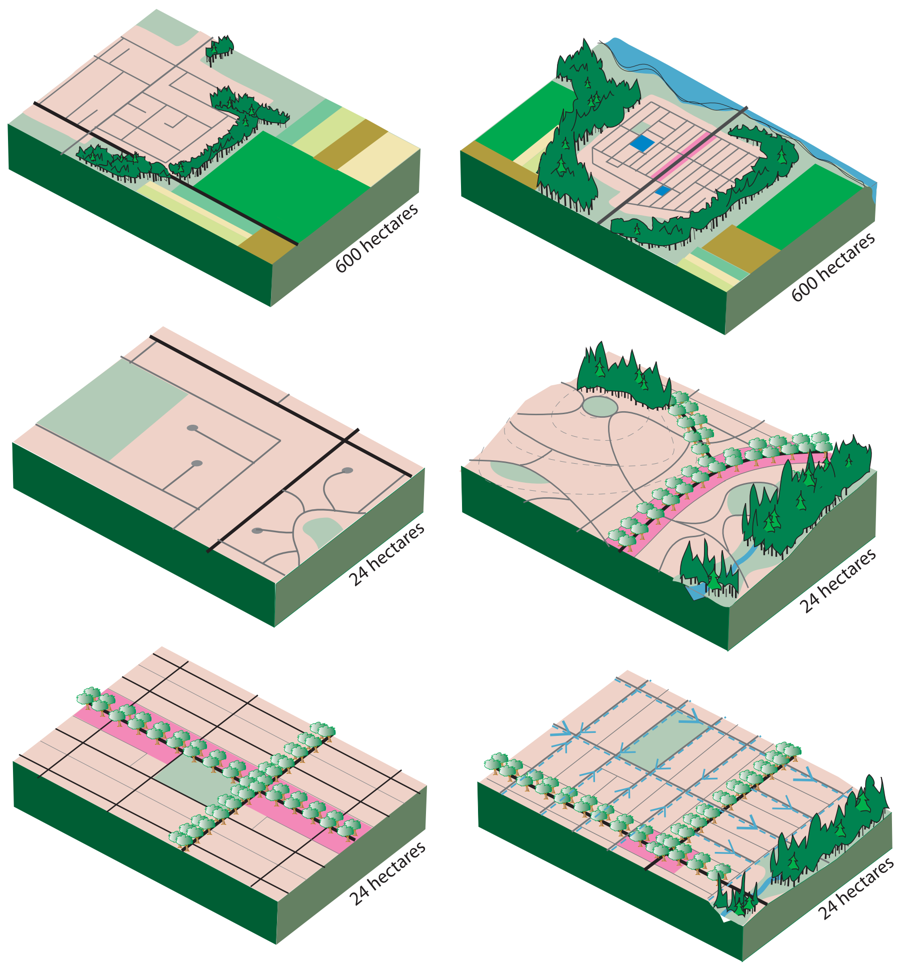
sustainable urban landscapes neighbourhood pattern typology



produced by

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The University of British Columbia James Taylor Chair in Landscape and Liveable Environments

produced for

the Sustainable Development Research Institute

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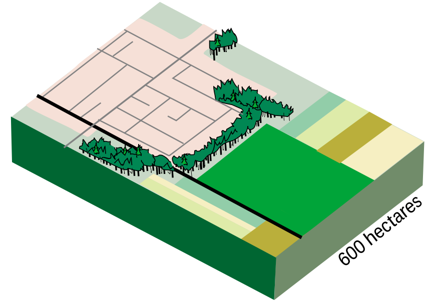
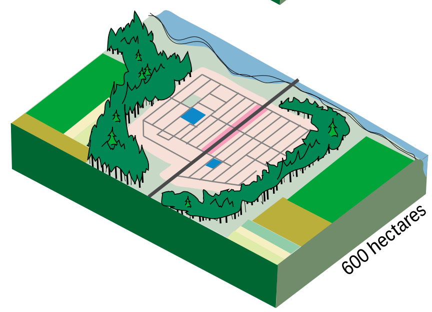
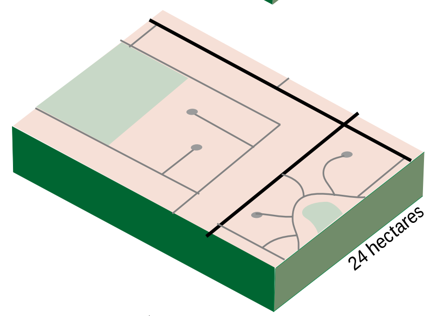
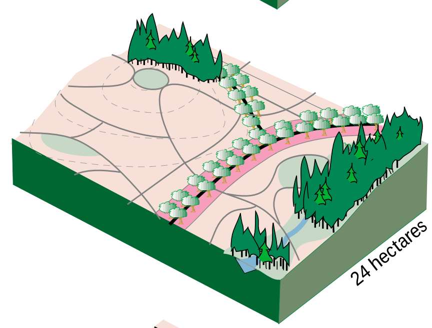
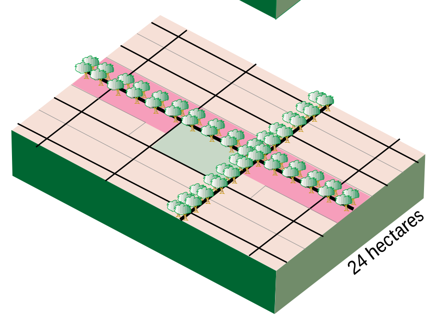
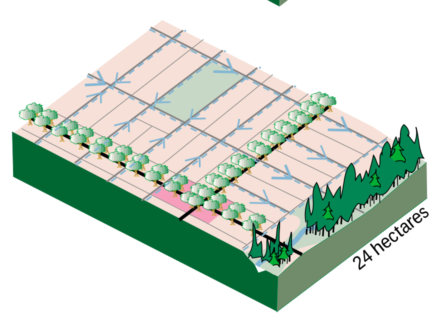












A growing body of research is illuminating the connection between patterns of neighbourhood development and the sustainability of our region. The mix of land uses, density of development, and arrangement of streets describe a neighbourhood development pattern. These three features have been jointly implicated in influencing sustainability factors such as: travel behaviour, home affordability and value, the formation of social ties, and permeability to rainwater. A fine-grained land use mix places amenities and employment close to residents. Higher density developments put enough people in the neighbourhood to support public transit and local shops. A well-interconnected street arrangement makes it easier and faster to get where you are going. Studies of neighbourhoods with these features show a general decrease in travel distance and trip duration and an increase in the walk/transit mode share.[1] Neighbourhoods where there is a reduced dependence on the car are also more conducive to the formation of social ties.[2] Higher densities (smaller lots and dwellings, and more people) may allow the cost of developing such neighbourhoods to be substantially lower.[3] Yet many residents prefer, and are even willing to pay more, for smaller homes in strong communities proximal to good transit and amenities. A well-interconnected street pattern also facilitates the use of infiltration-based stormwater systems, which can reduce downstream consequences of development by between 80 and 100%.[1] Clearly, land use mix, density and street arrangement are factors influencing neighbourhood sustainability.

Recognition of this connection challenges us to re-evaluate the neighbourhood development pattern as a fundamental determinant in the realization of sustainable communities. Once replicated on multiple sites, a neighbourhood development pattern becomes an integral part of the fabric of the region. And, just as the health of each cell contributes to the overall health of the body, the sustainability of each neighbourhood helps to determine the ultimate sustainability of the region. Regional sustainability begins with the choices we make about the neighbourhoods we build.

This study forms the basis of the Neighbourhood submodel of Georgia Basin QUEST (GB-QUEST) – the interactive web-based game that allows players to develop "what if?" scenarios for the future development of the Georgia Basin region (www.basinfutures.net). The Neighbourhood submodel looks at the neighbourhood as a regional building block. Rather than examining the effects of land use mix, density and street arrangement independently, possible combinations of these three features were explored. All sequences were attempted, with a final constellation of six Neighbourhood Patterns identified as representative of our study area, the Georgia Basin. Each Neighbourhood Pattern is described by a unique combination of street arrangement, land use mix, and density range (see table, opposite page). Data was collected to determine the relative sustainability of each pattern. Although almost all of these Neighbourhood Patterns are pre-existing, the purpose of this study is to describe how each would function as *new development* in the Georgia Basin. The results of this research will be applied in the GB-QUEST game, where the user may combine different patterns to explore the implications of Neighbourhood Pattern on the creation of a sustainable region.

Sustainability Factors

The data collected for the six Neighbourhood Patterns has been distilled into five sustainability factors: walkability, vehicle kilometres travelled ("VKT"), affordability, housing mix, and effective permeability. These factors were selected to reflect years of research and public policy that have evolved in response to an increased concern about the ecological, economic and human costs of continued unsustainable urban development. In BC, these policies generally state that all residents have the right to fresh air, clean water and affordable housing. This means communities should be designed to reduce dependence on the automobile; to protect the functioning of streams and ecologically sensitive areas; and to foster a high quality of life for present and future citizens.[4] The five sustainability factors help to indicate how successful each Neighbourhood Pattern is in achieving these goals. A brief description of each sustainability factor follows below. A detailed outline of the methodological approach is found in the *Methodology* section.

Walkability

Walkability measures the percentage of the population within an average 5-minute walk from daily destinations. Daily destinations include: school, recreation, local shopping and, for some, work. Density and land use mix, as well as the physical street pattern, influence walkability. A fine-grained and diverse land use mix puts residents close to their daily needs, while higher densities provide the population required to support local shops and public transit.[5] A well-interconnected street pattern makes trips on foot quick and direct.

Vehicle Kilometres Travelled ("VKT")

VKT measures the average kilometres of vehicle travel per household per day. Density, land use mix and street pattern influence VKT. Greater land use mix and higher densities combined with an interconnected street pattern decrease trip duration, frequency and distance, and increase the walk/transit mode share.

Affordability

Affordability measures what percentage of existing Georgia Basin households could afford to purchase a home in each Neighbourhood Pattern. Affordability is broken down by different housing types, and given as an average.

Housing Mix

Housing mix describes housing choice within the community by measuring the percentage deviation from a benchmark housing selection. Housing mix is different from affordability in that it describes what range of different housing types are available to residents, not the cost of residing there. A good housing mix ensures that a wide range of family types can have their preferred housing needs accommodated in the neighbourhood.

