

Evolving the Urban Dwelling

Addressing Critical Challenges in Residential Design and Development

by

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AUTHOR'S DECLARATION

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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ABSTRACT

In examining the Canadian residential fabric, this thesis advocates for the design of urban dwellings which respond directly to a number of contemporary urban challenges. A number of these challenges stem from the largely suburban nature of North American cities; there are major concerns about the relative isolation and automobile dependence of contemporary suburbs, their spread into conurbations, and their environmental impacts. On the other hand, there are challenges with many typical urban infill developments as well; they are often developed for a limited range of households, lack much in the way of connections to the outdoors, and, in contrast to some of the key arguments for intensification, often perform below the level of energy efficiency we might reasonably expect in a compact, contemporary, and sustainable urban form. All of these challenges are further discussed and evaluated in chapter three of the thesis.

In attempting to address these challenges in a holistic manner, this thesis makes a case for conscientiously increasing the density of the many existing low-density areas within our urban fabric, in a form which incorporates varied outdoor spaces, varied uses, varied unit types and sizes, within a relatively energy efficient form and skin. Chapter four looks at design principles, strategies, and precedents, as well as schematic designs which attempt to integrate and synthesize these objectives.

In order to illustrate the application of these principles and schematic designs to an existing low density urban area, chapter five proposes a more detailed design on a large site in Westboro, Ottawa, an evolving semi-suburban area whose development dates largely from early and mid 20th century.

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I - INTRODUCTION





Cities face challenges specific to their eras, cultures, climates, technologies, and so forth. Contemporary Canadian and American cities are no different in facing their own challenges; they must accommodate anticipated population growth, they must contend with current ecological, social, and economic issues, while providing a high quality of life and a positive daily environment.

As a major element of cities, dwellings are important in contending with such challenges. Dwellings form much of our immediate environment, take up large geographical areas, and influence the shape and structure of cities. As such, they are intimately linked to issues of urban growth, as well as human and wider ecological well being. This thesis focusses on the design of a dwelling fabric which seeks to come to terms with a number of key urban challenges in our contemporary cities.

In identifying *some* of these challenges, consideration of the nature of our contemporary cities is in order. First, contemporary North American cities have been shaped in fundamental ways by patterns of residential suburban growth beginning in the 19th century, and in particular, by the automobile oriented post WWII suburb. Urban historian Kenneth Jackson wrote that “suburbanization has been the outstanding residential characteristic of American life”, a characteristic often shared in Canadian life.¹ Since at least mid 20th century, cities have expanded their boundaries at a rapid pace. The suburban dwelling has become the typical dwelling of much of the North American middle class. Any exploration of the dwelling in North American cities thus needs to thoughtfully consider this long-standing trend of suburban growth.

This rapid suburban growth has been the subject of voluminous discussion and critical reflection for decades and more. Major intellectual and cultural icons such as Lewis Mumford and Jane Jacobs raised numerous criticisms of post war suburban growth in the early 1960s; their classic and hugely influential texts – Mumford’s *The City in History* (1961) and Jacobs’ *The Death and Life of Great American Cities* (1961) – voiced some concerns of the era, and anticipated many later criticisms of suburban expansion. While the post-war suburb provided relatively sanitary, comfortable, and affordable dwellings for a growing middle class, this residential landscape was criticized for being isolating, lacking in easy access to

urban amenities, for rapidly pushing natural and rural areas further and further away from more central city areas, for creating a system totally dependant on the automobile, for creating an extravagant, extensive, and inefficient system of infrastructure, for drawing people, resources, and political will away from existing city areas, and for lacking many of the positive characteristics of earlier suburban residential developments. These criticisms remain relevant today, as the post-war suburb makes up much of our landscape, and continues to grow, in varied forms, in order to accommodate sustained population growth. Moreover, additional concerns, pertaining to the sustainability and energy intensity of the suburban form, have also come to the forefront. These concerns are further discussed in chapter three.

Today, in reaction to some of these issues with suburban growth, there is a marked policy emphasis in many cities on accommodating growth through urban intensification and infill development. Official plans of many major Canadian cities explicitly call for increased population densities and growth within established city areas. The Ontario government’s *Places to Grow Act* directs population growth in the Greater Golden Horseshoe to existing urban cores.² Its first guiding principle is to “build compact” in order to address a number of the concerns listed above.³ In dealing with an anticipated population growth of approximately 20% by 2031, the city of Ottawa Official Plan states that “the city will manage growth by directing it to the urban area where services already exist or where they can be provided efficiently” and that “by pursuing a *mix of land uses* and a *compact form of development*, the city will be able to support a high-quality transit service and make better use of existing roads and other infrastructure rather than building new facilities.”⁴

While intensification addresses many of the important challenges facing largely suburban Canadian and American cities, it also faces challenges of its own. Typical contemporary infill dwellings can be limited in type, in the amenities which they provide, in the types of households they appeal to and accommodate, in their connection to the outdoors and access to natural light, and in terms of many of the ecological benefits which they should be expected to provide. The architecture of the tall, glass skinned condominium building is an iconic example of this: while it

is a viable, liveable, and sought after dwelling type for many households, it has distinct limitations. Its market is primarily young singles, couples without children, empty nesters, and retirees, and, in some markets, investors and speculators. It provides little in terms of outdoor space and has limited spatial and sensory connection to the outdoor environment. Access to outdoor space often requires a trip through a corridor and an elevator. Access to natural light is more challenging in such large buildings, as most units are typically single aspect. From a wider urban design perspective, there are daylight challenges in terms of overshadowing. Also, compared to what we might reasonably expect from a large aggregation of dwellings attached on most sides, the fully glazed tower often has relatively poor energy performance. Moreover, both construction costs and land costs tend to be significantly higher in urban developments. Of course the nature of contemporary urban residential development is highly varied, including everything from townhouses to large slab towers, but arguably, the majority of contemporary urban infill projects share many of these limitations.

This thesis proposes urban dwelling types which react to some of these fundamental urban and suburban challenges. As urban dwellings, the design proposals stand in contrast to the relative isolation, low density, and the rapid outward growth of suburban dwellings. However they also seek to confront some of the limitations seen in much urban residential architecture. Drawing on an expanded discussion of these challenges in chapter three, the *key, interrelated challenges* that the design proposals seeks to address are summarized below:

DESIGN CHALLENGES:

- Provision of public and private open spaces within the urban fabric
- Accommodating a range of household types
- Creating an urban environment with facilities, services, commerce, transit, etc. that are readily accessible by a wide variety of means and facilitate pedestrian travel
- Decreasing life cycle energy consumption in our residential buildings and urban fabric

- Limiting the continuous spread of the urban area (sprawl or conurbations)
- Maintaining adequate access to natural light, air, views
- Generally, creating a quality urban environment

These over-arching challenges guide the thesis. In addressing these challenges through design, a number of design principles and strategies are put forth in chapter four, Part I. These are:

DESIGN PRINCIPLES AND STRATEGIES:

- **Modest range of density** - loosely, a net population density of 200-400 residents per hectare, a gross population density of 80-175 people per hectare, and a net F.A.R. of 1.5-3
- **Mixed Use**
 - As a strategy to complement and optimize density
 - For greater amenity and walkability
- **Dwelling unit relation and connection to outdoor space**
 - Varied relationships between outdoor spaces and dwellings
 - Sensory connection to outdoors
 - Use of modified ground plane
- **Varied Unit types and Sizes**
- **Energy Performance**
 - Compact massing
 - Relatively high performance envelope
 - Window orientation
 - Operating energy intensity of roughly 100 kWh/m² or less for new dwellings, with progressively lower targets in future

The issue of population **density** is important in cities, influencing many of their characteristics. Urban density plays a critical role in addressing a number of the key challenges outlined above; it can reduce distances between people and programs, help create conditions for a mixed use environment, provide alternatives to the growth of conurbations, and create a more compact, efficient built fabric - hence it's inclusion as a

design principle.

While there are many metrics of population density, this thesis employs two basic metrics: *people per hectare*, and *FAR*. *People per hectare* specifically measures population density, while *FAR* measures the density of the built form regardless of the density of population. *FAR* and *people per hectare* are further broken down into *gross* and *net* - *gross* considers a wider urban area, including the area of roads, public right of way, and, in some cases, areas with non-residential programs, while *net* includes only the area of an immediate residential site or sites, excluding streets and public rights of way. In this thesis, *gross urban population density* will generally be taken to include a wider urban area, including areas with strictly non-residential programs (including, eg., parks, roads, institutions, industrial areas, commercial areas, etc.) in order to try to account for the urban density of an area on the whole.

The range of densities noted in the principles above is significantly above that of current and planned suburban neighbourhoods in Ottawa and most Canadian cities, but it is below a level that necessarily implies closely spaced high rise buildings or crowded living conditions, and is at a level that is comparable to many pedestrian oriented mixed use historic cities incorporating outdoor spaces. Moreover, in the context of a city such as Ottawa, densities at these levels would, on the basis of official population growth projections, theoretically be able to accommodate all of the anticipated population growth within existing urban sites available for redevelopment.

Incorporation of **mixed uses** in the design is important not only for increasing the amount of nearby amenities, facilities, workplaces, etc., and in helping to create a more lively, pedestrian oriented urban fabric, but also because it could allow for a more optimal increase in urban density. Programs requiring large spaces and less direct access to natural light or views, such as large retailers or storage spaces can be accommodated in deep, low podium structures. Accommodating such programs on the site eliminates the need to locate them elsewhere, freeing up more urban land. Other programs requiring better access to light, such as residences, can be located above in a fabric with thinner floorplates. The roofplanes of various programs can become usable urban spaces.

The importance of **outdoor space** within the urban fabric, and its relation to the dwelling, is another critical design principle, and it is a theme that is explored throughout the thesis. Varied outdoor spaces are an important amenity, and bring natural light into a dense urban fabric. Like density, outdoor space within a city is important in shaping its character. Yet outdoor space and density have in some cases been at odds with one another. The design proposal seeks to provide a balance of urban density and outdoor space, incorporating a mix of public and private outdoor spaces within an urban fabric at the densities outlined above, in some cases incorporating modified ground planes to allow greater, more intimate integration of outdoor spaces in the built fabric.

In order to accommodate population growth across a wide spectrum of households, urban residential development will have to provide a **variety of unit types and sizes**, with appeal to varied demographics. As noted above, and as further discussed in chapter three, many contemporary urban residential developments cater to a limited market: singles, young professionals, empty nesters and so on. The design proposals will incorporate a variety of unit types, with varied amenities, layouts, and sizes in order to create comfortable urban dwellings for a wider spectrum of households. Providing nearby, intimate outdoor spaces for some units will go some way towards making urban dwellings befitting a wider range of households, providing more easily supervised spaces for young children to play, spaces for avid gardeners, for family gatherings, and for overall enjoyment of the outdoors.

Finally, if the design proposal is to holistically consider some of the major challenges in our cities, it must confront the issue of sustainability, specifically **energy use**. This is especially true since dwellings account for a large portion of overall national energy use. Moreover, it is widely recognized that many of the key design decisions affecting the energy performance of a building are made in early schematic design, so if energy use is to be considered, it should be addressed at early, conceptual stages⁸. Therefore the design proposal necessarily includes consideration of some of the major factors affecting energy use at the schematic design phase. The thesis will look specifically at some architectural factors affecting energy use - schematic massing, envelope design, glazing, and

orientation - in the discussion of general design principles and strategies in Part I of Chapter four.

In implementing these general design principles and strategies, the thesis puts forth a number of schematic design dwelling types in part II of chapter four. These are explored alongside relevant precedents which use similar principles and strategies. The schematic types are then implemented in a more detailed design proposal. This proposal is intended to be a fuller demonstration of how the design principles, strategies, and schematic types of the thesis might be implemented.

The detailed proposal is for a developing inner suburb of Ottawa. Like any city, Ottawa has distinct characteristics and qualities, however it also shares many of the fundamental growth patterns of the North American city. While it has retained an actively populated, relatively lively and well used downtown core - unlike the downtown cores of many cities which have been decimated by suburban flight - Ottawa has also experienced the rapid and sustained suburban growth characteristic of most North American cities. Most of the built up area of Ottawa city today is suburban. This suburban growth has developed in the general pattern of what George Baird and Barton Myers termed the *uni-centred city*: the typical North American city with a relatively dense, tall core, surrounded by a wide, low periphery that rapidly decreases in density with increased distance from the core. As a uni-centred city, population densities in central districts of Ottawa are significantly higher than peripheral districts. The downtown core is dominated by tall buildings while the periphery is composed primarily of low buildings, with occasional scattering of apartment buildings, office towers, and condominiums. As discussed in chapters three and four, this general trend is largely continued by contemporary development in Ottawa - as it is in other cities - and is projected to carry into the future: present and future residential development of central neighbourhoods consists primarily of larger condominiums at relatively high densities, while peripheral locations are developed primarily as a mix of relatively low density single detached and row houses.⁶

Therefore, since the detailed design proposal is in the context of a city which has developed - and continues to develop - along the familiar lines of the North American uni-centred city, the proposal has wider

significance, relating to the urban challenges that are shared by many Canadian and North American cities.

The detailed design proposal is for a large, low density commercial site located along a rapidly developing main street in Westboro. Westboro is a largely suburban residential neighbourhood composed primarily of single detached pre-war (pre-1946), and early post-war (1946-1960) houses. It is an inner suburb in the city of Ottawa, within approximately three kilometers of downtown. The site - wholly occupied by a single large retailer with ample surface parking - represents a common type of site found along major streets in North American cities: the sites of suburban malls, big box stores, power centres, etc. Such sites are estimated to make up 5% of urban land available for redevelopment in Ottawa.⁷ As large, commonplace sites, developed at low densities, with single storey buildings and large areas of surface parking, and with little or no need for land assembly, these sites represent a tremendous opportunity for urban and suburban redevelopment. And as a site in an existing low-density urban area, outside the high rise core, the design proposes one way to re-imagine much of the commonplace low density urban fabric in our cities.

THESIS STRUCTURE AND CHAPTER OVERVIEW

Chapter two of the thesis examines a number of historic urban dwelling types and urban residential patterns, looking specifically at urban density, urban outdoor space and it's relation to the dwelling, and mix of use within the residential fabric. The chapter looks at a few patterns and types which have been historically prevalent, exhibiting general trends in a number of eras and cultures, and housing relatively large portions of the urban population. Analysis of these types and patterns will point to some conclusions that will inform the thesis design principles, strategies, and ultimate design proposal - though it should be noted that the analysis is not taken to be historically comprehensive or definitive in scope.

In particular, the chapter looks at the widespread integration of outdoor spaces in the urban dwelling types of many historic cities, indicating that such outdoor space has often been historically valued in

an urban context, that these spaces have often been ubiquitous even in many dense, highly built up cities, and that a close connection between dwelling and outdoor space is not unique to the North American suburban experience. The chapter also looks broadly at historic population densities, in order to provide a better understanding of the range of historic population densities, and to provide a broad basis for comparisons. As the chapter progresses the scope of historical analysis narrows to look primarily at European cities from the middle ages on, and then North American cities from the 19th century and after. The chapter ends with discussion of the post-WWII suburb, which leads into chapter three.

Chapter three highlights some of the important characteristics of contemporary suburban and urban dwellings in Canada, focussing in particular on Ottawa and Toronto. Much of the information here is drawn from municipal statistics, census data, various writers, the author's personal experience living in Canadian cities, as well as other anecdotal sources such as advertisements and articles on new residential developments. In critically analyzing a number of these characteristics, seven key challenges - summarized above - are identified.

Discussion of these challenges leads to chapter four, which discusses design principles and strategies which directly address these challenges. Part I of chapter four further discusses the design principles summarized above. Part II discusses the principles and strategies in relation to a number of precedents, and shows how the principles and strategies might be implemented in a number of schematic design types. Part III discusses how some of these principles might be implemented on the proposed type of site.

Finally, Chapter five implements these principles and strategies on a specific site in Ottawa, as a demonstration and design exploration. Here, three very schematic options are put forth, one of which is explored in greater detail.

ENDNOTES - CHAPTER I

1. Jackson, *Crabgrass Frontier*, p. 304
2. The Greater Golden Horseshoe is defined by Ontario Regulation 416/05, s.2 (the places to Grow Act) as Brant, Dufferin, Durham, Haldimand, Halton, Hamilton, Kawartha Lakes, Niagara, Northumberland, Peel, Peterborough, Simcoe, Toronto, Waterloo, Wellington, and York.
3. Ontario, Ministry of Public Infrastructure Renewal, *Growth Plan for the Greater Golden Horseshoe*, p. 10.
4. City of Ottawa, *Official Plan*, S.2.1
5. City of Ottawa, “Land Area, Population and Households by Ward”.
6. City of Ottawa, “New Dwelling Units by Sub-Area”; City of Ottawa, Planning and Growth Management Research and Forecasting Unit, *2009 Annual Development Report*;
7. City of Ottawa, “Where We Will Live: Summary of Total Potential by Unit Type.”
8. Clarke, *Energy Simulation In Building Design*; Malkawi and Augenbroe, eds. *Advanced Building Simulation*; Straube, *Personal interview with author*; Petersen and Svendsen “Method and simulation program informed decisions in the early stages of building design”.

II - HISTORICAL ANALYSIS OF KEY URBAN DWELLING TYPES





This chapter looks at urban dwelling from a broad historical perspective. It examines a number of historic cities, key historic urban dwelling types, and aggregations of urban dwellings, including examples from some of the first cities to contemporary suburbs. It focusses on dwelling types and urban fabrics that have been historically widespread, and that have housed a relatively wide range of urban populations. The breadth of the chapter narrows as it progresses, moving from a more global perspective to an emphasis on European cities in the medieval ages, eventually focusing on developments in Canada and the United States, then specifically in the more regional context of Ottawa and Toronto. In relating to the design principles of the thesis, the main focus of this chapter will be analysis of urban densities, of the varied character and roles of outdoor spaces in the urban environment, and how the mix of uses within the residential fabric of the city has changed in western culture from medieval European cities onwards.

The historic analysis in this chapter leads to a number of conclusions. First, the analysis indicates that historic cities have generally developed at substantially higher overall densities than contemporary North American cities (see FIG. 2.1, and appendix 1). The density of the high-rise cores of contemporary uni-centred North American cities is more than offset by the wide, low density, suburban periphery. And while suburban peripheries are as old as cities themselves,¹ the large scale popular growth of this periphery, as a contiguous, low density suburban area, really only begins in the 19th and 20th centuries. As a result of this widespread suburban growth, even a relatively tall and dense North American city such as Toronto, with a gross population density of 40 people per hectare² (within the boundaries of the City of Toronto proper, excluding municipalities such as Markham, Mississauga, Brampton, etc.) and with the second largest number of high rise buildings in North America, is low density by historic standards. Data collected in research for the thesis shows that, prior to the 19th century, larger western cities tended to develop at gross densities of around 100 - 300 people per hectare - much higher than the gross density of contemporary North American cities. Moreover, unlike contemporary uni-centred cities, the various areas of pre 19th century cities tended to develop at more uniform densities, in

more contiguous patterns, and within a more distinct urban boundary.

Secondly, this chapter highlights a number of examples of cities and dwelling types which, though developed at such comparatively high densities, integrated significant amounts of public and private open spaces within the urban fabric. The chapter looks, for example, at a number of dense cities composed primarily of courtyard houses, whose courtyards provide intimate outdoor spaces integral to the dwelling. Ur, among the first cities, was composed almost entirely of courtyard dwellings and had a gross density estimated at between 150 and 350 people per hectare. Many medieval European cities and towns, composed largely of rowhouses in tight blocks, and at general gross densities of 100 to 200 people per hectare, contained large public open spaces for markets, religious and public gatherings, as well as private yards on the narrow lots behind the rowhouses. Therefore, while there is often a tension between urban density and open space, the two ought not be viewed as mutually exclusive at relatively moderate levels. The historic precedents in this chapter show that provision of a variety of public and private outdoor spaces needn't be thought of as some sort of suburban phenomenon or ideal, or as a cultural phenomenon particular to suburban nations such as the United States and Canada. Therefore the creation of a relatively dense urban fabric does not necessarily entail a dearth of outdoor spaces and urban verdure.

Thirdly, the examples of denser cities that incorporate outdoor space in and around their residential fabric say something of the value that various societies and individuals may place on outdoor space in the urban fabric. While it would be misguided and fallacious to base the case for open space in contemporary urban cities solely on the fact of its existence in historic precedents - because societies differ across times, and because the widespread historic existence of a custom does not in any way justify it³ - the fact that many cultures have provided public and private open space within dense residential areas of their cities can nevertheless be interpreted as support for the notion that outdoor space has been valued by many living within an urban context.

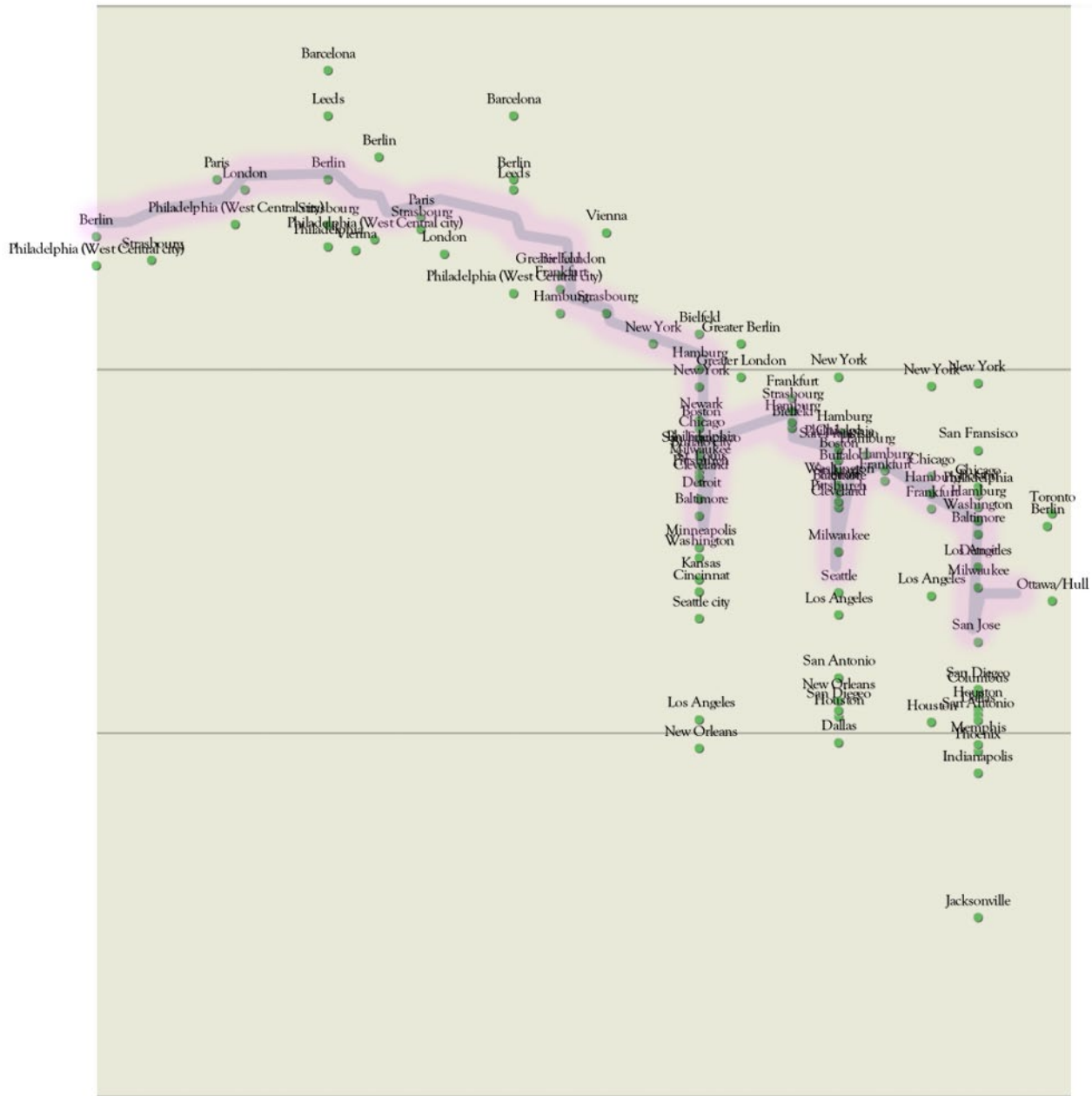
Fourthly, while this chapter looks at a number of examples of relatively dense cities where dwellings have a close relation to outdoor space, it also notes tensions between density and access to open space.

Medieval cities and towns allowed for the proliferation of rowhouses, chequered yards, gardens and orchards up to some levels of urban density, but where city populations grew and outward urban expansion was restricted - as in the 17th and 18th centuries⁴ - densities rose higher, the rowhouse was heightened, open spaces were built over, and the relation of the dwelling to open space began to change with the development of superimposed dwellings and the eventual development of formal apartment buildings in the 19th century. At density levels much beyond that of the most dense medieval cities or courtyard cities - very roughly, perhaps at gross densities generally above 250 - 350 people per hectare - the fundamental pattern of the rowhouse or courtyard house either becomes overcrowded, as it did in much of the west during the industrial revolution, or gives way to vertically superimposed residences. Thus, beyond certain levels of urban density, integration of smaller scale outdoor spaces adjacent to dwellings may require new dwelling types which can integrate such spaces in superimposed dwellings and building types. This last point is explored in the design strategies and types in chapter four.

Finally, though historic conditions of commerce, trade, work, transportation - and life in general - are of course radically different from those of today, one may note the existence of a more mixed use urban fabric in most historic cities. Medieval European cities are perhaps one of the best historic examples of an intimately mixed urban fabric, where commerce and industry were commonly an integral part of individual dwellings. In the development of apartment buildings in ancient Rome and in 19th century Paris, commercial areas were often separated from the household and located at the ground floor. Generally, closer integration of uses prior to the 19th and 20th centuries was necessitated by the fact that the primary mode of transportation was walking. This close integration of uses is clearly reversed in many suburban areas of contemporary cities, where different functions are widely spaced apart.

These points serve to inform a number of the design principles of the thesis. They situate the discussion of urban density within a much broader historic context, illustrating a range of historic urban densities and how these relate to particular urban environments and dwelling types in particular historic contexts. They show the prevalence of do-

mestic outdoor spaces within a range of urban environments, both dense and diffuse. In drawing these points from historic examples, one must of course be aware of the radical difference in contexts: differences in culture, climates, technologies, etc., from one historical context to the next. However the need to consider context holds true for *every* architectural precedent and case study - whether ancient or contemporary - and thus it is hardly the case that historic examples hold no significance for contemporary cities. Here, the historic analysis lays some basic groundwork which helps inform some of the design principles of the thesis - principles which are further established and elaborated in chapters three and four.



This graph shows, on a logarithmic scale, the gross urban population density of a number of historic cities. Information is collected from a number of sources, many of which are based on estimates. Earlier ages include a wider range of global cities, while the data in the medieval ages shows more European cities, and a mix of European and North American cities from the 1800s on. This distribution reflects the overall structure of Chapter 2, which puts the contemporary North American city in a historic context focusing first on global cities, then narrowing in scope to look more at western European cities. European cities show a marked increase in density in the early and mid 19th century, which, along with North American cities, begins to drop off from the late 19th century on. The cities shown in the United States in 1930, 1960, and 1990 are the top 20 most populated US cities of that time.⁵

1800 1810 1820 1830 1840 1850 1860 1870 1880 1890 1900 1910 1920 1930 1940 1950 1960 1970 1980 1990 2000 2010
 1800 A.D. to 2010 - European and North American cities

ANCIENT CITIES AND COURTYARD DWELLINGS

The courtyard house is a critically important dwelling type in urban history. It was the basic type of dwelling in the first known cities, in cities across much of the Asian continent, in many Greek and Roman cities, and in medieval Islamic cities. The following section will briefly discuss a range of contexts in which the courtyard dwelling has been a predominant dwelling type, examining its urban density in a number of illustrative examples, and some of the varied purposes which the courtyard space has served. While the courtyard type has seen much variation across cultures and regions, its widespread use points to the value that various cultures have placed on intimate outdoor spaces in urban areas, and it is an example of a simple method for incorporating such spaces in relatively dense urban environments.

The first cities in history are generally thought to have appeared around 3500 B.C. in Sumeria, part of modern day Iraq. These were cities such as Ur, Uruk, Nippur, and Eridu. They emerged as important centers of trade, wealth, political power, and intellectual development, with vital relations to the surrounding agricultural areas. Ur is one of the best documented of these cities, and offers important insights into the urban dwelling fabric of these first cities.⁶ Excavations of residential quarters of the city typically show a tight building fabric of courtyard houses, each house abutting one another on most sides, connecting to the rest of the city by means of narrow, irregular streets (FIG. 2.2). Estimates of the gross population density of the city of Ur range from roughly 150-350 people per hectare.⁷ By any measure, this is high density compared to contemporary North American cities: the density is anywhere from 5 to 35 times higher.⁸ The courtyard house was the primary dwelling unit across a wide range of social classes, with larger houses of wealthier families placed among more modest households.⁹ The individual houses – generally one or two storeys - varied in size, but were all organized around one or more private courtyards. This general form is an exceedingly important precedent in the history of the urban dwelling, as “the essential features of the

Ur house survived a life span of over 6000 years,” influencing civilizations throughout the Middle East and beyond.¹⁰

Indeed, other early civilizations had similar patterns of urban residential development. Cities along the Indus River, such as Mohenjo-Daro in the 3rd and second millennia BC, show extensive use of the densely arranged courtyard house in the urban residential fabric. Many other early cities, such as the famed city of Babylon, show the same basic form of dwelling fabric. The basic form of the courtyard dwelling seen in Sumerian cities, though subject to local and historical variations, has been ubiquitous in Middle Eastern and North African civilization for millennia. FIG. 2.5 shows a typical example of a relatively modest courtyard dwelling in Morocco.

In the early civilizations of modern day China, the courtyard house was also the basic urban dwelling unit, though the urban fabric of cities in China differed significantly from that developed in Mesopotamia and the Indus valley. Unlike the complex organic geometries of the cities of Sumer or Indus, many early Chinese cities were ordered by rectilinear geometries. Moreover most early Chinese dwellings were rarely more than one storey, and the cities were typically of lower population densities than more western early cities.¹¹ Often, the courtyards of Chinese dwellings were formed by a number of distinct dwellings, belonging to different members of the same extended family. Due to the large geographical area of China, and its diverse climate regions, the basic courtyard type was adapted and varied from region to region.

The courtyard dwelling also played a central role in Ancient Greek and Roman civilizations. It appeared in very early Greek culture, and was the basic dwelling unit in Greek cities beginning at least by the 5th century BC,¹² with continued prominence in Roman Greece.¹³ It was also a primary dwelling unit in Roman cities. However, as the city of Rome became densely populated, large multi-unit courtyard apartments - *insulae* - became more common. *Insulae* were several stories tall, and often had shops or work areas on the first floor.¹⁴ These began appearing in the 4th century BC, and by at least the 3rd century AD, when the population density of Rome had risen to an estimated 580 people per gross hectare, *insulae* would become the predominant form of dwelling unit in the city

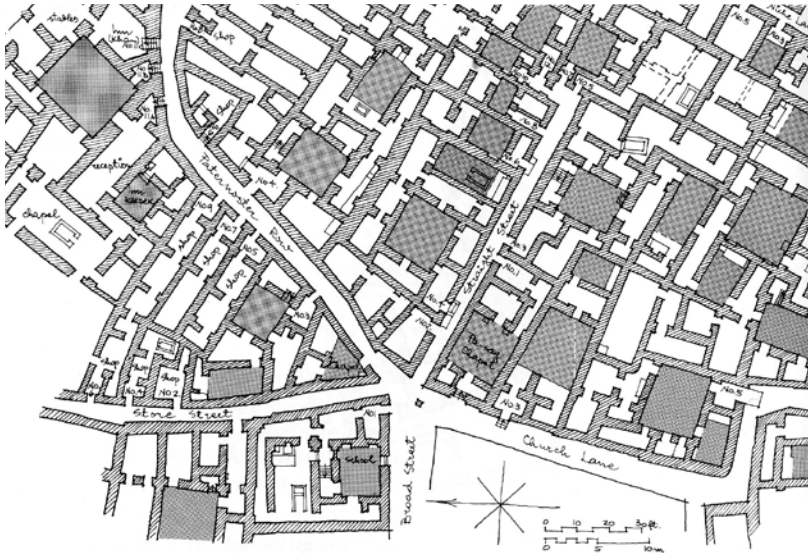


FIG. 2.2 UR, RESIDENTIAL QUARTER
 Approx gross F.A.R. : 1.5. Gross urban population density estimates: 150-400 ppl/Ha. Greyed areas are courtyards.

FIG. 2.3 MOHENJO-DARO RESIDENTIAL QUARTER

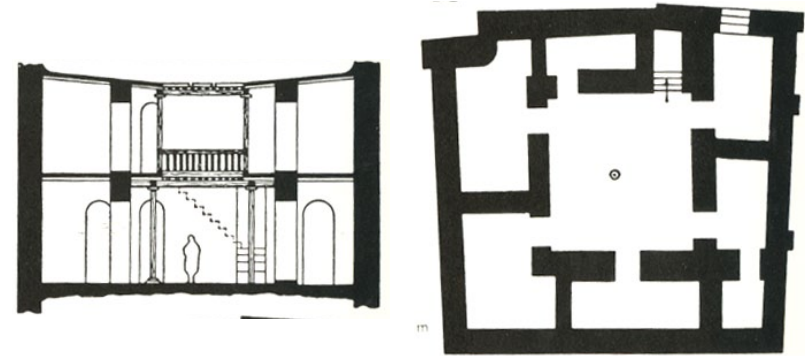
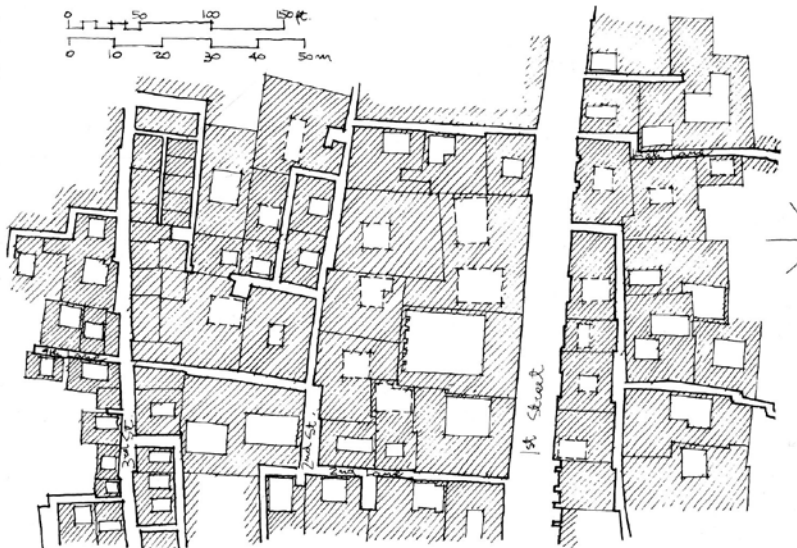


FIG. 2.4 TYPICAL UR HOUSE

FIG. 2.5 MODEST COURTHOUSE DWELLING IN MOROCCO
 1:500
 Shown with urban context (bottom). Approx net F.A.R. : 1.43. Approximate gross urban density: 75-125 ppl/Ha.

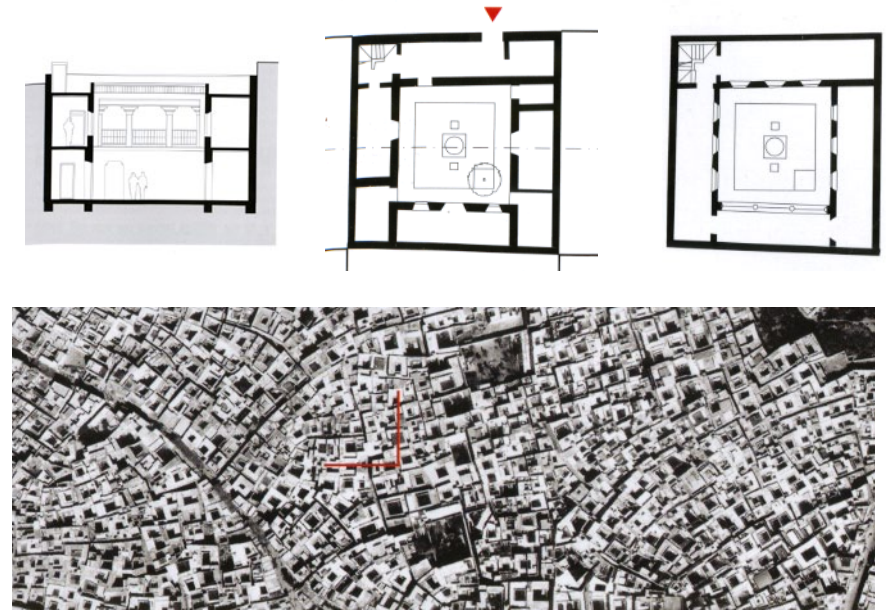
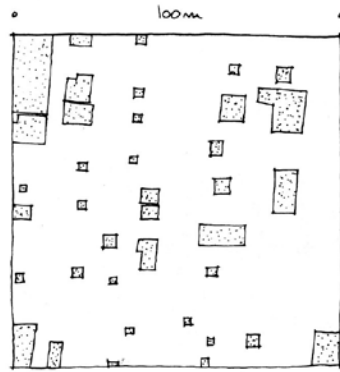


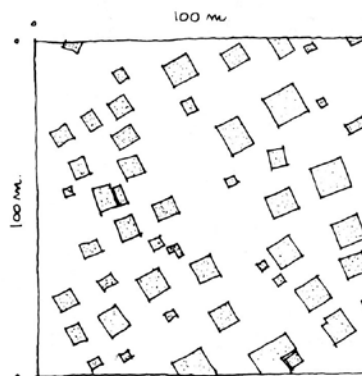
FIG. 2.7 PRIVATE OPEN SPACE IN SELECTED COURTYARD CITIES

Pompeii



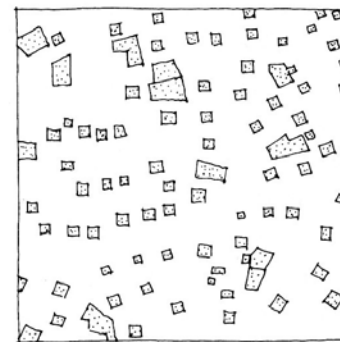
plan of private open space

Tunis



plan of private open spaces

Baghdad



plan of private open spaces

of Rome, while Roman courtyard houses – *domus* – became exclusive to the very wealthy.¹⁵ In the *insulae*, we have an early example of the shift to superimposed dwelling types that have a fundamentally different relation to outdoor space.

Beyond Greece and Rome, the courtyard dwelling has appeared in Europe in early Gaul,¹⁶ and has been a house type in Spain. Clearly then, the essential form of the courtyard dwelling, as a series of spaces formally arranged around one or more central open spaces, has been one of the most common types of urban dwelling in human history, over a wide range of cultures, places, climates, social classes, eras, and generally, for an extremely diverse range of inhabitants. Because of this, it is difficult to assign a particular ‘function’ or ‘purpose’ to the courtyard. Various authors have interpreted courtyard dwellings in terms of religious or civic virtues, climatic benefits, activities, and so on.¹⁷ While these may help explain particular modifications and adaptations of the type, given the extremely wide range of application, it is clear that the existence of the general type cannot be explained solely in terms of particular religious or social views, climates, inhabitants, or activities. The courtyard dwelling demonstrates that, for a wide variety of reasons, private open outdoor space has been an integral part of the urban dwelling in widely varied contexts throughout history. As Schoenauer writes, “the central open space *becomes what the inhabitants make of it*”, often taking the form of a “patio or small garden”¹⁸. While no one particular function can be assigned to the courtyard, authors have documented a wide range of typical uses, including¹⁹:

- Domestic activities
- Family gathering
- Eating
- Provision of natural light
- Circulation space
- Natural/garden space
- Spiritual space representing a vision of paradise
- Space representing human connection with nature
- Orchards and fruit production

- Promotion of ventilation and cooling

As a simple outdoor space then, the courtyard can provide a wide range of amenities to the urban dwelling. It can become a quiet outdoor retreat, a cool space in an arid climate, a lush garden, a place to sit in the sun, an open air family room. While the courtyard house has been seen in many climates, including some more northern climates, the type seems rather characteristic of slightly more equatorial regions, likely due to the fact that, (i) the high angle of the sun throughout much of the year in these regions allows direct sunlight to penetrate deep into the courtyard year round, and (ii) dwellings which have generous openings onto outdoor spaces are perhaps better suited to warmer climates. While the courtyard no doubt plays a crucial role in providing light and ventilation in a dense urban fabric, its role in providing a certain quality of space, and in providing space for varied outdoor uses and programs, as well as its cultural and religious significance, are all also important. It is a global example of the value that can be placed on access to intimate outdoor space within a dense urban context. While it would be a fallacy to argue that urban outdoor spaces are beneficial or necessary solely on the basis of this historic precedent - a fallacious appeal to tradition - the ubiquity of the courtyard type does provide some evidence that urban outdoor space is considered valuable and useful in many societies. It also serves as an example of how intimate outdoor spaces can be integrated in a dense building fabric.

FIG. 2.8 DELOS RESIDENTIAL QUARTERS
courtyards in grey

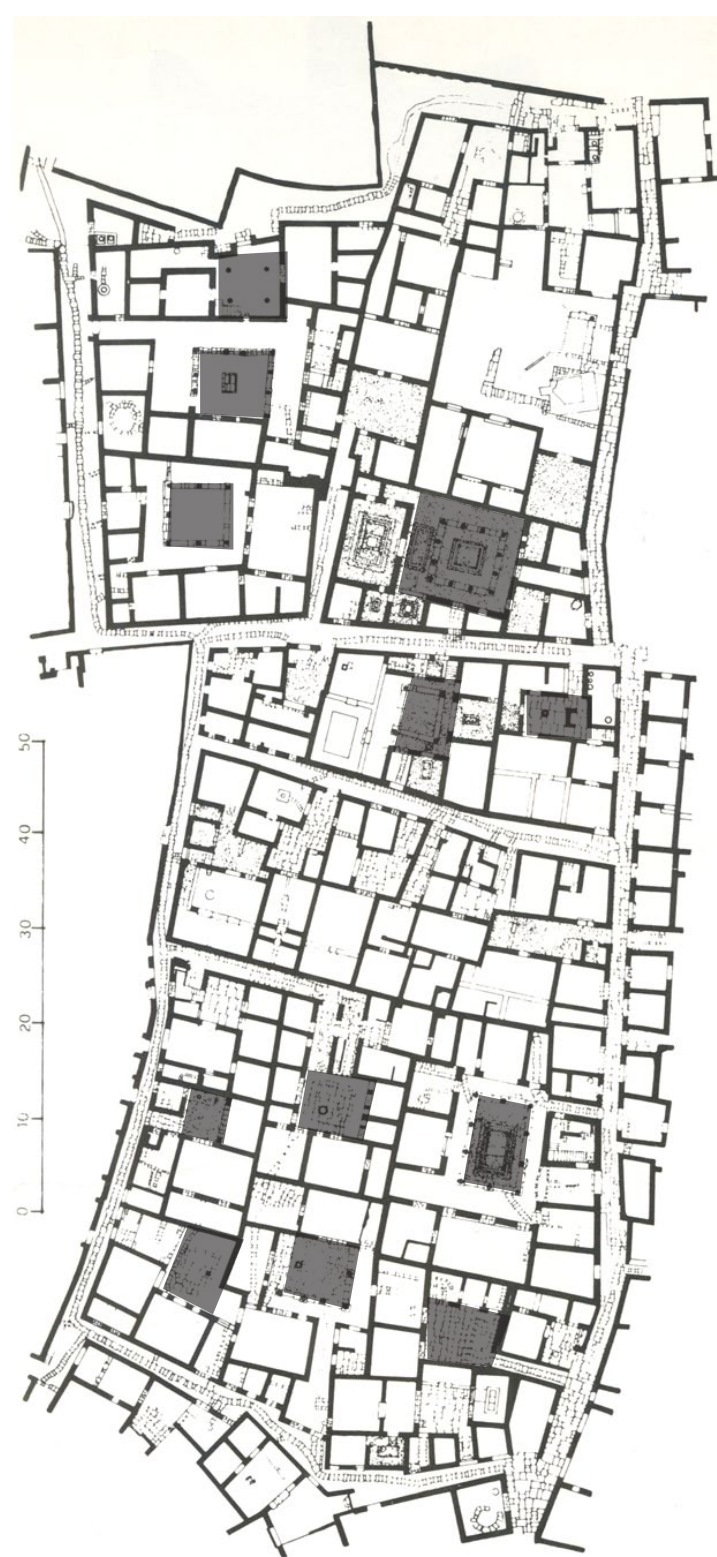




FIG. 2.10 FREIBURG 1575

A	Das Schloß	9	Kauffhaus	18	V...
B	S. Peter kirch	10	vor der Stadt	19	S...
C	St. Ulrich kirch	11	Malt	20	N...
D	St. Margarethe kirch	12	St. Ulrich berg	21	D...
E	St. Nikolaus kirch	13	St. Margarethe berg	22	B...
F	St. Peter kirch	14	St. Nikolaus berg	23	L...
G	St. Ulrich kirch	15	St. Peter kirch	24	...
H	St. Nikolaus kirch	16	St. Ulrich kirch	25	...
I	St. Peter kirch	17	St. Nikolaus kirch	26	...
J	St. Ulrich kirch	18	St. Peter kirch	27	...
K	St. Nikolaus kirch	19	St. Ulrich kirch	28	...
L	St. Peter kirch	20	St. Nikolaus kirch	29	...
M	St. Ulrich kirch	21	St. Peter kirch	30	...
N	St. Nikolaus kirch	22	St. Ulrich kirch	31	...
O	St. Peter kirch	23	St. Nikolaus kirch	32	...
P	St. Ulrich kirch	24	St. Peter kirch	33	...
Q	St. Nikolaus kirch	25	St. Ulrich kirch	34	...
R	St. Peter kirch	26	St. Nikolaus kirch	35	...
S	St. Ulrich kirch	27	St. Peter kirch	36	...
T	St. Nikolaus kirch	28	St. Ulrich kirch	37	...
U	St. Peter kirch	29	St. Nikolaus kirch	38	...
V	St. Ulrich kirch	30	St. Peter kirch	39	...
W	St. Nikolaus kirch	31	St. Ulrich kirch	40	...
X	St. Peter kirch	32	St. Nikolaus kirch	41	...
Y	St. Ulrich kirch	33	St. Peter kirch	42	...
Z	St. Nikolaus kirch	34	St. Ulrich kirch	43	...

MEDIEVAL TOWNS AND CITIES

Where the courtyard dwelling was the basic residential type of many ancient cities, the rowhouse was the basic dwelling unit of most European medieval towns and cities. These were typically arranged in irregular perimeter blocks, often surrounding varied open spaces - yards, orchards, gardens, workspaces, etc. The houses often included mixed programs, and interior spaces tended to be loosely organized. Workshops and small industry, commercial fronts, and storage spaces were often contained within the lower floors of the house. The basic medieval fabric created villages and cities with gross urban population densities typically ranging from 100-200 people per hectare, which contained a relative abundance of nearby commerce, public and religious buildings, services, and public and private open spaces. Largely surrounded by protective walls, cities were contained within a specific area, creating a sharp demarcation between urban areas and surrounding rural areas. In its synthesis of urbanity, density, diversity of programs, outdoor spaces and verdure, the overall form of European medieval towns and cities is in some way instructive to contemporary urban design.

With the fall of the Roman Empire, the courtyard house, formally arranged around one or more roughly central courtyards, declined in importance in Europe.²¹ After the Fall of the Roman empire, Europe experienced massive de-urbanization. The political and social structures of the widespread Roman Empire fell, and cities became massively depopulated as populations migrated to the countryside. Once Europe saw some stabilization under emerging feudal powers, able to provide protection to groups of centralized populations from potential invaders, cities once again began to grow. The continent underwent a pronounced and sustained period of urban growth beginning as early as the 10th century.²² Villages and cities became established as centers of security and protection, then trade, commerce, and medieval industry.

The form of the emerging medieval city fabric borrowed heavily from the gabled rural dwellings of Europe, eventually becoming a dense

fabric of attached row-houses surrounding a patchwork of rear plots of open space. If the courtyard dwelling was the primary unit in most ancient cities, the attached rowhouse, facing directly onto the street at one end, and onto an open space of varied dimensions at the other, was the primary dwelling unit in European medieval cities as well as many later cities. Lewis Mumford, described their form:

“Houses, only two or three stories high at the beginning – were usually built in contiguous rows around the perimeter of their rear gardens; sometimes in large blocks they formed inner courts, with a private green, reached through a single gateway on the street. Freestanding houses, unduly exposed to the elements, wasteful of the land on each side, harder to heat, were relatively scarce... Continuous row houses forming the closed perimeter of a block, with guarded access on the ground floor, served as a domestic wall: a genuine protection against felonious entry in troubled times.”²³

“...as far as usable open spaces go, the typical medieval town has at its foundation and through most of its existence a far higher standard for the mass of the population than any later form of town, down to the first romantic suburbs of the nineteenth century...one must not look at the narrow streets between the houses without remembering the open green or the neatly chequered gardens that usually stretched behind.”²⁴

Indeed, this basic fabric - rowhouses forming a tight perimeter around chequered rear lots - is often still evident in many aerial maps of European villages cities drawn around the tail end of the medieval ages, in the 16th and 17th centuries. Despite the rapid urban growth of these centuries, many of the maps still clearly show the earlier medieval pattern described by Mumford; even at these later dates one often sees the chequered greens behind the perimeter blocks of row houses. Though not strictly measured or precise, these maps are important historic documents, since there exist relatively few unaltered examples of earlier urban medieval dwellings, and measured records of medieval dwellings are scarce.²⁵ In many of the maps, we see a diversity of open spaces surround-

ed by the ubiquitous row house: tiny lots, large lots, orchards, gardens, yards with small outbuildings and sheds, and so on. Thus, like the courtyards of eastern dwellings, many of the plots of land behind the medieval row house provided urban dwellers with an outdoor space that could be used for a variety of purposes. In the maps one also sees many civic open spaces: squares and marketplaces around the churches and civic spaces, monastic cloisters, cemeteries. Streets were also important public spaces and areas of commerce. Moreover one sees that the surrounding defensive walls of the cities formed a clear demarcation between town and the nearby rural areas, often less than a kilometer from the center of the city, as city dwellers sought protection from invaders and rival feudal powers. So open landscapes of verdure were both close at hand on a large scale (in the agricultural and natural surroundings) and on a smaller scale, generously interspersed within the city fabric.

While medieval European cities and villages were composed largely of individual low rise rowhouses, and contained a significant amount of varied open spaces - both public and private - within their fabric, their population densities were still high relative to contemporary North American cities. Of all the reliable figures and estimates on gross urban population densities compiled for this thesis, the range for European medieval and Renaissance cities is 95 people per hectare at the low end (Dublin 1050 AD) and over 300 at the high end, with an average of around 200 people per hectare. Chandler puts a common range for typical, pre-industrial European walled cities at 100 - 200 people per hectare.²⁶ Partly, this density is likely due to the fact that standards of privacy and separation of individual spaces were different in the middle ages: spaces tended serve a wider range of uses and tended to be shared by a wider range of people. Houses were often the home of a wider family, sometimes housing the workers or apprentices of the household industry. Rooms were open to one another, and the notion of a corridor separating distinct rooms was not widely used.²⁷ Therefore there was likely less space per person. However, the general form of the deep, narrow, and two to four storey rowhouse also allows for a substantially higher built density than contemporary suburban areas, on the basis of form alone, regardless of cultural differences in how space is used. Moreover streets were nar-

rower, and cities did not require extravagant amounts of space for vehicle circulation and parking.

Along with higher densities, medieval cities were also characterized by a high degree of mixed use. Typically, the ground floor of many houses was often commercial space or a workshop. Medieval industry took place largely within a widened domestic sphere. Separation of functional areas within cities, as with discrete separation of individual spaces within the home, would gradually come in centuries after the middle ages. Additionally, since commercial and industrial spaces were often located below the primary living spaces of the house, they did not require separate sites, which further increased the density of the medieval city.

In European medieval towns and cities then, the typical organization is an urban fabric of attached individual houses, with various other uses integrated, surrounding internal open spaces of likewise varied uses, coming together in a larger pattern defined by an organic and irregular system of urban blocks and streets interspersed with public buildings - churches, cathedrals, guild halls, hospitals, monasteries - and public open spaces. Though much of this medieval fabric has largely disappeared in major European cities, under centuries of renovation, addition, and war, it formed the basic foundation for modern European cities. With a general trend towards increasing population density - seen in FIG. 2.1 and Appendix 1 - the medieval pattern was altered significantly, as urban open spaces were increasingly built over to accommodate population growth.²⁸

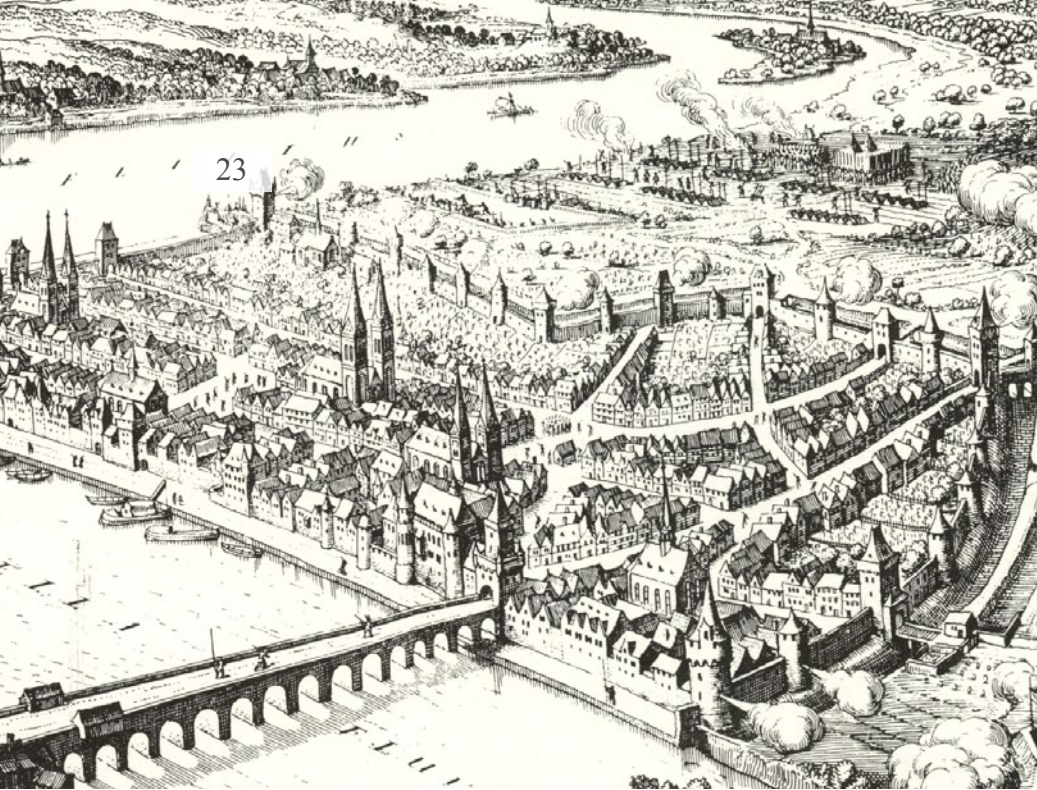


FIG. 2.14 IEPER (YPRES) 1649
 (Opposite) Estimated gross urban density in 1300:
 268 ppl/ha (Chandler)

FIG. 2.13 CITY OF KOLBENZ 1632.



FIG. 2.12 LONDON 1560.
 From *Civitates Orbis Terrarum*.
 Estimated gross urban density in 1380: 167 ppl/ha (Hartog)
 Estimated gross urban density in 1832: 268 ppl/ha (Hartog)



16TH-18TH CENTURY EUROPEAN URBAN GROWTH

*“The overcrowding [of medieval villages and cities] is nearly always a later (frequently Renaissance) abuse of the original scheme caused by the expense of removing and rebuilding fortifications” - Patrick Abercrombie*²⁹

Medieval cities lay the foundations of subsequent urban growth in Europe, and provided a stable foundation which withstood the ravages of catastrophic plagues and wars. While these plagues and wars devastated the populations of much of Europe, the long term trend beginning in the early Middle Ages was nevertheless urbanization and population growth. Cities grew more populated, and also denser. On the European continent, expansion of many city areas became more difficult, as perimeter defenses grew increasingly entrenched, costly, and labor intensive, restricting outward growth of the city.³⁰ Therefore as populations grew, urban density tended to increase, and buildings started to grow upwards. Many of the open spaces of the medieval fabric began to be filled in with small buildings, additions, sheds and so on. As retired architect and researcher Rudolph Hartog writes, after the medieval ages “former two storey houses were re-built with the addition of a third story” and “the need to accommodate even more of the urban population did not lead to an extension of the towns, but to the filling of free spaces within them and the loss of the vineyards and gardens that were part of the medieval urban pattern”.³¹

Thus, the general trend in western towns and cities from around the end of the medieval period to the peak of the industrial revolution seems to be increasing population density and constriction.³² New city creation and expansion was common in the middle ages, and population growth during the medieval ages was kept in check by the plagues and war. However as plagues subsided, and as populations consolidated in many of the existing urban centres, urban populations continued growing in constricted fortified cities. In general, this intensification took the

form of incremental additions, by building on existing open spaces and adding additional stories.

Much of the urban fabric of Paris, for example, grew incrementally upon the medieval fabric until the 19th century. Medieval rowhouses were extended back into rear yards, and along side streets (see, eg. FIG. 2.15). Buildings were increased in height, by converting attic spaces into living spaces, extending the height of roofs to several stories, or simply adding additional stories. By the 18th century, Paris was a city of primarily four storey buildings³³ and by the 19th century it was a city of six and seven storeys.³⁴ Addition and conversion of roof spaces led to the development and widespread use of the mansard roof in Parisian buildings. As medieval row houses were renovated or replaced with taller buildings in the 16th, 17th, and 18th centuries, they were separated into informal dwelling quarters for a greater number of inhabitants. These dwellings were somewhere in between the extended medieval household, and the formal apartment dwellings, conceived of as distinct, vertically superimposed, horizontally separated units that would gain prominence in Paris and other major European capitals the 19th century:

[during the mid 18th century] when Paris was still a four-story city, the densest districts in the center did contain six- and seven-storey constructions with certain similarities to apartment buildings. But examination of how these constructions were actually used reveals that they were shared houses rather than true apartment buildings. Seventeenth century examples show that the floors above the ground floor had a rather ill-defined layout of large and small rooms. The rooms in a building were not strictly defined in functional terms. Staircase landings opened directly into a large number of interconnected rooms... This way of dividing up a constructed volume linked tenants and owners closely, for they basically lived together - from one floor to the next, and indeed even from one room to the next - without having, strictly speaking, and apartment of their own. Things changed completely when the rental property was created, for it was made up of identical superimposed units defining on each floor the main volumes of a traditional residence: a kitchen, a salon, bedrooms and dressing rooms. Moreover,

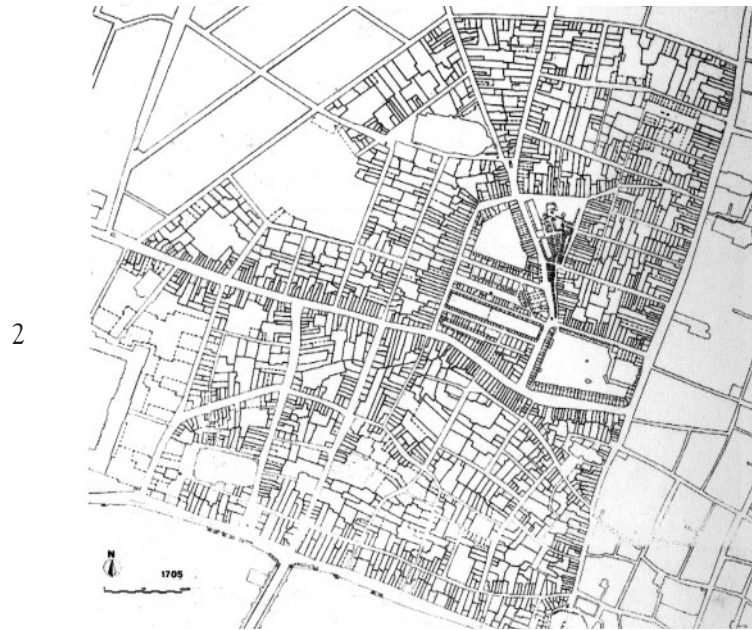


FIG. 2.15 LOT PATTERNS IN LES HALLES, PARIS
 1 - Late 14th Century 2- Early 18th Century

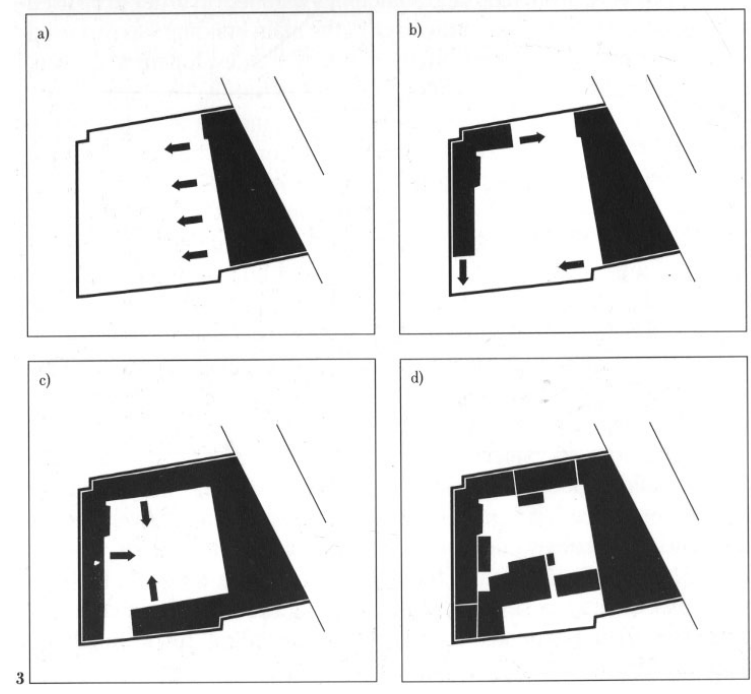


FIG. 2.16 TYPICAL PATTERN OF LOT FILLING IN PARIS

*in rental buildings the rooms in each residence were laid out around an entry hall separated from the staircase and the landings.*³⁵

As in the 4th century BC in Rome, where a large increase in urban population and density began the transition from courtyard dwellings (domus) to apartments (insulae) for all but the very wealthy, population growth in 17th and 18th century Paris led to the development of the apartment building, culminating in the 19th century immeubles. In short:

*In Paris the 18th century was a period of transition to apartment house living, when larger houses were let as single floor, self contained apartments, serving every class of inhabitants.*³⁶

While many continental cities grew upwards, leading to dwellings that were first informally horizontally separated, then later formally separated into discrete single storey apartment units, English cities were not as constrained.³⁷ Due in part to its natural fortification as an island nation, England remained somewhat of an exception to the widespread need for costly city defenses. This meant that London and many other English cities were more easily able to expand in area as population grew. In turn, this meant that cities such as London were long able to maintain the pattern of the more individual rowhouse facing onto the street and a rear yard. The Georgian era saw a formalization and standardization of this general type in the development of the terrace house. Architectural historian John Summerson describes the basic organization of the terrace house:

The typical site of a London house is therefore a long strip of ground running back from the street. The house covers the front part of the strip; the middle part is garden or courtyard; and at the back is, in the larger type of house, a coach house and stabled served from a subsidiary road.

Georgian London was a city made up almost entirely of these long narrow plots with their tall narrow houses and long narrow gardens or courts. Practically the whole population lived in one version or another

*of such houses.*³⁸

Summerson contrasted the terrace house, vertically arranged between party walls, with the developments on the European continent:

*The insistent verticality of the London house is idiomatic. The French learnt at an early date to live horizontally and most, if not all, Continental capitals followed the French lead. In London, only bachelor lawyers lived in 'chambers', and the blocks of apartments of high social standing was unknown until Henry Ashton Built the flats in Victoria street in the 1850s.*³⁹

Very generally then, we have two different streams of development in early modern European cities: the gradual modification of the medieval rowhouse into taller buildings, horizontally separated, eventually leading to the development of apartment buildings on much of the European continent (Paris is used a leading example), and the adaptation of the vertically separated medieval row house, seen in the cities of England and also, for example, in Amsterdam.⁴⁰ The former is a radical alteration of the relationship between the dwelling and outdoors, while the latter retains - to some degree - the relation of the medieval rowhouse.

However, even where this spatial relation was retained, there were important changes from the medieval character. First, in contrast to the medieval rowhouse, the Georgian terrace house was typically conceived more or less exclusively as a residence. Workshops and stores were typically not part of floor plans. Functions were more clearly defined by room and by floor, and could more often be accessed separately by corridors. Also, city areas often became more functionally separated into residential, commercial and industrial quarters.⁴¹

Secondly, following the trend of building over now tighter, smaller open spaces, rear yards of the houses were not often used as open spaces or gardens, but were taken up by stables, privies, storage space, or refuse. Lack of formalized garbage collection meant that rear yards often accumulated waste.^{42 43}

Perhaps the most outstanding example of Georgian city building



FIG. 2.17 QUAI DE LA MEGISSERIE, PARIS
Upward extension and growth of the rowhouse in Paris.

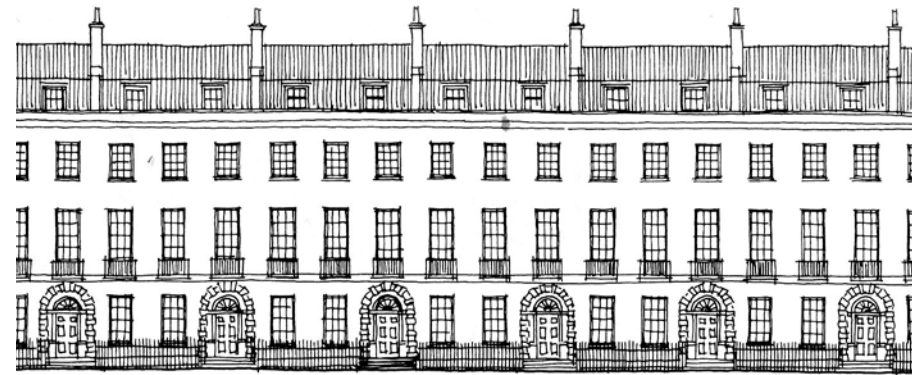


FIG. 2.20 BEDFORD SQUARE, LONDON
Eighteenth century London terrace houses.

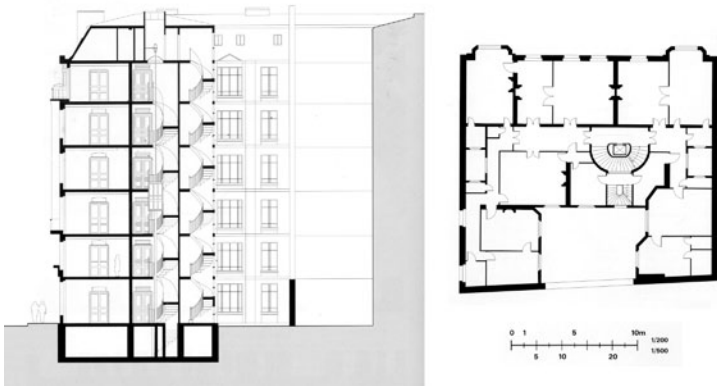


FIG. 2.18 19TH CENTURY PARISIAN APARTMENT

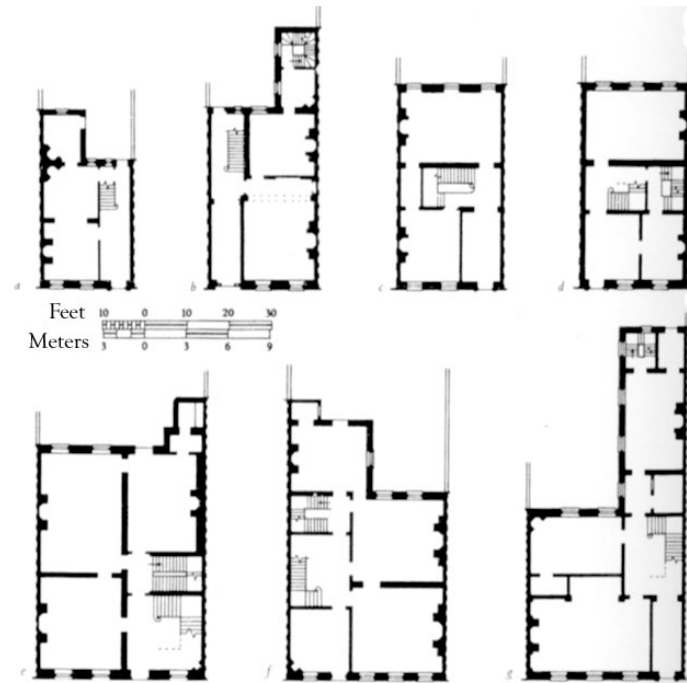


FIG. 2.21 GROVESNOR ESTATE HOMES, LONDON

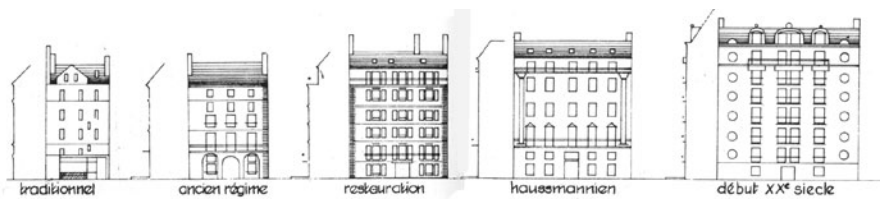


FIG. 2.19 EVOLUTION OF PARISIAN DWELLING



is the city of Bath. In the 17th century it became a fashionable, genteel city. The city as a whole is an example of a comfortable synthesis of urbanity and natural landscapes. The city's residential fabric is composed of relatively narrow, two to four storey terrace houses, often arranged around squares, crescents, and circuses which provide public and semi-public spaces of verdure. As at the royal crescent, many of the buildings are sited with respect to the topography, going to great lengths to create a visual connection to the nearby countryside. One need not walk far from the city before one finds oneself in grassy hills, forests, and isolated follies scattered in the open landscape surrounding the city.

Today, while the city retains a very real sense of connection to the surrounding countryside, encouraging elements of it to enter into the city in the treed circuses, grassy crescents, and rear gardens, it is hardly suburban. The basic dwelling unit of Bath is essentially that of Georgian London: the terrace house. The city is easy to navigate by foot, and is well connected to nearby cities by train. It has a university, many museums, shops, pubs, etc. While the Georgian row house was generally not designed as a mixed use building, its inherent flexibility has allowed many residential quarters of Bath to develop as mixed districts with ground floor shops and services. The form of the dwellings themselves admit of a higher urban density than North American suburbs (FIG. 2.22). Moreover, the dwellings can be easily re-configured to suit a number of household types as household demographics change.

