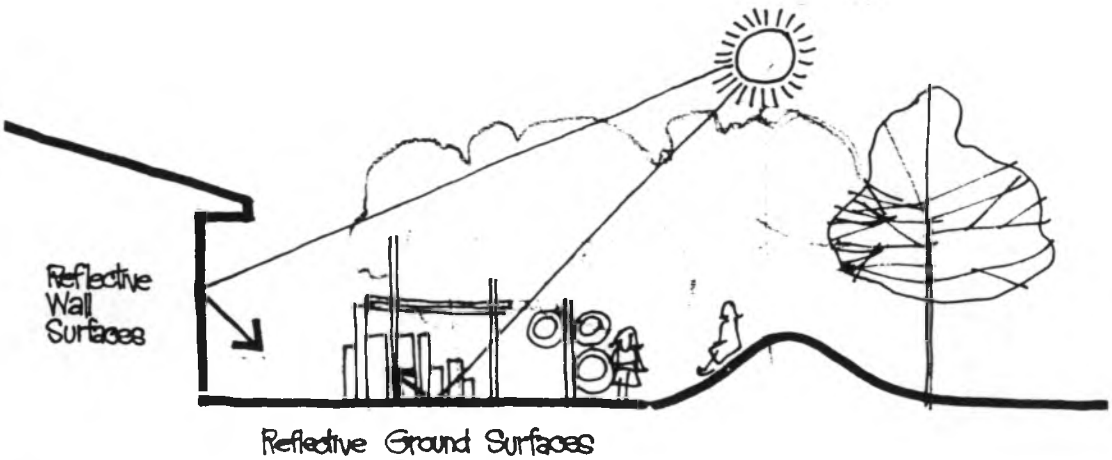


Figure 32

Shading devices attached to the building (such as slats, adjustable shades, and removable sashes) as well as free-standing devices such as fences, walls, and sun screens, can be used to shield the building from the summer sun. Their most common use will be on the south and south-west building faces. Such devices must be designed and positioned so as not to block sunlight to the unit during heating seasons; this can be accomplished by a careful study of the local seasonal sun angles. (Figure 33)

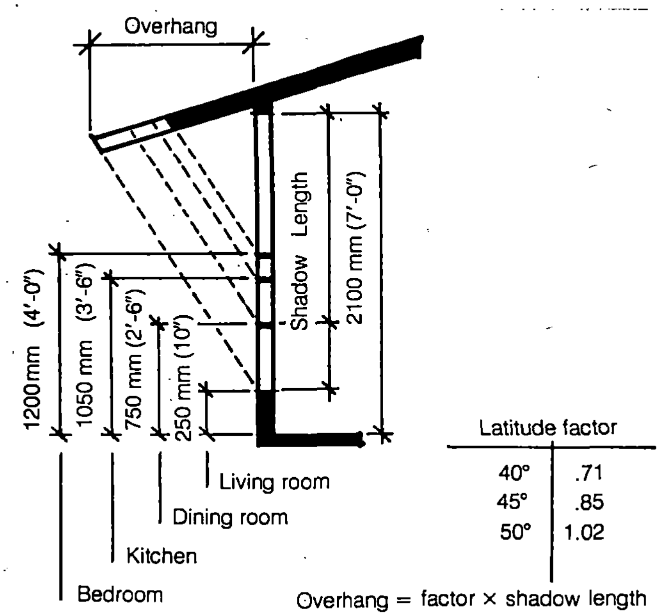


Figure 33: Preferred projection of Roof for Effective Shading

(Source: CMHC, 1977, p. 27)

Costs and Benefits

Substantial financial benefits have been claimed by several authors for climatically-sensitive site planning, but the necessary analytical work to make estimates precise has only recently begun. The savings will vary significantly among different climatic regimes. For example, Olygay (1965) suggests that building orientation on south-facing slopes can result in fuel savings of 22-30% over locations on flat lands (in the temperate climatic zone). Middleton Associates suggest that energy savings of 10 to 15% are possible with proper house orientation*. However, a study currently underway (1979) by the Ontario Ministry of Housing on residential area design and energy conservation, indicates that the energy savings from correct orientation alone may be limited to only 3 to 5%, even in the relatively favourable climate of southern Ontario. Energy savings are however, quite substantial (38 to 40%) when densities are doubled from single family detached (18 units/ha) to townhousing (36 units/ha).

It is clear that measures to improve solar insolation (such as increasing south-facing glass areas) must be balanced with other design responses within the housing unit, to store heat and prevent heat losses at night. These include insulated shutters and thermal sink devices such as concrete floors and walls with high thermal mass, rock pits, water tanks, etc.) With integrated energy conservation design of both the site and individual dwellings, it is possible that the full energy savings from passive solar design may be much greater than the Ontario results suggest.

A further benefit of the proper solar orientation of the housing unit (with the long axis of the building in the east-west direction) is that it allows easy incorporation of "active" solar collector devices as that technology becomes cost-effective.

While tradeoffs may have to be made between the optimal "solar" orientation and other factors such as terrain conditions, climatically-sensitive planning is relatively cost-free, requiring few changes in housing construction or servicing technologies, in comparison with conventional subdivision practice.

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* Statement, Canadian Institute of Planners Conference, Calgary, July, 1978)

References: Climate

1. American Society of Landscape Architects Foundation; Landscape Planning for Energy Conservation, (Reston, VA, Environmental Design Press, 1977)

2. Central Mortgage and Housing Corporation; The Conservation of Energy in Housing, (Ottawa, NHA 5149, 1977)

3. Keplinger, D.; Designing New Buildings of Optimum Shape and Orientation, (Ottawa, ECE Seminar, October, 1977)

3. Land/Design Research Inc.; Cost Effective Site Planning, (Washington, National Association of Home Builders, 1976)

4. Olygay, V.; Design with Climate, (Princeton, 1965)

5. Ontario Ministry of Energy; Perspectives on Access to Sunlight, (Toronto, May, 1978)

6. Schoenauer, N.; Shape and Orientation of Buildings: Design for Energy Conservation in the Sub-Arctic, (Ottawa, ECE Seminar, October, 1977)

7. Wallace, McHarg, Roberts & Todd; Adaptive Architecture, (Ponchantrain New Community, 1973)

8. ---- ; Woodlands New Community: Guidelines for Site Planning, (Philadelphia, December, 1973)

D.4 VEGETATION

Vegetation (including trees, shrubs, and ground cover) has an important role in moderating climatic extremes, sheltering buildings from wind effects, and in absorbing air-borne pollutants. Trees, in particular, can have a highly beneficial effect: in winter they absorb solar radiation, thereby moderating falling temperatures, and in summer they provide evaporative cooling through foliage.

Deciduous trees and shrubs can balance the needs for winter solar orientation (requiring exposed south-facing building faces) with the needs for summer cooling (which mitigate against such exposures). Trees planted or retained to the south-east, south, and south-west of housing units can provide the required summer shading, while their leaves drop in the fall, permitting the winter sun to shine through to the unit.

Year-round wind protection to the windward (usually north and west) of housing units can be provided by a combination of coniferous trees and shrubs, as well as fences and other barriers (see Figure 34).

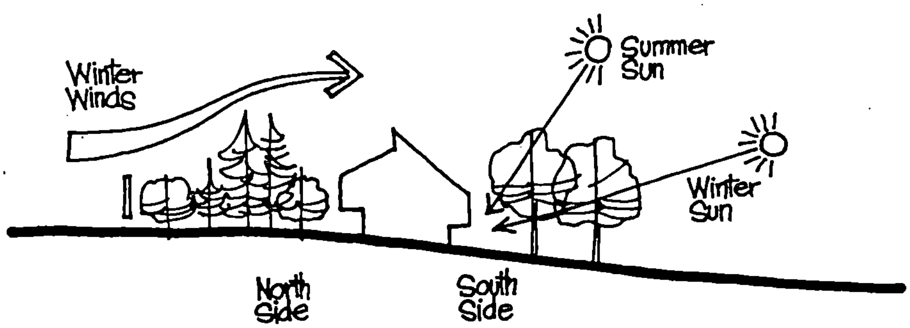

Figure 34

All trees should be planted at a sufficient distance from structures so that the root systems do not interfere with building foundations.

Shrubs and ground cover can also lower summer temperatures by releasing moisture stored in their foliage. The strategic location of such vegetation around the dwelling can create cooling breezes to reduce the need for artificial cooling. (CMHC, 1977, p. 24). Figure 35 gives an example of a landscaping arrangement of coniferous and deciduous shrubs and trees that can help to reduce the energy requirements of a dwelling on the north side of an east-west street. (Source: CMHC, 1977, p. 24)

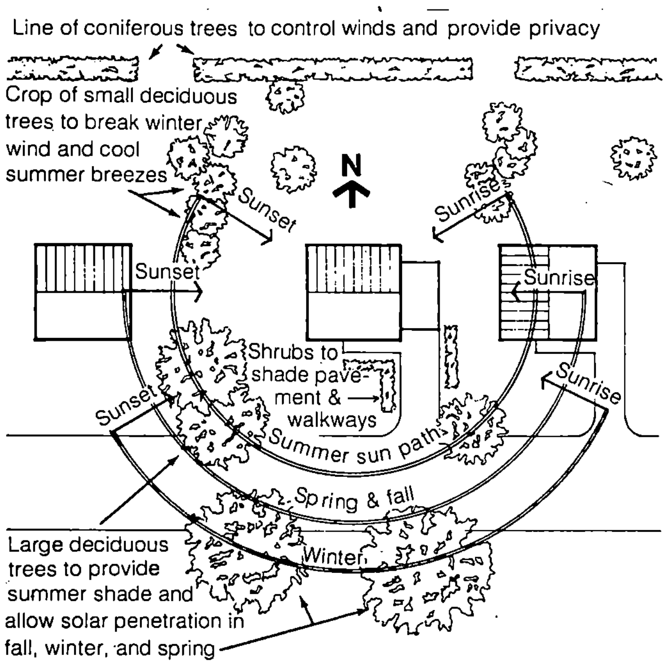

Fig. 2.6 Effective use of trees around a dwelling on the north side of an east-west street

Figure 35

Viable clumps of trees also serve other important functions: the mass of tree roots underlaying steep slopes may be the only mechanism capable of retaining the soil in place. Thus, existing vegetation should be retained on all "no-build" slopes (generally those greater than 15 to 18%) Trees should also be retained some distance back from the tops of banks in order to prevent erosion and gullying. (Figure 36).

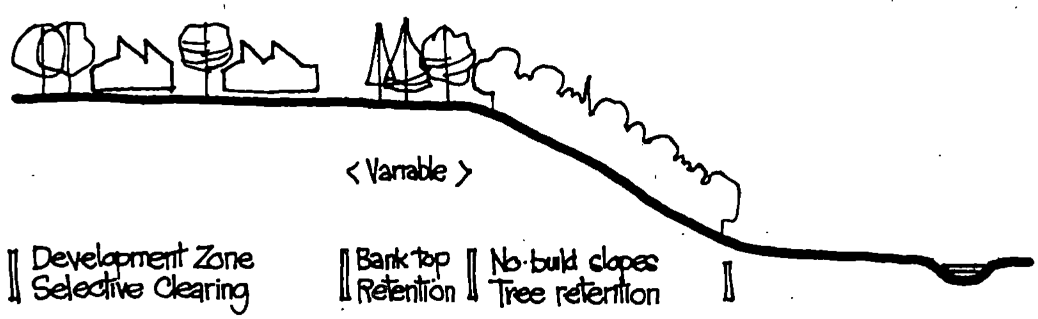

Figure 36

Healthy woodlots also have a vital environmental role in controlling runoff and erosion, and filtering pollutants.

Shelterbelts of trees and shrubs can also be retained or planted to reduce wind velocities and control snow drifting. The precise interactions between trees and shrubs of different species and sizes, and buildings of different shapes and sizes, under changing wind conditions, is a complex subject, which must be restudied for every particular context.

As a general rule, a shelterbelt of medium (50%) penetrability will substantially reduce wind velocities for a short distance to the windward, and for a long distance (up to 25 tree heights or more) to the leeward. Wind velocities are reduced to a minimum, a short distance to the lee of the shelterbelt. (see Figure 37).

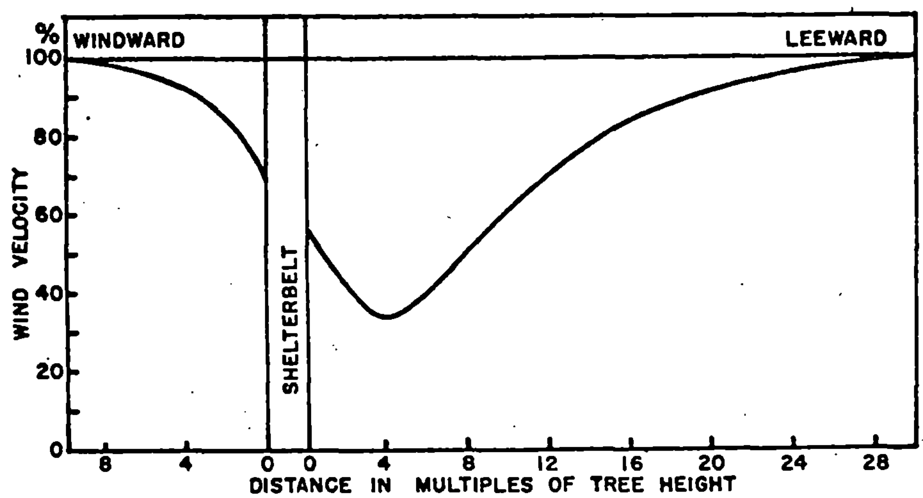

FIGURE 119. Mean wind speeds near shelterbelt of medium density. Data obtained by Nageli (after Staple).

Figure 37: (Source: Chang, 1968)

Windborne snow is deposited wherever there is a local drop in wind velocity. This, in open areas, a properly designed windbreak can cause snow to deposit immediately adjacent to, and some distance from it. This is an important factor to consider in locating transportation routes, pathways, driveways, and the housing unit itself. (Figure 38).

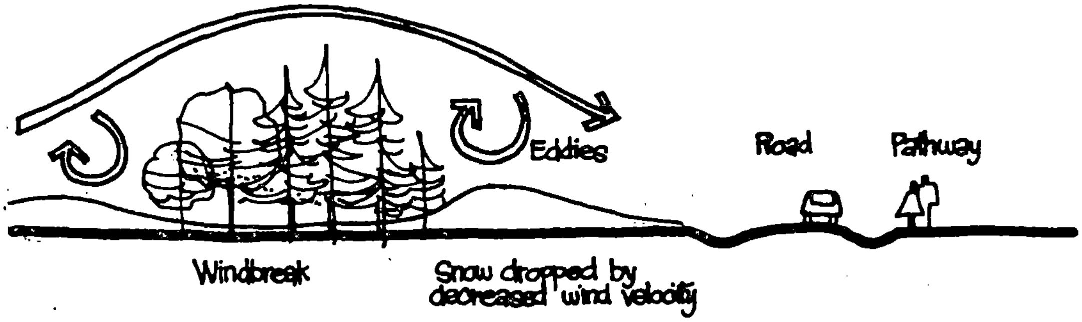

Figure 38

Robinette (1972) also notes that prudent planting can greatly reduce the costs of snow removal on parking lots and other areas. Velocities increase through openings in shelterbelts, as well as at the ends of windbreak planting, resulting in snow scouring. This can be used to provide snowfree parking lot entries, roadways, or walkways.

Preservation of Existing Vegetation

Site planning and housing design should be flexible and adaptable in order to maximize tree preservation on each particular land parcel. As lots become smaller; reducing front, rear, and side yards, as well as house size, trees and landscaping take on greater importance in softening and giving character to more dense and urban neighbourhood streets. (Figure 39).

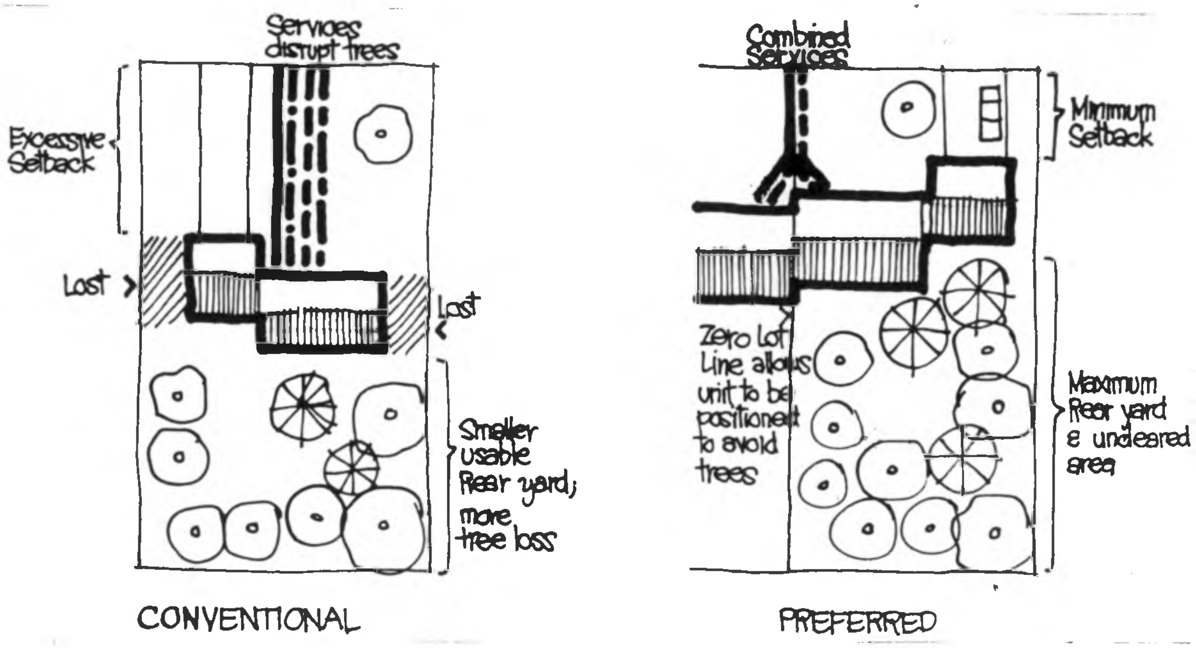

Figure 39

Sound construction practices for tree preservation include:

- selective rather than massive site clearance
- identification of areas subject to erosion
- precautionary steps to protect healthy stands of trees, as well as individual feature trees.
- maintenance of water tables (by avoiding drastic grade changes).

Since the probability of tree survival is far greater in woodlots than for individual specimens, viable clusters of trees should be retained wherever possible. Alteration of the water table is the greatest threat to woodlot stands, and therefore, natural grades and drainage should be maintained in the vicinity of the woodlots to be preserved.

Specific protective measures include:

- Tree evaluation: identification of species groupings, quality of trees, and survival ratings, in view of the proposed grade changes (if any).
- "Self-maintaining" tree stands should be identified and designated for protection (i.e. requiring no human intervention or management if hydrological and ground cover conditions are maintained).
- All trees and woodlots to be retained should be cordoned off with snow-fencing or hoardings, to keep them free from damage by construction equipment. (see Figure 40)

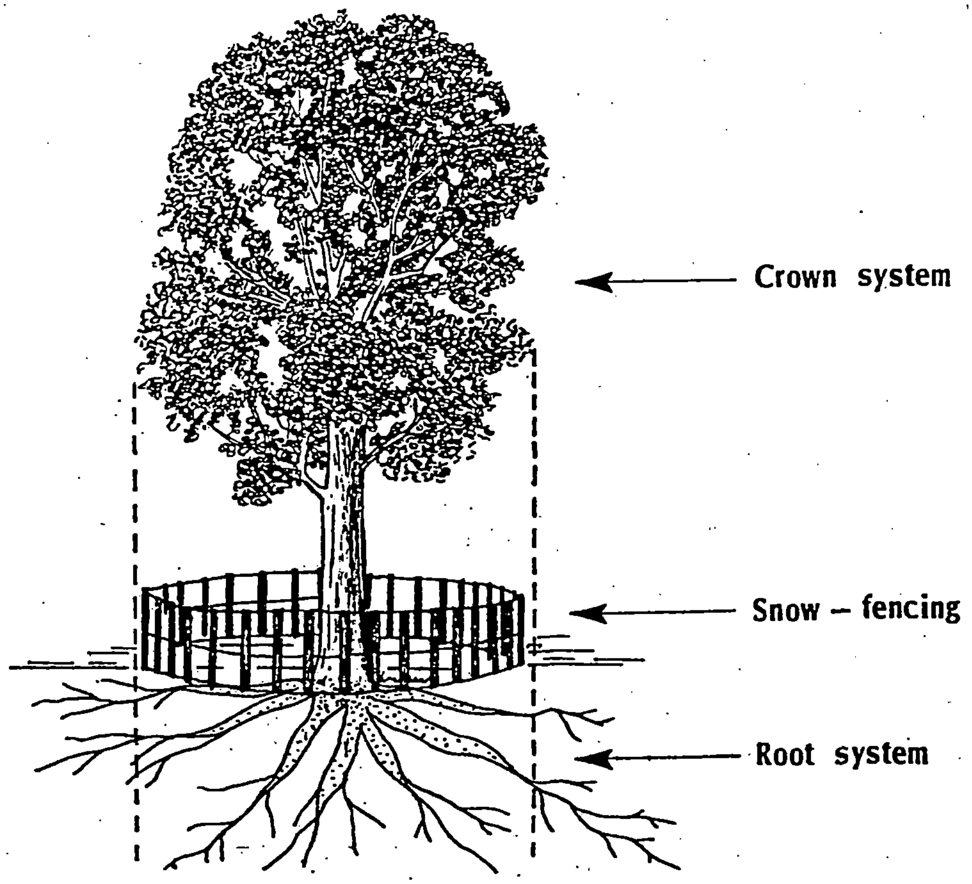

Figure 40: Tree Protection

Source: Cadillac-Fairview Corporation

- Primary and secondary drainage channels should be accompanied with vegetation easements, 15 to 100 m wide.

- Care should be taken during construction not to sever tree roots, make land cuts which would expose tree roots, or cause root soil compaction from heavy equipment.

- If tree removal is necessary for road construction, trees to be removed should be taken out gradually, one year prior to actual construction, so that the adjacent trees have time to adapt to the changes.

The retention of individual trees may not always be in the long term best interest, or even physically practical. The decision to retain depends on factors such as a tree's health, age, position on the site, windthrow hazard, etc. Again, individual specimens may be particularly susceptible to changes in the water table.

Trees vary considerably in their ability to tolerate soil filling. Generally, filling tends to lead to root suffocation, compaction, crown rot, and eventually, death. There may be tradeoffs between the desire to retain a tree on site, and the requirements for lot drainage. In many fill cases, a tree "well" with drainage tile may be the only feasible way to save major specimens.

Figure 41: Treetop Estates, Oakville, Ontario

A ravine-edge townhouse project which benefits from the retention of existing trees.

(Photos: T. Martin)

Costs and Benefits

The planting of new vegetation, and the retention of existing trees and vegetation both have potential economic benefits:

- Tree shelter belts, 15 to 20 m wide, can substantially lower wind velocities (see Figure 37), which, in turn, will reduce convective heat losses. In one community in northern Quebec, for example, a reduction in wind speeds from 30 km/h (in open areas) to 8 km/h (in sheltered areas) was estimated to reduce heat losses by up to 50%*. Tree shelter belts must be fairly dense and wide, since single or double tree rows have a relatively minor sheltering effect.

- Every m^2 of a development site which can be retained in its natural vegetative cover can reduce landscaping costs by $2.00 or more; a substantial savings for lots with 100's of m^2 to be landscaped. In one example, a Planned Unit Development project of 700 units on 46 ha, on a wooded hillside in New Jersey**, where selective rather than widespread clearing was practiced, the following savings were realized:
  - $625 to $675/ha in clearing costs
  - $300 to $500/unit in reduced landscaping costs, since trees were already in place
  - further savings of $1.00 to $2.50/$m^2$ on steeply sloping areas which did not require sophisticated ground covers for stabilization.

Tree protection measures also have a generally favourable benefit/cost ratio. Benefits include:

- avoidance of new tree planting costs ($150+/tree) and removal of existing tree costs
- increased project amenity and lot sale prices (as high as $500 to $2,000/lot with mature trees) (see Figure 41).

Some of the costs of tree protection include:

- tree identification and tagging ($4/tree)
- re-usable snow fencing and other protection costs ($30/tree ±)
- greater skill and care required in machine movement, grading, and location of trenches.