Effective Permeable Area

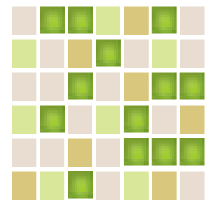
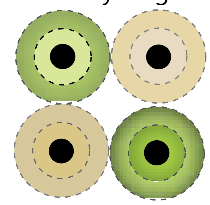
Impervious areas are surfaces like roofs, paved streets and sidewalks that rain water cannot seep through. Permeable areas are surfaces like lawns, gardens and forest floors that rain water can seep through. When rain hits impervious surfaces, it runs off and is usually collected in underground stormwater pipes and channelled directly to streams. In other cases, the water may run off onto another, permeable surface, where it can slowly infiltrate into the soil. The infiltration of rainwater is important to recharge groundwater, which in turn recharges streams in times of low rainfall. Infiltration also prevents stream scouring, which occurs when large volumes of rainwater are conveyed to streams during storms, usually by underground stormwater systems. Regular ditches, although they may allow some infiltration to naturally occur, are not designed specifically for infiltration and also deliver much of their collected water directly to streams.

Permeable area is a measure of how much of the land is capable of infiltrating water, in situ. Impervious area is a measure of how much of the land is covered by impervious surfaces that cannot be infiltrated by water, in situ. When most of the rainwater from an impervious surface can be directed to and infiltrated by another permeable surface, it is considered to be effectively permeable. This occurs when a roof delivers its rainwater to a cistern that is used to water the yard; when a driveway delivers its rainwater to an on site infiltration pit; or, when a street drains into roadside swales designed to maximize infiltration. Effective permeable area (EPA) is a measure of how much of the land is permeable to rain water or delivers rain water to another permeable area.

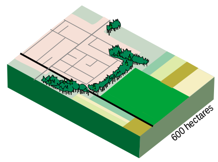
In the following pages, the six Neighbourhood Patterns are described and discussed in relation to the five sustainability factors. For a table summarizing this discussion, please see Appendix 1. For the detailed Neighbourhood Pattern data tables that were used to formulate most of these results, please see Appendix 2.

Notes

1. See: Reid Ewing, "Alternative Views of Sprawl: Counterpoint - Is Los Angeles-Style Sprawl Desirable?" *American Planning Association*, Vol. 63, No. 1, Winter (1997); R. Cervaro and C. Radisch, "Travel Choices in Pedestrian Versus Automobile Oriented Neighbourhoods," *Transport Policy*, Vol. 3 (1996): 127-141; and L.D. Frank and G. Pivo, *Relationships Between Land Use and Travel Behavior in the Puget Sound Region*, Washington State Department of Transportation, Seattle (1994): 9-37; Criterion (1996): 12.
2. Lance Freeman, "The Effects of Sprawl on Neighbourhood Social Ties," American Planning Association Journal, Vol. 67, No. 1 (2001): 69-75.
3. Patrick M. Condon and Jacqueline Teed *Alternative Development Standards for Sustainable Communities: Design Workbook*, University of British Columbia, James Taylor Chair in Landscape and Liveable Environments (1998).
4. British Columbia, Growth Strategies Amendment Act, 1995 (Part 25 of the Local Government Act, 1995); British Columbia, Bill 26 (otherwise known as the Local Government Statues Amendment Act, 1997).
5. Michael Bernick and R. Cervero, Transit Villages in the 21st Century, McGraw-Hill, New York (1997): 75-84.

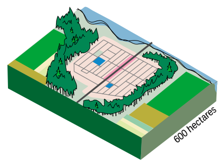
street arrangement	land use mix	density range
		

rural pattern



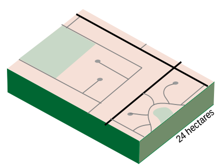
street arrangement	land use mix	density range
broken network	low	very low

village pattern



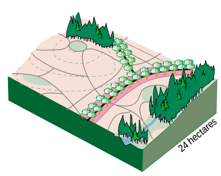
street arrangement	land use mix	density range
interconnected network	medium	very low

auto oriented pattern



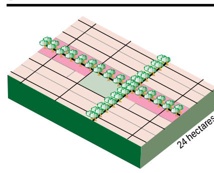
street arrangement	land use mix	density range
dendritic	low	very low - low

landscape oriented pattern



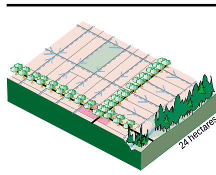
street arrangement	land use mix	density range
modified network	medium	low - medium

pedestrian oriented pattern



street arrangement	land use mix	density range
interconnected network	high	medium - high

pedestrian & green infrastructure pattern

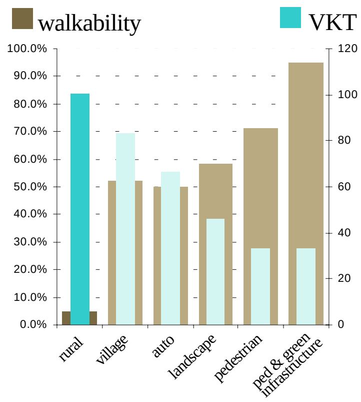


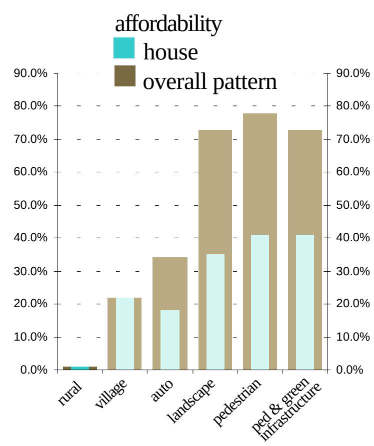
street arrangement	land use mix	density range
connected network & green infrastructure	high	medium

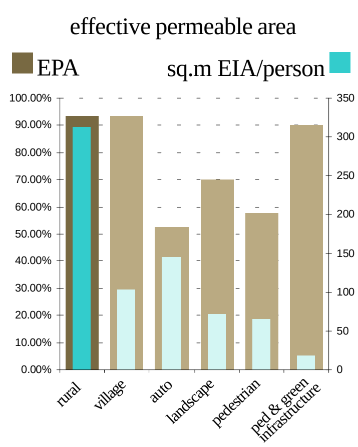
above
Six patterns of neighbourhood development were identified and compared for this study. Each Neighbourhood Pattern was derived from a unique combination of street arrangement, land use mix, and density range.

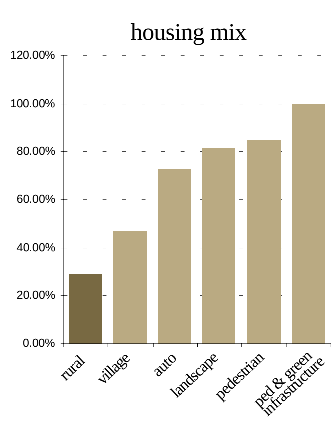
Six Neighbourhood Patterns

rural pattern









The Rural pattern arises when urban expansion encourages the removal of land from the edges of agricultural areas for development as acreage homes. A discontinuous network, created through infilling the existing wide-spaced agricultural road grid, characterizes the street system. Shops and services are in distant malls and big-box malls along major streets. These streets may have sidewalks but often no street trees, and have many lanes to move traffic quickly. Residential streets are narrow with a crushed stone edge and swale instead of curb and gutter, and have no street trees or sidewalks.

Consisting almost entirely of very large single family homes, the Rural Pattern has the lowest density of the six patterns (210.7 people/sq.km) and almost no land use mix. This expansive pattern has implications for mobility, as the broken street network, a lack of nearby amenities, and infrequent and difficult to access transit means nearly all daily excursions, including trips to work and school, must be made by car. As a result, only 4.7% of residents are within an average 5-minute walk to daily needs, generating the highest VKT of the six patterns (100.3 VKT/household/day).

Historically, the first families to move here are usually drawn by privacy, quiet and low prices. Typically these conditions are temporary and, built in an urban area where land values are higher, the very large yards and houses of this pattern are expensive to purchase and develop. Very large yards also mean fewer people per hectare to pay for infrastructure. Fewer than 1% of Georgia Basin households could afford to live in this pattern. The poor range of housing types (29% of benchmark) also means that the needs of only a few family types can be met.

Elementary schools and parks are typically designed for auto access and are fronted by a parking lot. Schools are usually large, one-storey buildings. Parks are infrequent but large and cater to active recreation, although they often include preserved natural space.

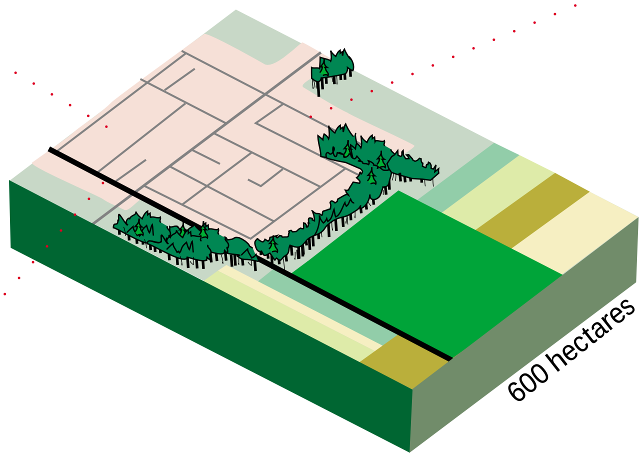
Stream corridors and natural space may also be preserved in individual yards, although some clearing around streams occurs, which reduces fish habitat. Roadside drainage swales collect stormwater from rooftops, driveways and streets. Although these swales are intended to deliver rainwater to streams, some beneficial infiltration also occurs. This, combined with large, permeable yards means the pattern has a relatively high permeability to rainwater in residential areas (87.4%) and in the overall neighbourhood (93.4%). Very low density, however, means there are 313 square metres of impervious surface per resident.