Some other European cities, such as Amsterdam, also continued to grow along the lines of the rowhouse. Areas of Amsterdam, such as the Jordaan, developed in the 17th century around newly created canals, employed the basic rowhouse type - a perimeter block of rowhouses around rear yards, facing a public street:

buildings were based on lots that averaged twenty-six feet in width... There was a minimum distance of 160 feet between the backs of buildings: and the garden space for each lot was therefore around 26 by 80 feet: a generous space for both lovers of gardens and those who sought outdoor repose. This plan brought the delights of the suburbs, its open space, its gardens, its trees, within the closer compass of the city.⁴⁴

FIG. 2.22 THE ROYAL CRESCENT, BATH (OPPOSITE)

The front facade of the crescent in monumental, uniform, and palatial, while the rear facades show much individuality and alteration by the inhabitants. The public front opens immediately onto shared public spaces, while the rear opens onto narrow private yards.

FIG. 2.23 THE CIRCUS, BATH.

Measuring the built density of the terrace houses in this central location of Bath shows an approximate gross FAR of 1 - a modest urban density that allows for a series of public and private open space. While not an exceptionally high urban density, this is much higher than typical post-war suburbs, and newer, denser suburbs of attached houses (see FIG. 2.33 - FIG. 2.40) and in line with the density of some 'high density urban areas' in cities such as Boston (FIG. 4.2).



The rowhouse was also a prominent dwelling type in the new cities of the United States. It was adopted in the first permanent European settlements in the United States, and by the early 19th century “had become the basic form of residential building in New York, Boston, Philadelphia, Baltimore, Providence, and other large communities on the eastern seaboard”.⁴⁵

In many cases, however, as density increased, the rear yards of 16th, 17th, and 18th century rowhouses became built over, and often filled with refuse. In many cases, rear yards in urban areas were relatively small, used for outhouses and not for leisure, recreation, gardening, or any such activity.⁴⁶

Thus in the centuries following the initial re-urbanization of Europe in the middle ages, and during the colonization of the new world, much of the character of the medieval city gradually changed. In many new dwellings the house became a more domestic building, with commercial and industrial functions pushed out. There was also increased pressure on open spaces, and many constricted cities on the European continent had to grow upwards, leading to the vertical extension of older rowhouses, and the eventual development of the apartment building. Less constricted cities grew by adapting and reinterpreting the rowhouse type, though here too, outdoor space was often restricted. However in many cases, the density and congestion of western cities would not truly peak until the industrial revolution and the 19th century, as concentration of industry in cities brought large numbers of people from the countryside to work in factories.

NINETEENTH CENTURY AND INDUSTRIAL CITIES

“The rapid growth of towns and cities during the eighteenth and nineteenth centuries, due to the organization and concentration of industries, took place without any proper regard being shown for health, convenience or beauty in the arrangement of the town, without any effort to give that combination of building with open space which is necessary to secure adequate light and fresh air for health, adequate un-built-on ground for convenience, or adequate parks and gardens for the beauty of the city” - Raymond Unwin⁴⁷

It is well understood that, leading up to and during the industrial revolution, Western cities generally became highly crowded, that dwelling standards saw an overall decline, and that sanitation and access to light and air all suffered as a result. Norbert Schoenauer writes that “towards the end of the 19th century the living standards of the great majority of urban dwellers reached the lowest point in the history of occidental development to that date.”⁴⁸ Intellectuals and writers such as Engels and Dickens famously wrote about the cramped and squalid living conditions of the working class, a class which formed the majority of urban populations. Mumford was no less disgusted by the industrial city:

it is plain that never before in recorded history had such vast masses of people lived in such a savagely deteriorated environment, ugly in form, debased in content... never before has human blight so universally been accepted as normal: normal and inevitable.⁴⁹

Access to light and fresh air was generally diminished for many urban dwellers, as open spaces were built over, buildings were increasingly closely spaced, and many existing upper and middle class residences were divided into smaller units, many lacking even windows to the outdoors. Sanitation and hygiene, access to running water, waste disposal, fresh air,

and light were highly limited. The period saw a proliferation of notorious dwellings such as cramped back to backs and larger tenement blocks containing many dwellings with little access to natural light and fresh air (eg. FIG. 2.23 - FIG. 2.26). In many cases, sanitary conditions were bad enough to cause cholera outbreaks that prompted reformers, health and building officials, and even the general population to demand and enact building regulations that would attempt to curtail problems of urban development and congestion.

Nevertheless, the nineteenth century did see the rise of more civilized urban arrangements, such as the formal development and refinement of the apartment building in Paris, which in most cases provided a sanitary and spacious contrast to the many tenements. The basic Paris apartment building type is well known: it was a mixed use building with retail spaces on the ground floor and with self contained single level residences above - accessed by a central staircase - all facing onto the street on one side and a slender courtyard (little more than a light shaft) on the other. The typical apartment unit had a double aspect configuration, receiving light from both the street and the slender courtyard. This model was extremely influential, shaping the development of apartment buildings in the 19th century United States and throughout the West.⁵⁰ The rise in the apartment in Paris was complemented by similar developments elsewhere.

The apartment alters the relation of the dwelling to outdoor space in a formal way: outdoor space is no longer a part of the individual dwelling, or even adjacent to it. Thus access to good quality, varied public outdoor space becomes more important with apartment living. While the apartment offered comfortable living conditions for some, the general squalor, and the cramped and unhealthy conditions of many, together with the general deterioration of quality of urban life in nineteenth century cities - along with technological, geographic, economic and often racial factors - contributed to a fundamental shift in the opposite direction in North America in particular. Many fled cities for the open countryside in the what was the beginning of sustained suburban growth.

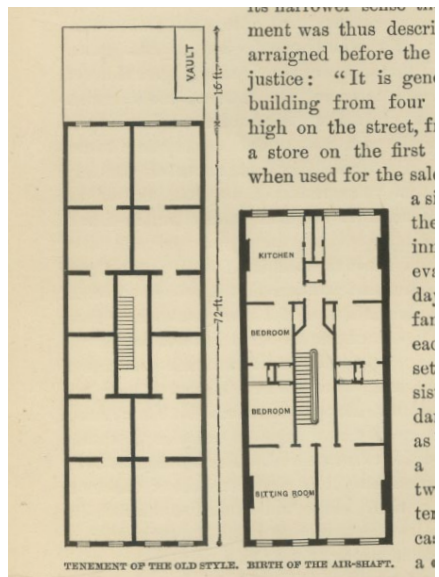


FIG. 2.24 TENEMENT APTS, NEW YORK CITY

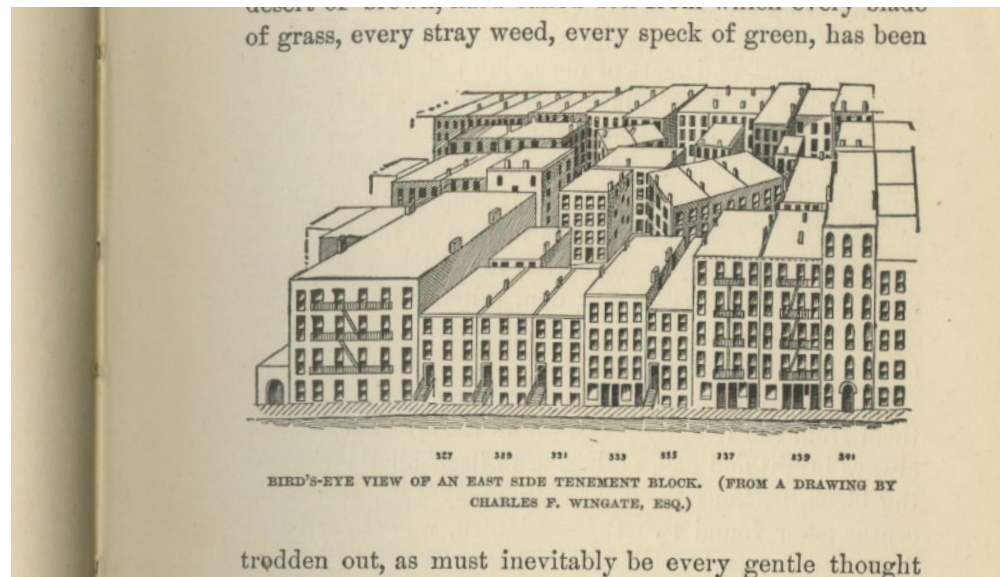


FIG. 2.25 TENEMENT BLOCKS, NEW YORK CITY

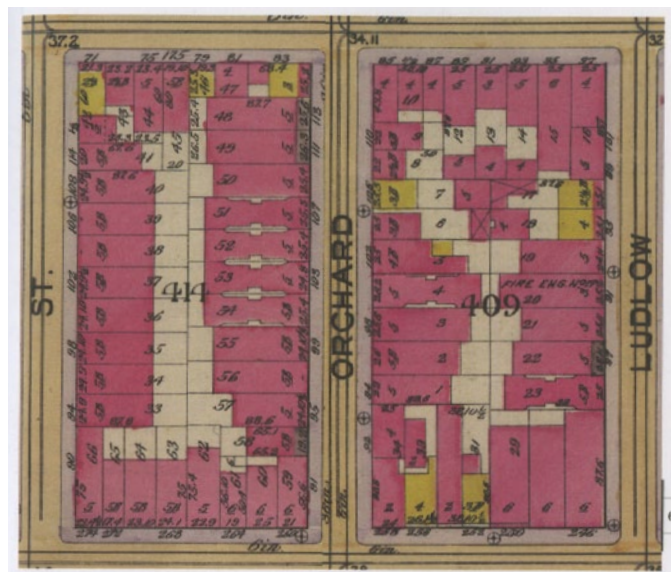


FIG. 2.26 TENEMENT BLOCKS, NEW YORK CITY



FIG. 2.27 TENEMENT BLOCK COURTYARD

SUBURBAN GROWTH

While many cities in the industrializing west became severely crowded and congested in the 19th century, the era also marked the beginnings of a sustained pattern of upper and middle class suburban growth – most notably in the United States. Urban historian Kenneth T. Jackson writes:

Between 1815 and 1875, America's largest cities underwent a dramatic spatial change. The introduction of the steam ferry, the omnibus, the commuter railroad, the horsecar, the elevated railroad, and the cable car gave additional impetus that would turn cities 'inside out' and inaugurate a pattern of suburban affluence and urban despair... Indeed the phenomenon was one of the most important in the history of society, for it represented the most fundamental realignment of urban structure in the 4,500-year past of cities on this planet.⁵¹

Jackson gives a detailed account of how this first wave of suburbanization led to the establishment of large and prominent upper-class suburbs in most American cities. This shift helped to raise the social status of suburban living. As new transit modes appeared, increasing the area of transit coverage, decreasing transportation costs, and providing a higher quality of service, larger tracts of land outside of major cities became available and affordable for wider segments of the population.⁵² As the term 'streetcar suburb' implies, the invention and mass implementation of electric streetcars were crucial in the development of early suburbs. While the first wave of suburbanization, largely reliant on steam powered rail, was predominantly upper and upper-middle-class, the streetcar helped open suburban living to a wider portion of the middle class. Indeed, prior to the wide scale adoption of the automobile, the United States had by far the largest network of electric streetcars in the world. This, together with massive urban population growth, the cramped conditions of industrial cities, increasing racial tensions in cities as African Americans migrated from the south to inner cities, and a number of the

key economic factors listed below, fundamentally changed the nature of upper and middle class dwelling in the United States.⁵³ Some key economic factors mentioned by Jackson are:

- *Focus of US streetcar companies on large volume of ridership with inexpensive fares versus the European focus on higher fares with lower volumes*
- *Large supply and relative low cost of land*
- *Relatively high per capita wealth of US population compared to all other industrial nations*
- *The low cost and ease of construction of the platform frame house*
- *Private property ownership and little regulation on land use*
- *Public policy⁵⁴*

All of these factors meant that “for the first time in the history of the world, middle class families in the late 19th century could reasonably expect to buy a detached home on an accessible lot in a safe and sanitary environment.”⁵⁵

These early streetcar suburbs retain a character that is quite different from the automobile oriented post WWII suburbs. While they have a sense of open space and verdure, their greater proximity to the city center, their relative higher densities, narrower lots, the forward placement of homes on their lots, and their development along somewhat more pedestrian lines lends them some degree of urbanity that is absent in most post-war suburbs.⁵⁶ Lots in pre-war suburbs, often around 50' wide, while much wider than the typical 20' to 25' wide lots of urban rowhouses, are narrower than many of the post WWII lots with typical widths starting at 70' and going up.⁵⁷ The 1926 Sears Roebuck Catalog of homes advertises houses that can generally be built on lots less than 45' wide, with a wide selection of houses that can be built on lots less than 30' wide.⁵⁸ Therefore these houses were generally closer together, and population densities were generally higher than in post-war suburbs, which in turn meant that amenities such as neighbourhood shops and facilities were not as widely spread out, and were more accessible by foot.⁵⁹

The author's own experience of neighbourhoods developed along

streetcar lines is that, while they have often retained a somewhat suburban character, they nevertheless often link to interesting main streets or commercial centers which have a sort of urban quality, a variety of stores and services, and good pedestrian access. Along with single detached dwellings, they often contain a mix of older semi-detached dwellings, rowhouses and even some walk-up apartment buildings, as well as newer apartment buildings. Toronto has its share of neighbourhoods developed along these lines. Ottawa also has such neighbourhoods, such as the Glebe and many areas of Wellington West. These neighbourhoods combine relative proximity to the central city, shops, restaurants, cultural venues, etc., with significant private and public open spaces, trees, small yards and gardens, and individual homes offering both privacy and nearby community facilities, as well as inherent flexibility in the form of potential renovation or alteration by the users. In short, they offer a wide range of amenities.

Due in part to this high range of amenity, dwellings in many of these neighbourhoods often command exceptionally high real estate values today. We see the pattern in areas of Ottawa such as the Glebe and many areas along Wellington west and Richmond road in Ottawa, and the pattern is seen in Toronto, where many older suburbs, close to, but not in the very centre of the city, often adjacent to major main streets such as Yonge, Bloor, the Danforth, and Queen, have very high real estate values, in practice affordable only to the upper and upper-middle classes.⁶⁰

In Ottawa, there appears to be some close relation between current income levels and areas served by early public transit, especially the streetcar. Prewar streetcar suburbs command a price premium and tend to be upper-middle class (see FIG. 2.41). In part, this is likely a legacy of the fact that these neighbourhoods were developed for the upper and upper-middle classes. However, it also represents the basic fact that these areas are highly attractive due to the high level of amenities they provide, as in a competitive market economy highly desirable goods will command high prices which are more affordable to the upper classes. This points to a significant demand - from larger households as well as couples and singles - for good quality urban dwellings

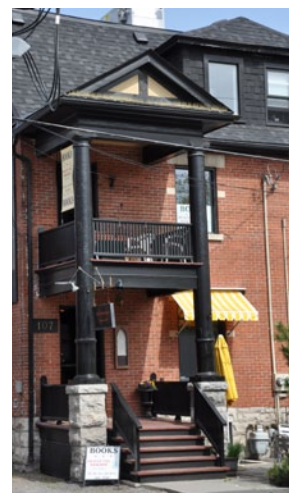
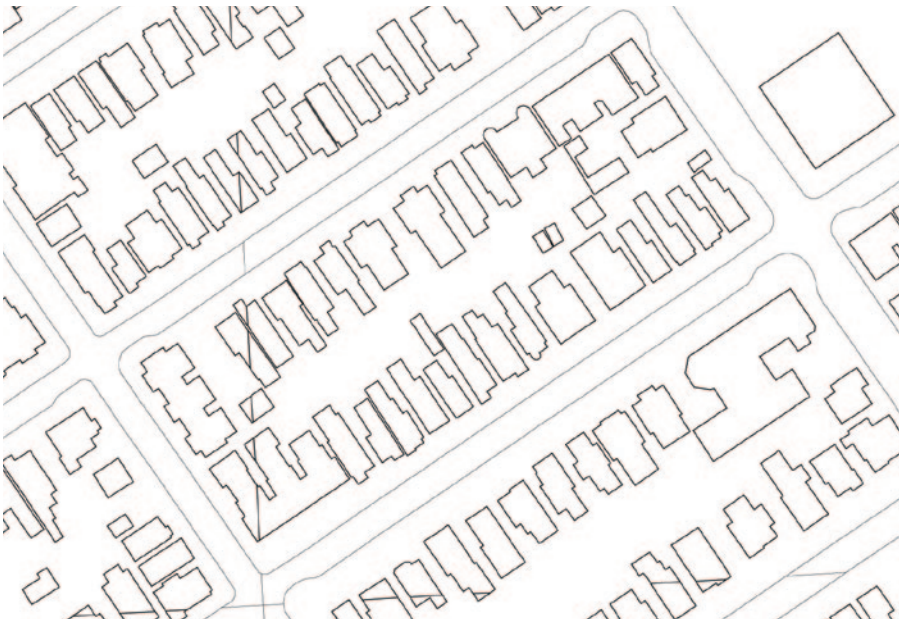


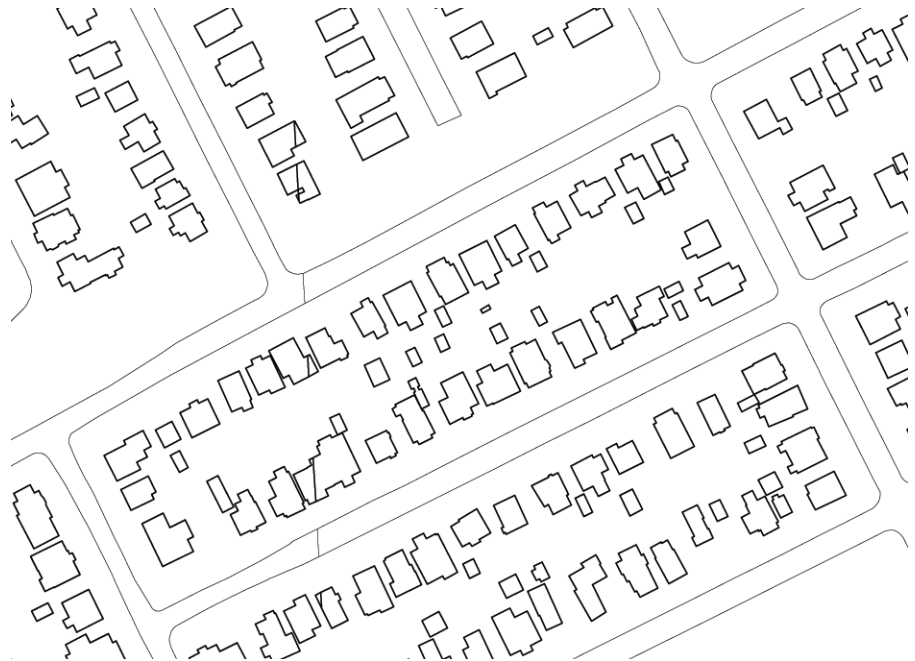
FIG. 2.27 - FIG. 2.32 THE GLEBE
Clockwise from top left: Bank St., single detached houses, row houses, walk-up apartments, house converted to bookstore, Bank St. storefronts.



FIGS. 2.33-34
CENTRETOWN - James St and Kent St.
 Pre-War Residential Neighbourhood/Suburb - Primarily homes built prior to 1946 ⁶¹
 Approx net FAR of block: 0.85 - 0.9
 Approx gross FAR or block: 0.7 - 0.75



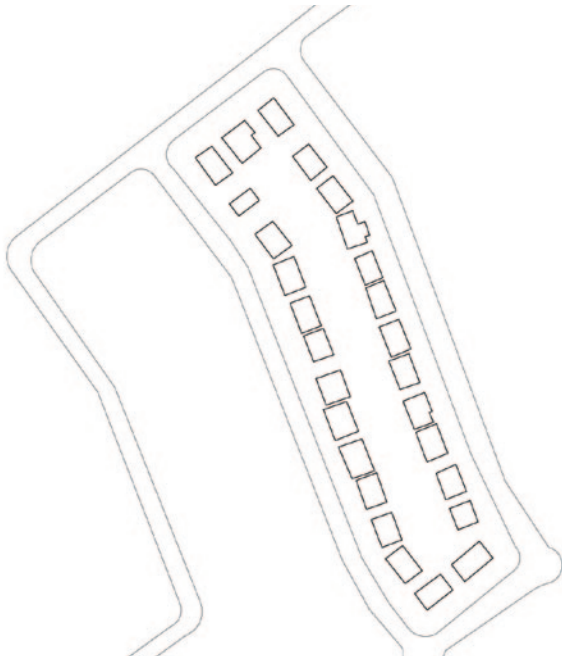
FIGS. 2.35-36
WESTBORO - Byron Ave and Clarendon Ave
 Early-mid 20th Century Suburb - Primarily homes built from pre-1946 - 1960
 Approx net FAR or block: 0.45
 Approx gross FAR or block: 0.35





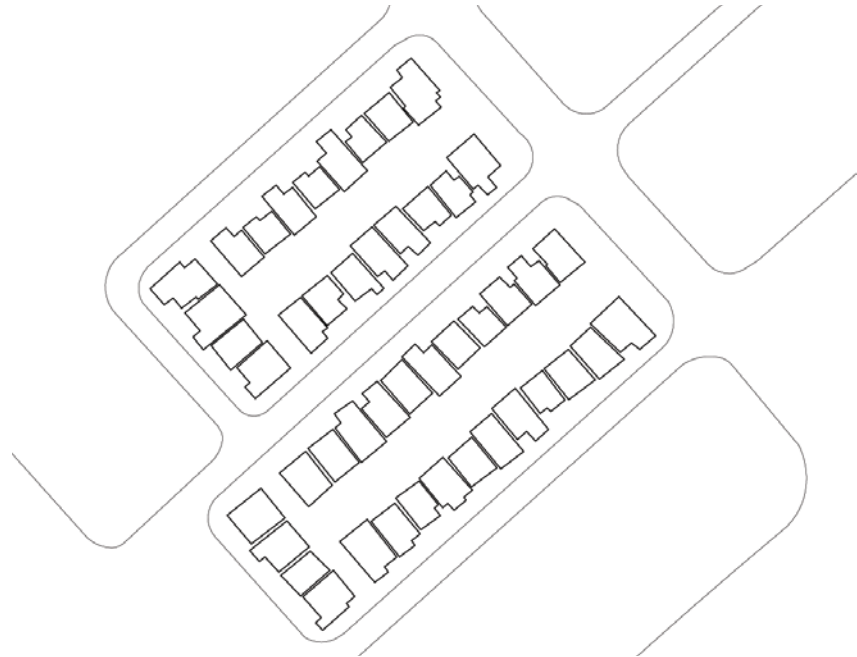
FIGS. 2.37-38

OTTAWA WEST - Lambeth Walk and Gateway Rd
 Postwar Suburb - Primarily homes built from 1946 - 1970
 Approx net FAR of block: 0.25
 Approx gross FAR or block: 0.2



FIGS. 2.39-40

KANATA FAIRWINDS - Hunter Dr. and Sonesta
 New Suburb - Mid 2000s with ongoing development
 Approx net FAR of block: 0.65
 Approx gross FAR or block: 0.5



offering a high amount of amenities such as easily accessible commercial areas and outdoor spaces.

While late 19th and early 20th century suburbs of many Canadian and American cities have often retained a more pedestrian scale and a proximity to varied programs, the subsequent growth of the post-WWII automobile suburb developed along very different lines, on a vastly larger scale, and at even lower levels of population density. Lot sizes grew wider, non-domestic facilities, such as centers of employment, industry, commerce, or civic activity, grew farther apart, and became more automobile oriented. While the streetcar brought peripheral urban lands surrounding their routes into the middle class housing market, the widespread and incredibly rapid adoption of the automobile in the United States, along with sizeable government subsidies in the form of road construction, opened up land in between and beyond suburban railroad and streetcar routes. As road building and automobile use flourished in the United States, streetcar networks - which by contrast received no subsidies - floundered. Transit networks in Europe quickly overcame the large American lead in the development of modern public transit, surpassing US systems by as early as 1910 in terms of ridership and technological sophistication.⁶²

With continued suburban growth and annexation of surrounding areas, the geographical area of cities expanded dramatically, and as a result, the density of urban areas has fallen to historically unprecedented levels. While the range for most cities and towns prior to the 20th century seems to fall between gross urban densities of 50 and 500 people per hectare, with most cities roughly falling between 75 and 300 people per hectare, the typical North American city today appears to have a gross urban density of between 10 and 50 people per hectare. Ottawa is somewhere between 15 and 20 people per gross hectare of urban area. FIG. 2.1 at the beginning of this chapter shows this overall pattern clearly. The general pattern of the post-WWII suburbs should be familiar to most residents of Canada and the United States today. It constitutes the majority of our dwellings, and continues to be a significant aspect of growth today. The following chapter will consider the post-WWII suburb in more detail.

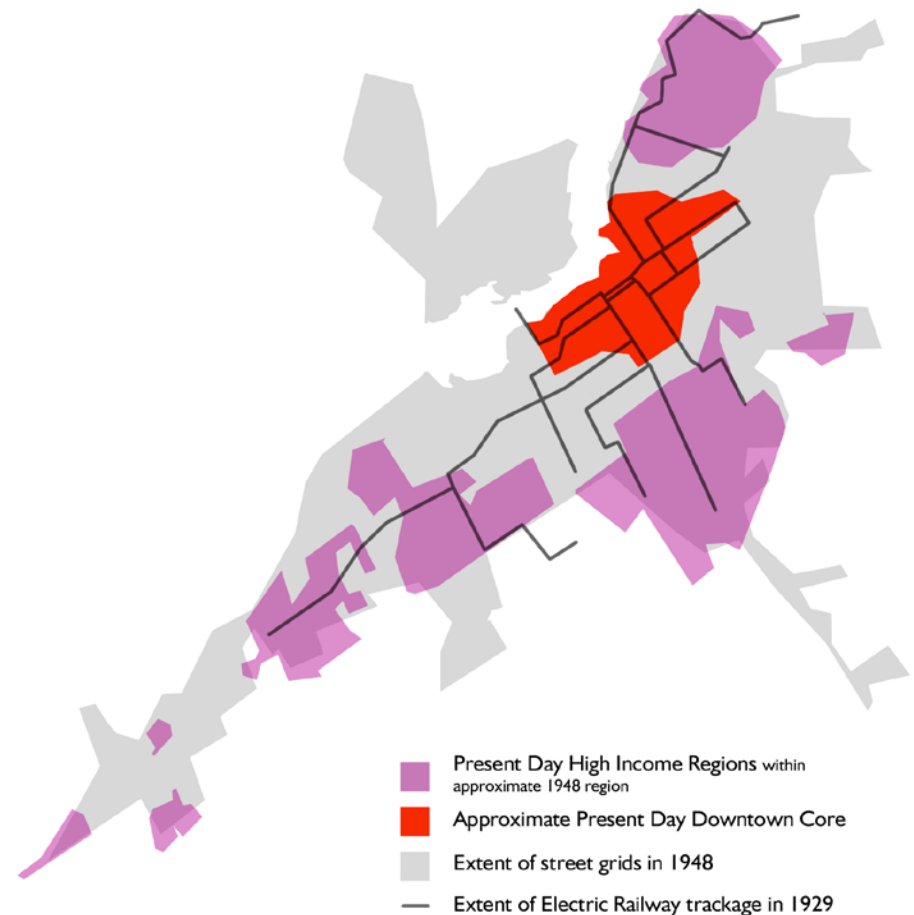


FIG. 2.42 OTTAWA STREETCAR NEIGHBOURHOODS

This map shows a number of things. It shows the extent of the streetcar system in 1929. Overlaid on top of this is the extent of the grid system of streets in 1948. This extent can reasonably be taken to fairly faithfully represent the limits of the built up residential areas of the city in 1948. This represent the extent of the city developed along streetcar lines just as the post-war automobile suburb really begins to grow. We see that most of the peripheral areas served by streetcars up to mid 20th century are relatively wealthy neighbourhoods today.



FIG. 2.43 OTTAWA - URBAN AREA IN 1948 AND TODAY

Comparison of 1948 area of street grids with present day city. The light green region is the greenbelt mandated in the 1950s. The darker region at the centre shows the extent of street grids in 1948. The light grey patchwork represents a combination of street networks and subdivided lots today. Greyer areas mean more streets and subdivided lots: essentially these are the built up areas. The growth in the area of the city between 1948 and today is fairly dramatic.

CONCLUSIONS

A number of conclusions may be drawn from the foregoing discussion. Until the advent of rail and the streetcar, the city was a relatively compact entity. Dwellings were closer together, varied city functions tended to be more closely interspersed, and walking was the primary mode of transport within the city. Population densities were typically much higher than those of contemporary cities in much of the developed world. Yet historic cities often integrated outdoor spaces within the urban fabric. Public and private outdoor spaces within the urban fabric have evidently been valued by many cultures. Cities within a comparatively moderate range of urban density have often seen a prevalence of dwelling types which integrate a component of outdoor space, particularly in two basic forms of the courtyard house and the rowhouse. In dense urban areas, popular shifts away from these types have seemed to occur primarily in cases where relatively high population growth and restrictions on outward growth brought densities to high levels.

In such cases, the relationship of the dwelling to outdoor space changed dramatically, in particular in the development of vertically stacked apartment dwellings. Looking at FIG. 2.1, it is notable that widespread development of stacked dwelling types and apartment buildings occurred in a rather exceptional way in three cities showing some of the highest historical densities prior to the end of 19th century: Rome, Paris, and Edinburgh (Edinburgh being one of the few cities in Britain to adopt apartments before the mid 19th century). In these cities dwellings shifted from courtyard dwellings or rowhouses to horizontally separated, stacked dwellings. 19th century Paris in particular adapted relatively well, and on a large scale, to the change with the development of highly influential apartment buildings - often for the growing middle classes - and spacious public open spaces. These apartment buildings added an valuable dwelling type to the design vocabulary of high density cities. They allowed for increased density in relative comfort and sanitation, even providing double aspect units receiving light and air from two sides. Moreover, they retained, to some degree, the mixed use nature of the medieval buildings, though the shops and facilities on the ground floor were now formally

separated from the dwellings.

Other dense cities, as in England or in Amsterdam, accommodated population growth with a greater degree of urban expansion and creation of new city quarters, adapting the medieval row house type to the conditions of the era. However, the nature of the dwelling was also changing in many ways. In many cases the intimate mixture of uses seen in medieval dwellings changed somewhat, beginning at least with the development of more formal dwellings in the 18th century, and with the consolidation of much industry during the industrial revolution. Industry was no longer a familiar part of the home. To some degree, the adapted rowhouses also maintained the relation of the dwelling to the yard, the garden, the urban orchard, or outdoor workspace. However as populations became increasingly dense, these spaces often ceased to function in these capacities, instead serving as building plots, stables, mews, junkyards, or cesspits. Also, new dwelling types - such as cramped back to backs of the 19th century - housing many in windowless rooms - emerged on grand scale. Today however, the spaces behind a London Terrace house, a New York rowhouse, or a rowhouse in the Jordaan have often reverted back to gardens or usable outdoor spaces which in many cases are viewed as a important amenities.⁶³

Naturally, in many cases there has been a tension between urban density and urban outdoor space. However the two do not preclude each other, and the modest urban yard predates the expansiveness and functional segmentation of the North American suburb by several millennia. The growth of the suburb in North America represents an extreme end of the spectrum of city density, spatial separation, and insularity. The residential skyscraper, on the other hand, represents the opposite extreme.

In our own age, intensification of our cities - largely suburban and low density - means a change in the character of our dwellings and of the urban fabric, but this ought not preclude provision of outdoor spaces and verdure in the intensified forms. For one, the density of contemporary North American cities is so low that widespread increase in density does not necessarily entail a drastic shift to tall apartment buildings. But also, in many ways the project of creating urban dwellings that adequately synthesize urban densities, outdoor spaces and verdure, a mix of uses,

and adequate access to light and air within a pedestrian environment is hardly radical. It is arguably the continuation and evolution of an urban tradition established in medieval urbanization, which formed the basis for many contemporary Western cities and the re-gensis of city life in Europe.

ENDNOTES - CHAPTER 2

1. Mumford, *The City in History*, p. 483
2. City of Toronto. "Population and Dwelling Counts."
3. Eg. the widespread historic existence of slavery provides no moral justification for it.
4. Hartog, *Europe's Ageing Cities*, p. 41
5. Mumford, *The City in History*; Hartog, *Europe's Ageing Cities*; Jackson, *Crabgrass Frontier*; Chandler, *4000 Years of Urban Growth*; Schoenauer, *6000 Years of Housing*; Benevolo, *The History of the City*; Gibson, "Population of the 100 Largest Cities in and Other Urban Places in the United States"; City of Berlin and Senate Department, "Population Density"; City of Ottawa, "Land Area, Population and Households by Ward"; City of Toronto, "Population and Dwelling Counts."
6. Schoenauer, *6000 Years of Housing*, p. 102
7. Depending on whether surrounding suburban regions of Ur are counted.
8. Schoenauer, *6000 Years of Housing*, p. 102; City of Ottawa, "Land Area, Population and Households by Ward"; Gibson, "Population of the 100 Largest Cities in and Other Urban Places in the United States"; City of Toronto, "Population and Dwelling Counts."
9. Schoenauer, *6000 Years of Housing*, p. 104
10. Ibid. p. 102
11. Chandler, *4000 Years of Urban Growth*, p. 7
12. Schoenauer, *6000 Years of*, p. 129; Westgate, "The Greek House and the Ideology of Citizenship" p. 231.
13. Papaioannou, "Domestic Architecture of Roman Greece".
14. Benevolo, *The History of the City*; Schoenauer, *6000 Years of Housing* p. 128
15. Chandler, *4000 Years of Urban Growth*; Benevolo, *The History of the City*, p. 176
16. Carme Belarte Franco, "Courtyard Houses and Other Complex Buildings in the Protohistory of Southern Gaul", 235-259.
17. eg.: Abdelmalek, "The Courtyard houses of Southern Algeria"; Laffah, "The Courtyard Garden in the Traditional Arab House"; Petruccioli, "The Courtyard House"; Brown and Memarian, "The Shared Characteristics of Iranian and Arab Courtyard houses".
18. Schoenauer, *6000 Years of Housing*, p. 209
19. Abdelmalek, "The Courtyard houses of Southern Algeria"; Laffah, "The Courtyard Garden in the Traditional Arab House"; Petruccioli, "The Courtyard House"; Brown and Memarian, "The Shared Characteristics of Iranian and Arab Courtyard houses".
20. Mumford, *The City in History*; Schoenauer, *6000 Years of Housing*; Benevolo, *The History of the City*.
21. Schoenauer, *6000 Years of Housing*, p. 213
22. Ibid., p. 234
23. Mumford, *The City in History*, p. 282
24. Ibid., p. 289
25. Loyer, *Paris Nineteenth Century*, p. 39; Schoenauer, *6000 Years of Housing*, p. 229; Pearson, "Medieval Housing in English Towns", p. 1
26. Chandler, *4000 Years of Urban Growth*, p. 6,7

27. Loyer, *Paris Nineteenth Century* ; Mumford, *The City in History*, p. 284
28. Hartog, *Europe's Ageing Cities*.
29. Ibid., p. 34-35
30. Hartog, *Europe's Ageing Cities*; Schoenauer, *6000 Years of Housing* p. 267; Mumford, *The City in History*.
31. Hartog, *Europe's Ageing Cities*, p. 42
32. This is corroborated by some of the data collected in FIG. 2.1 and shown again in Appendix 1.
33. With six and seven storey buildings in denser districts.
34. Loyer, *Paris Nineteenth Century*, p. 48
35. Ibid.
36. Binney, *Townhouse*, p. 68
37. Schoenauer, *6000 Years of Housing*.
38. Summerson, *Georgian London*, p. 49
39. Ibid., p. 52
40. Vermeulen, "An Architecture of Daily Life," p. 39-40; Mumford *The City in History*.
41. Mumford *The City in History*, p. 383
42. Jackson, *Crabgrass Frontier*, p. 56
43. Also, influenced by the printing revolution, styles - Palladian style in particular - became important in house design. Styles were promoted through publication of books of plans, and architectural publications such as Vitruvius Britannicus (Summerson, *Georgian London*, p. 58, 59). Houses were somewhat standardized into various grades of house, and were more regulated by building acts enacted in following of the London Fire. Where the fronts of medieval rowhouses were often idiosyncratic and varied, the facades of individual Georgian rowhouses held together in uniform palatial fronts.
44. Mumford *The City in History*, p. 443
45. Jackson, *Crabgrass Frontier*, p. 55
46. Ibid., p. 56
47. Unwin, *Nothing Gained by Overcrowding!* p.1
48. Schoenauer, *6000 Years of Housing*, p. 217
49. Mumford *The City in History*, p. 474
50. Firley and Stahl, *The Urban Housing Handbook*, p. 278; Schoenauer, *6000 Years of Housing*, p. 322,332
51. Jackson, *Crabgrass Frontier*, p. 20
52. Indeed, transit development and real estate development often went hand in hand, with operators of many transit companies focussing most of their business efforts on real estate development.
53. Jackson, *Crabgrass Frontier*.
54. Ibid., p. 290-296
55. Ibid., p. 136
56. Blais, "Smart Development for Smart Growth," p. 5
57. Fader, *Density by Design*, p. 6; Binney, *Townhouse*, p. 106; Summerson, *Georgian London*; Mumford, *The City in History*.
58. Sears, Roebuck and Co., *Small Houses of the Twenties*.

59. Mumford wrote of earlier suburbs: "As long as the railroad stop and walking distances controlled suburban growth, the suburb had a form. The very concentration of shops and parking facilities around the railroad station in the better suburbs promoted a new kind of market area, more concentrated than the linear market along an avenue." Mumford, *The City in History*, p. 506
60. See, eg., Micacchi, "Redeveloping the Avenues," p. 48
61. Sample houses listed for sale in this block and nearby streets date from 1903-1910. Hollywood parade rowhouses shown in above image [at left] date from 1892.
62. Jackson, *Crabgrass Frontier*, p. 168
63. Firley and Stahl, *The Urban Housing Handbook*, p. 127

III - CONTEMPORARY URBAN AND SUBURBAN GROWTH IN CANADA





We each had to write a report. I found two things going on in the United States and Canada: high rise apartment construction, which seemed not to work for families, and suburbia, which also seemed not to work, though it offered amenities that people generally preferred when they had a choice...I felt we had to find new forms of housing that would re-create, in a high density environment, the relationships and the amenities of the house and the village.

- Moshe Safdie ¹

This chapter broadly examines a number of key characteristics of contemporary residential growth and development in Canadian cities. It briefly discusses suburban developments as well as more central, urban developments, and presents a general comparison of some general characteristics of the two. The discussion and comparison serves as a base for a critical discussion which identifies some key challenges - outlined in the introduction of the thesis - facing contemporary residential development.

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FIG. 3.1 MONARCH GROUP HOME PAGE, 2010

CONTEMPORARY SUBURBAN GROWTH

Though suburban growth at the periphery of many Canadian cities is expected to be somewhat slower in coming years, due in part to aging populations, smaller household sizes, city planning initiatives, and changing attitudes, it is nevertheless expected to remain a large portion of urban growth.² The post-war suburban neighbourhood continues to be seen as one of, if not the primary way to accommodate many new families and households.

As discussed in chapter two, the nature of the suburb evolves with time. Many more recent suburban neighbourhoods have developed at higher densities than those of the post war decades,³ with narrower lot sizes, the shift away from housing types such as the bungalows and ranch houses of the 1960s and 1970s, and a good number of taller, attached dwellings such as rowhouses. Mattamy homes, for instance, now advertises 30' to 40' wide lots as 'widelots' - lots which are actually quite narrow in comparison to those of many post-war suburbs from mid-century. FIG. 2.33 - FIG. 2.40 in chapter two show examples of suburban neighbourhoods in Ottawa that illustrate some of these changes in suburban density over the course of the century.

Despite some changes towards higher density, suburban growth generally remains low-density and spread out compared to historic urban developments. While some development is moving towards narrower lots, the average lot size for new single detached Canadian houses in 2010 was generous at 50' by 115'.⁴ Future greenfield suburban developments around the periphery of Ottawa, like those in the Fernbank and Barhaven South community plans, are planned at gross densities of roughly 40 persons per hectare - higher than most post-war suburbs, but much lower than urban historic norms and many contemporary urban areas.⁵ Moreover, it is evident from the design of such contemporary suburban communities that the predominant mode of transportation remains the automobile, that mixed use development is rather limited, and that access to most non-residential programs favours an automobile commute.

Even many of the relatively suburban communities built along new urbanist lines - which strive to attain a somewhat greater degree

of density, mixed uses, urbanity, and pedestrian-friendliness - have had some difficulties achieving these goals. Automobiles often remain dominant, inhabitants must generally commute significant distances to work by car, and neighbourhood businesses struggle to compete with large suburban malls, commercial strip malls, and power centers. The new urbanist community of Cornell in Markham, for example, has struggled to live up to its goals:

More than 10 years ago, a charismatic Cuban American architect embarked on a bold plan to transform a plot of Ontario farmland into a bustling urban utopia, a place where dwellers would swap cars for walking shoes and enjoy a sense of urbanity in what would have otherwise been just another suburb. Or so that was Andres Duany's plan.

Instead, cars today zip up and down the narrow avenues and not a pedestrian, charming coffee shop, nor restaurant is in sight. It is a Tuesday afternoon, and two beauty salons are inexplicably closed for the day, a real estate office is locked with snow piled high outside its door, not a single child is playing in Mews Park, and the convenience store sees only a trickling of residents. Here and there a York Regional Transit bus rolls along, but public transportation to, from and within Cornell is far from comprehensive.⁶

While the suburban fabric evolves over time, and in some cases seems to be moving towards a more compact form, arguably much of the essential nature of the post-war suburb remains in contemporary suburbs.

Discussions and analyses of the post-war suburban fabric are voluminous, and it would be beyond the scope of a design thesis to treat the subject in full depth. As with so many broad, complex social issues, a full treatment would require analysis with regards to diverse sociological, economic, political, environmental factors. In the following section the thesis will summarize a number of frequently identified, interrelated characteristics of suburban developments, which are contrasted with some characteristics of contemporary urban developments in more central areas of Canadian cities. First, contemporary infill development is briefly introduced.

CONTEMPORARY URBAN AND INFILL RESIDENTIAL DEVELOPMENT

The fabric of central city areas of Canadian and North American cities is diverse; this fabric incorporates older suburbs and single detached homes, high rise condominium developments, social housing, financial districts, shopping districts, and so on. Despite the great diversity, there are some commonalities in many contemporary urban residential developments. One is the markets and demographics they tend to be oriented to. Downtown cores of Ottawa and Toronto, while heavily populated, tend to be populated by a younger demographic, and by smaller households.⁷ The majority of new residential construction within established areas of cities such as Toronto and Ottawa generally takes the form of condominiums, with a general emphasis on larger buildings over 8-10 storeys high.⁸ These condominium units are generally developed with a few particular markets in mind: younger singles (often professionals), young couples seeking a first home, empty nesters, seniors, and recently, a large market of investors and speculators.^{9,10} Households such as middle aged couples, families with children, or simply people who desire a more immediate and tangible connection to outdoor spaces, are often not part of the condo development equation. Suburban developments continue to be seen as the primary solution to housing demand from these households. Consequently, much of the development within urban areas does not accommodate a large portion of the population. As a result, such households seeking urban dwellings must choose from a limited supply of new urban dwellings developed with them in mind, or a likewise limited supply of existing homes within urban areas, or dwellings in suburban areas which tend to cater explicitly to middle class families, middle aged couples, and other households not accommodated in urban areas. Existing houses within urban areas grow smaller in supply as portions of them get replaced by denser urban developments, and the market for these houses in Canadian cities is fiercely competitive, as the high prices of

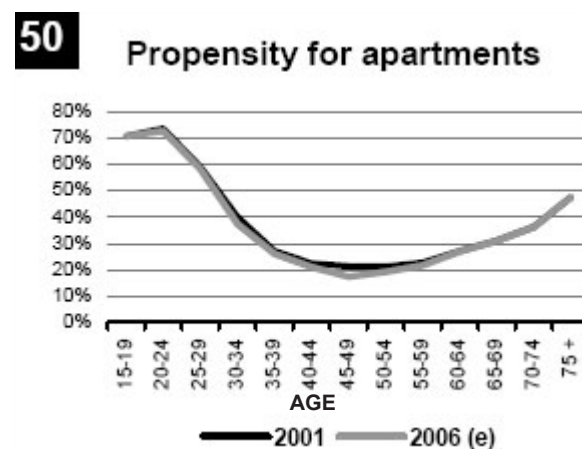


FIG. 3.2 ESTIMATED PROPENSITY FOR APARTMENT DWELLING BY AGE GROUP, OTTAWA

many older homes in established urban neighbourhoods attests.

The characteristics of typical contemporary urban developments are summarized and contrasted with a number of characteristics of suburban developments in the following section.

CONTEMPORARY RESIDENTIAL DEVELOPMENT

Density

Suburbs

- Low density relative to historic cities, to most contemporary world cities, and to central areas of North American cities
- Wide spacing of dwellings and other buildings
- Average gross urban population density of outer suburbs of Ottawa is 17 people per hectare ¹¹

Central Areas

- Overall higher density with greater range of densities
- Frequent mix of lower density forms of dwelling with higher density forms
- Downtown core of Ottawa at gross urban density of 65 people per hectare. Higher than suburban periphery but still relatively low by historic or global standards ¹²

Transportation

Suburbs

- Automobile primary means of transport
- Limited feasibility of extensive public transit, pedestrian travel
- Large areas devoted to roads, surface parking. Eg: Street and road rights of way occupy 21% of total urban land area in urban area of Ottawa, with wider roads in suburbs accounting for 23% of all developed suburban land. Roads use 25% of land in many planned future suburbs of Ottawa ¹³

Central Areas

- Better transit service, greater feasibility for improved transit
- Automobile congestion
- More amenable to pedestrian travel

Land and Construction Costs

Suburbs

- Relative low cost of peripheral lands a major factor in growth of middle class suburbs in North America from late 19th century on ¹⁴
- Low cost of rural land a critical point in Ebenezer Howard's conception of the Garden city ¹⁵
- Lower building costs (lower, simpler buildings, surface parking vs. structured parking, etc.). Mass built platform frame suburban housing can be built at construction costs as low as \$75/sq.ft ¹⁶
- Relative low costs of suburban development a significant factor driving both residential and commercial suburban growth
- Land costs remain low where there are no physical or regulatory barriers to outward growth ¹⁷
- New Suburban homes often advertised at prices of \$175 - \$250 /sq.ft

Central Areas

- Significantly higher land costs
- Significantly higher construction costs for many standard multi-unit dwelling types: typical construction costs of high rise apartment buildings in Ottawa range from \$110/sq.ft to \$152/sq.ft ¹⁸
- Requirements for non-combustible construction, fire safety, egress, elevators, etc. in denser urban dwelling types contributes to higher costs
- Condominium units in more central areas of Ottawa and Toronto easily sell for over \$400/sq.ft
- Possibility of lower construction costs for mid-rise development with any potential future approval of mid-rise wood frame code changes (eg. as in BC)

FIG. 3.3 URBAN DENSITY IN OTTAWA BY CITY WARD

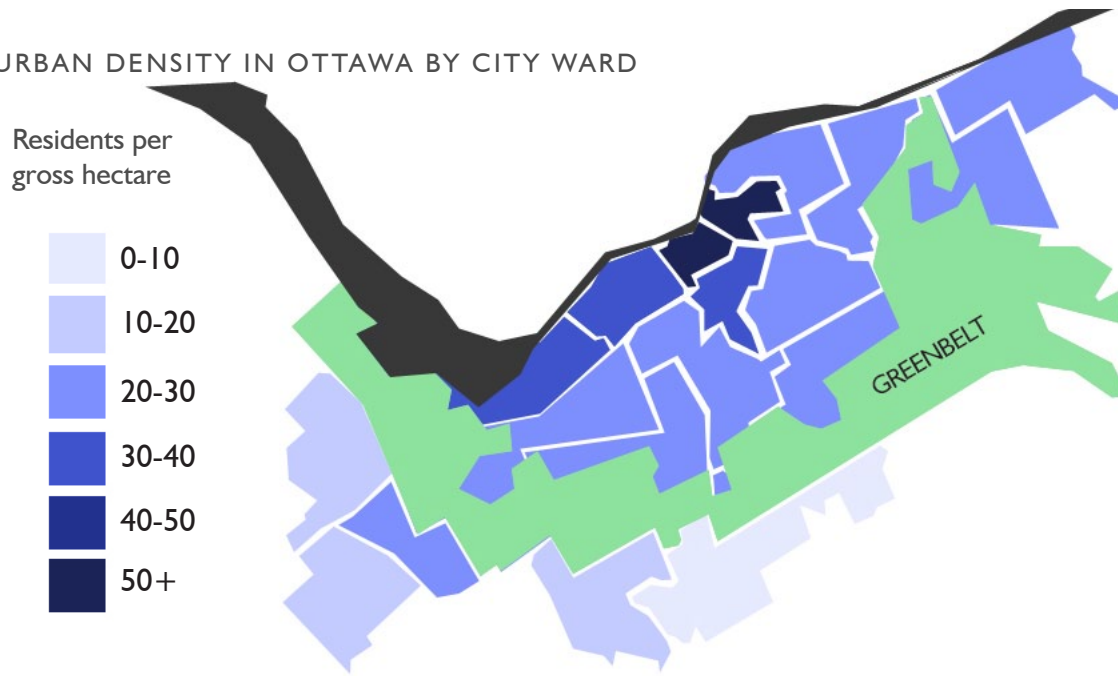


FIG. 3.4 SAMPLE COST COMPARISON

	COMMUNITY/BUILDING	SAMPLE UNIT	ADVERTISED SALES PRICE/ SQUARE FOOT FLOOR AREA
NEW SUBURBAN HOMES	Half Moon Bay, Kanata	Townhouses	\$183.00
		Detached houses	\$185.00
	Cornell, Markham	Attached 4 bed	\$208.00
		Detached 4 bed	\$224.00
		Detached 3 bed	\$248.00
	NEW URBAN CONDOMINIUM UNITS	111 Richmond, Ottawa	1 bed
2.5 bed 2 bath			\$405.00
Westboro Station, Ottawa		2 bed	\$479.00
		2 bed with terrace	\$469.00
Six 50 King St., Toronto		1 bed	\$456.00
		2 bed + den	\$456.00

Integration of mixed use

Suburban Areas

- Little retail, services, offices, employment, industry etc. integrated with residential fabric
- Zoning restrictions on mix of uses in suburban areas
- Low density of suburban areas often unable to support nearby businesses and services¹⁹
- Lack of mixed use and nearby commercial and public amenities contributes to automobile dominance
- Functions other than dwelling are located in widely spaced, low-rise, automobile accessed facilities surrounded by large areas of surface parking: malls, power centres, business parks, industrial parks, etc.

Central Areas

- Proximity to greater range of facilities, services, retailers, offices, etc.
- Concentrations of people allow for large enough volume of people to support more closely spaced mixed uses²⁰
- Pedestrian access to multiple uses facilitated by proximity
- More dwelling types with mixed uses within single buildings (apartments with retail at grade, etc.)

Dwelling and Household Type

Suburbs

- Larger dwelling types in suburban areas - typically single detached and attached houses
- Detached types with larger exterior surface area
- Average size of new single family houses has grown rather steadily in Canada and US since at least mid-century²¹
- Suburban areas often marketed to and populated by families with children, young couples, larger households: in Ottawa, average household size decreases with increased distance from the city centre. Average household size of outer suburbs is 3 people, average for

inner suburbs is 2 people.²² Outer suburbs of Vancouver are around 3 with similar numbers in Toronto²³

Central Areas

- On average, populated by smaller, younger households. Fewer families with children. Average household size in downtown core of Ottawa is 1.6 people.²⁴ In downtown Vancouver it is 1.7²⁵
- Apartment buildings and condominiums form much larger portion of building stock compared to suburban regions. Most new dwellings in core neighbourhoods of Ottawa in buildings of five or more stories²⁶
- More grouped units with less exterior surface area
- New construction in central areas of Toronto and Ottawa is dominated by large condominium buildings²⁷
- Condominium market generally geared to single professionals, empty nesters, couples without children, investors and speculators²⁸

Unit Access to Light, Outdoor Views, and Air

Suburbs

- Detached dwelling form gives access to light, views, air from four sides, two or three sides for rowhouses and semis
- Low density, widely spaced, low-rise form results in little overshadowing, little blocking of views

Central Areas

- As simple matter of geometry, higher density and larger form of buildings makes abundant access to natural light more challenging
- Emphasis on larger buildings (apartments, condominiums) results in predominance of single aspect units or double aspect corner units due to widespread use of economical double loaded corridor. Single aspect units have fewer variations in views and daylight
- Increased overshadowing of urban areas, especially with high rises

Access to Open Spaces

FIG. 3.5 INFILL DEVELOPMENT IN OTTAWA BY TYPE 2001-2005
(excluding student residences and retirement residences)

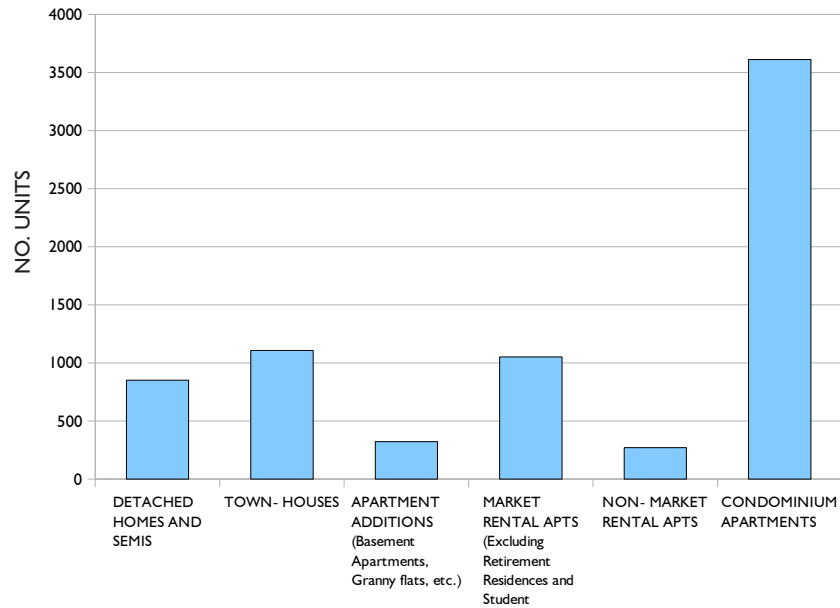
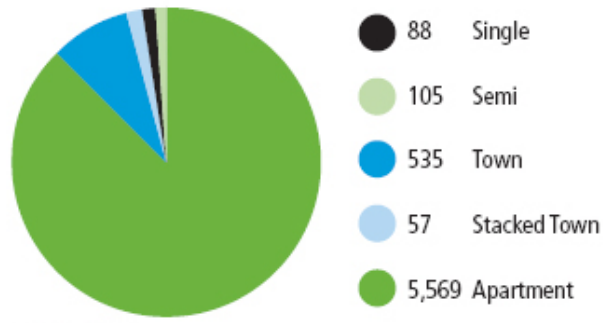


FIG. 3.6 NEW DOWNTOWN DWELLINGS BY TYPE 1996-2006



Source: City of Ottawa



FIG. 3.7 CLARIDGE PLAZA
One of the larger recent condominiums in Ottawa, along Rideau street.

Suburbs

- Near universal access to domestic outdoor spaces
- Yard as defining feature of suburban dwelling
- Typical lots sizes of 50'x100' in pre-war suburbs, 70'x100' in many post war suburbs of 1960s and 1970s, generally shrinking in 1990s with 40' and even 25' wide yards now more common²⁹
- Yard viewed as important area for young children, and also supports a wide array of outdoor activities: "In an approximate order of frequency, it is used for sitting, playing, cooking and eating, clothes drying, gardening, entertaining, and storage"³⁰

Central Areas

- Fewer outdoor spaces integrated with dwellings - predominance of typical apartment and condominium forms limits access to outdoor space
- Public parks and outdoor areas become critically important in central areas with dearth of domestic outdoor spaces. Eg. importance of Central Park in Manhattan, Stanley Park near high-rise core of Vancouver
- Emergence of a trend towards incorporating shared and private outdoor spaces in larger, dense building types (vegetated terraces, larger patios)

CRITICAL DISCUSSION

As mentioned, critical discussions of suburban and contemporary urban developments are voluminous, often controversial and polemical. Moreover, despite some of the commonalities and general characteristics mentioned above, there is great variety in built environment from context to context. Therefore the following critical discussion is not to provide a completely comprehensive overview of all the issues in contemporary suburban and urban development, but simply to present and discuss some critical challenges, based on the above discussion of key characteristics, which inform the design efforts of the thesis. In the sub-

urban context, these challenges are summarized as *isolation, sustainability, and the conurbation*. In the context of contemporary urban residential development, the challenges are summarized as *demographics and households, outdoor space, energy performance*, and also an aside on *money*.

SUBURBAN DEVELOPMENT CHALLENGES

ISOLATION

If one were to characterize the nature of the contemporary suburb in a few words, one could say that it is a development form which is focussed around providing a maximum amount of space and private amenity for individual dwellings at a low initial cost, while sacrificing ready access to many external, public amenities and shared facilities. Prominent criticisms of the suburbs often focus on the relative isolation of suburban communities,³¹ which is largely a result of low density and single use-zoning - two key suburban characteristics outlined above. This isolation - the distancing of dwellings from everything non-domestic and from each other - is one of the fundamental characteristics of the contemporary suburb, and one of its chief challenges. As a result of this relative isolation, suburban inhabitants often face relatively long commute times for many activities, and are limited in terms of pedestrian or transit access to varied facilities. The pedestrian experience of the contemporary suburb can be monotonous. The automobile orientation severely limits the ability of anyone not able to drive - children, younger adolescents, many elderly persons, poorer people, etc. - to many amenities. Moreover, reliance on automobile transport aggravates congestion in many cases, making commutes and drives to central areas even longer, further isolating suburban communities. Thus, creation of a less isolated urban fabric, with better, shorter, and more varied means of access to varied programs, is a significant challenge.

SUSTAINABILITY AND ENERGY USE

There are also many criticisms of the suburbs which focus around

the environmental impact and energy intensity of the suburbs. These are critical points, as climate change and resource scarcity are likely some of the most important issues facing contemporary society. In summarizing the environmental arguments for and against the compact city, one author writes that “the main justification for the compact city is the need for the least energy intensive patterns of activity to cope with the issues of global warming”.³² Some concerns about the sustainability and energy intensity of suburban development are:

- **Automobile dependence and vehicle emissions.** Emissions from automobile use relating to suburban communities are a major concern, since, as noted above, heavy automobile use is one of the key characteristics of the contemporary suburb. As passenger travel from automobiles and light trucks is estimated to make up for approximately 15% of Canada’s greenhouse gas emissions, automobile travel is significant source of pollution.³³
- **Dwellings with high ratio of exterior surface area to floor area.** The prevalence of detached, or minimally attached dwellings in suburban areas means that these dwellings will have large surface areas through which heat is conducted and through which air leaks, thereby increasing heating and cooling loads. Since domestic heating and cooling are significant sources of energy use, especially in climates such as Ontario’s, this is a significant concern. Residential space heating alone is estimated to account for 9% of Canada’s greenhouse gas emissions.³⁴ This point is further discussed in chapter four, part I.
- **Large Dwellings.** In addition to the above point, the often relatively large size of suburban homes contributes to the energy load - heating and cooling in particular - of dwellings. One of the characteristics of new suburban single family dwellings already noted was the rather steady increase in house size since mid-century. Despite the fact that average household size has diminished significantly since that time, the typical size of new detached houses has grown in Canada, from 770-1,200 square feet in the 1940s, to 1,100 to 1,300 square feet in the 1960s, to an average of around 2000 square feet today³⁵. In the United states, notwithstanding a recent drop during the US hous-

ing crisis, the average size of new single family houses in the United States has risen steadily, from 1690 square feet in 1982, to a high of 2470 ft² in 2007, despite a steady decrease in the number of people in the average household³⁶. At an average of 650 to 700 square feet per person, the largely suburban nation of the United States has one of, if not the highest amount of dwelling floor area per person in the world.³⁷

- **High Land use.** Suburban developments use large amounts of land that is generally covered by natural or agricultural vegetation. The land is covered by impermeable surfaces that create storm water runoff, while eating up agricultural lands and natural habitat.

At least one life-cycle analysis of residential energy use in Canada has supported many of the concerns about the energy intensity of the suburbs in comparison to the urban living. The study, carried out at the University of Toronto, compared greenhouse gas emissions of typical urban residents to suburban residents. It concluded that per capita greenhouse gas emissions of suburban residents are indeed significantly higher than those of more urban residents : on the order of 2 - 2.5 times higher.³⁸ The study looked at energy used for transportation, dwelling operation (heating, cooling, lighting etc.), and embodied energy in the construction of the dwellings. On the basis of square meter of living space, the study estimated that emissions from suburban residents were also higher, though they were higher by a smaller margin. This is because measuring energy use by floor area removes the effect of larger homes in the suburbs, and, despite the increased compactness of urban dwellings, urban dwelling types and suburban dwelling types nevertheless tend to have similar energy intensities in terms of energy use per unit floor area. Reasons for the similarities in energy intensity are explored in the discussion of urban dwelling development.

THE CONURBATION

At least one more key concern with suburban developments is the pace at which they expand the area of a city, and the way in which

they distance rural and natural areas from existing urban areas. The 'natural' setting of many new suburban neighbourhoods is often a major selling point of these developments,³⁹ yet with continued suburban expansion, these natural areas are often converted into new suburban neighbourhoods. One finds examples of residents of a recent subdivision who complain that another, newer, adjacent subdivision will ruin the natural setting of their community.⁴⁰ As this cycle continues, the city becomes increasingly remote from natural areas, and the surrounding region becomes what Patrick Geddes termed the conurbation: a continuous, widespread mass of low density urbanized area that swallows once separate communities. In Ottawa, the attempt to prevent this pattern with the legislation of a greenbelt surrounding the city has meant the city has developed at a somewhat higher density than many other North American cities, however suburban development has nevertheless leapfrogged over the greenbelt, and continues to grow outward, gradually engulfing previously separate towns such as Stittsville and Manotick in a suburban fabric.

In short, the focus on spaciousness and maximization of private amenity within the suburban dwellings leads to a dearth of many wider amenities within the urban region, and poses significant problems from a broader environmental perspective. Addressing these issues requires a rebalancing of priorities, with greater emphasis on the quality and sustainability of the the urban fabric as a whole.

URBAN DEVELOPMENT CHALLENGES

Intensification of existing urban areas provides a clear alternative to continued outward suburban expansion, the development of ever larger conurbations, and addresses many of the challenges and issues with suburban growth. It can foster a more vibrant city atmosphere, with pedestrian access to a wide array of services and urban amenities, and a more diverse public realm. Moreover, latent in a more compact city is the potential for more sustainable city growth, with increased viability of transit services, walkability, and a more compact and energy efficient

built form. However there are also challenges with current urban development and intensification.

DEMOGRAPHICS AND HOUSEHOLDS

One key issue is how urban population growth, across a wide spectrum of households, can be accommodated by further urban development. It was noted above how most current residential developments within urban areas cater specifically to target markets such young singles, childless couples, empty nesters, and real estate speculators. As one developer of mid-rise condominium units in Vancouver put it: "The residential units sell to local empty nesters, seniors and singles who work in the area. Few families buy these units"⁴¹. The same holds true for most condominium developments. Yet it is not necessarily the case that urban locations appeal only to these households; in the discussion of older inner suburbs and residential neighbourhoods in chapter two, it was noted that many central residential neighbourhoods are popular among a wide range of households, many of which have the financial means to buy in peripheral suburban locations if they wished. Arguably then, it is not so much that urban living appeals primarily to the households targeted by condominium developers, but that the character of dwellings in newer urban developments have limited appeal, and also that the relative low initial cost of suburban developments factors heavily into the decision of many home buyers.

Widening the range of households accommodated by urban residential developments is critical. In Toronto, for example, the lack of diversity in household types in central urban areas has been so pronounced that the city has considered legislation requiring developers to build larger condominium and apartment units that are more suitable for families.⁴² While it is true that, on average, households are getting smaller, that fewer people may be having children, and that populations are getting older, and thus that some demographic trends favor the development of units suitable for, and sought after by, smaller households and an aging population, households such as families persist as important social units. More than forty percent of Canadian households have chil-

dren at home, half of all Canadian households are married couples, and over one quarter of all households are married families with children at home.⁴³ Moreover, in terms of dwellings and land use, larger households are the most significant of all, since they require much more space than single households, and many of the established dwelling types catering to them – suburban single family detached houses, semis, and rowhouses – have the lowest densities and require the most land.

OUTDOOR SPACE AND CONNECTIONS TO THE OUTDOORS

Another important challenge, related to the above point, is the fact that a large portion of new urban dwellings typically have very limited access to outdoor space. We have seen that modest outdoor spaces have been an integral part of urban dwellings in many historic cities. From the first cities, private outdoor spaces were characteristic of many early urban dwellings throughout the Middle East, South East Asia, Northern Africa, China, Ancient Greece and Rome, Medieval Europe, and into modern times. A quiet domestic outdoor space within the urban environment is not in every case an idle bourgeois luxury. It has been a historic fact of urban living. It can create a more tangible connection with the exterior environment. As Kevin Lynch noted, it can also create an important amenity for families and specifically for young children, providing easily supervised spaces in which young children will spend much of their outdoor time.⁴⁴ It also allows one to partake in a number of activities which the apartment unit, with only a balcony, cannot easily support. It allows one to cultivate and interact with natural systems in a daily, intimate, casual way. In a dense urban areas where vegetation and natural environments are much more scarce, provision of outdoor space is arguably even more important than in suburban areas. Lending some support to this view is a growing body of research that posits a relationship between mental and physical health and proximity to green space.⁴⁵ In particular, there is emerging evidence of reduced rates of anxiety, depression, and cardiovascular disease in populations living near and among significant amounts of green space. One study concluded that:

*green space is more than just a luxury, and the development of green space should therefore be allocated a more central position in spatial planning policy. Healthy planning should include a place for green space and policy makers should take the amount of green space in the living environment into account when endeavouring to improve the health situation of the elderly, the youth, and lower socioeconomic status groups, especially in urban environments.*⁴⁶

In summing up this body of recent research, another study by some of the same authors states:

- *There is increasing evidence for a positive relation between green space in the living environment and a number of self-reported indicators of physical and mental health.*
- *Small-scale psychological research showed that exposure to green space has a positive effect on stress reduction and attention restoration.*
- *Several epidemiological studies have shown that green space is positively correlated with self-perceived health, number of symptoms experienced and mortality.*⁴⁷

This research further supports the notion that outdoor space and green space are indeed important in the urban context. This is not to say that *all* dwellings should require direct access to outdoor spaces, or that the provision of a certain amount of outdoor space incorporated with dwellings is some fundamental criteria which *all* dwellings ought to meet. Apartment units in larger buildings offer an ideal dwelling for many people. Some households do not want the added maintenance of outdoor spaces. The careful planning of public parks at a larger urban scale will provide outdoor spaces that adequately serve many of these households. The point here is that, *in addition to* the development of more standard types of apartments and condominiums, and the careful planning of public parks, urban intensification should include housing types which incorporate outdoor space in varied ways, to create an urban fabric with some dwellings that have a more intimate relation to outdoor spaces

and verdure.

In addition to the limited access to outdoor space, it was noted that urban dwellings often have more limited visual and sensory connection to the outdoors, as a result of the common single-aspect, double loaded corridor configuration. Access to natural light and views in a more dense urban environment was very explicitly noted as a challenge by early modernist architects interested in mass housing, and it remains a design challenge today.

ENERGY PERFORMANCE

Another challenge with contemporary urban development is the energy performance of many typical higher density residential buildings. It could reasonably be expected, on the basis of the common sense notion - and the well known precept of building science - that grouped dwelling units with less surface area, should, all else being equal, lose less heat than scattered, individual units. Urban planners and others will occasionally advocate for denser building types on this basis.⁴⁸ However, all is not equal in the design of single family homes and larger apartment and condominium units. Scattered suburban homes and high rise apartments are constructed, heated, operated, and ventilated in different ways. As a result of some of these differences, data for the energy use of different Canadian residential building types often show only slightly better energy performance - or in some cases *worse* performance - in larger multi-unit dwellings compared to individual houses (FIG. 3.8).⁴⁹ A CMHC report on high-rise residential buildings, which cites higher energy intensity in high rise apartments compared to single detached houses, cites a number of reasons for this:

Higher energy consumption in high-rise residential buildings reflects the fact that envelopes are not as airtight, nor as thermally efficient. Air leakage rates in high-rise buildings are significantly higher than those found in lowrise buildings. Typically, highrise apartment buildings have lower insulation levels, poorer windows, and more thermal bridging than lowrise residential buildings. As well, their ventilation

*systems generally operate without the benefit of heat recovery...High-rise buildings also have high electrical demands, specifically for corridor, parking garage, and exterior lighting requirements, as well as for motors for elevators, pumps, and fans.*⁵⁰

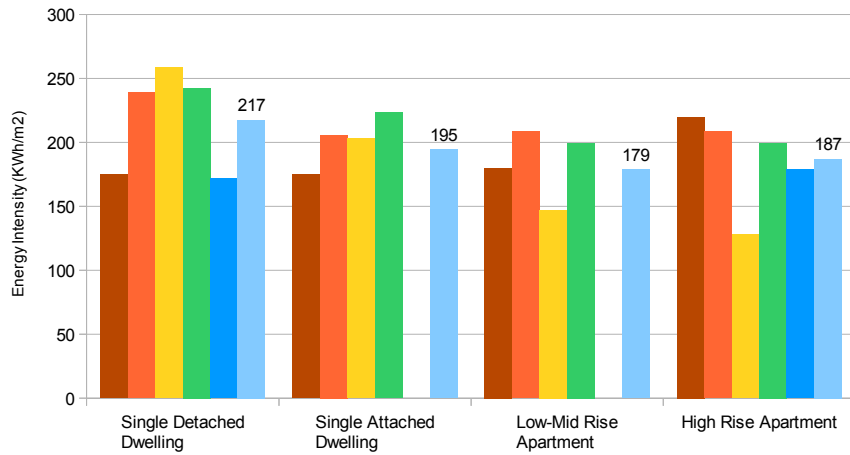
In addition to these points, we may add the practice of building large new residential buildings with primarily glazed envelopes, in order to compensate for lack of access to the outdoors and the typical single aspect configuration of most condominium units. This extensive use of glazing in the envelope contributes significantly to the lower insulation levels of larger residential buildings noted above.⁵¹ As a result we get a curious situation where condominium buildings are often advocated on the basis of energy savings and sustainability, yet are skinned with one of the most energy intensive envelopes possible, with the addition of extensive balconies that breach the building envelope in order to create large thermal bridges that act like heat sinks (FIG. 3.9, FIG. 3.10). This is also known as Harley Davidson architecture, in reference to the large heat sinks on Harley Davidson engines.⁵² This curious situation extends even into publications on sustainability. For example, if one peruses the residential high-rise case studies in a publication such as *GreenSource* - "the magazine of sustainable design" with case studies that provide "in-depth, data-rich reports on sustainable design" - one finds that, of the six projects with published energy consumption figures (either actual or simulated) *only one* shows energy performance much below regional averages for larger multi-family residential buildings, with at least two projects that are well over their regional averages.⁵³

In sum, the development of urban dwellings that successfully begin to address issues of climate change and resource use and scarcity, requires the revisiting of many typical building design practices. Chapter four will discuss a number of very basic strategies for addressing energy performance.