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* Fermont, Quebec

** Pine Run, New Jersey (Planners: Rahenkamp, Sachs, Wells & Associates)

References: Vegetation

1. American Society of Landscape Architects Foundation; Landscape Planning for Energy Conservation, (Reston, VA, Environmental Design Press, 1977)
2. Cadillac Fairview Corporation; Tree Policy - Erin Mills, (Toronto, 1976-78)
3. Central Mortgage and Housing Corporation; The Conservation of Energy in Housing, (Ottawa, NHA 5149, 1977)
4. Chang, J.H.; Climate and Agriculture, (Chicago, 1968)
5. Design Branch, Department of Public Works; Landscape and Site Development, (Ottawa, 1972)
6. Robinette, G.O.; Plants, People, and Environmental Quality, (Washington, D.C., U.S. National Parks Service, 1972)

D.5 CONSTRUCTION: EROSION AND SEDIMENTATION CONTROL

Construction has the highest potential of all of man's land-based activities to cause loss of soils (as high as 350 tonnes/ha or 3 500 tonnes/ km^2). The loss of soil directly affects the ability of the landscape to support vegetation (paricularly lawns and gardens), and in some cases, to support structures and foundations.

Urban development areas under construction can produce 20 to 200 times as much sediment as farmland or wooded areas (Figure 42). When this sediment gets deposited in waterways, it can create special problems in harbours and navigable rivers. For example, $232,000,000 was spent in the U.S.A. in 1974 to dredge 275 000 000 m^3 of sediment from harbours and waterways. (Layne, 1976)

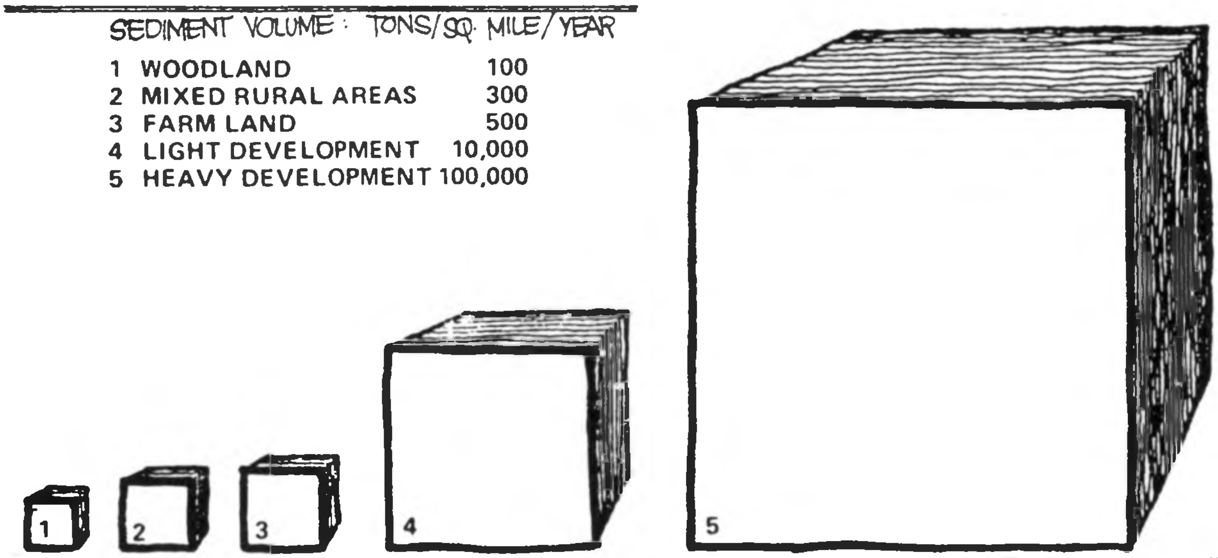


Figure 42: Volumes of Sediment Eroded from Land of Different Uses

(Source: Leopold, 1968)

Erosion damage to construction sites can include rilled or gullied slopes, gullied waterways and channels, washed out roads and streets, undercut pavements and pipelines, and debris in work areas. This damage must be repaired, causing delays and cost increases.

The potential downstream effects of the transport of eroded soils include:

- siltation (a particularly severe problem in reducing the capabilities of water reservoirs and harbours)
- loss of aquatic habitats
- interference with groundwater recharge
- more frequent floods of greater magnitude.

Downstream engineering measures to alleviate erosion, such as impoundments, dams, levees, stream bank protection, etc., can be extremely expensive and yet, do not deal with the source of the erosion. Dealing with the problem at its source is far more economical and environmentally sound.

The basic principle in construction operations, as in the completed proect, is to do as little to the land as possible, thereby allowing natural drainageways to be maintained, and existing trees and vegetation to absorb runoff and retain the soil. Other important principles include:

- Construction operations on sites where erosion may be potentially severe should be scheduled at times of the year when runoff is lightest (for example, summer rather than spring)

- Existing vegetation should be retained to the greatest extent possible, particularly on slopes

- Soils should be exposed in the smallest areas possible for the shortest amounts of time. Grading should be completed in one area before moving to other areas. Temporary vegetation, such as rye grass or millet can be used as a mulch to protect exposed areas, with permanent vegetation being planted as soon as possible after construction.

- On exposed banks, surfaces should be roughened to decrease runoff and slow the downhill movement of soil. On slopes, construction equipment should move transversely across the slope, so as not to leave the site more susceptible to erosion. Cultivation and seeding should also be done across slopes if possible.

- Topsoil should be retained on all areas except those acturally to be built on; in construction areas, topsoil should be stripped and stockpiled nearby for future regrading.

- Grading should be restricted to the street right-of-way until storm sewers are installed, or conveyance swales and sediment traps are constructed.

Even with the above measures, surface runoff and some erosion may occur during construction, and measures should be taken to detain runoff on the site before discharge into the watershed. These include the use of:

- Dikes, ditches, terraces, etc. to divert and slow runoff, particularly over slopes. All structures of this type need a stable outlet to dispose of water safely.

- Chutes and downpipes to convey runoff from a higher to a lower elevation.

- Temporary sediment basins upslope from storm inlets. Larger basins should have perforated risers to permit gradual draw-down.

On slopes, the establishment of permanent vegetative cover may have to be aided through measures such as chemical stabilizers, netting or matting, and other retention devices.

These measures are described more fully in Figure 43.

Costs and Benefits

Construction practices for erosion and sedimentation control generally emphasize reduced grading, excavation, and large scale earth movement, enabling site development costs to be reduced as much as $2.00/m^2. However, additional operational costs such as preplanning, selective clearing, and more precise machine movement, must also be considered.

Consideration for construction operations is essential in site planning since it may be possible to avoid areas with high earthmoving costs, such as steep slopes with erodible soils. By clustering development on more favourable terrain, it is possible to maintain housing yields while minimizing erosion hazards. Sensitive planning can also avoid major environmental features such as large clumps of trees, which would be costly to clear or build near (not to mention the loss of benefits).

Direct erosion control methods such as temporary sediment basins, ditches, dykes and terraces, as well as temporary vegetation, add some additional costs to construction, which will vary with local conditions. Generally however, these are more than compensated by savings on the repair of gullying and erosion damage, and the loss of topsoil from the construction site.

Figure 43: Construction Practices: Erosion and Sedimentation Control

(Adapted from Tourbier & Westmacott, 1974)

1. Minimization of Stripped Areas

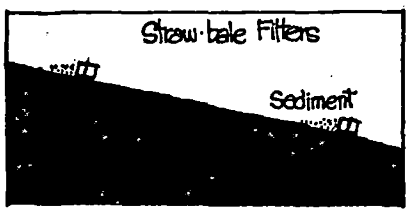
Existing or new (both temporary and permanent) vegetative covers and mulches are used to minimize wind and water erosion. Topsoil is stored in nearby stockpiles for later re-use.

Benefits:
- low cost
- vegetative cover prevents erosion, and also traps sedminent
- the developer avoids potential regrading costs which might be necessitated by erosion.

Liabilities:
- possibly higher earthmoving costs, since construction equipment must return for each area stripped.
- storage piles of topsoil may disrupt construction operations.

Costs:
- wide variance in costs; from $100 - 500/acre = $250 - $1,250 /ha, depending on the availability of materials, and economies of scale.

2. Barriers and Filters (Hillsides); Checkdams (Watercourses and Channels)



This involves the use of straw bale filters, and other means such as wire fences, stakes, rocks, brush, and sandbags, placed at right angles to the flow of runoff to trap sediment from construction.

Benefits:
- sediment control relieves the need to import additional topsoil to the site

Liabilities:
- periodic maintenance and removal of sediment required
- may limit the manoeuvrability of equipment on the site.

Costs:
- minor installation and removal costs

3. Vegetative Cover Protection

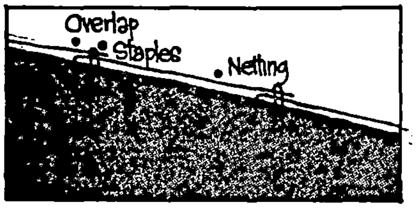
These include various methods for stabilizing the soil after final grading:

- Chemical stabilizers: soil binders prevent soil erosion either by forming superficial surface protection or by binding the top few millimetres of soil. Some products can form an effective chemical mulch which can help to conserve soil moisture during dry periods. Application is often combined with hydroseeding, all in one operation.

  Costs: $750 - $1250/ha

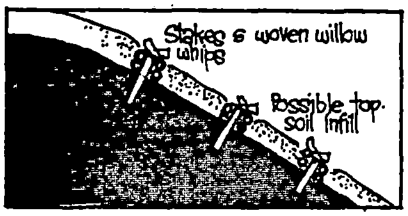
Figure 43: Construction Practices: Erosion and Sedimentation Control (Continued)

3. Vegetative Cover Protection (Continued)



- Netting or Matting: combinations of jute, paper, or chemical fibres within a retaining net; used on steep slopes (including swales and channels) to stabilize vegetation. The soil is stabilized by mechanical means; and netting must therefore be anchored in place to prevent slippage during rainstorms. Only unskilled labour is required for installation.

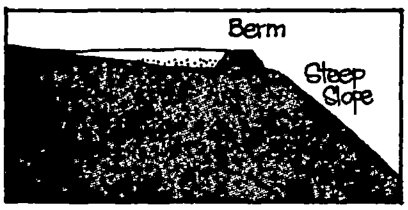
  Costs: $1.00 - $2.00/$m^2$



- Bio-technical Means: these include sod walls, fences of timber, stakes, willow, or brush, sometimes in combination with a mesh or netting. Used on steep slopes, cut and fill banks, and unstable soil conditions that cannot be stabilized through seeded vegetation.

  Costs: more expensive than conventional slope stabilization, due to hand labour costs.

4. Temporary Diversions and Berms



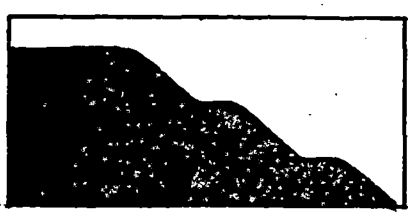
Temporary landforms (berms and ridges) are used to divert runoff away from critical areas during construction, and to minimize erosion from highly susceptible areas.

Benefits:
- erosion control: prevents siltation of permanent storm drainage systems.
- minimizes regrading necessary after construction erosion.

Limitations:
- removal and disruption costs

Costs:
- $5 - $6/m.

5. Benches and Terraces



Benches and terraces modify the form of steep slopes by roughening them, and reducing slope length, in order to reduce erosion hazards. Runoff is slowed and diverted along ridges, increasing the potential for infiltration.

Figure 43: Construction Practices: Erosion and Sedimentation Control (Continued)

5. Benches and Terraces (Continued)

Benefits:
- checks runoff flow
- traps sediment

Liabilities:
- may increase cut and fill costs significantly
- must be removed for permanent grading.

Costs:
- not detailed (more expensive than diversion berms).

6. Chutes and Downpipes

Asphalt chutes and flexible downpipes can be used to convey construction runoff from a higher elevation to a lower elevation.

Benefits:
- prevents erosion damage to slopes
- prevents siltation of partially completed storm drainage systems.
- minimizes delays caused by severe storms during the construction period.

Liabilities:
- removal costs
- limitations to the length of slope which can be protected.

Costs:
- Chutes: $500+ (10 m length)
- Downpipes: $4/m

7. Temporary Impoundments and Sediment Basins

The use of temporary ponds to detain sediments from runoff before it is discharged from the construction site; can be formed from earth embankments, straw bales, rock, etc.

Benefits:
- reduces downstream, and off-site damage
- prevents the loss of re-usable topsoil

Liabilities:
- removal costs (unless incorporated into final grading plan)

Costs:
- vary with design conditions.

References: Construction

1. Layne, Elizabeth N.: The Natural Environment: A Dimension of Development, (New York, National Audubon Society, 1976)

2. Leopold, L.; Hydrology for Urban Land Planning, (Washington, D.C., U.S. Department of Agriculture Circ. 544, 1968)

3. Soil Conservation Service, U.S. Department of Agriculture; Controlling Erosion on Construction Sites, (Washington, Agricultural Information Bulletin 347, Dec., 1970)

4. Tourbier, J. & Westmacott, R.; Water Resources Protection Measures in Land Development: A Handbook, (Newark, Delaware, University of Delaware Water Resources Center, April, 1974, NTIS No. PB-236 049)

D.6 ENVIRONMENTALLY SENSITIVE AREAS

Environmental Resource Areas (E.R.A.'s) or Environmentally Sensitive Areas (E.S.A.'s) are land and water sites which are vital to a community's safety, health, and welfare, or have potential as renewable or non-renewable productive resources. Included are wetlands, groundwater (aquifer) recharge areas, hillsides, shorelines and surface water bodies, wildlife nesting areas and woodlands. In addition to the above "sensitive" areas, some provinces and municipalities protect economic "resource" areas such as gravel pits, mineral deposits, and prime agricultural lands from encroachment by development. This chapter deals only with the management of environmentally sensitive areas already identified in the environmental assessment phase of the development planning process.

Environmentally Sensitive Areas such as wetlands and groundwater recharge areas are permanently lost through conversion to farmland (by drainage and filling) and to urban development. For example, in the Winnipeg Region, over 100 000 ha of wooded or marsh areas have been drained or cleared since 1946, representing a loss of over 45% of the wooded lands and 5% of the marsh lands in the Region.

Other areas such as the Rattray Marsh, an important migratory bird staging area in Mississauga, Ontario, have only been preserved from residential development after protracted legal battles and financial negotiations. Needless to say, the cost to the public sector to acquire such lands is much higher after they have been planned for development, than before. In other areas such as the estuarine wetlands in British Columbia's Fraser River estuary, the battle for preservation has not been successful: more than 70% has been lost to urban activities such as dyking and landfill.

The importance of Environmentally Sensitive Areas goes far beyond their aesthetic or wildlife habitat values: wetlands remove silt and other pollutants from groundwater, and protect communities from flooding and drought by serving as water recharge areas; woodlands protect watersheds and soil, increase water infiltration, reduce air pollution, and moderate temperature extremes. The loss of such areas in an urban watershed can seriously affect regional drainage patterns and result in major erosion and flooding problems. Sensitive areas also have high educational values, since their ecosystems are generally more diverse than other agricultural or urban lands.

The designation of E.S.A.'s in some parts of Canada has been attacked by the development industry as infringing on property and development rights. Possibly the most important and legally defensible rationale for Environmentally Sensitive Area management lies in the watershed protection functions of such areas (to maintain groundwater supplies and minimize flooding). This must be demonstrated on a case by case basis, since not every woodlot or swamp may be worthy of preservation or restriction from development. However, even for such minor Environmentally Sensitive Areas, there may be development strategies which are compatible with their ongoing maintenance. This kind of planning is still largely undeveloped in North America, although the Woodlands New Community near Houston, Texas and the Amelia Island residential community in Florida by the Philadelphia planning firm of Wallace, McHarg, Roberts & Todd, are examples of sensitive design responses to environmental resources of unique quality. (ref.)

D.61 Hillsides and Steep Slopes

While groundwater or vegetation are potentially renewable resources (that is, damage can be restored through appropriate management practices), hillsides are non-renewable. Slopes and soils exist in balance with vegetation. This equilibrium of vegetation, slopes, soils, and geology can be affected by development, with potential consequences such as:

- Loss of slope stability and accompanying soil erosion can cause hazards to human safety through landslides, slumps, and gullying. Remedial measures to correct such conditions can be extremely expensive and often subject to repeated failure.

- Local water quality can be affected by erosion and stream siltation, possibly necessitating water supply from distant sites.

- Construction and servicing costs can be prohibitive on some slopes. In most parts of Canada, this is generally taken as slopes in excess of 15 to 18%, although in British Columbia, stable slopes up to 27% have been developed. However, above a gradient of 20%, road and driveway access becomes difficult. The presence of rock can exacerbate these problems, particularly if blasting is required for underground services.

- If a hillside is drastically altered and graded for easier construction, the aesthetic qualities which attract buyers may be lost.

Appropriate development responses include the following:

- Extreme slopes (25% - 27% and greater) should be left undisturbed where human safety and development costs are critical. Slopes between 15% and 25% should be analysed carefully for stability and development feasibility.

- On moderate slopes which are developable, housing, roads, and utilities should be aligned with the contours of a slope. (Figure 44)

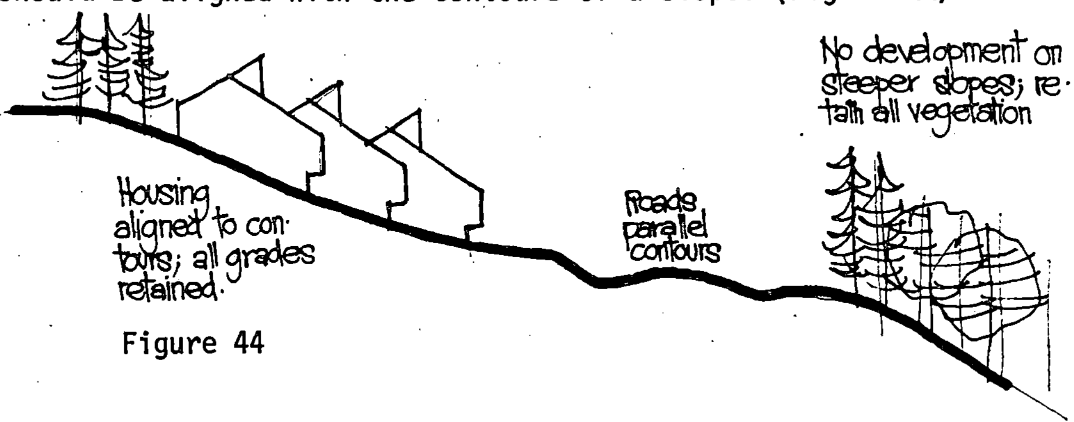


Figure 44

- Hilltops should be retained in ungraded condition.

- Existing vegetation should be retained on slopes as much as possible - this is particularly critical on the upper reaches of a hillside.

- The bases of hillsides should be examined carefully before development, since disturbance at the base can trigger mass soil movement.

- Original drainage patterns should be retained, and not blocked by new development.

- Slope/density ratios should be established - generally the higher the % gradient of the slope, the less intensive the development and grading permitted, in order to minimize environmental damage.

D. 62 Groundwater Recharge Areas (Aquifers)

Groundwater forms an essential link in the hydrologic cycle. It is fed by precipitation percolating through the soil and by seepage from surface water bodies. Groundwater therefore moderates the amount of surface water by absorbing it during flood periods, and releasing it during dry spells. It also provides the prime source of water for human use in many areas of Canada.

Contamination of groundwater reserves may necessitate the pumping of water from distant supply areas; excessive withdrawl can cause land subsidence, or encourage salt water intrusion in coastal areas. Frequent causes of groundwater pollution include: extensive paving (reducing the land area normally available for infiltration and filtration of sediments through the soil; inadequate or poorly sited septic disposal systems and landfill sites; extensive irrigation and drainage networks in agricultural areas; and excessive use of road salts in urban areas.

Examples where the results of groundwater mismanagement have been extremely costly include the Los Angeles Basin, where water supplies must be piped from reservoirs as far away as 500 km, and parts of Long Island in New York State, where salt water intrusion has occurred, necessitating extremely strict water conservation measures.

Appropriate development responses include:

- Careful location of sanitary landfill sites, septic disposal systems, and construction disposal sites to avoid contamination of recharge areas; limitations on the amounts of impervious surfaces in development projects.

- Water conservation practices are essential where withdrawl of groundwater exceeds the rate of recharge. Controlled use of wet meadows, ponds, and marshes for recharge purposes may be necessary in some areas.

- In areas of low filtration, effluents may have to be transported away from a recharge area. (This was done in the site selection for a resource community in the Lake St. Joseph area of northwestern Ontario: water supplies were drawn from one drainage basin, while treated effluent was discharged to an adjacent drainage basin. The community was located between both areas. Landfill sites may also have to be located outside watersheds from which watersupplies are drawn.

D.63 Wetlands

Many parts of Canada harbour extensive inland wetlands. These include low areas at the shallow edges of lakes and rivers, poorly drained lands, and lands partially covered with water for some of the year. Also included are marshes, swamps, bogs, wet meadows, and prairie potholes. It has been estimated that wetlands cover 1.3 million km^2 or 14% of Canada's land mass.*

However, very little of this wetland resource lies within 40 km of Canada's 23 largest cities and several major urban centres (for example Regina, Saskatoon, Toronto, and Windsor) have virtually no large wetland areas (i.e. greater than 60 ha) within 40 km of the city centre. This lack of wetland areas near some major cities minimizes problems of loss or degradation from population or development pressures, but also means that many urban residents do not have access to these areas as conservation lands or refuges of flora and fauna.

Traditionally wetlands near urban areas have been filled and drained to increase the area of developable land or to reduce mosquito production. However, it is not generally realized that wetlands do provide several important watershed functions in a cost-effective way:

- flood and drought protection: 1 ha of marsh can absorb up to 2 800 000 L of water, releasing water slowly, maintaining stable water tables, and augmenting stream flow at dry times.

- water filtration and removal of silts, nutrients, and phosphates. Plants in wetlands trap sediments from the water moving through them.

The normal beneficial functioning of wetlands can be disrupted by outright filling, silt-laden runoff and excess pollutants from development, and excessive nutrient and phosphate loadings.

Acceptable responses include:

- outright avoidance of wetlands for development, with possible incorporation into open space design; provision of reasonable buffer zones bet-

* Lands Directorate, Environment Canada, Ottawa

ween wetlands and building sites

- erosion control measures during construction
- community and regional standards for fill lines, dredging, and dumping.

D.64 Shorelines and Coastal Areas

Many Canadian cities are situated on sea coasts or on major river systems leading to the sea. Canada is also a country of fresh water lakes, and many more inland cities have substantial lake or river frontages.

Salt water coastal areas include wetlands, sand, rock, and other varied shorelines. The interchange between salt and fresh water can be quite complex in the bays, lagoons, estuaries, and coastlines which make up Canada's ocean boundaries. Coastal wetlands (salt marshes) nourish many types of aquatic life, vegetation, and waterfowl.

In their undeveloped state, shorelines (both coastal and inland) receive fresh water runoff, slowing it and cleansing it of sediments and nutrients. The interactions between land and water environments are often shifting and changing, but in most natural shorelines, a dynamic equilibrium is reached with littoral deposits and vegetation serving to stabilize shorelines from further erosion.

Physical disruption can alter coastal wetlands and shorelines; exposing them to uncontrolled erosion and losses in water quality and aquatic life. If the natural flow of fresh water to coastal areas is blocked by development, it can cause underground aquifers to become polluted by the intrusion of salt water, endangering community water supplies.