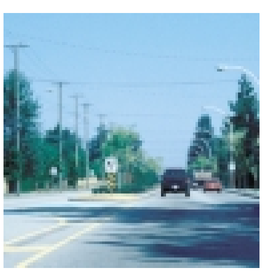
rural pattern

house

local shopping

local street

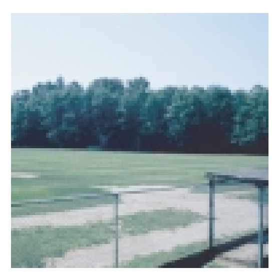




major street

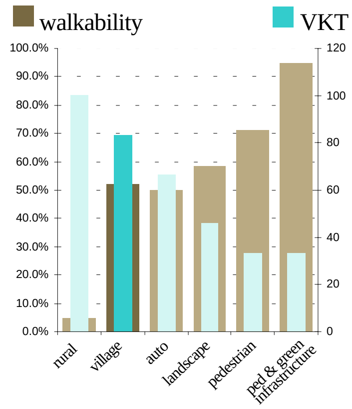
major business/
commercial

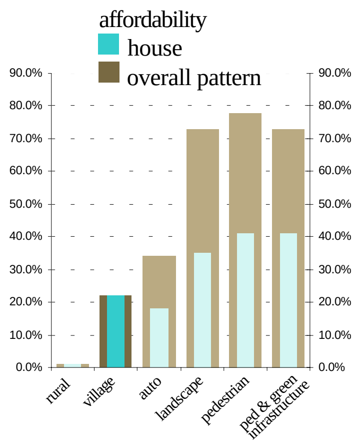
school

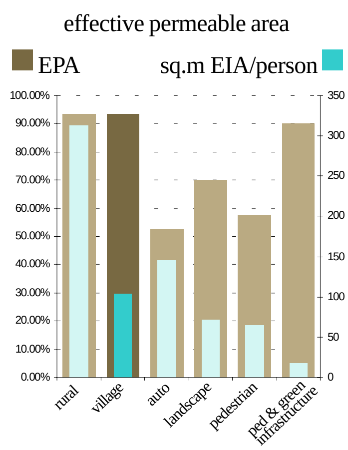


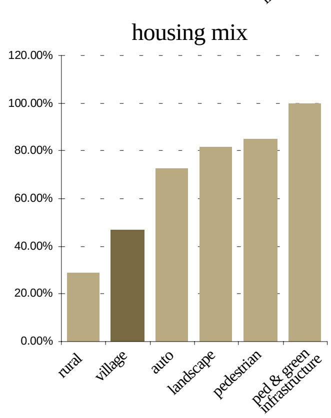
recreation

Six Neighbourhood Patterns
village pattern









The Village Pattern is a compact, urbanized area bounded by natural or agricultural land. Streets are arranged in an interconnected grid. There is one major street at the centre of the neighbourhood where cafes, shops and services are usually located. Sidewalks and street trees also line the main street. Residential streets are typically narrow with a gravel edge and swale instead of curb and gutter, but often have no street trees or sidewalks.

Although the population is grouped in the village core, the required band of undeveloped land results in a low overall density of 618.6 people per square kilometre. At such a low density only 24.3% of residents are within a 5-minute walk of daily destinations. Density is low even within the village core (1749.3 people/sq.km), where large residential yards and a “very low” land use mix means only 55.2% of residents can easily walk to daily destinations. The remainder of daily trips must be made by car, often at long distances from the village, resulting in a high VKT second only to the Rural Pattern (83.4 VKT/ household/day).

Destinations other than daily shopping are designed to cater to auto access. Major business and commercial areas are located in big-box retail malls outside of the village. Elementary schools are located within the village, and are generally large, single-storey buildings fronted by a parking lot. Parks are found in conjunction with schools and offer a range of active recreation facilities.

Except for a few apartments above shops along the major street, the Village Pattern is primarily made up of single family houses. This poor housing mix (46.7% of benchmark) cannot meet the needs of a wide range of family types. Low density, high transportation costs, and large yards and homes means only 22% of Georgia Basin households could afford to live in this pattern.

Stormwater from rooftops and streets is captured in roadside drainage swale. Although swales are not designed to enhance infiltration, some naturally occurs. The large yards, unpaved driveways, narrow streets and partial stormwater infiltration mean the Village residential core exhibits a respectable permeability to rainwater (44.2%), despite its relatively condensed development. Overall, permeability is very high (93.6%) when the surrounding undeveloped land is considered. However, relatively low density, even in the Village core, means that there are about 103 square metres of impervious surface per person.

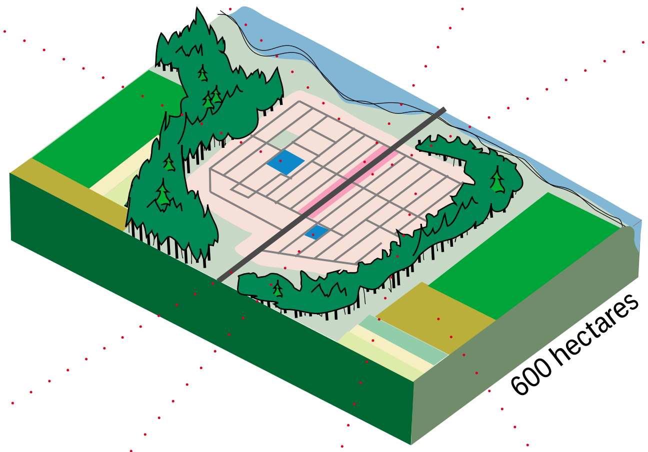
village pattern

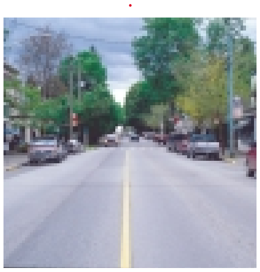
recreation

local street

local shopping

apartment

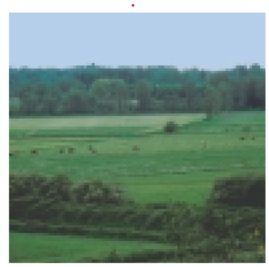




major street

school

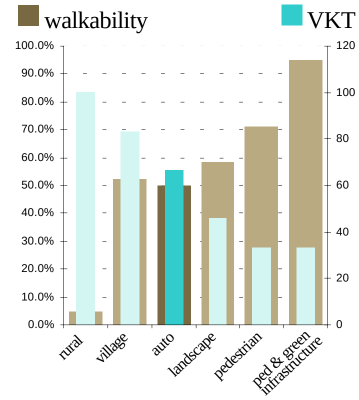
large house

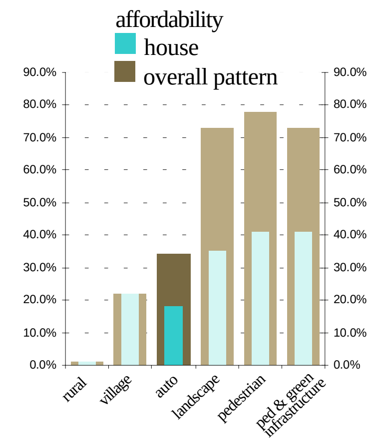


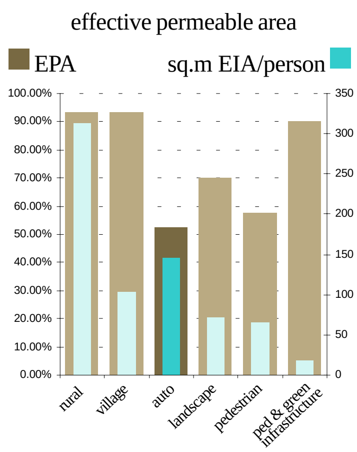
wild/agricultural buffer

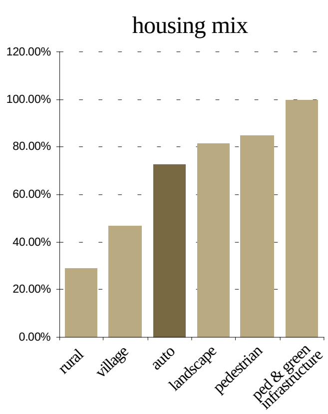
major business/ commercial

Six Neighbourhood Patterns
auto oriented pattern









The Auto Oriented Pattern is laid out in a dendritic, or branching, street system. Houses front onto residential streets that feed into collector streets, which feed into major streets located at wide intervals. Major streets have sidewalks but often no street trees and are designed to move many lanes of traffic quickly. Local streets are wide and often have neither sidewalks nor street trees. Many local streets are dead-ended, which minimizes local traffic, but can interrupt the district wide flow of auto, foot and bike traffic.

Although much more dense than either the Rural or Village Patterns, the Auto Oriented Pattern remains relatively low density when compared with traditional urban communities (3264.8 people/ sq.km). The relatively low density, coupled with the pattern's "low" land use mix and dendritic street arrangement, means only 50% of residents can reach their daily destinations on foot. Infrequent and limited bus service means the remainder of trips are made by car. These trips are often of a relatively long duration, given the unconnected street arrangement. VKT in this pattern is 66.6 kilometres per household per day.

Most destinations cater to automobiles, not pedestrians. Shops and services are generally found in malls and strip-malls along major streets. Schools are very often large, one-storey buildings fronted by a parking lot. Parks are often found in conjunction with schools and provide for a range of active recreation activities.

The Auto Oriented Pattern has a greater mix of housing types, which can meet the needs of a wider range of families (72.8% of benchmark), but few Georgia Basin households could afford Auto-Oriented single family homes (18%). The housing alternatives, however, are more equitably priced, making the Auto-Oriented Pattern overall affordable to 34.3% of families.

Unlike the previous two patterns, the Auto Oriented Pattern uses curbs and gutters on the street and an underground stormwater management system. Rainwater from roofs, driveways and streets is collected in catchbasins without any chance of infiltration. Despite wide paved streets and driveways, the large yards of the Auto Oriented pattern maintain 46.0% effective permeability in residential areas, and 52.5% throughout the overall neighbourhood. Relatively low residential densities mean that impervious surface per person remains high (146 sq.m/person).