AN ASIDE ON MONEY

Finally, in comparison to suburban development, urban dwellings

FIG. 3.8 ENERGY INTENSITY OF CANADIAN RESIDENTIAL BUILDING TYPES - VARIOUS SOURCES - KWh/m²



- CMHC, "Healthy High Rise"
- Natural Resources Canada, "Secondary Energy Use by Energy Source and End use"
- Natural Resources Canada, "Survey of Household Energy Use"
- 2030 Challenge, "Averages for Site Energy Use and 2030 Challenge Energy Reduction Targets by Residential Space/Building Type"
- Norman, MaClean and Kennedy, "Comparing High and Low Residential Density"
- Average of all sources



FIG. 3.9 MODERN CONDOMINIUMS, TORONTO



FIG. 3.10 MODERN COMPUTER HEAT SINKS

must deal with the economics of generally higher land values and higher construction costs. The development of high density buildings types with smaller unit sizes in central areas has as much to do with these factors as it does with other urban design considerations. One Bloor, for example, will be a seventy storey tower not because seventy storey towers are necessarily the pinnacle of urban design, or because that represents some optimal urban density, but because the value of that address requires spreading the land cost over a number of residential units and commercial tenants, because seventy stories means more revenue than sixty-nine storeys, and because zoning or the OMB has allowed it. In many ways, this is likely a circle that feeds itself, as the possibility of higher development - which translates to higher revenues - can act to push land values up, while increased land values in turn tend to dictate higher developments.

Even at high levels of density, high land values, together with significantly higher construction costs and a competitive urban real estate market, create high dwelling costs in urban areas. Generally the largest segment of households in outer suburbs of Ottawa is households of 4-5 people. At modest space standards of 20-25 square meters per person, such households would easily pay over a half million dollars to live in a roughly 100 square meter condominium unit in central areas of Ottawa. By contrast they can easily buy a suburban home double the size for much less. This cost discrepancy is no doubt a major factor in the decision of many larger households with greater space requirements to opt for suburban living.

Addressing these issues through design alone is impossible, and thus a proper treatment of the subject is perhaps beyond the scope of the thesis, but the issue nevertheless bears mentioning, because it is a critical factor in urban design. Some further discussion of a few economic factors is found in Appendix 2. The subject of costs of structured parking is briefly discussed in Appendix 3, as this is a major additional cost of compact development in urban areas. However at a wider scale the issue of high land costs in central areas is largely a social and economic issue, and to some degree, higher construction costs in central areas are a policy issue, as the higher construction costs are in part due to code restrictions on combustible construction, which have been in part re-evaluated

in recent code changes in British Columbia. Alternative construction methods should be explored to bring costs of urban development down, however such a detailed discussion falls somewhat beyond the more schematic scope of this thesis.

CONCLUSIONS

In the foregoing discussion of the nature of dwellings in many Canadian cities, particularly Ottawa, this thesis has identified a few key interrelated challenges which the development of dwellings should seek to address:

- Provision of significant public and private open spaces within the urban fabric
- Accommodating a range of household types
- Creating an urban environment with facilities, services, commerce, transit, etc. that are accessible by a wide variety of means
- Decreasing life cycle energy consumption in our residential buildings and urban fabric
- Limiting the spread of conurbations
- Maintaining adequate access to natural light, air, views
- Generally, creating a quality urban environment

These challenges shape the design efforts of the thesis. The design goal is to research and develop models of urban dwelling which address these challenges by proposing urban dwelling types which consider a broader range of households, seek to attain a modest range of urban density, a high level of energy performance, while providing good access to outdoor spaces, natural light, and air, and allowing for the integration of diverse programmatic elements. How this is further interpreted, and how the design is approached, is the topic of the following chapter.

In a sense, some of the historic precedents we have looked at offer some clues to how to begin answering approaching these challenges. But today the urban scale has changed dramatically. Urban populations

are orders of magnitude larger, and are projected to continue growing as urbanization and population growth continues at least until mid 21st century, where, according to the United Nations, world populations could potentially peak as global fertility rates drop.⁵⁴ On a global scale, a city such as Ottawa - of roughly one million people- is rather small compared to the many metropolises of tens of millions of inhabitants. By contrast, medieval cities and villages, while often dense compared to contemporary North American cities, were considered to be large when they reached populations of 30,000 or 40,000. At one million inhabitants, Rome was considered an enormous metropolis. Ancient Greek cities consciously capped their populations at thirty of forty thousand inhabitants, founding new cities when these limits were reached. Today the human population covers the globe and uses a tremendous amount of natural resources. Clearly the quantitative scope of urban issues has changed. Moreover, transportation and building technologies, which have allowed cities to grow up and out, have also fundamentally changed urban issues. Cultural changes also alter the nature of cities. So while historic precedents offer important insights and are sources of ideas, contemporary urban issues are in many ways quantitatively and qualitatively different.

What this thesis proposes then, are contemporary design approaches to urban dwelling and ways of aggregating units which seek to create a wider range of urban dwellings, in a relatively dense environment that incorporates outdoor spaces and a mix of uses, in an energy efficient built fabric, responding generally to the challenges of our own time and place. The following chapters of this thesis will examine design principles and strategies, contemporary precedents, and schematic designs which attempt to address some of these challenges.

ENDNOTES - CHAPTER 3

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3. Eg. Fader, *Density by Design*, p. 6
4. Canadian Home Builder's Association, "Pulse Survey", p. 11
5. City of Ottawa, "Fernbank Community Design Plan" and "Barhaven South Community Design Plan."
6. Blaze Carlson, "In Markham, the Dream of an Urban Village that Never Was."
7. City of Ottawa, "Neighbourhood Demographics" and "Size of Household by Sub-Area; Micacchi, "Redeveloping the Avenues," p. 12
8. City of Ottawa, "New Dwelling Units by Sub-Area", "Residential Intensification in Ottawa", "2009 Annual Development Report" and "2010 Annual Development Report"; Urbanation, "Understanding the Market Context".
9. Mclean, "The Vancouver Experience"; City of Ottawa "Propensity Projections for the City of Ottawa"; Willcocks, "Encouraging Family-Friendly Condominium Development and Creating Complete Communities in Downtown Toronto."; Vermeulen, "An Architecture of Daily Life," p. 13
10. Marr, "Speculators, foreign investors betting on Toronto Condo Market" ; Gold, "Canadian real estate: a piggy bank for Chinese investors"
11. City of Ottawa, "Land Area, Population and Households by Ward"
12. Ibid.
13. City of Ottawa, "The Use of Land in the City of Ottawa".
14. Jackson, *Crabgrass Frontier*.
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17. Krugman, "That Hissing Sound".
18. Waier Ed., *R.S. Means Building Construction Cost Data*.
19. Jacobs, *The Death and Life of Great American Cities*; Schmitz and Scully, *Creating Walkable Spaces*.
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21. U.S. Census Bureau, "Median and Average Square Feet of Floor Area in New Single-Family Houses"; Canadian Mortgage and Housing Corporation, *Summary Report: The Changing Housing Industry in Canada, 1946-2001*.
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29. Fader, *Density by Design*, p. 6
 30. Lynch, *Site Planning*, p. 269
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 32. Frey, “Compact, Decentralized, or What?,” p. 331
 33. Natural Resources Canada. Office of Energy Efficiency. “Canada’s GHG Emissions by Sector, End-Use and Sub-Sector.”
 34. Ibid.
 35. Canadian Mortgage and Housing Corporation, *Summary Report: The Changing Housing Industry in Canada, 1946-2001*.
 36. U.S. Census Bureau, “Median and Average Square Feet of Floor Area in New Single-Family Houses”.
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 39. Kaplan, “Out in the Country.”
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 42. Willcocks, “Encouraging Family-Friendly Condominium Development and Creating Complete Communities in Downtown Toronto.”
 43. Statistics Canada. “Census families in private households by family structure and presence of children” and “Household size, by province and territory”.
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 45. Groenewegen et. al., “Vitamin G: effects of green space on health, well-being, and social safety” ; Maas, Verheij, Groenewegen, de Vries, and Spreeuwenberg, “Green space, urbanity, and health: how strong is the relation?” and “Morbidity is Related to a Green Living Environment.”; Bowler et al. “A Systematic Review of Evidence for the Added Benefits to Health of Exposure to Natural Environments” ; Richard Mitchell, and Frank Popham. Effect of exposure to natural environment on health inequalities” ; Stigsdotter et. al., “Health Promoting Outdoor Environments – Associations between green Space, and Health, Health-Related Quality of Life and Stress Based on a Danish National Representative Survey.”
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 49. Natural Resources Canada. Office of Energy Efficiency. “Table 2 : Residential Single Detached Secondary Energy Use by Energy Source and End-Use” and “Table 3 : Residential Single Attached Secondary Energy Use by Energy Source and End-Use” and “Table 4: Residential Apartments Secondary Energy Use by Energy Source and End-Use”; Canadian Housing and Mortgage Corporation, *Healthy High-rise*, p. 29

50. Canadian Housing and Mortgage Corporation, *Healthy High-rise*, p. 29
51. As glazing and curtain wall typical for these buildings have insulation values of around R2 or R3, compared with the standard R21 wall in single family homes, see, eg. Straube, "The future of Window Technology...is here" p. 1
52. Lstiburek, "Building Science Insight 005: A Bridge Too Far."
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IV - DESIGN PRINCIPLES, STRATEGIES, PRECEDENTS, AND SCHEMATIC DESIGN TYPES





This chapter puts forth a number of design principles, strategies, contemporary precedents, and schematic designs that seek to address some of the design challenges outlined in the previous chapter. Many of the principals and strategies are interlinked and overlapping; the goal is not to identify strictly discrete strategies or principles, but to give structure to the discussion of some of the overall approaches that will be taken in the design. *Part I* of the chapter discusses the key principles and strategies:

discussed alongside relevant precedents bearing some conceptual similarities to the type. Finally, *Part III* of chapter four introduces a type of site which presents widespread opportunities for the application of the principles and schematic designs, putting forth a number of general strategies for sites of this nature.

DESIGN PRINCIPLES AND STRATEGIES

- Density
 - Loosely, a net population density of 200-400 residents per hectare, a gross urban population density of 80 - 175 people per hectare, and net F.A.R. of 1.5 - 3
- Mixed Use
 - As strategy to complement and optimize density
 - For greater amenity and walkability
- Dwelling unit relation and connection to outdoor spaces
 - Relationship between outdoor spaces and dwellings
 - Sensory connection to outdoors
 - Modified Ground Plane
- Unit types and sizes
 - Varied sizes, layouts, amenities to accommodate varied households in urban environment
- Energy Performance
 - Compact massing
 - Relatively high performance envelope
 - Orientation
 - Total operating energy intensity of approximately 100 KWh/m² or less for residential areas, with more aggressive targets over time

In *Part II* of the chapter, the principals and strategies are illustrated in a series of loosely defined schematic design types, which are

CHAPTER IV - PART I - GENERAL DESIGN PRINCIPLES AND STRATEGIES

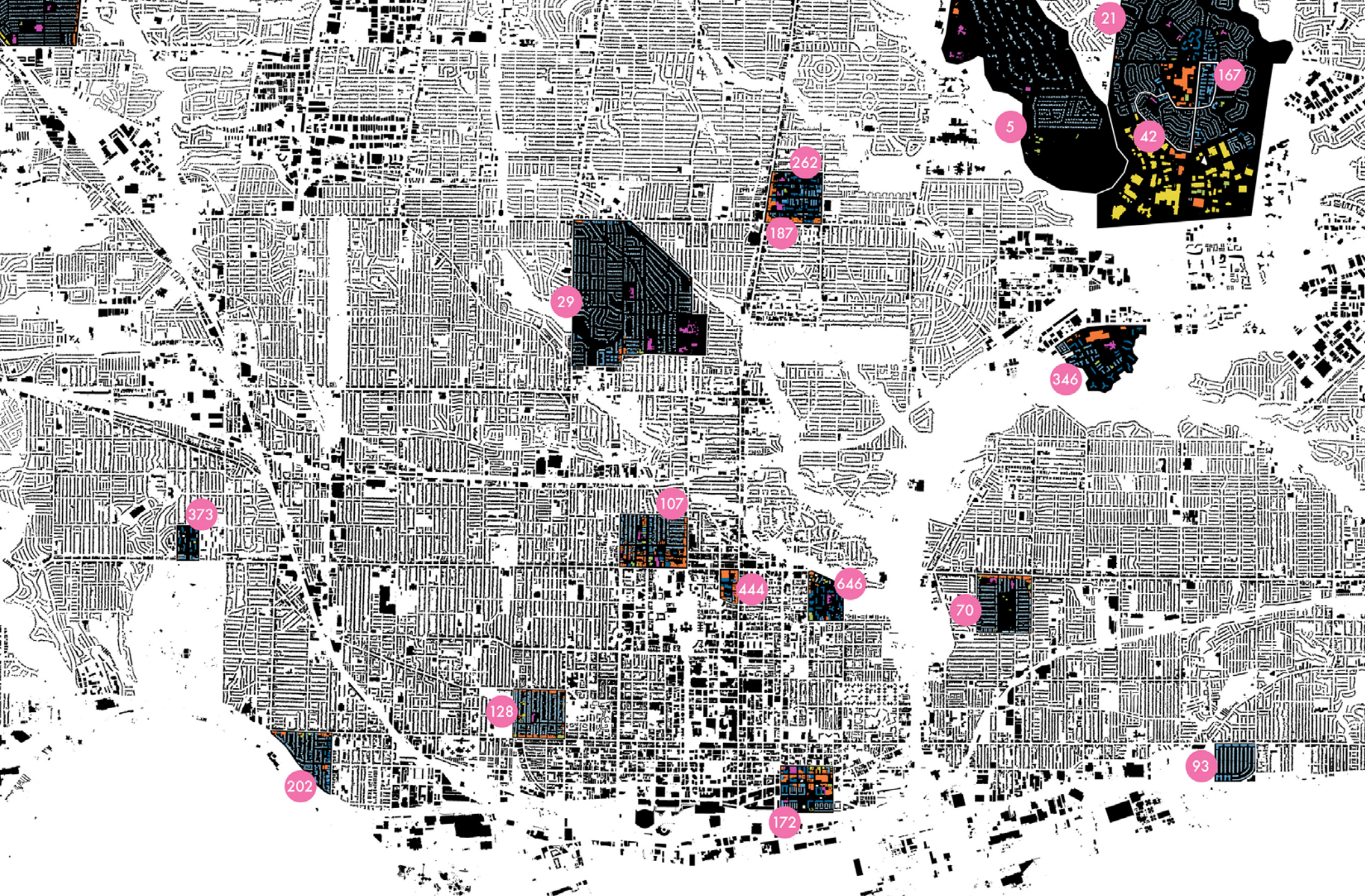


FIG. 4.1 TORONTO BY THE NUMBERS
 Map by E.R.A. Architects Inc. showing gross urban density in people per hectare of various Toronto neighbourhoods.

URBAN DENSITY

Density is an important factor that shapes many characteristics of a city.¹ Jacobs viewed density as one of the key factors in creating successful urban neighbourhoods. Hence, determining the level of density that is appropriate and desirable in a given context is important, if difficult. Prescribing specific levels of density is difficult, as the approach can be overly simplistic, can be insensitive to context, and may not take into account the qualitative experience of a place. Yet discussions about density should involve some quantities, as this can allow for more informed decision making and gives a basis for comparisons.

There are numerous metrics of density. These include, for example, people per gross unit area, people per net unit area, dwelling units per unit area, bedrooms per unit area, and floor area ratio (FAR). Each has strengths and weaknesses. As explained in the introduction, the metrics most employed in this thesis are people per *gross* unit area, or *gross population density* (gross including the area of the site in question, as well as a wider urban area including roads and rights of way, and potentially accounting for nearby non-residential areas), people per *net* unit area or *net population density* (net including only the area of a specific site, and not, for example, area of surrounding streets), as well as gross and net FAR. FAR has the advantage that it takes into account the density of the *built fabric*, regardless of cultural standards of floor area per person, or of building use. On its own, however, FAR does not measure population density per se, so other measures, such as gross and net population density in terms of people per unit area, are also helpful.

In the previous chapter, it was noted that dense urban environments can provide many advantages. Jacobs argued that a certain level of urban density was essential in creating a vibrant urban environment with diverse activities and services. Density brings people closer together, which can, in the right environment, create more social opportunities, and, Jacobs argued, create safer neighbourhoods. Higher densities make public transit more viable, and have the potential to create a more energy efficient built fabric.

While higher densities can confer many advantages, it must be

acknowledged that, as city fabric grows denser, with more built up area, access of dwelling units to things like light, air, outdoor spaces, and immediate physical and sensory connection to the external environment, becomes more challenging. This is simply a result of geometry. Jacobs argued eloquently for higher densities in cities, and her arguments provided valuable insights into the nature of cities, urban amenities, variety and diversity of uses. However she paid little attention to the fact that high densities can present design challenges in terms of many other amenities. When speaking of strategies for urban density, Jacobs speaks of “packing” dwellings onto land (as in ‘packing groceries into a bag’, or ‘meat-packing’). Jacobs was a prophet and preacher of high density, but her conclusions are in some cases debatable. For example, while in some instances hesitant to discuss density in terms of quantities, she does emphatically state that gross densities of 250 people per hectare and urbanity “can be combined only theoretically” as such densities and mixed uses are “incompatible because of the economics of generating city diversity.”² Yet this thesis has shown that historic and contemporary city areas at densities far below 250 people per gross hectare have been able to create lively, mixed urban environments, time and time again. She also states that, for individual neighbourhoods, “as a rule I think 100 dwellings per [net] acre will be found to be too low”.³ Translating this last figure to people per gross hectare ⁴ that might reasonably be a gross density of 420 people per hectare. By comparison, downtown wards of Ottawa have a maximum gross urban density of 67 people per hectare. Medieval cities had gross densities of around 100-200 people per hectare. Few historic cities had more than 300 people per gross hectare. Jacobs’ own home neighbourhood of the Annex has a gross density of around 100 people per hectare (FIG. 4.1). Of the regions showing densities on FIG. 4.1 only two of these⁵ are shown to have gross densities at or above 420 people per hectare. Granted, many of these numbers depend on how areas are measured, and will vary depending on sizes of the areas measured, but nevertheless the contrast between most urban areas and Jacobs’ prescriptions is startling. Jacobs’ discussion of urbanity and density at times seems to propose a simplistic linear correlation between density and urbanity - more density = more urbanity - for which Mumford sharply criticized

her. For many households and residents, densities of around 400 people per hectare may be appropriate. Yet to say anything below this number is “too low” seems at odds with the urban character of many cities and neighbourhoods which provide counterexamples.

For urban dwellings in existing contemporary Canadian cities then, what loose range of densities might one begin to consider? First, one may note that, at gross urban population densities of around 20-40 people per hectare, the existing density of contemporary Canadian cities is relatively low, so accommodating significant population growth should not require very high densities in the near future. However, since development of new dwellings is constrained to a limited number of sites (not every urban area can realistically be targeted for intensification) certain sites may have to be developed at higher densities.

Secondly, one should consider recommendations from various sources, such as official plans and urban studies. For example, the Ontario Places to Grow act mandates certain density levels in various cities in Southern Ontario. Central areas of Toronto are targeted for minimum densities of 400 people *and jobs* per hectare, while centers in smaller cities are targeted for minimums of 200 or 150 people and jobs per hectare. This does not translate directly into people per hectare, as it leaves open how much of an area is to be developed for residents, and how much for employment. Nevertheless, at the rough ratio of 2 persons to 1 job stated in the Places to Grow documentation, this could be roughly translated to required minimums of 266, 133, and 100 residents per gross hectare (plus jobs) assuming an even distribution of jobs and residents.⁶

Third, though there are fundamental quantitative and qualitative differences between historic and contemporary cities, and though decisions about our future need not be rigidly constrained by situations in our past, it may nevertheless be helpful to consider what range of population densities were common in pre-20th century cities in developing appropriate ranges of population densities. It allows one to view the contemporary situation from a wider perspective. For example, an understanding of the mixed use nature of medieval cities and their range of densities allow us to critically question some of Jacobs’ assertions regarding density levels. It also allows us to critically reflect on common notions

FIG. 4.2 TYPICAL FAR BY BUILDING TYPE IN BOSTON AREA ⁸

	Building Type	FAR
Rural	Single Family, 100 acres	0.0005
	Single Family, 25 acres	0.0018
Suburban	Single Family, acre	0.05
	Single Family, 1/2 acre	0.09
	Single Family, 1/4 acre	0.18
	Townhouse	0.88
Urban	3-storey apartment	1.38
	6-storey apartment	1.72
	12-storey apartment	2.87
High Density Urban	Townhouse	1.16
	3-storey apartment	2.07
	6-storey apartment	2.53
	12-storey apartment	5.05

such as the idea that increasing density means high rise building, which is often used to justify large point tower developments which are motivated by economic considerations. Based on the information gathered for this thesis, a typical range for cities prior to the 20th century is between 50 and 300 people per gross hectare. European cities have tended to be above 100 people per gross hectare. The average of all pre -20th century cities for which data was collected is around 200 people per gross hectare. Of course, these figures should be balanced against cultural differences, including what we can assume are generally smaller space standards of older civilizations.

It was noted that floor area ratio (FAR) is also an important measure of the built density of sites and urban areas. In addition to providing a some idea of population density, it can also be used to discern how much other types of activities - such as retail or offices - can be accommodated within a specific built form. It also provides a measure of density

independent of cultural space standards. FIG. 4.2 shows FAR by residential building type based on typical examples in the Boston area. It shows a range of around 1-5 for urban buildings types. Low rise, higher density areas, such as courtyard dwellings in UR, rowhouses in Amsterdam, rowhouses in Brooklyn, tall Georgian terrace houses, seem to have FARs of around 1 - 2 (see eg. chapter 2).⁷

One ought also consider projections for population growth, together with the amount of land area available for further development. In this case, growth projections specifically for the city of Ottawa - the context of the final design exercise - are discussed. Based on the city of Ottawa's own high growth scenario, assuming a high population growth beyond 2031, the city might grow by 200,000 - 400,000 people in the next 2-3 decades.⁹ Excluding provisions for certain greenfield sites, the city has identified around 1,650 net hectares of sites - 2,200 gross hectares - within existing city areas that have potential for redevelopment.¹⁰ Accommodating 100% of the population from high growth scenarios on these sites would require a net population density of approximately 125-250 people per hectare, and a gross density (including areas of roads and rights of way within these sites) of approximately 60 -130 people per hectare. However, new greenfield suburban communities around the urban periphery are already part of the city's official plan, and some degree of further suburban growth is to be expected as a reality, so it should not be expected that all of Ottawa's growth will need to be accommodated within these areas. On the other hand, it was noted that not all sites are likely to be developed to their full capacity - if they are even developed at all - so it should not be expected that the *all of the area* of all the available sites will be available for dwellings for the growing population. It would be difficult to quantify these assumptions, and it is far beyond the scope of the thesis to produce a detailed statistical analysis of population growth projections, land use projections, development assumptions, and strict density parameters. Rather the goal is to provide a very rough sketch of what might be some desirable levels of density that are in keeping with the design goals of the thesis.

Roughly then, for the design proposal, the thesis proposes a net population density of between 200 and 400 people per hectare, which, on

FIG. 4.3 SOME ANTICIPATED DENSITY LEVELS FOR FUTURE DEVELOPMENTS IN OTTAWA ¹¹

Area type	Dwelling units/Gross Hectare
Greenfields	24
Mainstreets	235
Downtown	532

the assumption that the net to gross ratio for the proposal might be 40% (ie. assuming the design proposal only takes up 40% of any new development and that other land will be required for, eg., parks, new streets, non-residential facilities such as hospitals, schools, industrial facilities, etc.), might reasonably translate to a gross urban density of 80 - 175 people per hectare. In assuming this net to gross ratio, this gross density takes into account areas for new parks, streets, surrounding rights of way, and strictly non-residential development (eg. industrial, institutional, and commercial). This rough range of densities could be considered beneficial in the city's growth. Development densities within these ranges could accommodate a large proportion of Ottawa's population growth for several decades and more. Indeed, it could theoretically accommodate *all* of the anticipated population growth for the next several decades if developed at relatively even levels of density on *all* available development sites. Moreover, this range is roughly in line with some targets such as those outlined in Ontario's Places to Grow act, which directs population growth to many urban centres in southern Ontario. It also reflects a range of density that has many historic precedents, in a wide range of cultures, and has allowed for the creation of compact, walkable cities with a variety of mixed uses. Such densities should be able to support some degree of mixed use within the urban fabric, and should facilitate the use of urban transit, especially if development works in tandem with existing and planned transit routes. In addition to population density levels, this range of density should ensure that floor space is provided to accommodate non-residential spaces, creating urbane, walkable neighbourhoods with easy access to a variety of activities and services. Such densities will also favour compact, attached

building types, with potential for significant energy savings through building massing. Attached buildings at these levels can be achieved with relatively modest mid-rise buildings, reducing the impact of the buildings on adjacent areas in terms of over shadowing, wind, and contextual massing. The level of density is not so high that it precludes the possibility of good access to sunlight and outdoor spaces interspersed within the urban fabric - again as we have seen in historic precedents. However, based on historical figures, it can be expected densities within the middle and upper end of this range will likely require exploration of some superimposed forms of dwelling, and thus incorporation of domestic outdoor spaces may require some new strategies: these are discussed in the following sections.

Of course, in response to neighbourhood, economic, historic contexts, etc, appropriate density levels will vary significantly from site to site. The goal of this thesis is not to prescribe density levels for all sites, but to explore what rough levels may prove reasonable and beneficial in the design approaches.

It should perhaps be noted that the approach taken above contrasts with the city's assumed development patterns. The range of densities proposed for the thesis assume a more even, if still varied, distribution of densities throughout potential redevelopment areas. As Barton Myers, George Baird, and others have noted, this more even distribution of density runs counter to the typical development patterns of the North American *uni-centred city*, where central regions are developed at high density in high rise buildings, with densities dropping off rapidly to low levels into the surrounding suburban periphery. The uni-centered approach is implicit in the city's assumptions regarding the density of future development: peripheral areas are to be developed at relatively low densities, while central areas develop at much higher densities with smaller units (FIG. 4.3). Myers and others advocated for a more even distribution of densities across a wide range of sites available for redevelopment - what was termed "urban consolidation" - and that is the approach taken here in attempting to develop sustainable urban dwellings which provide a high quality of life, a positive urban environment, and good access to outdoor spaces for a wide range of people. Part II of this chapter will look at precedents that specifically emerged from ideas of urban consolidation, such as Diamond and Myers' Hydro Block .

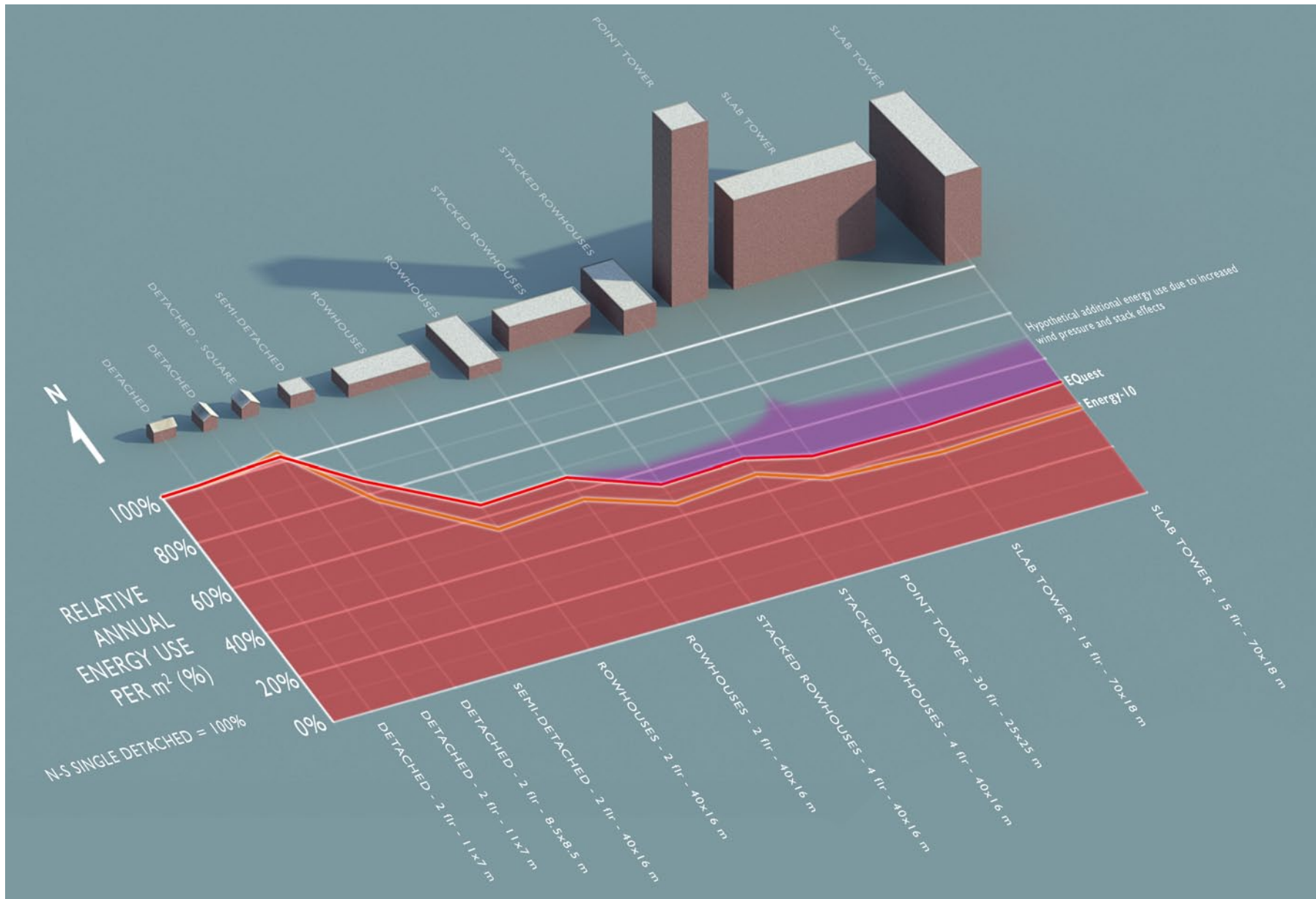
ENERGY PERFORMANCE

Canadian dwellings make up for around 17% of total Canadian energy use.¹³ Space heating of residential buildings alone - by far the largest load from Canadian residential buildings, followed distantly by hot water heating - accounts for around 9% of national greenhouse gas emissions.¹⁴ Together with the understanding that climate change, energy use, resource depletion, and rising commodity prices are all some of the defining issues facing us today, this means that residential energy use is a clear target for energy conservation. Strategies to reduce these loads are integral to any form of sustainable urban dwelling. The concept of sustainability of course encompasses much more than just energy use. However, since energy use is one of the most pressing issues directly affected by dwelling design, it is a primary focus of this thesis - hence the design principle of energy performance. This thesis looks at a number of strategies relating to the energy performance of dwellings.

MASSING

The relation between massing and energy performance has already been noted in chapter three. It is reiterated here for clarity, and because it is an important concept: compact massing, with lower ratios of exterior surface area to usable floor area can greatly affect the performance of a building. Less exterior surface area means less area through which heat can be conducted (area is a factor in the basic steady state heat conduction equation: $q=UA(T_i - T_o)$) and through which air leakage can occur. This favours compact and simple shapes, larger buildings, and grouped units. FIG. 4.4 shows the results of some schematic energy simulation exercises which demonstrate some relations between residential building massing and energy use. It shows clearly that, *all else being equal*¹⁵, more compact, grouped forms with lower ratios of surface area to floor area tend to use significantly less energy than smaller detached forms. In low and medium rise forms, row houses and stacked rowhouses perform relatively well in the index. Thus, while juggling other concerns - such as the need for access to views and light, and the creation of massing

FIG. 4.4 ENERGY USE VS. BUILDING FORM AND ORIENTATION



Results of schematic energy simulations comparing building forms. Each form has the same envelope, window to wall ratios, occupancy, internal loads, etc. The only variables changed are the form and orientation. Facades on each orientation have same properties, including the same window to wall ratios. The increased wind pressure shown in the high rises shows only conceptually how taller building form might be affected by increased wind pressure and stack effects. See appendix 5 for a more detailed specification of building properties used in the simulations.

that responds to the other design goals of the thesis - the idea of relatively compact and simple massing is a basic strategy in this thesis. In part II of this chapter, this strategy is quantified in each schematic type by examining the ratio of exterior surface area to floor area.

ENVELOPE

Massing determines the amount of exterior surface area through which heat can be transferred, while the design of the envelope itself determines how much energy passes through a given portion of the envelope, and by which heat transfer mechanism. As data from CMHC shows, heat loss through the envelope of multi-family buildings tends to be governed by three major factors: air leakage, conduction and radiation through windows, and conduction through walls (FIG. 4.7).¹⁶ Controlled ventilation (as opposed to air leakage), which is shown as 20% of heat loss, is presumably not affected by the envelope. These three factors, then, as the major elements of heat loss in multi-unit residential buildings, need to be considered in the design of high performance building envelopes.

In considering these factors to create a relatively high performance envelope, three very basic strategies are put forth in the thesis:

1. A continuous envelope with relatively high thermal resistance and minimal thermal bridges (R25-R40 for walls, R4 and up for windows)
2. An airtight envelope (dwelling unit tightness of 0.50 - 1 ACH @ 50 Pa)
3. Limitation of window areas to reasonable amounts, balanced against the need for light, views, and transparency (50% max WWR for dwellings)

(1) and (2) limit conduction and air leakage, where (3) is in place because windows have much lower thermal resistance than properly insulated opaque walls, and can admit unwanted solar radiation without the proper design steps. Further discussion of these points, and discussion of the range of values suggested above, is in Appendix 3. The range of values are loose guides for the design purposes of this thesis and they may be revised based results from further research, costs, or in specific contexts; they are not intended to be prescriptive. The values are used in carrying out schematic energy simulations that are discussed in Part II of this chapter.

FIG. 4.5 EFFECTIVE OVERALL WALL R-VALUE AS A FUNCTION OF WINDOW TO WALL RATIO

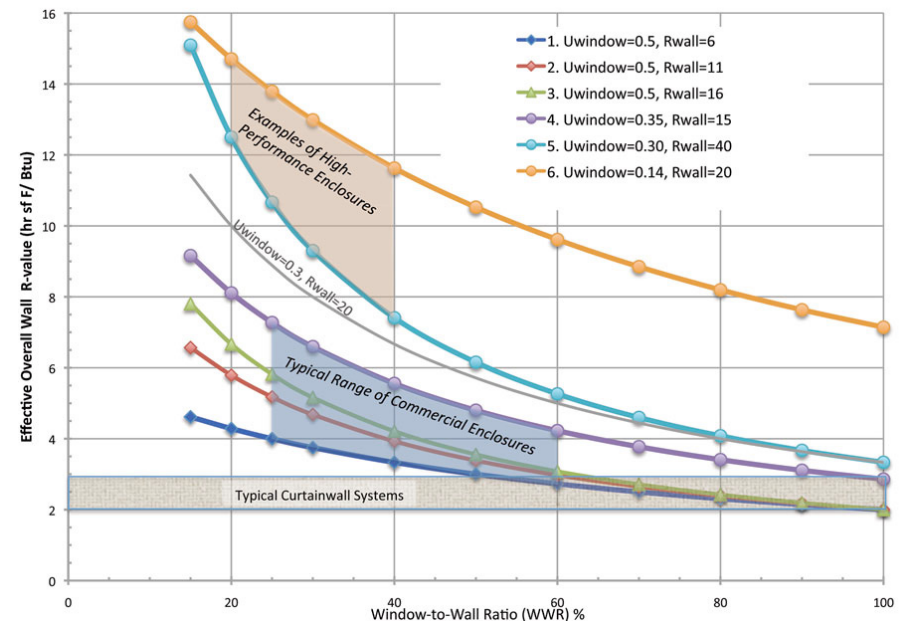


FIG. 4.6 TOTAL ENERGY SAVINGS IN TEST SIMULATION AS A FUNCTION OF INCREASED INSULATION

Additional layers of insulation give diminishing returns

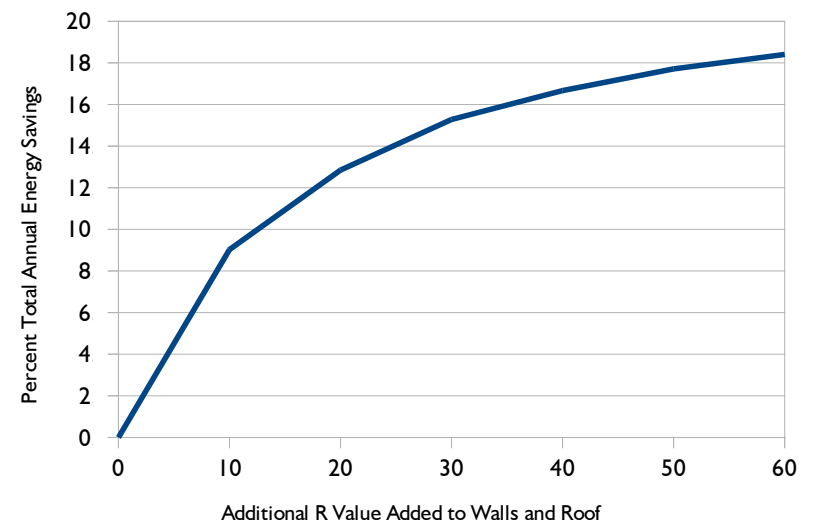


FIG. 4.9 MINIMUM STANDARDS FOR BUILDING ENVELOPES SET OUT BY VARIOUS CODES AND STANDARDS, AND TYPICAL AIR LEAKAGE RATES FOR CANADIAN HOUSES

MINIMUM STANDARDS FOR VARIOUS RESIDENTIAL BUILDING TYPES IN ONTARIO

	WALLS Min. Imperial R Value	WINDOWS Min. Imperial R Value	AIR LEAKAGE Max. ACH @ 50 Pa
Model National Energy Code	12 - 21	1.7 - 4	None
ASHRAE 90.1	11.4 - 20.5	1.75 - 2.2	None
OBC requirements for Part 9 Buildings	22	2.8	None
Passivhaus	37.9	7.1	0.6

INTERNATIONAL AIR TIGHTNESS STANDARDS FOR DWELLINGS¹⁷

	AIR LEAKAGE Max. ACH @ 50 Pa
Switzerland	3.6
Germany	1.8 - 3.6
Denmark	2.8
Belgium	1 - 3
Finland	1
Netherlands	6

AVERAGE CANADIAN HOUSE AIR LEAKAGE RATES¹⁸

From a sample of 5733 Houses	AIR LEAKAGE ACH @ 50 Pa
Pre 1921 Houses	13.7
1921-1945 Houses	12.2
1946-1960 Houses	8.3
1961-1970 Houses	6.9
1971-1980 Houses	6.1
1981-1990 Houses	4.76
1991-1997 Houses	3.1 - 4.4
1995-2000 Houses	3.7
2001-2005 Houses	3.5
2006-2009 Houses	2.8

FIG. 4.8 ENERGY USE IN MULTI-UNIT RESIDENTIAL BUILDINGS

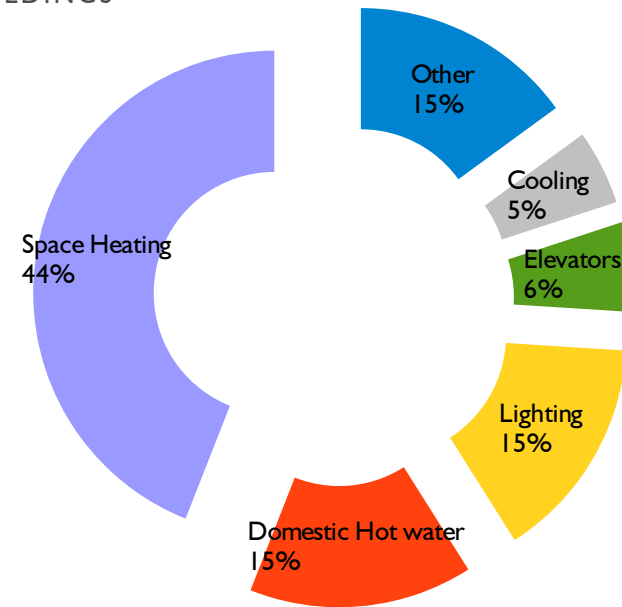
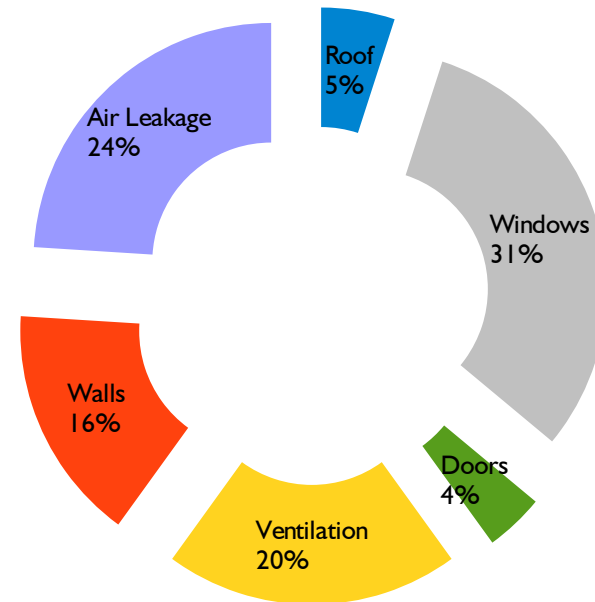


FIG. 4.7 HEAT LOSS IN MULTI-UNIT RESIDENTIAL BUILDINGS



ORIENTATION

It is well known that orientation in general can affect, among other things, the energy use of a building. The degree to which it affects energy use is perhaps less widely discussed, and will likely depend on a number of variables, especially building design. Research for the thesis looked at the effect of orientation in a few different building configurations through some schematic energy simulations. The simulations showed that, in an Ontario climate, the energy use of buildings with the same window to wall ratios on every facade seemed very little affected by overall building orientation (FIG. 4.4). This parallels some energy simulations carried out by Barbara Ross for Ontario office buildings, which showed that different orientations of various shapes of buildings that have the same envelope and the same window to wall ratios on all sides, without shading, vary in overall energy use only by marginal amounts. Energy consumption of the test buildings in Ross' simulations varied by only about 1%.¹⁹

However, when window to wall ratios are varied on different orientations, and shading devices are introduced, it seems that orientation can begin to make a larger difference in terms of overall energy use. For instance, energy simulations - carried out in Energy10 - of a simple building, with a large south facing window shaded by an overhang, and few windows on other orientations, showed that variations in orientation can make a significant difference in energy use (see FIG. 4.13). Turning the building from a strict, southern orientation to an eastern orientation, for example, showed an 8.4% increase in annual energy use. Minor changes in orientation produced negligible differences in overall energy use. Some properties of the building used in these energy simulations are specified in Appendix 5.

Thus, rather than speak of general building orientation as an important factor in a building's energy use, it may be more fruitful to think of *window* orientation, as some energy simulation studies seem to indicate that the effects of gross building orientation can often be overstated; the overall energy consumption of some building configurations can be virtually unaffected by orientation. On the other hand, the annual energy

consumption of buildings with significant variations in window to wall ratios on each facade, and/or with shading, can be significantly affected by orientation. In orientation then, glazing seems to be the important factor, though minor variations in orientation (eg. 10 degrees) seem to be largely negligible. Larger variations in orientation seem significant.

In a Canadian climate, passive solar design may possibly be used to optimize building performance, but it can be complicated and may require some detailed understanding of energy in buildings, sophisticated modelling, and can introduce complexity in the simulation process.²⁰ Use of passive design, or indeed any energy optimization strategy, is further aided by testing of various design options through energy simulation exercises in the schematic design phase.²¹ Testing at the schematic design phase gives early feedback at the most crucial decision making phase. Some schematic energy simulation of various window and shading configurations done for the thesis gave somewhat inconclusive results regarding the use of passive solar energy. A basic conclusion regarding passive solar design in cold climates such as Ottawa is when in doubt, when unable to properly test strategies at a schematic stage though energy simulation, and when budgets or other constraints mean high quality glazing and good, dynamic shading is not feasible, more modest amounts of glazing are likely the best option. If, on the other hand, sufficient time, resources, and knowledge are available, more aggressive passive solar glazing strategies may be explored. The subject bears further investigation but is somewhat beyond the scope of the thesis.

Orientation can also affect the feasibility of integrating photovoltaic and/or solar hot water systems. In high performance buildings, hot water - the second largest load after space heating in typical Canadian residential buildings - becomes an even more significant load as other loads are optimized. Therefore integration of solar hot water can be important in reducing loads when larger loads, heating loads in particular, are reduced.

Therefore the general design approach to orientation for the thesis will be to roughly orient blocks to maximize northern and southern exposure, and to favour double aspect units. This will provide controllable light to the units, allow for the possibility of using passive solar strategies

using modest amount of glazing, and possibly allow for easier integration of PV and solar hot water systems. Single aspect units around double loaded corridors may perhaps be better served by modest amounts of glazing in a building orientation favoring east and west exposures, as this will ensure some access to sunlight for most of the units. Moreover, as some simulations have shown, this should have relatively small effects on overall energy performance if only a limited amount of glazing is used.

PERFORMANCE TARGET

Finally, the performance target of 100KWh/m² or less in operating energy for dwelling units is intended to be a realistically achievable goal for new dwellings designed today in an Ontario climate. The Thin Flats in Philadelphia (FIG. 4.62), and the Dorset street building in Waterloo (FIG. 4.12), are examples of contemporary urban dwellings in similar climates, and at mid-levels of density, which achieve roughly these levels of performance. This target is roughly in line with the 50% goal of the 2030 challenge, which seeks to attain net zero carbon emissions for new buildings by 2030 (ie. it is roughly halfway to the goal of net zero).



FIG. 4.12 DORSET STREET BUILDING, WATERLOO ON



FIG. 4.10 EXAMPLE OF DYNAMIC EXTERIOR SHADING - DOCKSIDE GREEN - VICTORIA BC.

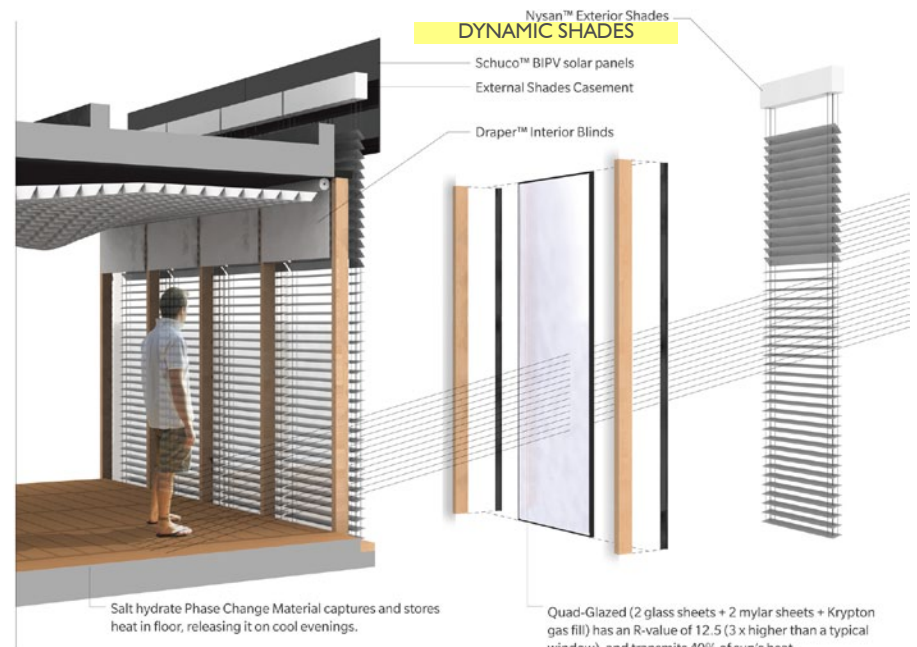


FIG. 4.11 EXAMPLE OF DYNAMIC EXTERIOR SHADING ON THE NORTH HOUSE.

The shades are essentially exterior grade venetian blinds, which can be closed or open to prevent or allow solar radiation from passing through the glazing, modulating solar heat gains according to varying conditions.

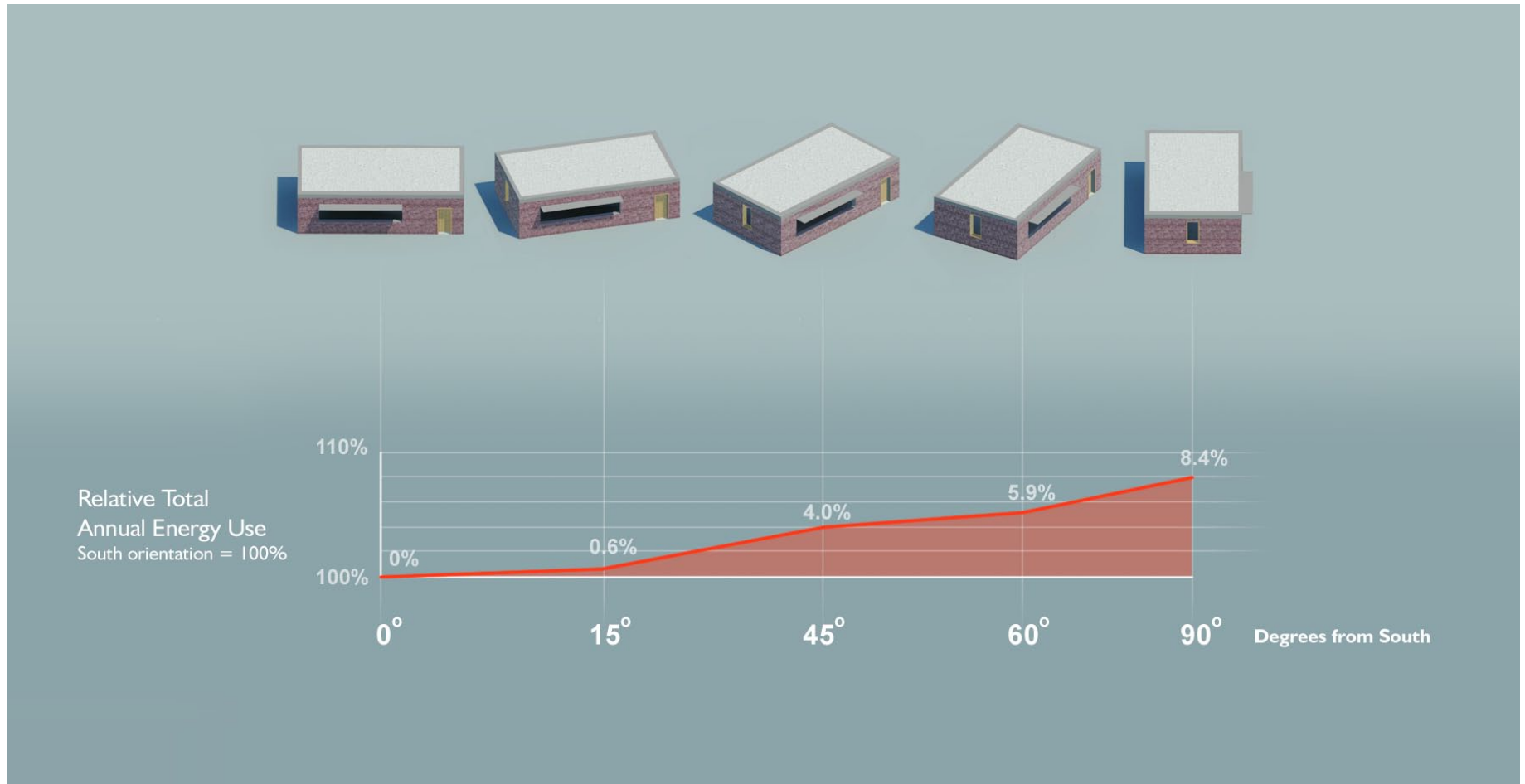


FIG. 4.13 ORIENTATION VS. ANNUAL ENERGY USE - SAMPLE BUILDING WITH VARIED WINDOW CONFIGURATIONS

This figure shows some results of schematic energy simulations carried out on a small building with varied window configurations: a south facade with a large window that is shaded by a fixed overhang, and other facades with relatively little glazing and no shading. In this case (as compared to the simulation results shown in fig 4.4) orientation can make a significant impact. See appendix 5 for more detailed specifications of building properties used in the simulations.

MIXED USE STRATEGIES

A mixed use fabric clearly provides a greater range of nearby programs and facilities. It can add to the vibrancy of a neighbourhood and its streets. It can help create streets populated at different times of the day. It lends itself to pedestrian travel. These factors have all been discussed in chapter three as important factors in urban design.

In this thesis, mixed use development is proposed as a strategy not only to provide these benefits, but also as a means of strategically increasing density of the built form. Program elements with different requirements can be integrated with one another to optimize the use of land on a site. Most significantly, programs requiring less direct access to daylight and the outdoors, (such as large format retailers, markets, malls, storage spaces, light industrial space, or parking and vehicle circulation) can be placed underneath or behind other program elements requiring better daylight access (such as residences or offices). This approach can be used to increase overall density, while preserving better access to light and views for dwellings. It optimizes the use of a site. This strategy was employed in many of Henri Sauvage's apartment buildings, where areas with deep floor plates and limited access to daylight were reserved for programs such as cinemas, swimming pools, storage, or larger gathering spaces (see FIG. 4.87). Other projects demonstrating similar approaches are the Citadel Almere, District Lofts, and Westboro Station, all discussed in part II of this chapter. As at Sauvage's Rue Des Amiraux, this strategy can compliment terraced approaches to providing dwellings with outdoor spaces. Also, placement of commercial or public programs on lower floors raises dwellings higher above street level, which can in some cases be desirable in denser urban locations with busy streets.

In incorporating mixed uses this thesis proposes programs at various sizes and scales, from small retailers and offices, to larger programs such as grocery stores or farmer's markets. In creating walkable, mixed use neighbourhoods, some planners urge the incorporation of a range of tenants and retailers, including, for example, both small local businesses as well as larger retailers. In urging for a mix of retail types, the Urban Land Institute writes that many "pedestrian districts include national re-

tail tenants for economic sustainability, plus regional and local businesses to create a unique character and a sense of place" - though some cities, such as San Francisco, have exceptionally healthy, mixed, pedestrian urban environments even with few national retail tenants.²⁴ Small businesses provide unique, specialty goods and services, make room for smaller independent organizations, businesses, and enterprises, and can create a porous, mixed and more lively streetscape. However larger tenants such as grocery stores, farmer's markets, department stores, cinemas, or even aggregations of retailers, can also play a role in mixed use developments. They are part of the commercial makeup of the contemporary city, and they can provide things that may not be provided by smaller tenants.

In fact, many larger stores are beginning to once again turn their focus on more urban locations, rather than expanding primarily in suburban locations, taking cues from more urban focused retailers. The Globe and Mail writes that "after two decades of building big-box stores, many retailers are shrinking the size of their outlets as consumers turn to more convenient formats".²⁵ Loblaws in particular "plans to add new conventional stores by opening small urban formats - starting with a recently launched market-style grocer in Toronto - as well as large supermarkets in the heart of Canadian cities." This move away from suburban power centres and big box retail should be encouraged by mixed use developments. Retailers, large and small are part of the commercial landscape of cities, and both will need to be accommodated to some degree by mixed use developments. Industry and commerce is obviously no longer exclusively at the same scale it was in the medieval city, when most industries and stores could be accommodated in single homes. While smaller tenants provide a pedestrian friendly, porous, fine grained street facade, larger tenants can be accommodated behind these. The Citadel Almere and the Vauban Solar development, discussed in part II of this chapter, are contemporary examples that incorporate both smaller and larger retailers with dwellings in a strategic way.

As well as a way to increase the vitality and walkability of an urban area, and strategically increase density, mixed use can also diversify the revenue of a project quite significantly. As Edward Sonshine, CEO of Canada's largest REIT, notes, the retail space in an urban development is

often more valuable than residential space, sometimes doubly so.²⁶ Thus incorporation of large retail spaces in deep floor plates can create a significant revenue stream from the developer’s perspective, increasing the economic viability of mixed use projects.

In addition to retail, a wide array of services, based on context and perceived need, should be considered, as one of the overall goals of mixed use is to provide a compact city with a diversity of easily accessible resources.

VARIED UNIT TYPES AND SIZES

Urban dwellings should accommodate a diverse range of households. In expanding the diversity of urban dwellings, this thesis places some emphasis on accommodating larger households, as these are the households that are often not accommodated by contemporary urban developments. However, a range of household sizes - from single persons to larger families - will be considered in the final design proposal in chapter five.

Regarding the question of unit size, it is impossible to predict the exact household composition and spatial needs of future residents, so the issue will be examined at a rough level. Unit flexibility will also be important in accommodating changes.

First, the thesis looked at residential floor area per capita for various countries (FIG. 4.15). Statistics for Canada were not found, but they may be assumed to be similar to those in the United States, given some of the similarities in housing trends. The United States seemingly has the world’s highest living area per capita, at around 65-60 m²/person, while wealthy European countries have roughly 35-45 m²/person.²⁸ Data from the United Kingdom shows that, in the UK at least, the amount of floor area per person tends to be negatively correlated with household size, with larger households tending to have 20 - 30 m²/person.²⁹ Developing nations have substantially less living area. If we assume that

FIG. 4.15 AVERAGE DWELLING FLOOR AREA PER PERSON FOR VARIOUS COUNTRIES (M²/ PERSON) ²⁷

Of all countries examined, the United States has the highest average floor area, and Canada is assumed to have a similar average.

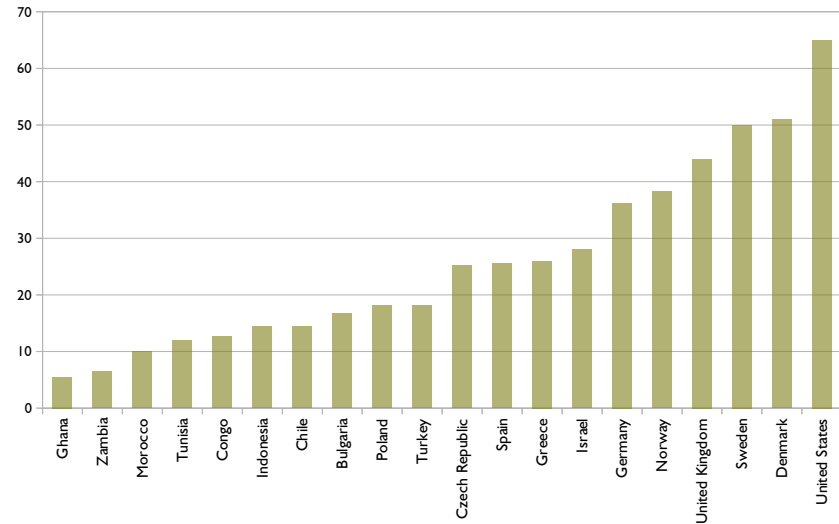


FIG. 4.16 HOUSEHOLD SIZE - CITY OF OTTAWA ³⁰

	Total Households	As Percent
1 person	88,075	27%
2 persons	104,645	33%
3 persons	51,445	16%
4-5 persons	68,675	21%
6 or more persons	8,050	3%
avg. household size	2.5	-

the space standards for the units proposed in this thesis, representing a more compact and efficient form of development, will reflect European standards somewhat more closely - say an average of 50-45m²/person, with 40-25m²/person for larger households - this gives a rough basis for determining unit sizes. On this basis, units for households of between 3-6 people might range from 75m² to over 200m², though allowance should be made for significant deviation from average standards.

Secondly, we might begin to roughly sketch out possible unit sizes in terms of minimum dimensions of rooms, and number of rooms. Some minimum sizes might be:

- 9m² bedrooms
- 5m² kitchen
- 15m² living room
- 9m² dining room
- 4m² bathroom
- additional 30% - 40% for circulation, storage and small ancillary rooms.

Based on these figures, a minimally sized three-bedroom one-bathroom unit might be 80m² (20m²/person for four people) A less minimally sized unit, perhaps with an additional room for a den or office, a second washroom, and more storage space might be over 100 m² (more than 25 m²/person for four people). A three bedroom unit following minimum Ontario Building Code requirements for room sizes, and allowing for an additional 30% of floor area for circulation and ancillary rooms might be roughly 60 m².

Such information serves as very basic unit planning information for this thesis. Significant allowances are made for varied households, varied conditions within unit types, changes in demographics, and so on.

Unit types and spatial qualities will also vary in the design proposal, reflecting different ways of aggregating units, different types of relations to outdoor spaces (see following discussion on connection to outdoors), different forms of unit access, different relations to the ground plane, and so on. Larger rowhouse units may be organized in a way that

takes advantage of the flexibility of the rowhouse type, with the ability to be split into smaller units (see, eg. demonstration unit in FIG. 5.49, chapter five). This variation and flexibility will provide a range of different conditions which, along with varied unit sizes, will be suitable for varied households.

DWELLING UNIT RELATION AND CONNECTION TO OUTDOOR SPACES

SENSORY CONNECTION TO OUTDOORS

In creating sensory connections between outdoor space and dwelling units, this thesis will explore dense urban configurations that can accommodate visual connections to the outdoors from multiple orientations, creating more varied daylighting conditions, more varied exterior views, and a general sense that the dwelling is open to the exterior environment in several directions. This multi-directional sense of connection to the outdoors, even in deep row-units with modest glazing, can arguably create a greater sense of fluidity, openness, and freedom than even the most highly glazed single aspect unit. This is not to exclude single aspect units or to argue entirely against the economy of the double loaded corridor, but rather to provide a greater range of urban dwelling types, with some that strive for an increased sense of connection to the outdoor environment.

RELATION TO OUTDOOR SPACE

This thesis has noted that urban outdoor spaces, closely integrated with urban dwellings, and also in the form of public squares, markets, circuses, pedestrian streets and so forth, have been ubiquitous in many historic cities at urbane densities. It has looked at historic models of ur-

FIG. 4.17 DWELLING UNIT RELATION TO OUTDOOR SPACE

RELATION 1



HORIZONTALLY ADJACENT

- Outdoor space in view of indoor spaces. Provides view of garden space and supervised area for children
- Requires more area
- Can be overshadowed by adjacent building.
- Can be stacked
- Can be horizontally combined as rowhouses, back to backs.

RELATION 2



INTERNAL

- Provides view to outdoor space from many rooms of house.
- Limited direct sunlight in outdoor spaces northern or southern latitudes, especially in winter
- Requires more area
- Cannot stack units on top
- Easily combined horizontally

RELATION 3



VERTICALLY ADJACENT

- Outdoor space has good access to sunlight.
- More complex access to outdoor space
- Space not overlooked by indoor space (more difficult supervision of small children, less visual connection with outdoor space)
- Cannot stack units on top

RELATION 4



DISSOCIATED

- Typically more public or shared outdoor spaces (parks, allotments, etc)
- More serendipitous social opportunities
- Less opportunity for modification of space (eg. gardening)
- Much less restriction on design of individual dwelling units.

ban dwelling which provide a synthesis of urbanity, access to light and air, outdoor spaces and verdure: courtyard houses of many diverse cultures, medieval rowhouses, the carefully sited Georgian terrace houses of Bath, etc. It has discussed the importance of nearby outdoor spaces for various households, and for a multitude of potential uses. It has also noted the growing body of public health research which posits significant emotional and physical health benefits from proximity to green space. In short, it has established that there is crucial value in outdoor spaces - large and small, public and private - within a denser urban environment.

In integrating such spaces with a contemporary urban fabric of

dwellings, one might begin by asking: what are the key types of relations between dwelling units and outdoor spaces? The relation of a dwelling to outdoor space is an important characteristic. This thesis identifies four basic relations: *horizontally adjacent*, *vertically adjacent*, *internal*, and *dissociated* (FIG. 4.17).

Different relations may be more desirable in different circumstances. For example, for many households and individuals, good access to dissociated outdoor space, such as a nearby park, square, or path system, may be the most desirable relation. Many households prefer the convenience and low maintenance of an apartment or condominium

unit, with parks and public spaces for outdoor spaces. These households are the ones best accommodated by the majority of contemporary developments in central urban areas. The dissociated relationship can be achieved by virtually any form of building type if the question of outdoor space and green space is addressed at the wider scales of site planning and urban planning.

Implementation any of the other three types of relations can be achieved by a more limited set of building types. Building types that aggregate units with these relations are perhaps best explored through design exercises and precedents. This is done in Part II of chapter four. Part II proposes schematic types which seek to implement the design principles discussed in Part I, namely *Energy Performance, Density, Mixed Use, Access to Outdoor space*, etc. Each of the schematic types is loosely categorized by the way in which they aggregate units that exhibit one or more of unit-outdoor space relations 1-3. The schematic types are displayed alongside relevant precedents which share fundamental conceptual similarities to the type.

First, however the thesis discusses a general strategy which enables a wider range of possibilities for the integration of outdoor space, and for more varied relations between dwellings and outdoor space in a dense urban fabric: use of a modified ground plane.

MODIFIED GROUND PLANE

Definition: Primarily horizontal plane or planes recreating conditions typically found in outdoor spaces at grade (eg. outdoor gathering space, gardens, fields, vegetated areas), but integrated in the built structure in locations other than the natural ground plane. See examples on opposite page.

The modified ground plane is not a new idea: arguably it is seen at least as far back as the mythical Hanging Gardens of Babylon. Moshe Safdie credited the Hanging Gardens as one of the inspirations for Habitat 67.³¹ One can also see the idea of the modified ground plane in Le Cor-

busier's emphasis on the rooftop garden, one of his five points of architecture. He stressed that the rooftop garden was important in making up for the portion of land and open space lost by the construction of a building. The subject of the modified, three dimensional ground plane has been investigated in a number of recent Architecture theses at Waterloo.³² We see a sense of the idea creeping into the housing market as many newer condominium projects begin offering small rooftop terraces as amenities. A limited number of other projects integrate the idea in a more extensive way. In a sense, the modified ground plane allows us to retain open spaces and verdure in a denser built fabric, and therefore, the idea of relatively dense urban dwellings that have access to outdoor space and the idea of the modified ground plane are complimentary. Open spaces and verdure can be integrated within the built fabric in a greater variety of ways, opening up new possibilities.

In addition to facilitating new outdoor spaces, integrating the modified ground plane in buildings can provide a number of other benefits. Where implemented as green roofs, they retain stormwater and can significantly reduce the loads on storm sewers, many of which are already overtaxed or aging. They can also contribute to a cooler urban environment in hot weather, combating the urban heat island effect. Additionally, as at the Vancouver Convention centre or Next 21 in Osaka, they can integrate ecological systems and habitats within the urban environment. Both these projects create habitats and stopping grounds for birds and insects, with natural vegetation such as field grasses and trees. Other

FIGS. 4.18-29 EXAMPLES OF THE USE OF THE MODIFIED GROUND PLANE.

(1) Le Corbusier's roof terrace at Villa Savoye. (2) Liebskind proposal for a NYC tower (3) Sunship, Freiburg (4) Fashion House Condos, Toronto (5) De Citadel Almere, Almere (6) 60 Richmond, Toronto (7) Mountain (8) Hanging gardens of Babylon (9) Next 21, Osaka (10) Habitat 67, Montreal (11) Vancouver Convention Centre (12) 2000 Dutch Pavilion, Hanover.



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potential benefits might include increased roof membrane lifespan and increased roof insulation.

Intensive green roof building systems support the idea of the modified ground plane in a direct way. They create an infrastructure which can support a wide range of surfaces and vegetation; they can be harscaped or planted, allowing for the creation of diverse environments. On an intensive green roof with a growing medium of adequate depth, the range of potential vegetation is wide open, and, writes the OAA, “with few exceptions, the choices are limitless...virtually any type of plant suitable to the local climate can be accommodated.”³³

One of the primary considerations with green roofs is the structure to support increased loading. According to the OAA, while this can present a significant expense for existing buildings, in new projects the cost implications for the structure can be minimal:

*Additional loading is one of the main factors in determining both the viability and the cost of a green roof installation. If a green roof is part of the initial design of the building, the additional loading can be accommodated easily and for a relatively minor cost.*³⁴

Therefore modified ground planes with some flexibility, capable of supporting a wide range of surfaces, vegetation, and landscapes, are feasible contemporary design elements. Terraces and green roofs have come a long way since Le Corbusier experimented with the idea in the infamously leaky and impractical roof garden at Villa Savoye. This thesis will look at a number of projects which incorporate the idea of the modified ground plane with residential projects in the second part of this chapter. The first precedent discussed in part II of this chapter - MVRDV's 2000 Dutch Pavillion - puts forth the basic idea of the modified ground plane in a clear, diagrammatic, and abstract way.

CHAPTER IV - PART II - SCHEMATIC TYPES AND PRECEDENTS

Part II of this chapter looks at a number of precedents and schematic designs that are loosely categorized into types. Each type reflects the way in which the dwelling units are combined and the relation of the dwelling units to outdoor space. In implementing the principles and strategies outlined at the beginning of this chapter, the focus of the schematic types is on a variety of dwelling types which integrate outdoor spaces with most of the dwelling units (relations 1-3), in a relatively compact massing that, where possible, allows for double aspect units.

Many of the schematic types generally feature dwelling units larger than 80 square meters, in order to be able to accommodate larger households. However many of these are configured to be convertible to smaller units (see, eg. FIG. 5.49 in chapter five). The schematic mid-rise towers are assumed to be able to incorporate various uses in ground level podiums. Incorporation of mixed uses is further explored in the final design proposal in chapter five. Likewise, incorporation of a greater variety of dwelling types, including more standard urban types, such as condominium or apartment units in double loaded corridor buildings, is further considered and implemented in the more comprehensive design scheme in chapter five.

A number of quantitative metrics relating to some of the design principles are used to compare precedents and schematic designs. Where possible, use of these metrics is consistent, however in many cases there is insufficient information to be able to provide reliable information for every metric. Estimates are made of the net FAR of the schematic types and precedents, and population densities are estimated from the FAR using a number of basic assumptions.³⁵ Net densities are easier to quantify in this case, as net density accounts only for the immediate area of the site - which can be easily obtained or estimated - whereas the figures for gross urban densities are somewhat more speculative, in that these make assumptions about land use in surrounding areas or in urban development in general. Generally, net area is assumed to be half the gross urban area, in order to provide room for additional non-residential programs (eg. parks, industry), and to provide a more even, more conservative, comparison with other figures of gross density.³⁶ Where possible, figures relating to the construction cost and sales prices of the precedents are

presented.