Acceptable development responses include:

- prohibition of structures (land or building) which would alter the flow of fresh water to coastal areas
- establishment of vegetated buffer zones between developed areas and the drainageways leading to shorelines.
- setback regulations for development near shorelines, particularly those subject to erosion or change. Housing forms and foundations which are sensitive to, and do not interfere with natural processes, should be required by local codes. (Figure 44)

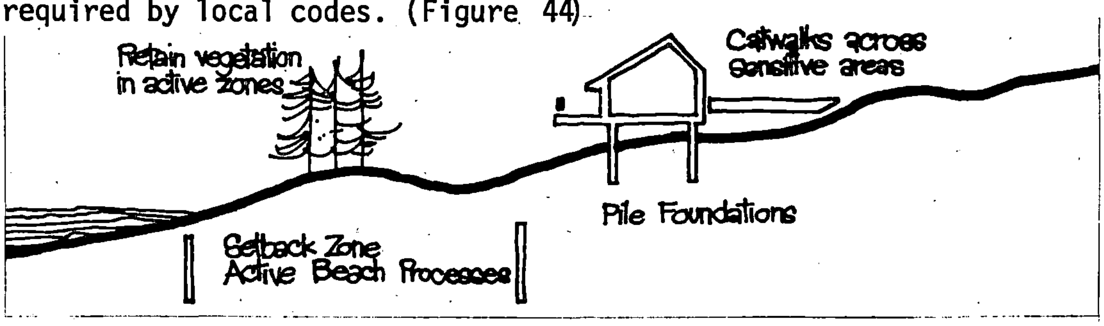


Figure 44: Development Near Shorelines or Coastal Areas

Costs and Benefits

The costs and benefits of Environmentally Sensitive Area management are still largely unexplored in Canada, by both the private and public sectors:

Important costs include:

- costs of identification and mapping, normally borne by planning agencies. Depending on terrain conditions, this may average $1/ha.
- the costs of formulating appropriate responses to Environmental Resource Areas. Once the area has been identified, responses can be delayed until development is actually likely to affect an area or its zone of influence. These costs can be part of the normal planning and development costs borne by an applicant. However, if an environmental impact statement is required, costs may range as high as $50 to $100/ha.
- costs of the approval process: public authorities should ensure that the planning approvals process is not lengthened by the requirement to deal with an Environmental Resource Area.
- costs of development rights foregone: this may be handled by transferring such rights to more developable lands.
- costs of ongoing monitoring, protection, and upkeep. Normal urban park maintenance costs run about $7,000/ha/year, but the upkeep of Environmental Resource Areas should cost substantially less, since many areas such as wetlands are largely self-regulating.

Important benefits include:

- prevention of damage such as flooding and landslides, and avoidance of costly engineering downstream control measures such as dams and impoundments.

  For example, in Massachusetts, a network of 17 large wetlands along the upper and middle sections of the Charles River watershed are protected from development. Ranging in size from 40 to 950 ha, their chief purpose is to control flooding. In a recent flood, several million dollars of damage was done to the heavily urbanized areas downstream (Boston and Cambridge) while the upper 2/3 of the watershed sustained less than $400,000 in damage. The U.S. Army Corps of Engineers judged this natural systems flood control program to be both more effective and less costly than various alternative engineering solutions.
- avoidance of excessive construction and servicing costs
- the value of the retained resource, particularly for wildlife, tourism and recreation, etc. For example, the presence of a unique natural area, the Point Pelee National Park, contributes substantially to the local economies of nearby Leamington and Kingsville by attracting tourists from all over central North America.

References: Environmentally Sensitive Areas

1. Carroll, Allen; Developer's Handbook, (Hartford, Connecticut Department of Environmental Protection, 1975)

2. Dickert, Thomas, & Sorenson, J.; Collaborative Land Use Planning for the Coastal Zone, (Berkeley, University of California IURD Monograph No. 27, March, 1978)

3. Layne, Elizabeth N.; The Natural Environment: A Dimension of Development, (New York, National Audubon Society, 1976)

4. McKee, John; Coastal Development: Cost-Benefit Models, (Brunswick, Maine; Public Affairs Research Center, July, 1969)

5. Thurow, C.; Toner, W.; Erley, D.; Performance Controls for Sensitive Lands, (Chicago, ASPO Report No. 307-308, June, 1975)

E. SPECIFIC RESPONSES for CANADA'S ECOLOGICAL PLANNING REGIONS

Canada is a vast country with many distinct physiographic areas, and to a lesser extent, climatic zones. This multi-faceted nature of the Canadian landscape means that some of the general development and management responses discussed above may have to be modified in the highly specific environmental conditions of a particular zone or site.

Many differentiations of Canada's landscape and climate are possible, and indeed, have been proposed by other authors (for example, Bondy, 1976). For the purposes of this report, Canada has been divided into 5 "Ecological Planning Regions", in which the climatic and physiographic conditions were chosen to be as similar or homogeneous as possible for each region, thus requiring development adaptations different from the conditions in other regions. These regions are: (see Figure 46)

1. Great Lakes/Maritimes
2. Boreal Forest/Canadian Shield
3. Prairies
4. Pacific Coast and Intermontane
5. Arctic and Sub-arctic.

This particular division does not rule out the presence of certain local conditions within the Region which may be quite different from the norm for that area. For example, some of the highest and lowest rainfalls and snowfalls in Canada can be found within the Pacific Coast/Intermontane Region in British Columbia; however, the common environmental condition which affects development throughout the Region is, of course, sloping mountainous, and sometimes rocky, terrain.

For each Region, this chapter goes on to describe:

- general conditions and development concerns or limitations
- important environmental components and development considerations
- development and planning principles for
  - terrain
  - storm water drainage
  - climate
  - vegetation
  - construction
  - housing and community form.

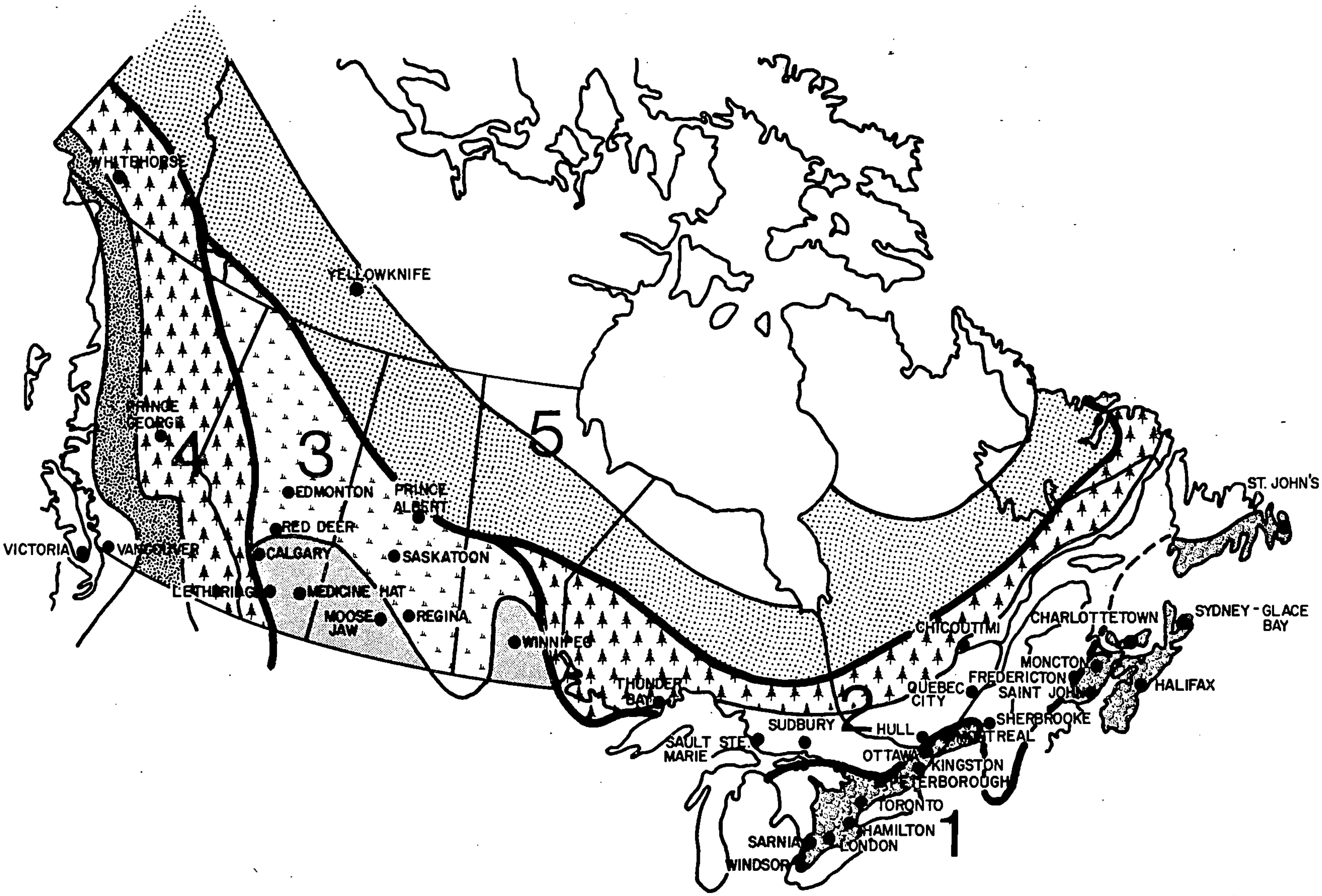


Figure 46

ECOLOGICAL PLANNING REGIONS

E.1 GREAT LAKES AND MARITIMES

General Conditions

The climate in the lower Great Lakes and St. Lawrence lowlands area is cool continental with warm summers. This area is in one of the major storm tracks of North America and is subject to very changeable weather. In the Maritimes, winters are generally cold and snowy, with cool, cloudy, and often foggy summers. Areas adjacent to the Atlantic Ocean and Great Lakes experience a more moderate climate than areas further inland. Only small areas in the Niagara Peninsula and southwestern Ontario have a mild enough climate for vegetable and tender fruit cultivation.

The St. Lawrence area has gently rolling and flat terrain conditions with excellent agricultural soils. The Niagara Escarpment is a prominent natural feature in this area. Pockets of sand, stone, and gravel occur throughout southern Ontario. The Maritimes have a variety of uplands, lowlands, and valleys, with generally limited agricultural capability, except in Prince Edward Island.

Cleared deciduous forest predominates in southern Ontario, boreal forest in much of the Maritimes. There are some coastal areas in the Maritimes with stunted tree growth due to wind effects. Vast peat bogs often occur in areas of poor drainage.

Development Issues

- Land Use

  Growing urban and non-farm rural development in the Montreal-to-Windsor axis has resulted in severe land use conflicts between agriculture and development. The planning of development to avoid Class 1, 2, and 3 (high agricultural capability) lands is of particular concern in the favourable climatic zones of south-western Ontario and the Niagara Peninsula.

  Public concerns over recreational land use are also emerging:

  - citizen outcries against the lack of public access, and private ownership of, shorelines, escarpments, and other environmental features.

  - damage to fragile areas by overly intensive recreation (such as the sand dunes at Picton and Wasaga Beach)

  - the encroachment of development on potentially valuable recreational lands.

  Large-scale developments may be increasingly required to provide solutions to such problems within the project boundaries.

- Urban Runoff

With intensive urbanization in this region, runoff problems such as excessive erosion and downstream flooding, are becoming acute in some areas. New developments should fully investigate the potential of "source control" methods such as:

- reduced road widths and impervious surface areas
- protection of water recharge areas
- run-off controls to retard surface water flow and to encourage infiltration.
- detention and retention ponds.

- Land Sensitivity

In the more urbanized areas of this region (particularly southern Ontario) mature natural communities are disappearing, and new developments which might adversely affect remnant natural communities (such as marshlands and mature deciduous forests) should be planned to avoid these areas.

GREAT LAKES/MARITIMES
(Not including Newfoundland)

Important Environmental Components	Normal Conditions	Development Considerations
1. Terrain		
• Aspect	Highly variable; frequently associated with glacial features	Leeward slopes have potential for fuel savings in winter.
	North and south facing slopes vary in the amount of sun received.	South facing slopes are best for winter heat gains, but overheating in summer must also be controlled (vegetation, roof overhangs)
• Topography	Slopes are generally moderate, with the exception of some areas near water courses and geological features.	Development should be avoided on or near steep slopes with erosion, servicing, and structural stability problems.
	Unusual landforms are present in some areas (e.g. Niagara Escarpment, Cape Breton Highlands).	These areas are major scenic resources, and sensitive planning is needed to prevent desecration.
• Soils	Soils range from coarse glacial deposits to clays.	Soils are generally good for development, except where poorly drained clays are found.
	Permeability is good except in clay areas.	The erosion potential on clay plains is high because of heavy runoff, and recharging of groundwater may be poor where clay plains have been cleared of natural vegetation.
• Parent Materials	Extensive glacial tills and moraines.	Pit and quarry operations pose aesthetic limitations for development.
• Geology	Many unique glacial features of scenic and scientific interest	These features should be retained in their natural undisturbed states, wherever possible.

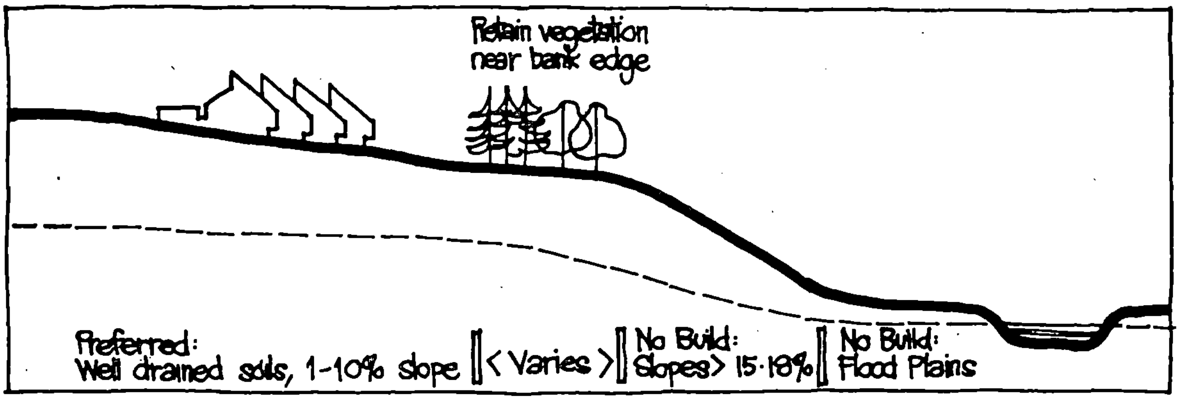
Important Environmental Components	Normal Conditions	Development Considerations
2. Water		
• Surface Runoff	Flow rates in lowlying areas may be high for brief periods in spring	Development should be avoided on flood plains.
	Permeability is good except in clay plain areas.	Lowlying clay areas may be subjec to moderate flooding and erosion during spring runoff.
	Agricultural and urban areas may lack suitable vegetation cover.	This can result in excessive run-off - may require planting and th use of suitable storm water management techniques.
• Frost	First occurrence is usually in September.	Generally not a problem; limits the use of exotic plant species.
	Freeze-thaw cycles.	These can result in pavement cracking and heaving; deep, well-drained gravel underlays are necessary.
• Ice	Ice flows up to 1 m thick are discharged in rivers during spring break up.	Development sholud be avoided in flood plains, and set well back on prevailing wind shorelines on ice-prone lakes because of property damage.
• Ground Water Table	Ground water is readily available in most areas	Water limitations may occur in hardpan and clay plain areas wher recharge is slow; limitations to water supply may be a consideration in large developments.
	The probability of ground water exceeds 80% in most areas.	Few areas are isolated from adequate water supplies.
• Ground Water Storage	Ground water storage capacity is good in most areas.	Only of concern in clay plain areas, or where bedrock is near the surface.

Important Environmental Components	Normal Conditions	Development Considerations
3. Climate		
• Temperature	Winter temperatures are cold; to -30°C	Winter heat losses require substantial insulation and micro-climatic shelter.
	Wide seasonal extremes	Housing design must balance summer cooling with winter heat conservation.
• Precipitation	Snowfall is moderate to heavy, with greatest snowfalls occurring in the Maritimes and in the lee of the Great Lakes.	High recreation potential High costs of snow removal in some areas; may also affect roof design and road location.
• Wind	Prevailing winds are westerly to northwest in winter - more variability in the Maritimes	Heat losses are heaviest on north and west building faces - openings and exposed surfaces should be minimized.
	extensive snow drifting in some areas.	Sheltering may be required in areas where open fields promote drifting and whiteouts.
4. Vegetation and Wildlife		
• Vegetation	Most of the original forests have been cleared and secondary succession is common.	Cutting of remnant forests should be avoided as these are relatively rare.
	Most water courses are forested; other areas are in various stages of succession.	To prevent erosion, forest cover adjacent to water courses should not be removed; adequate vegetation should be maintained on non-porous soils.
	Trees have a marked effect on micro-climate.	Deciduous trees provide shading in summer, (particularly useful in paved heat sink areas); conifers provide good winter windbreaks. Trees are also an excellent air pollution sink.

Important Environmental Components	Normal Conditions	Development Considerations
• Vegetation continued	Mature forest communities are rare.	Developments should avoid damage to such communities wherever possible.
• Wildlife	Most species in this area are amenable to limited disturbance.	Diverse and representative wildlife areas, particularly wetlands should not be developed.