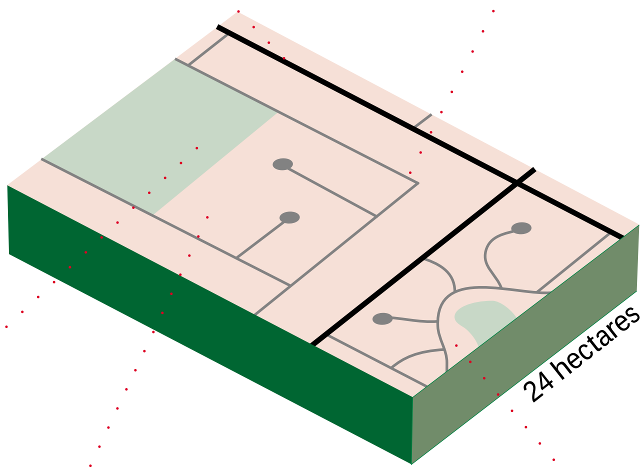
auto oriented pattern

school

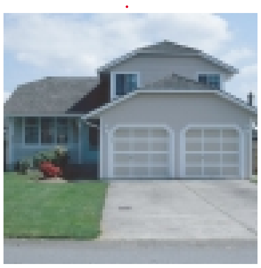
major street

local street

apartment

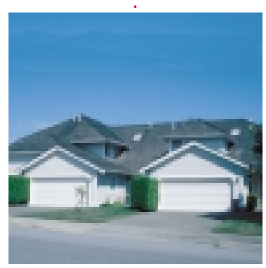


recreation



house

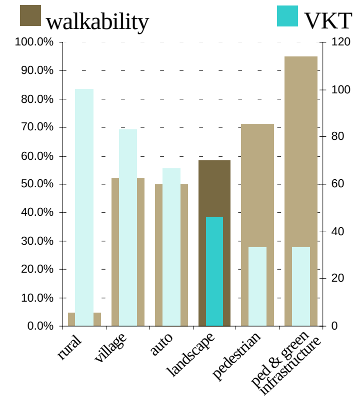
local shopping

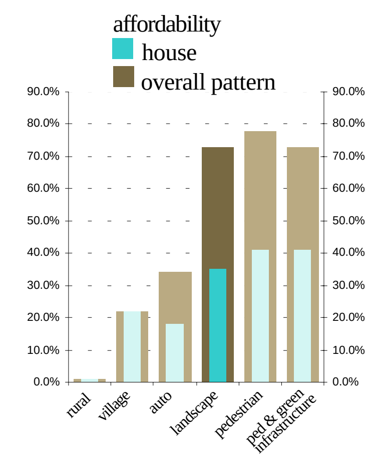


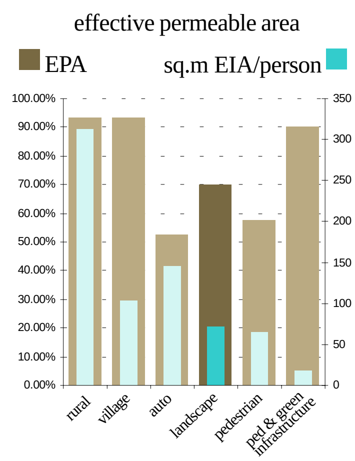
ground-oriented
multi-family

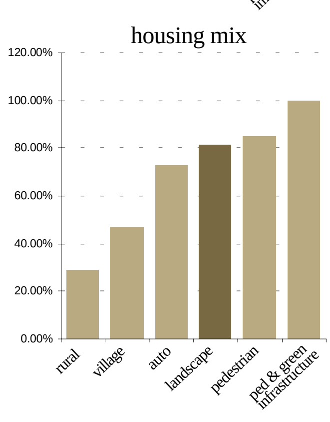
major business/
commercial

landscape oriented pattern









This neighbourhood pattern is based on the interconnected street system and adapts to fit the shape of stream corridors, parks, and steep slopes. This modified network of streets balances sensitivity to landscape features with connectivity. Streets in this neighbourhood are pedestrian friendly. Major streets have a central, tree-lined boulevard. Trees and sidewalks line both sides of the street. Local streets are narrow with street trees and sidewalks on both sides. Auto access to houses is usually via a back lane rather than a front driveway.

By occasionally breaking the grid in deference to landform, the modified street network creates unusual block shapes and causes inefficiencies in lot configuration. This results in a less-than-optimum density of 4194.5 people per square kilometre. Moderate density, a "medium" land use mix, and a fairly interconnected street system mean over one-half of residents can walk to their daily needs (58.5%). Meandering roads mean longer distances between destinations and make driving more attractive; however, frequent and efficient transit service and relative proximity to major business/commercial areas means VKT remains fairly low (45.9 VKT/household/day).

Local shopping is situated along the major street. Shops inhabit the ground floor, often with apartments above, and front directly on the street. On-street parking provides auto access rather than street-front parking lots. Schools are multiple-storey and small but frequent. Schools also front directly onto the street. Parks and preserved local ecosystems are an important part of the landscape. These areas allow rainwater to seep into the ground naturally and slowly refill streamways, maintaining native fish habitat. Because this pattern preserves undeveloped land in greenway systems, 70.0% of the overall pattern remains permeable to rainwater infiltration. Even in residential areas, permeability remains high and, because densities here are higher, there are only about 71.5 square metres of impermeable surface per person.

About 73% of Georgia Basin households could afford to live in this pattern. A relatively high housing mix (81.5%) would provide them with a wide range of housing choices, allowing a wide range of family types to live in the neighbourhood. Due to higher densities (more people to pay for infrastructure) and smaller yard and house sizes (less expensive to purchase and build), 35% of Georgia Basin households could afford to own a single family home, although only 3.5% could afford the large houses that are a component of this pattern.

The Pedestrian Oriented Pattern is laid out in an interconnected street

landscape oriented pattern

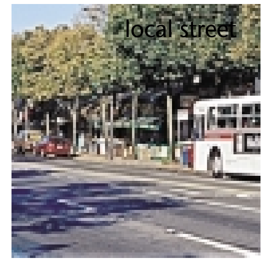
recreation

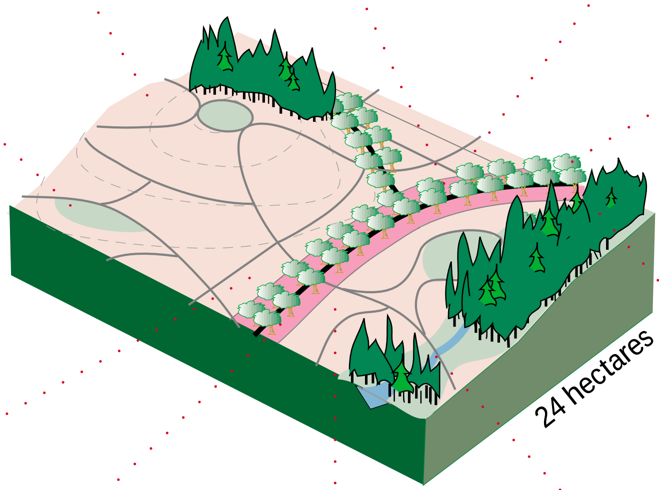
large house

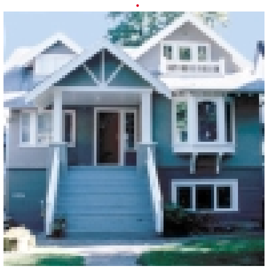
apartment

lane

local shopping

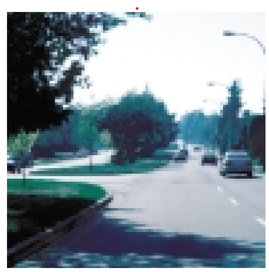




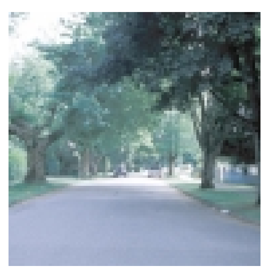


house

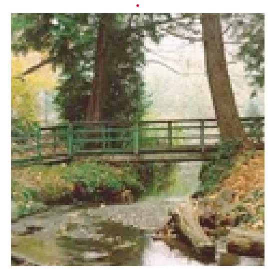
ground-oriented multi-family



major street



local street

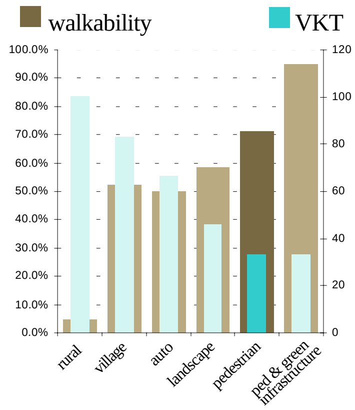


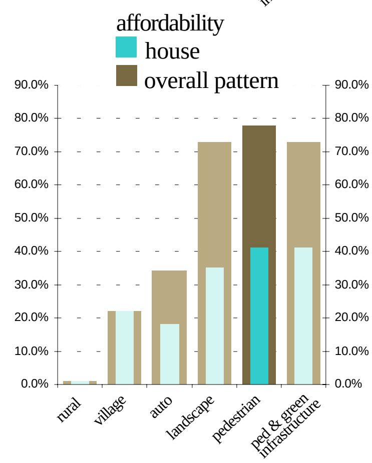
preserved stream/ greenway

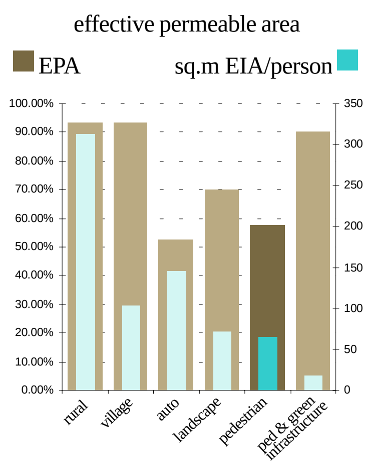
major business/ commercial

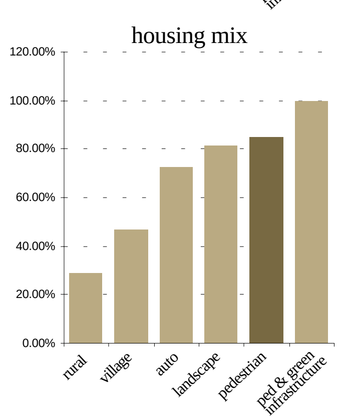
school

pedestrian oriented pattern









system, which shortens distances between destinations. Narrow roadways, street trees and sidewalks make many of the streets pedestrian friendly. Major streets, found every few blocks, are lined on both sides by sidewalks and street trees and are usually well served by transit. These streets are often the hub of civic and commercial services. Almost all residential areas have back lanes to keep the narrow, tree-lined local streets from being dominated by garages and driveways.

With small yards and many apartments, this pattern exhibits the highest density of all six (6511.7 people per square kilometre). High density, a highly interconnected street pattern, and a "high" land use mix mean that 71.2% of neighbourhood residents are within a 5-minute walk to daily destinations, and 95% within a 5-minute walk of local shopping. High walkability and frequent transit service mean the Pedestrian Pattern generates the lowest VKT per household (33.2 VKT/household/ day).

Schools are usually multiple storey, small and frequent. Schools front directly on the street and are very easy to walk, bike, or bus to because they occur within a 10-minute walk of almost all homes. Parks are common, although natural spaces are rare.

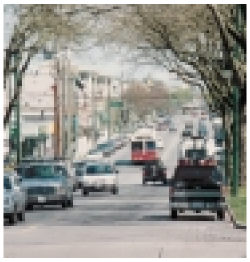
The Pedestrian pattern has a good mix of housing types (85% of benchmark). This means there are many different kinds of housing in the neighbourhood to meet the needs of many different kinds of families. Smaller yards and houses, particularly smaller "large" houses, means yards are less expensive to buy and houses are less expensive to build. It also means there are more people per square kilometre to pay for infrastructure. The result is that 78% of Georgia Basin residents could afford to live here.

The streets generally have curbs and gutters feeding directly into an underground stormwater management system. Stormwater has little opportunity to infiltrate into the soil. However, despite having the highest density of all the study patterns, the residential and overall permeable areas of this pattern (43.3% and 57.6% respectively) are comparable to that of the Auto Oriented pattern (46% and 52.5% respectively). This is because the Pedestrian pattern has tall and narrow houses, no driveways, skinny streets and narrow, often crushed stone, lanes. Compared per person, the Pedestrian pattern has about half the impervious surface per person as does the Auto Oriented neighbourhood (65 sq.m/ person). This means there are more people to share the use, cost and impact of buildings, streets and sidewalks in the Pedestrian pattern.