Schematic energy simulations were carried out for a number of the schematic building types, again, for purposes of comparison. These simulations were carried out in eQuest, and looked primarily at the way in which some of the architectural strategies outline in Part I of this chapter - such as massing and envelope design - affect the energy use across types. A very simple HVAC system is used in the simulations that in no way presents an optimized or well calibrated mechanical design. Some of the basic variables and assumptions used in the energy simulations are given in appendix 5. In addition, metrics relating to energy use of the schematic types - such as the ratio of external surface area to internal floor area, and presumptions about adequate glazing ratios - are also included to provide some further basis for comparing the expected energy performance of the types.

Qualitative aspects of each precedent and schematic are also discussed. The discussion interprets the way in which the precedents and schematic types employ some of the principles and strategies discussed in Part I of this chapter, the way in which units are aggregated, the way in which the designs deal with some of the challenges identified, and their overall qualities. Potential strengths and weaknesses or difficulties are discussed for each type and precedent.

The first precedent stands apart from the other precedents, as it is more of an illustration of the abstract notion of the modified ground plane than a project with actual dwellings.



FIG. 4.30 2000 DUTCH PAVILION

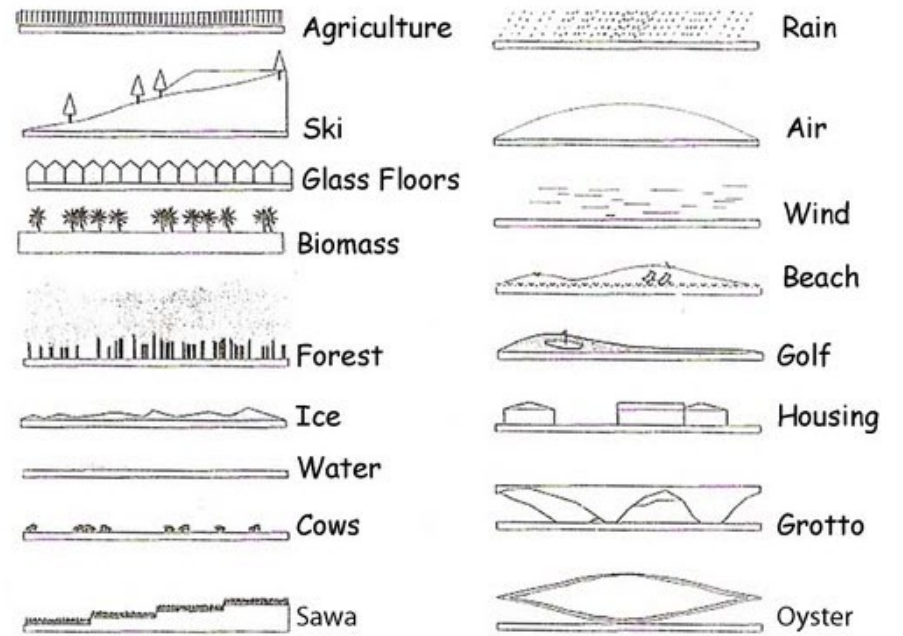


FIG. 4.31 POSSIBLE FLOORS IN PAVILION

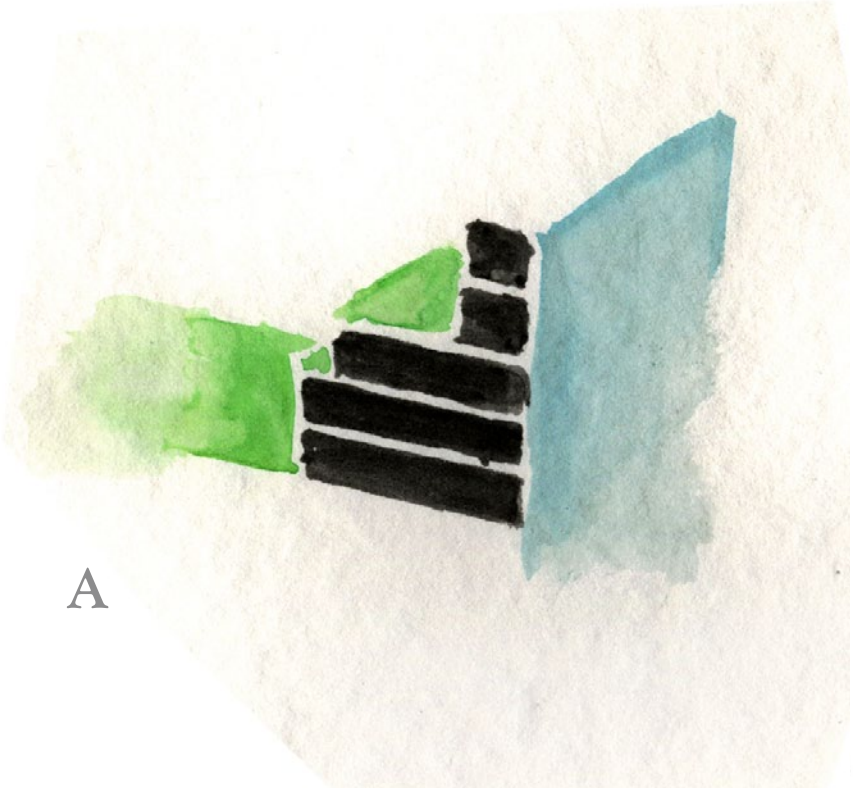
EXPO 2000 DUTCH PAVILION - HANOVER 2000 MVRDV

While the 2000 Dutch Pavilion contains no dwellings, and is not specifically about dwelling, it is a project which tackles some abstract ideas that have broad significance for this thesis. The pavilion is a clear, explicit exploration of the idea of modified and vertically stacked ground planes. Indeed, the project is less a building than a illustration of these concepts. The pavilion's designers describe the project as a 'laboratory' for the idea of vertically integrating modified ground planes:

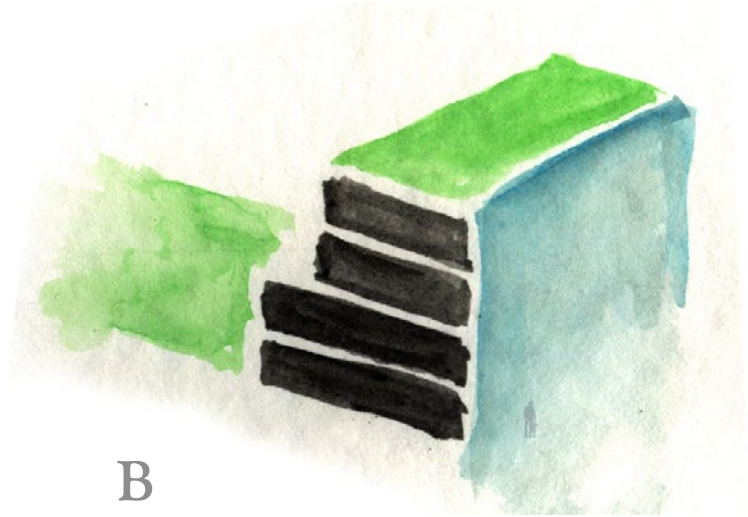
Perhaps in the near future extra space will be found not just by increasing the [Netherlands's] width but by expanding vertically. This kind of operation would seem to be applicable to many more countries. It raises questions of global significance. Can increasing population densities coexist with an increase in the quality of life? What conditions should be satisfied before such increases in density take place? What role will nature, in the widest sense, play in such an increase in density? Is not the issue here 'new nature', literally and metaphorically?...Nature arranged on many levels provides both an extension to existing nature and an outstanding symbol of its artificiality.”³⁷

FIG. 4.31 shows some of the “possible floors” that might be considered in the newly created ground planes and ‘new nature’. Note that one of these potential floors is a floor for housing. The actual pavilion included an artificial lake, a ‘forest’ landscape with large trees, and a dune landscape, among other things. Incorporation of these elements within the built form have shown just how far it is actually possible to take the idea of stacking land, even if these extremes are just in a demonstration project in this case. While the 2000 pavilion is an experiment with this idea of modified ground planes and vertically stacked landscapes at an abstract level, design explorations and precedents in the following pages will include projects which apply the idea of the modified ground plane and vertically integrated outdoor spaces in more pragmatic urban projects, integrating them with dwellings.

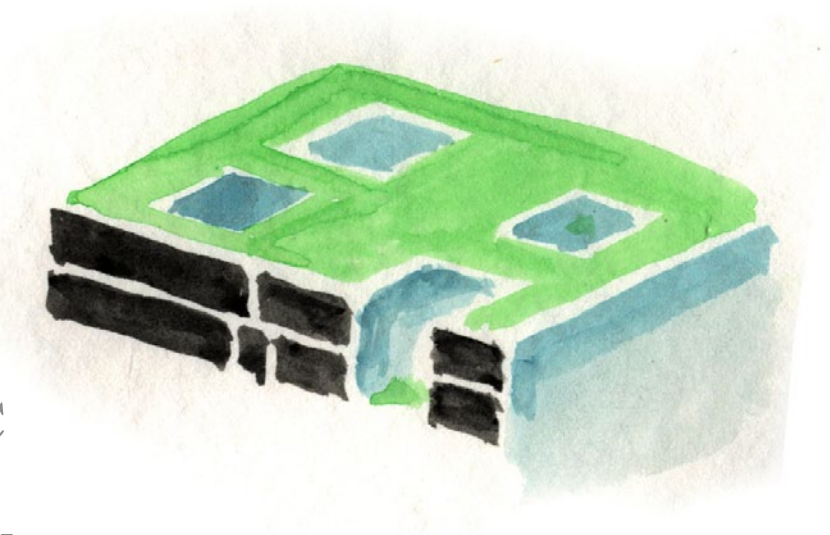
SCHEMATIC TYPES - A- F



A

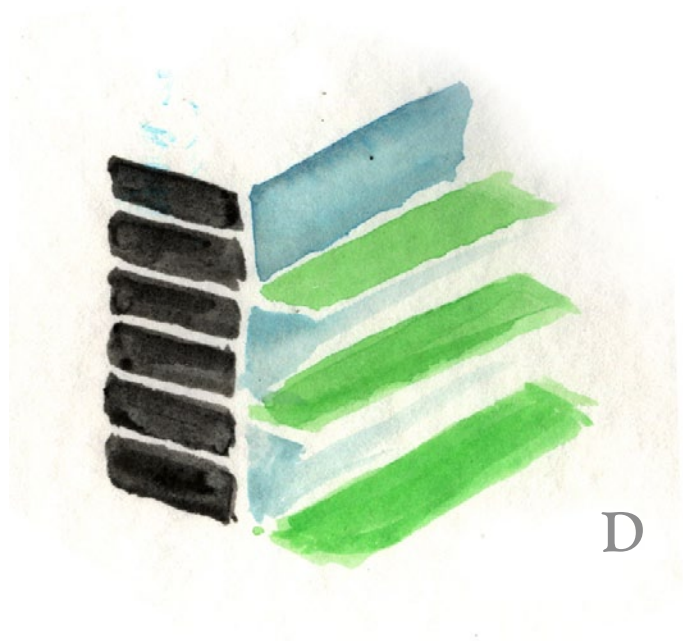


B

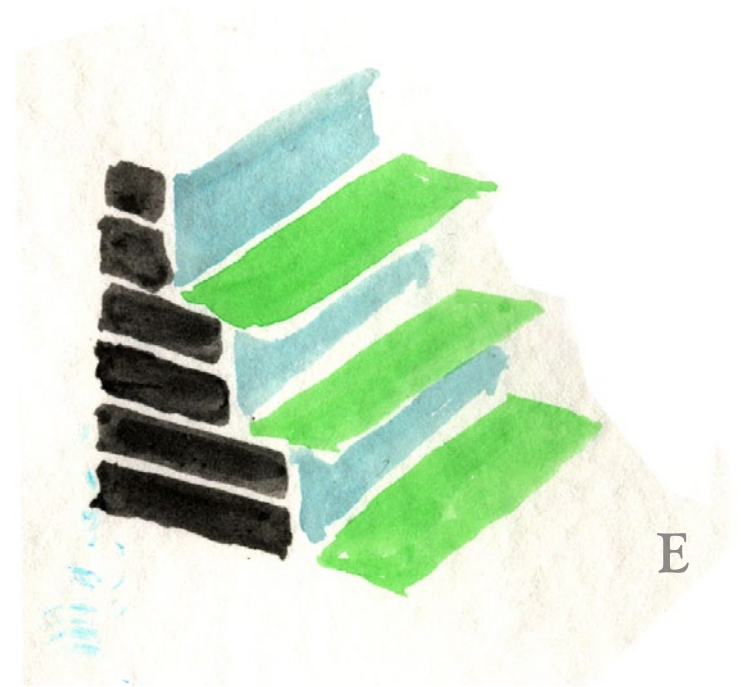


C

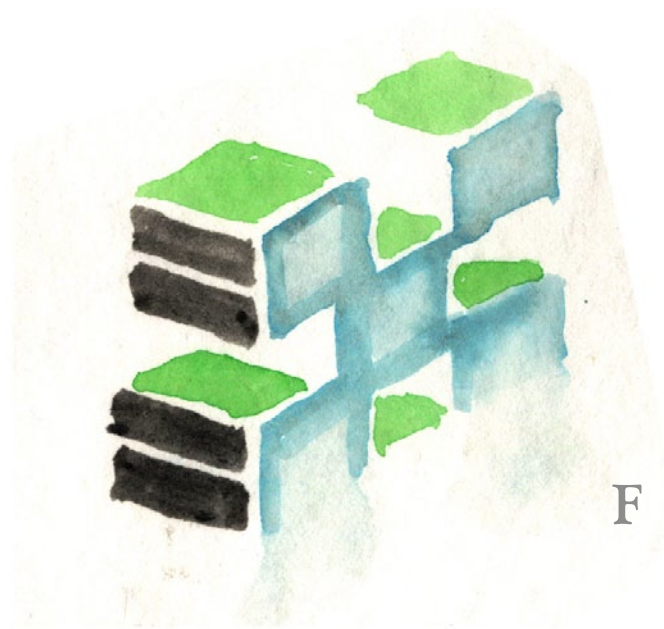
FIG. 4.32 SCHEMATIC TYPES



D



E



F

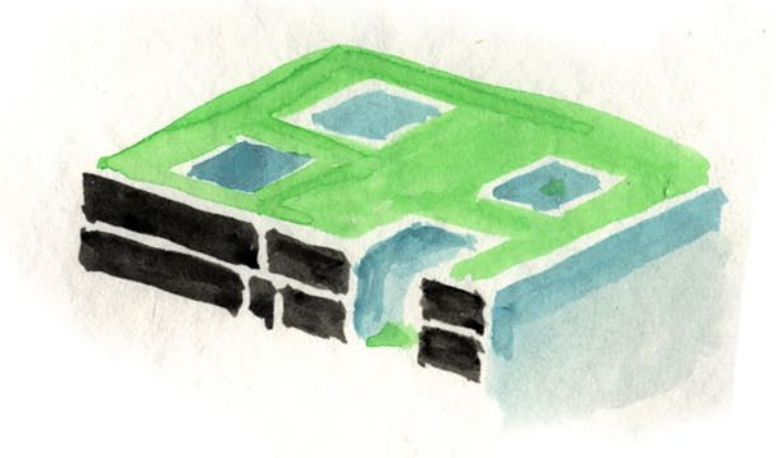
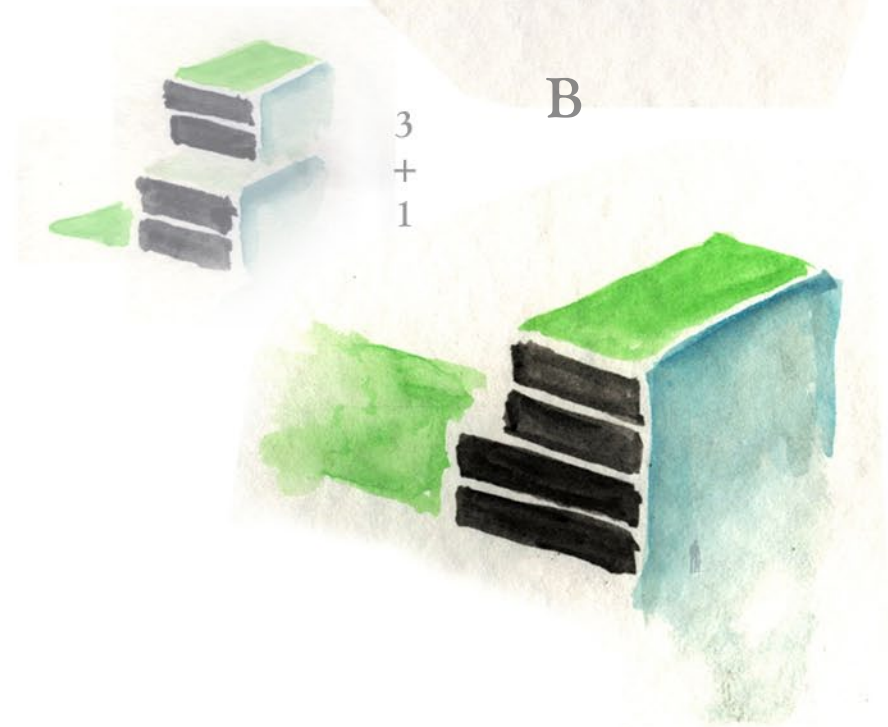
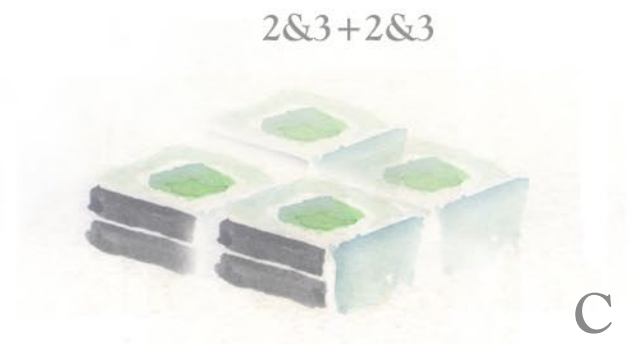
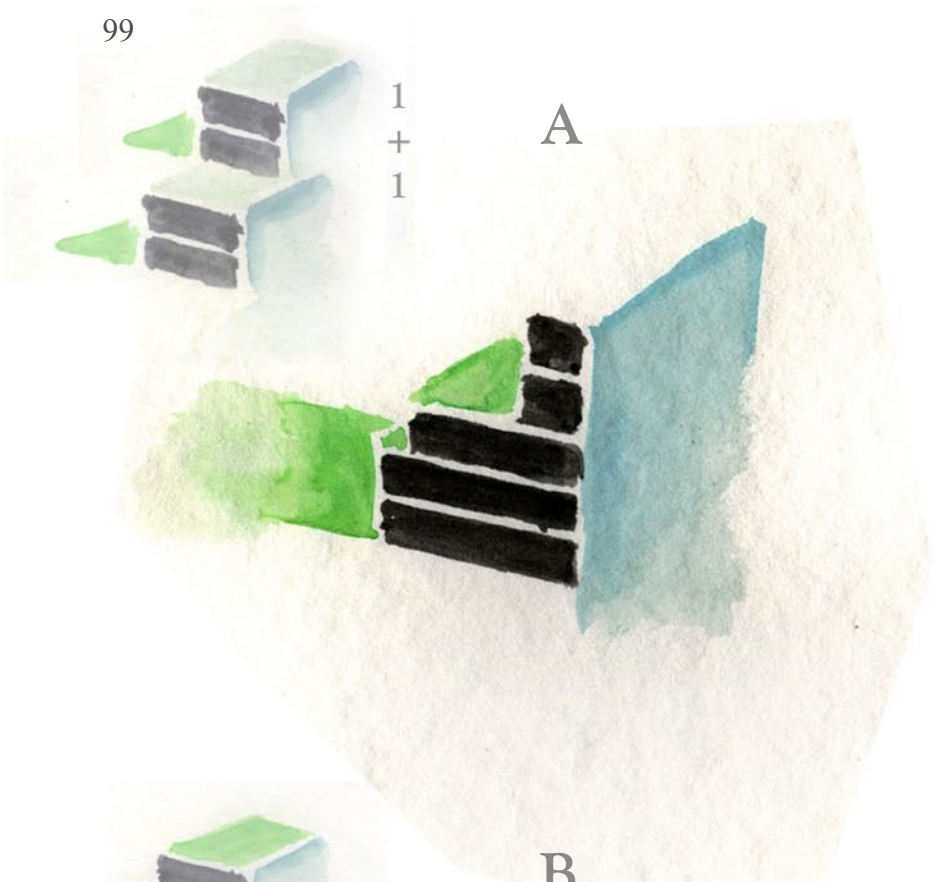
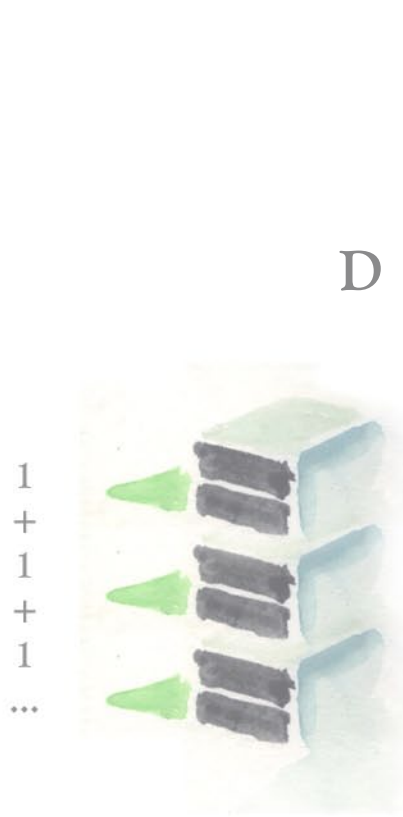
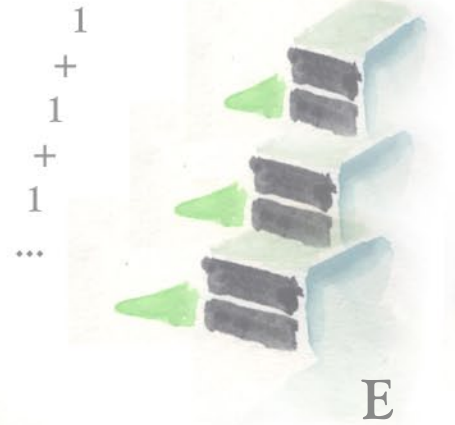
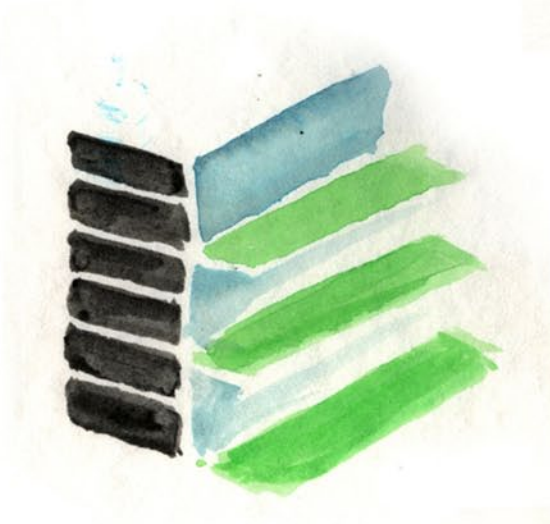


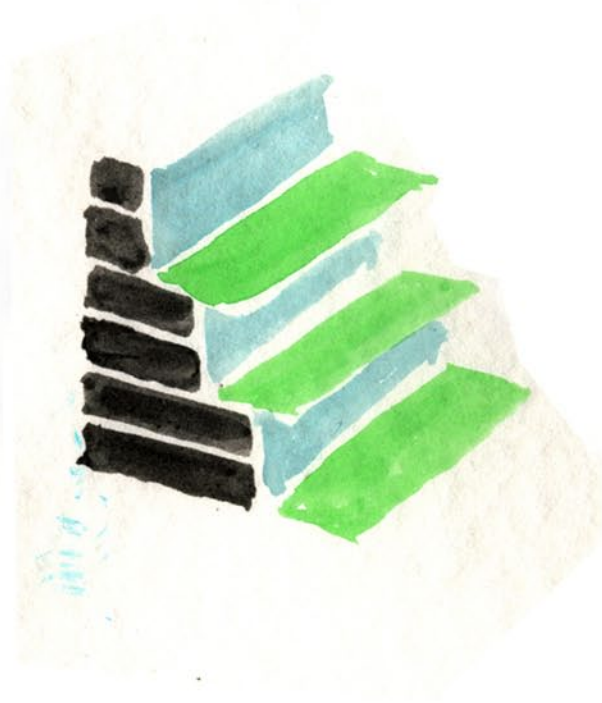
FIG. 4.33 SCHEMATIC TYPES ILLUSTRATED BY RELATION OF UNITS TO OUTDOOR SPACE



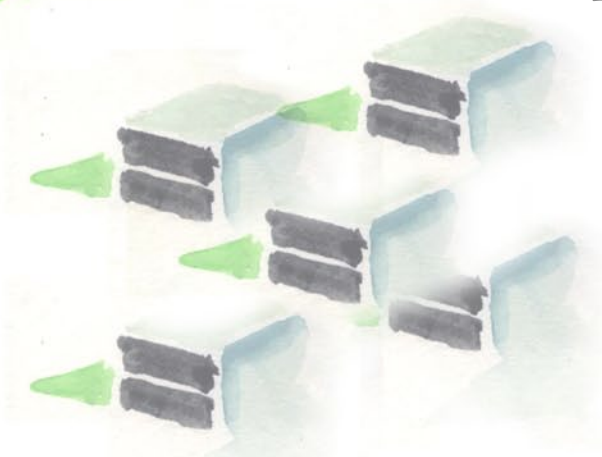
D



E



F



1 + 1
1
1 + 1

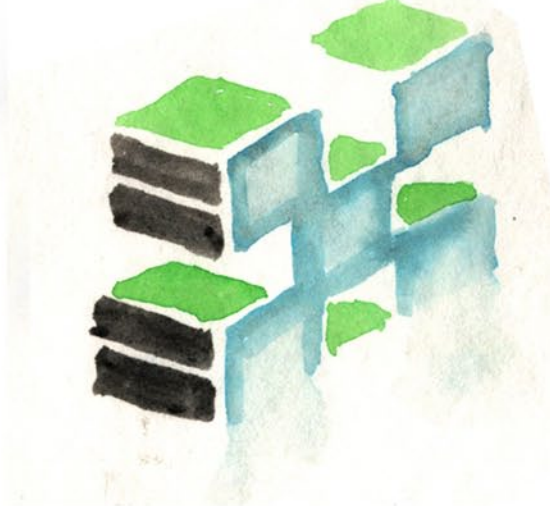


FIG. 4.34 TYPE A - STACKED ROWHOUSES WITH SET BACK ROOF TERRACES

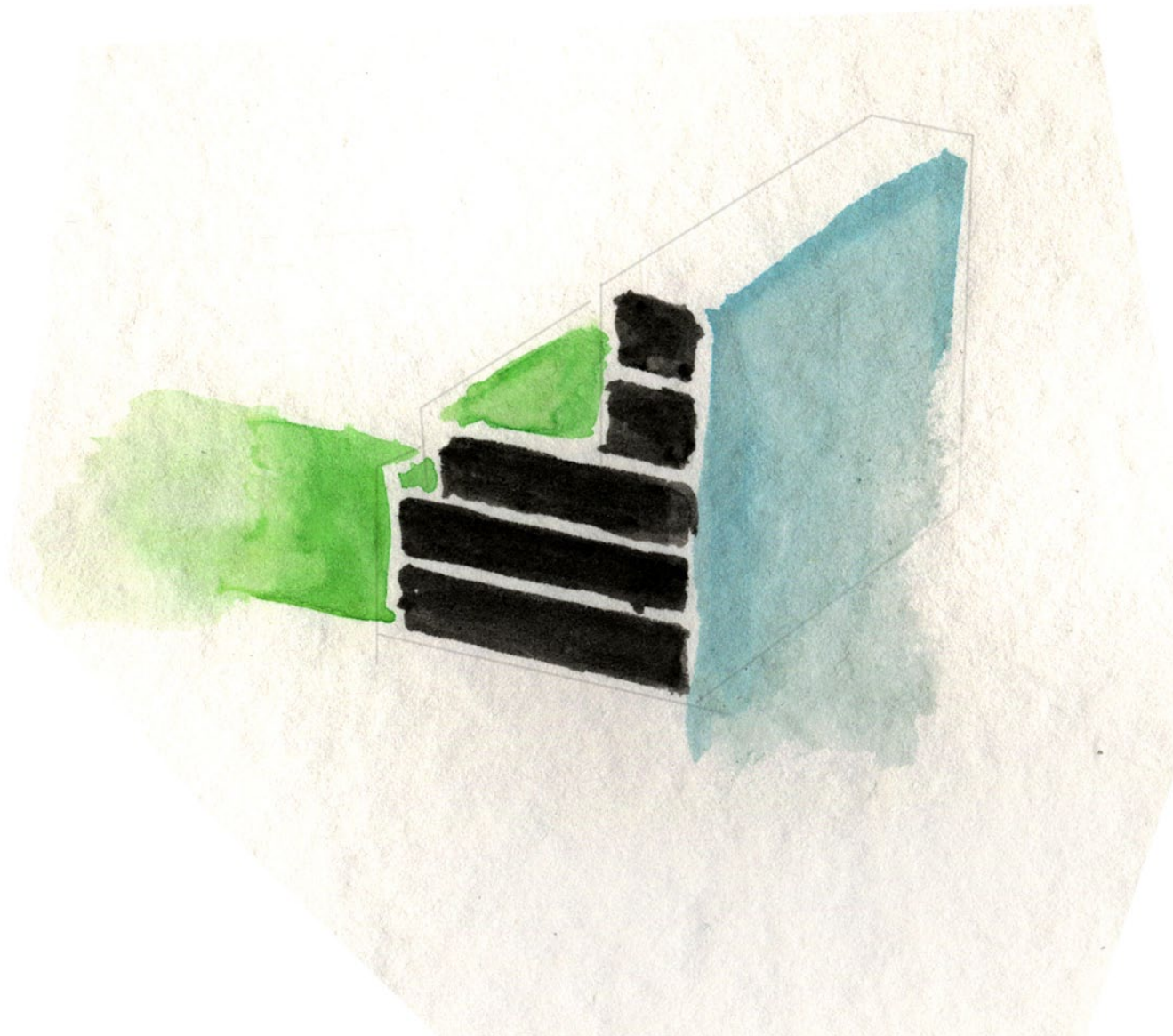
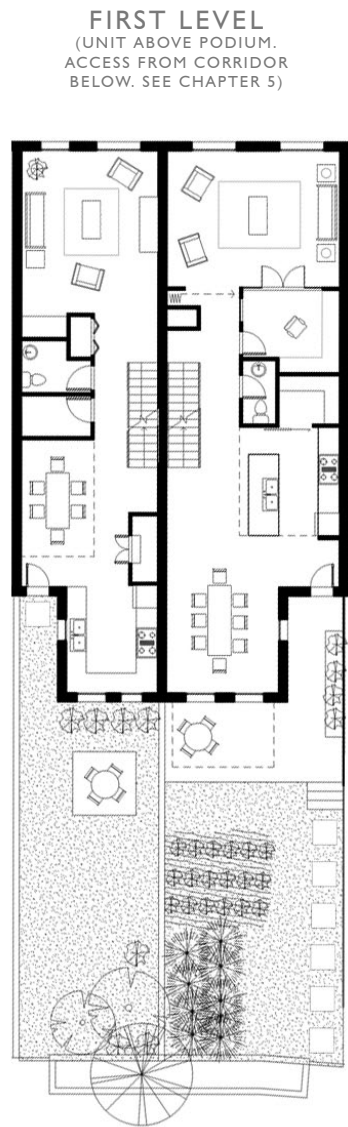




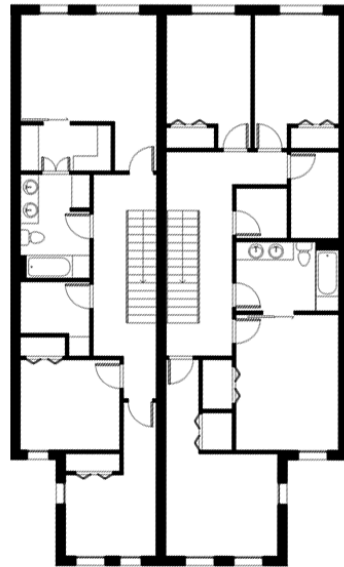
FIG. 4.35 TYPE A - STACKED ROWHOUSES WITH SET BACK ROOF TERRACES

FIG. 4.36 TYPE A DEMONSTRATION UNITS



ROW HOUSE UNITS
140 M² +

SECOND LEVEL

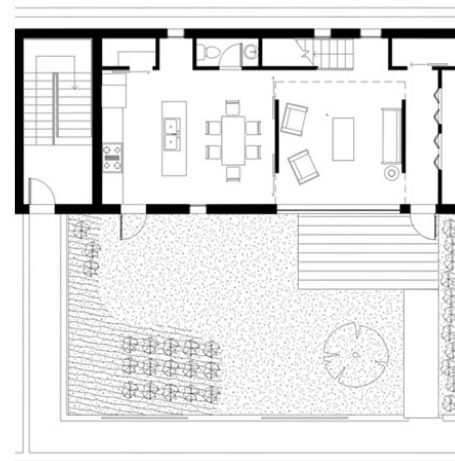


CORRIDOR



APARTMENT UNIT
50-100 M²

FOURTH LEVEL



MAISONETTE
90-150 M²

FIFTH LEVEL

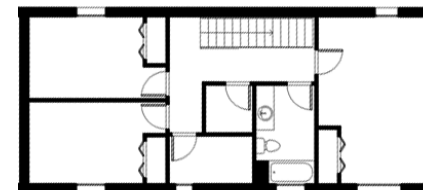
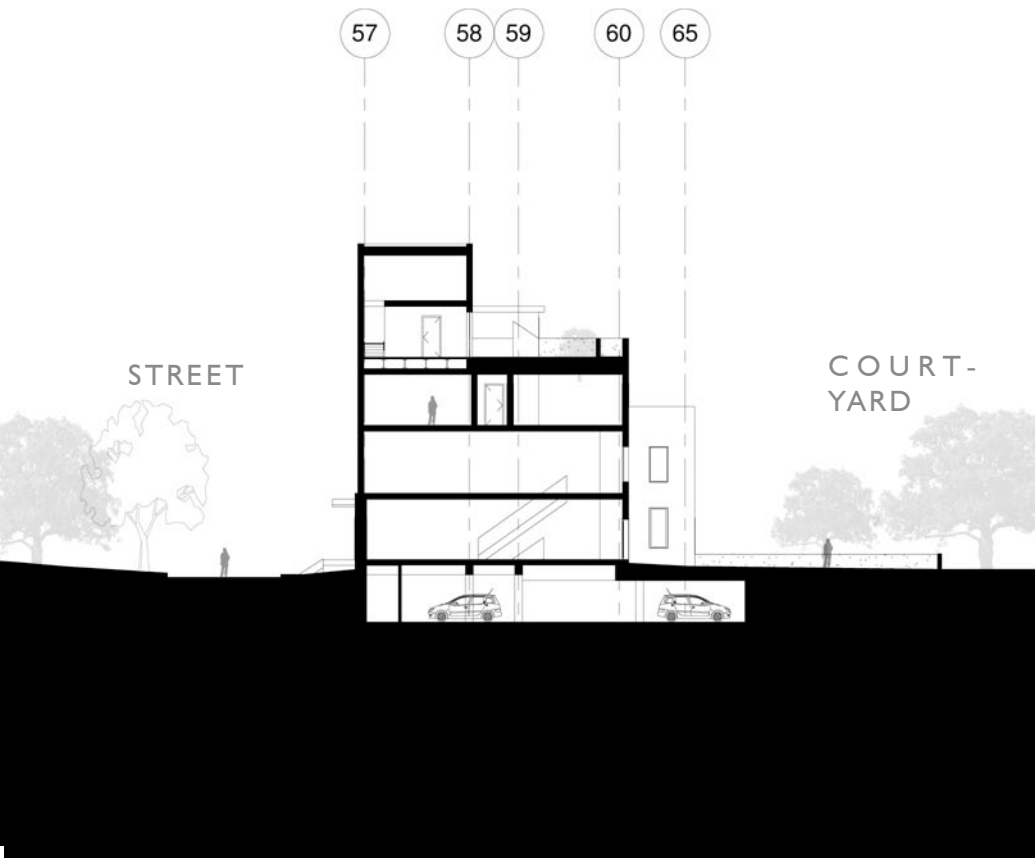


FIG. 4.37 TYPE A SECTION



Ext. to Int Floor Area	0.45
Range of Unit sizes (m ²)	50+
Approx Net F.A.R.	1.7
Approx. Net Density (p/Ha)	250 - 430
Approx Gross Urban Density - 50% net to gross (p/Ha)	125-215
Ext. Surface Area to Int.Floor Area	1.2
Percent Exterior area Glazed	~ 15 - 30
SIMULATED ANNUAL SITE ENERGY USE - OTTAWA (KWh/ m ²)	
Baseline design meeting envelope design recommendations	111
Baseline design, subtracting 50% from hot water and electricity loads for solar hot water and renewables	74

KEY FEATURES

- 2 storey units at grade with the potential to be re-organized into two one-storey units. One storey apartment units above accessed by corridor. Two storey maisonette units above accessed directly by elevator and stairs in some cases, by corridor or exterior walkway in others.
- Upper maisonette units open directly onto roughly 10m x 7m terrace with intensive green roof. First floor of maisonettes sits on raised floor to match height of green roof and create flexible mechanical and electrical cavity. Upper maisonettes potentially wood framed.
- Overall form solid at front to provide simple, unified, bright street facade. Form steps back in section at rear of building to create terraces, reduce overlooking of yards, and is recessed in plan on lower units to bring light deeper into space and provide more rooms with windows.

FIG. 4.38 POTENTIAL INTERIOR DAYLIGHTING STRATEGIES FOR DEEPER UNITS

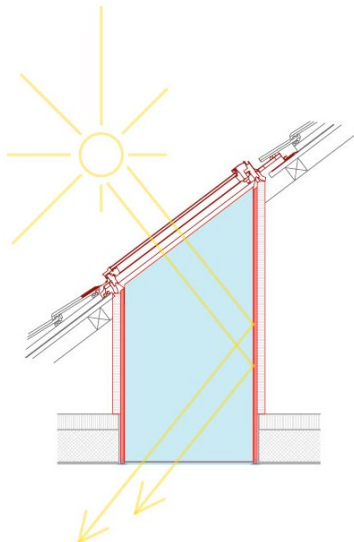


- Middle apartment units for smaller households. Universally accessible from double loaded corridor. Some units have access to smaller terrace
- Bottom units open onto yard. Accessed either at grade or by other means if on top of podium (eg. FIG. 5.44)
- 1 level below grade parking

ISSUES:

- Coordinating access to upper units more challenging
- Deeper lower units, but depth is comparable to many well used historic row houses, and depth offset by double aspect of unit
- Stepped form can be expensive

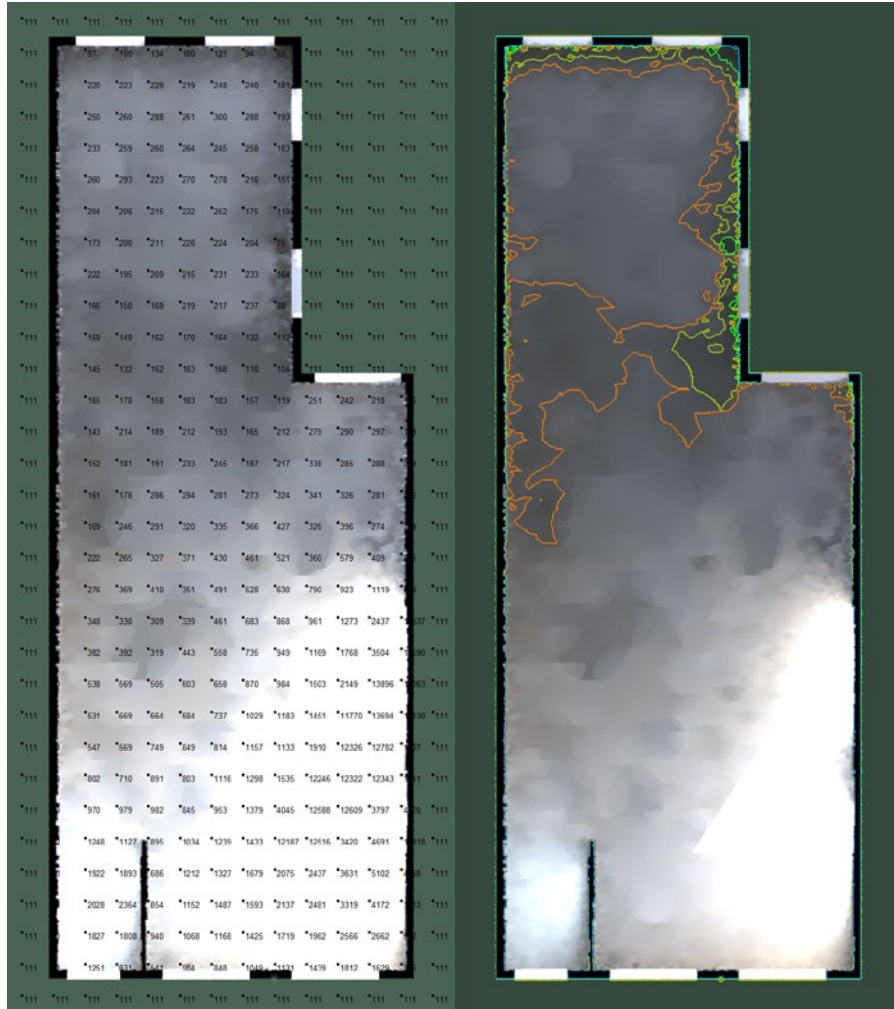
FIG. 4.39 POTENTIAL INTERIOR DAYLIGHTING STRATEGIES FOR DEEPER UNITS



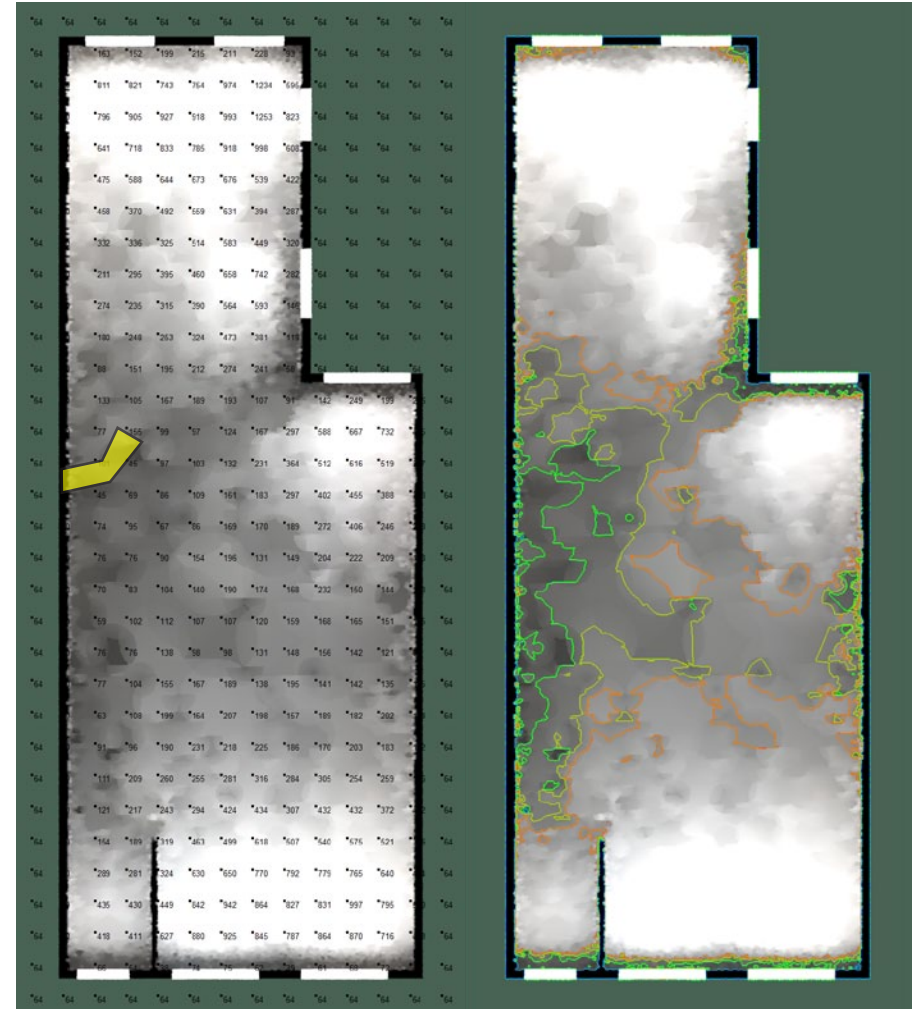
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FIG. 4.40 TYPE A DAYLIGHT ANALYSIS - ILLUMINANCE (LUX) - SAMPLE GROUND FLOOR

The daylighting figures show simulated illuminance levels (in Lux) for sample plans of the schematic design, at various times of year and with different sky conditions. The plan is 17 meters deep. Recommended illuminance levels for non-specific uses in residential occupancies fall between 50 and 200 lux. A hotel lobby, has a recommended illuminance of 100-200 lux. An office area might be at 400 lux.³⁸ The images below show that, at key times of the year (eg. winter solstice), the majority of space will be daylit above 50 lux, and most spaces in the building will be daylight above 100 lux. Note that, from image to image, the relative brightness of the image is not directly comparable because brightness is adjusted in each to create a legible image - numerical values must be used for useful comparisons. Areas shaded in yellow receive less than 50 lux of daylight illuminance.



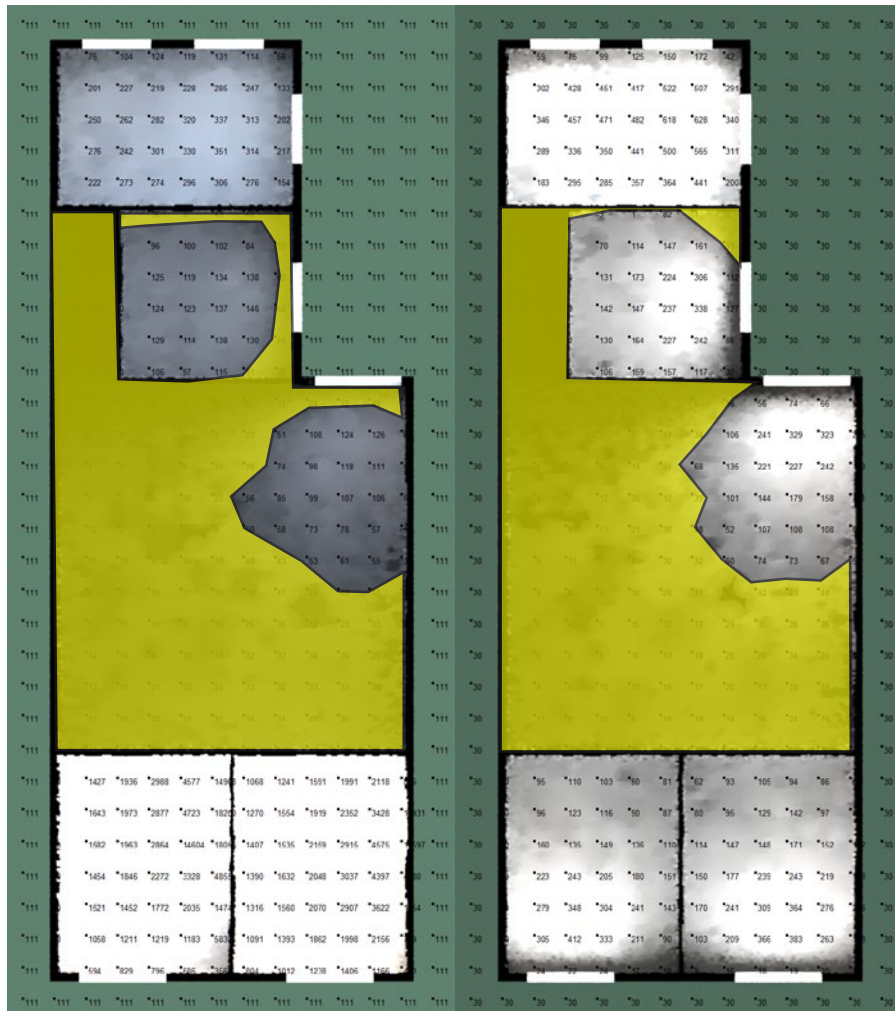
Sunny, Dec 21, 1400



Sunny, Mar 21, 1400

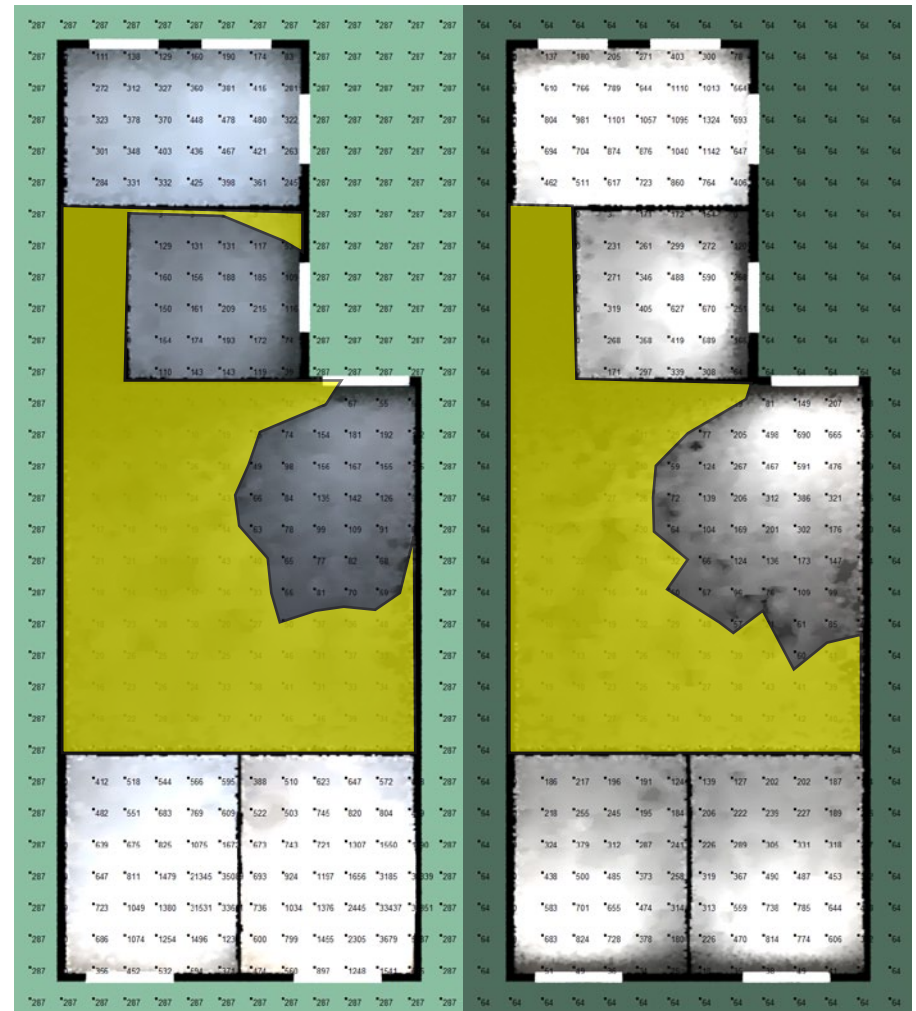
FIG. 4.41 ILLUMINANCE (LUX) - SAMPLE SECOND FLOOR

 Areas shaded in yellow receive less than 50 lux of daylight



Sunny, Dec 21, 1400

Overcast, Dec 21, 1400



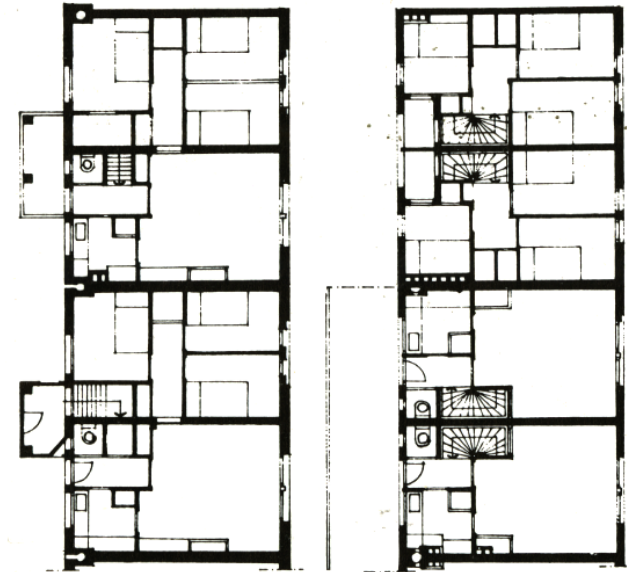
Sunny, Mar 21, 1400

Overcast, Mar 21, 1400

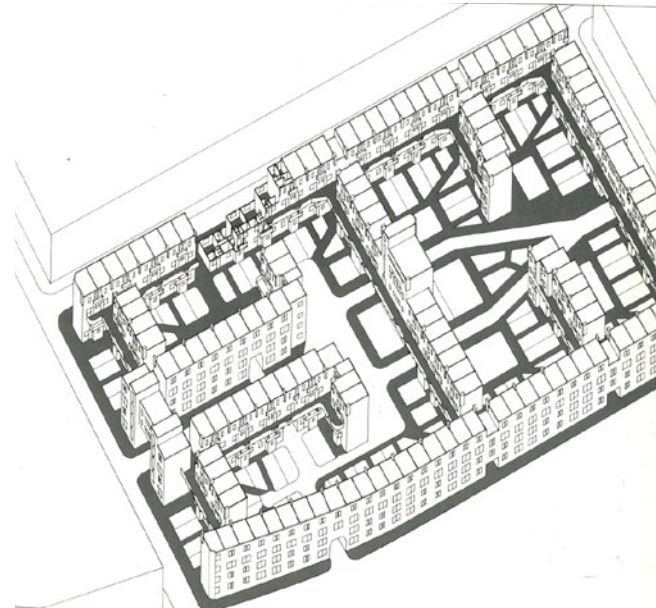


FIG. 4.42 INTERIOR COURTYARD

FIG. 4.43 EXTERIOR GALLERY



a
0 10 20 FT
0 5 10 M
FIG. 4.44 PLANS AND AXONOMETRIC



SPANGEN QUARTER - ROTTERDAM 1918

MICHIEL BRINKMAN

Approx Net F.A.R. 1.25

Approx. Net Density: 215-360 p/Ha

Approx. Gross Urban Density (50% net to gross): 110 - 180 p/Ha

Unit Access: Access at grade and elevators to exterior path

Outdoor Space: Courtyard divided into large shared areas and paths, smaller yards, and an open walkway.

The Spangen Quarter was developed as middle class social housing for the municipality of Rotterdam.³⁹ The project stacks two storey rowhouse units (or maisonettes) above one storey units on the ground and second floors. The maisonettes are accessed by a wide, elevated walkway at the third floor which doubles as an outdoor space. Units on the first two floors are accessed by entrances at grade with internal staircases. Like the Hydro Block, the inner courtyard of the Spangen Quarter has both smaller scale, more private outdoor spaces as well as larger public spaces. The organization of the spaces within the block are somewhat varied, while the exterior perimeter presents a uniform, unadorned wall.

URBAN CHARACTER

The plain facades facing the public streets surrounding the Spangen quarter are characterized by repetitive patterns of windows of the dwelling units. Unlike blocks of rowhouses, party wall housing, and seemingly most urban configurations, the units in the Spangen Quarter are accessed from interior courtyards, so there are very few doors that open onto the street. Despite the presence of the windows and occasional openings into the courtyards, this arguably creates a somewhat imposing and anti-social atmosphere in the public streets. There are no front doors, porches, stoops, and the sidewalks are quite narrow. This can be contrasted with the street facade of the Hydro Block (FIG. 4.46), which, though also quite spartan and plain, creates a more sociable street atmosphere with a pattern of front doors, terraces, windows and plantings. De-

velopments very similar to the Spangen Quarter block, located just a few streets over, also provide more animated streetscapes simply by providing a street side access and small balconies.

OUTDOOR SPACES

The Spangen Quarter is much more animated in the series of interior courtyards, which combine public spaces with more private yards. These open spaces are quite generous and provide a welcome change from the more austere streets. The gallery, which provides access to the maisonettes, even acts as a sort of “poor man’s terrace” with enough space for socializing, outdoor furniture and potted plants (see FIG. 4.43).⁴⁰ Spaces underneath the gallery are somewhat shaded however. This seems like it could be avoided by varying the depth of the units. This way facades would remain more brightly lit, and their appearance less sombre. This would also reduce the degree to which the top units overlook the more private interior courtyard spaces, and reduce the visual bulk of the buildings, giving the courtyard spaces a more open atmosphere.

SUMMARY

Spangen quarter provides an early modernist example of a social housing development which attempts to provide private and public open spaces within a relatively dense context. The gallery access to maisonette units is novel for the era, and it suggests some possibilities for stacking configurations of rowhouses, as well as terrace space for upper units. The street environment surrounding the complex would likely benefit from entrances for some of the units, and potentially some more varied program elements (commercial fronts, offices, or community programs) which opened onto the street.

- Denser type with inner courtyard providing combination of smaller yards and larger communal spaces
- Innovative use of gallery to provide access to maisonettes and modest terrace space. May be issues with privacy and views into units from walkway.



FIG. 4.45 HYDRO BLOCK COURTYARD



FIG. 4.47 HYDRO BLOCK COMMUNITY GARDEN

FIG. 4.46 STREET FACADE



HYDRO BLOCK - TORONTO 1978

DIAMOND AND MYERS

Approx. Net F.A.R. 1.72

Approx. Net Density: 290-500 p/Ha

Approx. Gross Urban Density (50% net to gross): 145-250 p/Ha

Unit Access: Access at grade, single flight of stairs to unit, single loaded skip stop corridor

Outdoor Space: Courtyard with shared spaces and community garden and individual private yards. Small terraces for upper apartments.

The Hydro Block, designed by Diamond and Myers, is a social housing project in the Kensington neighbourhood of Toronto. Single floor apartment units are accessed either from stairs off the street, or by a single loaded, skip-stop corridor. These units are above two story row houses accessed by stairs off of the street. There is a sizeable courtyard space behind the building, which is divided into shared space and small private yards for the rowhouse units. Some apartments units on the top floor have access to very modest private roof terraces. The project is an illustration of how relatively high densities can be reached in existing low rise neighbourhoods, while respecting their scale and providing useful communal and individual outdoor spaces.

URBAN CHARACTER AND EXTERNAL AMENITY

Some of the aesthetic of the development may seem somewhat institutional. Nevertheless the overall scale and massing of the Hydro Block, and the use of the rowhouse type, relate well to the surrounding low rise fabric of detached and semi-detached homes, while providing a good number of units and a reasonable increase in neighbourhood density. Clearly addressing the street, the residential units provide Jacobs' eyes on the street, lending the street a more social character. The development is a far cry from the large tower blocks which can both literally and figuratively come to overshadow well established, older urban neighbourhoods.

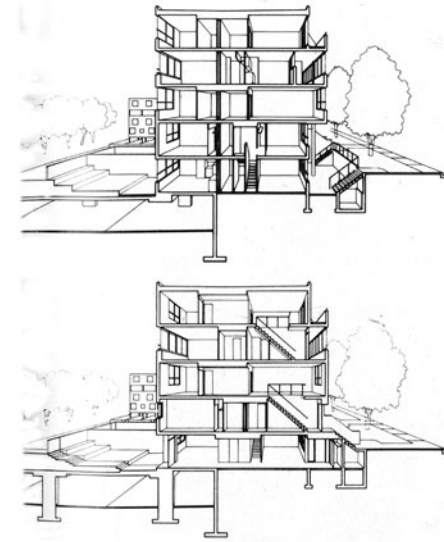


FIG. 4.48 SECTION

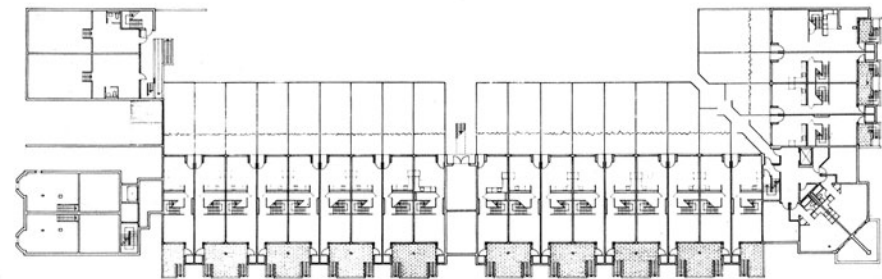


FIG. 4.49 GROUND FLOOR PLAN

It reflects the urban consolidation approach championed by Diamond, Myers, and Baird which emphasized urban densification through more modestly scaled projects implemented throughout the existing urban fabric.⁴¹

Because the development is in a well established central neighbourhood, rather than a peripheral location, residents have extremely easy access to a number of urban amenities. There are restaurants and cafes across the street. Subway stations, a number of major civic institutions, and shopping facilities are all within walking distance. Yet for all the urbanity and density of the development, it still retains a sense of the scale of the existing low rise neighbourhood, and a connection to intimate outdoor spaces, both private and public.

OUTDOOR SPACE

What is achieved on the Hydro Block site is a working synthesis of public and private outdoor spaces. The interior of the block, open to the residents, is not dominated by a single, large anonymous “public” grounds; the ground level row houses have more intimate yards which then open onto a well proportioned public space that is well used and maintained by residents. There is a flourishing, exceptionally well maintained community vegetable garden in the communal outdoor space (FIG. 4.47) and children use the space to play whenever the weather is nice.⁴² Units at the top floor also have small private terraces facing the street.

One key design decision which allows the Hydro Block to integrate the pleasant, and well used outdoor spaces is the decision to make the investment in a parking structure. Many developments of comparable density and form, seeking to avoid the costs of structured parking, lack the livability of the Hydro Block project as a result. Their courtyards are parking lots which have little or no outdoor spaces designed for people. These can give the development an antisocial, desolate character. By contrast, at the Hydro Block, parking is located below grade, and the space above is created as a modified ground plane, which, though less immediately noticeable than in projects such as the Freiburg settlement

or De Citadel Almere, is still an important piece of infrastructure which supports a wide range of uses, surface materials, and plantings, allowing for yards, gardens, and public courtyards.

ENERGY

The compact form of the Hydro Block, and its relatively modest amount of glazing, could mean that new projects taking a similar approach, with a good envelope and mechanical system, could reasonably be expected to have relatively good energy performance.

SUMMARY

The Hydro Block project illustrates ways in which higher densities can be achieved in existing urban areas of lower density without completely overwhelming the existing fabric, while providing a range of good private and public open spaces for the inhabitants. Moreover, as a social housing project, it shows that it can be made feasible for a wider range of income levels, with the proper investment. Even if some of the aesthetic of the building lends it an institutional character, it is gentle in overall massing and conception.

- Successful integration of urban density, public and private outdoor spaces in existing neighbourhood.
- Massing which achieves higher level of density but relates to existing neighbourhood.
- Investment in structured parking allows for combination of denser buildings and usable outdoor space.

FIG. 4.50 CITADEL ALMERE PLANS AND SECTIONS

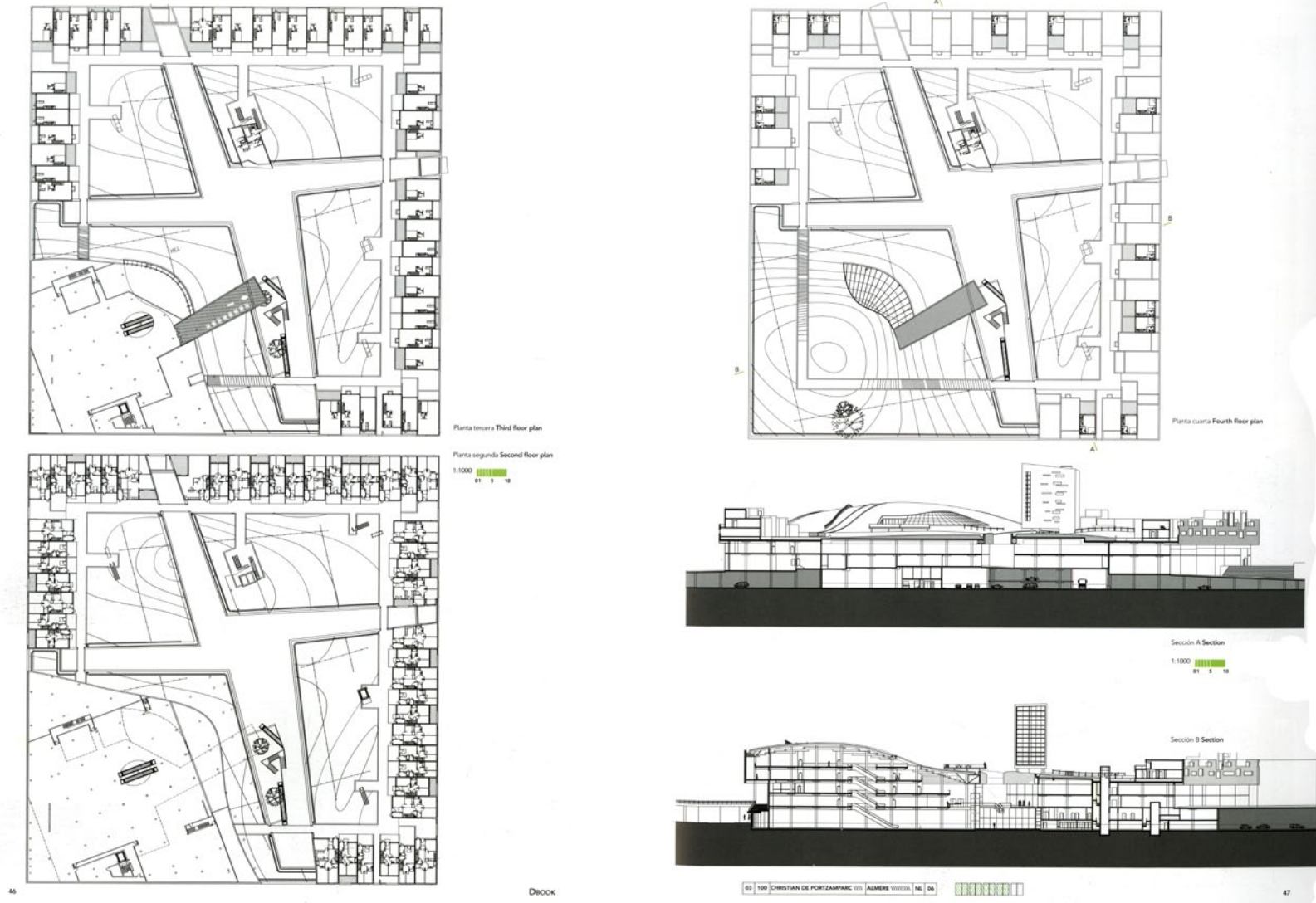




FIG. 4.51 ROWHOUSES AT ROOF LEVEL



FIG. 4.52 AERIAL RENDER

DE CITADEL ALMERE -
ALMERE, NETHERLANDS
2006
CHRISTIAN DE PORTZAMPARC

Approx. Net FAR (Dwellings and retail) : 1.5 - 2
 Approx. Net FAR (Dwellings only): < 0.5
 Net Density: 100 p/ha
 Approx Gross Urban Density (50% net to gross): 50 p/Ha
 Unit Access: Elevators to exterior path
 Outdoor Spaces: Extensive pedestrian paths at grade and on roof, large vegetated lawn on rooftop.

The Citadel Almere is a central component of an OMA masterplan for the relatively young city of Almere. The complex itself is designed by Christian de Potzamparc, taking cues from the OMA plan. The Citadel is explicitly designed around the notion of vertical layering of uses - part of the OMA concept for the site - and this is evident in the final product. This makes the project hugely relevant as a precedent, given that intelligent layering of uses, including various outdoor spaces, is one of the strategies discussed in this thesis. The layering of uses places parking and vehicle circulation below grade, a large shopping centre, public plazas and pedestrian streets at the ground and first floors, and residences and a semi-public field above.⁴³

OUTDOOR SPACES

The Citadel Almere provides generous open spaces. Two wide pedestrian streets cross through the block, and the block is surrounded by pedestrian-friendly open spaces. Probably the most striking feature of the development is the wide, grassy field that is formed by the roof of the shopping centre - a sort of modified ground plane. The individual rowhouses face onto this field, which acts as a sort of formal lawn.

While this lawn no doubt provides a pleasing visual amenity to

the inhabitants, its implementation, while visually dramatic, is revealed to be somewhat disappointing. It is an extensive green roof, which means inhabitants cannot walk on it. It cannot be modified and supports no real activity. It cannot support individual or community gardens, or children's play, which seems like a missed opportunity. Compared to the following precedent - the Solar development in Freiburg - which has a less dramatic but more useful vegetated roof, the Citadel roof is somewhat cosmetic in terms of its social uses. The potential exists in the scheme for a much more dynamic outdoor space, providing a much wider range of amenity. This said, the scheme still presents an interesting precedent and at least *suggests* interesting possibilities - possibilities which are made real in some of the following precedents.

INTEGRATION OF MIXED USE

While mixed use buildings often incorporate only small retailers or offices with larger complexes of living units, Citadel Almere is interesting because it integrates a large shopping mall containing both large and small retailers, with relatively low density rowhouses. It is an illustration that mixed use does not necessarily entail a particular housing type (eg. apartments), or program type for the base. With sufficient access to transit and enough parking capacity (Almere features 2 levels of underground parking) larger retail tenants can also be accommodated where this is beneficial. Also, like other projects we look at, the retail base, with limited need for daylight, allows for a deep plan with high site coverage (~86% coverage), with narrower floorplates in the residences above for better access to daylight and outdoor air.

SUMMARY

De Citadel is a good illustration of the general idea of the strategic stacking of uses - both in terms of interior and exterior spaces - and the possibilities they present. Ground level remains free for pedestrians and public uses, while areas above have plenty of sunlight, open space, and verdure. At the same time, the stacked configuration of major retail,

parking, and housing ensures a much more compact use of land than would a similar, but horizontally organized scheme. In addition we could well imagine that various areas of what is currently the inaccessible formal lawn could be used in a variety of different ways, including community gardens, gathering spaces, and small individual yards for the rowhouses.