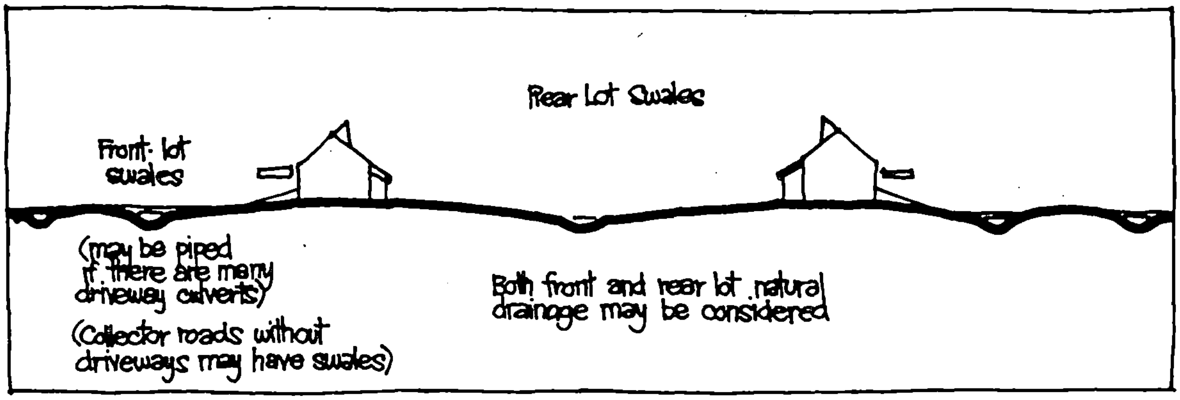
1 Terrain

Figure 47



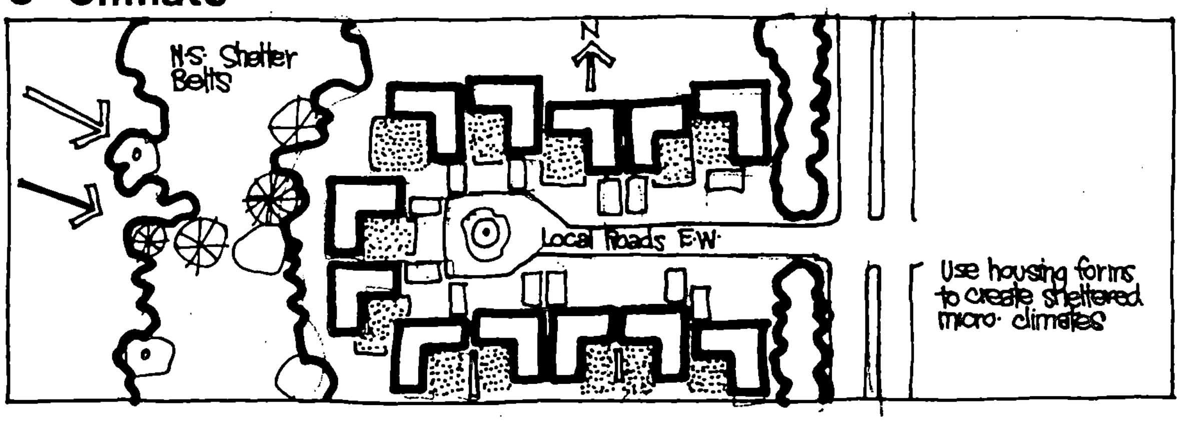
2 Storm Water

Figure 48



3 Climate

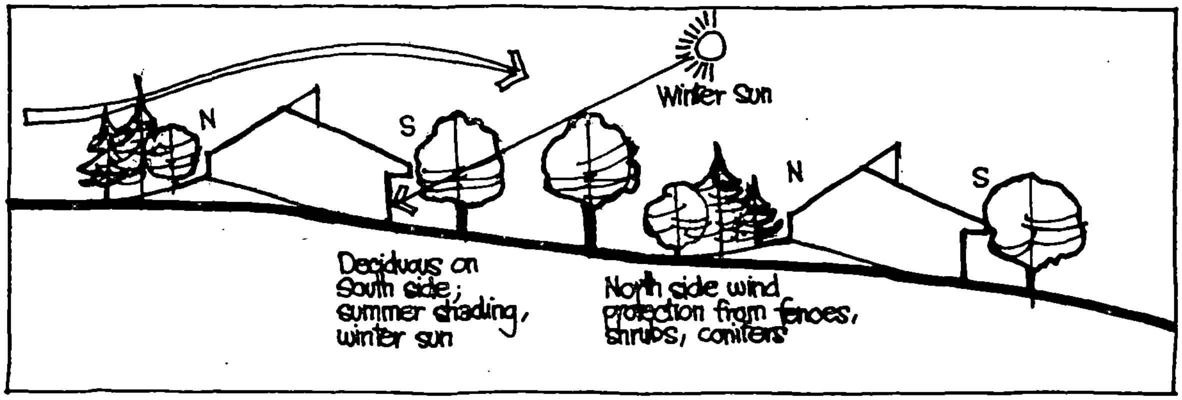
Figure 49



GREAT LAKES / MARITIMES

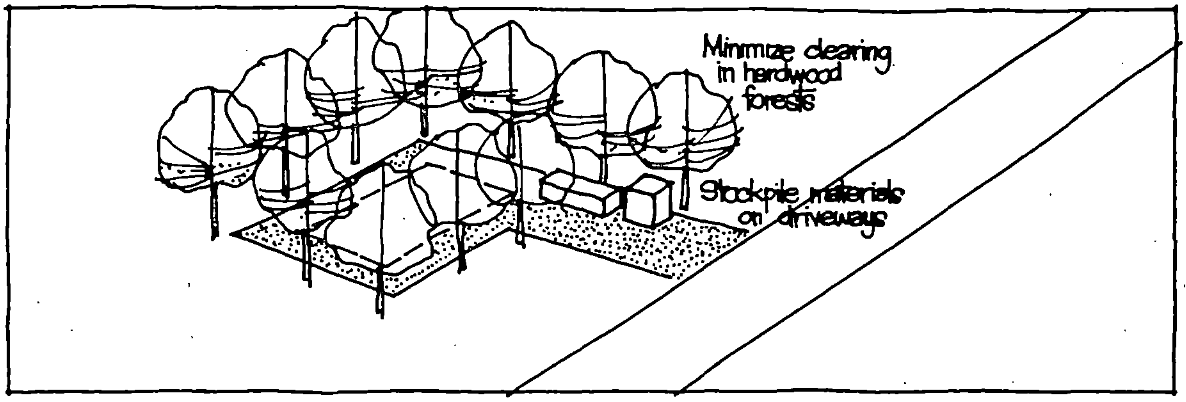
4 Vegetation

Figure 50



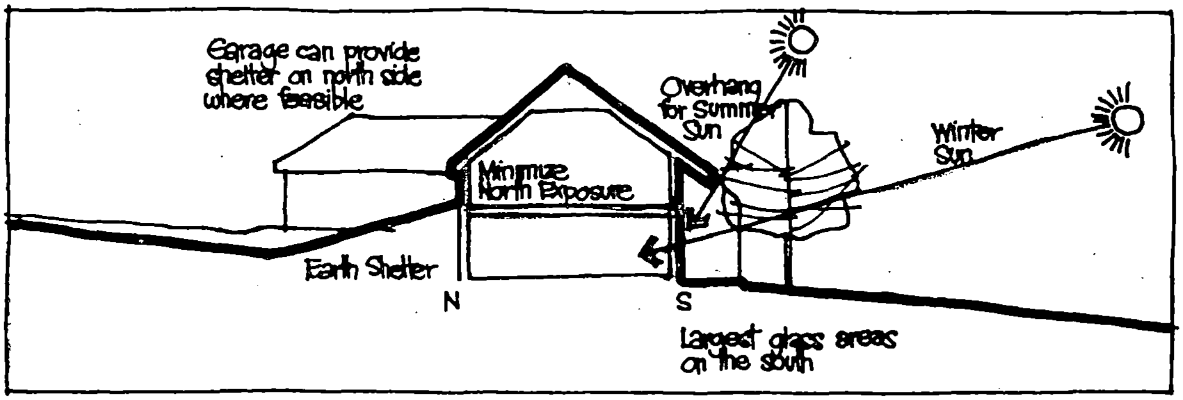
5 Construction

Figure 51



6 Housing Form

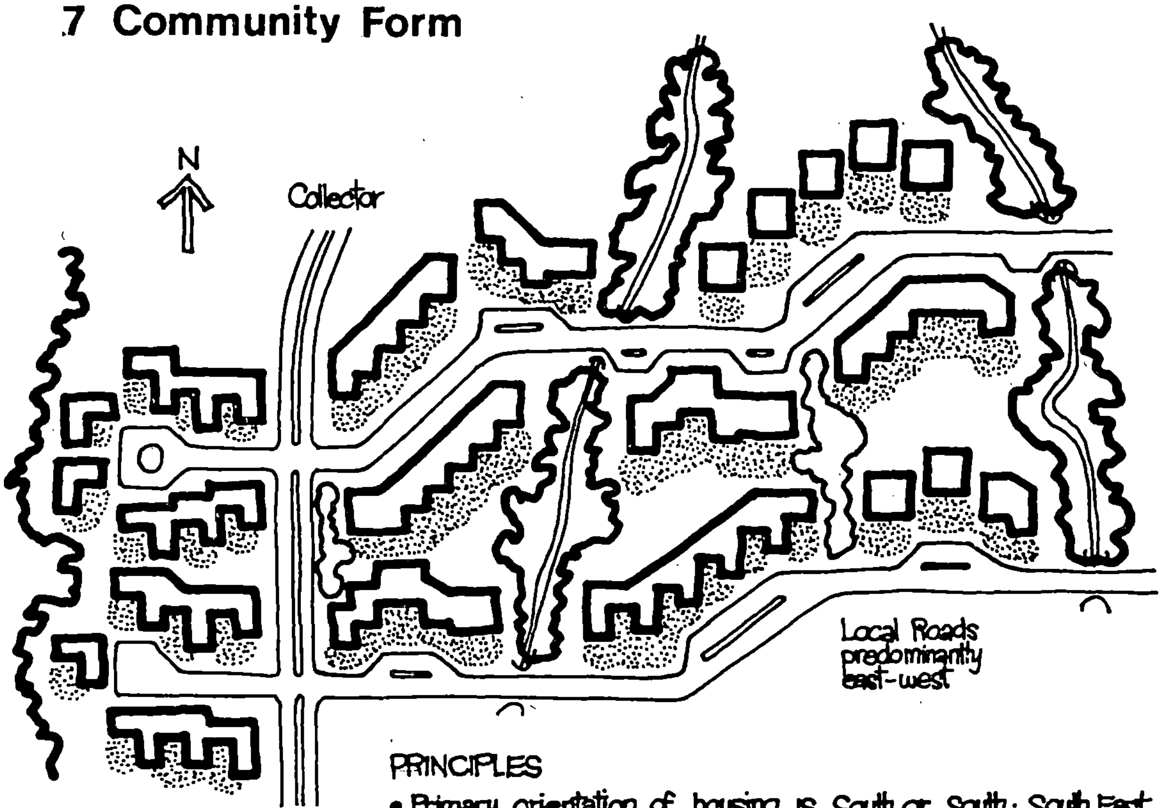
Figure 52



GREAT LAKES / MARITIMES

7 Community Form

Figure 53



PRINCIPLES

- Primary orientation of housing is South or South · South East
- East · West streets are staggered to avoid channelization
- Existing watercourses and treed areas retained for natural drainage, pedestrian and bicycle routes
- High percentage of clustered units
- North · South shelter belts

E.2 BOREAL FOREST/CANADIAN SHIELD

General Conditions

Forests, water, and rock are the strongest characteristics of this region which covers much of North-Central Canada.

The climate in this region is one of short summers and severe winters. Precipitation averages from 25 to 100 cm/year.

Topography consists of rolling uplands and plateaus with some lowlands and plains. Northern areas are characterized by discontinuous and scattered permafrost, and a combination of forest and barren vegetation. Southern areas are noted for numerous lakes, swamps, and bogs, with mixed deciduous and coniferous forests.

Soils are thin, low in fertility, poorly drained, and generally unsuited for agriculture. Organic soils (peats, bogs, etc.) are often found intermixed with rock outcroppings.

Development Limitations

- Soils

  Many sites are unsuitable for normal construction procedures because the overburden is either too shallow, or bedrock occurs at the surface. Sites underlain by thick glacial deposits are most preferred for development.

  With shallow overburden and impervious underlying rock, many areas are poorly drained, resulting in extensive areas of muskeg. These areas are impassable except in winter, when snow must be piled and compacted to make winter roads.

- Climate

  Winter temperatures can be severe, and snowfall, particularly in the eastern areas of this region, is deep and soft. Transportation is difficult in any case because of weather conditions, and snow road surfaces must be compacted to permit vehicle movement. However, winter may also be the only feasible time to move construction materials into certain areas.

  Standing pools of water in swamps and bogs often form breeding grounds for insects, and limit the suitability of many boreal areas. Construction in the summer months can be uncomfortable on this account. The best sites for construction are open and wind-blown plateaus, which may conflict with winter wind comfort conditions. Thus, tradeoffs may have to be made in site selection, between ideal summer and winter wind conditions.

- <u>Fire</u>

Fire can be a major threat at the community scale. Communities must be planned for fire protection, including measures such as:

- townsite location near lakes or ample water supplies
- large cleared fire breaks in the direction of the prevailing winds (can be used for open space, playing fields, etc.)
- control stations.

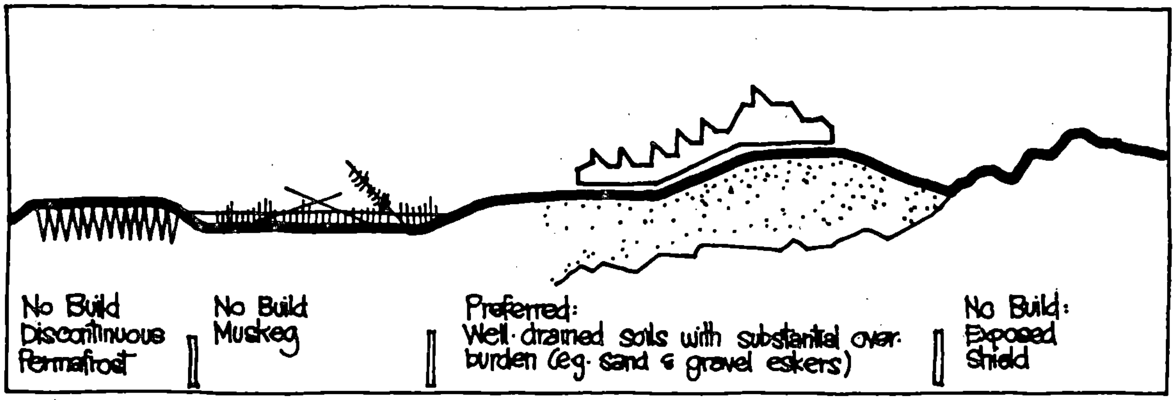
BOREAL FOREST/CANADIAN SHIELD

Important Environmental Components	Normal Conditions	Development Considerations
1. Terrain		
• Aspect	North and south-facing slopes vary greatly in the sun received.	South-facing slopes are excellent for heat conservation.
• Topography	Variable, but generally not severe.	Some local problems exist where there are steep slopes, but suitable development sites are abundant.
	Snow accumulates in lowlying areas.	This can result in drainage and local transportation problems.
• Soils	Soil composition is variable; coarse mineral and organic soils are common, and tend to be shallow.	Shallow soils may make disposal by septic tanks, and construction of basements, unfeasible in many areas.
	Soils are generally permeable, but mixed with peat bogs and swamps.	Drainage in highland areas is usually good; this contrasts with stagnant saturated organic soils in lowlying areas, unsuitable for development.
• Geology	Bedrock is frequently exposed or near the surface.	Rock can provide a solid foundation base, but excavation is often difficult and costly for services. Transportation routes may also be costly to build.
2. Water		
• Surface Runoff	Flow rates are high during spring melt off	Development should be avoided in lowlying areas.
	Thick coarse soils have poor water retention.	Soils promote rapid runoff in spring; soils can also become quite dry in summer.
	Many lakes, rivers, and wetlands.	Developments should provide access to water for recreational purposes.

Important Environmental Components	Normal Conditions	Development Considerations
• Frost	Damage to roads from heaving and cracking	Substantial sand and gravel underlays are required.
• Ice	Ice flows exceeding 1 m in thickness are discharged in spring.	Developments in flood plains and lower valleys should be avoided.
• Ground Water Table	Highly variable, and often non-existent because of slopes and shallow soils.	This is an imposition only in low-lying areas; surface water bodies (lakes and rivers) will usually satisfy domestic water needs.
3. Climate		
• Temperature	Severe winter temperatures; to -50°C	Serious heat losses in winter; larger projects should consider collective sheltered building forms; winter construction limitations.
	Pronounced seasonal variations.	
• Precipitation	Snowfall is heavy, especially in eastern regions.	Snow can be used as an insulating medium on roofs (in moderate snowfall areas only). Deep uncompacted snow can cause transportation difficulties.
• Wind	Ground speeds are generally low.	Sheltering of buildings from the wind is not critical except in open areas, or near large lakes.
4. Vegetation and Wildlife		
• Vegetation	Growth is slow where soils are thin.	Disruption of vegetation on thin soils and slopes greater than 15% can cause total erosion, leaving only bedrock.
• Wildlife	Beaver activity is high in many areas.	Damming of streams and culverts can cause unexpected flooding.

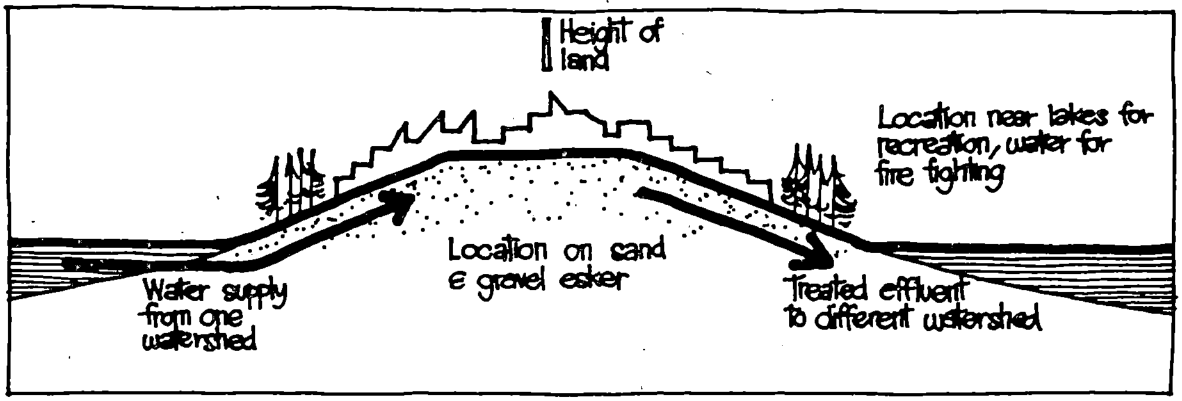
1 Terrain

Figure 54



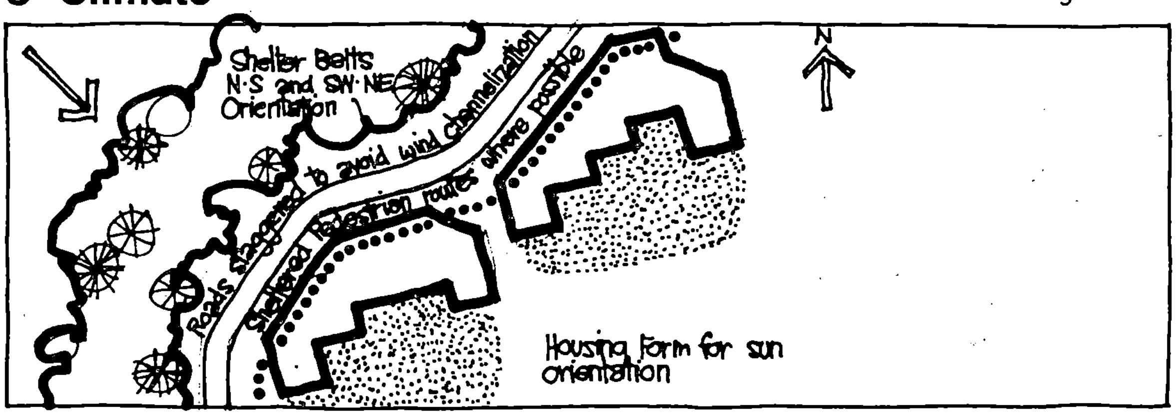
2 Storm Water

Figure 55



3 Climate

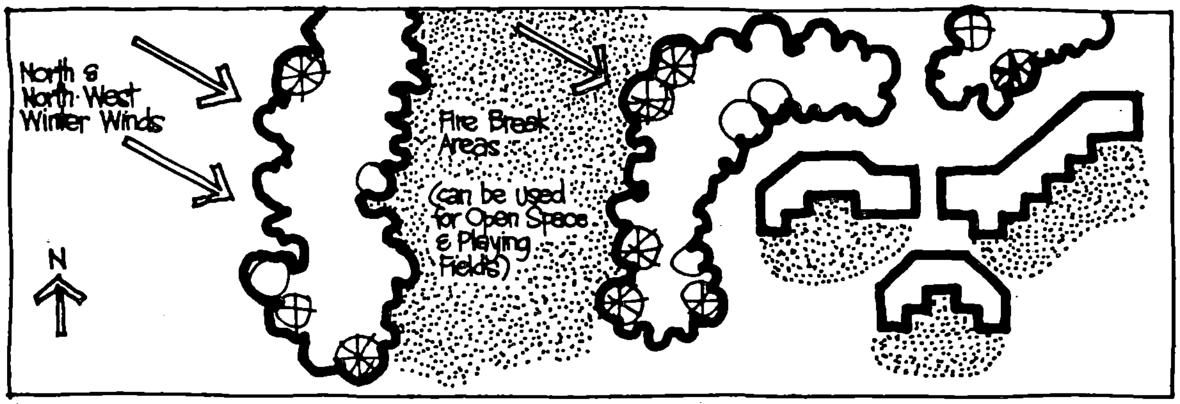
Figure 56



BOREAL FOREST / CANADIAN SHIELD

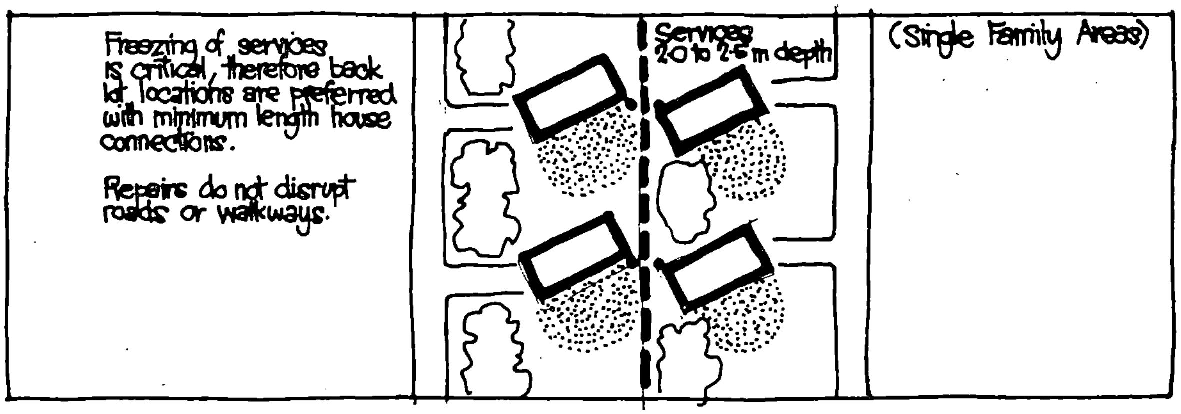
4 Vegetation

Figure 57



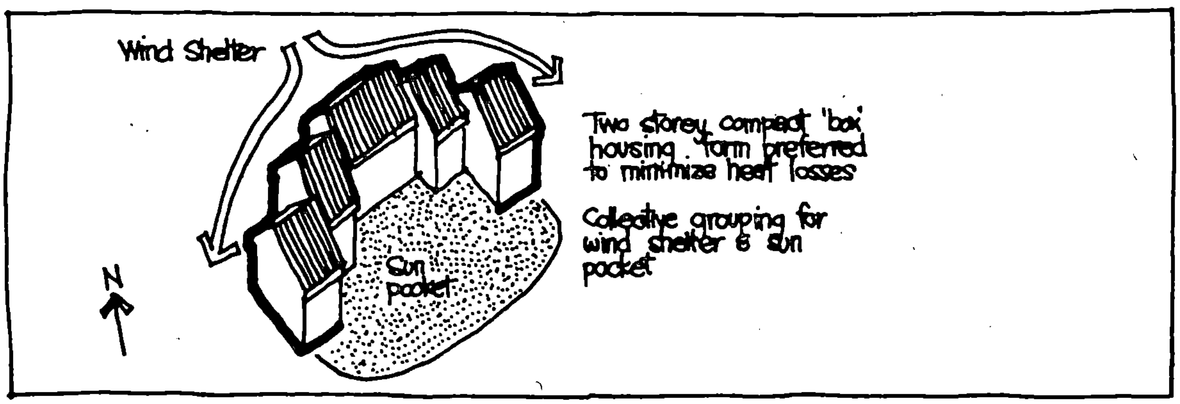
5 Construction

Figure 58



6 Housing Form

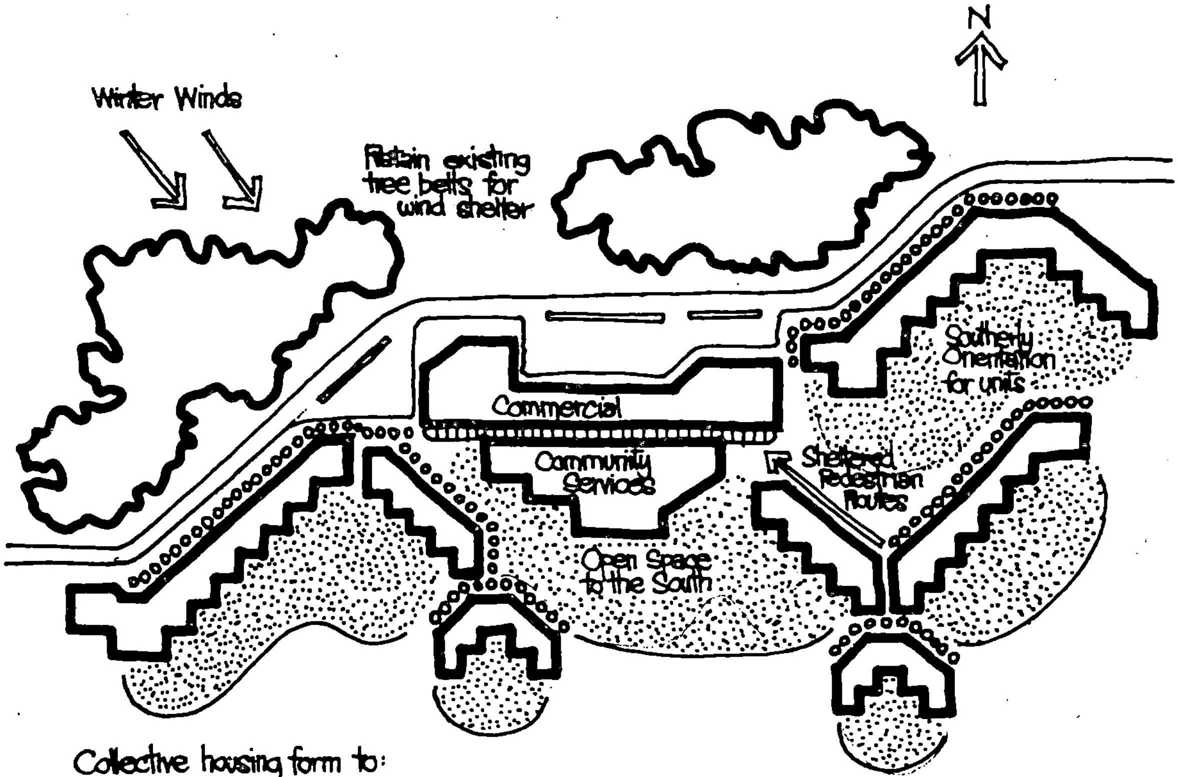
Figure 59



BOREAL FOREST / CANADIAN SHIELD

7 Community Form

Figure 60



Collective housing form to:
- minimize heat losses
- provide wind shelter
- provide sheltered pedestrian routes

E.3 PRAIRIES

General Conditions

The Prairie climate is continental with short, warm summers, and very long and cold winters. Precipitation is least in the fall and winter, and heaviest in summer (when most needed). Parts of southern Alberta and Saskatchewan are semi-arid. The weather is highly variable: chinooks (warm winter winds) and blizzards can create sudden weather changes. Hailstorms are common.

The predominating landform is, of course, level and gently undulating plain, with only occasional relief (such as the Qu'Appelle Valley in Saskatchewan). Fertile grassland soils make this one of the richest agricultural areas in Canada. Clay soils in Manitoba are subject to poor percolation, and spring flooding is common in parts of southern Manitoba.

The predominant vegetation is grassland, with mixed forest and grassland zones to the north.

Development Limitations

- Climate

  Cold winters, combined with high winds and drifting snow, in an exposed terrain, pose considerable hardships in many areas. Housing and community form should be planned to provide wind shelter and minimize drifting. The planting of substantial wind screen tree belts should be considered in all large development projects.

- Soils

  The combination of clay soils with low permeability and flat topography can create surface drainage problems and difficulties with septic tile beds, as well as potential groundwater pollution.

  Developments should be directed to more permeable soil conditions or clustered in groupings which permit affordable piped communal services.

- Water Supply

  In drier areas of southern Alberta and Saskatchewan, the availability of water is an important consideration in rural residential and large construction projects. Use of water-saving devices (such as low-volume toilets) should be considered. Native vegetative planting and tree belts could have an important role in retaining soil moisture.

PRAIRIES

Important Environmental Components	Normal Conditions	Development Considerations
1. Terrain		
• Topography	Flat to rolling	Most forms of development do not have topographical constraints; however, coulees should be avoided because of insects (ticks) and erosion dangers.
		The flat topography also makes drainage difficult in some areas.
• Soils	Most soils are clay loams; hardpan areas occur in drier regions	Permeability is normally adequate except in hardpan areas; excessive moisture loads can cause problems (standing water, etc.)
	Some of the best agricultural lands in the country	Development should avoid Class 1 and 2 agricultural capability lands.
2. Water		
• Surface Runoff	Can be excessive in spring, especially on clay soils, or with mountain snows.	Severe flooding of lowlying areas may occur, especially where clay soils are present (e.g. Winnipeg)
	Soil permeability is frequently poor, particularly in hardpan areas.	Low absorption rates promote runoff; detention and retention ponds may be necessary.
	Dry areas are particularly sensitive to runoff	Removal of the sod mat in dry areas can lead to extensive erosion.
• Ice	Ice flows exceeding 1 m in thickness are discharged in the spring.	Developments in flood plains should be avoided.

Important Environmental Components	Normal Conditions	Development Considerations
• Ground Water Table	Generally adequate except in southern Alberta and Saskatchewan.	Water for domestic and industrial uses is limited in some areas.
	The probability of ground water averages 50 to 70%	Water shortages occur in the more southerly areas.
	Cyclical fluctuations in the water table are common.	The water table drops appreciably during the drought cycles, and seasonal changes are pronounced.
• Ground Water Storage	Storage capacity is usually high.	
3. Climate		
• Temperature	Winter temperatures are cold; to -40°C	General heat loss problems for buildings; substantial insulation and sheltering are needed.
		Winter limitations on construction.
	Wide seasonal variations.	Housing location and design must balance winter heat loss concerns with summer heat gains.
	Daily variations can be wide, with blizzrds and chinook winds.	Drying out of vegetation and premature budding are common; soil erosion and flash flooding dangers.
• Precipitation	Rainfall occurs primarily in the summer.	Important to the maintenance of vegetation during the hot summer months; some flooding occurs during storms.
	Snowfall is comparatively light, but remains for long periods.	Snowfall is an important contribution to ground water supplies; retention can be enhanced with vegetative cover.
	Hail storms are comparatively frequent in summer.	A potential source of damage to some structures and vegetation.