This hypothetical pattern is currently being realized in the development of

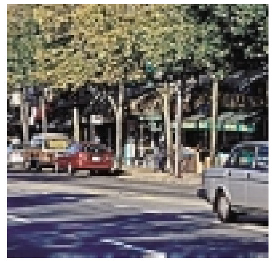
Six Neighbourhood Patterns
pedestrian pattern

major street



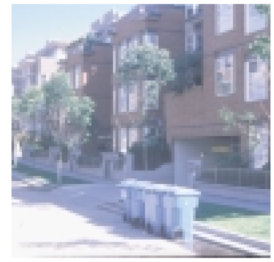
ground-oriented
multi-family

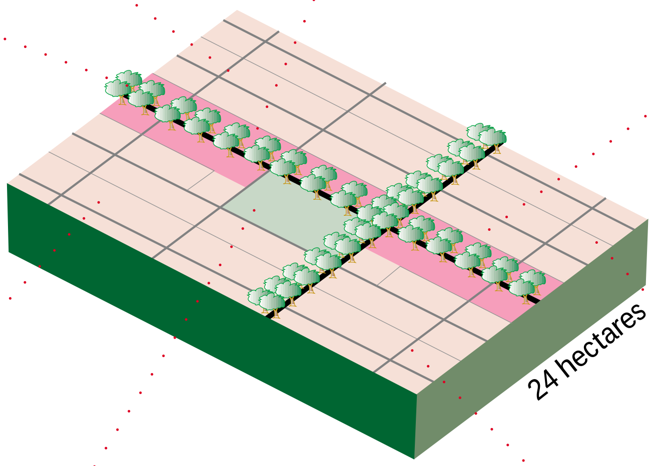
local shopping

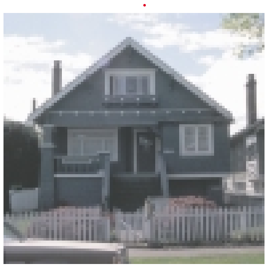


school

apartment



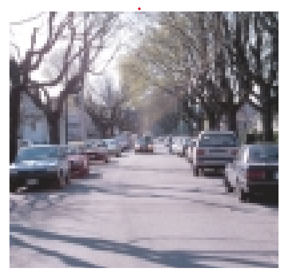




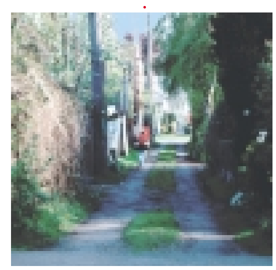
large house

recreation

major business/
commercial

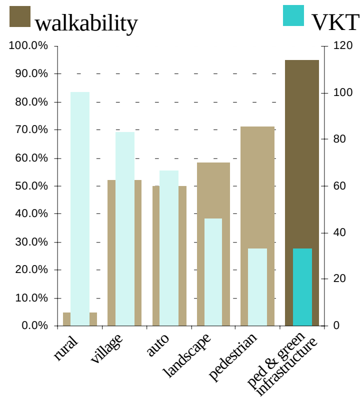


local street

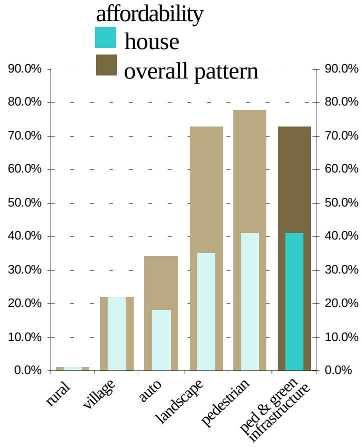


lane

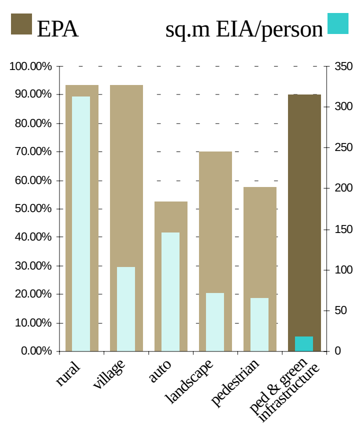
pedestrian & green infrastructure pattern



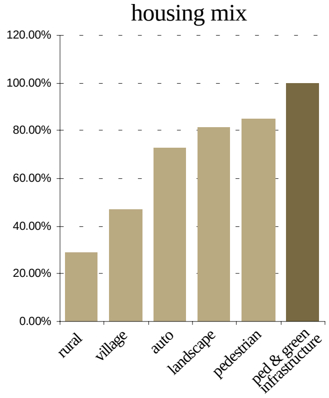
affordability



effective permeable area



housing mix



the East Clayton community, Surrey. Modelled on the Pedestrian Oriented pattern, it adds a “green” infiltration-based stormwater management system and stream preservation. Pedestrian traffic flow on the sidewalks of interconnected streets is matched by stormwater flow in a parallel roadside swale system designed to maximize rainwater infiltration. Just as residents are connected with their daily destinations through the most efficient routes, rainwater filters directly into the soil where it recharges groundwater and, eventually, streams. Eight to 12 times a year, water from major storms flows to schoolyards, which double as community retention areas. Residential yards have on-site infiltration systems, and at least 40% of the neighbourhood is covered by tree canopy to naturally absorb rainwater as it falls. This ensures 90% of the whole neighbourhood, including residential areas, remains permeable to rainwater. Compact development and minimized paved surfaces means this pattern has only 18 square metres of impervious surface per person.

Streets have sidewalks and street trees on both sides. Major streets have a central, tree-lined boulevard. Narrow local streets have a crushed stone shoulder rather than a curb and gutter. Rainwater flows from the street into swales located in the boulevard on both sides of the street. Auto access is via a back lane, keeping streets from being dominated by garages and driveways.

Local shops with suites above front directly onto the major street. Schools are integrated into the landscape in “school/park” sites that merge recreation, preservation and infiltration. Recreation and transportation greenways protect preserved streams.

Small yards and fewer apartments give this pattern a density of 5600 people per square kilometre. The relatively high density, “high” land use mix and interconnected street pattern, including greenways, means this pattern generates the highest walkability – 95% of residents are within a 5-minute walk of their daily destinations. Like the Pedestrian Oriented pattern, this generates the lowest VKT (33.2 VKT/household/day).

This pattern’s housing mix was formulated by the City of Surrey Planning Department to correlate with the housing objectives set out in the Liveable Region Strategic Plan. It was selected as the ideal housing mix for this study and, as a result, the Pedestrian & Green Infrastructure pattern achieves 100% for housing mix. Small yards and houses means 73% of Georgia Basin households could afford to live here.

Data collection was carried out in two ways: a GIS survey of Statistics Canada census data; and, ground

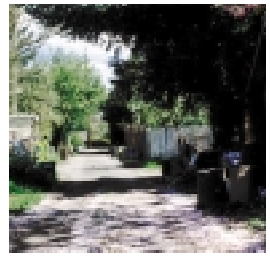
pedestrian & green infrastructure pattern

house

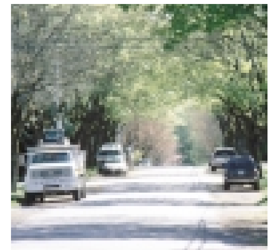
large house

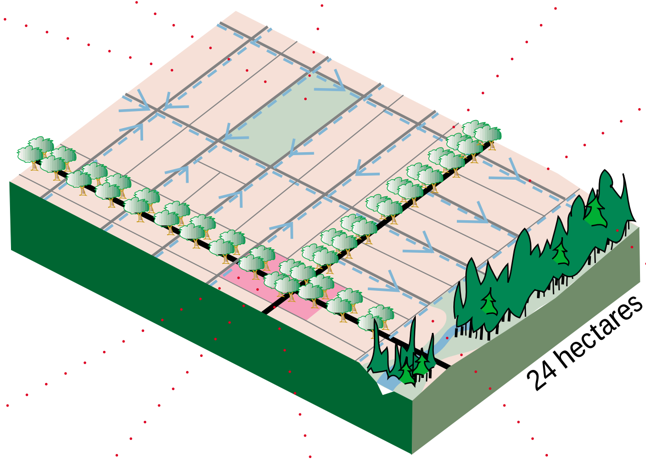
recreation

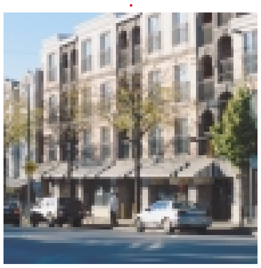
lane



local street

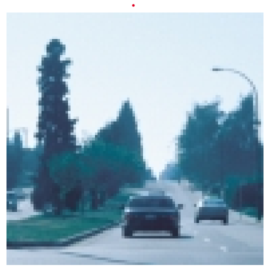




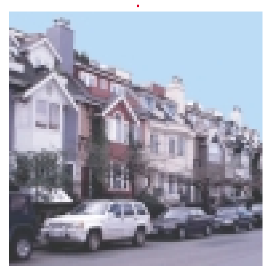


apartment

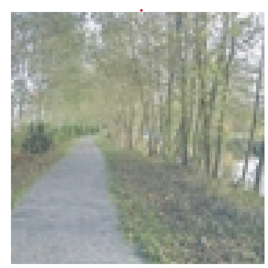
local shopping



major street

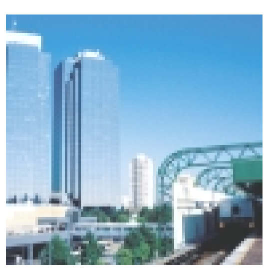


ground-oriented multi-family



preserved stream/ greenway

major business/ commercial



school

neighbourhood pattern typology

Methodology

Data Collection

reconnaissance. The data collected was chosen on the basis of the five sustainability factors: walkability, vehicle kilometres travelled ("VKT"), affordability, housing mix, and effective permeability. Data was collected at two scales: 1) from detailed Study Sites; and, 2) from larger Component Neighbourhoods surrounding the Study Sites.

Study Sites
In virtually all cases, data on the Neighbourhood Patterns was gathered by examining actual sites within the Greater Vancouver Regional District (GVRD). Prior to the selection of these sites, the kinds of residential development inherent to each Neighbourhood Pattern were identified. Four types of residential development were generally identified: Large House (with lots wider than ten metres); House (with lots less-than-or-equal-to ten metres wide); Ground-Oriented Multiple Family (multiple family development where each residence is accessed directly from the street, such as townhouses or duplexes); and, Apartment/ Condominium (multiple family development where each residence is accessed from an interior corridor). Based on these four residential types, each Neighbourhood Pattern was conceptually divided into between one and four Study Sites. Each Study Site represents one residential type found within the Neighbourhood Pattern.