- Example of strategic vertical layering of large and small commercial space, row houses and apartment buildings, and public and semi-public outdoor space.
- Clear implementation of a modified ground plane.
- Shows an approach to urban intensification that uses a mix of dwelling types, integrating housing types other than apartment units.
- Large floorplate allows high site coverage, yet residential units above have good access to natural light and views.
- Integrates outdoor spaces and vegetation: roof plane as formal lawn, pedestrian paths through large block



FIG. 4.54 STREET FACADE



FIG. 4.53 ROOFTOP ROW HOUSES

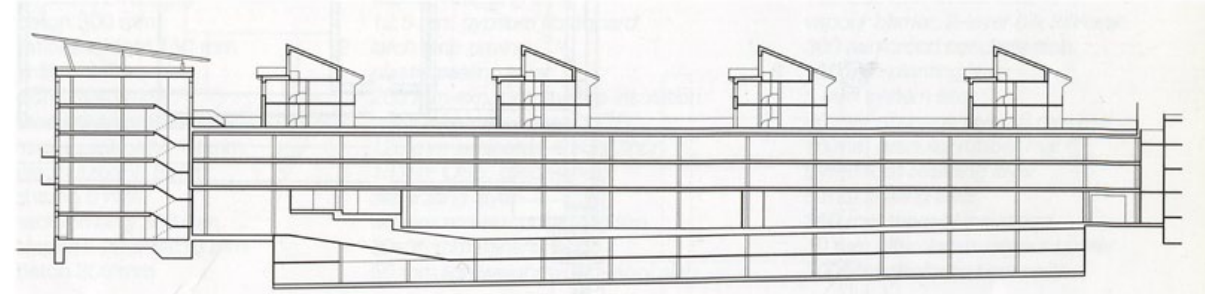


FIG. 4.55 LONGITUDINAL SECTION

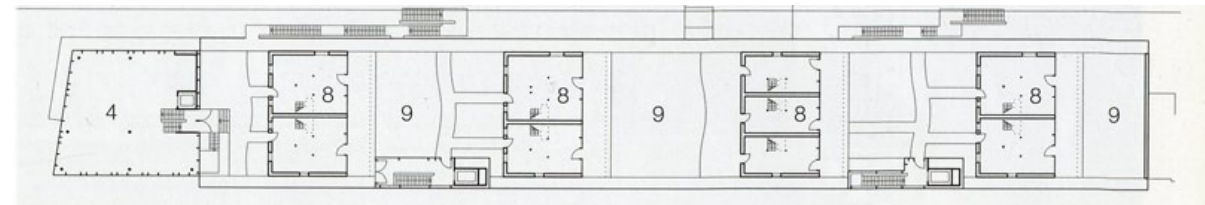


FIG. 4.56 4TH FLOOR PLAN AT ROOFTOP ROWHOUSES

VAUBAN SOLAR SETTLEMENT FREIBURG - 2000 ROLF DISCH

Approx Net F.A.R. (Houses only): 0.5
Approx Net F.A.R. (Houses + Podium): 1.95
Approx Net Density: 80-130 p/Ha
Approx Gross Density (50% net to gross): 40-65 p/Ha
Unit Access: Elevators to exterior path
Outdoor Space: Flexible vegetated terraces. Landscaped retail street-front.

The Vauban Solar Settlement is a net *positive* energy mixed use development consisting of dwellings, offices, and retail. The dwellings consist of a mix of row houses at grade, and similar rowhouses placed atop a three storey podium (the 'sunship') which contains the offices and retail. Using the roof of the podium to create generous and flexible individual outdoor spaces for the dwellings, the project is an innovative, high performance example of the use of a modified ground plane to create new outdoor spaces integrated within a mixed urban fabric with a good balance of public and private amenities.

While the podium structure is reinforced concrete, the rowhouses are of light wood construction, demonstrating that relatively inexpensive home building techniques can be adapted for freestanding dwellings atop a larger structure.⁴⁴

URBAN CHARACTER

While the rooftop terraces provide private outdoor spaces for individual households, the podium underneath provides more public uses such as retail, offices, and non-profit institutions. It also creates an animated and colourful public streetfront which integrates with local transit.

Compared to some other forms of dwelling fabric, the population density of this project is relatively low. However, as previously noted, population density is only one measure of the compactness of an urban

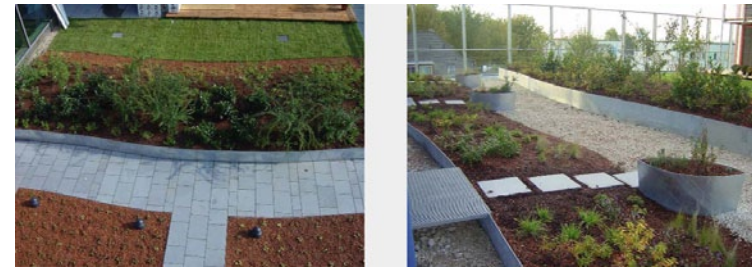


FIG. 4.57 ROOF GARDENS

fabric. By integrating commercial space - including some larger retailers and offices - the Freiburg development not only provides nearby amenities and important programs, but it also frees up space which may have otherwise been used for these programs, thereby leading to an overall increase in urban density.

OUTDOOR SPACE

The roof of the three storey commercial podium acts as a sort of

modified ground plane for the rooftop dwellings. The 300mm concrete roof slab, which is extremely heavily insulated, supports a 150mm deep extensive planting layer, as well as live loads from occupants and guests, creating a lushly vegetated terrace - protected from the wind by a three metre tall glass guard - which is well suited to a number of outdoor activities. The planting layer and incorporation of beds can support a variety of vegetation, enabling residents to plant gardens. The flexibility of these spaces creates a wider range of potential outdoor amenity.

ENERGY

Without measuring, we can infer, based on dwelling type, that the ratio of surface area to floor area for the Freiburg rowhouses should be smaller than for detached houses, yet is probably significantly larger than more compact forms of dwellings, such as stacked rowhouses, or apartment buildings with double loaded corridors. Yet this moderate surface-area to floor area ratio is more than made up for by the performance of the building envelope, and the extensive use of renewable energy. Even the extensive south facing glazing goes beyond the norms of typical construction in several respects: glazing is triple paned and the strict orientation permits solar gains which are controlled by overhangs and dynamic shades. Roofs and walls have at least 300mm of mineral fibre insulation, which, excluding any thermal breaks, translates to an R value of R-36.⁴⁵ Thus we have a relatively compact form, with an excellent thermal envelope. Adding energy generated by the extensive PV arrays yields a net energy positive development which actually creates an income for residents when they sell excess energy to the grid.

SUMMARY

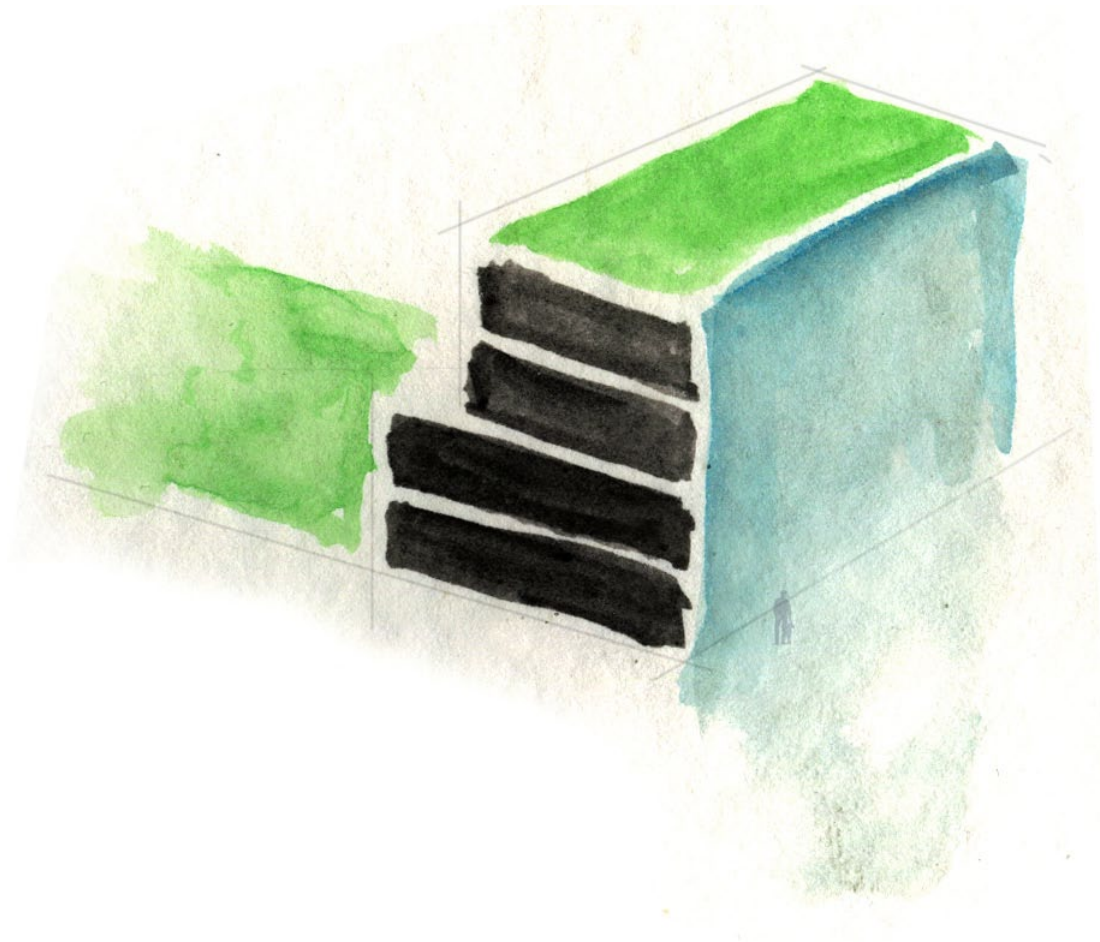
The solar development in Freiburg is an excellent example of a modern, mid-density community which actually delivers exceptional, and *measurable*, energy performance. Given how many residential projects are marketed as sustainable, regardless of their energy performance, this is a somewhat unique feature. The project also stands out in the way

that it makes much more use of the site than would typical residential developments of single family homes, and helps create a much more urbane fabric, while at the same time offering dwellings with a wide range of amenities, such as ample access to light, air, and outdoor spaces. Moreover, the modified ground plane element which creates many of the outdoor spaces is a significant piece of infrastructure that allows inhabitants to use the terrace spaces in a variety of ways, capable of supporting lawns and gardens with a variety of plants and hardscaping.

KEY POINTS

- Example of effective mix of uses employing modified row house type.
- Clear and effective use of modified ground plane showing a range of possibilities opened up by a flexible, modified ground plane that uses a substantial intensive green roof.
- Highlights what can be achieved in terms of energy performance with a highly insulated, tight envelope, careful orientation and glazing strategies, and integration of renewable energy.
- Combination of concrete podium with light frame wood construction for residences above allows for use of economical structure for residences.

FIG. 4.58 TYPE B - STACKED ROWHOUSES WITH ROOFTOP TERRACES



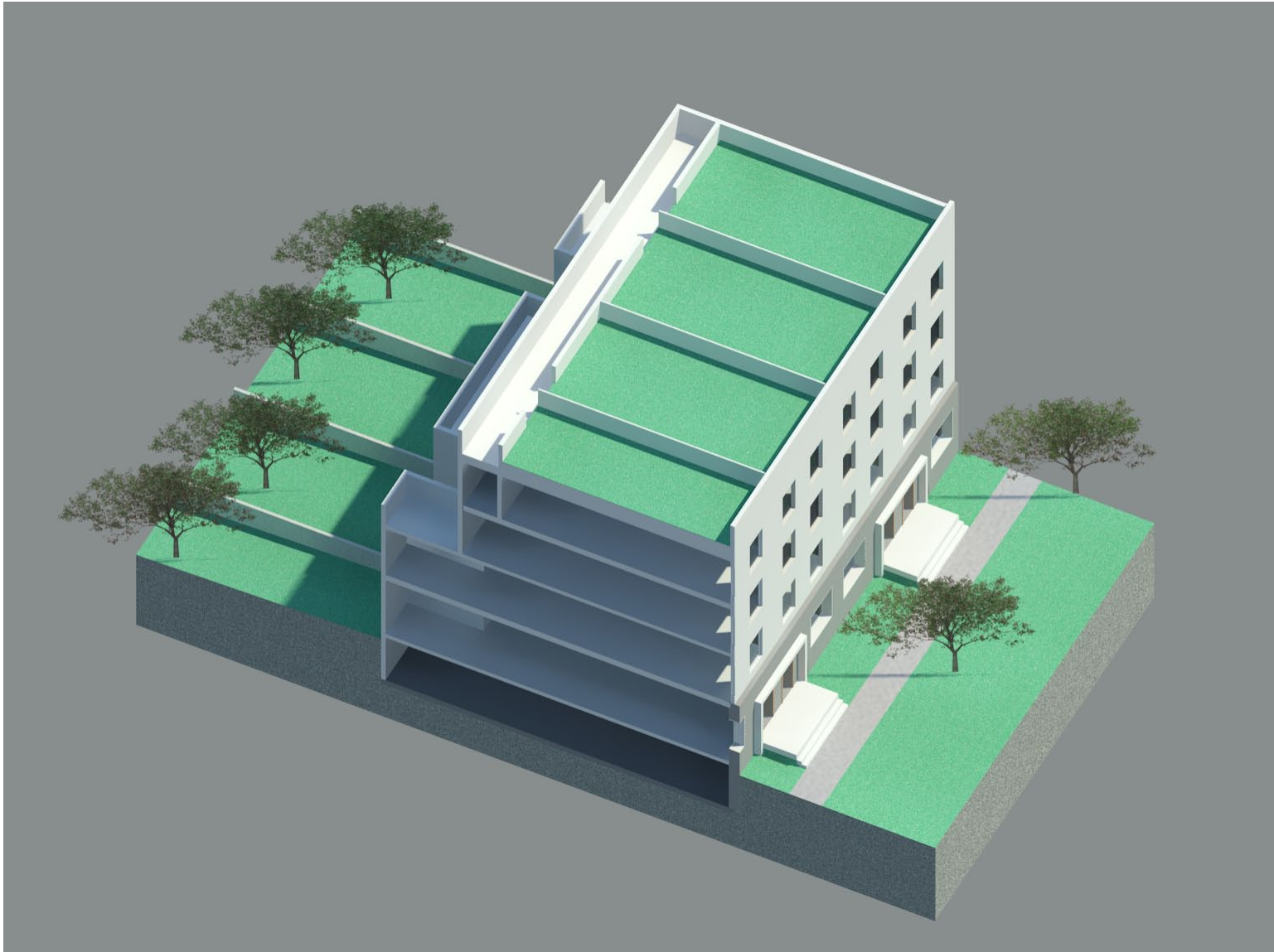


FIG. 4.59 TYPE B - STACKED ROWHOUSES WITH ROOFTOP TERRACES

FIG. 4.60 TYPE B DEMONSTRATION UNITS - 1:200

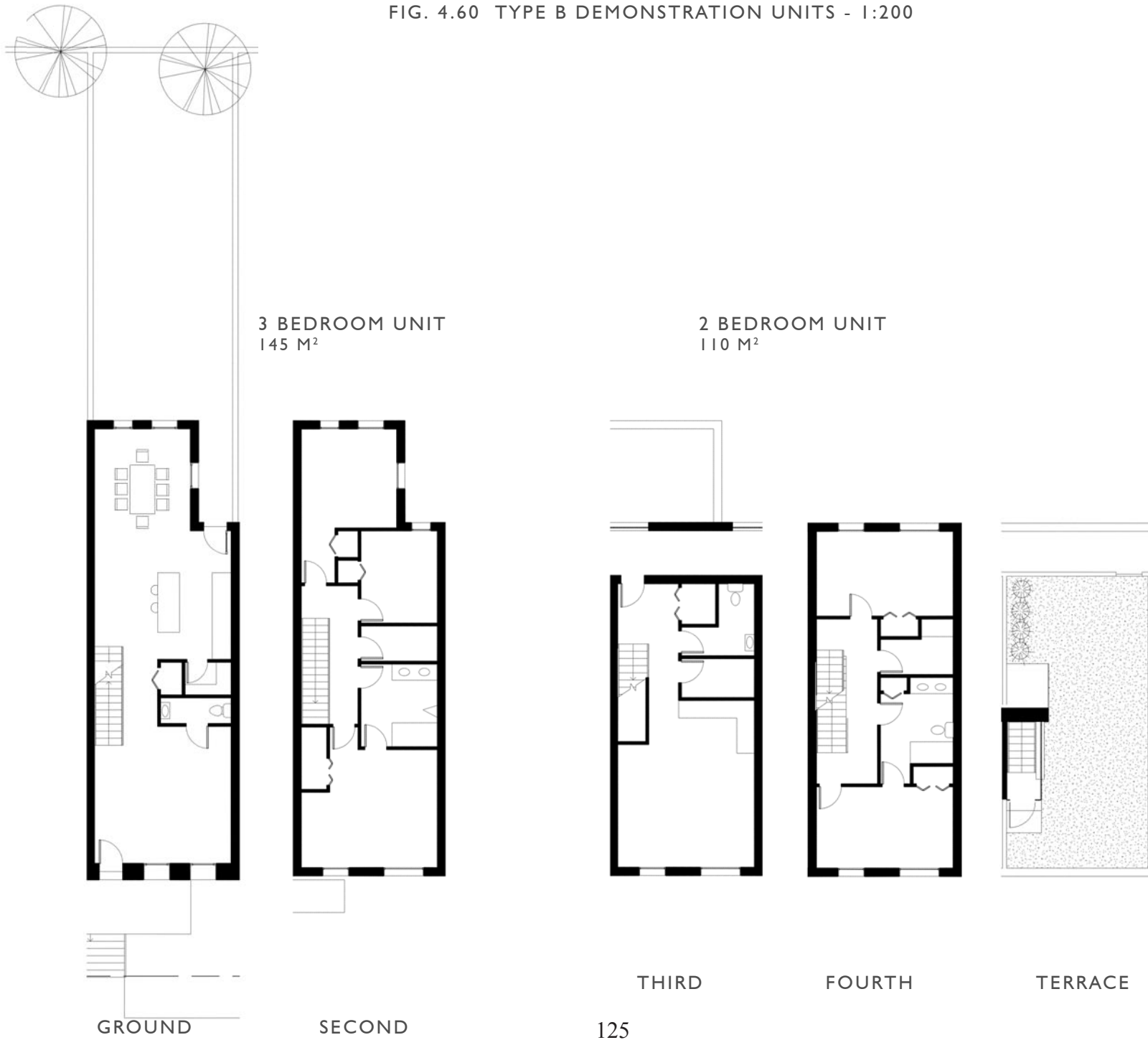
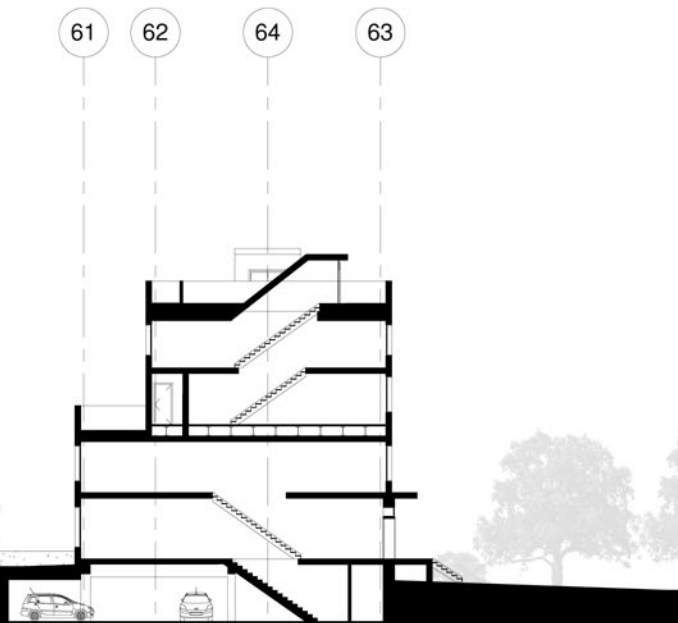


FIG. 4.61 TYPE B SECTION



Ext. to Int Floor Area	0.5
Range of Unit sizes (m ²)	80+
Approx Net F.A.R.	1.7
Approx. Net Density (p/Ha)	265- 450
Approx. Gross Urban Density - 50% net to gross (p/Ha)	150 - 255
Ext.Surface Area. to Int.Floor Area	1
Percent Exterior area Glazed	30
SIMULATED ANNUAL SITE ENERGY USE - OTTAWA (KWh/ m ²)	
Baseline design, meeting envelope design recommendations	100
Baseline design, subtracting 50% from hot water and electricity loads for solar hot water and renewables	67
Baseline design adding dynamic shading, increased insulation, window R value, and air tightness.	85

KEY FEATURES

- Stacked two-storey units
- Lower units accessed at grade or, if commercial at grade, through corridor and/or external paths. Access to modest yard. Overall form solid at front to provide simple, unified, street facade. Form steps back in section at rear of building to create terraces, reduce overlooking of yards, and allow for more sun into courtyard. Building is recessed in plan on lower units to bring light deeper into space and provide more rooms with windows.
- Upper units accessed by corridor. Access to rooftop terraces. Significant area of terrace as flexible intensive green roof. Space can be provided for solar hot water and/or photovoltaics

- Rooftop terrace access options: Stair leading directly from upper floor of upper units, through roof, to terrace (shown in FIG. 4.60), or external stair on exterior of building. External stair less convenient but retains more area for roof terrace and does not require large openings through structure.
- Double aspect, long and narrow units - similar to typical older row houses in this respect.
- 1 level below grade parking
- Top units stepped back slightly to avoid excessive overlooking of bottom unit yard, create sense of greater openness from yards, and allow more sunlight into yards.

ISSUES:

- Roof terraces not directly visible from within units - less useful as outdoor area for very young children
- Snow accumulation on terraces

THIN FLATS - PHILADELPHIA 2009

ONION FLATS

Approx. Net F.A.R. 2.26

Approx. Net Density: 430 p/Ha

Approx. Gross Urban Density (50% net to gross): 160-300 p/Ha

Unit Access: Access at grade, single flight of stairs to upper unit

Outdoor spaces: Vegetated roof terraces and small grade level yards

Simulated Site Energy Use: 104 KWh/m² ⁴⁶

Cost: \$2250USD/m² (\$210 USD/sq.ft.) ⁴⁷

Approx Sales Price: \$300+ USD/sq.ft. ⁴⁸

The Thin Flats are a reinterpretation of the common, deep, narrow Philadelphia rowhouse. The project is four storeys with two, two-storey row house units stacked one above the other. The lower units open onto a small yard at grade, while the upper units access a vegetated terrace that sits on the modified ground plane at roof level. The double aspect of the units enables light and views from both sides, as well as the possibility of cross ventilation. Additionally, light wells and translucent floors bring light into the deep (approximately 20m) floorplate. According to the building's architect and developer, Tim Macdonald, the units are occupied by a relatively diverse range of inhabitants, including families with children, young couples and professionals, groups of roommates, and so on.⁴⁹

Individual units are fairly large at around 220 square meters, though the plan likely allows for the possibility of easily dividing the lower units into two units with separate entrances, though the organization of the stairwell in the upper units would make this more difficult. Regardless, the wood frame structure does make the internal configuration of the units more flexible than a steel or concrete frame.

URBAN CHARACTER

At an F.A.R. of 2.26, the Thin Flats have a reasonable urban



FIG. 4.62 SECTIONAL PERSPECTIVE



FIG. 4.63 ROOFTOP TERRACES

density in a configuration that provides many important amenities. The massing of the Thin Flats relates well to the surrounding urban fabric, by borrowing from adjacent and prevalent row-house types and massing. Like the Hydro Block, by facing directly onto the street, the flats provide eyes on the street, lending it a safe and sociable atmosphere.

OUTDOOR SPACE

The rooftop terraces evidently support a fairly diverse range of surfaces and plants, which gives them a certain flexibility, and provides a welcome green space. The green roof is described as “semi-intensive” so it is not clear exactly to what extent the planted areas of terrace can support various plantings and human traffic. A significant portion of the remaining open space at grade is used for surface parking, somewhat impinging on the amount of outdoor space available to the lower units. However, the scale of the parking area is not dominant, and at only nine units, the limited scale of the project may have reduced the economic viability of structured parking.

ENERGY

The project is said to use 60% less energy use than typical new construction, and is certified LEED platinum, which does entail some level of commitment to sustainability. Simulations projected energy use at 104 KWh/m², which essentially meets the current target set out by the thesis. A number of factors contribute to the energy performance of the building, including:

- Good surface area to floor area ratios.
- Relatively good insulation
- Solar hot water - becomes more important as other areas of energy use are optimized.

SUMMARY

The Thin Flats are an excellent example of modestly scaled urban dwellings on a number of fronts: they provide a good level of density, light, indoor and outdoor space, at a scale which references and fits comfortably within the existing urban fabric, and does not overwhelm or overshadow neighbouring sites. Moreover, the building massing, envelope, and incorporation of efficient systems result in a project with a relatively good overall energy performance.

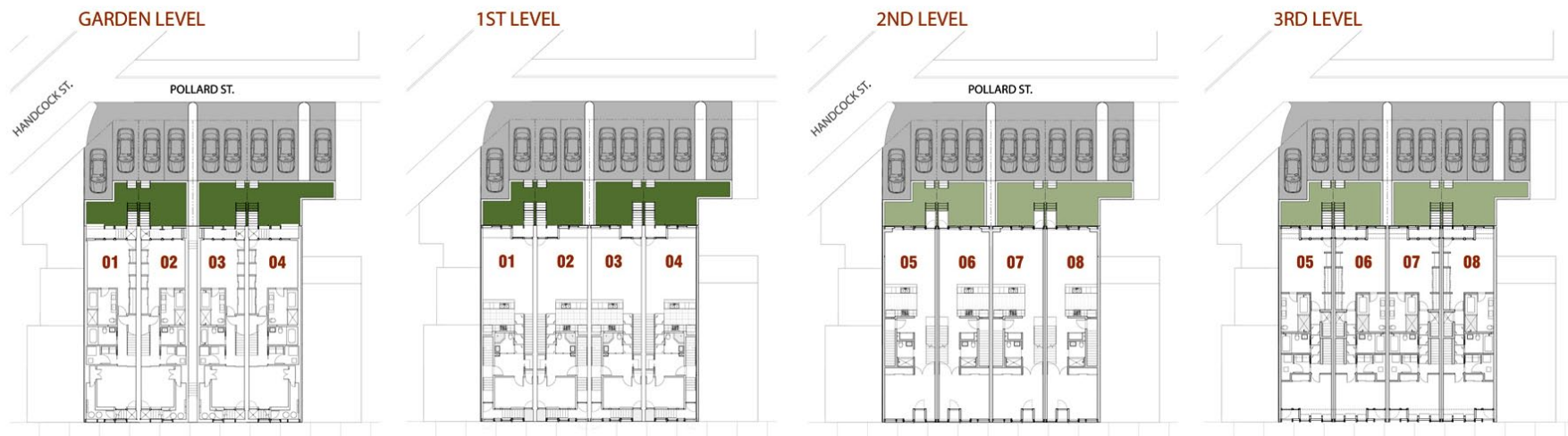


FIG. 4.64 THIN FLATS FLOOR PLANS

REDPATH STACKED TOWNHOMES TORONTO - 1996 ARCHITECT UNKNOWN

Approx. Net F.A.R. 1.6

Approx. Net Density: 270-460 p/Ha

Approx. Gross Urban Density (50% net to gross): 135-230 p/Ha

Unit Access: Access at grade, private stairs to upper units

Outdoor space: small rooftop terraces, shared alleys between buildings.

Approx Re-sale Price: \$350-400 CAD /sq.ft.⁵⁰

The Redpath townhomes are an example of what is a much more common approach to stacked townhomes in Toronto. Typically, these are back-to-back units, resulting in mostly single aspect units. Upper units have access to a small rooftop balcony, while lower units may open onto shared open spaces or public spaces. As back-to-back units, some of the amenity of the double aspect rowhouse - looking onto a street at one end, and onto a more quiet court at the other, and with more varied access to light throughout the day - is lost. The rooftop patio provides some outdoor amenity, however, as a patio, it provides much less flexibility and potential than the terraces examined in some of the other precedents.

KEY POINTS

- Established type demonstrating some feasibility of the stacked rowhouse approach in Toronto.
- Configured more as apartment units than as rowhouses: back to back, mostly single aspect.
- Limited outdoor spaces for rowhouse type: small rooftop patio, narrow pedestrian lanes surrounding building.
- Back to back configuration means there is little differentiation between public street face of building and interior courtyard space.

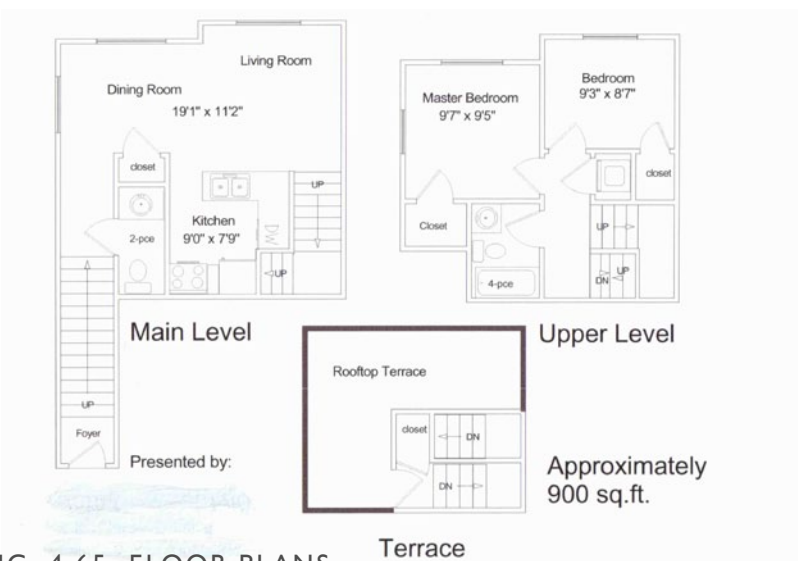
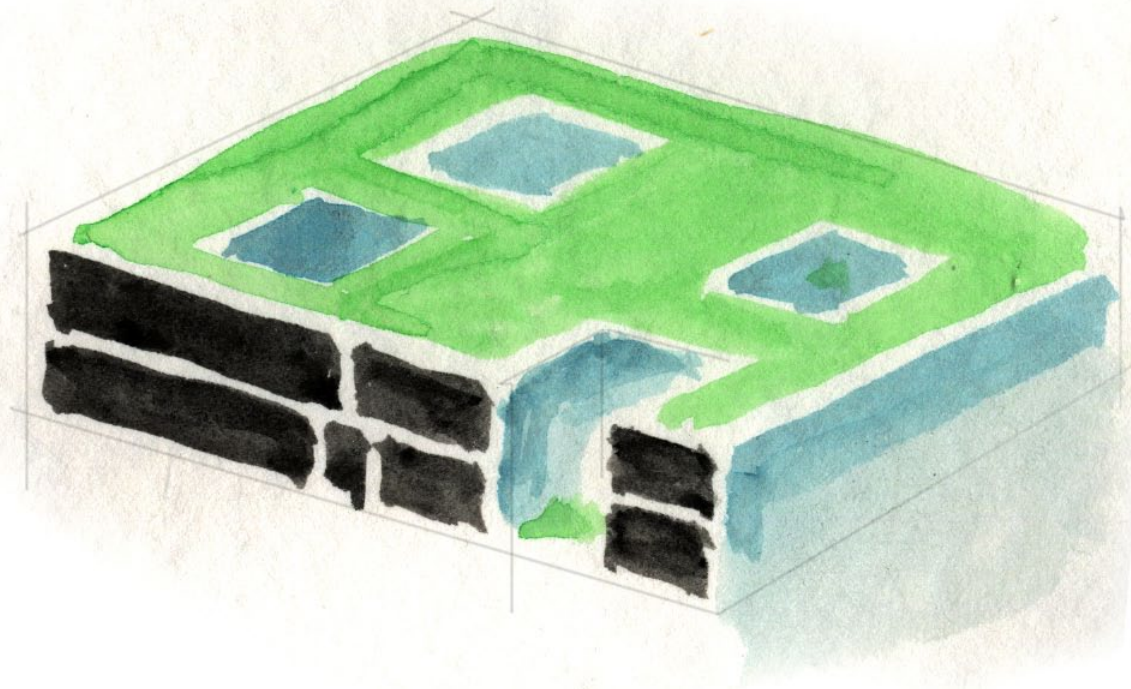


FIG. 4.65 FLOOR PLANS



FIG. 4.66 VIEW FROM STREET

FIG. 4.67 TYPE C - ATTACHED COURTYARD DWELLINGS



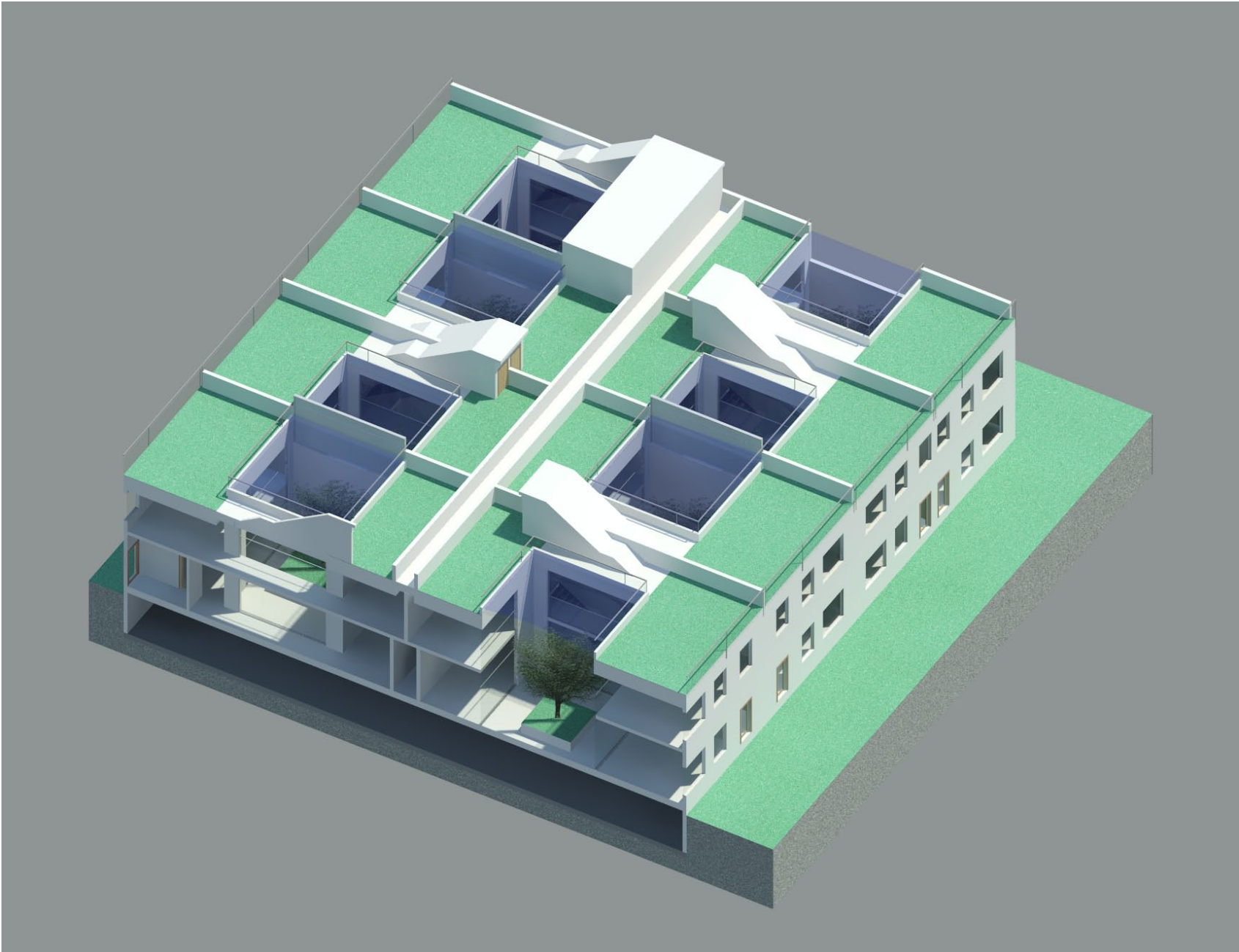
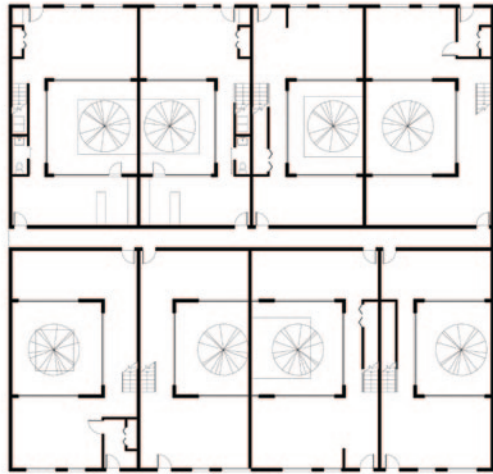
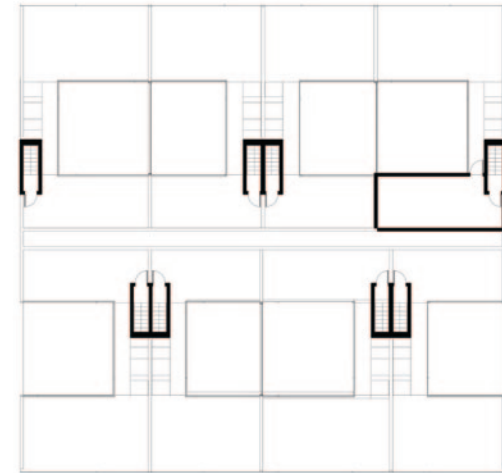


FIG. 4.68 TYPE C - ATTACHED COURTYARD DWELLINGS

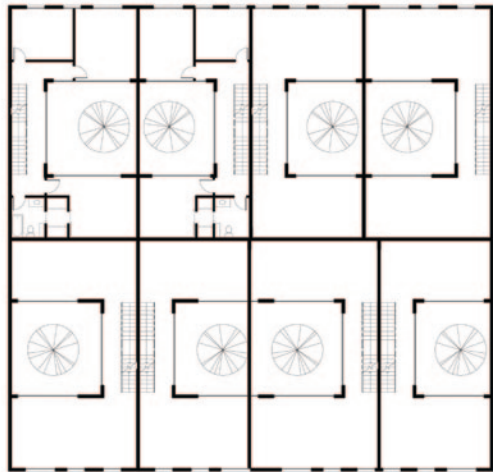
FIG. 4.69 TYPE C DEMONSTRATION LAYOUTS - 1:500



GROUND FLOOR

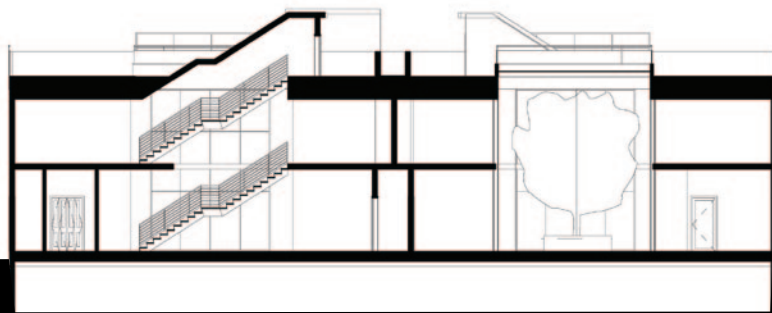


ROOF TERRACES



SECOND FLOOR

FIG. 4.70 TYPE C SCHEMATIC SECTION



Ext. to Int Floor Area	0.7
Range of Unit sizes (m ²)	100+
Approx Net F.A.R.	1.3
Approx. Net Density (p/Ha)	200 - 330
Rough Gross Urban Density - 50% net to gross (p/Ha)	100 - 165
Ext.Surface Area. to Int.Floor Area	0.9 (enclosed courtyard) 1.4 (open courtyard)
Percent Exterior area Glazed	~ 30 (including glazed court)

SIMULATED ANNUAL SITE ENERGY USE - OTTAWA
(KWh/ m²)

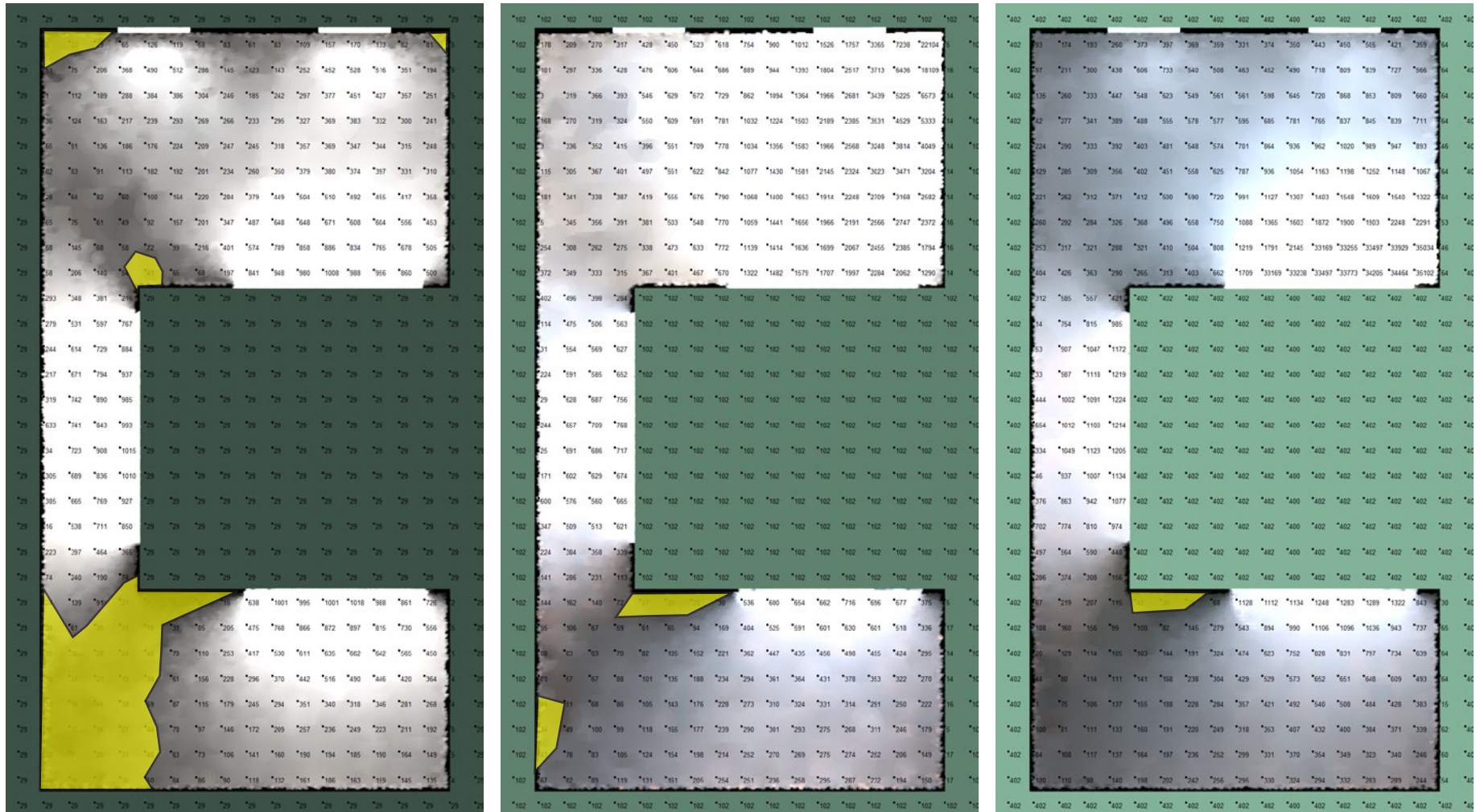
Baseline design meeting thesis envelope design recommendations.	137 KWh/m ²
Baseline design, subtracting 50% from hot water and electricity loads for solar hot water and renewables.	95 KWh/m ²

KEY FEATURES

- Central courtyard space, potentially altered with seasons. In winter: potentially enclosed with glazing or ETFE cushions creating heated winter garden. Prevents snow accumulation in courtyard, keeps external surface area minimized. Despite large ETFE area, overall building glazed area remains somewhat modest with compact form and modest amount glazing on other facades. Allows diffuse light into spaces. In summer glazing or ETFE opened and courtyard open to air.
- Roof terrace provides additional outdoor space with access to full sun year round. Also provides space for potential addition.

DAYLIGHT ANALYSIS

FIG. 4.71 ILLUMINANCE (LUX) - GROUND FLOOR - NORTH FACING UNIT



Overcast, Dec 21, 1400

Sunny, Dec 21, 1400

Sunny, Jun 21, 1400

Areas shaded in yellow receive less than 50 lux of daylight

- Virtually all rooms face onto courtyard space - heavy glazing is possible in envelope around courtyard if space is closed off during winter months

ISSUES:

- Limited direct sunlight in courtyard space
- Lower density than other types explored
- Higher energy use
- Potentially complex scheme for seasonal courtyard modification

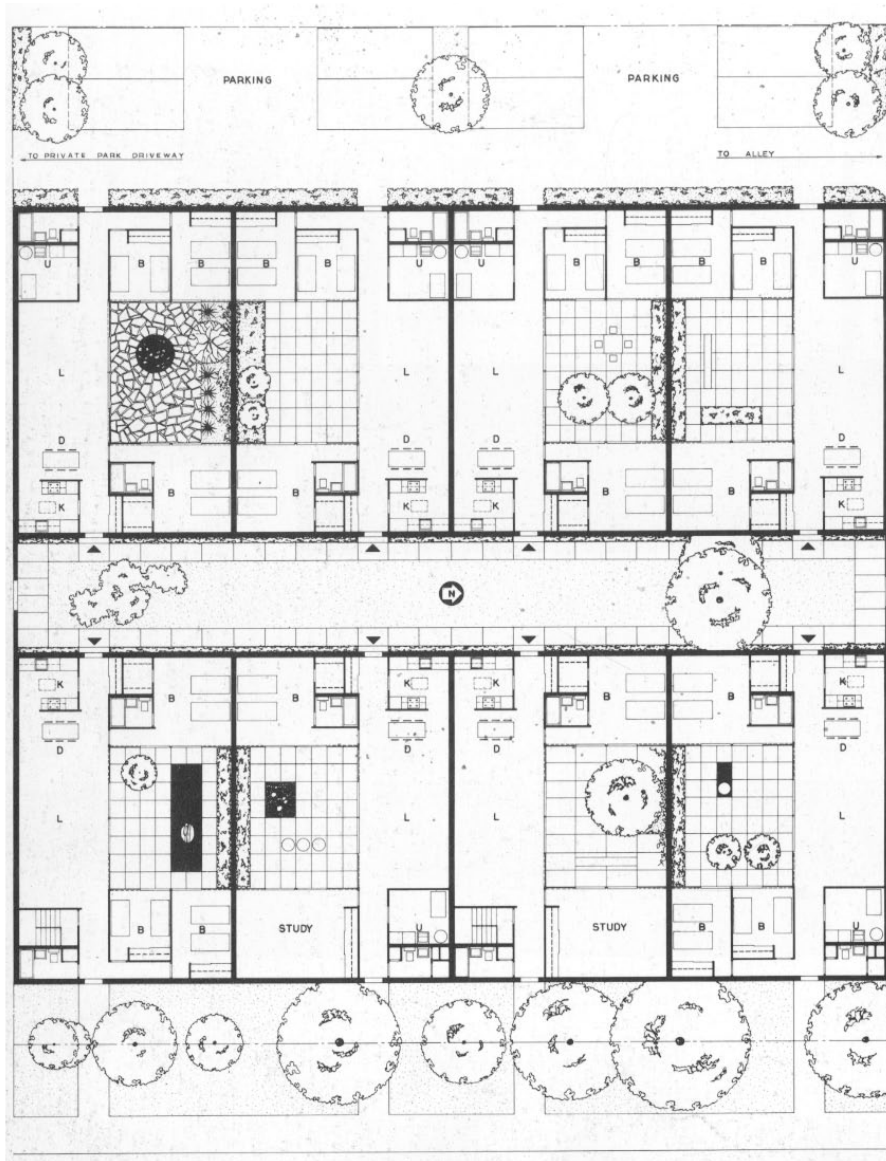


FIG. 4.72 ATRIUM PLANS AND PHOTOS
 Clockwise from top: Floor plan, shared courtyard, private courtyard.

MADISON PARK ATRIUM HOUSES CHICAGO - 1961 Y.C. WONG

Approx. Net F.A.R.: 0.5
Approx. Net Density: 80-130 p/Ha
Approx. Gross Urban Density (50% net to gross): 40-65 p/Ha
Unit Access: At grade
Outdoor Space: Small private courtyards and larger shared courtyard

Examples of multi-unit courtyard dwellings in Canada and the United States are few and far between. The courtyard dwelling is not an established type in our housing culture, likely due to its relative scarcity in many western European cultures, and the predominance of the row-house type. The courtyard dwelling is a more prevalent type in Southern American countries, influenced by Spanish and Portuguese colonial powers. Nevertheless, examples of courtyard dwellings in Canada and the United States do exist. The Madison Park houses are one such example. Somewhat similar to traditional Chinese and middle eastern courtyard houses, the exterior walls have few or no windows, and rooms are arranged entirely around the courtyard.

URBAN CHARACTER

Given the complete lack of windows facing either the street, or the semi-public space in the centre of the block, the scheme is rather introverted, similar to the urban fabric of many ancient middle eastern and Chinese cities.

The houses are some of the lowest density precedents examined in the thesis. While the character is radically different, the level of density is comparable to many suburban neighbourhoods primarily composed of two storey detached and semi-detached homes. The density of this scheme could of course be increased by adding a second floor to the scheme, perhaps adding some windows to compensate for the increased

shadowing of the courtyard space, and in order to connect more to the street.

OUTDOOR SPACE

The scheme creates a variety of outdoor spaces by providing both internal private courtyard spaces and a semi-public space in the centre. Private spaces are small, but receive a good deal of light, and seem relatively flexible, capable of supporting various paved surfaces, plants, and even trees. The courtyard space provides light to the interior of the houses, and a visual connection to the outdoors from almost every major room in the house.

The semi-public space at the centre presents various possibilities. It can be used as a place for children to play - though the fact that no windows overlook the space means it would be difficult for parents to supervise the space. Adjacent kitchen spaces, for example, could have windows opening onto this space. The shared space can also be used as a social space where inhabitants of the complex can informally meet and socialize.

ENERGY

With a good envelope, one might expect a moderate level of energy performance from this housing form, given the following points:

- Form not particularly compact with one storey and open courtyard.
- Little glazing at exterior walls but extensive glazing in courtyard.

SUMMARY

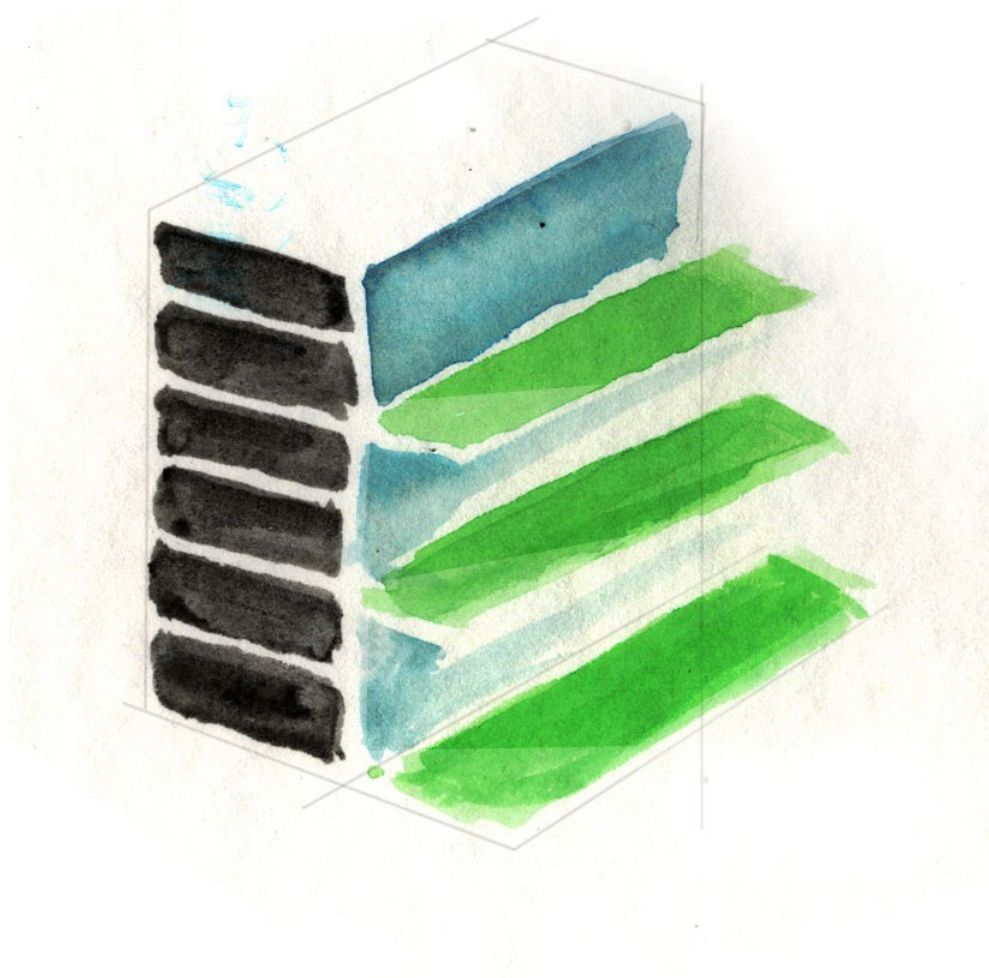
The Madison Park dwellings are an interesting example of a type rarely seen in North America. Some units in the complex are listed for sale at \$379,000 USD, which is an above average sale price for the area - even in terms of price per square foot⁵¹ - indicating that the dwellings are used and relatively sought after, thus illustrating *some* potential viability

of the type in North America, and in a relatively northern climate.

The dwellings could potentially contribute better to the surrounding fabric if some windows opened onto the street and the inner shared courtyard. While relatively low density, the project density could be easily be increased by adding a second storey.

- Example of North American courtyard housing providing mix of shared and private outdoor spaces.
- Relatively low density form that could be reconceived in higher density two storey form.

FIG. 4.76 TYPE D - MID-RISE STACKED DWELLINGS WITH VERTICALLY STACKED TERRACES



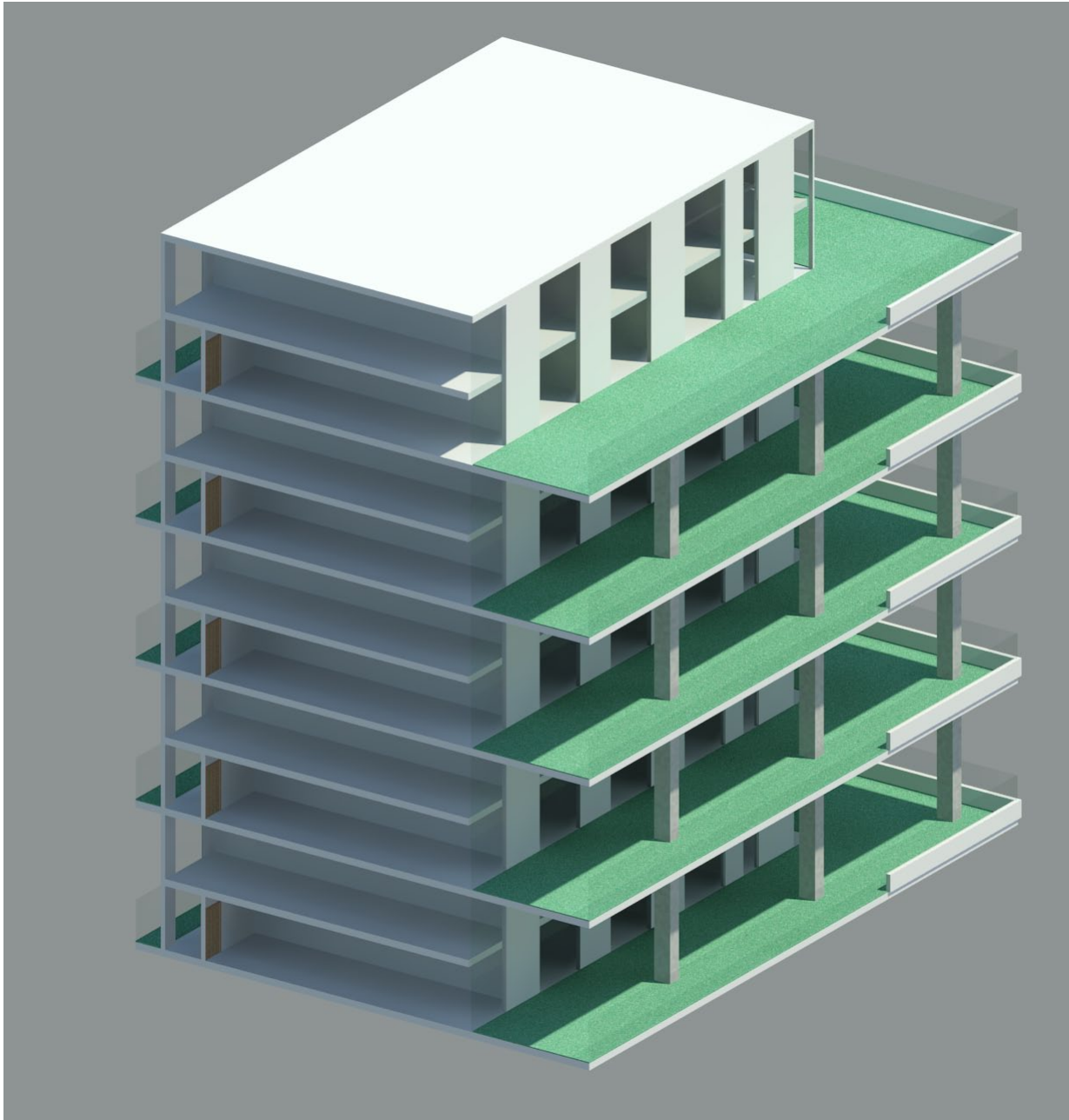
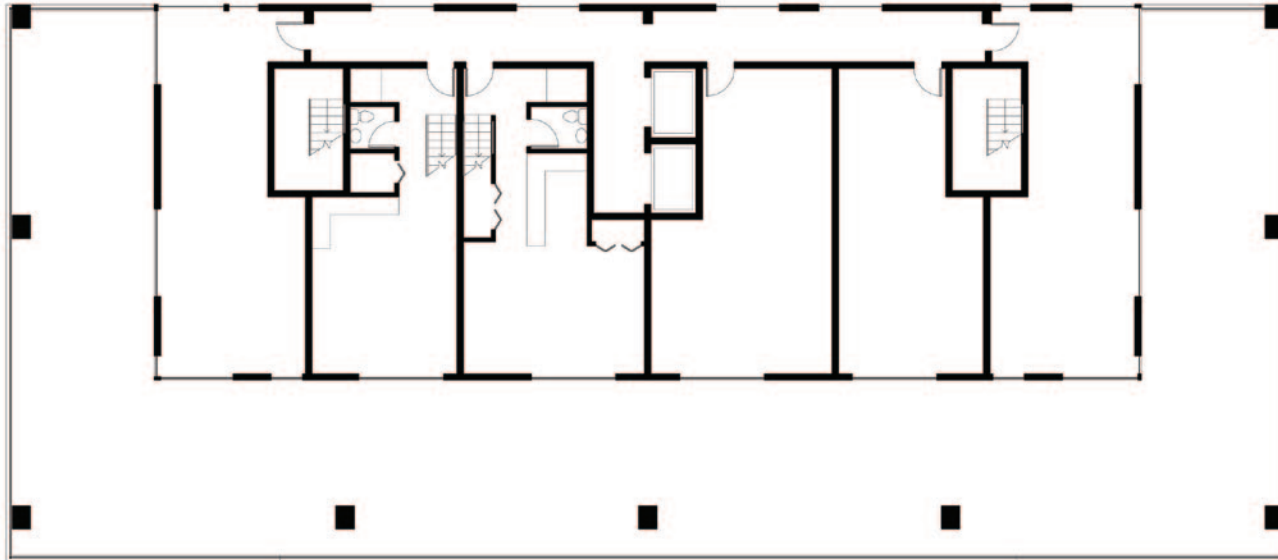


FIG. 4.77 TYPE D - MID- RISE STACKED DWELLINGS WITH VERTICALLY STACKED TERRACES

FIG. 4.78 TYPE D DEMONSTRATION LAYOUT AND UNITS - 1:250



Lower Floor



Upper Floor

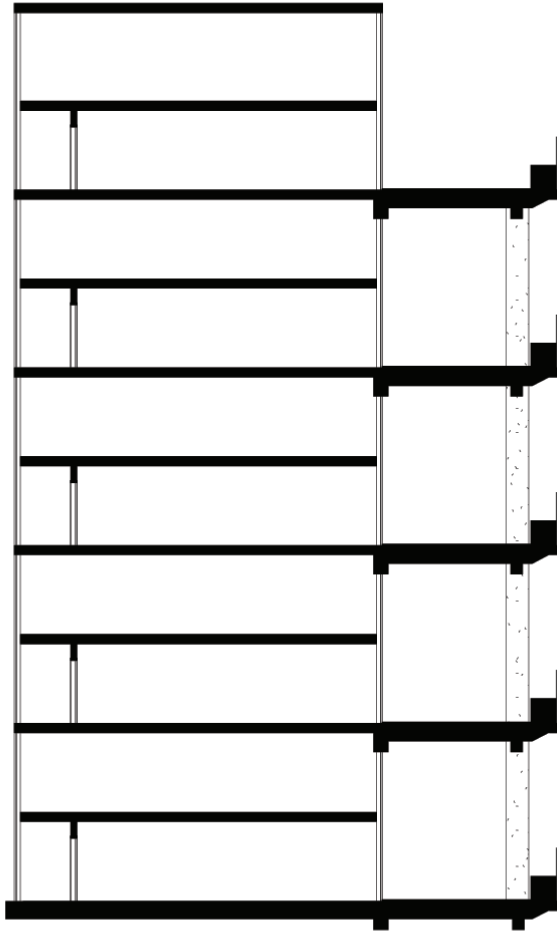


FIG. 4.79 TYPE D SCHEMATIC SECTION

	6 Storey	8 Storey	10 Storey
Ext. to Int Floor Area	.23	.23	.23
Range of Unit sizes (m ²)	80+	80+	80+
Approx. Net F.A.R.	2.6	3.5	4.4
Approx. Net Density (p/Ha)	400-685	540-915	675-1140
Approx. Gross Urban Density - 50% net to gross (p/Ha)	200-440	270-460	340-570
Ext.Surface Area. to Int.Floor Area	.78	.74	.72
SIMULATED ANNUAL SITE ENERGY USE - OTTAWA (KWh/ m ²)			
Baseline design meeting thesis envelope design recommendations.	102 KWh/m ²		
Baseline design, subtracting 50% from hot water and electricity loads for solar hot water and renewables.	57 KWh/m ²		

KEY FEATURES:

- Stricter orientation: terraces should be oriented roughly south
- Double height units accessed by single loaded, skip floor corridor. Double height to allow for deeper terraces. Terraces treated as flexible intensive green roofs to allow varied landscaping
- Terraces create significant shading - could be beneficial for passive solar, but detrimental for access to light

ISSUES:

- Significant overshadowing of units on terrace elevation, especially on second storey of units.
- Wind and snow accumulation on terraces a potential problem
- Terraces can potentially create visual disconnection from street and surrounding areas and could create shadowed street facade if placed facing street
- Higher winds on upper terraces
- Upper units more disconnected from any lower level amenities

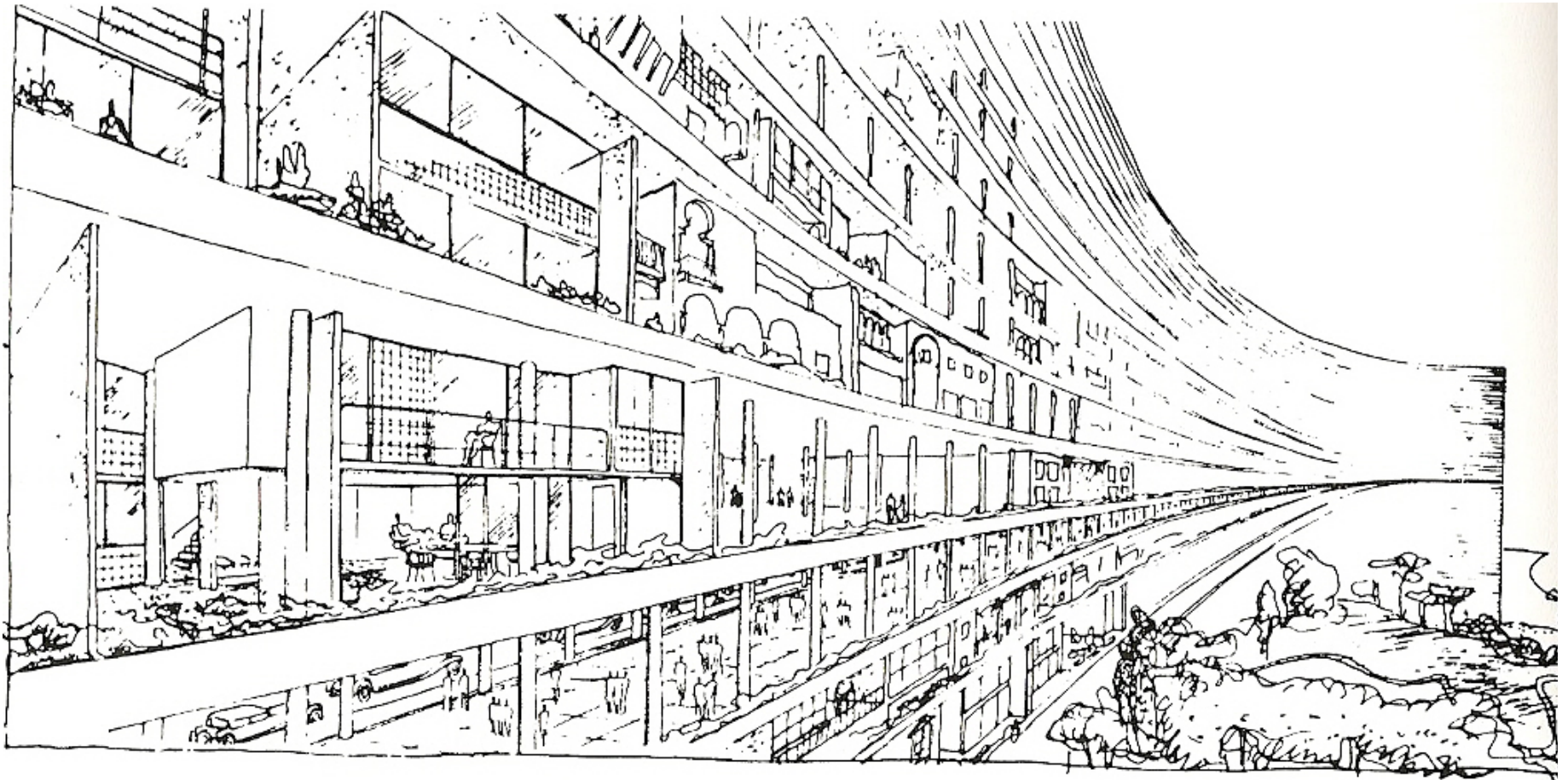


FIG. 4.80 LE CORBUSIER'S DRAWING OF DWELLINGS IN THE PLAN OBUS
In addition to the dwellings, the drawing also shows the levels that are used as freeways and pedestrian streets.

PLAN OBUS - ALGIERS - 1930s

Le Corbusier

The Plan Obus was an unsolicited, radical urban design scheme developed by Le Corbusier for the city of Algiers. The aspect of the plan most relevant to the current discussion is Le Corbusier's massive infrastructural proposal for working class dwellings, depicted in a well-known perspective drawing (FIG. 4.80). The proposal is interesting because it is a clear illustration of the strategy of vertically stacking individual dwellings with terraces to achieve a dense fabric providing inhabitants with outdoor spaces.

A massive, winding slab of decks, built as a highway system, was to provide the structure for the dwellings. The dwellings would then be constructed as infill, suited to individual preferences:

"On each level individual houses would be built side by side, each according to the desires of the occupants...we have a kind of open planning, founded on broad based participation and initiative"⁵².

Similar to Le Corbusier's Immeuble Villa designs, the dwellings are double height, and each is provided with a generous, double height outdoor space, which is shown as being adapted to a number of uses (varied gardens, dining areas, rest areas, etc.). Some of the dwellings are recessed further, providing more outdoor space, while others are closer to the slab edge, providing more indoor space; presumably the decision reflects the inhabitants' priorities.

The ideas anticipate some later theorizing about the nature of mass housing and the requirement of flexibility and the freedom of the inhabitants to design and modify their own dwellings within a dense urban environment of attached dwellings. We can see theorist John Habraken's notion of infrastructure *supports* - which are essentially structures that create artificial building plots for individual dwellings - in the structural slabs of Le Corbusier's scheme.

Le Corbusier's drawings remain powerful depictions of the idea of large infrastructure providing new plots for individual homes. Like the

2000 Dutch Pavilion, it illustrates the simple strategy of stacking not only units and interior areas, but also outdoor areas and program elements traditionally associated with land and the ground plane: roads, gardens, pedestrian paths, etc. The scheme illustrates a particular vision of Le Corbusier's idea of the vertical garden city: a dense urban milieu that also provides important amenities generally associated with the house.