Important Environmental Components	Normal Conditions	Development Considerations
• Wind	Velocities are often high	Heat losses can be high because the exposed terrain does not slow down wind; also an important cause of soil erosion. Sand and debris can damage structures; windthrow of exposed vegetation is also possible. Evaporation is generally good.
	Winter winds are mainly from the north and west.	Windward faces experience the hig est heat losses; surfaces and openings should be minimized.
	Extensive snow drifting occurs in hollows and to the lee of obstacles.	Road alignments and shelter belts should be planned carefully to reduce drifting.

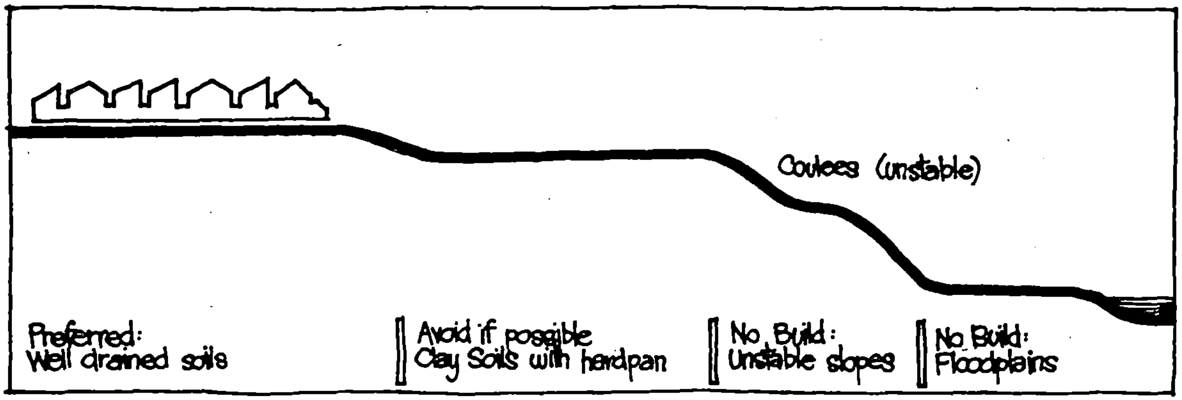
4. Vegetation and Wildlife

Important Environmental Components	Normal Conditions	Development Considerations
• Vegetation	Tree rows are frequently used as wind breaks.	Tree rows cut down winds, thereby reducing erosion and drifting; also reduce convectional heat losses from adjacent buildings. Trees should not be planted on ridge or hill tops, where windthrow may result.
	Undisturbed areas of natural prairie are rare.	Development should avoid these unique and rare communities.
• Wildlife	Wetlands are important waterfowl areas.	Development and/or drainage of wetlands should be avoided where possible.

PRAIRIES

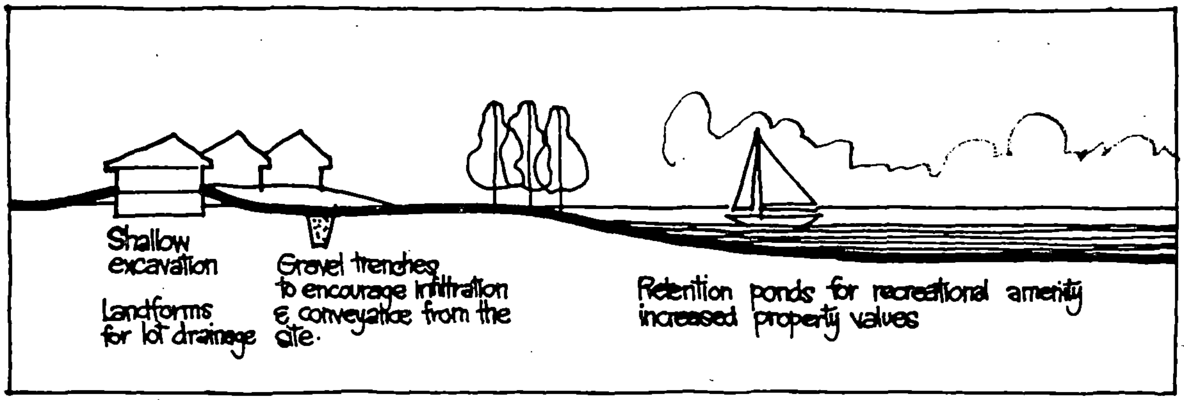
1 Terrain

Figure 61



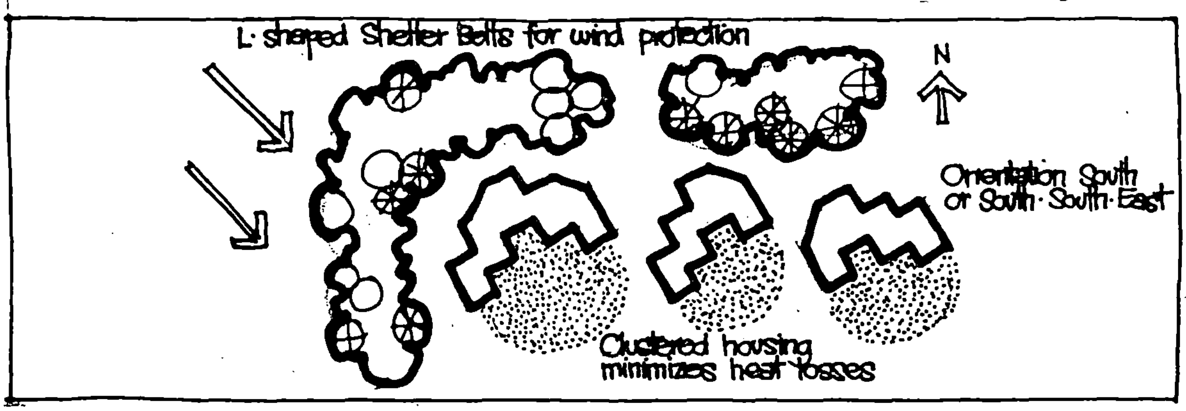
2 Storm Water

Figure 62



3 Climate

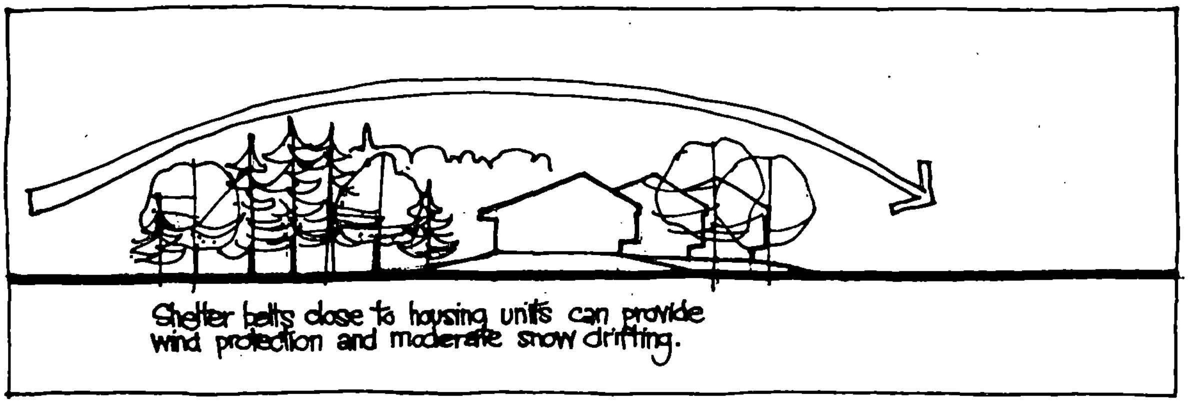
Figure 63



PRAIRIES

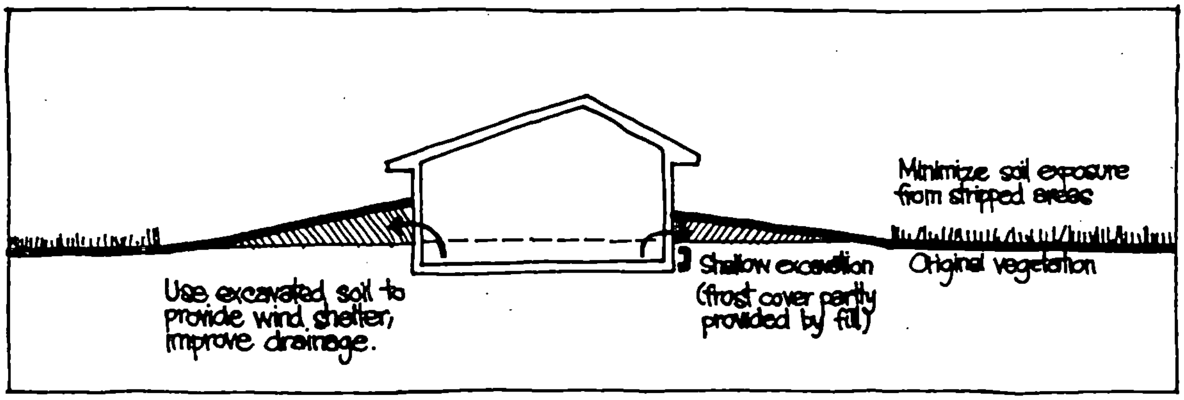
4 Vegetation

Figure 64



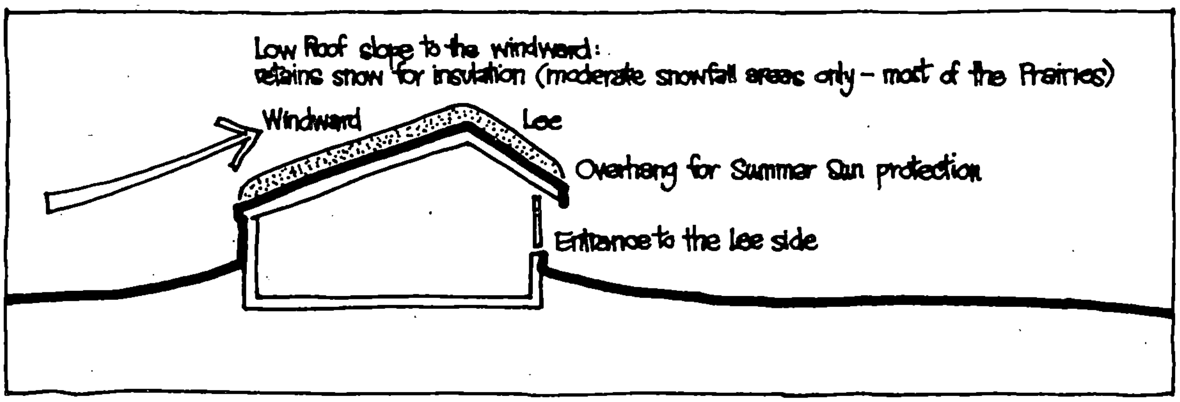
5 Construction

Figure 65



6 Housing Form

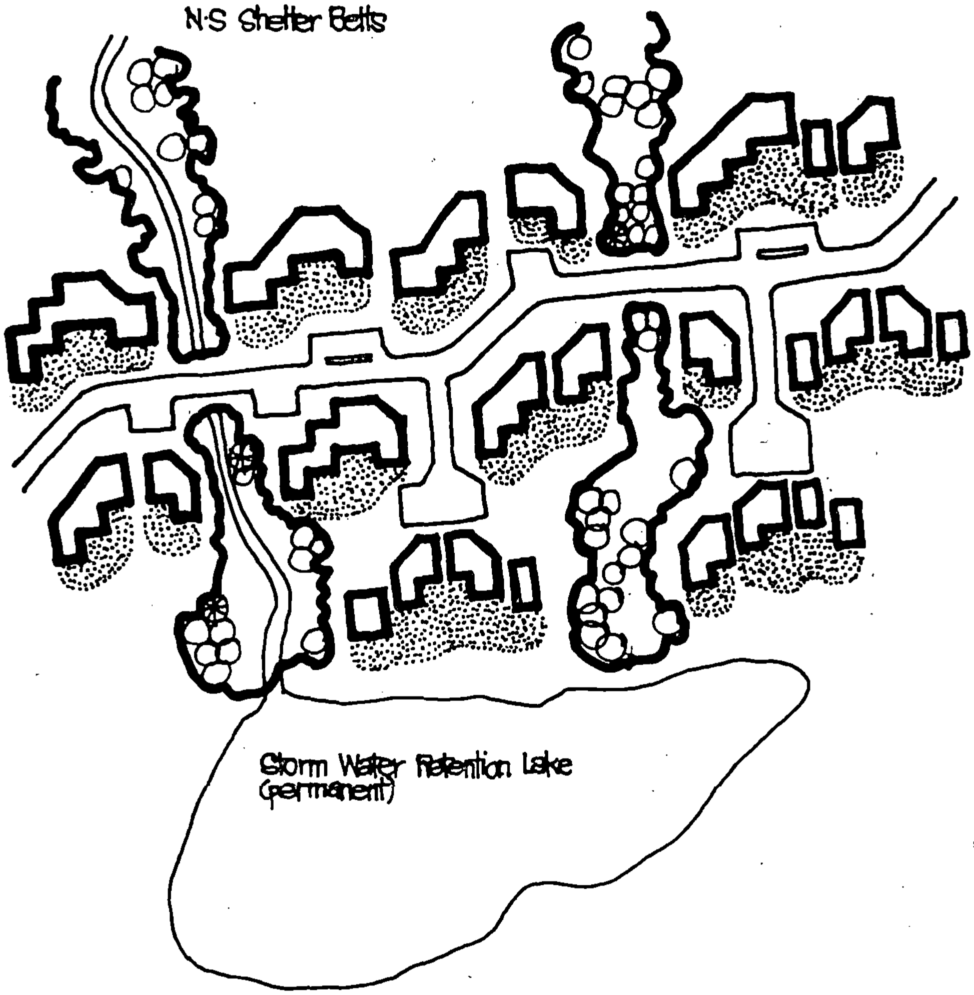
Figure 66



PRAIRIES

7 Community Form

Figure 67



Principles

- High percentage of cluster units
- Groupings of units for wind shelter & sun orientation
- Predominantly S or SSE orientation
- N·S Shelter belts

E.4 PACIFIC COAST/INTERMONTANE

General Conditions

There is great climatic variety if this region, due to its wide variability in terrain conditions. Coastal areas experience as much as 300 cm of precipitation annually, while some interior areas are semi-arid, with only 30 to 50 cm/year. Even within one zone such as Greater Vancouver, rainfall can range from 50 cm/year in White Rock in the south, to 400 cm/year at the top of Grouse Mountain, in the north. The Coastal climate is modified by the Pacific Ocean, and has moderate summers and winters. Interior mountainous areas range from a cool continental clmiate in the north, to semi-arid in the south. With the possible exception of the Okanogan Valley, the mountainous regions generally suffer from extensive cloud cover and low sunshine, with some areas of extremely heavy snowfall.

The landforms in this region are complex, including mountains, fiords, and coastal plains, interior uplands, and foothills. Soils are largely rock, with scattered arable areas in the coastal plains. Much of the coastal area is a seismic hazard zone. Mountainous terrain is also subject to other hazards such as avalanches and land slippage.

Vegetation is largely forested, with highly productive coniferous forests in coastal areas. Grasslands are found in interior zones where the dry leeward climate does not support productive forest growth.

Development Limitations

- **Topography**

  A rugged topography imposes severe limitations on the availability and accessibility of building sites. Landslides, and more commonly avalanches, also pose serious threats in some areas.

  Spring torrents are also a problem in some communities, and flood plains and unstable valley walls should be avoided for building.

- **Land Use**

  Areas suitable for agriculture and housing are limited, consequently, land use conflicts have been widespread. The British Columbia Agricultural Land Commission has imposed tight restrictions on the conversion of high capability agricultural lands to other purposes. These restrictions will, in time, force urban development onto lower capability soils (which may have constraints for development as well) and upland areas, requiring innovative planning and design solutions to maintain cost-effective land development.

- **Precipitation**

  Heavy rains in many localities pose erosional problems on construction sites with exposed soils, and can also result in construction delays. Intense runoff may require the use of control measures such as reservoirs, detention ponds, underground tanks, etc. to release storm water incrementally into watersheds in steep areas.

Snowfall in mountainous areas and on western slopes is often heavy, causing transportation difficulties. Communities in high snowfall areas must be designed for efficient snow removal, and precautions must be taken to ensure that buildings (particularly roof structures) are not encumbered by snow.

PACIFIC COAST/INTERMONTANE

Important Environmental Components	Normal Conditions	Development Considerations
1. Terrain		
• Aspect	West-facing slopes are subject to prevailing winds; east slopes are more sheltered.	Leeward slopes provide shelter from winds and precipitation.
• Topography	Slopes tend to be steep except for small coastal areas	Severe limitations on the numbers and qualities of available building sites.
	Surface stability varies depending on soil base, drainage, and slope	Slopes overlain by finely structured soils tend to be unstable; rock slides are a potential problem in some areas.
	Drainage is good except in lowlying areas near the coast, and in flood plains.	Development on flood plains and poorly drained lower areas should be avoided.
• Soils	Soil composition tends to be coarse, with varying depths	Except for lowlying areas, soils are generally well-drained and stable (in combination with moderate slopes)
	Moisture capacity is limited because soils are often coarse	Nonforested soils tend to dry out quickly in summer.
	The acreage of agriculturally productive soils is limited; alluvial deposits are good; others have moderate potential	Good farmland is at a premium; development on Class 1 and 2 lands is restricted.
	Many areas are heavily leached	Except for alluvial deposits, soils tend to be nutrient-deficient.
• Geology	Many fault zones and areas with seismic history in the coastal region	Seismic activity can cause landslides, mudslides, structural damage; landfill areas (especially clay) can liquify.

Important Environmental Components	Normal Conditions	Development Considerations
• Geology continued		Hazard land mapping of seismic, fault, slump, and slide areas is essential.
		Development should be avoided in fault areas, and on clay and unconsolidated fills.
2. Water		
• Surface Runoff	Runoff is frequently severe because of steep slopes and high rainfall.	Erosion of slopes and lowlands can be extensive; lowlying areas also experience flooding problems.
	Steep slopes promote intense runoff	Even when soils are permeable to water, steep slopes can make runoff a problem.
	Vegetation is lush in areas if high precipitation.	Dense vegetation is am important factor in reducing the rates and amounts of runoff.
• Ground Water Table	Adequate ground water is available in all areas except for south central B.C. and portions of south-eastern Vancouver Island	Arid conditions prevail in south central B.C. and south-eastern Vancouver Island during the summer months; moisture is adequate to abundant in other areas.
	High ground water probability in lowland areas	Adequate ground water is not a problem except in the areas mentioned above.
• Ground Water Flow	High flow rates	High ground water flow rates ensure maintenance of ground water levels in most areas, despite porous soils and steep slopes.
3. Climate		
• Temperature	Coastal areas have a moderate climate, but severe cold in the interior.	Coast: generally favourable Interior: heat loss and construction difficulties in winter.

Important Environmental Components	Normal Conditions	Development Considerations
• Temperature continued	Seasonal extremes are low on the coast; but wide variation inland	Coast: no limitations Interior: must balance summer and winter comfort conditions.
• Precipitation	Rainfall is moderate to heavy on windward slopes, and moderate to light on leeward slopes. Areas of south central B.C. are semi-arid.	Prolonged wet periods on windward slopes and in most coastal areas can make construction difficult; erosion from runoff and temporary flooding are problems in lowlying areas.
	Prolonged wet season in the fall and winter on the coast; seasonal distribution inland is more uniform.	Rain during the fall and winter months is a major inconvenience to construction projects in coastal areas.
	Snowfall is extremely heavy on west-facing slopes; light in the lowland and intermontane areas of the south.	Extreme snowfalls in mountainous areas, with depths to 8 m or more, pose severe limitations to winter travel; snow removal costs and roof loadings are also important. Mountain snows are an important component of a year-round water source for many areas.
	Storms are frequent with large amounts of snow being dumped in short periods of time.	Road alignment selection: locations in cedar and fir forests allow for maximum snow interception.
• Wind	Severe fall and winter gales and high winds are common	• sheltering on housing, with wide tree belts • location of housing on the lee sides of hills • windthrow of trees is common, therfore forest cuts must be well planned; isolated trees are potential hazards.
	Predominant wind direction is from the west and north-west	Heat loss and water damage to the windward sides of buildings

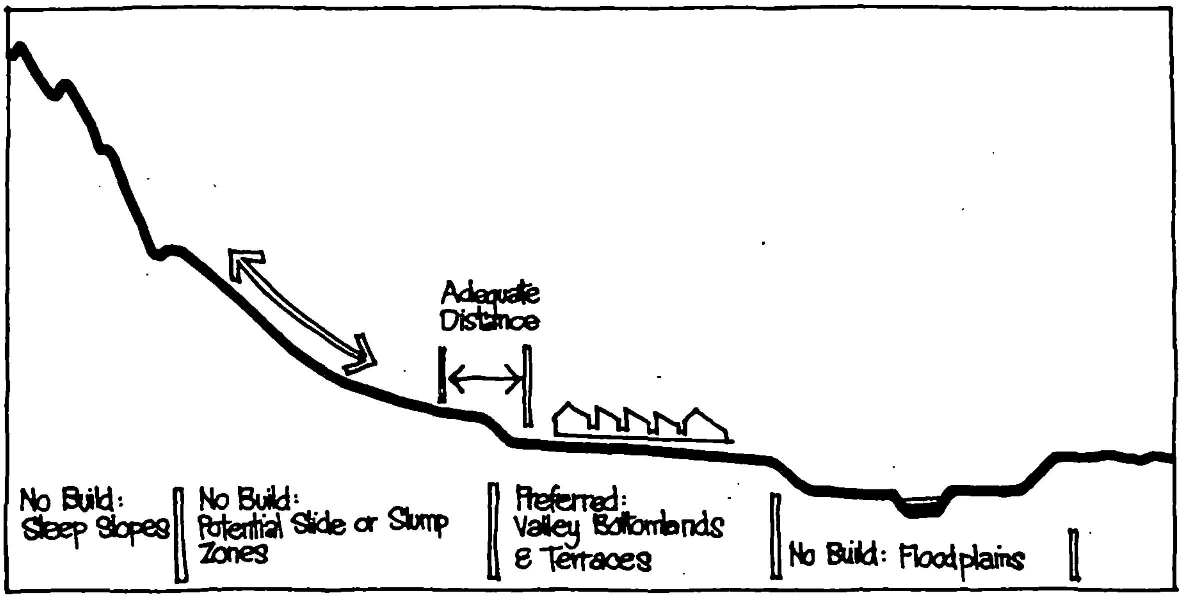
Important Environmental Components	Normal Conditions	Development Considerations
• Wind continued	Salt spray immediately adjacent to coasts	May be of some importance for structural components; wood and masonry must be treated.

4. Vegetation and Wildlife

• Vegetation	Trees and vegetation form an important buffer to runoff on slopes	Removal of vegetation can lead to severe runoff problems, as well as erosion.
	Forested areas and tree rows provide wind breaks and help trap drifting snow	The retention of, or planting of, trees reduces wind chill and snow drifting.