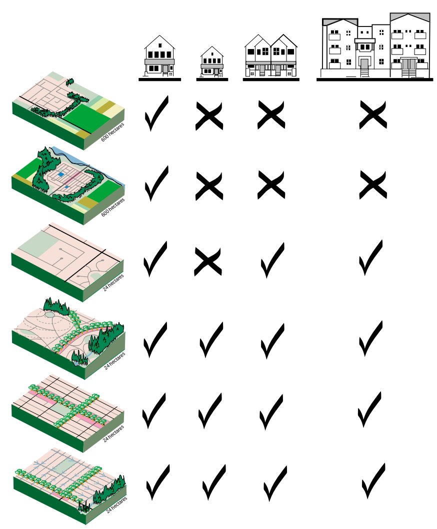
Out of this process, an overall requirement for seventeen Study Sites was realized (see below). For thirteen of these, a Study Site consisting of purely residential land use was selected from within the GVRD. The remaining four comprise the Study Sties for the Pedestrian & Green Infrastructure Neighbourhood Pattern, for which no built examples currently exist within the Georgia Basin. The East Clayton neighbourhood in Surrey was selected to represent the Pedestrian & Green Infrastructure Neighbourhood Pattern. Currently under construction, the East Clayton neighbourhood is as a prototypical "complete community," featuring not only residential, recreational, work, services and amenities, but also an environmentally responsible infiltration-based stormwater management system. Data was taken from the *East Clayton Neighbourhood Concept Plan*, City of Surrey, 2000 in lieu of real Study Sites (see table, facing page and *Appendix 3*).

Study Sites were selected following three primary criteria: residential type; conformance to the street arrangement of the overarching Neighbourhood Pattern; and, correlation to a pre-existing *Statistics Canada* "enumeration area." The final criterion was included in the interest of simplifying the data collection process; virtually all data required for the Neighbourhood Submodel was available by "enumeration area" through *Statistics Canada*.

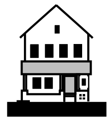
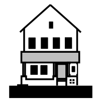
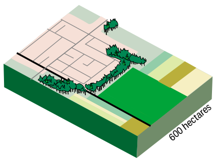
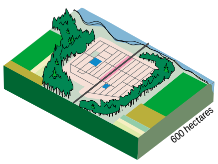
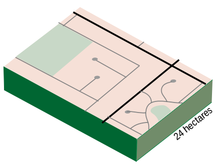
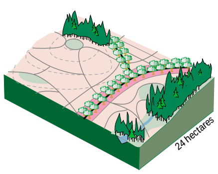
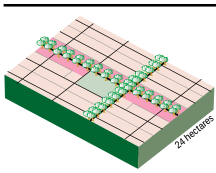
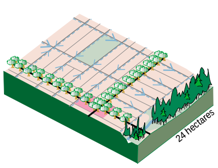
The Study Site was the locus of residential type-specific investigations, such as calculating residential permeability.

Component Neighbourhood
Surrounding each Study Site, the physical boundaries of the broader Component Neighbourhood were identified and delineated. While the land use within the Study Site is purely residential, the Component Neighbourhood may consist of various residential types, commercial, recreational and institutional (primarily school) areas, which fulfill a variety of daily needs for residents. The Study Site may be imagined as being embedded within the urban fabric of the broader Component Neighbourhood.

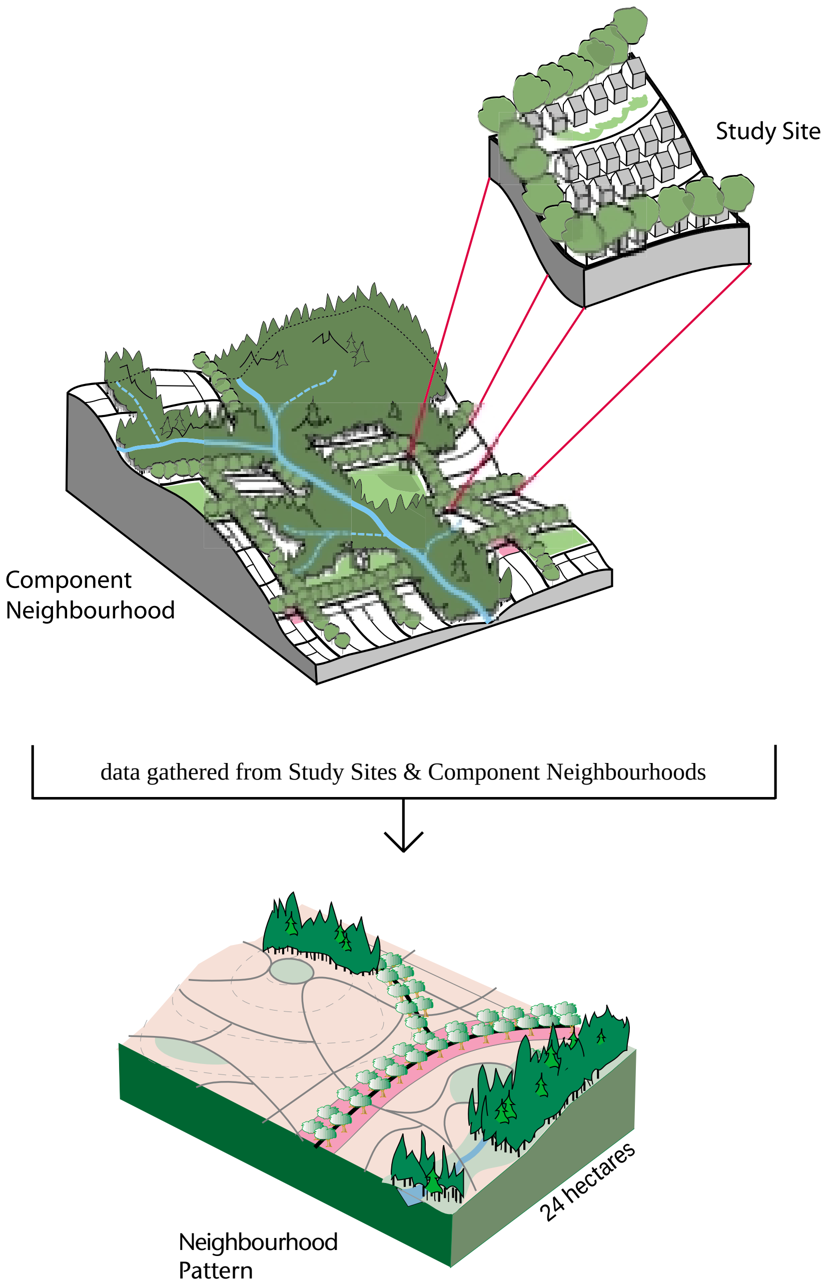
The boundaries of Component Neighbourhoods were selected following a number of criteria. The edges of a neighbourhood vary in character, particularly between



above
Each Neighbourhood Pattern was conceptually divided into between one and four Study Sites, based on the kinds of residential development inherent to each pattern. Each Study Site represents one residential type found within the Neighbourhood Pattern. Generally, four types of residential development were identified: Large House, House, Ground Oriented Multi-Family, and Apartment. Overall, a requirement for seventeen Study Sites was identified.

	 large house	 house	 ground-oriented multi-family	 apartment
rural pattern 	north of city, Langley	n/a	n/a	n/a
village pattern 	Fort Langley, Langley	n/a	n/a	n/a
auto oriented pattern 	Green Timbers, Surrey	n/a	Strawberry Hill, Surrey	Johnson Heights, Surrey
landscape oriented pattern 	Shaugnessy, Vancouver	Fraserview, Vancouver	Sullivan Heights, Burnaby	South Granville, Vancouver
pedestrian oriented pattern 	MacKenzie Heights, Vancouver	Kitsilano, Vancouver	Kitsilano, Vancouver	South Granville, Vancouver
pedestrian & green infrastructure pattern 	East Clayton, Surrey	East Clayton, Surrey	East Clayton, Surrey	East Clayton, Surrey

above
Thirteen of the seventeen study sites were identified through examination of aerial photographs and verified by ground recognissance. Information for the Pedestrian Oriented & Green Infrastructure pattern was derived from the East Clayton Neighbourhood Community Plan - the blueprint for realizing this hypothetical pattern in Surrey.



above
Up to four Study Sites and Component Neighbourhoods were selected for each of the Neighbourhood Patterns. Each Study Site was selected to represent one housing type found within that Neighbourhood Pattern. The physical boundaries of the broader Component Neighbourhood were then identified surrounding each Study Site. The Study Site should be imagined as embedded within the surrounding urban fabric of the Component Neighbourhood. The Neighbouhood Pattern should be imagined as a puzzle, in which the separate Study Site/ Component Neighbourhood pieces fit together to form one complete picture.

different Neighbourhood Patterns. Generally, correlation to a contiguous group of pre-existing *Statistics Canada* enumeration areas defined the boundaries of Component Neighbourhoods. Landform, major transportation routes, streams and other waterways also influenced the location of these boundaries.

The Component Neighbourhood provided information on broader context-based neighbourhood issues, such as walking distances to neighbourhood amenities.

Data collected from the Study Sites and Component Neighbourhoods was used to formulate scores for housing mix, affordability, vehicle kilometres travelled, permeability,

Data Analysis

walkability, land use mix, and density for each of the six Neighbourhood Patterns.

It is important to note a fundamental assumption made for this study: although almost all of these Neighbourhood Patterns are pre-existing, the purpose of this study is to describe how each would function as *new development* in the Georgia Basin. This means certain variables between existing Component Neighbourhoods, such as property value or distance to the Central Business District, have been held constant across all Neigbourhood Patterns.

Walkability
"The percentage of population within a 5-minute walk of daily needs."

Walkability measures the percentage of the population within a five-minute walk of daily needs, including: local shopping, schools, and recreation. Walkability to work was not determined. The accepted distance for a five-minute walk is 400 metres, which was measured radially (as opposed to along streets) from the centre point of parks, school and local shopping. In cases where daily needs were not located at a single point, but along a line, two parallel lines at 400 metres to either side of the amenity were established and the resulting area contained by the lines was measured. The area of the Component Neighbourhood surrounding each particular type of amenity was multiplied by the population density of the Component Neighbourhood. The product is an approximation of the number of people that can walk to a particular type of amenity within 5-minutes.

An overall number of people within a 5-minute walk of daily needs was produced for each Component Neighbourhood by averaging the number of people who could walk to local shopping, schools, and parks. A final Walkability score was produced for each Neighbourhood Pattern by weighing the Component Neighbourhood averages by the percentage of the population of that pattern who live in the particular Component Neighbourhood.

Vehicle Kilometres Travelled
"The average number of kilometres driven per household per day."