SUMMARY

- Early theoretical proposal for vertically stacked two storey dwellings opening onto large flexible terraces
- Proposal separates flexible infill dwellings from permanent infrastructure system
- Double height units allow for deeper terraces by reducing overshadowing of projecting terraces

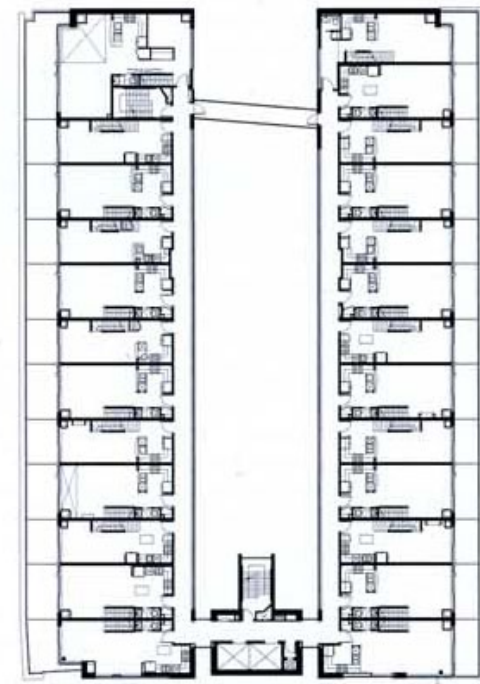
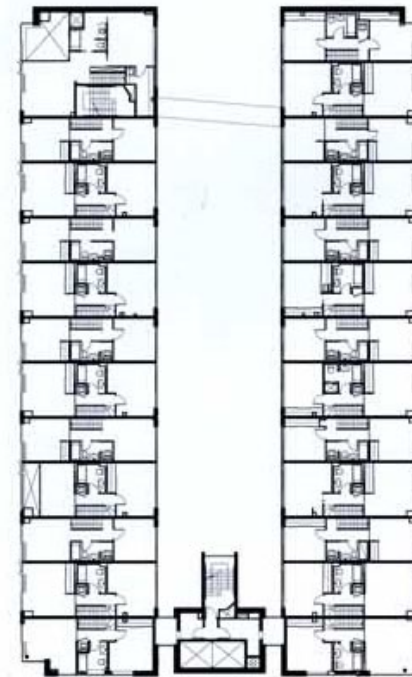
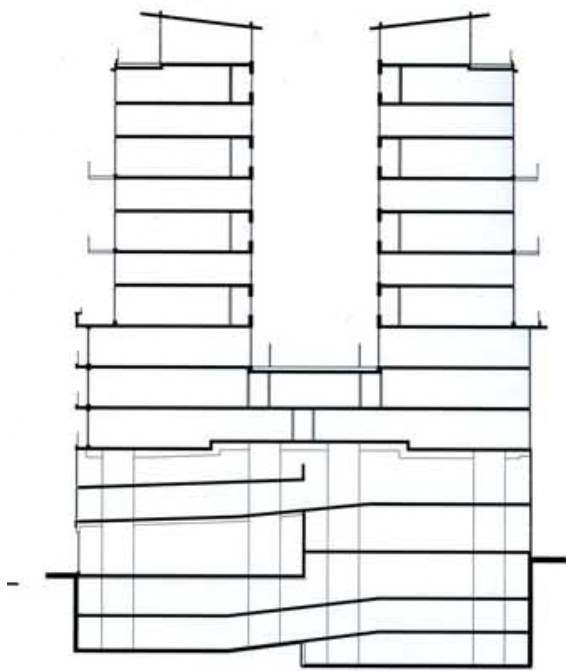


FIG. 4.81 DISTRICT LOFTS SECTION AND TYPICAL FLOOR PLANS



FIG. 4.82 DISTRICT LOFTS FROM RICHMOND ST.

DISTRICT LOFTS - TORONTO - 1999

ARCHITECTS ALLIANCE

Approx. Net F.A.R.: 11

Approx. Net Density: 925-1550

Approx Gross Urban Density (50% net to gross): 460-780

Unit Access: Double loaded corridor and Single loaded skip stop corridor

Outdoor space: Street front shops, larger balconies, narrow courtyard.

Approx. Cost (inflation adjusted to 2011): \$160CAD/sq.ft ⁵³

Floor plate depth (excluding balcony) = ~12.5m

District Lofts is a relevant precedent for a number of reasons. It is an innovative mixed use building which moves away from the double loaded building configuration that is standard for dense, mid to high rise urban development. Rows of double aspect units “maintain the conventional spatial organization of the anglo-American townhouse”.⁵⁴ Critic Ken Hayes describes the project as a sort of synthesis of high density urbanism and the traditional row house. In some ways, it recalls Le Corbusier’s dwellings in the Plan Obus; two storey house-like units are vertically stacked in a slab, facing out onto a terrace or relatively large balcony - though Le Corbusier’s scheme is obviously more radical in terms of the individuality of the units, the size of the terraces, and the overall scale of the project.

URBAN CHARACTER

District Lofts is undoubtedly a high density building type: it achieves a very high site coverage in an already dense context, and accommodates a large number of units and programs on a tight urban site. However, the height, width, and high site coverage of the building may also make it more difficult to use this type in a closely spaced manner and provide sufficient access to light. As with most high rises, this type likely

requires greater spacing than do lower rise types. However the basic parti of the District Lofts could be achieved at lower heights (say eight stories), although fewer stories may lessen the appeal of an already non-standard type to developers.

The first six storeys of the District lofts forms a street wall, and above this, the building steps back and provides large, continuous, expressive balconies. This, together with the southern orientation of the street facade, and the spacing of balconies at every other floor, avoids some of the issues that come up at the Rue Des Amiraux apartments in Paris, where the deep, continuous balconies can create a darker, arguably less appealing street facade. Street level retail and office space contributes to activity of the street.

OUTDOOR SPACES

The site plan and building configuration of the District Lofts allows minimal outdoor spaces on the site. The primary outdoor space on the site is the courtyard between the slabs which is essentially a light well. Most units access balconies which, though perhaps larger than typical (roughly two meters deep) still provide a relatively small outdoor area. Nevertheless, the units, with their double aspect plans do allow for a sense of openness and connection with the surrounding environment that exceeds that of many of apartment buildings.

Moreover, the double height and double aspect of the units could allow for deeper balconies that could create more generous, flexible outdoor spaces, perhaps more in line with those envisioned by le Corbusier in his plan for Algiers or in his Immeuble Villas, and perhaps exhibiting some of the flexibility and verdure of the rooftop units at the Freiburg rooftop dwellings. As a thought experiment, if we assume these deeper balconies were, on average, 5x5 meters per dwelling unit, and the construction cost was the same per square foot as a parking garage structure plus an additional \$250 per square meter for installing the assemblies to support an intensive green roof, that might roughly be an extra \$25,000 - \$30,000 in final sales price per unit - roughly the cost of a parking space - for a much larger, more flexible outdoor space akin to that shown in the

schematic design proposal.

ENERGY

- Slab tower type is very compact, though slightly less so here because of narrower floor plate (approximately twelve meters deep)
- Potential to use deeper continuous balconies for shading if oriented properly
- The highly glazed envelope could be problematic
- Cantilevered balconies are large thermal bridges

SUMMARY

The double aspect nature of the upper floors of the units, and the larger, continuous balconies hint at the possibility of implementing schemes such as the Plan Obus, where flexible house-like units with gardens and terraces are vertically stacked.

- Double aspect units provide more varied daylight access, views, and sense of openness to outdoors.
- Units which, to some degree, “maintain the conventional spatial organization of the anglo-American townhouse””
- Double height, double aspect units allow for potentially deeper balconies.
- Deep floor plate at first few floors used for varied programs with lesser requirements for daylight, allowing for optimal use of the site, while thinner floorplates at upper levels create better conditions for dwellings.

FIG. 4.83 TYPE E - MID RISE STACKED DWELLINGS WITH VERTICALLY WITH SET-BACK AND STACKED TERRACES

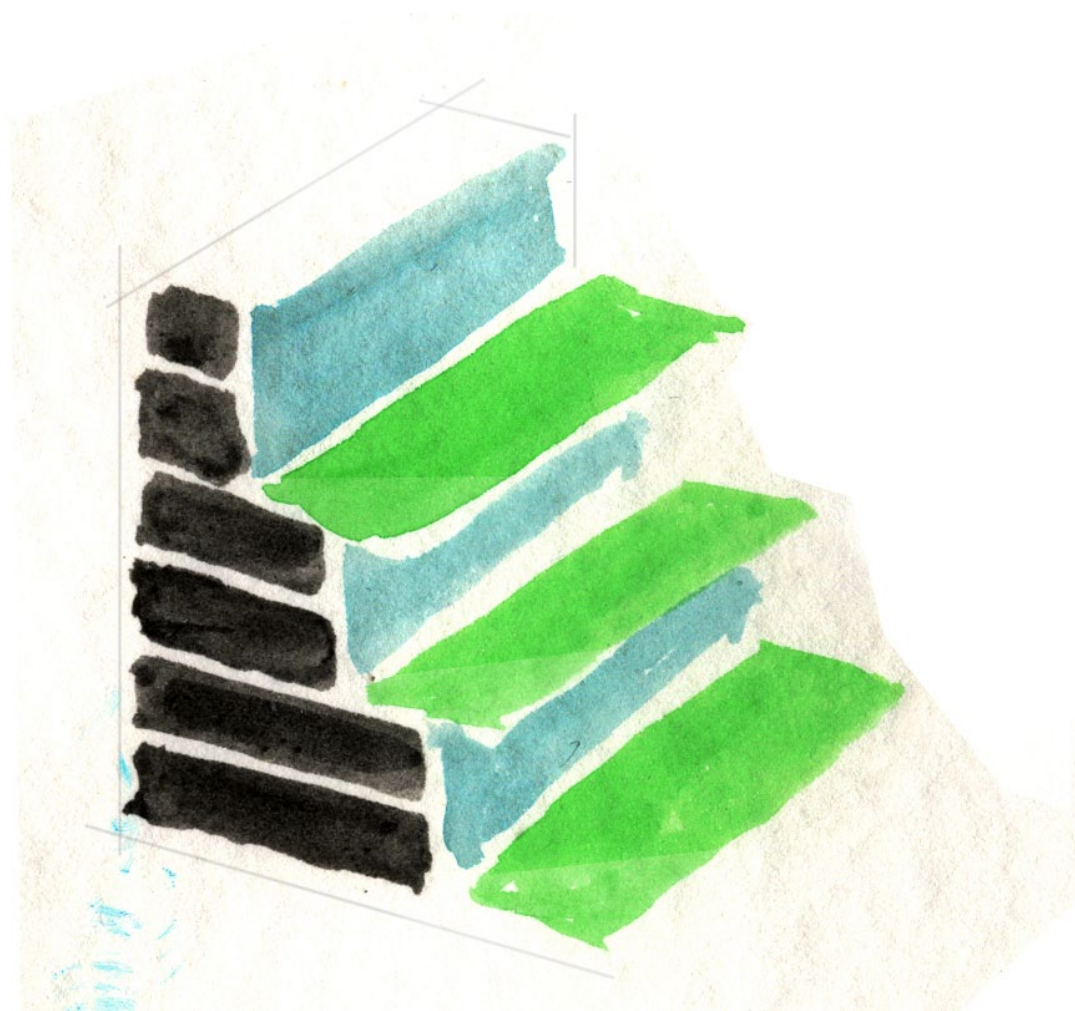




FIG. 4.84 TYPE E - MID RISE STACKED DWELLINGS WITH VERTICALLY WITH SET-BACK AND STACKED TERRACES

PLANS, SECTIONS, SIMILAR TO D

	6 Storey	8 Storey	10 Storey
Ext. to Int Floor Area	0.26	0.29	0.28
Range of Unit sizes (m ²)	80+	80+	80+
Approx F.A.R.	2.4	3.0	3.5
Approx. Net Density (p/Ha)	365-620	460-775	550-910
Approx. Gross Urban Density - 50% net to gross (p/Ha)	180-310	230-390	225-445
Ext.Surface Area. to Int.Floor Area	0.87	0.88	0.9
SIMULATED ANNUAL SITE ENERGY USE - OTTAWA (KWh/ m ²)			
Baseline design meeting thesis envelope design recommendations.	Not simulated - assumed slightly higher than type D		
Baseline design, subtracting 50% from hot water and electricity loads for solar hot water and renewables.	Not simulated - assumed slightly higher than type D		
Baseline design adding dynamic Shading, increased insulation, window R value, and air tightness.	Not simulated - assumed slightly higher than type D		

KEY FEATURES:

This type is similar to Type D, with the exception that floorplates decrease in depth with increasing height, stepping back terraces to create less shading on units and terraces. The form is somewhat less dense due to stepped form. Also, the stepping strategy limits the height of this type.

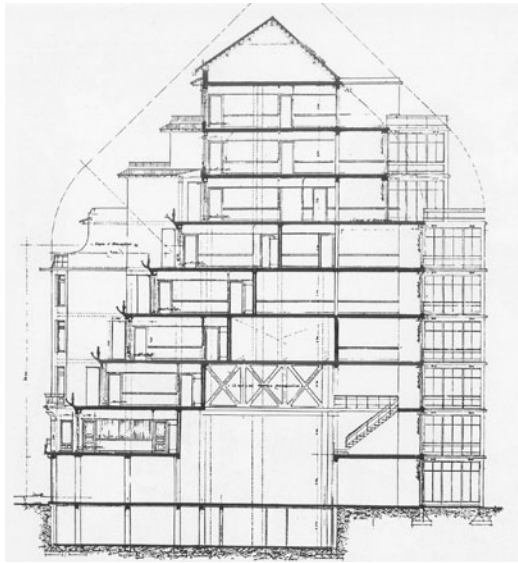


FIG. 4.85 RUE VAVIN SECTION

FIG. 4.86 RUE VAVIN

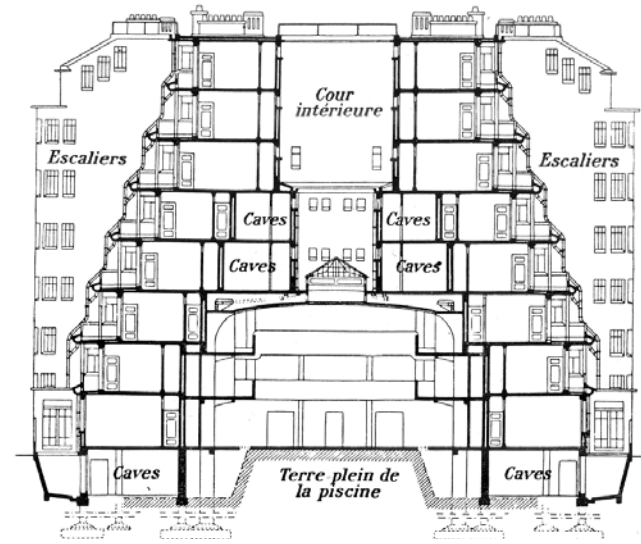


FIG. 4.87 RUE DES AMIRAUX SECTION

FIG. 4.88 RUE DES AMIRAUX



RUE VAVIN - PARIS 1912
 RUE DES AMIRAUX - PARIS 1922
 HENRI SAUVAGE

Unit Access: Single loaded corridor
 Outdoor Space: small terraces

Rue Vavin
 F.A.R. 4.3
 Approx. Net Density: 555-940 p/Ha
 Approx. Gross Urban Density (50% net to gross): 225-470 p/Ha
 Unit Access: Single loaded corridor
 Outdoor Space: small terraces

Rue Des Amiraux
 F.A.R. 4.9
 Approx. Net Density: 630-1060
 Approx. Gross Density: 500-850

Henri Sauvage is probably best known for the design of these two apartment blocks. Sauvage was interested in mass urban dwelling around the end of the 19th century. Like many in the emerging modernist movement, he was concerned with the design of dwellings and a city fabric that, in contrast to the overcrowded and unsanitary conditions of the late 19th and early 20th century, provided ample access to light, fresh air, and outdoor space. A strip of his drawings and captions (FIG. 4.89) serve to summarize some of his urban design thinking. Unlike le Corbusier, Sauvage was wary of towers and their relation to the city, calling them the ‘negation’ of the city. But he was equally wary of garden city concepts, opting instead to incorporate small scale individual outdoor spaces in denser urban buildings. His Rue Vavin and Rue Des Amiraux buildings

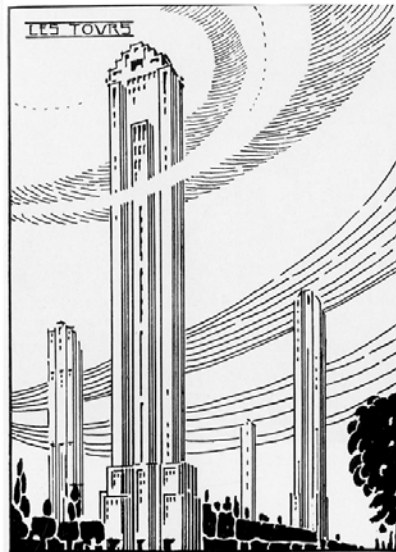
FIG. 4.89 DRAWINGS WITH CAPTIONS BY HENRI SAUVAGE



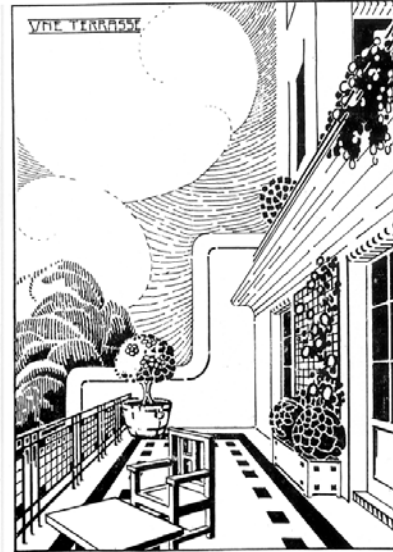
“The street of the middle ages, picturesque and insalubrious.”



“The street of today, a dark corridor.”



“The tower, the negation of the city.”



“The garden street, sunlight, verdure, and urban continuity.”

are some early 20th century examples of experimentation with mixed uses and terraces at a large scale.

URBAN CHARACTER

At Vavin and Amiraux, and in many of his unbuilt theoretical works, Sauvage used a combination of stepped, ziggurat like forms, and vertically stacked terraces, to provide well lit outdoor spaces. At Vavin the terraces hardly overlap one another, while at Amiraux they overlap a fair bit, forming sort of half open loggias.

Because the terraces at Vavin are smaller and do not stack above one another, the street facade remains very bright and well lit, and windows receive full sunlight. By contrast, the stacked terraces or loggias at Amiraux create more generous terraces, but the result is a slightly less illuminated facade with windows that receive less direct sunlight - especially on the north facade of the building. The result is a somewhat shadowed street facade. The deeper balconies also somewhat block views from windows to the street. As such, deep balconies and terraces stacked one above another may be more suitable to facade orientations receiving a good deal of sunlight, and not facing onto important streets. This would yield the additional benefit of a good deal of shade in the warmer summers, and more direct sunlight in the winters, and a more appealing street facade.

INTEGRATION OF MIXED USES

A frequent objection to the strategy of repeatedly stepping back to create terraces is that spaces underneath the building become deep and dark. In part, Sauvage circumvents this problem by placing program elements which require less or no daylighting in the unlit space. At Amiraux, Sauvage wanted a cinema in this space, but it was eventually decided to build a pool in the space. Other areas deep within the floorplate are occupied by rows of storage lockers (called “caves” in FIG. 4.87). This strategy allows for deep buildings with high site coverage, and effective use of daylight and fenestration where it is most required. Moreover, the

provision of substantial storage space, not only gives a use to dark spaces, but also locates a useful amenity very close by, which might otherwise be located in a remote storage facility. Indeed, integration of substantial storage facilities within residential buildings may be overlooked, as remote self storage facilities seem to be emerging to meet a large demand for storage space.

OUTDOOR SPACE

Sauvage’s Vavin and Amiraux apartment buildings are early examples of the use of terraces in an attempt to provide dense, modest, sanitary urban dwellings in which the inhabitants have direct access to light, air, and outdoor spaces. The building on Rue Vavin, with its more gentle and varied step backs, bright facades and jaunty planters, arguably provides a somewhat brighter, more appealing, and urbane street facade than the building on Rue Des Amiraux. Yet Rue Vavin’s terraces are quite small - hardly more than balconies. The more ample, overlapping terraces of Rue des Amiraux do provide a beneficial amenity, but may be better suited to specific solar orientations (eg. south), and to facades which do not directly address prominent urban streets. For example, the strategy might be best used on facades facing a sunny quiet courtyard, or several stories above street level, like at the District Lofts.

SUMMARY

Like other architects designing somewhat radical dwelling types - such as le Corbusier or Moshe Safdie - Sauvage evidently saw these projects as elements of a much larger urban scheme, one which never materialized at the scale he had hoped for. Nevertheless, the buildings exist as important precedents of mid-rise stepped terrace buildings providing slightly more ample, sunnier outdoor spaces, a type which has seen some degree of implementation in Canadian cities: for example buildings such as the St. James condominiums by Quadrangle Architects, or Ideal Condominiums by Architects Alliance, and Westboro Station. Even where the stepping strategy is more for compliance with zoning laws, the net effect is similar.



FIG. 4.90 IDEAL CONDOS, TORONTO

- Early example of terraced or stepped apartment buildings and integration of large mixed use programs.
- Use of programs requiring little daylight in deep floorplate, with residences at outer edge of deep floor plate and in thinner floorplates
- Vavin project provides small sunny terrace spaces
- Amiraux provides larger terrace spaces, but these are somewhat shadowed and create a darker, shadowed street facade
- Stepped form can arguably weaken street facade



FIG. 4.91 ST. JAMES CONDOS, TORONTO

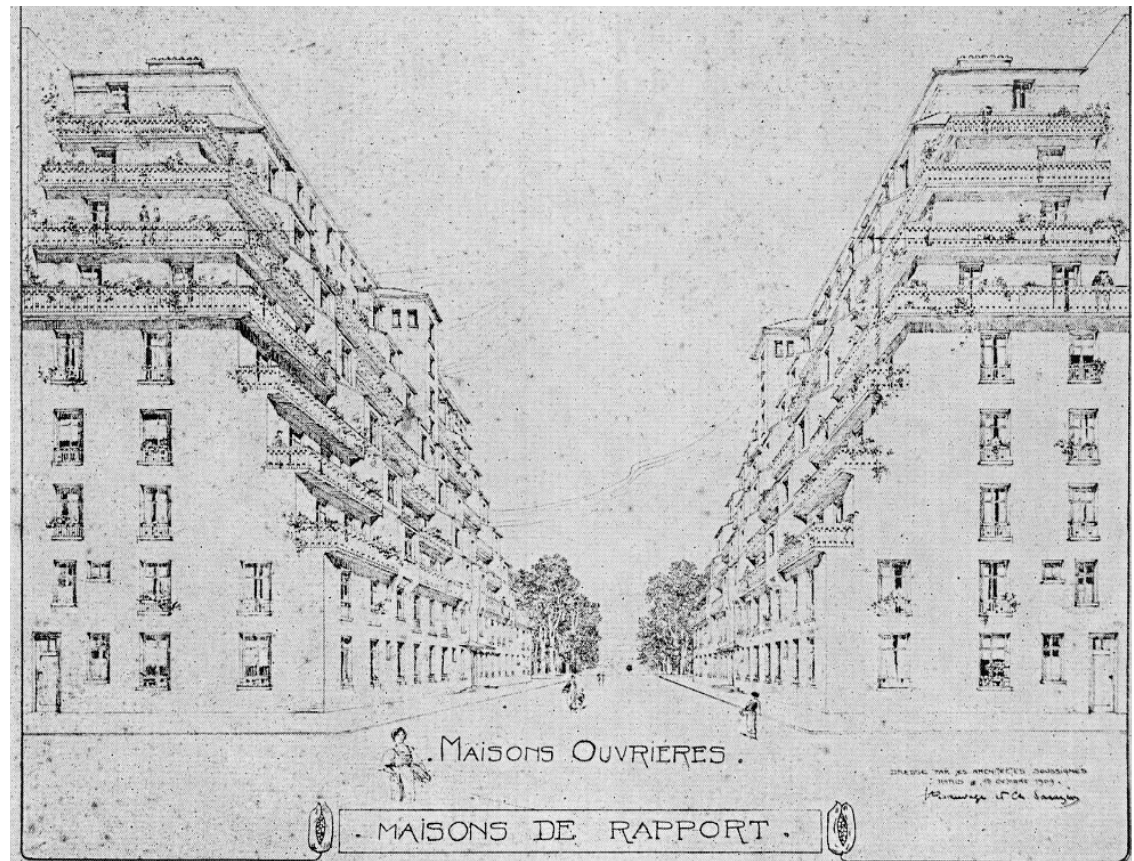


FIG. 4.92 HENRI SAUVAGE - "WORKER'S DWELLINGS"

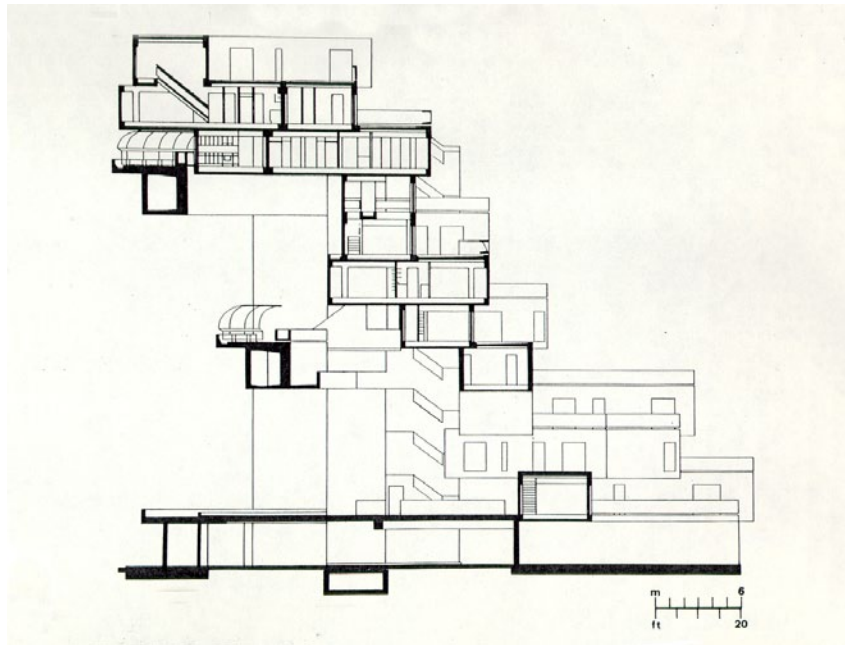


FIG. 4.93 SECTION



FIG. 4.94 HABITAT FORM



FIG. 4.95 TERRACES



FIG. 4.96 RECENT PROPOSAL BY SAFDIE

HABITAT 67 - MONTREAL - 1967

MOSHE SAFDIE

Approx. F.A.R.: <2

Approx. Net Density: --

Approx. Gross Urban Density (50% net to gross): --

Unit Access: Exterior walkways

Outdoor Space: Modest terraces, void spaces under building.

Safdie's fundamental approach to housing in North America shares some of the concerns of this thesis. Safdie was interested in new ways of creating a dense and lively urban environment that incorporated some of the traditional amenities of the house, such as outdoor spaces and gardens. Safdie was also interested in expressing the individuality of each dwelling unit, which, along with the influence of the urban forms of his childhood city - Haifa - is part of the motivation for the distinct massing of Habitat 67. Safdie has been critical of the homogenizing, uniform aesthetic of what he called "orthodox modernism", which, he argued, suppressed expression of individuality in favor of ideological commitment to collectivity. In Habitat, he argued that the focus is not necessarily on the collective or the individual, but on the "individual *within* his/her community" - a more balanced approach that is "a celebration of *both* community and privacy".⁵⁵

The project was largely funded by the CMHC, and was intended to be a model for mass housing development. Safdie wrote that "1967 was a moment of optimism and confidence in Canadian history" and in some ways Habitat, as a radical, ambitious and large public project is an expression of that confidence.⁵⁶ Safdie had hoped that the project might set the stage for new forms of housing and urban development, providing families with alternatives to the suburbs and apartment buildings. However these wider ambitions for Habitat were unrealized. Habitat remains unique, and it was never taken up in the way that Safdie imagined. In large part this is likely due to the extremely high construction costs of Habitat. A retrospective article in Canadian Architect wrote:

A post-construction evaluation showed that the varied groupings of forms that made Habitat so aesthetically exciting precluded it as a demonstration of rational systems building. At 20 units to the acre [roughly 125 people per hectare at 2.5 persons per unit] it had achieved the site density of traditional row housing, and at 8 to 10 times the cost of the latter it placed itself far beyond the reach of the clientele that CMHC, Habitat's sponsor, was mandated to serve. Clearly it was not an economical method of producing mass housing .⁵⁷

Nevertheless, even if it is not viable as a wider model, Habitat today is a popular place to live.⁵⁸ It draws a range of upper and middle class residents, arguably demonstrating that some of the amenities and character - and iconic status - which it provides are appreciated by some.

URBAN CHARACTER

Habitat's radical form creates a rather unique urban character. The complexity of the arrangement of the individual units in both horizontal and vertical directions is largely unprecedented in western housing types. In virtually any western urban context Habitat would create a strongly contrasting urban form. In contrast to a linear street wall, for example, Habitat creates a pattern that reads as complex; though the form has order, this order is not easily grasped. Where the more traditional city block creates a clear demarcation between public street and private inner courtyard, Habitat's private spaces are directly visually connected to the public realm.

A frequent criticism of Habitat centres around the large shaded void spaces underneath the ziggurat like forms of the building. These spaces do not seem well resolved, and do not invite much use. Where Sauvage filled such spaces with program elements requiring little natural light, Safdie leaves them void. While this allows for more exterior views from the dwelling units and access to more diffuse light, it is somewhat problematic. The large void spaces means that the built form of Habitat, despite being some ten storeys tall, achieves an FAR that appears to be less than two - not much more than many of the simpler low rise prec-

edents examined in this thesis.⁵⁹

OUTDOOR SPACE

In some respects, Habitat 67 achieves some of what Safdie set out to accomplish in that it does integrate comparatively generous private outdoor spaces in the building fabric. Due to the stepped form, the terraces receive ample sunlight, and are open to the sky above. The spaces are well furnished with potted plants, shrubs, small trees, outdoor furniture and awnings, and some have been partially converted into sun rooms.

ENERGY

Dr. Straube uses Habitat as an example of a building form with a high ratio of exterior surface area to floor area. Compared to a simpler, more compact form, Habitat could be reasonably expected to have not only higher costs, but also significantly higher energy use. This said, the multiple exposures of the building allow for access to light with only a modest amount of glazing, compared to more compact volumes which often attempt to make up for limited exposures to the outdoors with large, indiscriminating amounts of glazing.

SUMMARY

- Limited viability as a widespread form of housing due to high costs.
- Radically different urban form that would be difficult to relate to surrounding urban fabric.
- Stacked and set back configuration creates sunny outdoor spaces
- Set back configuration also creates somewhat problematic shadowed void spaces
- Large area of building envelope likely results in not only higher costs, but higher energy use.
- Multiple orientation of units allows for better and more varied access to natural light and views.

- Despite limited viability of Habitat as a specific model, as built it is a popular place to live, speaking perhaps to some of the amenities it offers and some of the fundamental ideas behind the design.



FIG. 4.97 WESTBORO STATION RENDERINGS

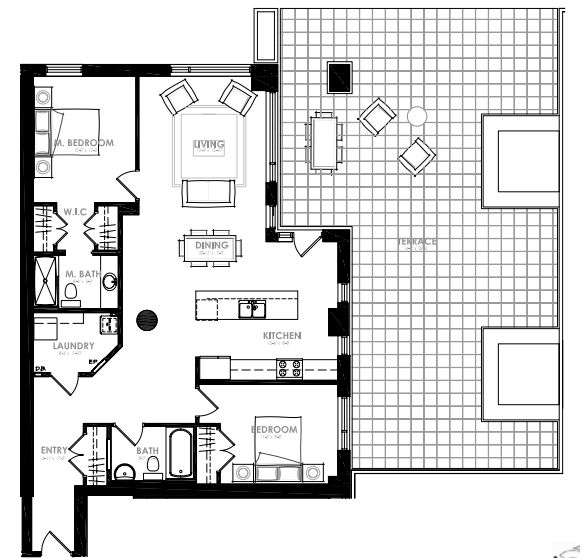


FIG. 4.98 TWO BEDROOM UNITS WITH TERRACES

WESTBORO STATION PHASE 2 - OTTAWA 2010-2011

BARRY HOBIN AND ASSOCIATES

Approx. Net F.A.R.: 3.2

Approx. Net F.A.R. (Residential area only): 2.5

Approx. Net Density: 380-650 p/Ha

Approx. Gross Urban Density (50% net to gross): 190-325 p/Ha

Unit Access: Double loaded corridor

Outdoor Space: Ground level public plaza, shared and private roof top terraces, balconies.

Unit Sale Prices: ~ \$4950/sq.m (\$460/sq.ft) + parking space

Westboro station is a multi-phase market-rate condominium development on Richmond Road in Ottawa. It is an important precedent because of its proximity to the site of the design proposition in chapter five, because it employs a number of the strategies discussed in this thesis (a sort of modified ground plane, terracing or stepping back, effective integration of mixed uses) and because it provides insights into the local housing market. The project consists of two seven storey stepped towers atop a deep, one storey podium. The retail and office spaces face onto a rapidly developing mainstreet - Richmond Road - in what is a rapidly developing neighbourhood.

Units range in type from one-bedroom units to two-bedroom units with a den and large terrace. They are for sale at market prices. Larger two bedroom units with generous terraces sell within a range of \$500,000 to \$600,000, which is in a similar range as older, 2-3 bedroom detached single family house prices for the area, and newer townhouse prices in the area.

URBAN CHARACTER

Westboro Station is one of many recent mid-rise condominium projects along Richmond Road/Wellington Street West which are rapidly intensifying the area. Zoning along this mainstreet generally prescribes a

6 storey height limit, however projects seem to be able to obtain variances to exceed this by building up to 9 storeys or more, which has important implications for any future projects proposed in the area. Among these projects, Westboro station is unique in the way that it steps back from the street. The stepped form provides some open and airy individual terraces, and reduces the visual bulk of the building, and allows more southern light onto the main street. At the same time it creates a somewhat more fragmented urban streetfront, and creates a visual disconnection of the towers from the street. The podium thus reads as a one storey mall-like structure with larger buildings set behind.

Like other precedents, this podium has a very deep floorplate, which can house program elements requiring less direct access to daylight and natural ventilation than residential occupancies. The deep floorplate achieves many of the benefits noted earlier (large leasable area for developer, higher FAR, good use of site space) in a relatively compact building form that still provides residential units and surrounding areas with good access to light and, together with the modified ground plane, access to outdoor spaces.

OUTDOOR SPACES

The design of Westboro Station provides a mix of both public and private outdoor spaces. At grade, in the public realm, the podium contributes to the mainstreet character with offices and retailers that open onto relatively wide sidewalks with plantings and street furniture. There is a public plaza located in between the two phases of the project. The roof of the podium acts as a new ground plane which provides planted and landscaped private terraces and semi-public courtyard spaces for the residents. At 50 to 75 square meters, the larger private terraces provide generous outdoor space for various activities. Unlike in the Freiburg solar development however, plantings appear to be restricted to pre-designed planters, meaning that the terraces are less flexible as garden spaces, and somewhat more limited in terms of landscaping.

The privacy and intimacy of many of the private and semi-public spaces is somewhat diminished by the fact that they are overlooked by as

many as 7 storeys. However, planters with trees will provide some visual privacy. Also, upper terraces that look out over lower terraces are set back from the edge of the roof, which reduces the degree to which terraces overlook each other.

While providing generous terraces for *some* units, the designers did not obsess over providing every unit with the same amenities. For example, many units have only small balconies. This is likely a reflection of two things. First, varied residents will value different things in a dwelling - not all will think a large terrace is important or even desirable. Secondly, trying to provide *every* unit with, for example, large terrace spaces would have been a more radical proposition in what is already a fairly innovative development in the Ottawa context, and may not have been economically viable. Such an approach could easily reduce the number of units built, or increase construction costs. The approach here is to combine a number of essentially standard market condominium units with some less conventional, terraced units.

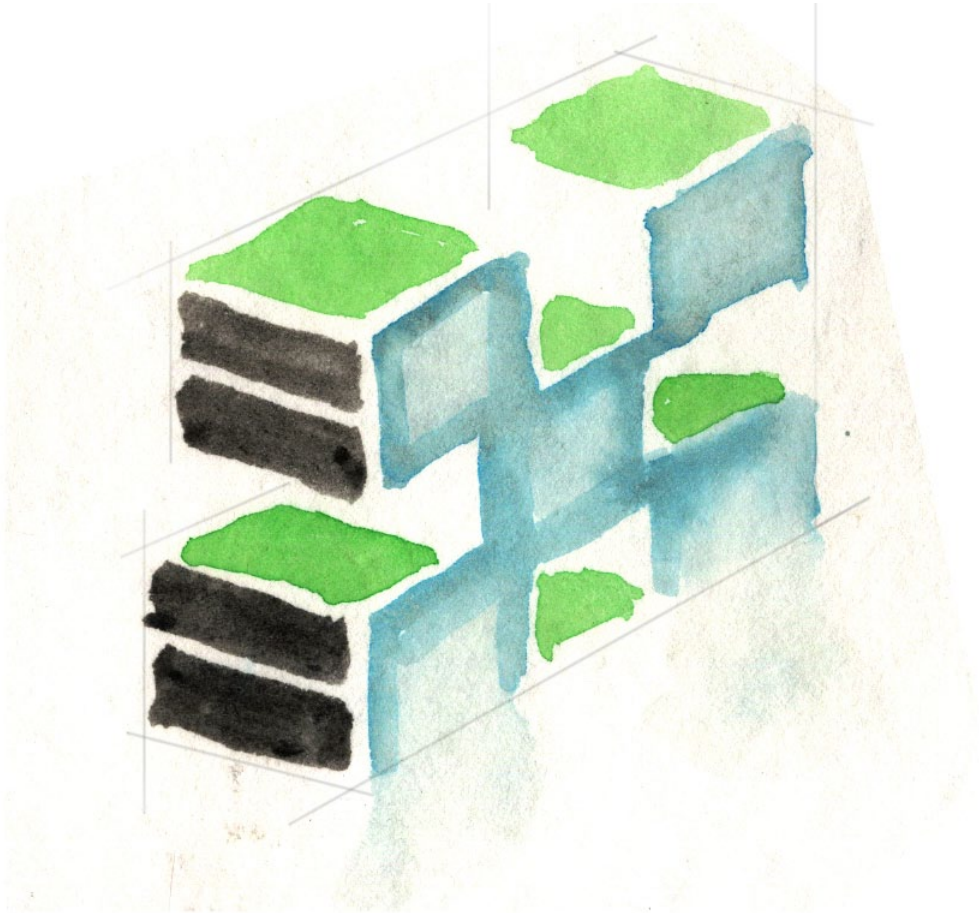
ENERGY

- Relatively compact massing
- Reasonable window to wall ratio for condominiums
- Some limited thermal bridging at smaller balconies

SUMMARY

- Example of stepped terrace building in immediate context of the final design proposition
- May be some concerns about extensive overlooking of terraces
- Mixed use for amenities, street activity, and optimized to various building floor plate depths

FIG. 4.99 TYPE F - STACKED DWELLINGS WITH RECESSED OUTDOOR SPACES



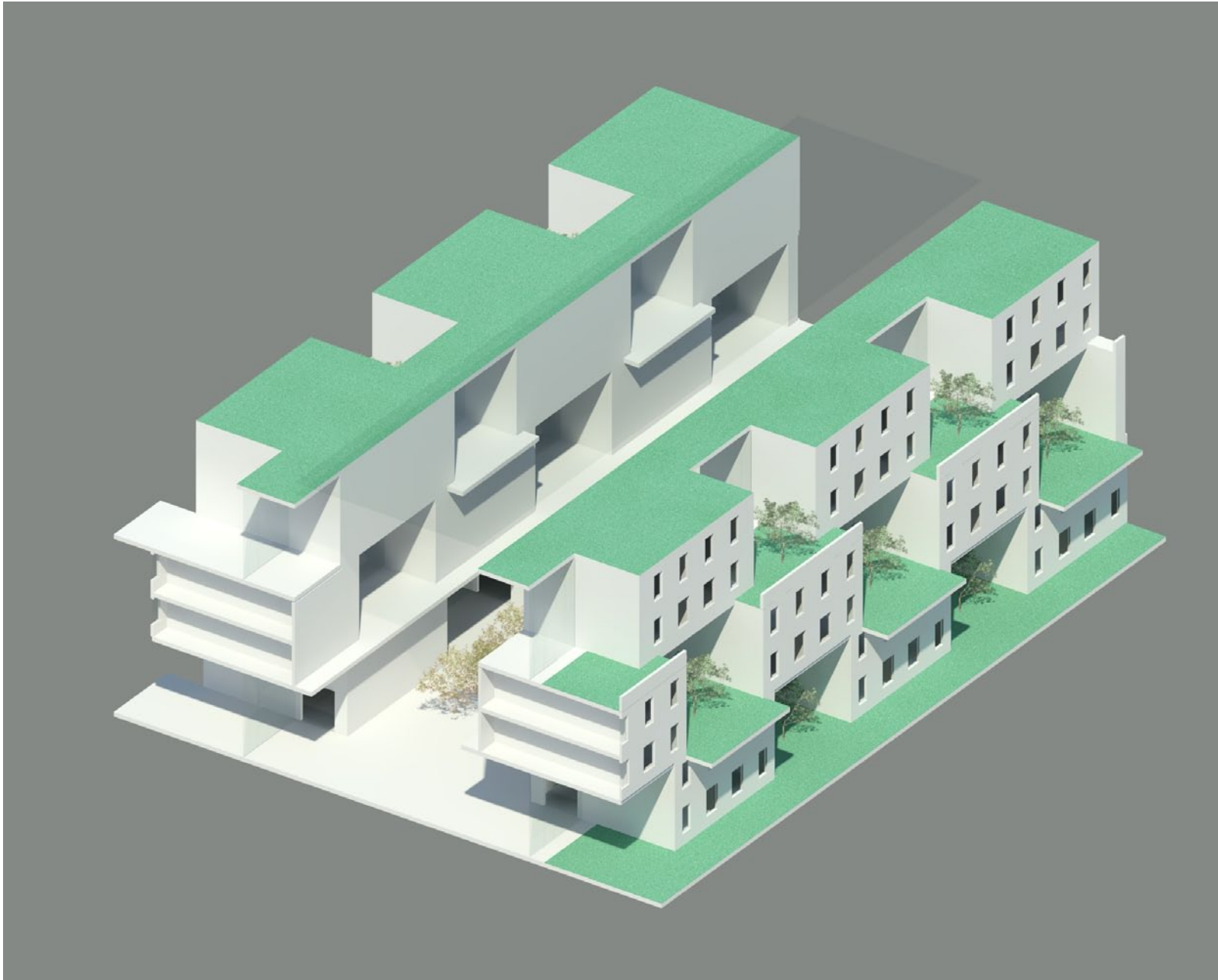
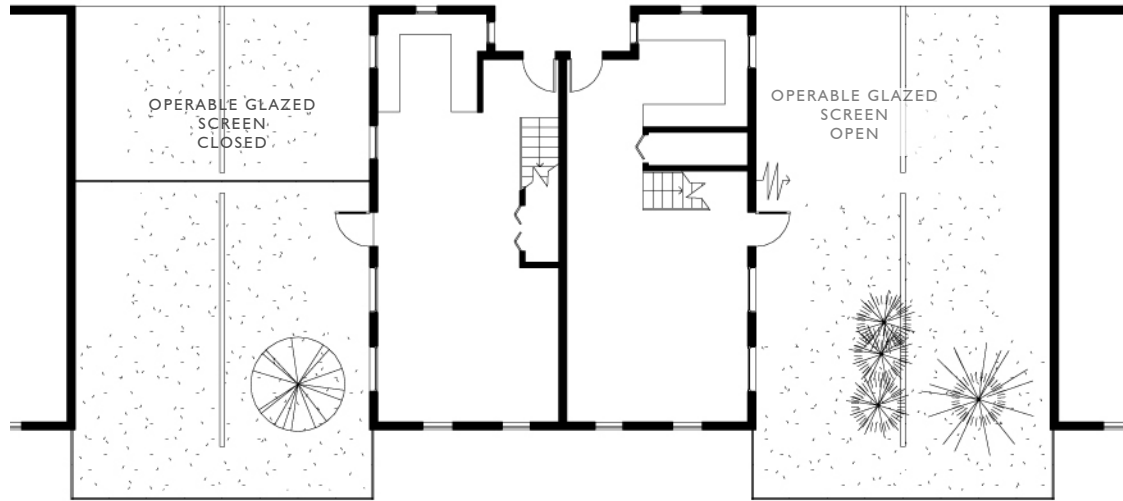
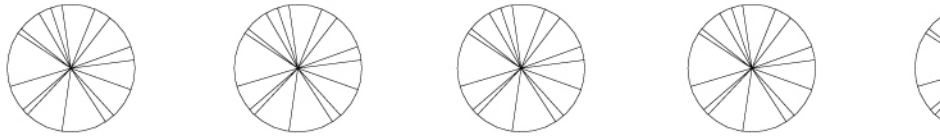
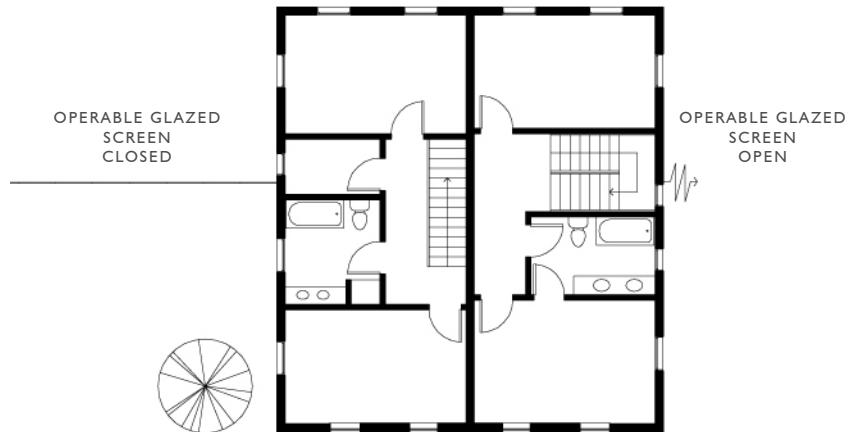


FIG. 4.100 TYPE F - STACKED DWELLINGS WITH RECESSED OUTDOOR SPACES

FIG. 4.101 TYPE F DEMONSTRATION LAYOUT AND UNITS - 1:200



DEMONSTRATION UNITS - BOTTOM LEVEL
100 M²



DEMONSTRATION UNITS - TOP LEVEL
100 M²



FIG. 4.103 EXTERIOR RENDER

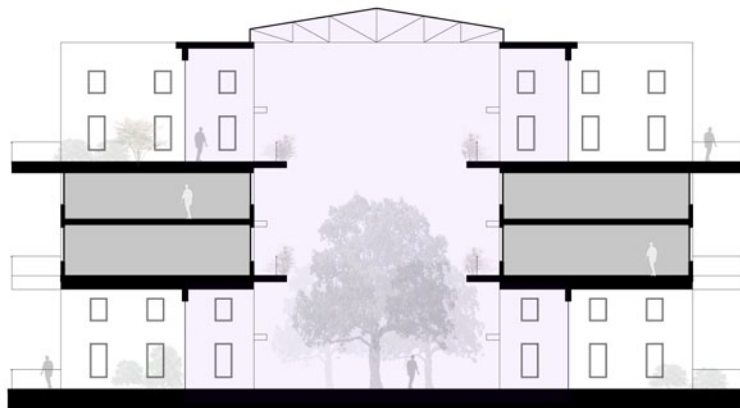


FIG. 4.102 TYPE F SCHEMATIC SECTION

Ext. to Int Floor Area	0.7
Range of Unit sizes (m ²)	80+
Approx. Net F.A.R. (excluding podium)	1.7 (6 storey) 1.8 (8 storey)
Approx. Net Density (p/Ha)	260 - 440 (6 storey)
Rough Gross Urban Density - 50% net to gross (p/Ha)	130 - 220 (6 storey)
Ext.Surface Area. to Int.Floor Area	~1.3 (building closed configuration)
Percent Exterior area Glazed	~60
SIMULATED SITE ENERGY USE - OTTAWA -(KW/h/ m ²)	

KEY FEATURES:

- Recessed spaces provide outdoor spaces.
- Potential for operable glazed walls at terraces. These to be open in warm weather, closed in winter and cold weather to reduce surface area. Similarly, space over courtyard could be covered with dynamic transparent envelope
- Units accessed from galleries on interior of courtyard
- 6-8 storeys
- Access flooring on first floor of units could provide a floor that is level with terraces and create flexible mechanical and electrical space

ISSUES:

- Different light conditions on different elevations need to be considered for treatment of outdoor space
- Relatively complex building form, with relatively large amounts of glazing. Also complex envelope
- Terraces have limited access to open sky - may feel enclosed
- Potentially expensive and complex to build
- Relatively low FAR given height of building

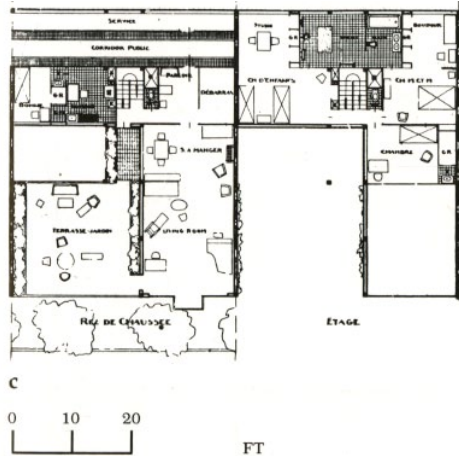
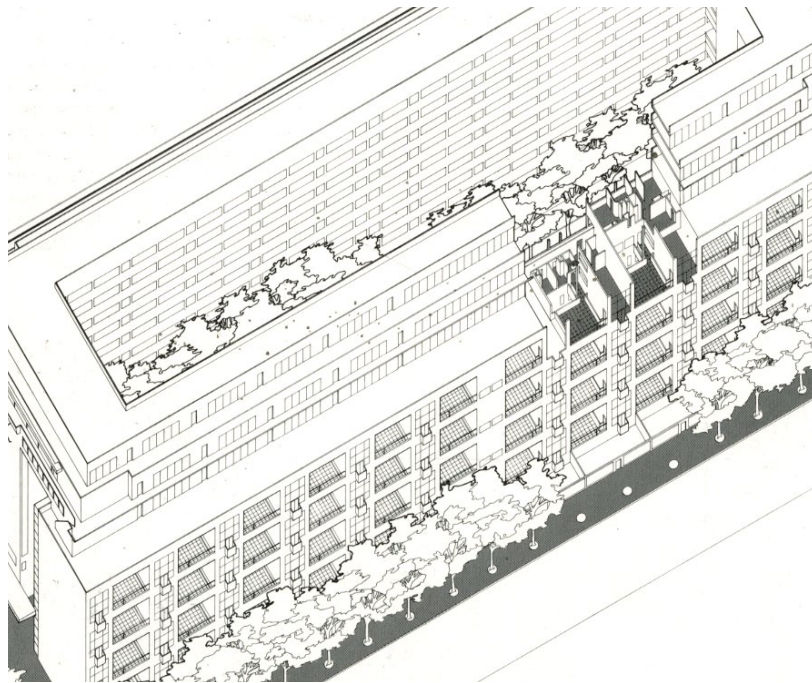


FIG. 4.104 IMMEUBLE VILLA AXONOMETRIC AND UNIT PLANS

IMMEUBLE VILLAS - PARIS (UNBUILT) 1922-1929

Le Corbusier

Approx. F.A.R.: 4.5

Approx. Net Density: 750-1250 p/Ha

Approx. Gross Urban Density - 50% net to gross: 325-625

Unit Access: Single loaded skip stop corridor

Outdoor space: Park and shared spaces in courtyard, private 65m² recessed terraces

Like the dwellings in the Plan Obus for Algiers, the Immeuble villas are part of Le Corbusier's wider urban plans. They are a component of the Ville Contemporaine, the Ville Radieuse, and the Plan Voisin. The units in the scheme are large, mostly double aspect units. At some 230 m² of interior living space with many double height spaces, plus 65 m² of double height terrace space, the Immeuble Villa units are large, not only by European dwelling standards of the 1920s - when housing conditions were generally quite poor and cramped - but even compared to the average single family detached home in the United States today.⁶⁰ The large, luxurious unit sizes seem somewhat at odds with the spirit of the small, but sanitary, light, and economical *minimum dwelling* which was the focus of many modernist architects at the turn of the century.

URBAN CHARACTER

As with many of Le Corbusier's plans, the Immeuble Villas exist as part of a newly created urban context. Thus there is little sympathy with the existing surrounding urban fabric because there is none. The project's context is a blank slate.

Unlike the stepped form, the recessed terrace form creates a strong vertical facade on surrounding public areas. By alternating solid building facade with recessed terraces, the scheme avoids the more uniformly shadowed facade seen at Sauvage's Rue des Amiraux. Furthermore, while the terraces of both Amiraux and the Immeuble Villas face

onto the street, the alternation of terrace spaces and with interior spaces at the street side of the Villas means that interior areas of the units have a much less impeded view of the street, which creates a better sense of connection to the street and may create a more social, safe street environment.

OUTDOOR SPACE

The provision of recessed private garden terraces in the scheme is perhaps the most innovative aspect of the scheme. Some of the following precedents will demonstrate comparable approaches. The terraces in the Immeuble Villas are quite large. They are created by recesses in the building, in contrast to the stacked horizontal bands of terraces at the Plan Obus.

The central courtyard is envisioned as some sort of public space, shown in some plans as tennis courts, in others as a park with various programmatic elements. While providing a useful amenity to inhabitants of the Villas, the character of such spaces, conceived as actively used public spaces, completely surrounded on all sides by eleven storey buildings, is questionable. Arguably, such interior open spaces, surrounded by tall perimeter block schemes may be forbidding in some proportions. Even schemes that try to make such courtyards feel open with large perforations in the building fabric may still have a certain daunting character, as in the conceptually similar scheme by MVRDV seen in FIG. 4.106. Courtyard spaces that are surrounded by less imposing buildings seem like they might invite more use as semi-public space, as in the Hydro Block (eg. FIG. 4.45) or the Spangen Quarter (eg. FIG. 4.42). Narrow and deep courtyards surrounded by proportionally tall buildings might, in many cases, be best as simple light wells and circulation spaces. It is difficult to fully gauge the effect of varied proportions and qualities of such spaces on the human psyche, so the issue is merely noted here.

SUMMARY

The Immeuble villas are an early exploration of a relatively tall, dense urban fabric which incorporates private outdoor spaces by creating recessed terraces within the building. While an innovative precedent, some of the spatial qualities of the block may be questionable, as is the exceptionally large size of the units.

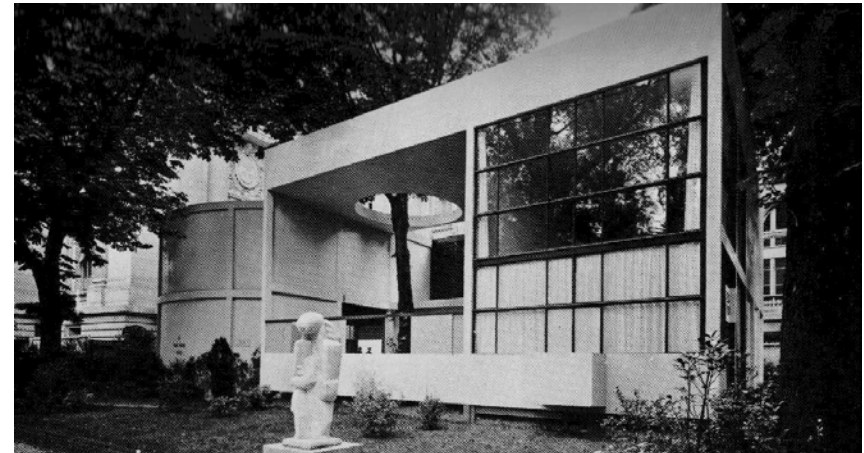


FIG. 4.105 IMMEUBLE VILLA UNIT MOCK-UP.



FIG. 4.106 CELOSIA - MADRID, SPAIN - MVRDV

ROAR ONE - VANCOUVER

2006

LANG WILSON PRACTICE IN ARCHITECTURE
CULTURE

Approx. Net F.A.R.: 1.82

Approx Net Density: 530 p/Ha ⁶¹

Approx Gross Urban Density (50% net to gross): 130-240 p/Ha

Unit Access: Exterior gallery in courtyard

Outdoor spaces: Central courtyard circulation space, individual terraces in a range of sizes, shared rooftop terrace.

Project cost (inflation adjusted to 2011): \$220 CAD/sq.ft

⁶²

Roar One is a five storey mixed use building containing market rate condominiums. The project creates recessed open spaces within the building by subtracting voids from a massing that reflects the maximum permissible building volume. In the abstract, the scheme bears some resemblance to the Immeuble Villas in the way that private outdoor space are created *within* the building, in the configuration of the units (double height spaces, double aspect units, private double height terraces), and in creating the building around a central, semi-public courtyard. Yet the scale of the project is radically different, and it is developed within an existing urban context, rather than as part of an entirely new district. At a project cost of \$220 CAD per square foot, the cost of the project is comparable to the cost of the Thin Flats, as is the height, volume, and overall density.

URBAN CHARACTER

Roar One integrates easily with the surrounding urban fabric, providing dwellings at a reasonable density, while not overwhelming the existing neighbourhood by, for example, radically breaking with the existing scale or casting large shadows. It creates a streetfront with public uses that contributes to the existing the mainstreet. The building occupies

most of the site, which is the depth of half a city block. Vehicle access is by a rear lane. Because of the existence of the lane, and relatively low density low rise development on the south half of the block, Roar One receives plenty of direct sunlight on its southern exposure, and the northern exposure, open to the street, receives much diffuse daylight. Access to light on the southern facade would be more limited if a scheme with similar massing was erected on the southern half of the city block.

OUTDOOR SPACE

The qualities of the outdoor spaces are varied; some are narrow and deep loggias, covered by floors above, while others are wider and shallower terraces open to the sky, or more generous large rooftop terraces. Variety and flexibility, to accommodate a diverse range of inhabitants, was one of the project's design goals, and this is apparent in the layout of these outdoor spaces, as well as the varied nature of the units. Individual outdoor spaces range seem to range from 15 to 100 m², while units vary in size from 80 to 200 m². The large rooftop terrace appears to be divided into a large private terrace and a semi-public terrace accessible to the building inhabitants. These outdoor spaces are primarily hardscaped, with a few planters spaced throughout. They are imagined more as large patios or hardscaped terraces than as spaces capable of supporting a wide variety of intensive vegetation or hardscaping materials.

As in the District Lofts, the courtyard space is relatively small relative to the building massing, acting primarily as a light and air shaft and circulation space. Using the courtyard for exterior galleries serving as the primary circulation space allows for double aspect units that have a much greater sense of openness than the standard double loaded corridor arrangement. Yet, because of the tight dimensions of the courtyard, and its use for circulation, the extent to which the facade can open onto the courtyard is quite limited, due to concerns for privacy. The result is an imaginative facade that is mostly opaque, but contains small amounts of glass block - arranged in a seemingly random, pixelated order - which gives some sense of connection to the small courtyard space, and provides a modest amount of natural light. By contrast, extensive glazing on the

FIG. 4.107 PLANS AND SECTIONS



FIG. 4.108 ROAR ONE IMAGES

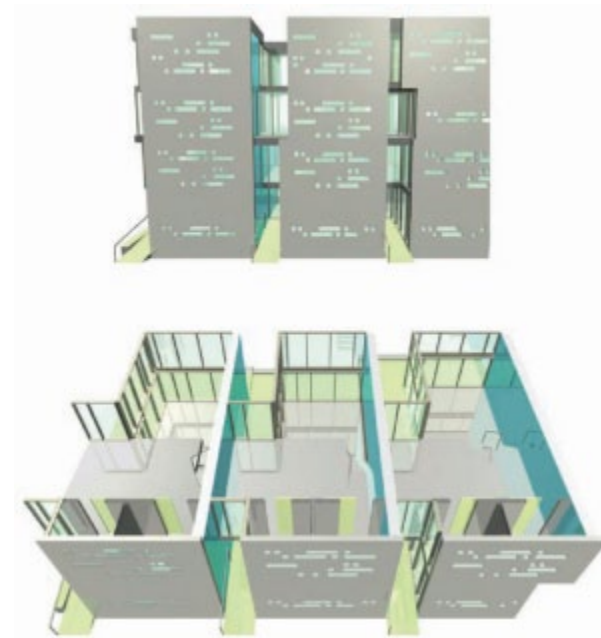




FIG. 4.109 VIEW OF PATIO FROM INSIDE

other facades creates an immediate connection the outdoors.

ENERGY

Given its design, there might be some concerns about Roar One's energy performance, particularly if the building type was located in a harsher climate such as Ontario. When asked in email correspondence, Lang Wilson did not have numbers on the energy performance of the building, so it is difficult to determine what the performance is. Judging from the architectural design and details however, and based on the analysis of energy performance in earlier sections of this chapter, we could reasonably posit that, placed in a harsher climate such as Ontario, Roar one's energy consumption might be quite high, and the building might require some redesign to provide reasonable performance in such a climate. Some key concerns centre around:

- Extensive use of standard double paned, aluminum framed, low R-value curtain wall and windows throughout the building on all orientations.
- Very high ratio of exterior surface area to floor area due to extensive building perforations.
- Large, continuous thermal bridges at concrete slab edges.

SUMMARY

Roar One provides a good example of a rather innovative residential type - a low-rise, relatively high density condominium building with recessed and terraced outdoor spaces contained within the building - that is achieved at a reasonably, if somewhat high, project cost of \$220 per square foot. Because the units open on many (often three) sides, their internal layout and partitioning may be more flexible, since, for example, bedrooms can be placed with greater freedom given the more ready access to windows opening to the outdoors. The complex way in which a variety of smaller scale voids in the building create outdoor spaces and bring diffuse sunlight into the building opens new ways of thinking about dense urban dwellings. We may wonder if design of this general type could be re-investigated to also provide greater flexibility in the outdoor spaces, and also to potentially provide better energy performance, especially in harsher climates such as Ontario.

60 RICHMOND - TORONTO - 2010

TEEPLE ARCHITECTS

Approx. Net F.A.R.: 6.85
Approx. Net Density: 1050-1800 p/Ha
Approx. Gross Urban Density (50% net to gross): 525-900 p/Ha
Unit Access: Single loaded corridor
Final Hard Costs: \$235/sq.ft (2010 costs) ⁶³

60 Richmond is another example of building with recessed outdoor spaces cut out of a volume occupying a large portion of the site's buildable space. The scale of the recessed spaces are larger than at Roar One; terraces are larger and fewer in number. Units are accessed by a single loaded corridor which wraps around a light well cut out of the middle of the building volume. The conceptual organization of the project is similar to projects such as Roar One and the Immeuble Villas, though here the cut out volumes are often shared spaces as well as private spaces.

URBAN CHARACTER

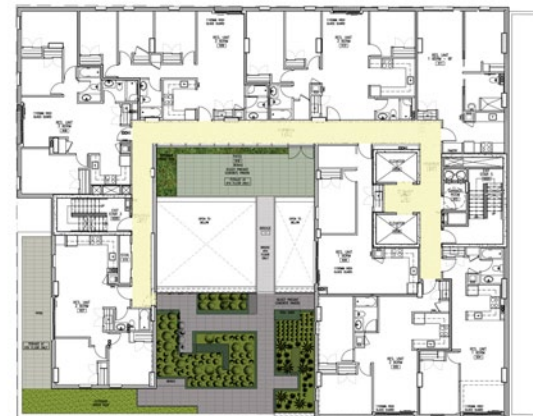
Like Roar One and Immeuble Villas, 60 Richmond is characterized by large voids cut out of the overall building volume. As a result, the building still retains a strong street presence and a sense of a simple, easily legible geometry that aligns with the existing facades along the street, contributing to a continuous street facade. At a net FAR of roughly 6.85, it is one of the higher density precedents examined. It provides this high density in a relatively compact form, occupying it's whole site, while allowing for access to light and exterior views from several directions, and access to outdoor spaces.

OUTDOOR SPACE

The outdoor spaces are small private balconies or terraces, and shared vegetated terraces with fairly large planing beds for community gardens. It remains to be seen how the shared spaces, embedded *within*



FIG. 4.110 VIEW FROM RICHMOND ST.



1:200 Sixth Floor Plan
Residential Corridor
Outdoor Amenity Space



FIG. 4.111 SIXTH FLOOR PLAN

the building, vertically as well as horizontally distributed, and closely surrounded by private units, will be used. Will they be successful, well used spaces, like at the Hydro block? Because of the rather unique nature of this precedent it is hard to anticipate how these spaces will be used. The precedent is somewhat of a social experiment which bears ongoing observation and discussion as the building's community evolves.

ENERGY ⁶⁴

While employing some similar strategies as Roar One, 60 Richmond is fundamentally different in terms of how it deals with energy issues. It is modestly glazed, has few thermal bridges, and fewer perforations than Roar One:

- Modestly glazed for contemporary apartment building (40% WWR)
- Relatively compact form despite voids in building (fewer and larger voids)
- Relatively high efficiency windows (eg. fibreglass frames)
- High levels of insulation in opaque facade
- Simulated to be 50% less than MNECB standards for utility costs

SUMMARY

60 Richmond is in many ways a fairly radical urban housing proposition. The location of community gardens and shared outdoor spaces, vertically distributed within the built fabric, should create something of a social experiment.

- Example of high density social housing with modest outdoor spaces tightly integrated within building
- Mixed use with commercial base
- Not inexpensive at \$235 per square foot in hard costs
- Varied access to light

FIG. 4.112 TYPE COMPARISON

TYPE	NET FAR	NET DENSITY (p/Ha)	Ext. Surface Area/Floor Area	BASELINE ANNUAL ENERGY USE (KWh/m ²)	COMMENTS
Typical Single Detached house	~ 0.5	~5-100	~ 2	230-250 ⁶⁵	--
Typical apt.	Varied	Varied	Varied	188-210 ⁶⁵	--
TYPE A	1.6	250-430	1.2	111	Stacked rowhouses with larger terraces. Double aspect rowhouses and smaller single aspect apartments. Open air terraces. Designing access to upper units can be more challenging. Relatively compact form. Flexibility of rowhouse type means lower units can be split into smaller units or accommodate small ground floor commercial space.
TYPE B	1.6	265-450	1	100	Stacked rowhouses with roof terraces. Relatively low, four storey form. Terraces open to sky. Compact form. Horizontal dimensions can be varied for very large units or 100 m ² two bedroom units. Rowhouses can be split into smaller units or provide commercial space at grade.
TYPE C	1.3	200-330	0.9 (enclosed courtyard) 1.4 (open courtyard)	137 ⁶⁶	Lowest density of all types Two floor low rise form. Generally larger units. Two outdoor space conditions in dwelling: courtyard and roof terrace. Most spaces in dwelling have outdoor views and indirect light from courtyard.
TYPE D (6 storey)	2.6	400-655	0.78	102	Tower configuration with stacked terraces. Horizontal dimensions can be varied for range of units size. Significant degree of shading, terraces may not feel as open and airy as some other types. Relatively simple, compact form.
TYPE E (6 Storey)	2.4	365-620	Slightly more than type D	-	Similar to type D. Terraces somewhat more open than D and F and less shading of building from terraces. Unlike D, limited height.
Type F (6 storey)	1.7	260-440	1.3 (enclosed courtyard and terraces)	-	Some light and views penetrate through building - could potentially allow for closer spacing of buildings. Extensive building envelope area - reducing this would require enclosing terraces or dynamic facades. Likely higher energy use than types A-E. Horizontal dimensions can be varied for range of unit sizes. Significant shading of terraces, terraces may not feel as open and airy as some other types. More complex form.

CONCLUSIONS

The schematic types illustrated above have attempted to implement some of the principles and strategies discussed in Part I of this chapter in a balanced way, creating dwelling units that support a high quality of life in a denser urban environment. Some of these principles and strategies will be addressed more clearly in Part II of this chapter and in chapter five, where greater definition of site context and a more complete design proposal for a specific site will allow for better implementation of some of these principles.

In general, units in these types have tended to be designed at larger sizes, roughly over 75 m², though some of the types also implement smaller units. The general focus on a range of larger units is to create types that might be suited to larger households and families, as well as couples or even singles, creating urban dwelling types that can, together with more familiar condominium or apartment buildings, accommodate a wide range of households within a denser urban environment. Moreover, many of the larger units in the types explored above are in simple rowhouse configurations, which are understood to be adaptable and can be split into smaller units. In the two storey lower units type A and B, enclosing a stair that is accessed from a streetfront door can divide a larger unit into two or more units.

Types A, B, and C are low rise types, and many of the units in these can be accessed at grade if the dwellings are not atop a podium. These types have a closer relation to the existing ground plane than D, E, and F, and many of the outdoor spaces here may be at grade. Outdoor spaces in these types are more open than in D, E, F, since they are not stacked and there is nothing overhead. Access design becomes somewhat more challenging in upper units of A, B, and C and will be changed in the lower units where these types are not at grade and are instead located above other storeys in a mixed use building, as at the Citadel Almere or the Freiburg Solar Development. The types can be repeated horizontally to form urban blocks, but cannot be significantly changed in height without a fundamental change in their character.

Types D, E, and F will likely be somewhat higher than the others,

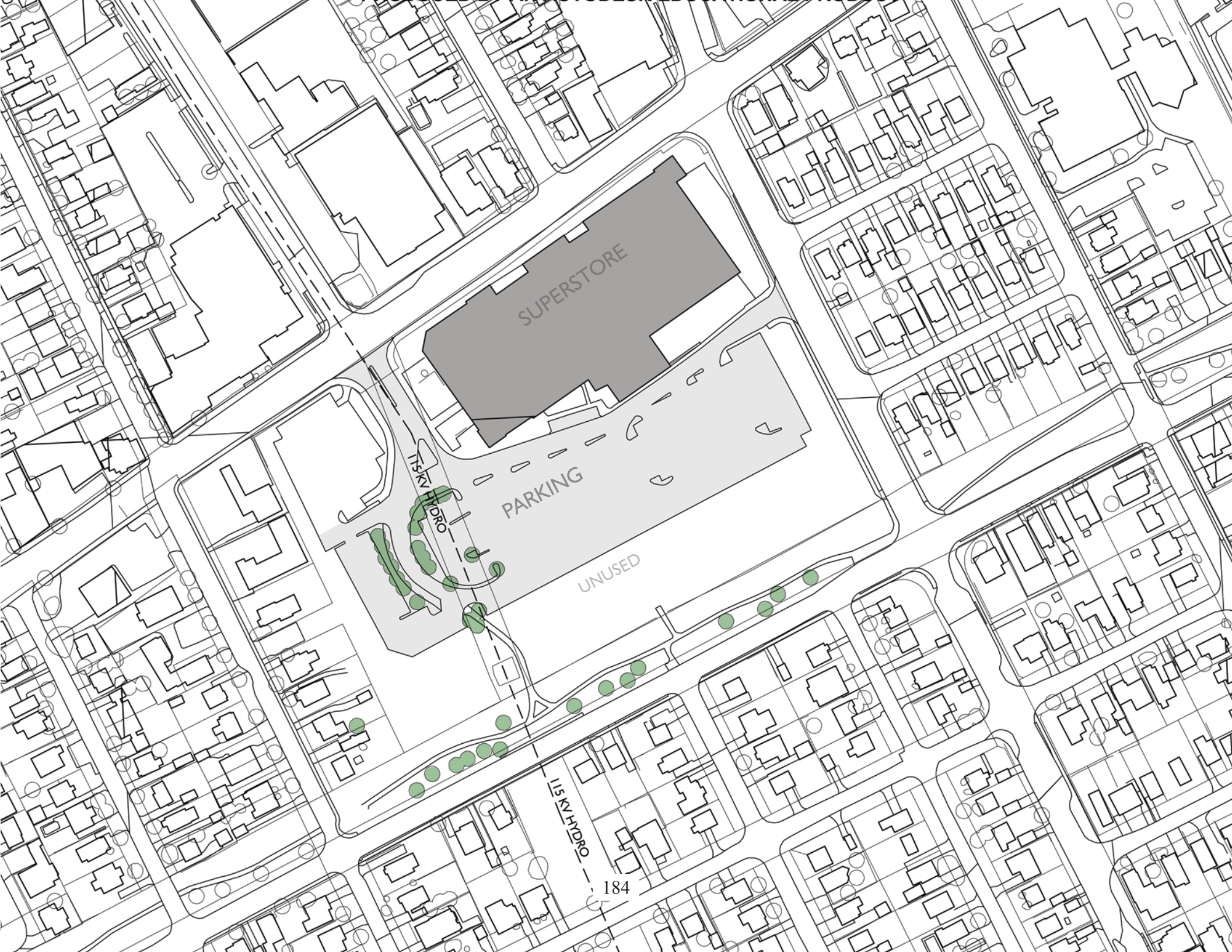
as these types can be extended vertically as well as horizontally (though, due to the stepped nature of Type E, its vertical height is limited). The appropriate height of these types may vary from context to context, and consideration of the various effects of tall buildings (eg. on shadowing, urban character, energy, etc.) is always important. These types can integrate with large commercial programs at grade in more standard ways, since typical units in these are accessed by vertical circulation elements and corridors. The nature of the outdoor spaces in these types are fundamentally different from the nature of those in types A, B, and C, since they are stacked to some degree, meaning they shade each other and have a greater sense of enclosure and spatial limitation. As units are higher, the outdoor spaces will change somewhat in quality, as they will have different views, have more distant relations to the existing ground plane and to shared spaces, and will be exposed to higher winds.