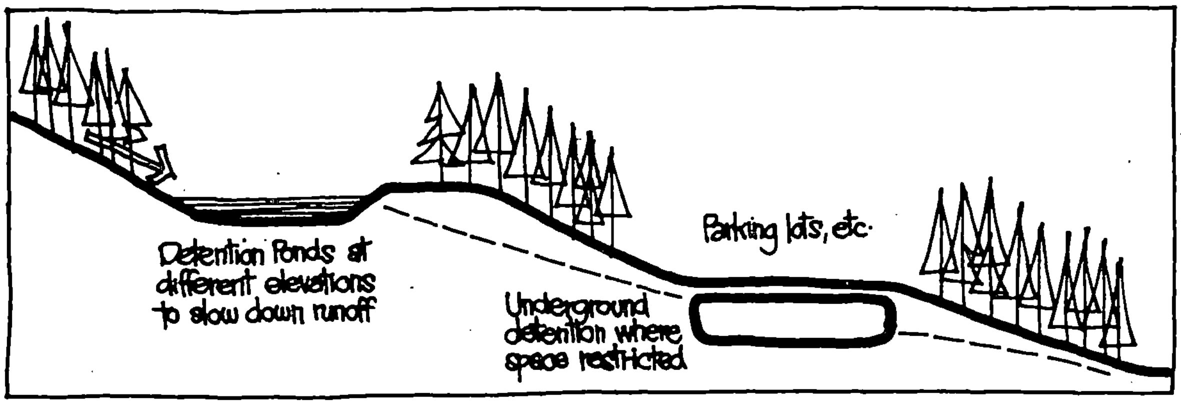
1 Terrain

Figure 68



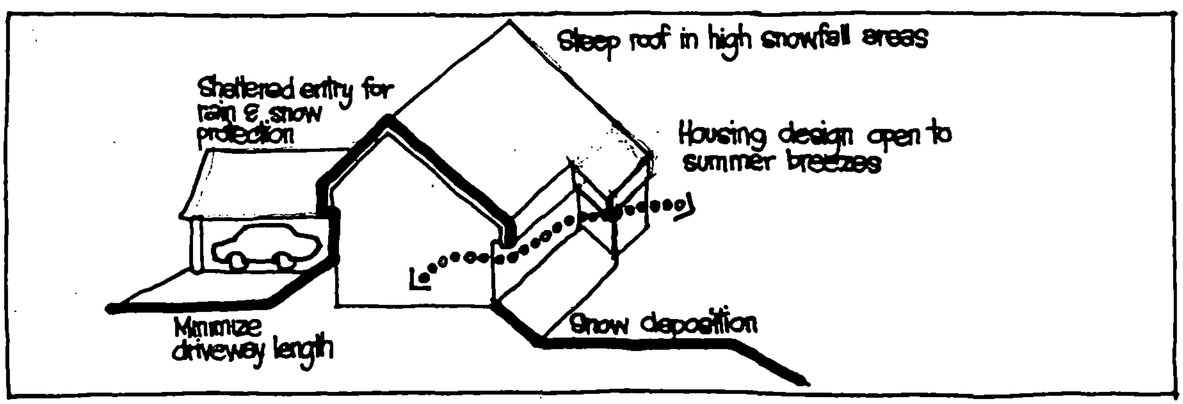
2 Storm Water

Figure 69



3 Climate

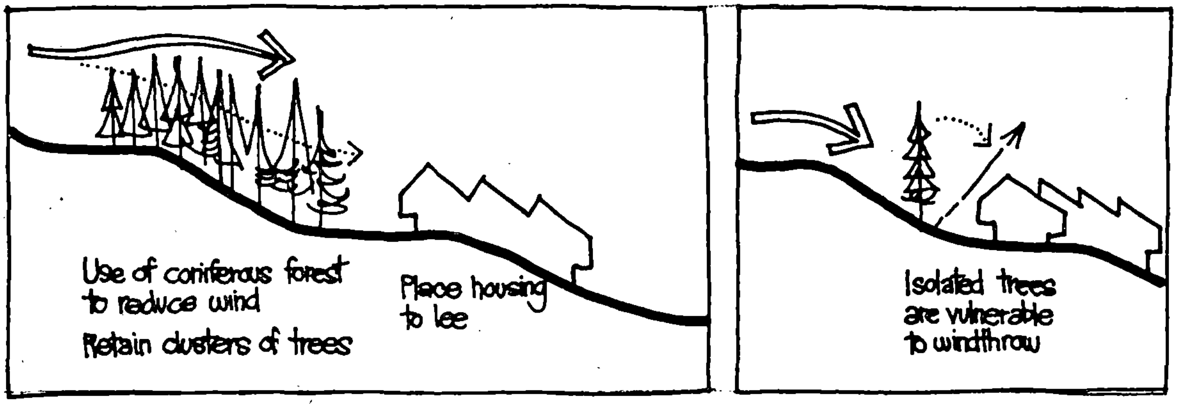
Figure 70



PACIFIC COAST INTERMONTANE

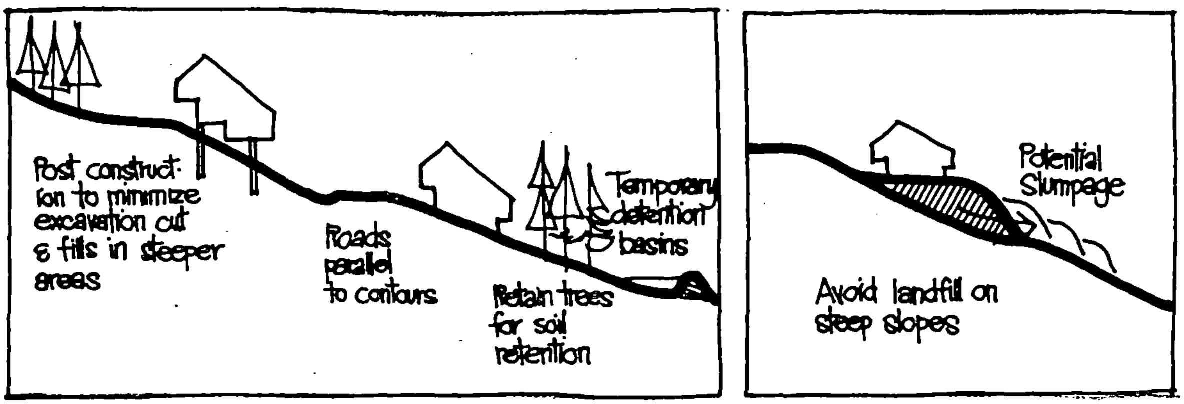
4 Vegetation

Figure 71



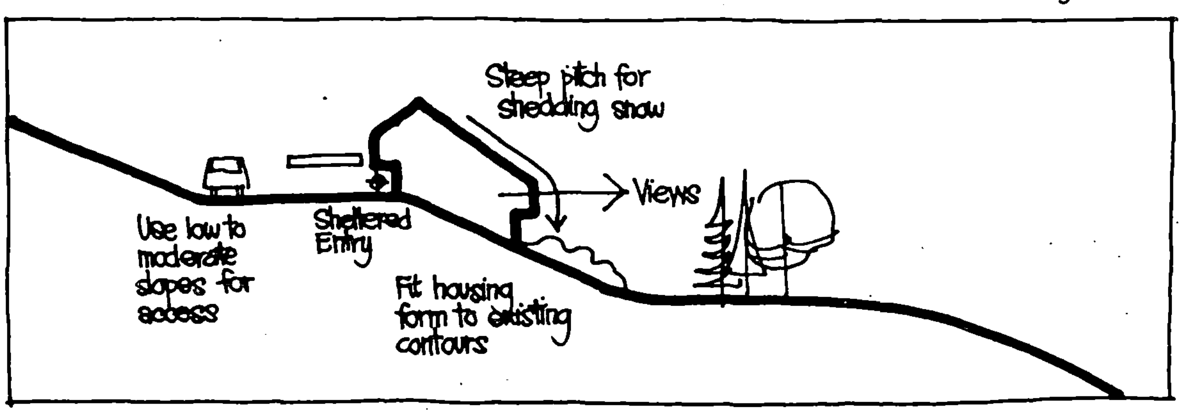
5 Construction

Figure 72



6 Housing Form

Figure 73



CASE STUDY: RESOURCE COMMUNITY, INTERMONTANE REGION

Tumbler Ridge Community Plan
(Thompson, Berwick, Pratt & Partners et al for the British Columbia Government, 1977-78)

This project is a financial, social, organizational, and physical Plan for the Tumbler Ridge permanent resource community in the North East coal development area of British Columbia. The design population of 10,000 (in 3,650 dwelling units) is to be achieved within 8 years.

Two alternative town configurations were developed:

Plan A: low density, occupying 526 ha

- consumes more land for physical services (mainly roads) and residential development (45% of the units are single family detached form)
- locates the town centre at the south end of the community
- uses existing groundwater supplies as the town water supply
- establishes an open space pathway system to link existing treed areas which are retained.

Plan B: higher density, occupying 402 ha

- requires less land: only 20% of the units are single family detached
- locates the town centre at the north west end of the site
- other principles are similar to Plan A.

Total capital costs for Plan B are $270 million ($74,000/unit) vs. Plan A: $285 million ($78,500/unit). The difference of $15 million, amounting to $4,500/unit, is made up of:

- lower housing costs in B ($137 million vs. $145 million) since B has fewer single family detached units

- less services required in B ($36 million vs. $44.5 million), assuming conventional roads and sewers for both alternatives.

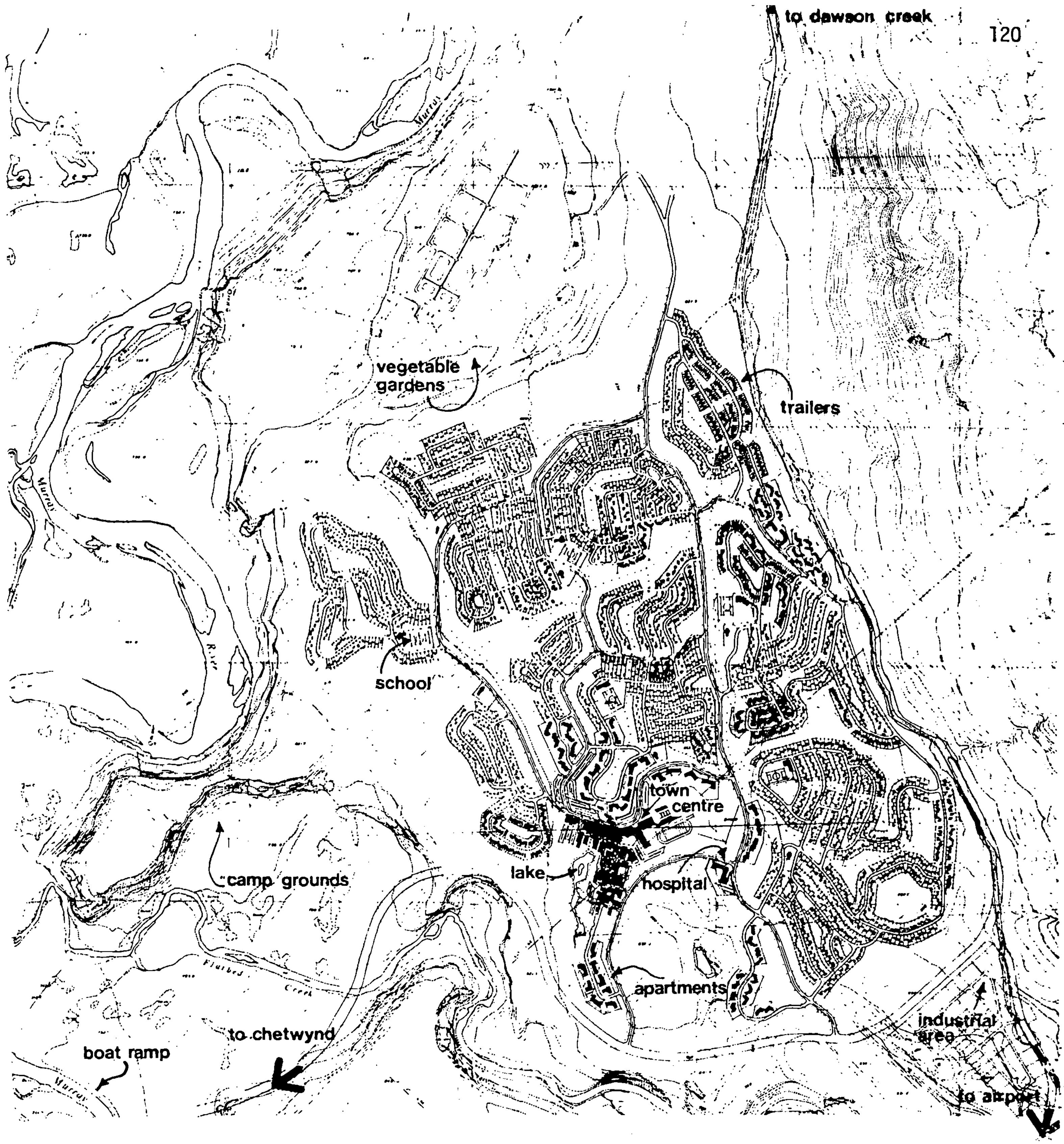
- Plan B would also have lower operating costs, both for individual energy consumption and for road-related costs (such as snow removal, police, and road maintenance).

Two alternative storm drainage systems were also costed:

- Conventional 2 stage: enclosed storm drains for roads (including catch basins, leads, and concrete curbs), and natural storm drainage for other uses

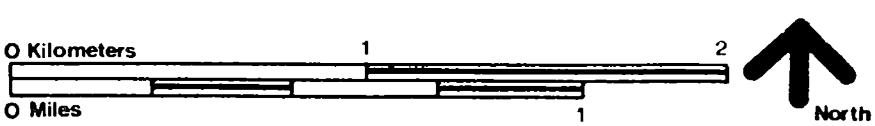
- Natural: road drainage via swales with no curbs, catch basins, or leads; natural surface drainage for other uses.

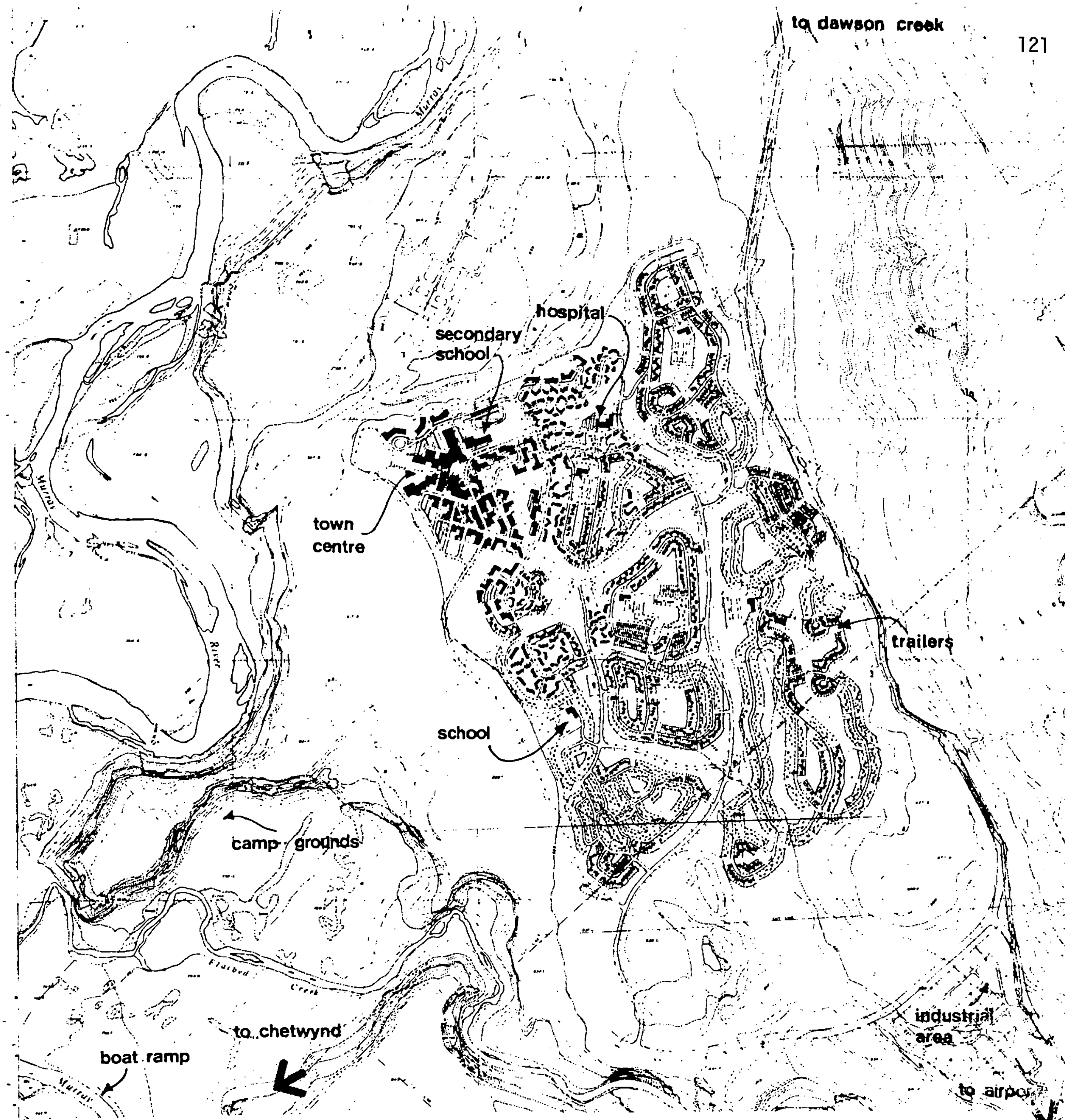
The gutter/swale system could save a further $2,140/unit over conventional services, and also avoid the rapid, short, high intensity discharge rates associated with piped storm drainage.



PLAN A

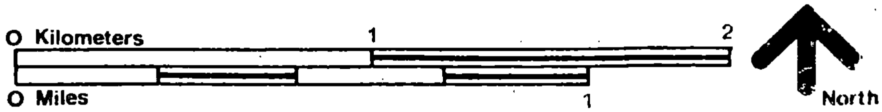
Figure 74





PLAN B

Figure 75



E.6 ARCTIC/SUB-ARCTIC

General Conditions

This region's climate is characterized by extreme cold for much of the year, and most of the northern arctic zone is continuous permafrost. The more southerly sub-arctic zone is within the limits of discontinuous and scattered permafrost. The short summers have long daylight hours, while the winter months are almost entirely in darkness or twilight. The lack of tree cover in the arctic makes the effects of unbroken winter winds particularly severe. Precipitation is generally low, averaging around 10 cm/year, although parts of Labrador experience up to 100 cm/year.

Landforms are varied, including mountains, uplands, plateaus, lowlands, and plains. Moraines, eskers, and drumlins are widespread. Drainage is generally poor because of the widespread permafrost.

Vegetation in the Arctic is tundra: scattered shrubs and lichens, with no trees. Sub-arctic vegetation has scrub forest-and-barren and boreal forest zones.

Development Limitations

- Extreme Climate

  Open air construction is normally possible only in the summer months. External services are difficult to construct and are costly. Building design requires particular attention to maintain a favourable internal climate at a reasonable cost; the lack of tree cover suggests the use of buildings and collective form to reduce wind effects and heat losses through infiltration. Complex building forms with fin effects must be avoided.

  The unusual light conditions (continuous daylight in summer, continuous twilight in winter), winds and cold for much of the year, together with isolation and boredom, can create psychological problems for residents from the south, and community social problems of transient populations and impermanence.

- Permafrost

  Foundations must be specially adapted to permafrost conditions, except where suitable areas of exposed bedrock can be found. Permanent heated structures must be raised above grade to prevent direct contact with surface soils, unless a very deep, well drained, gravel base is available. The combination of a thick gravel base with piles to bedrock is optimal.

  Surface transportation of bulk goods, including construction materials, is limited to the non-summer months, while construction per se, is feasible only in the summer months. This can create scheduling problems, and therefore, long range planning of proposed development projects is essential.

- <u>Infrastructure</u>

In most areas, there is little existing infrastructure; goods and services are extremely limited, and transportation networks virtually nonexistent. Since most construction materials must be imported, consideration of strength-to-weight ratios and volume-to-surface area ratios is essential in building design, since the costs of transporting materials are major components of construction budgets.

ARCTIC/SUB-ARCTIC

Important Environmental Components	Normal Conditions	Development Considerations
1. Terrain		
• Aspect	Variable	Leeward slopes provide shelter from winds, but also accumulate snow
	Radiation on south-facing slopes is prolonged but not intense	Preferred building sites are gentle, south-facing slopes
• Topography	Slopes greater than 15 to 18% tend to be unstable	Steeper slopes should be avoided for development
	Drainage is poor in lowlying areas and on gentle slopes with fine soils	Standing water and soil movement are common problems; gently inclined sand and gravel areas are comparatively well drained.
	Snow accumulates in low areas and to the lee of relief features	Low areas are unsuitable building locations; ridges and windward slopes are potential transportation corridors (for winter snow roads, for example)
• Soils	Variable composition and depth	Finely textured soils retain excess amounts of water and are unstable; coarse textured soils provide a good foundation where slopes allow adequate drainage.
	Continuous permafrost distribution in the north, discontinuous in the sub-arctic	Drainage is better in discontinuous areas, but uniform ground stability may be a problem. Well-drained non-permafrost areas are greatly preferred as sites, where available.
	Permafrost will deteriorate when surface is disturbed	Can lead to extensive ground slumping and erosion; excavation is also difficult.
• Parent Materials	Soil composition is variable, but sands and gravels are available	Eskers and moraines are preferred for building sites in the sub-arctic; sands and gravels are a good source of foundation materials

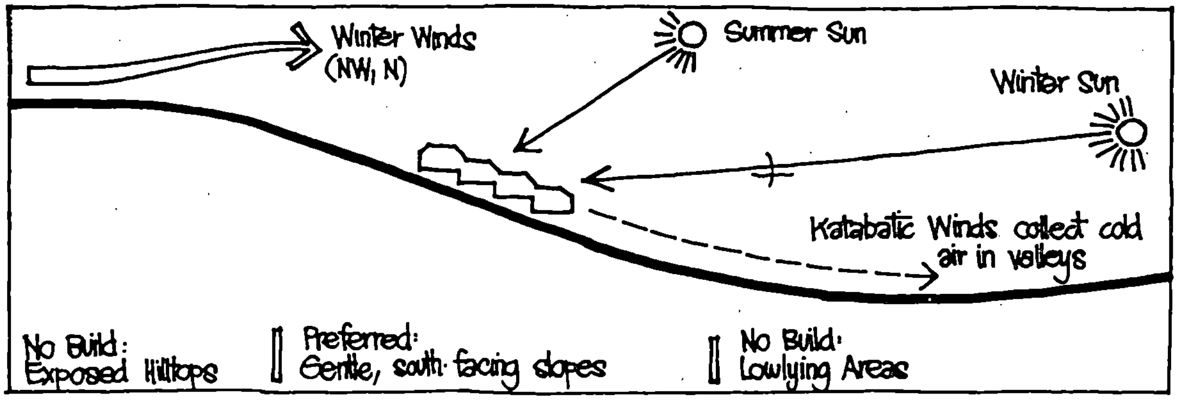
Important Environmental Components	Normal Conditions	Development Considerations
2. Water		
• Runoff	Often severe during June and July	Extensive flooding of lowlying areas; damage to structures, property, and transportation routes; erosion and deposition problems.
	Variable topography	Runoff accumulates in lowlying areas; flow is often heavy on slopes, resulting in erosion and deposition problems.
	Soil permeability is extremely low because of permafrost	Low absorption of surface water
	Water collects in depressions	Lowlying sites have limited development value; small lakes are a potential summer water source.
	Drainage patterns are variable, often poor	Limitations to development sites because of flooding and erosion.
	Solifluction (soil movement) is common on slopes	There is an unstable "active layer" where slopes exceed 15% and soils are finely structured; the banks of water courses are also often unstable.
• Permafrost	The active layer of permafrost varies from a few cm to 2 m or more depending on local conditions	Active layers are unstable; with much surface disruption. Underground plumbing must be heated or have continuous circulation. Buildings should be placed on existing sand and gravel beds or on gravel pads greater than 1 m thick, with air spaces, in order to prevent heat loss from the building to the permafrost.
• Ice	Rapid spring breakup	Large ice flows preclude development on flood plains; docking facilities may be difficult to locate.
	Depths up to 2 m	Surface transportation on ice is feasible, while water transport is limited for much of the year; ice is also a potential water source.

Important Environmental Components	Normal Conditions	Development Considerations
3. Climate		
• Temperature	Extremely cold winter temperatures; to -60^{o}C	Serious heat losses; compactness is essential for buildings and collective urban form; maximization of volume with minimal exposed surface area. Structures should use the insulating qualities of snow wherever possible.
• Precipitation	Occasional snow storms, more frequent in eastern regions	Disruption of transportation and communications
• Wind	High velocities, primarily from the north and west in winter	Shelter is needed; vegetation (where it is present - in the sub-arctic, for example) should be used as building shelter to reduce heat losses on windward faces. Windward building exposures should be minimized.
	"Katabatic" winds flow down slopes to collect cold air in valleys.	Preferred development sites are mid-slope; hilltops are exposed to winds, valleys receive cold air.
	Extensive snow drifting	Snow accumulates in hollows, ravines, and to the lee of obstacles; resulting in disruptions in transportation, and reduction in the insulating capacity of snow. In the arctic, building form must be used to reduce drifting, since tree cover is non-existent.