Vehicle Kilometres Travelled, or VKT, for each component neighbourhood was calculated using the "Greenhouse Gas Emissions from Urban Travel: Tool for Evaluating Neighbourhood Sustainability", produced by the Canada Mortgage and Housing Corporation. The tool uses an Excel spread sheet to calculate average daily VKT once the user has inputted the following 18 variables: street layout; kilometres of road; number of intersections; kilometres of arterials (3 or more lanes in both directions); kilometres of bike path; total gross land area; total number of housing units; distance to nearest commuter rail station; housing mix; number of jobs in a 1 kilometre radius; number of grocery stores in a 1 kilometre radius; expected household size; expected population under 16 years old; expected average household employment income; distance to central business district; number of jobs in a 5 kilometre radius of centre of neighbourhood; transit service vehicle hours; and, distance to nearest rapid transit. These variables were established for each Component Neighbourhood with the exception of distance to the central business district (CBD). The distance to the CBD was made constant at 15 kilometres so VKT reflected solely neighbourhood features, and not proximity of existing Component Neighbourhoods to a CBD. This provides a clearer illustration of the relationship between Neighbourhood Pattern and daily driving habits.

The VKT for each Neighbourhood Pattern was determined by weighting the VKT output for each Component Neighbourhood by its percentage of total households for that pattern.

Affordability
"The percentage of Georgia Basin households who could afford to buy a dwelling."

Affordability measures the percentage of existing Georgia Basin households that could afford to live in a particular pattern. Affordability, therefore, is a function of income distribution and housing cost. To determine the affordability of a Pattern, two fundamental assumptions were made: 1) the cost of construction would be held constant at $860.80 per square metre ($80.00/sq.ft); and, 2) the cost of land would be held constant at $74.13 per square metre ($300,000.00/acre). The purpose of these assumptions was to connect affordability to house and lot size, and to eliminate location as a variable affecting value. As noted, this allows the calculation to compare the affordability of each Neighbourhood Pattern as *new development* in the Georgia Basin.

Average unit and lot sizes were determined. For single family homes in the Rural and the Village Patterns, aerial photos and GIS software were used to determine an average lot and house size. For the Pedestrian Oriented and Landscape Oriented Patterns, detailed information regarding average house and lot sizes for different housing types in each of the Component Neighbourhoods was available in the *Housing Price Index User's Guide* produced by the Greater Vancouver Real Estate Board. For the Automobile Pattern, the same information was available through the Fraser Valley Real Estate Board's *Housing Price Index*. As the Pedestrian & Green Infrastructure Pattern is based on the Pedestrian Oriented Pattern, for this study it is assumed that lot and house sizes will be comparable between the two patterns. Average lot sizes, and in some cases, unit sizes for multi family residences, and apartments were not available, but were calculated using aerial photos, GIS software, floor area ratios, and the average unit dimensions from the *Housing Price Index*.

For each Neighbourhood Pattern, unit and lot size were then multiplied by their respective price constants (see above). This produced an average cost for each type of dwelling in each Neighbourhood Pattern.

To create an average Affordability score for each Neighbourhood Pattern, the average cost of each type of dwelling was weighed by its prevalence in the Neighbourhood Pattern (see housing type distribution in *Housing Mix*, above) to produce an average dwelling cost. Generally, it was assumed that an income of no less than one-third of the cost of a dwelling is required for that residence to be considered affordable for a family. Using Statistics Canada data, which identifies how many households in the Georgia Basin fall in the following income categories: 0-$19,999; $20,000-$39,999; $40,000-$59,999; $60,000-$79,999; and $80,000+, we were then able to estimate how many households earned the income required to afford the average dwelling cost of each Neighbourhood Pattern. A final Affordability score, represented by the percentage of Georgia Basin households who can afford to live in each pattern, was produced for each pattern by dividing the number of households who could afford the average cost of dwelling by the total number of households in the Georgia Basin.

Housing Mix
"The percent similarity to housing mix benchmark."

Housing Mix measures how closely the range of housing types in each Neighbourhood Pattern match a predetermined ideal mix of housing types. Five housing types, identified by Statistics Canada, were identified: Single Family Detached; Semi Detached; Town/Row Housing; Apartments Less than 5 Storeys; and, Apartments 5 Storeys or More. The distribution of housing types described by the East Clayton Neighbourhood Concept Plan was selected as the ideal benchmark against which the Neighbourhood Patterns would be compared. This pattern's housing mix was formulated by the City of Surrey Planning Department to correlate with the housing objectives set out in the Liveable Region Strategic Plan.

The distribution of housing types for each of the Neighbourhood Patterns was determined in one of three ways. For the Rural and Village Neighbourhood Patterns, which are comprised of a single Component Neighbourhood, the distribution of these types was taken from enumeration area data. The size and complexity of the Pedestrian, Automobile, and Landscape Neighbourhood Patterns, which are comprised of up to four Component Neighbourhoods, necessitated reliance on data provided in *Dwellings by Structure Type in Greater Vancouver* produced by the Policy and Planning Department of the GVRD in 1999. Housing distribution in the Pedestrian & Green Infrastructure Neighbourhood Pattern was taken from the *East Clayton Neighbourhood Concept Plan*, City of Surrey, 2000.

To formulate a Housing Mix score, the standard deviation from the benchmark was calculated for each Neighbourhood Pattern. Each standard deviation was then subtracted from 100, and the overall results were scaled between 1 and 100. The resulting Housing Mix score is represented as the percentage of the benchmark housing mix, with 100% being a perfect score. The Housing Mix score does not represent an actual percentage of the benchmark housing types. For example, a score of 50% would not necessarily correlate to that Neighbourhood Pattern having only half of the kinds of housing found in the benchmark. The Housing Mix score should be understood instead as representing the degree of similarity to the benchmark, relative to all Neighbourhood Patterns. The result is a Housing Mix score for each Neighbourhood Pattern that is intuitively understandable by users of GB-QUEST without comparison to other Neighbourhood Patterns, or the benchmark.

Effective Permeable Area
"The percentage of pattern area that is permeable to rain."

As noted, when most of the rain water from a surface is either directly infiltrated, or is redirected to and infiltrated by another surface, it is effectively permeable to rainwater (see *Effective Permeable Area*, Section 1). Effective Permeable Area, or EPA, measures the percent of effectively permeable surface area within a Neighbourhood Pattern.

The EPA for residential areas was determined from the Study Site of each Component Neighbourhood. The calculation was divided by streets and lots. For both, all areas that rain can infiltrate, or that direct most of their water to another surface where rain can infiltrate were considered permeable. Through ground reconnaissance, the kinds of effectively impervious areas in each Study Site were determined.

For Streets, EPA is the percentage of the entire Right-of-Way (ROW) that is effectively permeable. Aerial photos and GIS were used to determine the length of roads and ROW widths in the Study Site. The widths of the paved street surfaces and sidewalks were measured during ground reconnaissance, and multiplied by the road length to determine impervious area, wherever appropriate. The total ROW area minus the total impervious surface area gave total street EPA. Street EPA was converted to the percentage of total ROW area effectively permeable to water.

For lots, EPS is the percentage of the entire lot that is effectively permeable. Permeability was determined using GIS and aerial photos to establish average driveway area, and using the same average lot and building footprint as established for the affordability calculation (see *Affordability*, above). The total lot area minus the total effective impervious area within the lot gave total lot EPA. Lot EPA was converted to the percentage of total lot area effectively permeable to water.

To calculate EPA for the whole Component Neighbourhood, including other non-residential uses, total park, commercial, and school areas were determined. These were multiplied by impervious ratings to establish the total EIA for each of these land uses. The total area of each land use minus the EIA of each land use gave EPA for each land use. These areas were then combined with residential EPA for the Component Neighbourhood (derived by multiplying the percentage of permeable area by the total area of residential development in the Component Neighbourhood) and street EPA for the Component Neighbourhood (derived by multiplying the percentage of permeable area by the total area of ROWs in the Component Neighbourhood). Collectively, the sum of the impermeable area of the streets, residential areas, parks, schools, and commercial areas, divided by the entire area measured yielded the total EPA for the Component Neighbourhood.

Two patterns are served by ditches rather than by a conventional storm water system: the Rural and Village Patterns. Ditches, although they do allow some beneficial infiltration to occur, are intended to deliver rainwater to streams. This means they function largely the same way as underground stormwater management systems. For the purpose of this study, the infiltration effectiveness of ditches was assumed to be higher than it likely is, at 50%. For the Rural and Village Patterns, all EIA calculations were multiplied by one half to allow for the potential infiltration benefits.

To calculate EPA for the Neighbourhood Pattern, the EPA of each Component Neighbourhood was weighted by its percent of the total area of the pattern.

Permeability for East Clayton was taken from the East Clayton Neighbourhood Concept Plan.

EIA per person was also calculated for each neighbourhood Pattern by dividing the total EIA in each pattern by the total number of people residing in that pattern.

Land Use Mix
"The degree of intermingling of different activities."

Land use mix is one of the three factors that were used to generate the Neighbourhood Patterns (along with density and street arrangement), which were originally categorized as high, medium, low, very low and almost none. No additional data was required in this area.

Density
"The ratio of people to area."

Density was also one of the three factors used to generate the Neighbourhood Patterns, which were originally categorized in ranges of high, medium, low and very low. Specific densities for each Neighbourhood Pattern were calculated in the course of the study, as these were required as inputs to other calculations.

The density of both people and dwelling units was calculated for each of the Component Neighbourhoods. Population and total dwelling units for the enumeration areas that comprised each component neighbourhood was available from *Statistics Canada*.

To determine the density of people per square kilometre, the populations of the individual enumeration areas that comprised a Component Neighbourhoods were summed and divided by the total area of the Component Neighbourhood as determined using GIS.

Similarly, to determine the density of dwelling units per hectare, the total number of dwelling units for all of the individual enumeration areas was summed and divided by the Component Neighbourhood area.

The Neighbourhood submodel differs functionally and qualitatively from most of the other GB-Quest submodels. The outputs obtained from the Neighbourhood submodel are shaped through inputs provided by the user and do not rely upon inputs from other submodels. The major output of the Neighbourhood submodel will be images, descriptions and data related to the selected neighbourhood patterns, although numerical outputs from the Neighbourhood submodel will also provide inputs into the Cost of Living and Transportation submodels. Most of the information gathered during

neighbourhood pattern typology

Role in GB-QUEST

the Site Inventory phase of the study will be available to the user as verbal analysis, both in the input and output stages of play.

User Inputs

The user is presented with one slider and one matrix from which to make choices about the way neighbourhoods will develop. First, the user selects a position on residential density from the "Urban Development Density" slider. The user is presented with a continuum of five choices from "High Density" to "Low Density." Each option represents a preset ratio of high, medium, low and very low development densities. The chosen ratio will be applied to all new development within the Georgia Basin.