As expected, schematic energy simulations indicate that the more compact types tend to have the lowest energy use. In some cases, the compactness of the form was offset by larger areas of glazing (eg. type C, and D). In all types, even with what would be considered a high performance envelope, it was difficult to achieve a simulated annual energy use much below 100 KWh/m² without offsetting energy use with renewable energy and solar hot water. However it should be noted that further savings can likely be achieved with optimized HVAC design, as the HVAC modelling systems in the energy simulations were very basic and were not at all a focus of the simulation exercises in this thesis. The thesis focussed primarily on architectural strategies for reducing energy use, and simple, default values for the HVAC systems were used (see Appendix 5). Nevertheless this indicates that, in Canadian climates, while architectural and mechanical systems strategies are critical in reducing energy use, it may be difficult in practice to achieve energy use targets such as those outlined by, for example, the 2030 challenge, without the use of renewables and solar hot water.

Chapter five will look at implementation of some of these schematic types on a specific site in a more developed design proposal, integrating various other programs and responding to specific site contexts. First, the final component of chapter four looks briefly at a few site strategies.

CHAPTER IV - PART III - SITE STRATEGY

FIG. 4.113 SITE FOR DESIGN PROPOSAL IN CHAPTER 5 - EXISTING
(Opposite) a large retailer in a semi-suburban area with extensive amounts of surface parking.



SUPERSTORE

PARKING

UNUSED

115 KY HYDRO

115 KY HYDRO

184

The way in which one might approach redevelopment of existing city areas will be shaped by the context of various sites. The schematic types in Part II have for the most part been developed on the assumption that they will be located on relatively large sites; they are proposals for larger scale infill. Part III discusses a particular type of large site, prevalent in most North American cities: large, low density, single storey retail and commercial sites, generally in low density residential neighbourhoods. This type of site includes many shopping centres, strip malls, large retailers, power centres, etc. Their characteristics are familiar: wide, low-cost, single storey buildings set back from street edges and public areas, with large amounts of surface parking often covering more than 50% of the site. Such sites are commonplace. A city study of land available for redevelopment within existing areas of Ottawa attributes about 5% of urban land available for redevelopment to strip malls, shopping centres on 1-4 hectare sites, and shopping malls on sites over 4 hectares. The city's development assumptions regarding such sites leads it to assume that these sites represent more than 15% of the potential supply of new housing in the city.⁶⁷ These sites, as large tracts of underdeveloped property within existing city areas, requiring little or no land assembly once obtained, present significant opportunities for creation of new urban dwellings and an invigorated urban fabric.

FIG. 4.114 shows some of the core aspects of this thesis' general strategy for dealing with such sites. These are:

(1) *Addressing streets and public areas.* Perhaps one of the simplest and most direct ways of creating a more urbane, lively environment, is to simply locate retailers and programs on the site so that they address streets or other public areas.

(2) An obvious challenge in redeveloping such sites at higher densities - and one of the most critical economic imperatives relating to such development - is *reducing the area of surface parking* while still providing sufficient parking (as required by zoning by-laws, commercial tenants, residential tenants) in an economical fashion.

(3) *New circulation paths* on larger sites will create new pedestrian and vehicular routes, and will have to allow for the required fire truck

access. New paths will allow for varied pedestrian routes, creating a more porous and interesting pedestrian fabric.

(4) *Introduce additional programs and landscapes.* Here, the integration of unit types discussed in Part II, as well as other, more standard unit types (eg. single storey condominium units around double loaded corridors, rowhouses), as well as the design of new, stacked landscapes through the use of modified ground planes, comes into play. The addition of residential programs to these sites creates a more complete neighbourhood and increases density, while the creation of new landscapes provides new outdoor spaces and natural landscapes as vital parts of the urban environment.

(5) *Resolve in a coherent design proposal* that considers neighbourhood context. This is the goal of chapter five.

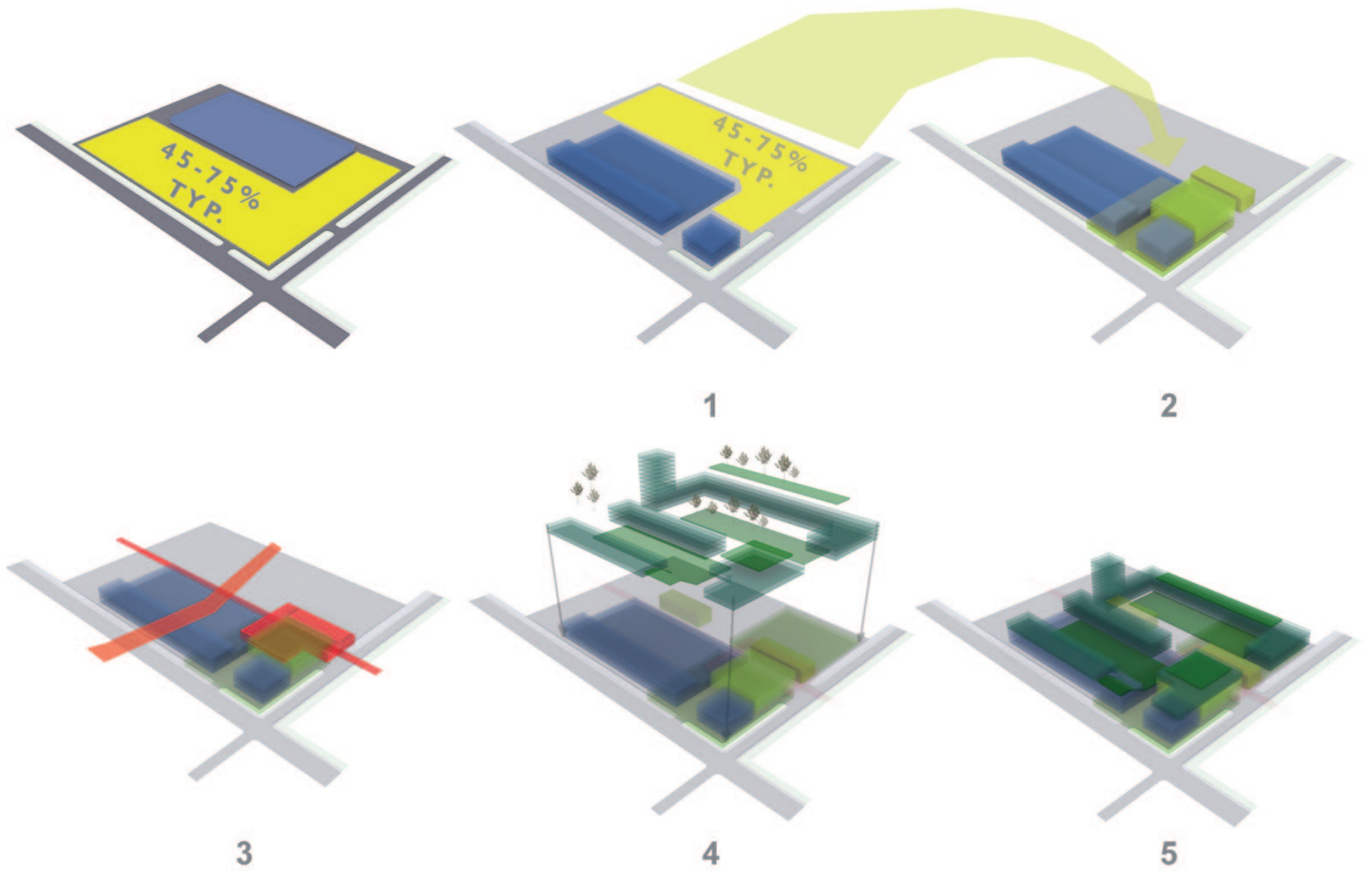
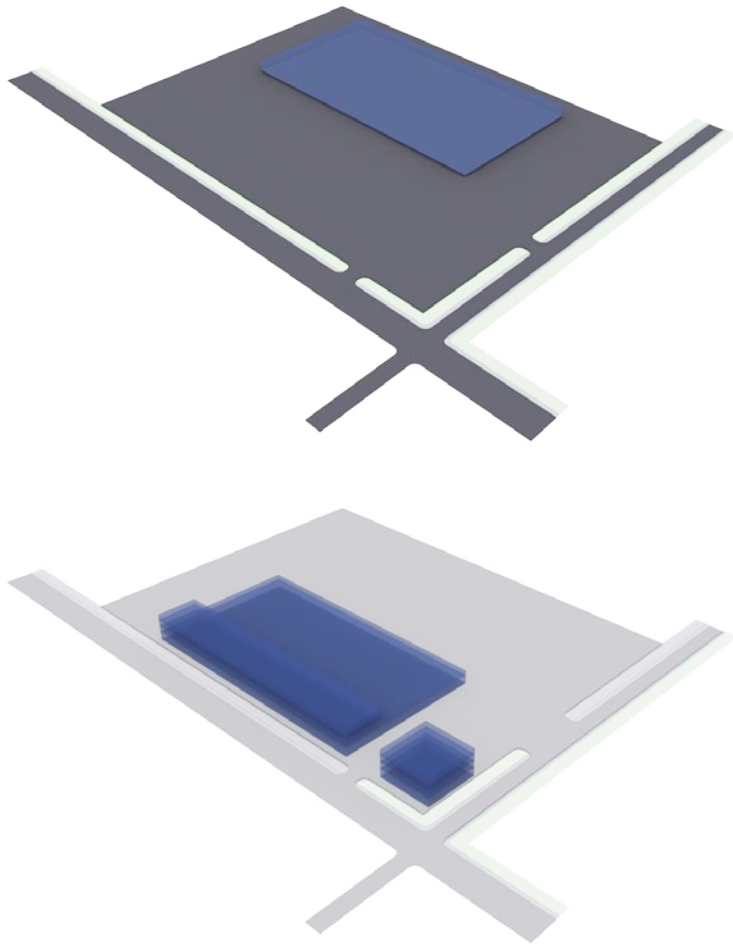


FIG. 4.114 SITE STRATEGIES

1 - ENGAGE ANY SURROUNDING PUBLIC AREAS WITH EXISTING AND/OR NEW COMMERCIAL OR PUBLIC PROGRAMS

FIG. 4.115 REORIENTING SITE PROGRAM



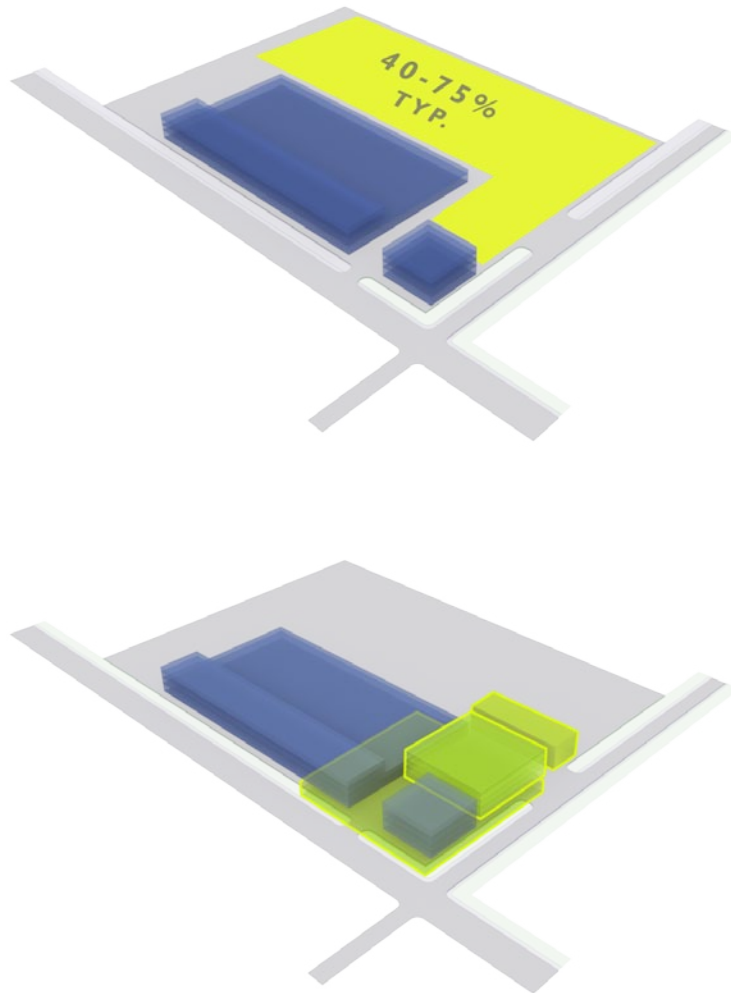
Typically, large commercial centres and retailers favor easy automobile access by placing parking adjacent to major streets. The rare pedestrian on the streets near these developments is faced with a rather bleak environment that often resembles an expressway more than any sort of pleasant urban atmosphere. Streets here exist solely for vehicle transportation.

In such cases, moving existing or new program elements closer to surrounding streets would go some way towards creating a more engaging environment, making pedestrian access easier, more intuitive, and more pleasant, and, along with a reduction in the amount of surface parking, might open up other areas of the site to program elements not requiring main street visibility. While the specific site of the design proposal in chapter five shares almost all of the typical characteristics of large commercial centres, it differs in that it's main storefront actually already faces the main street, and this alone noticeably improves the quality of street. In moving stores and programs forward, streets and public spaces conducive to a wider range of activity and to pedestrian travel can begin to come into form.

Influential urban designer Jan Gehl recommends that streetfront facades be varied, and smaller in scale and detail. He observes that "...if the facades lack interesting details - niches, holes, gateways, stairs, and so on - it can be very difficult to find places to stop...Good cities for staying out in have irregular facades and a variety of supports in their outdoor spaces".⁶⁸ In order to allow for this, the design proposal will provide segments of public facade that support modification by different tenants, which will speak to the varied nature of the services at the streetfront, and should help create a varied, human scaled streetfront. New paths and gaps in the street facade will create niches and gateways to create a porous environment with places to stop, change direction, etc.

2 - REDUCE AREA OF SITE DEVOTED TO PARKING

FIG. 4.116 REDUCING SURFACE PARKING



The most significant impediment to achieving smart development is parking. Large areas of surface parking are at odds with compact, smart development. Yet structured or underground parking accounts for 8% to 16% of costs for projects analyzed. These costs are the largest project cost component that could be effectively addressed by public policy, planning, and governmental initiatives⁶⁹

Adding structured or underground parking to an office building adds costs that competing buildings with surface parking do not incur. The underlying economic issue is that saving land by building denser building types does not result in significant cost savings, as land costs in the suburban and exurban areas tend to be very low. Thus at current price levels, land costs are not a particularly significant factor in the development cost structure.⁷⁰

Clearly, conversion of under used urban and suburban sites with large areas of surface parking requires a re-configuration of those existing parking spaces. While we should hope and expect that denser, more urban forms of development on such sites - and on other sites - should decrease the need for automobiles, it will still be necessary to provide some adequate parking space. As the quotes above note, and as many seasoned architects will confirm, this presents a challenge from a development perspective, as structured or mechanical parking adds significant costs to a project. In the minds of many developers and retailers, these costs are not often financially justified by the savings in land area when there are viable, *inexpensive, and large* tracts of land in the suburban periphery that are available for development. In order to realistically address urban development then, parking options and costs need to at least be considered. A brief consideration of a range of options available for reducing surface parking areas, and their associated costs, benefits, and disadvantages may be found in appendix 3. The options discussed are: *Reduced parking requirements, shared parking, underground parking, above ground structured parking, mechanical or automated parking.* Likely, some combination of these will be appropriate for any give project. Some of these options are implemented in the design in chapter five.



3 - NEW CIRCULATION PATHS

On large sites, denser redevelopment will require consideration of new vehicle circulation - fire fighting access in particular. This is a requirement of urban design. However, circulation for pedestrians will also be important to consider, in order to provide interesting routes and paths, and convenient pedestrian access to varied amenities. One of Jacobs' central recommendation for cities was that blocks be made relatively small, with frequent opportunities for pedestrians to turn corners, take different paths, and explore new areas of the city. She uses Rockefeller Plaza as a successful example of large block broken down into a series of smaller blocks, arguing that the success of Rockefeller Plaza would not be possible without the many openings and pathways that traverse the wide block.⁷¹ Jan Gehl also recommends creating varied street facades with "holes" and "niches": these can be created in part with new pedestrian paths through the urban fabric. In keeping with these ideas, and with the desire to create a varied, inviting pedestrian urban environment, large blocks in the design proposal will be traversed by landscaped pedestrian paths.

FIG. 4.118 NEW CIRCULATION PATHS

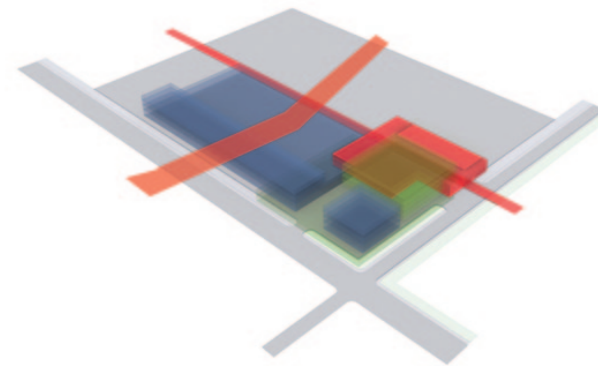


FIG. 4.117 ROCKEFELLER CENTRE

4 - INTRODUCTION OF NEW RESIDENCES AND LANDSCAPES

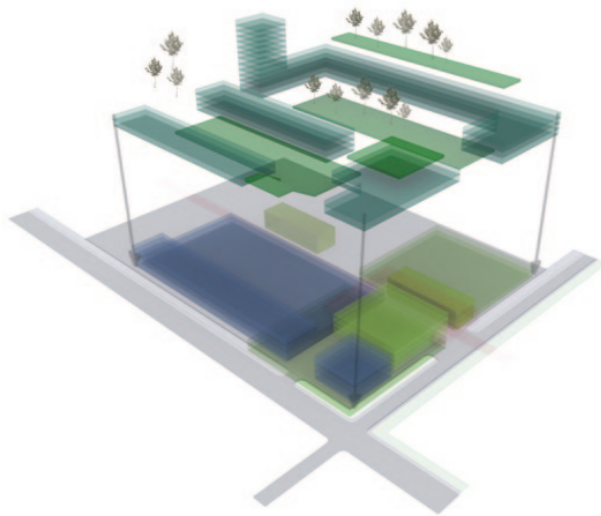
This is the implementation of the strategies and types developed in Parts II and III. The design proposal will incorporate some of the dwelling types laid out in Part II, and also other, more standard dwelling types (eg. standard mid-rise condominiums or apartments or row houses) in order to provide a mix of unit types, inhabitants, creating a mixed project with residences that have access to nearby urban amenities and open spaces.

Incorporation of modified ground planes (eg. as in the schematic type) will create new landscapes providing valuable and varied open spaces and verdure. Outdoor spaces will include a mix of public, semi-public or shared, and private areas. As well as providing spaces for gardening, socializing, children's play, and other activities, these should help create a generally verdant, pleasing, and biologically diverse urban environment.

5 - RESOLVE DESIGN

The final stage is to tie all of the design principals and goals established throughout the thesis into a more complete design, better illustrating some possible outcomes. This will be the subject of the following chapter

FIG. 4.119 NEW PROGRAM AND LANDSCAPES



ENDNOTES - CHAPTER 4

1. Gillham, "What is Sprawl?"
2. Jacobs, *The Death and Life of Great American Cities*, p. 211
3. Ibid., p. 212.
4. This is done by assuming the 1961 (the year of publication of *The Death and Life of Great American Cities*) average of 3.36 persons per household, and assuming that the net area or a compromises, on average, 1/2 the gross area.
5. St. James Town at a gross density of 650 people per hectare (and being the largest high-rise community in Canada) and a few blocks at Yonge and Bloor.
6. Ontario, Ministry of Public Infrastructure Renewal, *Growth Plan for the Greater Golden Horseshoe*, p. 16, 17, and Schedule 3.
7. Firley and Stahl, *The Urban Housing Handbook*.
8. Gillham, "What is Sprawl?", p. 291
9. City of Ottawa, "Population Projections."
10. City of Ottawa, "Summary of Land Area by Category."
11. City of Ottawa, "Summary of Land Area by Category," and "Summary of Total Potential by Unit Type".
12. This assumption is based on land use statistics for the city of Vancouver, the city of Mississauga, and the city of Ottawa.
13. Natural Resources Canada, Office of Energy Efficiency, "Canada's Secondary Energy Use by Sector, End-Use and Sub-Sector."
14. Natural Resources Canada, Office of Energy Efficiency, "Canada's GHG Emissions by Sector, End-Use and Sub-Sector."
15. Variables pertaining to envelope, internal loads, window to wall ratios, are kept equal for all buildings. The only variables changed are form and orientation.
16. Pride and Duncan Hill, "Top 10 Energy and Water Saving Tips in Multi-Unit Residential Buildings," p. 8
17. Pan, "Relationships between air-tightness and its influencing factors of post-2006 new-build dwellings in the UK."
18. Harris, *Air Leakage In Ontario Housing: Proposed Changes to the Ontario Building Code to Reduce Air Leakage*.
19. Ross, "Design with Energy In Mind", p. 410, 411
20. Clarke, "Energy Simulation", p. 15
21. Eg. Straube, *Interview with Author*; Clarke, "Energy Simulation"; Pope, *Interview with Author*; Malkawi. and Augenbroe, eds., "Advanced Building Simulation".
22. Canadian Mortgage and Housing Corporation "Research Highlight: Residential Solar Mass Wall Analysis for Canada," p. 3
23. The building was modelled twice - once without shading and once with extensive shading - and simulation results from the shaded building were used in warm months, and results from the un-shaded building in all other months, in an effort to simulate dynamic shading.
24. Schmitz and Scully, "Creating Walkable Spaces," p. 23
25. Strauss, "Loblaws' Leighton Has Learned from Experience."
26. Marr, "Living Above a City Store Becoming Trendy."
27. Boardman et. al., *40% House*, p. 29 ; Kees and Haffner, *Housing Statistics in the European Union*; United Nations, ACC Task Force on Basic Social Services for All. "List of Basic Social Services for

All Indicators,”; U.S. Census Bureau, *American Housing Survey for the United States: 2007*; Yan, “What Lies Difference of Average Living Space between China and Advanced Countries”

28. Ibid.
29. Boardman et. al., *40% House*, p. 29
30. City of Ottawa, “Size of Household by Sub-Area, City of Ottawa, 2006: Table 24”
31. Albrecht, *Global Citizen: The Architecture of Moshe Safdie*.
32. Eg. Arvai, “Re-visionaing Sustainable Urban Housing in 2020”; Malboeuf, “The Overnight City.”
33. Peck and Kuhn, “*Design Guidelines for Green Roofs*” p. 13, 16
34. Ibid., p. 11.
35. Densities are calculated based on the net F.A.R. of the basic type or precedent. The F.A.R. assumes an appropriate site size, including some setbacks where relevant, but excluding surrounding streets. *Net density* is calculated by multiplying the F.A.R. by 10,000 m² (1 hectare) and dividing the product by an assumed floor area per person (50 m²/person is assumed). Therefore, estimated net density = (FAR*(1 Ha)*10000m²)/ (assumed m²/person). *Gross density* is estimated by assuming a ratio for net area to gross urban area - in order to account for non-residential areas in the surrounding fabric (eg. public open spaces, streets, commercial buildings, etc). Therefore estimated gross density = ((Floor area/(Site area/net to gross ratio))*(1 Ha) *10000m²)/ (assumed m²/person).
36. The assumption of a 50% net to gross ratio for residential land use for the thesis proposals and case studies is drawn from land use figures for cities of Vancouver, Ottawa, and Mississauga. Residential and mixed use areas make up for approximately 30-40% of land in these cities. The assumption that the residences in the thesis proposals and case studies might take up 50% of re-developed land takes into account the mixed use nature of most of these, which mean that less land will be required for non-residential facilities.
37. MVRDV, “Expo 2000 NL Pavillion.”
38. Illuminating Engineering Society of North America, *IES lighting Handbook*, p. 2-6 - 2-10
39. Boake, “Spangen Housing Quarter.”
40. Sherwood, *Modern Housing Prototypes*.
41. Myers and Baird, “Vacant Lottery.”
42. Hydro Block Residents, *Interview with Author*.
43. Fernández, Mozas, and Apra, *Dbook*.
44. Detail, “ ‘Plus Energy’ Housing and Service Centre in Freiburg.”
45. Ibid.
46. Greensource, “Green Building Project Search.”
47. Fernández, Mozas, and Apra, *Density Housing and Construction Costs*.
48. Macdonald, *Interview with Author*.
49. *Ibid*.
50. Bill Joyce Real Estate Ltd., “Lillian/Repath Condo Townhomes.”
51. Trulia, “1380 East Madison Park, Chicago IL.”
52. Brooks, *Le Corbusier: Urbanisme, Algiers, and Other Buildings and Projects*, p. xvii.
53. Hayes, “The Vernacular Esoteric of Architects Alliance,” p. 81

54. Ibid., p. 77.
55. Safdie, "East and West," p. 236
56. Safdie, *Beyond Habitat by 20 Years*
57. Baker, "Inhabiting Habitat."
58. Ibid.
59. When measured from section drawings, though the FAR of Habitat is hard to gauge due to it's complexity.
60. Sherwood, *Modern Housing Prototypes*, p. 98
61. Fernández, Mozas, and Apra, *Dbook*, p. 216
62. Lang Wilson Practice in Architecture Culture, *Lang Wilson Website*.
63. Toronto Community Housing, "60 Richmond St. East: Closing Report."
64. Toronto Community Housing, "60 Richmond St. East: Sustainable Design."
65. Natural Resources Canada, "Table 3: Residential Single Attached Secondary Energy Use by Energy Source and End-Use"; 2030 Challenge, "2030 Challenge Targets: Canadian Residential Regional Averages."
66. Modelling of courtyard house limited by software, requiring some significant simplifying assumptions, thus modelling less accurate than other types.
67. City of Ottawa, "Summary of Total Potential by Unit Type"; City of Ottawa, "Summary of Land Area by Category."
68. Micacchi, "Redeveloping the Avenues," p. 23
69. Blais, "Smart Development for Smart Growth", p. 12
70. Ibid., p. 11.
71. Jacobs, *Death and Life of Great American Cities*, p. 182

V - DESIGN PROPOSITION





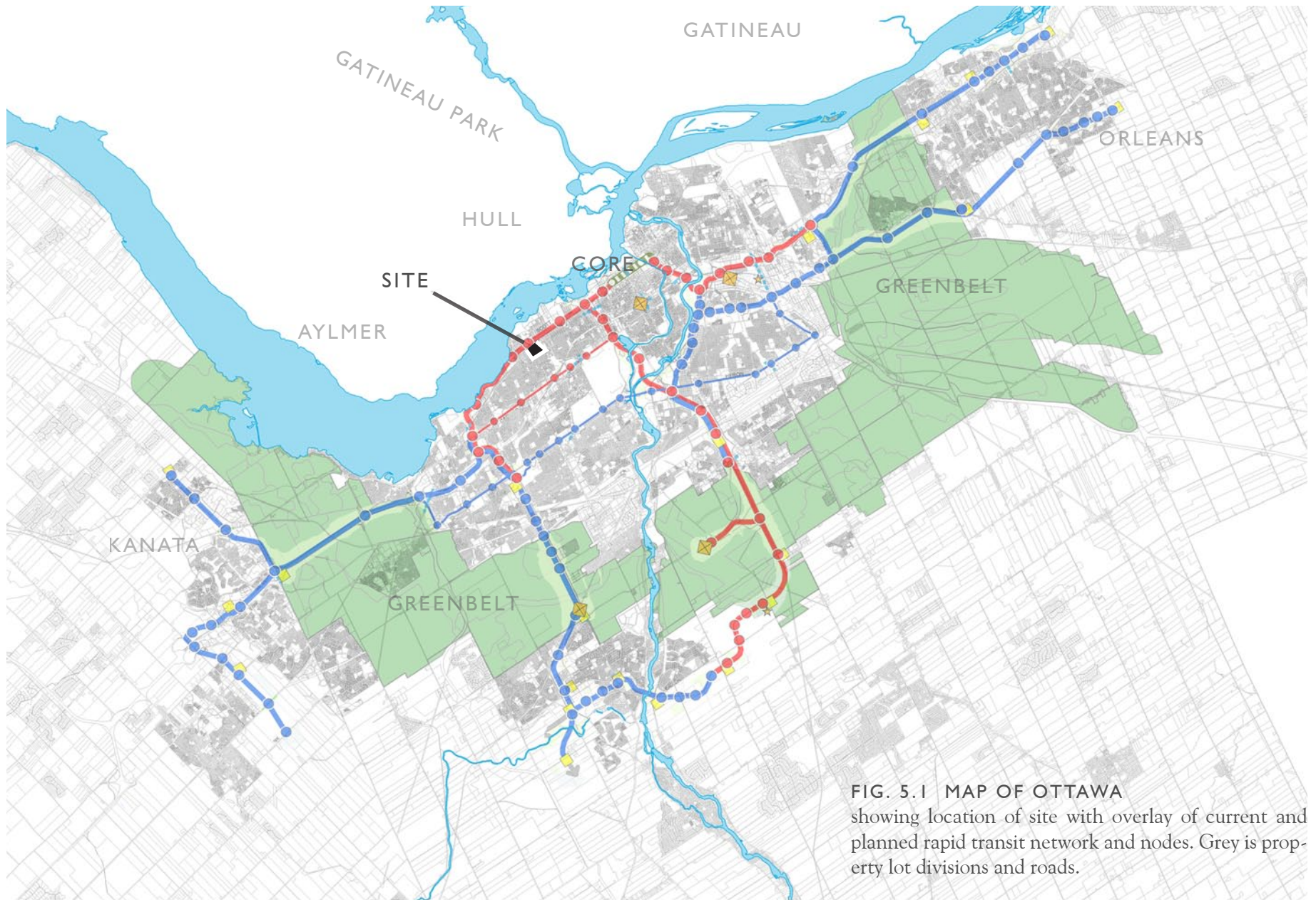


FIG. 5.1 MAP OF OTTAWA showing location of site with overlay of current and planned rapid transit network and nodes. Grey is property lot divisions and roads.

Some of the character of the site of the design proposition has already been discussed in the introduction and in chapter four. The site is in the west end of Ottawa, in the rapidly developing inner suburb of Westboro. Bordering the north end of the site is Richmond road (FIG. 5.2, FIG. 5.3, FIG. 5.4), which is a rapidly urbanizing main street. The street has a number of mixed use mid-rise condominium projects under construction or in planning. To the south of the site is a long, very narrow, multi-block park that sits on former streetcar tracks. It has a pedestrian and cyclist path. To the south of the park is Byron avenue, a relatively quiet residential collector road. The east side of the site is bordered by Kirkwood, an arterial road connecting to the 417 highway. To the east is an 115 KV power transmission line, which has been considered in the design with a 35 m setback. The blocks immediately around the site are composed primarily of single houses, some walk-up apartments, and low rise commercial buildings.

The site itself currently houses a one storey Superstore, with large amounts of surface parking. The development of the Superstore, an essentially suburban type, on this site has been viewed by many as a major missed opportunity in the area.¹ The potential for a conscientious increase in urban density on a major site in a developing area near a major transit node, for a more animated streetfront, and for diverse new programs, is missed.

The following design propositions seek to demonstrate how the design principles and schematic types established in the previous chapter could be implemented on such a large site, in an existing low density urban area, in order to meet some of this potential, and, in general, to address the urban challenges identified over the course of this thesis.

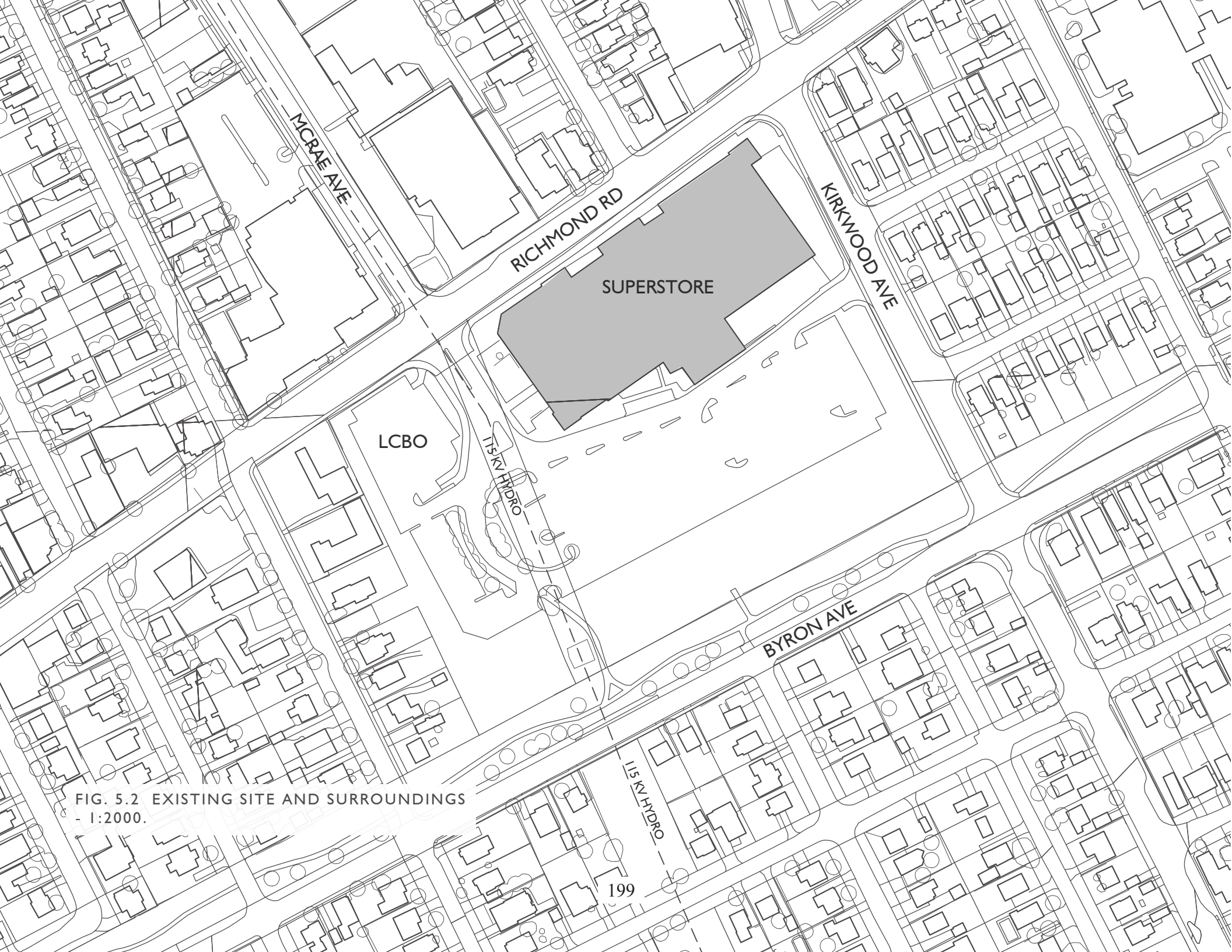


FIG. 5.2 EXISTING SITE AND SURROUNDINGS
- 1:2000.



SITE CONTEXT

FIG. 5.3 (ABOVE) LOCAL RICHMOND ROAD STREETSAPES.



FIG. 5.4 (BELOW) EXISTING SUPERSTORE SEEN FROM RICHMOND ROAD.





FIG. 5.5 BYRON AVE PARK AND BIKE PATH

FIG. 5.6 BYRON AVE PARK AND BIKE PATH

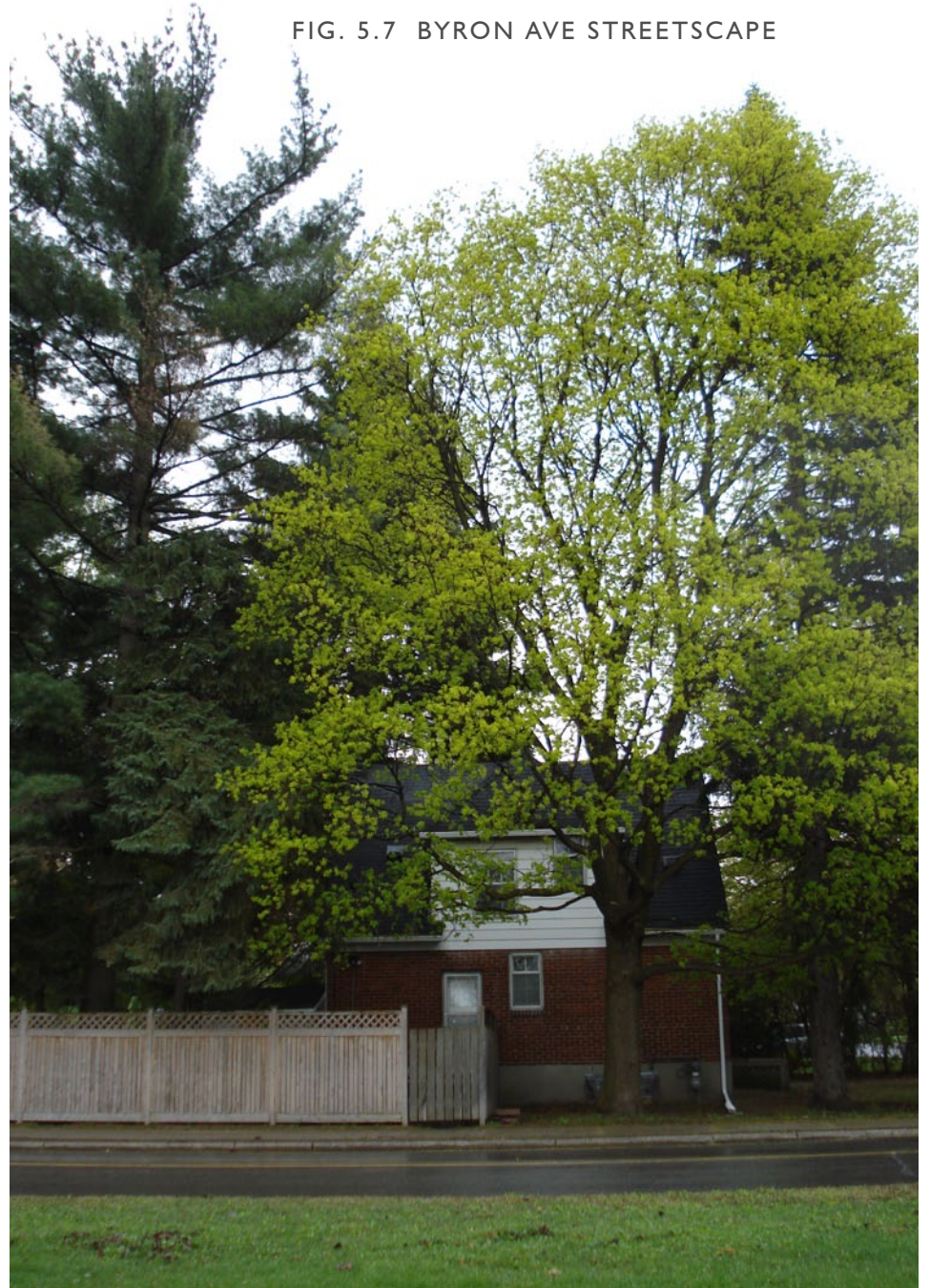


FIG. 5.7 BYRON AVE STREETSCAPE



FIG. 5.8 BYRON AVE STREETScape

FIG. 5.9 BYRON AVE STREETScape



SITE DESIGN OPTIONS

SITE DESIGN I - SEE DETAILED PROPOSAL

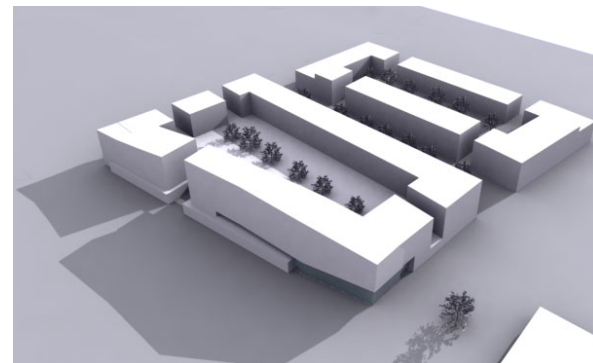
GROSS URBAN POPULATION DENSITY (50% NET TO GROSS):
~ 100-150 PPL/HA

NET URBAN POPULATION DENSITY: ~200-300 PPL/HA

- Predominantly stacked rowhouses - type A and B - and low-rise condominium or rental apartment units.
- Main street (Richmond Rd) lined with commercial and offices space and potential hotel
- General perimeter block form, opened in locations to allow more light, porosity, views, pedestrian paths



FIG. 5.10 SITE DESIGN I - NORTH - SOUTH SECTION



SITE DESIGN 2

GROSS URBAN POPULATION DENSITY (50% NET TO GROSS):
~ 180-210 PPL/HA

NET URBAN POPULATION DENSITY: ~360-420 PPL/HA

- Slightly higher density option. Mix of 6-8 storey type D slab buildings atop commercial base, type B stacked rowhouses, and 5-8 storey typical condominium or rental apartments.
- Higher density and height on main street, stepping down to existing low rise residential.

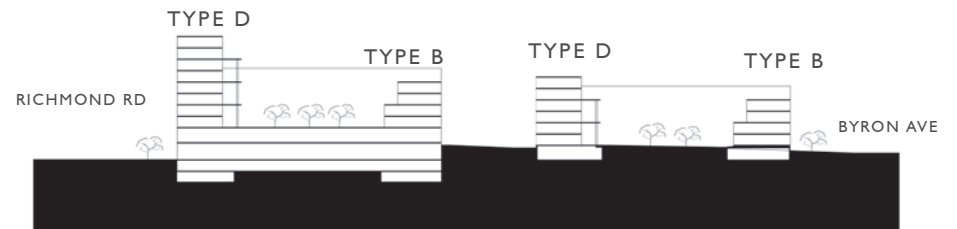


FIG. 5.11 SITE DESIGN 2 - NORTH - SOUTH SECTION

SITE DESIGN 3

GROSS URBAN POPULATION DENSITY (50% NET TO GROSS):

~210-270 PPL/HA

NET URBAN POPULATION DENSITY: ~420-540 PPL/HA

- Higher density option - mix of large courtyard buildings with type F and possibly type D units, type B stacked rowhouses, and more standard mid-rise condominium or rental apartments.
- Main street is fronted by mix of apartments, commercial, and hotel wrapped around courtyard.
- High density at main street edge, stepping down towards existing low density residential

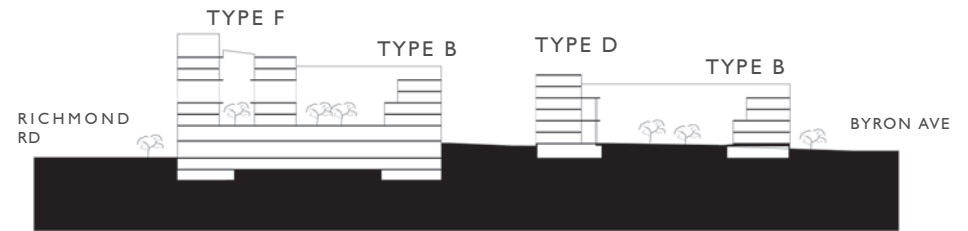
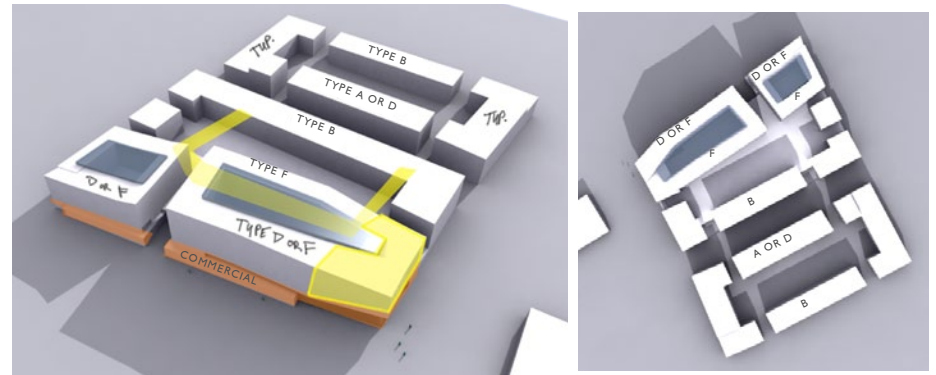


FIG. 5.12 SITE DESIGN 3 - NORTH - SOUTH SECTION



DETAILED DESIGN PROPOSAL

SITE DESIGN 1

- A. *Approximate Property area: 3 Ha*
- B. *Net property area excluding new street: 2.8 Ha*
- C. *Site area including half width of surrounding roads and Byron park: 3.9 Ha*
- D. *Site area including half width of surrounding roads, excluding area of Byron streetcar park: 3.5 Ha*
- E. *Gross residential floor area: 36,000 m²*
- F. *Gross non-residential (retail, office, community, commercial storage, etc.) above grade floor area: 19,000 m²*
- G. **Net site FAR - property only, excluding roads and Byron Park ([E+F]/B): 1.95**
- H. *Gross site FAR - including roads, excluding park ([E+F]/D): 1.6*
- I. *Estimated residential population: 550 - 820 p/Ha*
- J. **Estimated net urban population density (I/B): 200 - 300 p/Ha**
- K. **Estimated gross urban population density (I/[B x 2]): 100 - 150 p/Ha**
- L. *No. of double height rowhouse units: 117*
- M. *No. of single storey rental or condominium apartment units: 210*
- N. **Median size of stacked rowhouse units : 138 m²**
- O. **Average size of stacked rowhouse units : 142 m²**
- P. *Approx net leasable retail and office area: 13,000 m²*
- Q. *No. of retail and office parking spaces: 245*
- R. *No. of residential parking spaces: 400*
- S. *Residential parking spaces per unit: 1.2*
- T. *Approx. commercial parking spaces per 1000 sq.ft. of net leasable retail and office area: 1.75*

This proposal combines schematic types A and B with low rise rental apartment and/or condominium units. It is developed in two principal blocks: a north block facing onto the main street - Richmond road - and a lower south block facing onto the park and Byron Ave. These are loose perimeter blocks, which are cut in several spaces to provide a greater sense of openness, porosity and pedestrian access, and to bring more light into the courtyard spaces and streets. The buildings at the east and west side of the south block are more conventional double loaded apartment or condominium buildings. The north-south orientation of these double loaded buildings means the majority of units receive some direct sunlight at some point in the day. The building at the east end of the North block could also be condominium or rental apartments, or it could be conceived of as a hotel which can be directly accessed from the main street, perhaps contributing to the vitality of Richmond road.

Overall, the blocks have a more east-west orientation, in order to potentially use passive solar heating in many of the type A and B dwellings. The orientation will allow these dwellings, as primarily double aspect units, to receive both direct and diffuse natural light. Shading strategies should be explored on the southern windows of these dwellings in order to optimize any passive solar strategy. The proportions of the courtyards and the spacing of the buildings allows direct sun to hit the southern facades of these dwellings even in the depth of winter, and will allow direct sun to fall onto most of the outdoor spaces in the courtyards in warmer months, allowing inhabitants to grow a wide variety of plants.

The height of the development steps down towards the south to better integrate with the existing residential fabric at the south. The height of the proposed buildings at the south of the site suggest a gradual increase in density, from the single homes in the blocks to the south, to the 2.5 - 3 storey walk-ups along Byron avenue (FIG. 5.8, FIG. 5.9), to the four storey buildings at the south end of the proposed design. The north block reincorporates the existing grocery store in a somewhat unconventional, but not unprecedented two-storey format, freeing up some grade level space on Richmond road for other programs, such as small retailers, cafes, offices, etc. In an alternative scenario, the grocery store space might be a daily farmer's market. Commercial loading and storage,

as well as garbage disposal facilities for the project are concentrated in the eastern portion of the North block, at ground level. Above this, space is left unprogrammed - it could potentially connect to the loading bay below to form a self storage facility, or could be used for a number of other programs. The north block also incorporates flexible offices spaces at the outer perimeter of the second floor. The north-west corner of the block houses a cafe, a restaurant/bar/small music venue, and the main entrance to the grocery store.

The inner courtyards are divided between shared spaces for the residents - which provide social gathering areas and areas for children to play which can be easily supervised by many of the surrounding dwellings (FIG. 5.43) - and private yards which can be landscaped by the residents (FIG. 5.45, FIG. 5.46).

The scheme provides a total of 645 underground parking spaces, as well some potential space for a limited amount of surface parking. This is divided into residential parking levels and commercial parking levels.

For commercial and office spaces, the Urban Land Institute recommends 4 parking spaces per 1000 square feet of net leaseable commercial space in a smaller shopping centre, and 0.5-3 parking spaces per 1000 square feet of net leasable office space. In this scenario, this might entail roughly 350 - 450 spaces.² This iteration of the design proposal falls some 100 - 200 spaces short of these recommended ratios. However, given the pedestrian orientation of many of the stores and of the scheme in general, the proximity to rapid transit, and the densifying nature of the neighbourhood, this should be acceptable. Jane Jacobs recommended a strategy of attrition in dealing with automobiles in city building - gradual phasing out of automobile infrastructure and mass automobile use in urban areas - and gradual reduction of parking requirement can form part of this strategy.

With regards to residential parking, the scheme provides roughly 1.2 spaces per unit, which is more than adequate to meet Ottawa bylaw requirements (which are between 1 and 0.25 spaces per unit, depending on the area: 0.5 for apartment buildings in the neighbourhood of the site, and 0.75 for attached dwellings in the area). Additionally, given the pedestrian and transit orientation of the development, this residential

FIG. 5.13 DESIGN PROPOSAL SCHEMATIC PRO-FORMA

Approximate total property area (m ²)	30,000
Land Cost (\$/m ²)	1,750
Total cost of property	\$52,500,000.00
Approx. Residential Area (m ²)	36,000
Approx Non-residential Area Above Grade (m ²)	19,000
Below Grade Parking area (m ²)	22,000
Construction cost residential (\$/m ²)	\$1,900.00
Total Residential Construction cost	\$68,400,000.00
Construction cost – non-residential above grade (\$/m ²)	\$1,500.00
Total Construction cost – non-residential above grade	\$28,500,000.00
Construction cost below grade (\$/m ²)	\$550.00
Total construction cost below grade	\$12,100,000.00
Landscaping + roads + services	\$4,500,000.00
Total Construction cost	\$113,500,000.00
Soft Cost (30% total construction cost)	\$28,375,000.00
TOTAL COST	\$194,375,000.00
Profit (20% profit margin)	\$38,875,000.00
TOTAL COST WITH PROFIT	\$233,250,000.00
Cost to commercial + office (35% total costs)	\$81,637,500.00
Cost to residential (65% total costs, excluding residential parking costs and profit)	\$139,343,100.00
Sale price – residential (\$/m²) – assuming 85% Net to Gross	\$4,553.70
Sale price – residential (\$/ft²) – assuming 85% Net to Gross	\$423.04
Parking space – residential - (\$/space)	\$30,673.50
Annual Commercial + office lease rate for Payback in 15 years (\$/m²)	\$409.21
Annual Commercial + office lease rate for Payback in 15 years (\$/ft²)	\$38.02

parking ratio could be reduced and the parking scheme reorganized to provide more commercial and office spaces, even eliminating some parking spaces.

The density of the proposal can be measured in different ways. Gross density of the project, considering *only* the site and immediate roads and public rights of way surrounding it, is 150-250 people per hectare. However residential and mixed use developments, together with roads and rights of way, only make up part of the overall urban fabric - roughly 50 - 70 % of the urban areas of cities such as Vancouver, Ottawa, and Mississauga.³ To compare the density of the proposal to the urban density of large urban areas then, the area around the immediate site is doubled, to give a very approximate overall urban population density of 100 - 150 ppl/Ha. This density represents a roughly four to six fold increase in density compared to most areas of Ottawa. Likewise, comparing the net FAR of the design to the approximate net FAR of a sample block of the surrounding residential area (FIG. 2.35) gives a roughly fourfold increase in density.

With these levels of urban density, which include significant retail, office, and storage spaces, the proposal provides for a reasonable increase in urban density, with fairly generous spacings between buildings, streets, and relatively wide courtyards. These spacings are somewhat the result of the dimensions of this specific site. Density could be increased with a very similar scheme if these dimensions are altered, with somewhat narrower streets and courtyards.

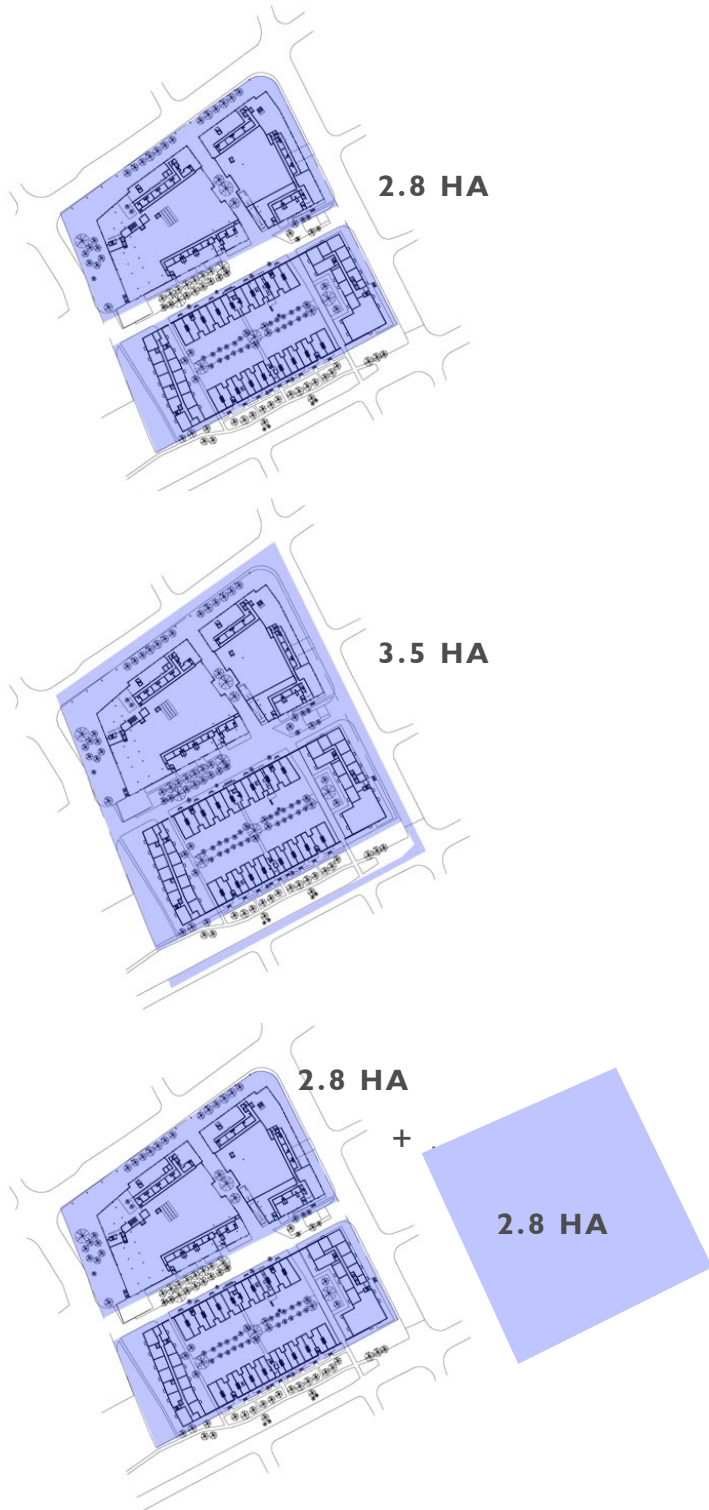


FIG. 5.14 DESIGN PROPOSAL DENSITY METRICS

Blue graphically indicates area measured for each metric

Net Density

Net area - Approximate area of property, no roads: 2.8 Ha

Net Density: 200-300 ppl/Ha

Net FAR: 1.96

Gross Density - Local area

Approximate area of property and surrounding roads: 3.5 Ha

Gross density of local area: 150 - 250 ppl/Ha

Gross local FAR: 1.57

Gross Urban Density - including additional area for non-residential programs (streets, parks, non-mixed use commercial areas, institutional areas, etc.)

Approximate area of property, plus additional area of equal size: 5.6 Ha

Gross Urban Density: 100 - 150 ppl/Ha

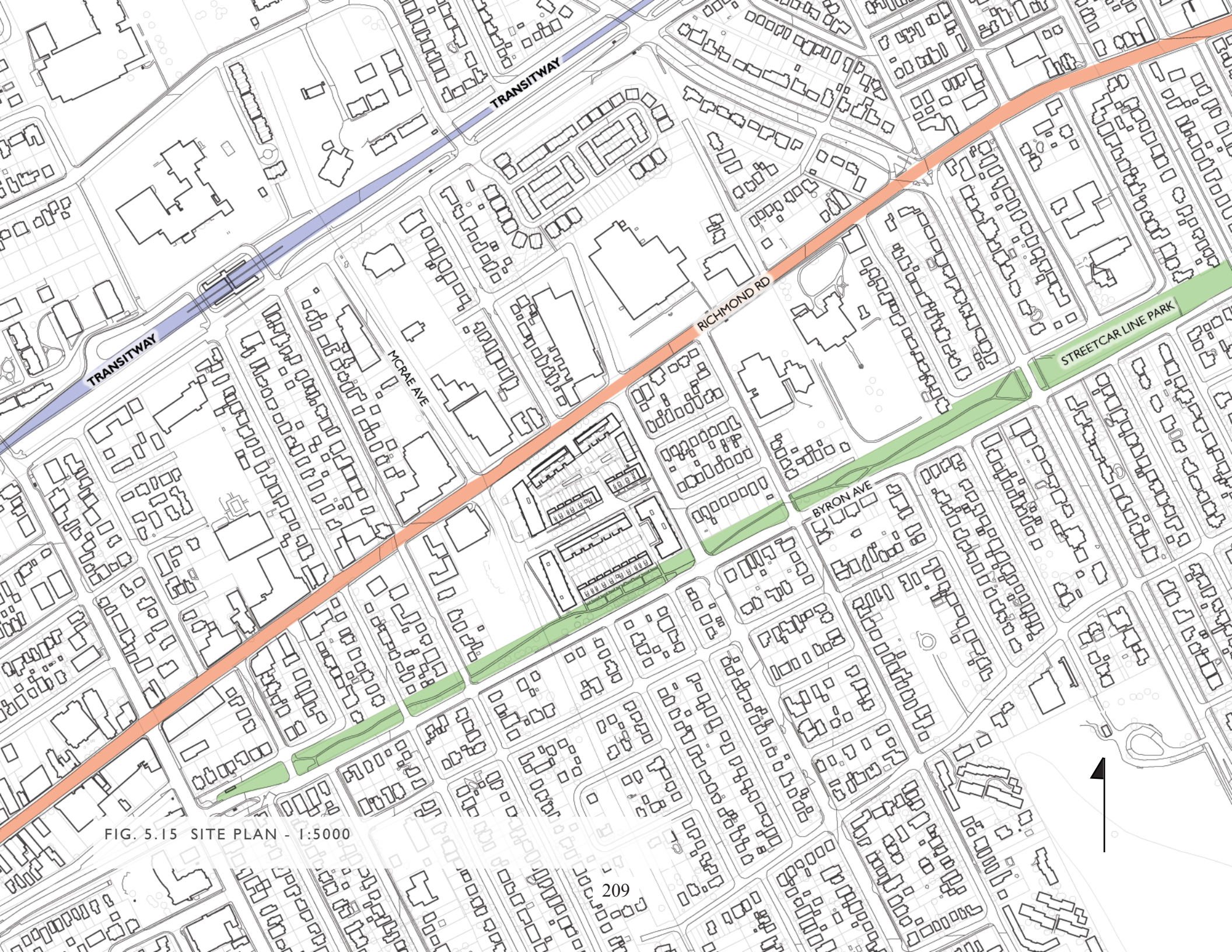


FIG. 5.15 SITE PLAN - 1:5000

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FIG. 5.16 DESIGN PROPOSAL AERIAL RENDERING



FIG. 5.17 VIEW FROM RICHMOND RD - MID-DAY IN LATE SPRING



FIG. 5.18 RICHMOND RD SCHEMATIC FACADE

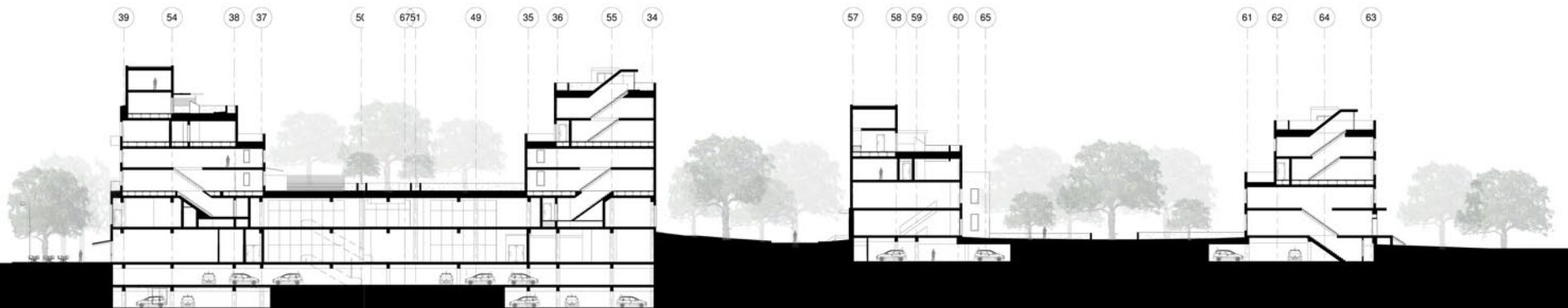


FIG. 5.19 SECTION A - 1:800



FIG. 5.22 SECTIONAL PERSPECTIVE - NORTH BLOCK
Looking east, May 15, 10:00 am



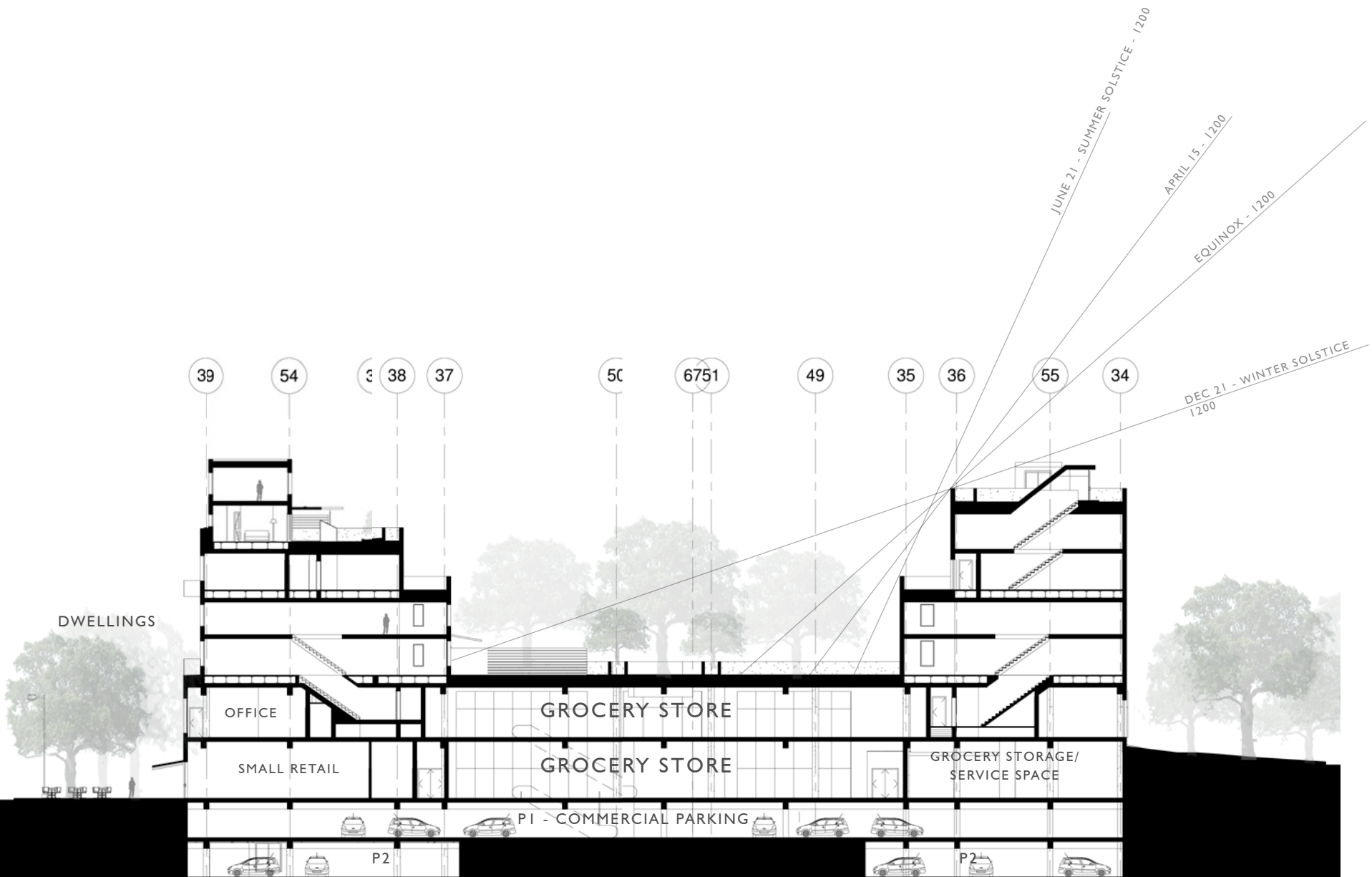


FIG. 5.23 SECTION A - 1:400

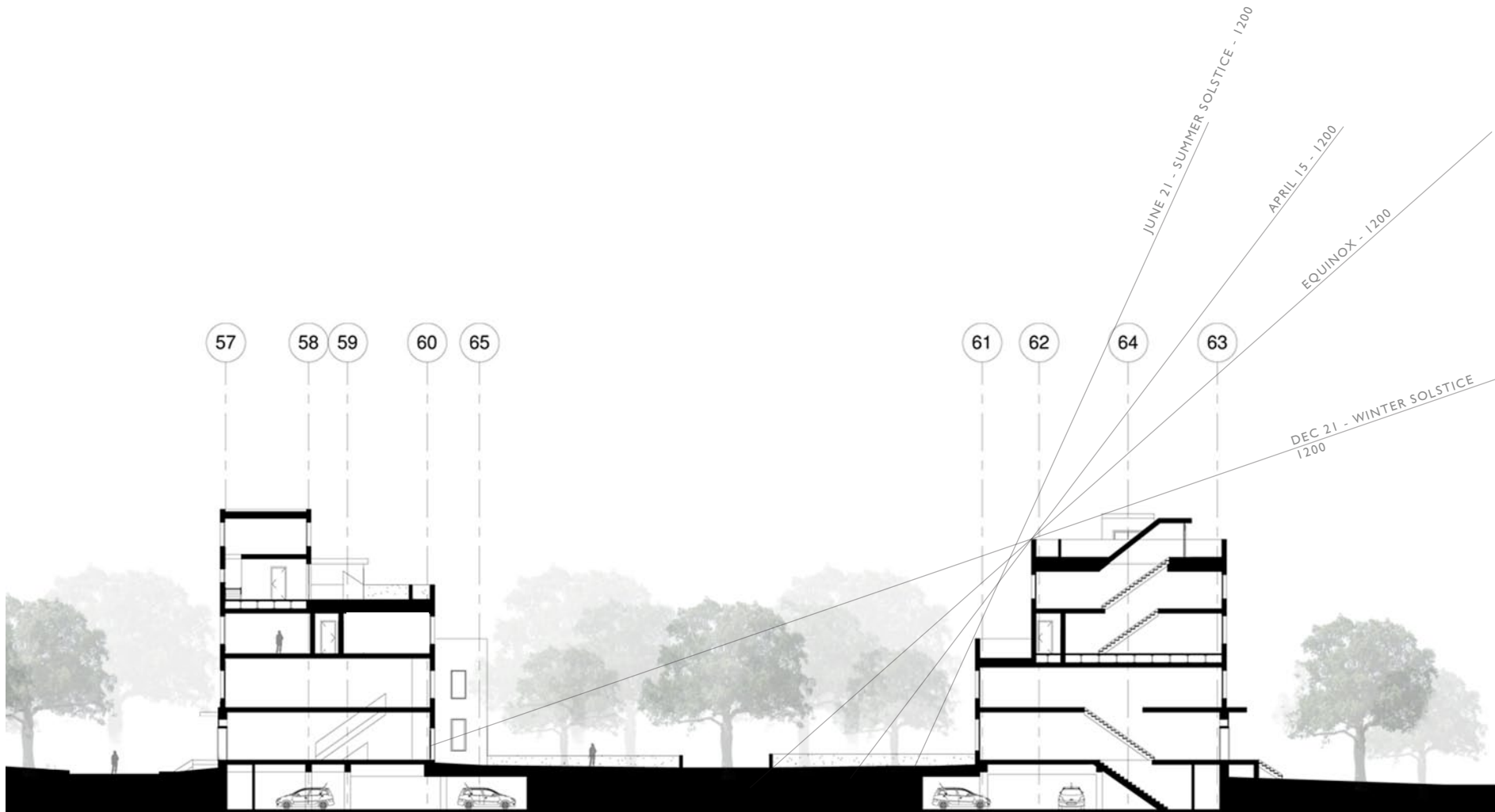


FIG. 5.24 SECTION A - 1:400

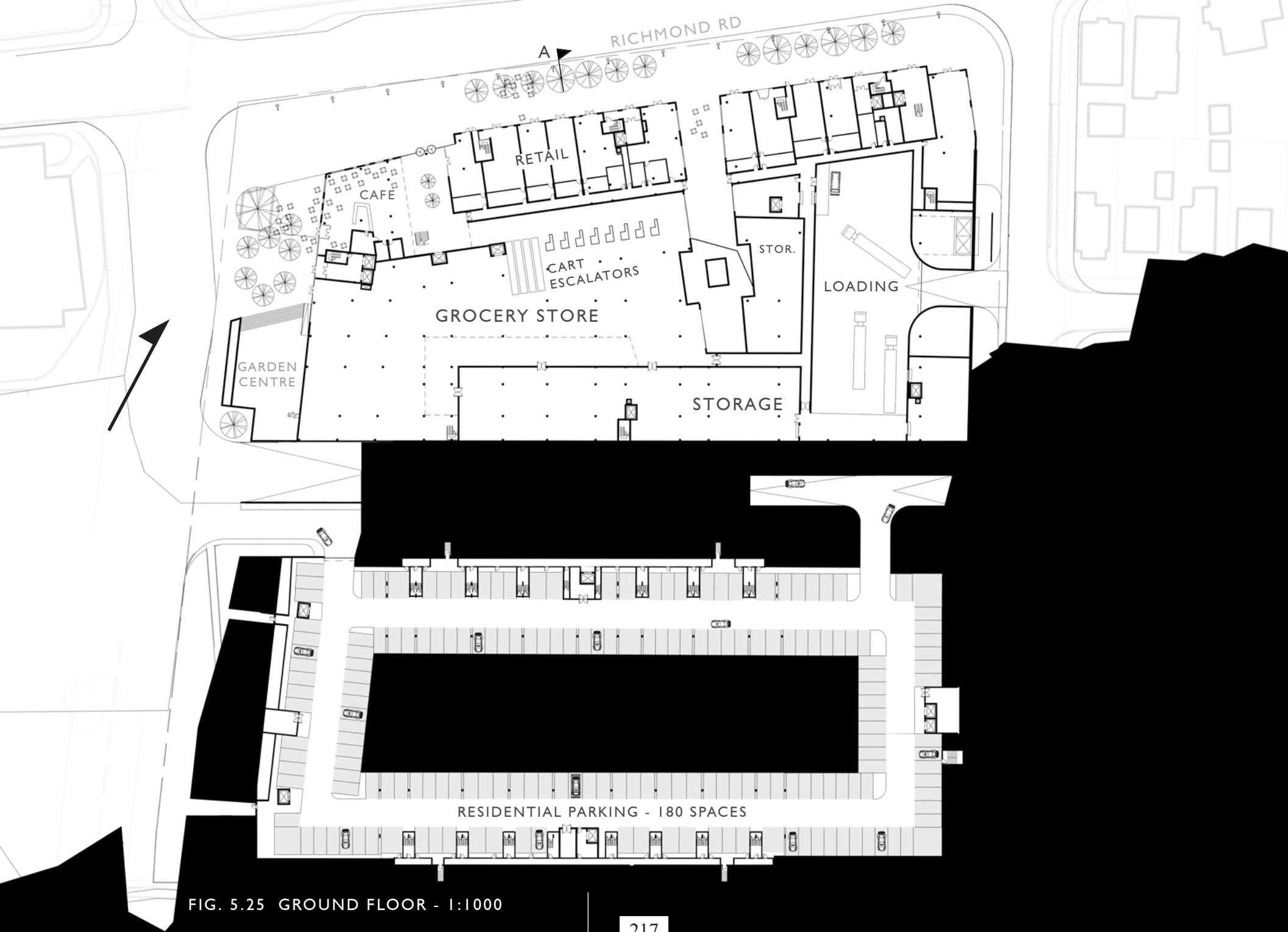
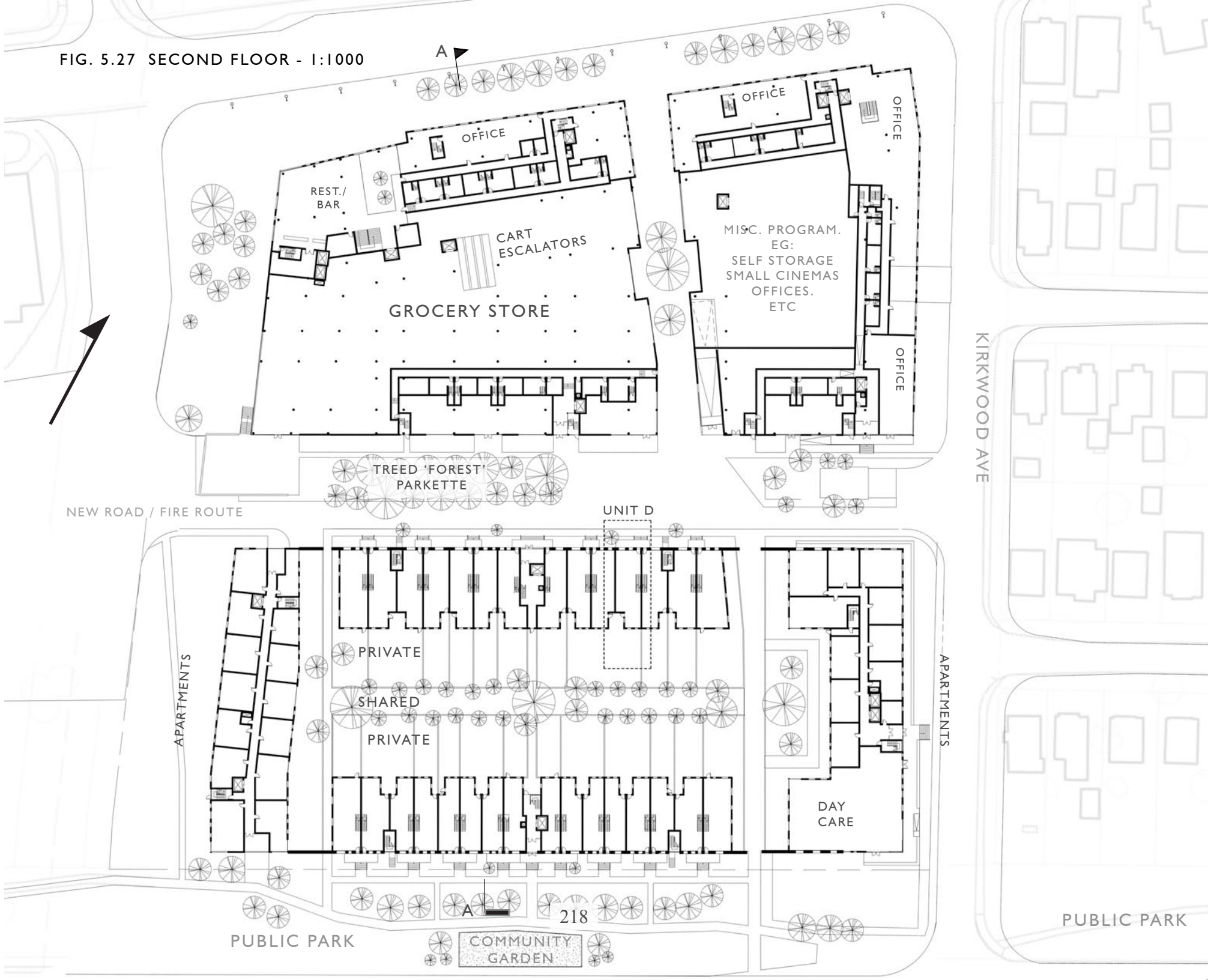