Important Environmental Components	Normal Conditions	Development Considerations
4. Vegetation and Wildlife		
• Vegetation	Vegetation reduces the thickness of the permafrost active layer	Vegetation communities should be preserved where possible, because they stabilize the permafrost.
	High sensitivity	Recolonization of disturbed sites is a slow process.
• Wildlife	Breeding sites are sometimes limited	Development should be avoided near waterfowl breeding areas and calving grounds for caribou.
	Caribou are sensitive to disturbance along migration routes	Development (particularly transportation corridors) should avoid caribou migration routes.

1 Terrain

Figure 76

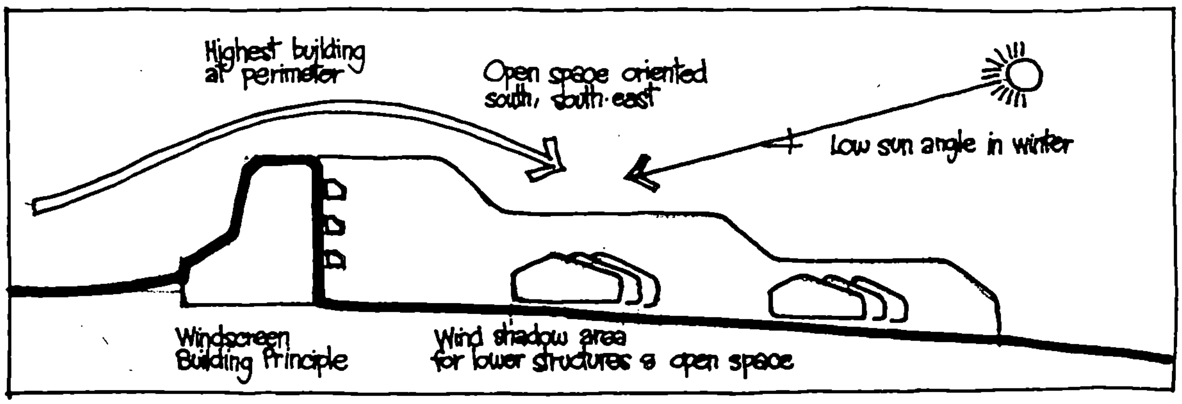


2 Storm Water

Figure 77

3 Climate

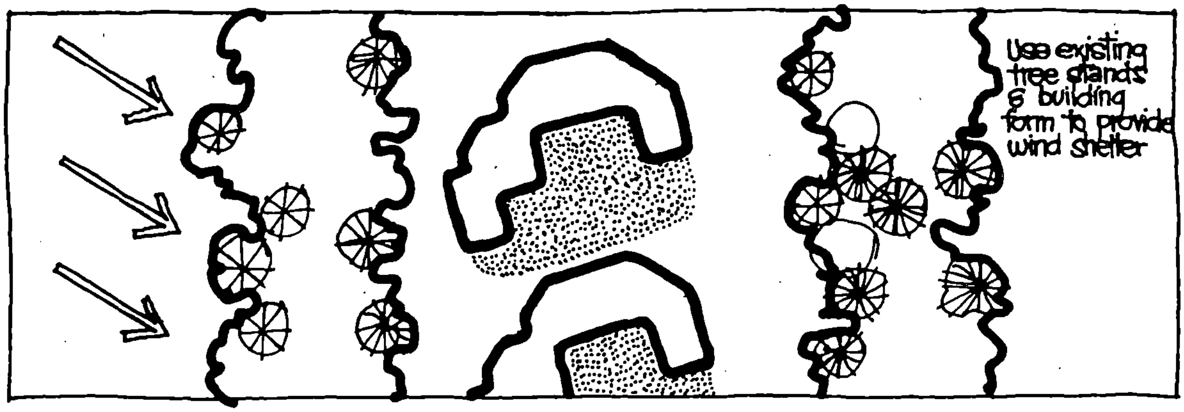
Figure 78



ARCTIC/SUB·ARCTIC

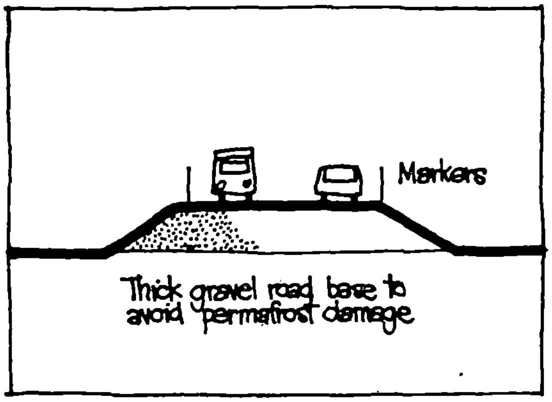
4 Vegetation (Sub·Arctic Only)

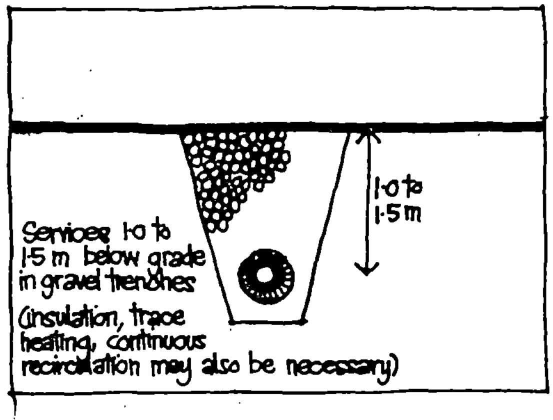
Figure 79



5 Construction

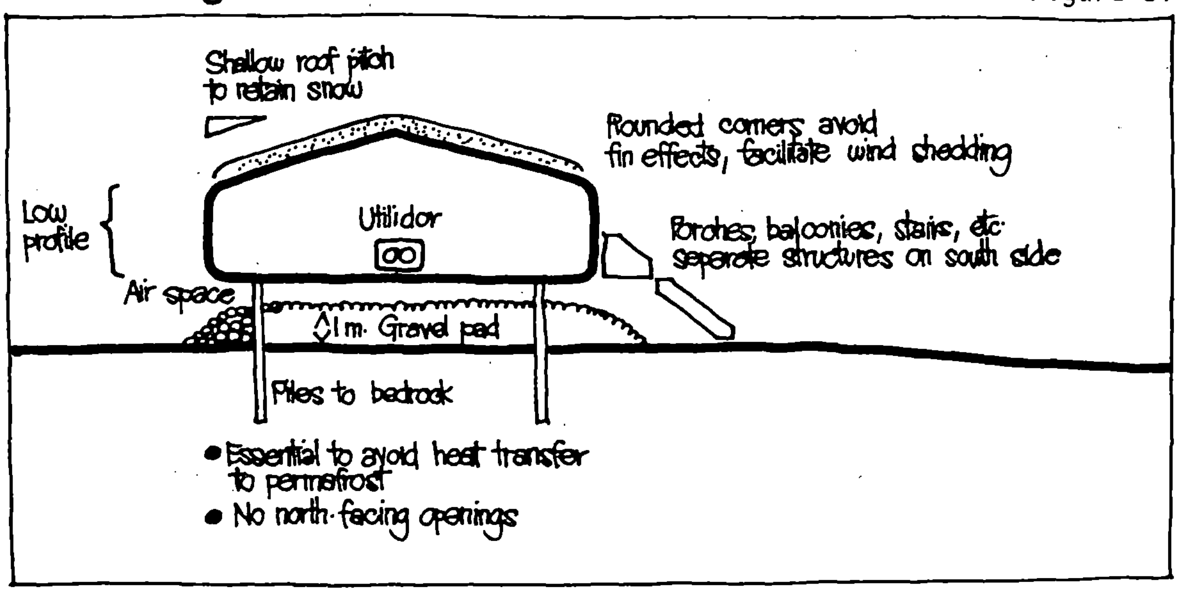
Figure 80





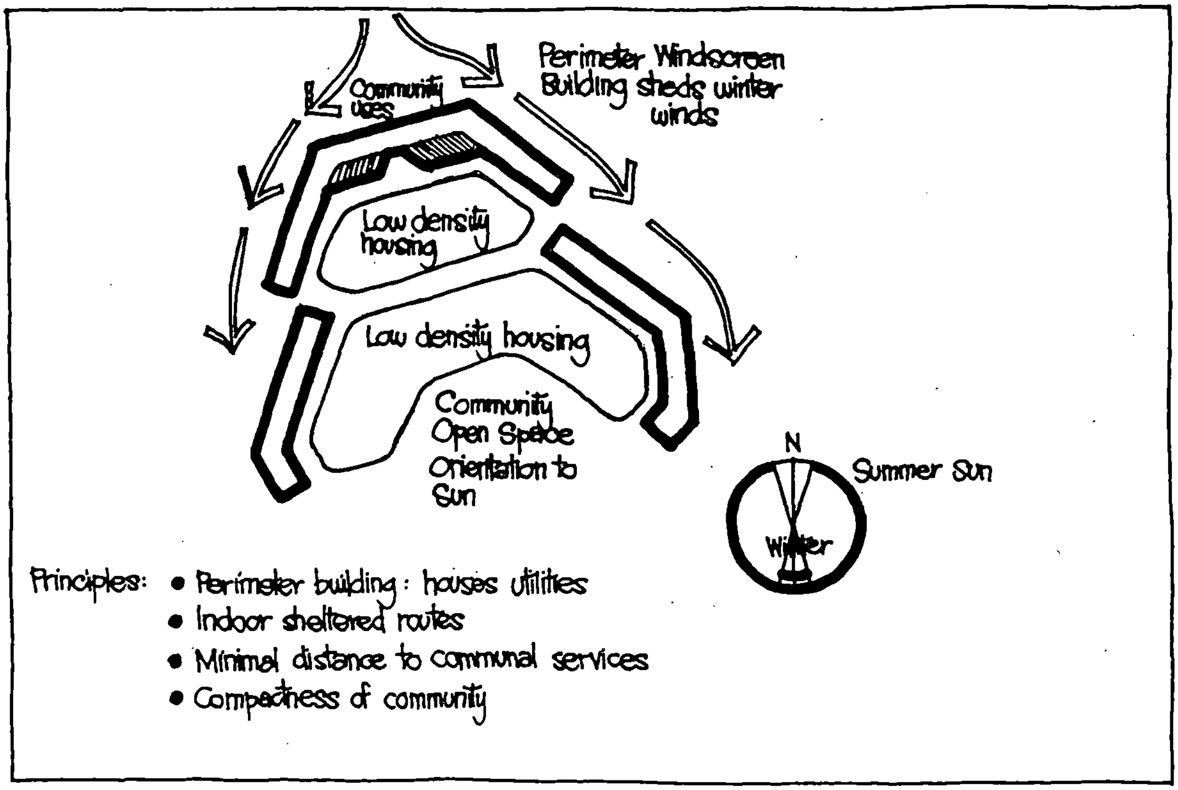
6 Housing Form

Figure 81



7 Community Form

Figure 82



CASE STUDY: RESOURCE COMMUNITY, SUB-ARCTIC

Fermont, Quebec
(Desnoyers & Schoenauer for Quebec Cartier Mining Co., 1973-76)

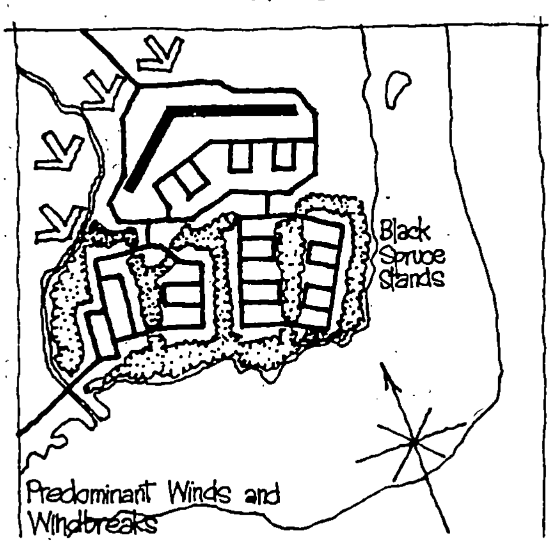
Fermont is a new resource community 800 km north east of Montreal in a sub-arctic setting, housing the workers and managers for the Mount Wright iron ore deposit. An overall population of 5,000 is accommodated in a compact plan, occupying only 77 ha, with roads occupying only 19 ha, or 2.3 m/person. The residential density of 65 persons/ha is relatively high for resource communities.

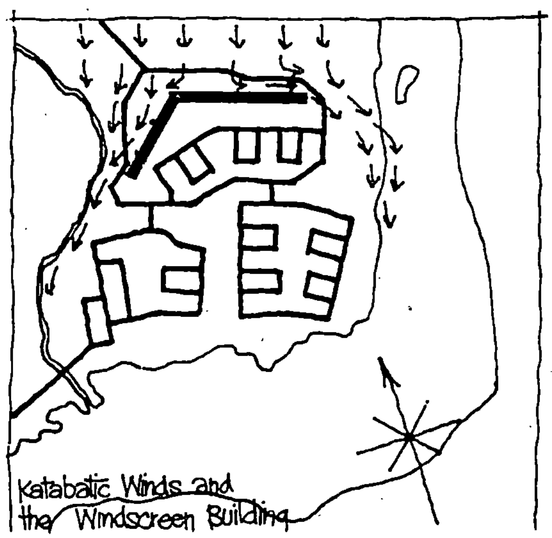
A number of environmentally-based planning responses are embodied in the project:

- Density and Compactness: reduces capital costs in paved roadways, curbs, sidewalks, sewers, lighting, hydrants, power distribution, etc.; also reduces operating costs in road maintenance, snow clearance, policing
- Windscreen Building: oriented to shed the katabatic winds around the community; the 5 storey height shelters lower buildings within the shadow area
- Windscreen Vegetation: strategically located bands of existing black spruce are retained to shelter the low density housing precincts.
- Building Design: interlocking split level apartments avoid the costs of a single-loaded corridor system.

Among the benefits claimed for the project are:

- a 60% reduction in infrastructure length and capital costs, and similar reductions in operations and maintenance costs (such as snow removal)
- improved micro-climatic conditions (increased temperature, reduced wind speed) for most of the community
- reduced heat loss from buildings - up to 50% over similar communities (the windscreen building has a relatively small exposed surface area/unit, as well as reduced wind speeds)
- opportunities for socialization in the town's 3 centres: recreation, education, and shopping, all enclosed within the windscreen building.





References: Specific Responses

1. Bondy, D.A.; Canada's Land Resource Supply, (Ottawa, Lands Directorate, Environment Canada, 1976)

2. ELUC Secretariat, British Columbia Ministry of the Environment; A Land Use Planning Framework, (Victoria, July, 1977)

3. Hendler, Bruce; Caring for the Land: Environmental Principles for Site Design and Review, (Chicago, ASPO Report No. 328, 1977)

4. Hilderman, Feir, Witty; Leaf Rapids, Manitoba, Development Plan, (Winnipeg, 1973)

5. Land Design/Research Inc.; Cost-Effective Site Planning: Single Family Development, (Washington, National Association of Home Builders, 1976)

6. Schoenauer, N.; Shape and Orientation of Buildings: Design for Energy Conservation in the Sub-Arctic, (Ottawa, ECE Seminar, 1977)

7. Thompson, Berwick, Pratt et al; Tumbler Ridge Community Plan, (Vancouver, British Columbia Government, 1977-78)

8. Underwood McLellan & Associates; General Development Plan, Resolute Bay, North West Territories, (Edmonton, 1978)

9. Wallace, McHarg, Roberts & Todd; Woodlands New Community: Site Planning Guidelines, (Philadelphia, 1973)

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F. IMPLEMENTATION

F.1 ISSUES

In many parts of Canada, there may be one or more constraints to implementing the environmental planning responses described above. These are perhaps best categorized by the interest groups they affect:

Development Industry

- the costs of the development process: a concern that the time required for approvals may be extended; with additional fees for environmental impact statements if required; and increased project uncertainty resulting from government regulation, and the imprecise designation of Environmentally Sensitive Areas.
- project costs: the development industry must be convinced that environmentally sensitive planning and development practices will save on current development costs, and have positive markeitng benefits.
- loss of development potential (particularly on or near Environmentally Sensitive Areas): loss of lands taken out of development for Environmentally Sensitive Areas; together with additional lands which may be required for swales, drainage basins, open space corridors, and the like.

Public Agencies and Authorities

- public goals: the concern and responsibility of public authorities for health, safety, and welfare, can, in some instances, be translated into overly restrictive or conservative municipal engineering standards which add to costs and restrict innovation.
- the downstream (off-site) impacts of development: capital costs for major engineering works and remedial measures, operating and maintenance costs, flood damages, etc.

Consumers

- possible resistance to innovative housing and site design: this can be reflected in an unwillingness to accept natural "unfinished" on-site landscaping; a concern with public standards (such as a reduction in sidewalks, drainage swales instead of storm sewers, etc.) and public safety (such as exposed water bodies and retention ponds).

Figure 83 summarizes these issues and some possbile resolutions to them.

Figure 83

IMPLEMENTATION ISSUES	POSSIBLE RESOLUTION
• Costs of the development process	• Mandatory response times for applications • Single co-ordinating agency for planning and environmental approvals • Environmental Impact Statement standards, common data base
• Costs of development	• Manual of practices and costs
• Loss of development potential	• "Agri-zoning" • Impact Zoning • Transfer of Development Rights
• Restrictive municipal engineering standards	• Performance-oriented standards
• Downstream impacts of development	• Performance-oriented standards (on-site)
• Consumer resistance to innovative housing and site design	• Marketing to stress amenity, reduced costs, energy conservation.

F.2 RESOLUTIONS

The Development Industry

The housing development industry is legitimately concerned that the costs of the development process not continue to escalate. With environmental planning issues, local authorities must ensure that there is no double jeopardy; that is, development projects should not have to go through separate planning and environmental approvals processes; and reply times must be acceptable (at least simultaneous with the present planning approvals system).

The costs of a project environmental impact statement (for example, for a 50 ha subdivision) can approach $10,000 to $25,000 under normal conditions. This figure can double if the project includes, or is near, an Environmentally Sensitive Area. Full Environmental Impact Statements should only be required in critical cases (for example, Environmentally Sensitive Areas of provincial or national importance). Costs can also be reduced if public agencies furnish a common environmental data base acceptable to all parties.

Project costs can also be increased through the uncertainty created by government Environmental Impact Statement regulations and approval requirements. Two Regional Municipalities in Ontario, Halton and Waterloo, illustrate differing approaches to Environmentally Sensitive Areas, which affect the development industry in quite different ways. In Halton, Environmentally Sensitive Areas are designated by location only, and it is up to the proponent of parcels on or near such locations to outline how the project will affect the E.S.A. and what mitigating measures he will take to avoid negative impacts. In Waterloo, the boundaries of Environmentally Sensitive Areas are rigidly fixed, leading to controversies about the significance of each area, their exact boundaries, the inviolateness of the resource, and so on. The performance-oriented approach of Halton is to be preferred from both public and prviate viewpoints.

The development industry as a group is also generally interested in reducing project costs. The documentation provided in this and other reports provides some of the information needed to reduce such costs. For example, savings of $1,000 to $2,000/unit over conventional practices are possible with natural landscaping and drainage practices; however, potential savings can also be wiped out or made unfeasible if approvals or the negotiations on the feasibility of the practices delay the project by 6 months or more.

Land developers and development interest groups have also expressed a major concern with the potential loss of development rights, for projects on or near Environmentally Sensitive Areas. Several resolutions are possible here:

- Transfer of Development Rights from the Environmentally Sensitive Area to adjacent lands, or to nearby lands with a development potential similar to that lost;

- Flexible Zoning which permits limited compatible development in environmental areas of some sensitivity. For example, "Agri-zoning" which permits residential development on low capability lands, while ensuring the maintenance of viable agricultural production on the high capability lands (see the Parkway Farms case study).

- "Development Impact Zoning" which relates the scale and intensity of development to the natural carrying capacity of the site, local finances, services, and constraints. This is a form of floating zoning which allows densities to be reallocated according to specific conditions within a large site. (see Impact Zoning case study).

Public Agencies

Many municipalities in Canada maintain conservative and overly precise engineering standards for project components such as:

- road pavement widths and right-of-way allowances
- curbs, gutters, and sidewalks
- house drainage and storm sewers
- lot grading and road drainage.

Unfortunately, the results of such standards are often to exacerbate the urban runoff problems of the kind discussed above (Chapter D.2, Storm Water) and to restrict innovative site development practices which could address such problems. The agencies which are concerned with watershed protection and flood management (such as the Conservation Authorities in Ontario) are often separate from the local municipalities which set development standards, and therefore indirectly legislate the amount of storm runoff into streams and rivers. In some cases, the runoff from existing completed development projects has "used up" existing stream capacity, meaning that subsequent projects cannot proceed unless they meet a "zero increase in runoff" standard.

As with Environmentally Sensitive Areas, a key to the introduction of environmental planning techniques, and particularly storm water management practices, probably lies in an approach which emphasizes performance rather than strict adherence to specifications, and shifts the responsibility to the developer to prove that his proposed design meets the required performance. Increasingly, municipalities should be requiring the developers of larger projects to devise solutions to environmental impacts within site boundaries rather than off-site (where the costs and solutions must be provided by public agencies). Such performance standards for storm water control, for example, would control such factors as outflow runoff intensities, % impervious surface, % clearing, % coverage by buildings, etc., leaving the developer free to adapt his project to meet these requirements. The developer benefits if his solutions result in lower project costs; the community often benefits as well, from lower operating and maintenance costs. (see Figure 84).

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CASE STUDY: AGRICULTURAL ZONING

Parkway Co-operative Farms, Mississauga, Ontario
(Cadillac Fairview Corporation, 1976)

This project proposes a co-operative farming community in the Parkway (greenbelt) zone between Mississauga and Brampton, Ontario. The Plan incorporates specialty crops, fishfarm, orchards, recreational trails and ponds, and some low density housing on poorer soils, intermixed with the productive agricultural lands.

Agriculture is to occupy 114 ha out of a total site area of 184 ha, with woodlots occupying 51 ha, and housing only 15.4 ha. The design population for the community is approximately 1,000 in 300 units.

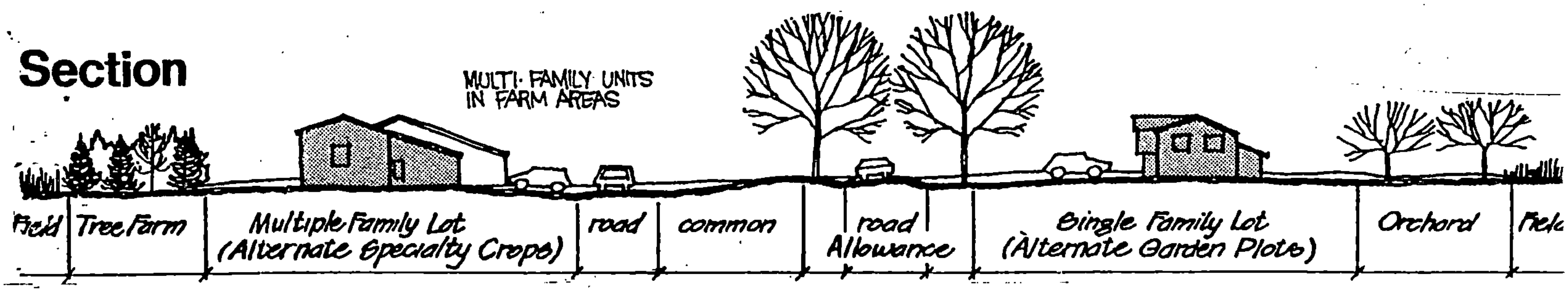
This project represents a serious attempt by a major private developer to respond to agricultural land preservation issues while still realizing development profit. Housing is to be sited on the most suitable (least valuable agriculturally) lands, while 90% of the land is to be kept in agricultural production or woodlots.

The key to the proposal is an organizational form (co-operative or condominium) which keeps a viable farm unit in operation. Every home owner also has a share in the farm operations, and the farm manager doubles as the condominium manager. The project cash flow analysis shows a break-even or modest profit on farm operations (generally feedlot or specialty crops in this part of Ontario).