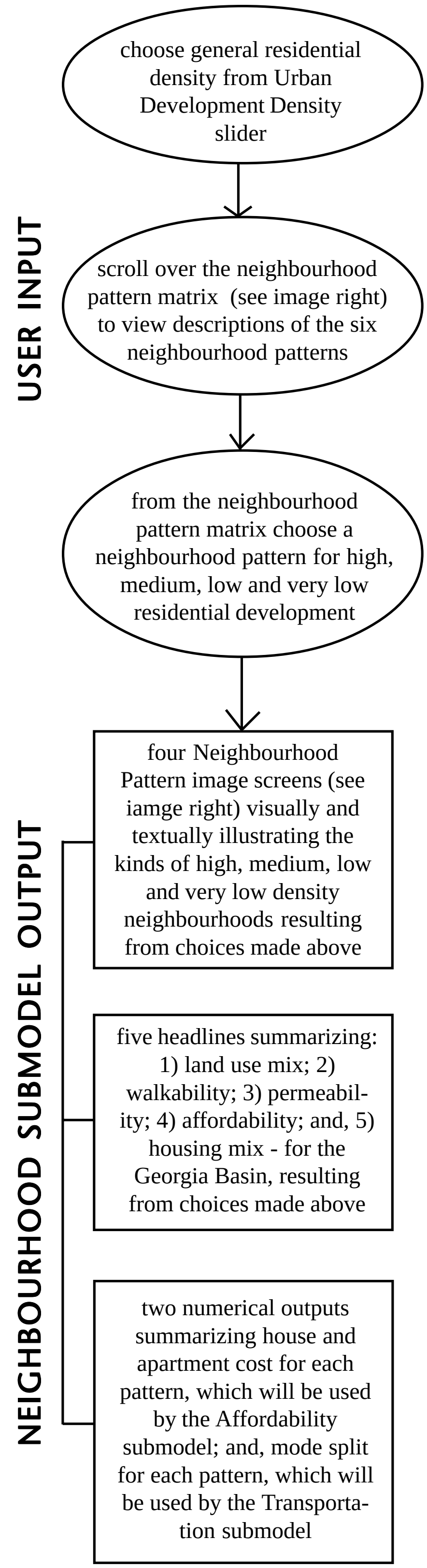
Second, the user selects one neighbourhood pattern for each of the four development densities. The neighbourhood patterns are presented to the user as diagrams organized in a matrix of density versus auto dependency (see figure facing page, top). As the user scrolls over each diagram in the matrix, additional information on the qualities of that neighbourhood pattern appears in the side-bar, including: description and, in some cases, origin of the pattern; walkability versus auto dependence; location of shops, services and schools; ability to accommodate different family types; location and type of recreation space; and, method of stormwater management. This information is based on the data gathered in the Site Inventory phase of this study, and is intended to assist more inquisitive users in making better-informed choices.

Neighbourhood Submodel Outputs

The Neighbourhood submodel will produce three types of outputs: 1) image screens that visually and textually illustrate the kinds of neighbourhoods resulting from the user's neighbourhood pattern selections; 2) five "Headlines" that highlight key impacts resulting from the user's neighbourhood pattern selections; and, 3) numerical outputs serving as inputs to the Transportation and Cost of Living submodels.

Image Screens

For each residential density, the Neighbourhood submodel will output a detailed image screen of the Neighbourhood Pattern chosen. Each screen will be comprised of the Neighbourhood Pattern diagram surrounded by thumbnail photographs of that pattern's component parts (see figure bottom right). The diagram is a repeat of that found on the input screen. The diagram depicts the arrangement of streets, developed areas and parks or open space typical of the Neighbourhood Pattern. The component parts that comprise a Neighbourhood Pattern may include: apartment, ground-oriented

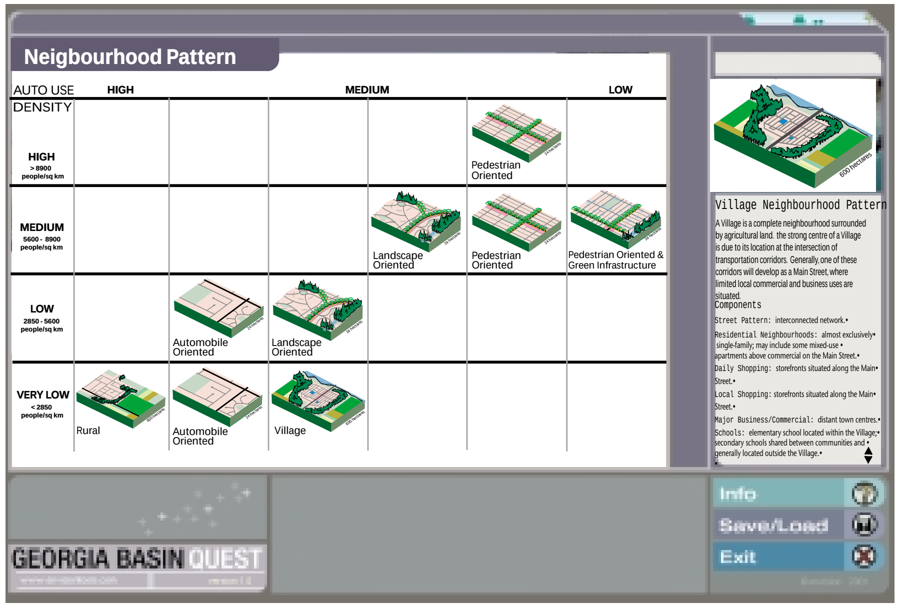


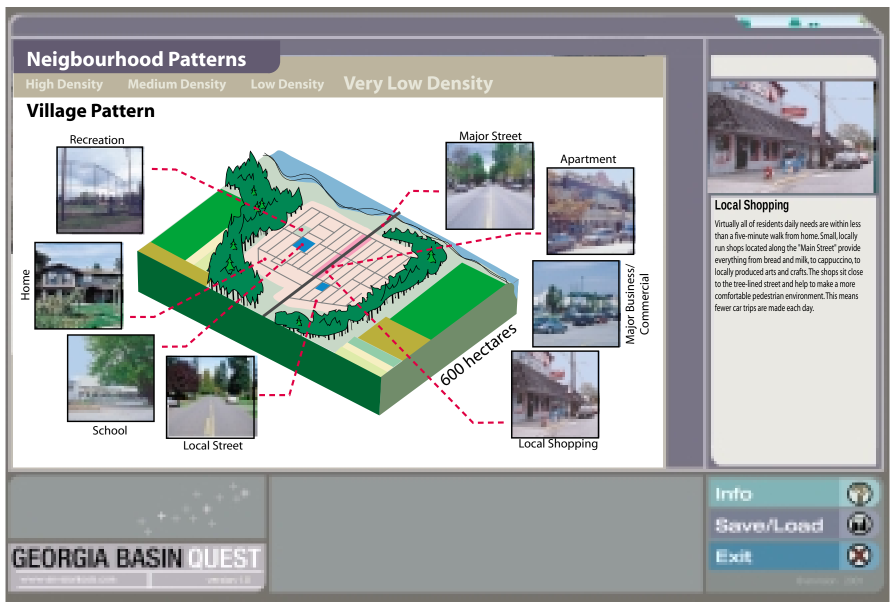
above
as show in the above flowchart, the Neighbourhood Submodel is shaped through inputs provided by the user and produces outputs that visually describe the resulting community.

multiple-family, house, large house, major street, local street, lane, preserved stream/greenway, recreation, school, local shopping, and major business/commercial. As the user scrolls over each thumbnail, additional information on that component part appears in the sidebar. This information is based on the data gathered in the Site Inventory phase of this study, and is intended to assist users in modifying their choices for consecutive games. The user will also be able to examine image blow-ups by "clicking" on individual thumbnails. The user will also be able to move between image screens, perhaps, as in the example mock-up, by "clicking" on the text "High Density," "Medium Density," "Low Density," and "Very Low Density."

Headlines

Five "Headlines" based on the five sustainability factors will also be output, including: 1) Land Use Mix – "The Georgia Basin has a (very low/ low/medium/high) Land Use Mix"; 2) Walkability – "X% of the population is within a 5-minute walk of daily needs"; 3) Permeability – "X% of the Georgia Basin is permeable to rain (Xm^2 of impervious area per person"; 4) Affordability – "X% of households can afford to live in the Georgia Basin"; and 5) Housing Mix – "The Georgia Basin has X% of the benchmark housing mix." The headlines will result from the sum of the corresponding datum for all neighbourhood patterns selected, weighed according to the ratio selected on the "Urban Development Density" slider. One of the sustainability factors, VKT, is not represented as a headline, as the Transportation submodel generates VKT as one of its ouputs. Instead, the Neighbourhood submodel will produce a Neighbourhood Pattern based transportation mode split, which will be used by the Transportation submodel as an input. This will capture the influence of Neighbourhood pattern on VKT (please see "Numerical Outputs"





top
After selecting a general position on density from the "Urban Development Density" slider, the user selects one neighbourhood pattern for each of the four development densities. The Pedestrian Oriented pattern is the only choice for high density. As the user scrolls over each diagram in the matrix, additional information on the qualities of that neighbourhood pattern appears in the side-bar.

bottom
One output of the Neighbourhood submodel is a series of image screens that visually and textually describe each of the patterns selected by the user. The user will be able to examine image blow-ups of the thumbnail photographs of the pattern's component parts by "clicking" on individual thumbnails. As the user scrolls over each thumbnail, additional information on that component part appears in the side-bar. The user will be able to move between image screens by "clicking on the text.

below). In addition to the four sustainability factors represented, one of the three factors used to generate the Neighbourhood Patterns – land use mix, is represented as a headline. Of the remaining two, density is a user input, not a submodel output; and, street arrangement is represented visually in the Image Screens (please see "Image Screens," previous page).

Numerical Outputs

Numerical outputs from the Neighbourhood submodel will provide inputs for the Transportation and Cost of Living submodels. As with the headlines, these outputs will result from the sum of the corresponding datum for all neighbourhood patterns selected, weighed according to the ratio selected on the "Urban Development Density" slider. For the Transportation submodel, the transportation mode split will be calculated.

For the Cost of Living submodel, the average cost of a typical single-family home, and a condominium will be calculated. These housing costs are derived from an average cost to build per square foot, plus an average cost of land per acre. The housing cost arising from this calculation is intended to capture how different sized houses and lots contribute to the affordability of each pattern.

For the breakdown of Transportation Mode Split by Neighbourhood Pattern, please see Appendix 4; for the breakdown of House and Apartment cost by Neighbourhood Pattern, please see Appendix 5.

appendix 1

Data Summary Table

appendix 2

Neighbourhood Pattern Data Tables

appendix 3

Component Neighbourhood & Study Site Maps

appendix 4

Transportation Mode Split by Neighbourhood

appendix 5

House & Apartment Price by Neighbourhood