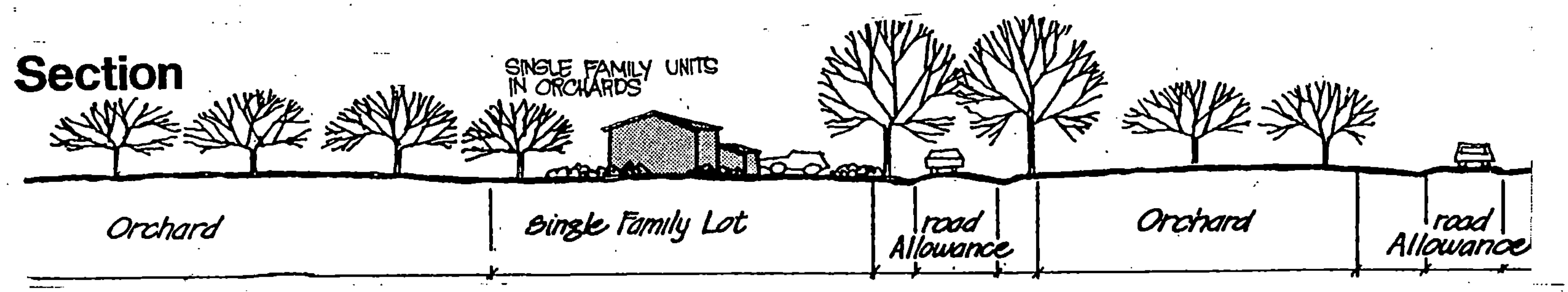
In addition to his housing development costs, the developer would invest $400,000 in initial farm operations, including woodlot and orchard planting, pond development, start-up funds, farm machinery, and buildings.

Other advantages of the proposal include the fact that it does not require the use of public funds for the acquisition of greenbelt lands, and the housing has economical self-contained services, with plenty of land for storm water percolation and effluent disposal.

Section



Section



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How impact zoning will work: a projected case study

The developer, whom we'll call Green, has taken an option on a 300-acre parcel. Existing zoning in the area calls for single-family houses at a maximum density of two units per acre. Green's original intention is to build just that, since he has always built single-family houses, and he feels most comfortable in that kind of market.

But a problem arises: Green has a market study made and finds he can expect an absorption rate of only about 50 single family houses a year at his average price of, say, $40,000. This gives him a build-out time of 12 years, and his cash-flow studies show that at such a rate his debt service will murder him.

But Green is lucky: The town has just passed an impact-zoning ordinance. So he has an opportunity to apply for a PUD with a higher density.

Green's first step is to go back to his marketing study. He finds there is a marked shortage of lower-priced units like townhouses and condominium apartments. If he is willing to move into this low-priced market, he can expect to sell at least 300 units a year. He decides on a six-year build-out period, which at 300 units per year adds up to 1,800 units, so he starts with an overall density of six units per acre.

Now Green goes to the town hall, checks the master ground-cover map *(page 63)* and discovers that on his site maximum allowable coverage is 20%. He takes this information back to his planning firm and is told that it will allow a density of four to five units per acre. Green re-estimates his build-out at a conservative 200 units a year (or a total of 1,200 units) and is satisfied with the result. He decides to plan a PUD under the impact-zoning ordinance.

Now a conceptual site plan is needed. Working with his planner, Green comes up with this:

The site's overall density is four units per acre. His rough apportionment of the 1,200 units calls for 400 condominium apartments, 400 townhouses and 400 single-family houses. (This is a high proportion of single-family housing for a PUD, but Green, as noted earlier, has been a single-family builder until now, and he feels safer with a high ratio in this market.)

In addition, the plan calls for 60 acres of open space in parks and green belts, 24 acres of roads and a six-acre commercial area.

Green takes his plan to the town hall, and now a whole new set of criteria, established by the town's impact study, comes into play:

- The town's growth rate has been established at 1,000 families, or about 3,000 people, per year. Green's projected sales rate of 200 units a year is a reasonable portion of that.
- There is adequate sewage treatment capacity in the municipal system. However, the nearest main is not close to Green's site. Connecting this main and installing a lift station will cost $200,000.
- In general road capacity in the area is adequate. But a nearby intersection will be overloaded; widening it and installing a traffic light will cost $100,000.
- Green's PUD will put an average of about 0.7 children per unit—or a total of 840—into the town schools. This is high for a PUD. Moreover, thanks to a plethora of new single-family housing in the town over the past few years, the school system is now filled, so Green's project will require capital outlays for new schools as soon as move-ins start. Hence, the expected revenue from the project will fall short of the combined school and municipal costs it will generate.

However, the town fathers consider Green a stable, dependable developer, and they feel his preliminary plans promise a high-quality project. So they begin negotiations.

The revenue deficit comes first. Raising prices would increase the project's assessment and thus boost the tax revenue it will generate. But Green feels this will narrow his market too much. He decides to forego some single-family houses and to build more townhouses and condominium apartments. The new mix—300 houses, 500 townhouses and 500 apartments—maintains the same level of ratables but decreases the number of school children to a point where the revenue deficit turns into a small surplus. With 1,300 units the overall density rises somewhat, but the ground coverage is still below the acceptable 20%. So far, so good.

Now comes the question of $300,000 for sewage hookup and the improved street intersection. Financed by the towns, these capital improvements would cost about 7% per year, or $21,000. If Green is willing to switch his mix further towards townhouses or condominium apartments—and so cut the school load by about $21,000 a year—the town agrees to lay the sewer line and fix the intersection.

But Green feels that decreasing his already reduced single-family ratio would create too much of a marketing risk. He decides instead to pay the $300,000 himself.

The negotiations are finished. Green is now ready to commission final plans and start developing.

Construction (Developer):

	New Standards		Previous Subdivision Regulations	
Paving	20' Collector. 15,560 sq yd @ 4.00/sq yd	$62,240	40' Collector 31,120 sq yd @ 4 00/sq yd	$124,480
	24' Local 19,866 sq yd @ 4 00/sq. yd	$79,464	36' Local 29,799 sq yd @ 4 00/sq. yd	$119,196
	Culs-de-sac—26 516 sq yd x 26 13,416 sq yd 13,416 sq yd @ 4 00/sq yd	$53,664	Culs-de-sac—26 1,080 sq yd x 26 28,085 sq yd @ 4 00/sq yd	$112,340
Curbing	None		45,922 lin ft @ 3 00/lin ft	$137,766
Swales	36,680 lin ft of sod @ $ 80/lin ft	$ 29,344	None	
	TOTALS	$224,712	TOTALS	$493,782

As the above table indicates, the difference in cost is $269,070 00—exclusive of the additional outlays for the storm lines and catch basins which would be necessary to take off storm water generated by the wide roads required by the previous subdivision regulations

Maintenance (Municipality):

New Road Widths		Previous Subdivision Regulations	
20' Collector 15,560 sq yd. @ 41/sq yd	$ 6,379 60	40' Collector 31,120 sq yd @ 41/sq. yd	$12,759 20
24' Local 19,866 sq yd @ 41/sq yd	$ 8,145 10	36' Local 29,799 sq yd @ 41/sq yd	$12,217.60
Cul-de-sac circle (45 outside rad 25' inside rad) 13,416 sq yd @ 41/sq yd	$ 5,500 60	Cul-de-sac (50' outside rad.) 28,085 sq yd. @ 41/sq. yd	$11,514 90
TOTAL	$20,025.30	TOTAL	$36,491 70

Average yearly maintenance costs for storm sewer is $750 per mile or $ 14 per linear foot Use of curbing in the standard subdivision probably would necessitate the use of twice as much storm line as a system which combined storm lines and grassed swales The following cost comparison results

4,550 lin ft @ 14/lin. ft	$ 637.00	9,100 lin ft @ 14/lin ft	$ 1,274.00
	$ 637.00/yr		$ 1,274.00/yr.

These maintenance costs represent a significant increase in the costs which homeowners bear as a part of their taxes

Figure 84

An example of the cost savings possible from changes in roadway standards.

(Millbrook Farms, a Planned Unit Development in Allentown, Pennsylvania; Planners: Rahenkamp, Sachs, Wells & Associates)

Source: <u>House & Home</u>, May, 1973, p. 72

One innovative approach is described in the Christina Basin Study (case study) which uses environmental performance standards for watershed protection: the costs for protective measures become the basis for development control rather than conventional zoning, which of course, excludes certain activities outright in each location. Often these cost factors will force developers to seek innovative design solutions for water protection, or move to alternative, less sensitive locations. The public agency assists developers by providing a manual of suitable water protection measures and their costs, and relating these to regional terrain conditions. This means that individual landowners can see how much it will cost to meet the performance standard for any activity on a given site, and therefore, what kind and intensity of development can be justified economically.

Consumers

Market resistance to environmentally sensitive planning and design can be addressed by publicizing several key points:

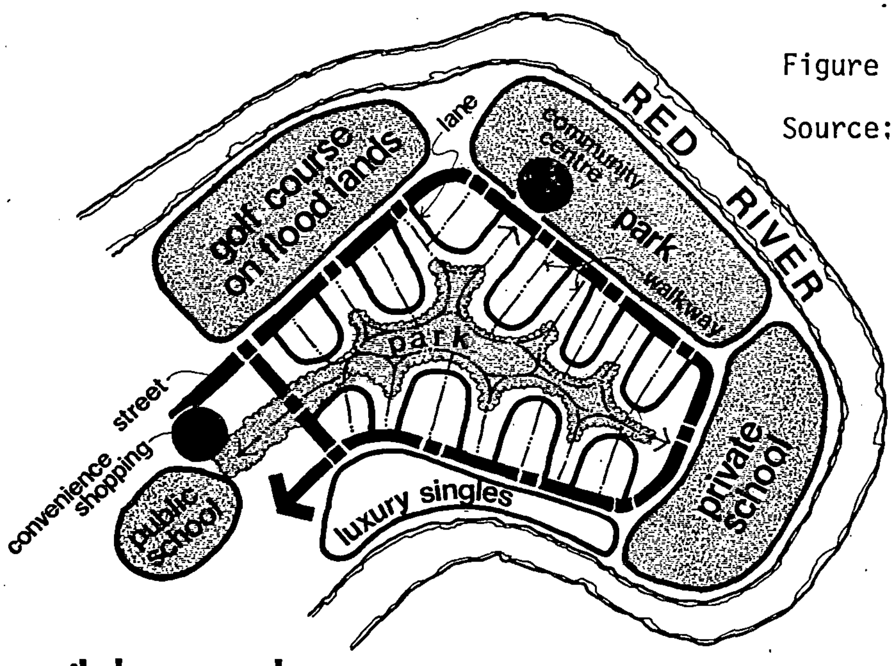
- reduced site development costs are directly refelcted in lower monthly carrying charges: for example, a reduction of $2,000 in overall costs could result in a $20 reduction in monthly mortgage payments.

- increased amenity and long term property value increases for sensitively designed projects.

  One example, Wildwood Park, is a 500 home cluster housing development in Winnipeg, begun in 1947. The plan (Figure 85) is based on the concept of a loop road cluster with the privacy areas of all homes oriented towards a major open space system. Between 1974 and 1977, homes in Wildwood have shown a 240% increase in value, with short resale times.

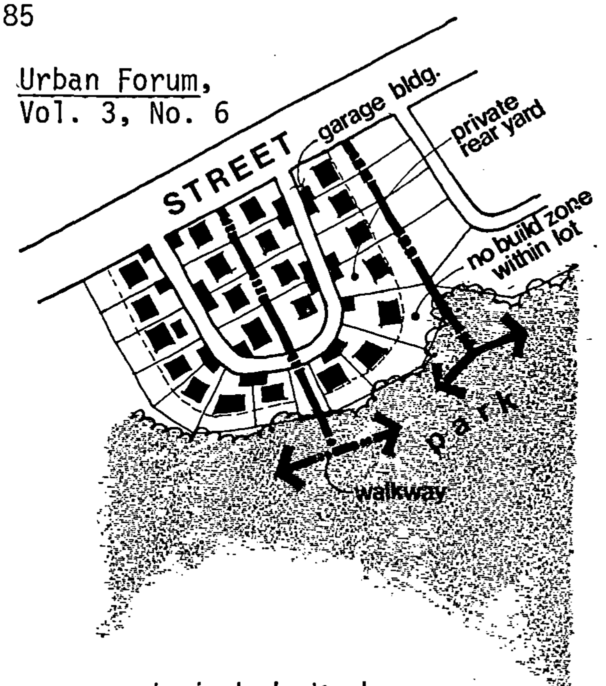
Figure 85

Source: Urban Forum, Vol. 3, No. 6



wildwood park

a cluster neighbourhood



a typical cluster loop

CASE STUDY

Christina River Basin Study
(J. Tourbier et al; Water Resources Center, University of Delaware)

The response to the impacts of urbanization on regional watersheds has generally been remedial and at the level of major public effort; i.e. dam construction, channelization, sewage treatment works, etc.

The Christina Basin approach emphasizes watershed management at the local and sub-regional level, by focusing upon those measures which serve to prevent increased detrimental changes to the ground and surface water regimen. In this process, a site's vulnerability to development is indicated by the costs of measures needed to protect on-site and off-site water resources.

The project develops a site classification protection system, identifying and mapping 41 different classes of land having a critical influence on water resources. In addition, water-related performance standards are set for different types and intensities of development, and protection measures described and costed for:

- control of erosion, sedimentation and runoff pollution
- controlling quantities of runoff on-site
- recharging of groundwater
- control of pollution from septic tanks and sewer exfiltration.

Thus, for any site class, any type of development can be costed in terms of the water protection measures required to offset its potentially undesirable environmental impacts. Where the costs of protection measures for a particular activity exceeds 1½ times the unserviced raw land cost of a site, that type of development can normally be considered unfeasible.

One map from the study shows the relative cost per acre of protective measures for single family housing at a gross density of 2 to 4 units per acre. Costs are highest in areas where there is a concentration of natural resources, and are indicated by the areas of darkest printing.

- specific marketing which builds the housing and community design concept on environmental attributes. such as "Treetop Estates" in Oakville, Ontario, or "Sackville Lakes" in Nova Scotia.

- increased energy and operating cost savings from passive solar site design and the use of natural vegetation.

  An example is the South March Township Energy Conservation Community (case study) in which marketing and design will be heavily oriented towards the savings possible from higher density clustered housing design and passive solar planning principles.

CASE STUDY

South March Energy Conservation Community, March Township, Ontario
(John Hix et al, for Cadillac Fairview Corporation, 1977)

This project for an energy-conserving community of 2,200 units (6,000 to 7,000 ultimate population) is located on 178 ha of land outside Ottawa. The overall housing density is 30 units/ha (townhousing density) with 54% of the total land remaining as reforested open space.

The emphasis in the project is on community redesign, including the orientation and geometry of streets, re-examination of suburban densities, and determination of the optimal level of compactness. The residential architecture is receptive to passive solar heat gains during winter.

- Site Plan: the road system for the community is largely east-west in a linear grid pattern to allow the optimal due south orientation for housing, with minimal shadowing

- Housing: a mix of 500 semi-detached, 1,525 grouped townhomes, and 175 apartment units, with no detached units (which have more exposed heat loss surfaces).

  House roofs and active living areas are oriented to the south.

  Conifer belts provide wind shelter to the north of housing units, deciduous trees provide summer shade to the south, but let in winter sun.

Costs and Benefits

- Individual Energy Conservation: a comparison between a standard single family detached unit in the Ottawa area and this community's attached townhousing shows a reduction in space heating requirements from 99 million kJ to 35 million kJ, resulting in a 48% reduction in monthly energy costs from $85/month to $44/month (1977 prices).

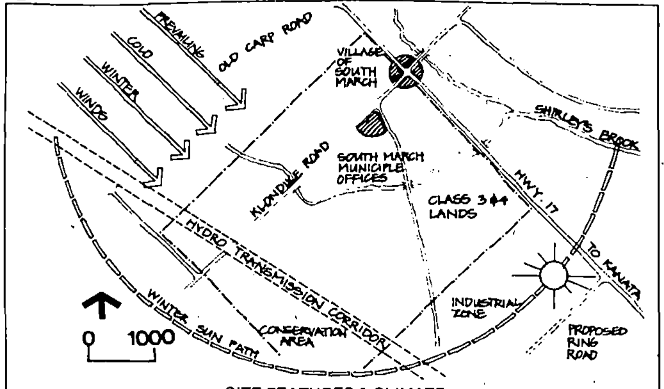
  Over the entire community, the cumulative savings total more than $1,000,000 annually in comparison with a low density suburb.

- Reduced Servicing Costs: a 50% reduction in road and infrastructure length together with reduced standards, permits a further cost reduction from $125/month to $52/month.

The cumulative savings for the community from both steps amounts to over $3,000,000 annually.

In addition, the Plan results in reduced municipal operating costs for those services which are street-related (such as fire, police, ambulance, road maintenance, snow removal, refuse collection, transit, etc.)

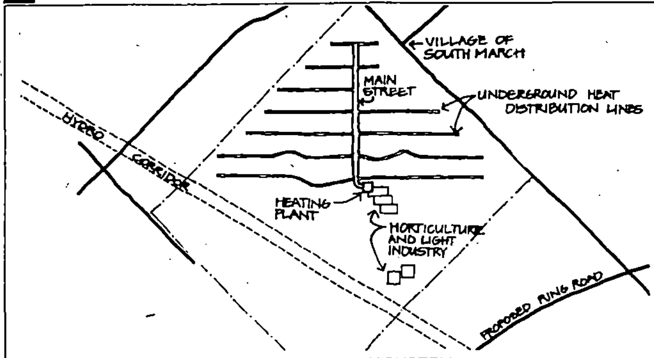
1



SITE FEATURES & CLIMATE.

The 441-acre (178 ha) located north of the March Township industrial park, has a conservation area to the south-west and slopes gently to the east. The winter climate and the northwest prevailing wind will determine the homes' orientation. Economic transportation is available to bring waste sources from Ottawa Valley forest companies.

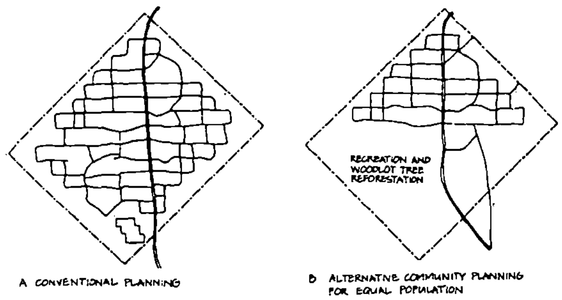
2



PROPOSED ENERGY SYSTEM.

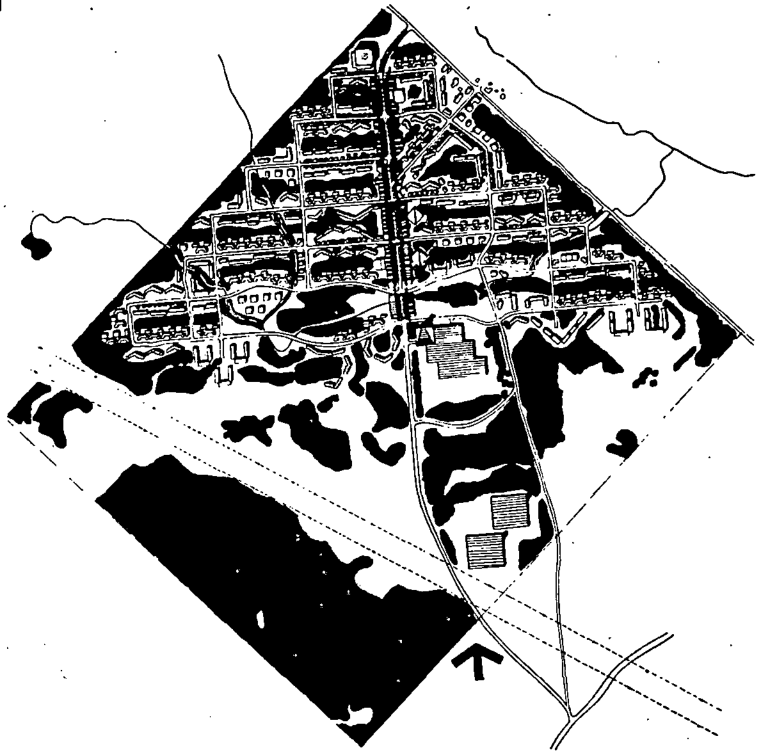
The community will be heated from a central plant with heat distributed via hot water piped underground — a low-temperature system popular in Scandinavia for some years. The system supplies space heating and domestic hot water to the entire community (residential, industrial and commercial). Initially, this will be a temporary, portable, fossil-fueled plant.

3



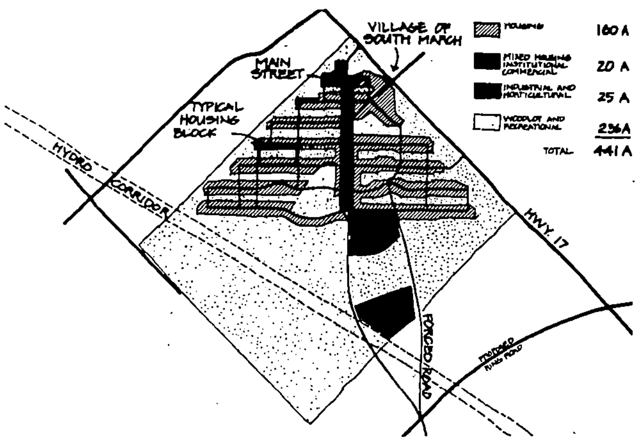
ROAD & SERVICE PATTERN.

A conventional suburban plan for 2,200 homes would occupy the entire site. The proposed plan uses minimized detached house form with emphasis on energy and cost efficient semis, grouped houses and garden apartments. These will be located along edges of large street blocks and for minimal sun shadowing.



PROPOSED DEVELOPMENT PLAN.

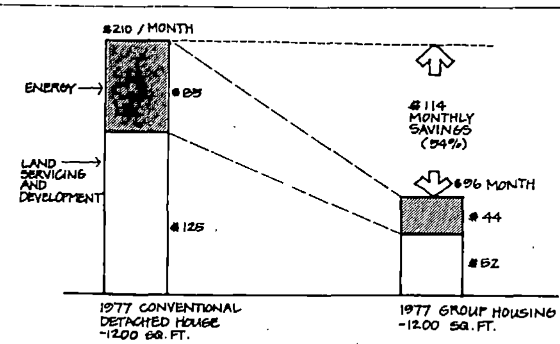
5



ROAD PATTERN & LAND USES

Road pattern is a continuous street grid relating directly to the "main street." The flexible pattern avoids tree groups, waterways and rock outcroppings, and combined with the site's easterly slope allows variety to the grid. Dead ends and cul-de-sacs are avoided to allow access for services and emergency vehicles. The simple pattern makes a mini-bus service viable. New road connections will be made with expansion.

6



MONTHLY ENERGY & SERVICE COST.

Grouped houses, properly constructed and oriented, with minimum exterior-surface area, employ energy conserving principles. Load per house is held to an average 33 million Btu's per year, with energy savings of $44 per month per unit.

Figure 86: South March Energy Conservation Community
Source: Canadian Architect, Vol. 23, No. 12, December, 1979
(pp. 48, 49)

References: Implementation

1. Hix, John et al; South March Energy Conservation Community, (Toronto, Cadillac Fairview Corporation, 1977)

2. Healy, Robert G.; Environmentalists and Developers: Can They Agree on Anything?, (Washington, The Conservation Foundation, 1977)

3. Muller, Thomas & James, Franklin J.; "Environmental Impact Evaluation and Housing Costs"; Paper delivered at the Annual Meeting of the American Real Estate and Urban Economics Association, Washington, May 29, 1975.

4. Pearson, Norman; Environmental Assessment Requirements and New Housing Projects, (Toronto, HUDAC, 1978)

5. Rahenkamp, John; Sachs, Walter; Wells, Roger; "A Strategy for Watershed Development (Wissahickon Creek Development Plan), Landscape Architecture, (April, 1977)

6. ---- ; York Agri-Community Final Report, (Philadelphia, July, 1973)

7. Richardson, Dan K.; The Cost of Environmental Protection" Regulating Housing Development in the Coastal Zone, (New Brunswick, New Jersey, Rutgers University, 1976)

8. Strong Moorhead; Hedlin Menzies; Llewelyn-Davies Weeks; Parkway Co-operative Farms, (Toronto, Cadillac Fairview Corporation, 1976)

9. Urban Land Institute; Environment and the Land Developer, (Washington, 1971)