FIG. 5.25 GROUND FLOOR - 1:1000

FIG. 5.27 SECOND FLOOR - 1:1000



PUBLIC PARK

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COMMUNITY GARDEN

PUBLIC PARK

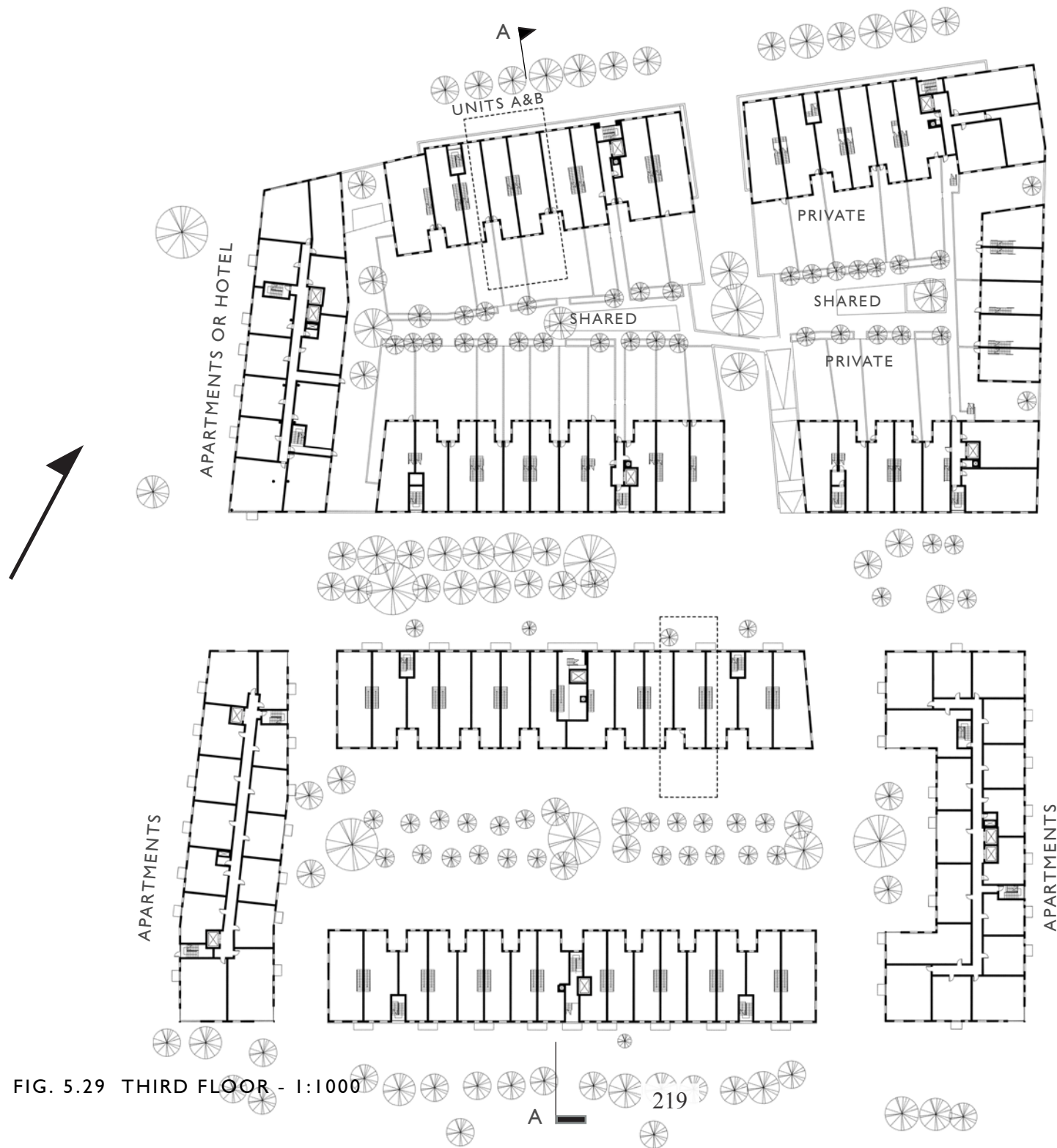
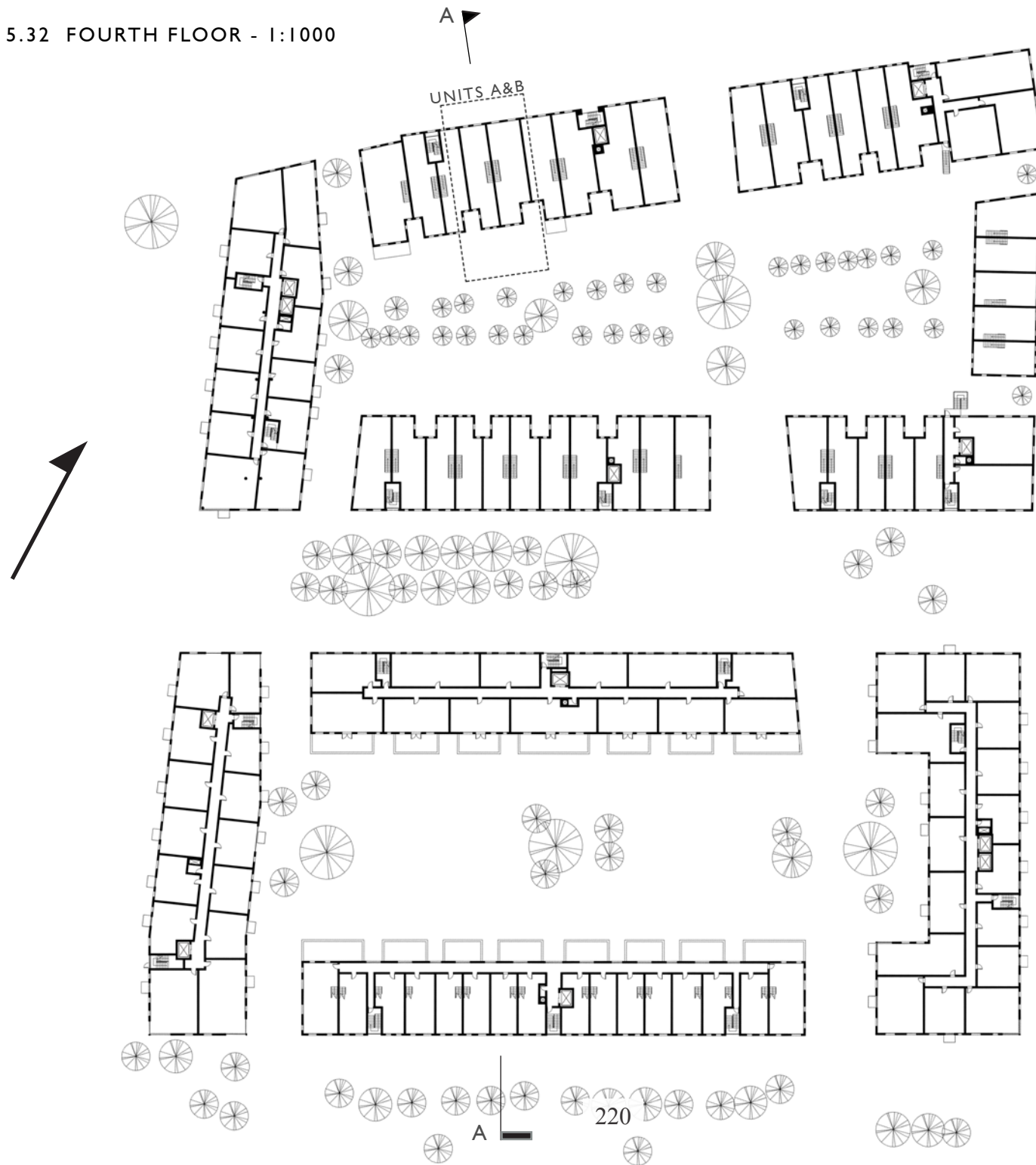


FIG. 5.29 THIRD FLOOR - 1:1000

FIG. 5.32 FOURTH FLOOR - 1:1000



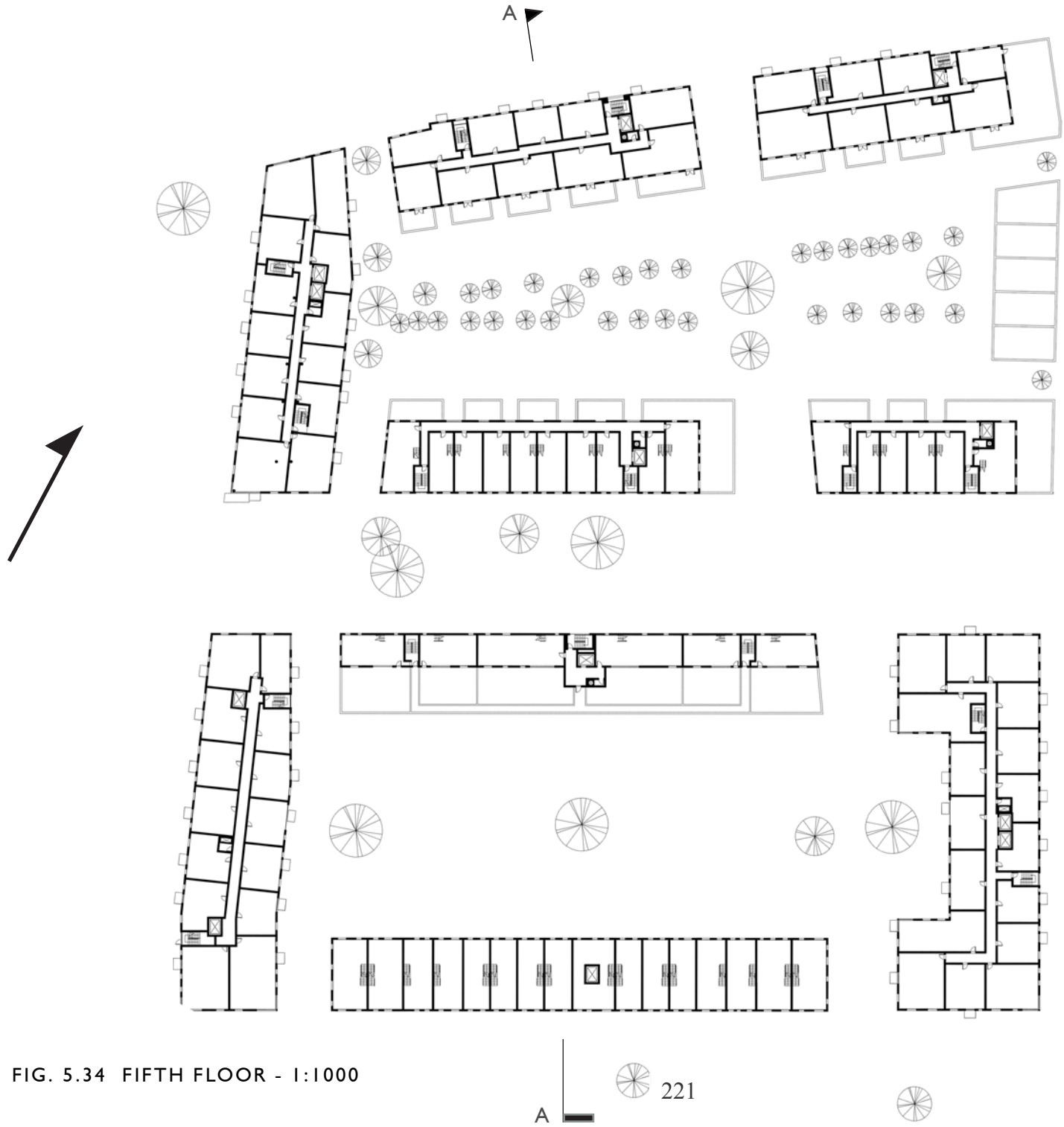
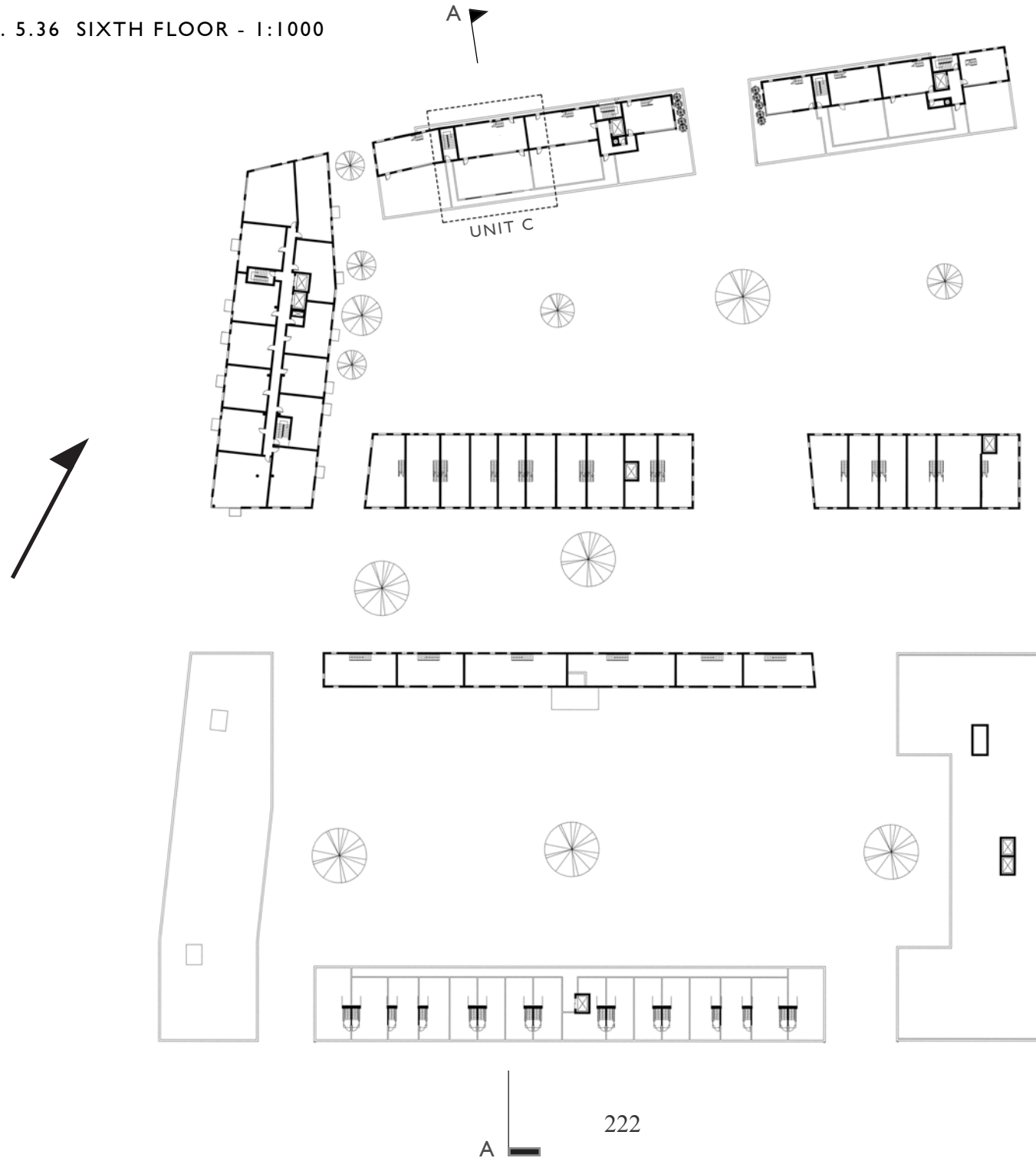


FIG. 5.34 FIFTH FLOOR - 1:1000

A 221

FIG. 5.36 SIXTH FLOOR - 1:1000



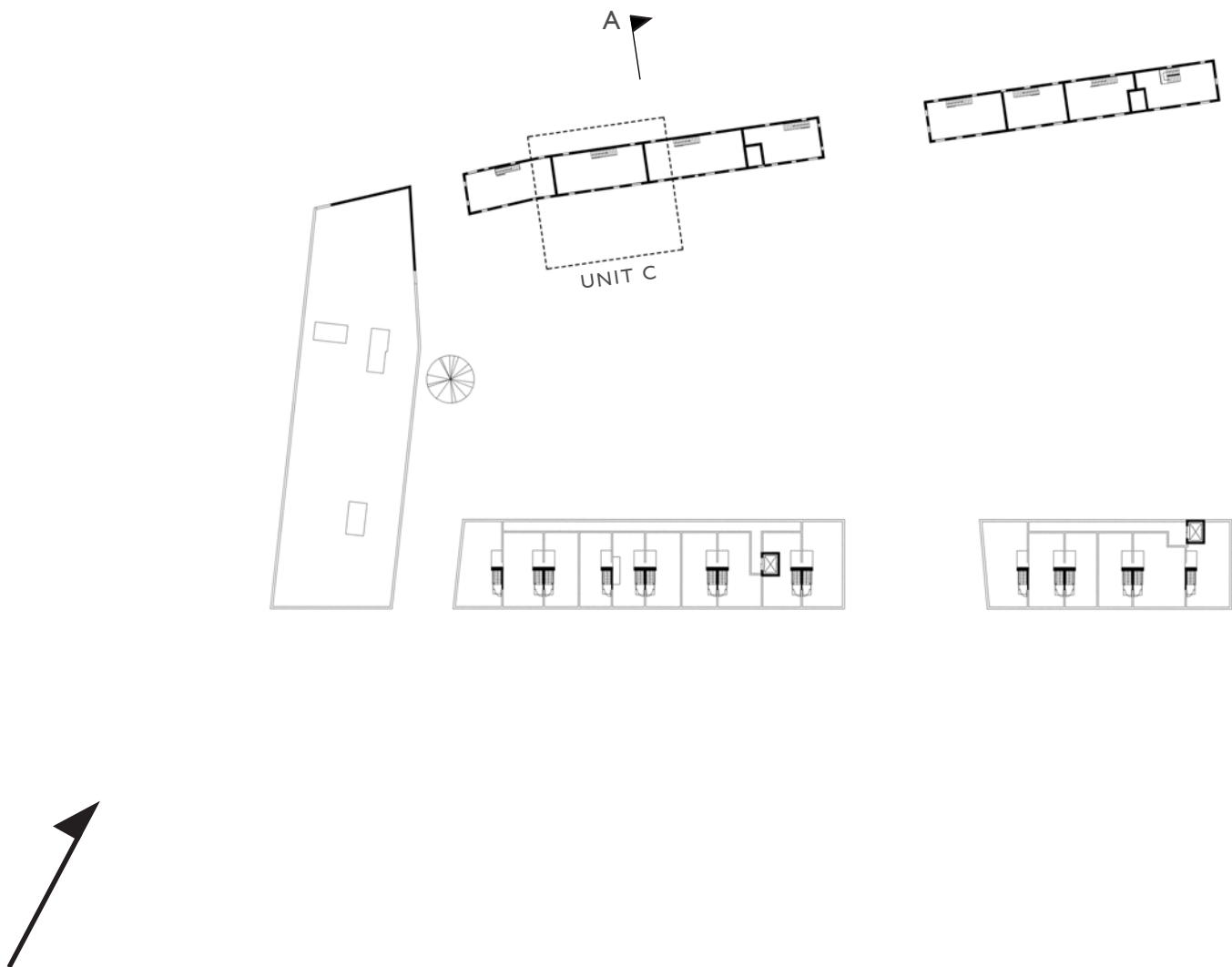


FIG. 5.38 SEVENTH FLOOR - 1:1000



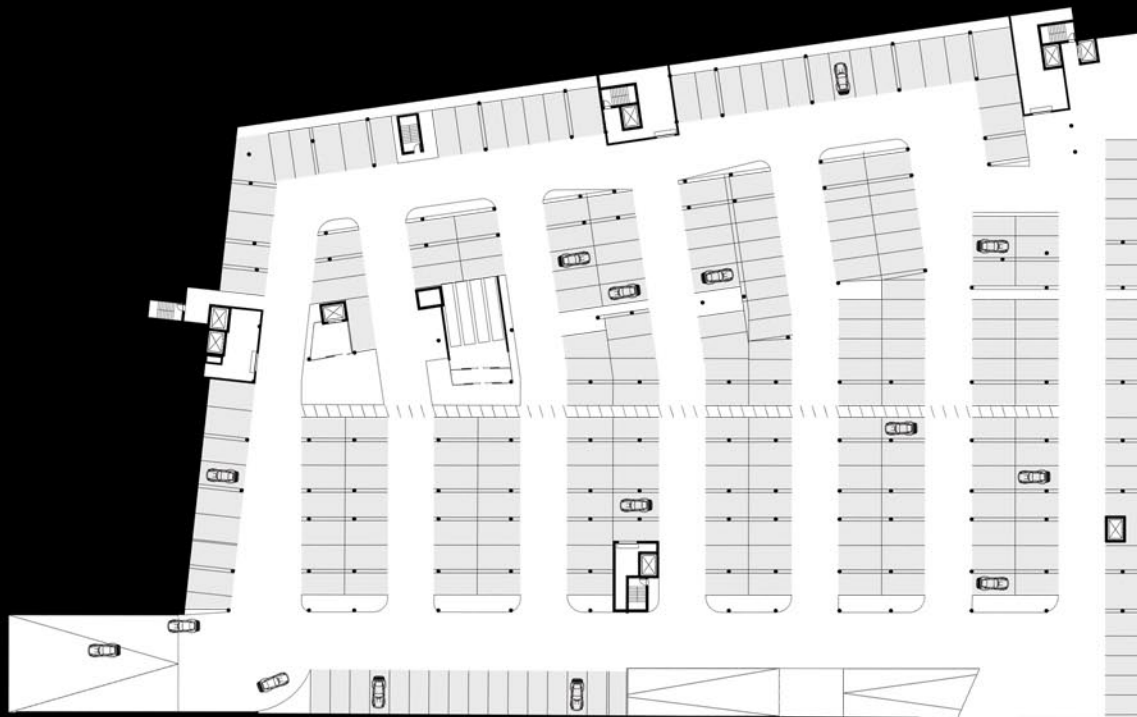


FIG. 5.41 UNDERGROUND PARKING - LEVEL I - 1:1000

Commercial parking - 245 spaces

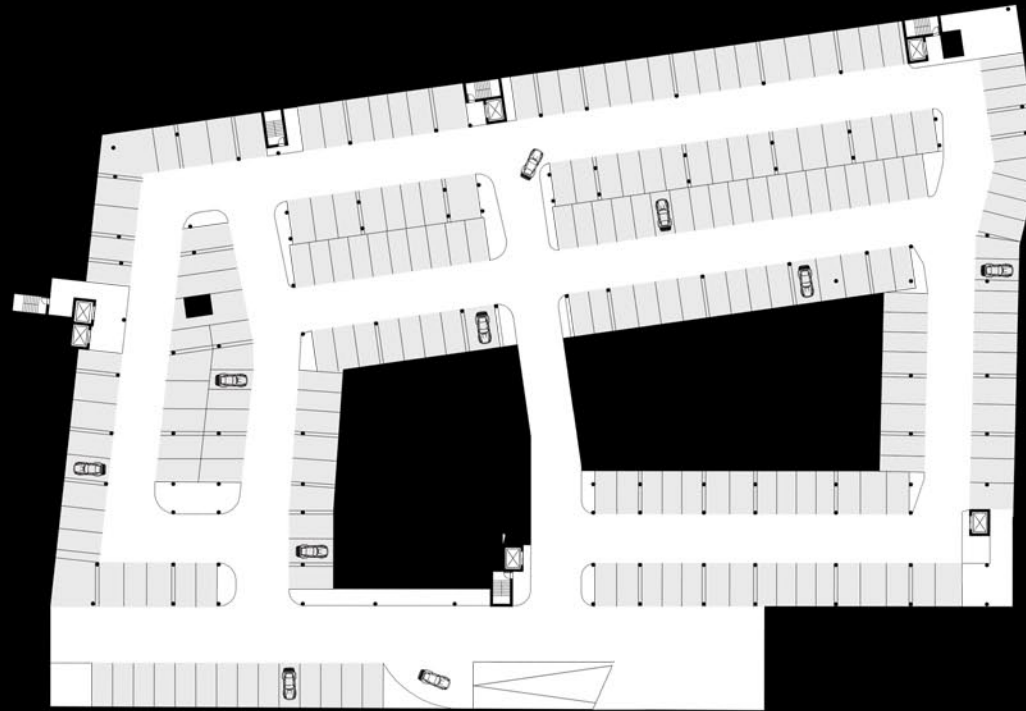


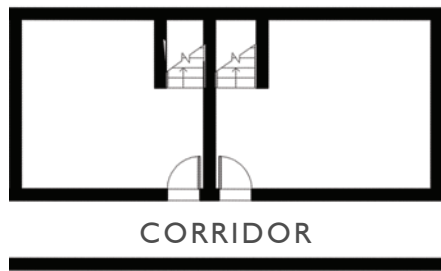
FIG. 5.42 UNDERGROUND PARKING - LEVEL 2 -1:1000

Residential parking for north block - 220 spaces



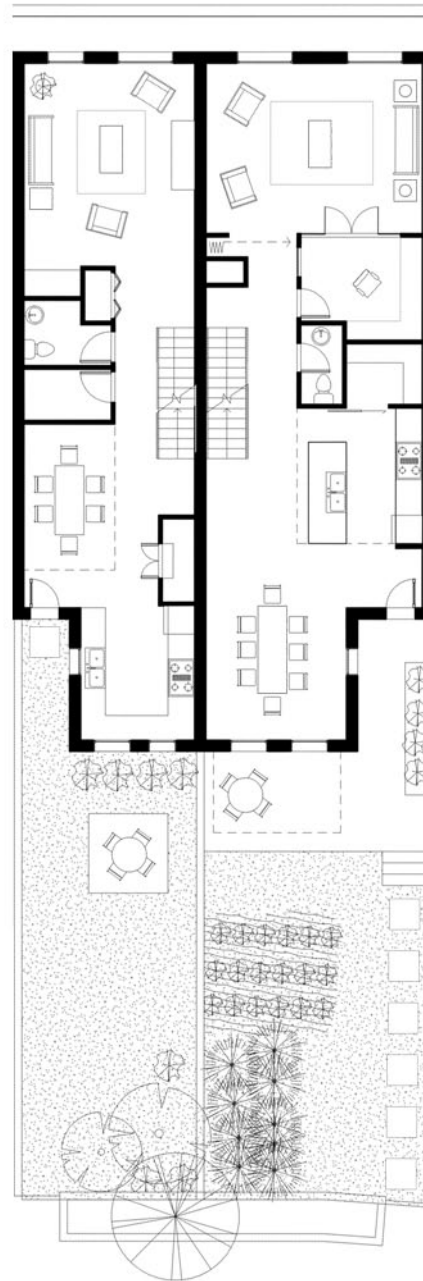
FIG. 5.43 VIEW OF SHARED COURTYARD AND PRIVATE YARDS AT THIRD FLOOR IN NORTH BLOCK
The stacked rowhouse units look onto a shared courtyard space that is partially screened by trees. Individual terraces of the units open onto the shared space.

FIG. 5.44 UNITS A & B - POTENTIAL LAYOUTS - 1:200

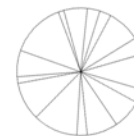
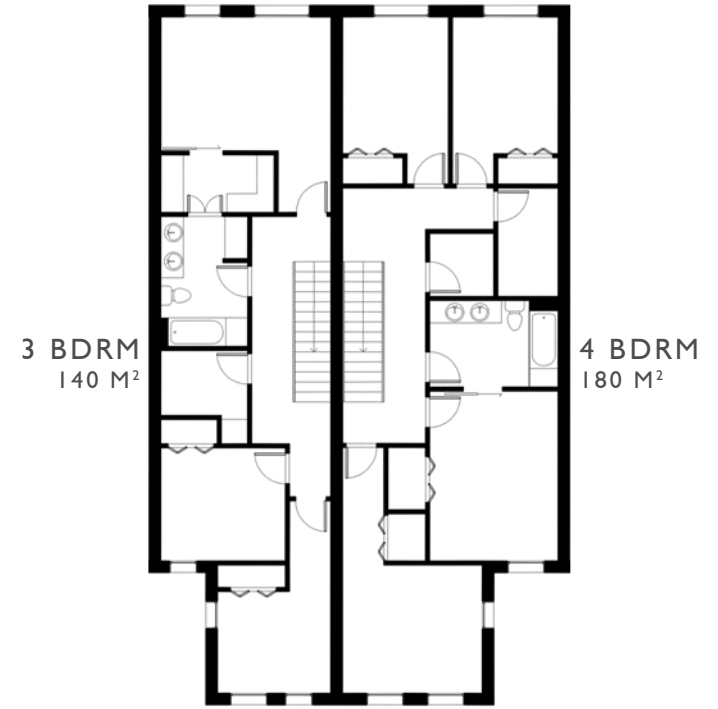


These are double height row units accessed either by a corridor on the second floor, or via the shared courtyard on the third floor. Both connect to stairs and an elevator. Sizes range from around 130 sq.m to over 200 sq.m. They can be subdivided into two units. Renderings of the rear yard are shown on the following two pages.

SECOND FLOOR



THIRD FLOOR



FOURTH FLOOR



FIG. 5.45 VIEW OF UNIT A&B YARDS

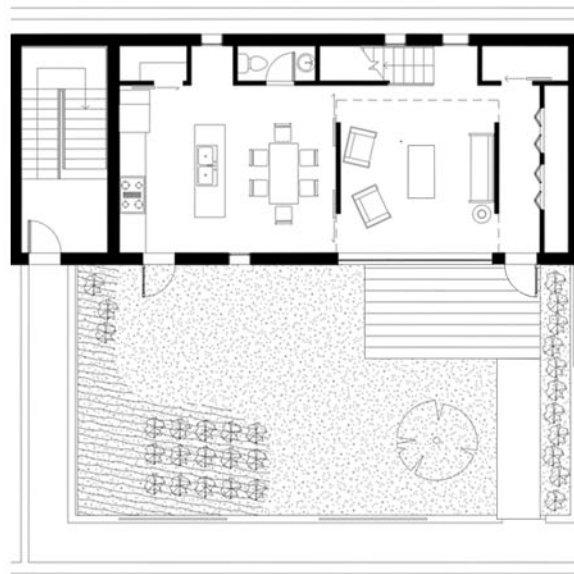


FIG. 5.46 YARD, UNIT A.

Looking away from unit, one looks onto the modest yard and the shared space beyond. A sense of privacy is maintained by a screen of trees and shrubs which act to break up the volume of the larger courtyard.

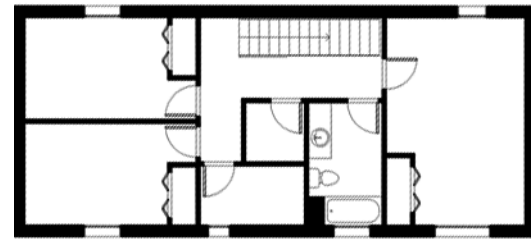
FIG. 5.47 UNIT C - MAISONNETTE - POTENTIAL 3 BEDROOM LAYOUT - 1:200

The maisonette units at the top are wood framed units. The exterior exposure on two long facades means they have excellent access to natural light. They are accessed via an exterior walkway which connects to stairs and an elevator. The size of these units ranges from under 100 m² to 150 m²



SIXTH FLOOR

3 BED -
ROOM
140 M²



SEVENTH FLOOR



FIG. 5.48 MAISONETTE TERRACE

FIG. 5.49 UNIT D - POTENTIAL MIXED USE LAYOUT - SMALL RESTAURANT AND APARTMENT - 1:200
(TWO STOREY UNIT ABOVE NOT SHOWN)

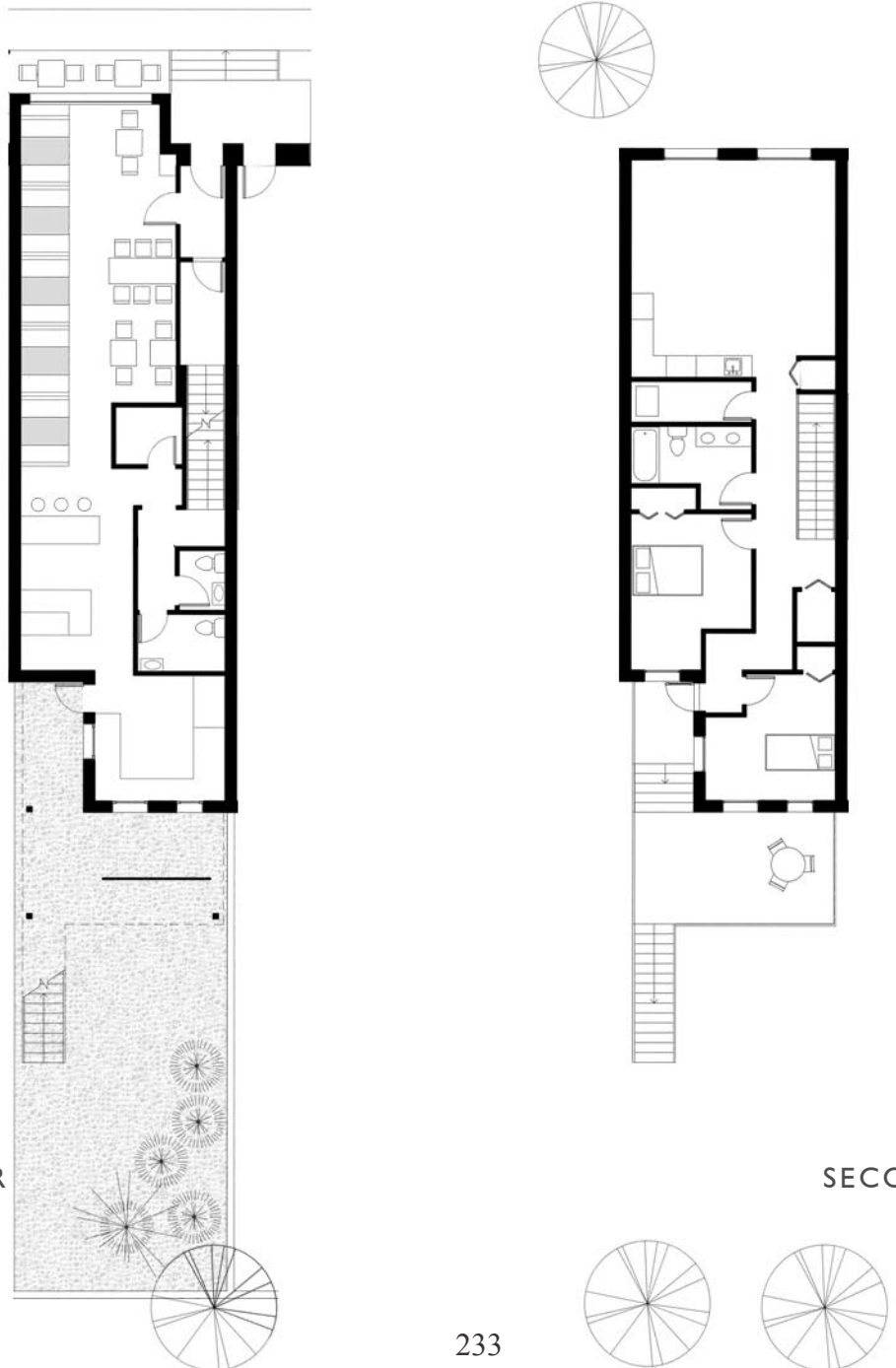
~30+ SEAT
RESTAURANT/CAFE

2 BEDROOM APARTMENT
88 M²

These row-house units are very similar to units A and B, except that they are accessed by an entrance at grade, and have stair access to underground parking one storey below grade. Units can be subdivided, as shown in the example here.

GROUND FLOOR

SECOND FLOOR



ENDNOTES - CHAPTER 5

1. Wiesbrock, Interview with Author.
2. Urban Land Institute and National Parking Association, *The Dimensions of Parking*.
3. City of Mississauga, “Mississauga Existing Land Use Study 2010” ; City of Ottawa, “The Use of Land in the City of Ottawa” ; City of Vancouver, “Understanding Vancouver: Land Use”

VI - CONCLUSION

The form of the contemporary Canadian city is, to a large degree, a legacy of mass suburbanization beginning in the 19th century, and in particular, automobile oriented suburbanization beginning in mid 20th century. This form is generally diffuse, low density, and functionally separated compared to pre-20th century urban forms prevalent in many eras and cultures. This thesis has discussed some characteristics and critiques of this suburban form, focussing in particular on three broad, widely acknowledged challenges facing it: *isolation*, *sustainability*, and the *conurbation* or sprawl.

In response to some of these challenges, today there are many public policy initiatives stressing intensification and densification of the existing urban fabric. The private sector has responded to demand for urban dwellings and alternatives to the suburban dwelling in large part with a growing supply of condominium units. In many cities, these condominium units - generally concentrated in larger buildings, and in central areas and specific development nodes - make up a majority of current infill development. While such developments, and some of the benefits they many bring, respond to many challenges facing our largely suburban cities, and seem viable for a number of household types, this thesis has argued that such forms of urban development themselves face a number of significant challenges. In particular, the thesis has discussed three challenges in many contemporary infill dwellings: i) *demographics and households* - the fact that the market for many urban developments is limited and often does not take into account, eg. larger households and families - ii) *connection to outdoors and outdoor space* - the fact that large urban residential buildings often provide little in terms of outdoor space, have limited sensory connection to the outdoors and verdure, create challenges in terms of access to natural light, and generally provide only a very dissociated spatial relation to the outdoors - and iii) *energy performance* - the fact that, on a per/m² basis, the bulk of existing and new large urban residential buildings do not seem to perform significantly better (or may in fact perform worse) than typical contemporary single

family detached homes in terms of operating energy use.

In response to these challenges, a number of design principles and strategies were proposed:

- a relatively modest, but urban, range of development *densities* that consider the need to accommodate future growth, that consider a wide range of historic examples of relatively compact, mixed, pedestrian urban fabrics that incorporate outdoor spaces
- *mixed use development* that provides amenities throughout the urban fabric and that also strategically increases density of the built form
- a form of development that provides a variety of *outdoor spaces*, varied *connections to the outdoors*, and varied spatial relations between units and outdoor spaces
- a variety of unit types that can *accommodate various households* which are typically not seen as viable residents for contemporary urban developments, as well as households seeking more typical apartment units
- and a *design approach which considers the relation between massing, skin, orientation, and energy use* in the balanced application of the preceding principles.

These principals and strategies were explored in a number of schematic types and case studies. The more detailed design proposal in chapter five is *one* possible implementation of these design principles, strategies, and types. This detailed design proposal applies the principles to a large, under used site in an existing, relatively low density urban area outside of, but in relative proximity to the urban core of Ottawa (roughly 15-20 minutes to the city centre by rapid transit, and approximately three kilometers distance). As with the majority of the geographical area of Ottawa, the area was primarily developed over the course of suburban growth during the 20th century. Such areas make up a large portion of the urban area of Ottawa - and of Canadian cities generally - and large, under used, automobile oriented sites within these areas (eg. shopping malls, large retailers, parking lots) are relatively common. Therefore, the design proposal can act as a model for using such large sites to intensify areas

of the existing low-density fabric that surrounds our urban cores in wide swaths and it does so in a way that attempts to grapple with the critical challenges outlined above and discussed over the course of the thesis. Applying the principles in a way that serves to moderately intensify existing low density areas reflects the design approach of urban consolidation championed by architects such as George Baird, Barton Myers, and Jack Diamond. This is opposed to the more common uni-centred, or multi-centred nodal approach, which concentrates density in high rise developments in specific regions while continuing low-density suburban growth in peripheral regions.

In implementing the design principles, the design proposal aims to strike a balance between density, unit types, access to sunlight, compact massing, and spatial and sensory connection to outdoor space. At an estimated gross urban population density of 100 people per hectare or more, a net FAR of 2, and including a mix of large and small non-residential programs, the design achieves a significant increase in density for the neighbourhood (the city ward of this area, for example, has a gross urban density of 34 persons per hectare), and represents a dense form of urban development compared to the majority of the existing fabric of North American cities. This level of density is roughly in line with the density targets outlined in the Ontario Places to Grow Growth plan for urban centres such as downtown Kitchener, Uptown Waterloo, downtown Hamilton, and downtown Guelph.¹ It is also comparable to many urban densities prior to the widespread adoption of the automobile and the spread of the suburb. Moreover, this level of density is at the low end of the three schematic design proposals for the site, so higher density options, which take into account the design principles of the thesis, and apply some of the other schematic design types explored in chapter four, could also be explored further.

In attempting to expand the range of units types available in urban residential developments - to expand the range of potential households accommodated by infill development, and create varied relations to outdoor spaces - the design proposal provides a mix of larger and smaller dwelling units. These include typical apartment or condominium units, double and single aspect units, and flexible two storey rowhouse and mai-

sonette units. The ratio of larger, two storey stacked rowhouse units with more direct access to outdoor spaces to more standard condominium or apartment units is roughly 1:2. The proposal provides units with a number of different relations between the individual units and outdoor spaces through the use of multiple modified ground planes at various levels. The modified ground planes create new outdoor spaces, incorporated within the building fabric. There are units with modest private outdoor spaces, and variety of public and shared outdoor spaces. These spaces act to serve a wide range of uses for outdoor space - creating spaces for informal socializing, for children to play, for sunbathing, for gardening, for sitting, etc. - providing an important amenity within a denser urban fabric, and allow for greater biological diversity within the city.

In terms of energy efficiency, the design takes into account massing, envelope or skin, and orientation. The grouped massing of the units creates a relatively compact building fabric. This compactness, measured in terms of surface area to interior floor area, is somewhat limited by the stepped, terraced, and recessed form of some of the units; this represents a compromise between efficiency of the built form and access to light and outdoor space. The design of the facade of the dwelling units consciously limits the amount of glazing in order to provide a more highly insulating envelope, which substantially affects building energy performance. At the same time, this limited glazing is arguably more than made up for by the double aspect orientation of many of the units, and the easy access to outdoor space - a rarity in contemporary urban development. Long portions of the block containing double aspect units are oriented roughly east-west, providing potential for use of some passive solar gains. A more detailed proposal would investigate the sizing and incorporation of solar hot water collectors and photovoltaics on unused roof spaces, in part of the terraces of these units, and along the south facades. Based on the highly schematic energy simulations discussed in chapter four, it is estimated that, if the recommended envelope design parameters (outlined in part I of chapter four) are followed, the annual site energy demand of the dwelling units in aggregate could be brought below 100 KWh/m² with minimal renewable energy inputs (this is for the residential portion of energy use and floor area only - the office, retail, and other components of

the program were not simulated and were not counted in the floor area). This *highly schematic* simulation result represents an energy use reduction of roughly more than 50% from the average single dwelling or apartment unit in Canada, through that result is slightly above the current regional energy reduction goals set out in the Architecture 2030 Challenge. A more optimized HVAC system would likely significantly improve the efficiency of the building, and better HVAC modelling would allow for more accurate simulation results. Incorporation of more significant renewable energy inputs would also reduce energy use substantially.

Incorporation of small and medium sized retail and office spaces on prominent streets, and larger retailers and programs within the deep floor plates, provide easily accessible urban amenities. They create a more pedestrian oriented urban environment, and an urban form which uses large areas of the site while maintaining access to light and outdoors for residential units above.

Alternate design options, incorporating taller building types - such as types D, E, and F - would achieve higher densities on the site, would represent a change in the character of the design, and would introduce significantly different unit types. The increase in density through use of these taller, stacked unit types would lead to more overshadowing of the units and surrounding areas, but might support more programs, population growth, and might create more attractive development pro-formas.

Regarding the pro-forma, one clear challenge for the current design proposal would be to make the economics of the project work. Based on numbers from the schematic pro-forma in chapter five (FIG. 5.13), and on comparable condominium prices for the area (eg. compared to Westboro station, seen in chapter four), many of the mid to large sized row-house units in this project could go upwards of \$650,000 in price. This is comparable to the cost of new, semi-detached infill houses that are currently being built in the area, or to condominium units of comparable sizes, indicating that the proposal could be economically feasible. However, these price levels are affordable to a limited number of households - very roughly, they are affordable to perhaps the top 25th or 30th income percentile of families in Ottawa with two or more persons.² Smaller

row-type units in the design might have a price of around \$400,000 - \$500,000 - affordable to perhaps the top 40th income percentile. More competitive prices, closer to \$3000/m² (as opposed to \$4000/m² - \$5000/m²) could substantially increase the affordability of larger units in the design proposal. To help achieve this, a number of measures could be explored to reduce residential construction costs (which are conservatively assumed to be relatively high in the pro-forma, in an effort to leave room in the budget for high performance windows, high levels of insulation, quality construction, the stepped form of the section, the incorporation of vegetated terraces, and possible implementation of renewable energy sources). Alternative construction methods for many of the residential units, using wood framing for residences atop a concrete podium (as in the Freiburg case study in Chapter four, and as is common in areas of British Columbia) or exploring pre-cast concrete construction, for example, could potentially reduce construction costs of some units. Also, the large retail program could help offset residential costs, as lease income from the commercial and office tenants would be a major component in the pro-forma of the project, potentially offsetting any lower priced residential units. As noted in chapter four, in many mixed use projects with major commercial tenants, the commercial space can sometimes be double the value of the residential space. At double the value of the residential space, the commercial and office space would then represent roughly one-third to one-half of the value of the total floor space in the design proposal. Municipal authorities could also provide incentives for the development - as a progressive urban development addressing a number of municipal objectives - though a number of measures (tax breaks, variances, etc).

The principles, strategies, types, and design proposals presented in this thesis do not claim to resolve all of these matters in full detail, but rather, they seek to acknowledge and address them in a general way, fostering a discussion of how we might realistically evolve large areas of the urban fabric of our cities in a way that strives to create a high quality urban environment for a wide range of households, and that directly addresses a number of critical societal challenges of our era.

ENDNOTES - CONCLUSION

1. Ontario, Ministry of Public Infrastructure Renewal, *Growth Plan for the Greater Golden Horseshoe*, p. 16
2. See discussion on affordability in Appendix 2.

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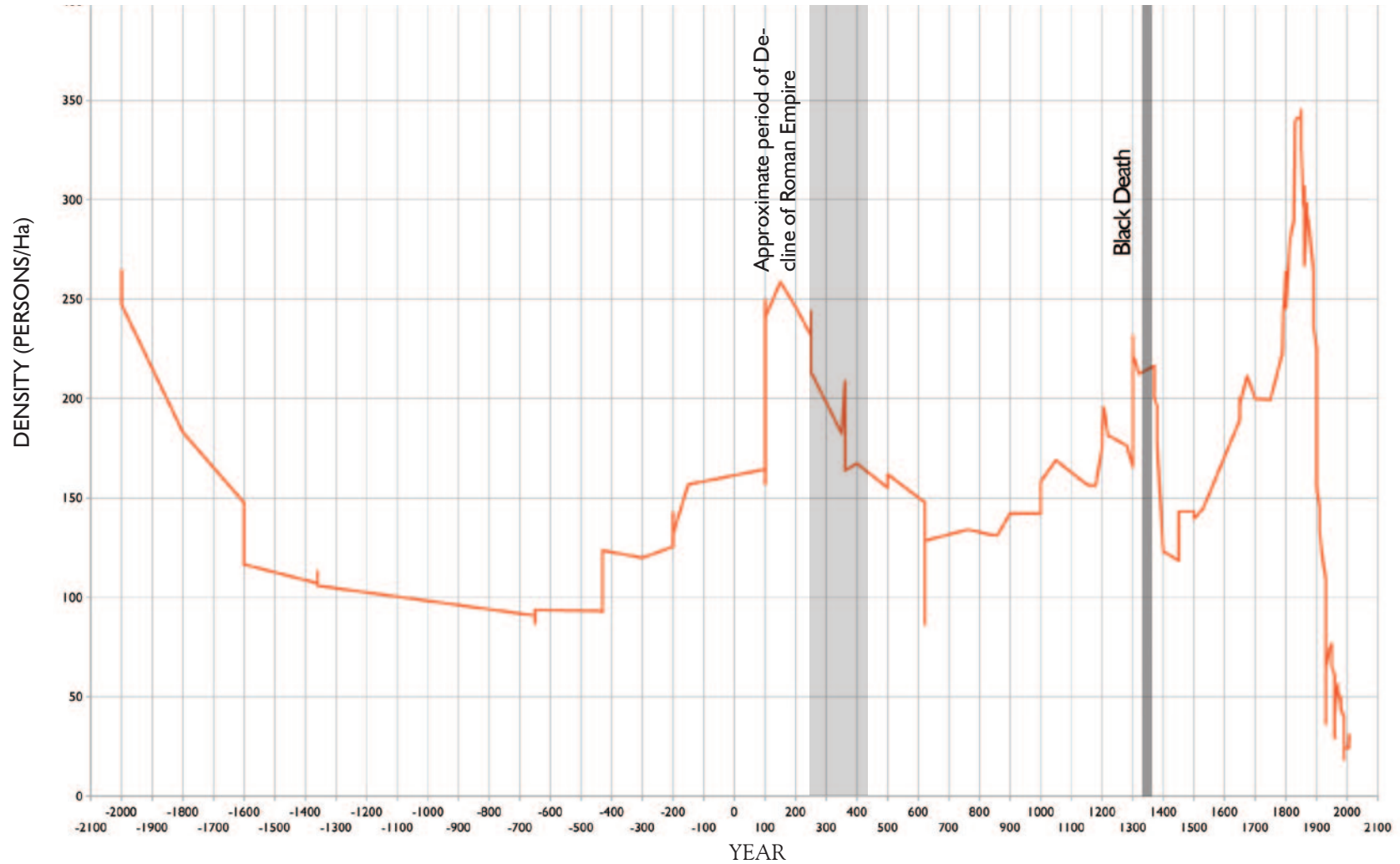
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APPENDIX 1 - MOVING AVERAGE OF GROSS URBAN POPULATION DENSITIES OF SELECTED CITIES

FIG.8.1 MOVING AVERAGE OF GROSS URBAN POPULATION DENSITIES



APPENDIX 2

ECONOMIC DISCUSSION

In discussing contemporary urban dwellings, at least some brief consideration of project economics is perhaps in order.

AFFORDABILITY

Different households have different requirements for housing, and also different income levels. In many instances, low income households will require financial assistance of some form in finding housing. This is a difficult topic, with many political and social dimensions, and it has been the subject of recent theses at Waterloo. Social housing is an important topic, but it is not a focus of this thesis. This thesis looks more at urban housing from the perspective of middle income households, specifically in the city of Ottawa.

Based on national census data, regional income statistics for the city of Ottawa, recommendations for expenditures on housing from the CMHC, an interest rate of 7%, a down payment of 10%, and an amortization period of 25 years, the ranges of maximum affordable housing prices shown in FIG. 9.2 are identified. Figures are rounded to the nearest 10,000 since they represent rough values.

COSTS

The cost of housing to the home buyer - the sale price - might be broken down into four types of costs:

- Land Costs
- Soft Costs (consultants, municipal fees, financing, marketing, etc.)
- Construction Costs
- Developer Profit

Land costs obviously vary considerably by location. A quick MLS search of properties in Toronto reveals it is not uncommon for properties on

main streets in Toronto with small, older, 2 storey retail buildings to sell for \$300 - \$500/sq.ft of lot area.¹ It is such high land costs, and the desire for large revenues from limited sites, that often drive the development of high density projects. For most home buyers, dwellings within many central areas of the urban core are financially beyond reach unless such high land costs are spread over a large number of units. For developers, taller, higher density projects mean larger revenues. Broader arguments for a certain degree of urban density must be carefully distinguished from the economic imperatives for increased density. It is difficult to find information on land cost specifically, since unbuilt urban lots are rare, and prices factor in the cost of existing buildings, but existing buildings will still factor into the price of any land purchase regardless. Complicating matters is the fact that land prices are affected by numerous complex factors such as real estate speculation, and violent, irrational, speculative market gyrations - as the recent housing crash in the United States has shown.

Soft costs can also be difficult to quantify, as with volatile markets come changing interest rates, affecting financing costs. Architectural design costs can be estimated from OAA fee rates - and other consultants can likewise be costed as a percent of construction cost. A rule of thumb might put total soft costs at around 30- 35 percent of total construction costs.

From 1940 to today, increases in average construction costs in Canada and the United States have roughly doubled general consumer price inflation.³ Construction costs are constantly escalating. Construction costs for typical mid and high-rise condominium projects in Toronto or Ottawa might range from \$135-\$160 per square foot, but that is of course subject to a fair bit of variability.⁴ The numbers in FIG. 9.2 serve only to provide a baseline for estimates.

Developer profit is yet another difficult question. Developers in Toronto have stated that the expected profit margin on urban residential development projects is around 10%.⁵ Without any direct experience from within the development business, it is hard to assess the credibility of this number. However, looking at the sales prices for condominiums around Toronto Ottawa, and roughly estimating standard construction costs and land costs, this number seems rather dubious. For example, considering one recent condominium project in Ottawa as a sample (see Westboro station, chapter four), if we use the cost assumptions in FIG. 9.2 and a land cost comparable to other nearby sites, the sales costs of the units indicates profit margins of around 20-40 percent depending on the assumptions used - even when using relatively

	0 - 20 th Percentile		20 - 40 th Percentile			40 - 60 th Percentile			60 - 80 th Percentile			80- 100 th Percentile	
	From	To	From	To	Mean	From	To	Mean	From	To	Mean	From	To
Economic Families – two or more people	-	\$160,000	\$160,000	\$320,000	\$240,000	\$320,000	\$470,000	\$395,000	\$470,000	\$680,000	\$575,000	\$740,000	+
Two Parent Families with Children	-	\$180,000	\$180,000	\$370,000	\$275,000	\$370,000	\$550,000	\$460,000	\$550,000	\$850,000	\$700,000	\$850,000	+
Lone Parent Families	-	\$90,000	\$90,000	\$170,000	\$130,000	\$170,000	\$260,000	\$215,000	\$260,000	\$400,000	\$330,000	\$400,000	+
Married Couples only	-	\$160,000	\$160,000	\$310,000	\$235,000	\$310,000	\$470,000	\$390,000	\$470,000	\$730,000	\$600,000	\$520,000	+
Unattached Individuals	-	\$70,000	\$70,000	\$130,000	\$100,000	\$130,000	\$200,000	\$165,000	\$200,000	\$300,000	\$250,000	\$300,000	+

FIG. 9.1 MAXIMUM AFFORDABLE HOME PRICE BY HOUSEHOLD TYPE AND INCOME PERCENTILE FOR CITY OF OTTAWA. Based on 10% down payment, 7% interest rate, 25 year amortization, CMHC recommendations (housing costs shouldn't be more than 32% of gross monthly income) and local and national income statistics.

high construction costs, soft costs, and land costs.

The above information provides us with the basis for a very schematic, rough feasibility analysis of any design proposals. In evaluating design proposals in chapter 5, much of the information discussed here will be used. These figures will be kept in mind in the design, and we will compare roughly estimated final sales prices to what middle class households of different types in Ottawa might reasonably be able to afford. Since the proposal for the project is urban dwellings that address some of the wider challenges faced by the contemporary city, partnerships between private, for profit development firms and non-profit firms or government organizations might be considered. This would reduce costs added by developer profit margins, and could potentially allow for provision of subsidized, more affordable units as well. It might also allow for application for grants, subsidies, reduced taxes, development incentives, or favorable financing terms.

ENDNOTES - APPENDIX 2

1. Kozak, "Development Economics of Mixed Use Mid-Rise: On Avenues."
2. Ibid.
3. Waier, Ed. *R.S. Means Building Construction Cost Data: 69th Annual Edition* ; Shiller, "Online Data".
4. Waier, Ed. *R.S. Means Building Construction Cost Data: 69th Annual Edition*; Straube, *Interview with Author* ; Kozak, "Mid-Rise Economics, Pro-Forma Analysis"
5. Kozak, "Mid-Rise Economics, Pro-Forma Analysis" ; Kozak, "Development Economics of Mixed Use Mid-Rise: On Avenues."

FIG. 9.2 2011 CONSTRUCTION COSTS FOR 8-24 STOREY APARTMENTS			
Total construction cost (CDN\$/sq.ft)	25th percentile	Median	75th percentile
Toronto	113	132	158
Ottawa	109	127	152

APPENDIX 3

ENVELOPE

Various minimum levels of thermal resistance for walls, windows, roofs, foundations, etc. are specified by various codes and standards for various climates. Some of these minimums for Ontario are shown in FIG. 4.9. As minimums, these ought to be exceeded in some cases. However, it should perhaps be noted that the amount of insulation, and the potential energy savings from additional levels of insulation, need to be measured against factors such as costs and buildability. Increasing insulation levels are subject to diminishing returns; the rate of energy savings diminishes with incremental increases in R-value FIG. 4.6. Thus increasing R-values to *extremely* high values - which cannot be addressed quantitatively here - may produce minimal gains while incurring some expense and construction challenges. Nevertheless, increasing insulation levels significantly beyond levels in current building practice, and indeed beyond the minimum levels stipulated by various standards, can result in very significant energy savings that are worth added costs.

Overall window area, as well as window thermal resistance and radiant transmission, is also a key design parameter. As a general rule - except perhaps where measures are taken to *carefully* tune passive solar strategies (see discussion on orientation and insolation) - reducing the amount of glazing in a building can reduce the energy consumption of the buildings by mitigating heat loss through windows, which are essentially a weak point. This suggests striking a balance between energy conservation, daylighting, views, and the aesthetic effect of glass facades.

Finally, air leakage needs to be addressed. Research for this thesis suggests that air leakage rates for buildings as a whole are not quantitatively addressed by standards such as the Ontario Building Code, the Model energy Code, or ASHRAE 90.1. Some European standards, such as Passivhaus and some European national standards, do specify maximum air leakage rates for dwellings. At 0.6 air changes per hour (ACH) at 50 pascals of pressurization, Passivhaus is considered one of the more stringent standards.¹ By contrast, data from pressurization tests on Canadian houses have shown that more recent housing stock, from around the 1990s onwards, tends to have air

leakage rates below 3 ACH @ 50 Pa (a significant decrease from the 10+ ACH @ 50 Pa that characterizes much of the older stock of dwellings). Local higher performance buildings have achieved significant levels of tightness, such as the Dorset Street mid-rise apartment building in Waterloo, with an air leakage rate of 1.1 ACH @ 50 Pa.² Standards such as Passivhaus, or the Finnish building code which mandates a maximum of 1 ACH @ 50 Pa for single detached dwellings, suggest that even higher air tightness values are feasible (FIG. 4.9). While these rates of leakage are not mandatory by local code regulations, or major North American standards, they set examples of targets that might be set for high performance dwellings. Of course, tighter buildings require proper ventilation, hence the crucial motto “build tight, ventilate right”, learned in part through experiences from the R2000 program in Canada.

For the purpose of laying out initial design parameters, with the overarching goal of reducing energy use and providing sustainable dwellings, the following range of envelope design values are recommended for the design project, located in the a cold climate. These numbers are loose guides for the design purposes of this thesis and they may be revised based results from energy simulation, further research, costs, or in specific contexts; they are not intended to be overly prescriptive.

- **Minimum Opaque Wall Resistance: R25-R40**
- **Minimum Whole Window Resistance: R4 (higher for high window to wall ratios)**
- **Air Leakage Targets: 0.5 - 1 ACH @ 50 Pa or less**

ENDNOTES - APPENDIX 3

1. Mead and Brylewski. *Passivhaus Primer: Introduction -An aid to understanding the key principles of the Passivhaus standard.*
2. Straube, *Dorset Street MURB Case Study.*

APPENDIX 4 - REDUCING SURFACE PARKING

This section briefly discusses and contrasts a number of the means of effectively reducing areas of surface parking .

REDUCED PARKING REQUIREMENTS

It should be expected that a general increase in urban density should make alternate forms of transit more viable, reducing the need for automobiles and parking space. Where zoning regulations may sometimes require excessive numbers of parking spaces,, there are ways to reduce the number of spaces required by zoning: for example, variances, cash-in-lieu, or land banking.¹ If a project is located close to good existing public transit infrastructure - such as subway or bus rapid transit - or near urban amenities that make driving less critical, the arguments for reduced parking requirements become stronger. Additionally, if the adoption of car-sharing programs becomes increasingly popular, providing an alternative to individual car-ownership, this will significantly reduce the need for parking spaces.

SHARED PARKING

Shared parking refers to the use of parking spaces by different programs at different times. The idea is that, since different programs tend to use parking at different times of the day, the differences in the parking schedules of these programs can be exploited and optimized so that the same parking spaces can be used by the different programs in different time slots, without conflicts, thus reducing the amount of spaces needed.²

ABOVE GROUND STRUCTURED PARKING

APPROXIMATE CONSTRUCTION COST PER STALL:
\$10,000 - \$15,000 ³

Benefits:

- Moderate costs
- Less surface area required than surface parking
- Can be integrated with building
- Can be heated in winter

Disadvantages:

- Moderate costs
- Air quality concerns
- Maintenance can be costly, especially in climates that use road salt in winter
- High mechanical, electrical, life safety system requirements
- Air quality concerns
- Maintenance can be costly, especially in climates that use road salt in winter
- High mechanical, electrical, life safety system requirements

UNDERGROUND STRUCTURED PARKING

APPROXIMATE CONSTRUCTION COST PER STALL:
\$10,000 - \$30,000 AND UP ⁴

Underground parking is possibly the most common approach to accommodating parking in a tight urban fabric. It does not intrude on the urban fabric, and makes use of what might otherwise be unused space. At around \$10,000-\$15,000 dollars per parking space, underground parking that is only one level underneath the building is cost competitive with above-ground parking, however parking spaces in additional levels beneath a first level can double in cost, increasing in price as more levels are added. Costs are also highly dependant on soils conditions. One concern with underground parking garages that seems little discussed is air quality, even in ventilated spaces. At least one study that has looked at toxins contained in the air in underground garages found levels of certain toxins such as benzene and Nitrogen dioxide in underground garages to be somewhat “problematic”, and in some

cases somewhat “above the threshold for non-carcinogenic effects”, and warranting further study.⁵ Though these can be addressed with better ventilation, and limiting exposure to underground parking garages, it is something to consider.

Benefits:

- Potentially unused areas under site are used
- Can be integrated with building
- Does not cast shadows/reduce access to daylight
- Less surface area required
- Can be heated in winter

Disadvantages:

- Potentially high costs
- Cost can increase depending on soil conditions (eg. costs can increase dramatically if blasting through bedrock required)
- Costs per unit increase with number of storeys below grade
- Indoor air quality concerns
- Maintenance can be costly, especially in climates that use road salt in winter
- High mechanical, electrical, life safety system requirements

MECHANICAL AND AUTOMATED PARKING

APPROXIMATE CONSTRUCTION COST PER STALL:
\$25,000 - \$40,000 AND UP ⁶

Mechanical parking systems have yet to see widespread adoption in North America, due in part to generally lower land costs and greater availability of land. However, some condominium projects in Toronto and Vancouver have begun using automated parking systems, and if urban density increases, and longer timelines are considered, mechanical parking may become more feasible. Automated parking systems are the most efficient in terms of space, require relatively little in the way of lighting, heating, and life safety. They also require much less mechanical ventilation as cars are not running when

they are being parked. Engines being off during parking might potentially lead to improvements in the air quality in and around parking structures. Users will not be exposed to the potential cocktail of pollutants and carcinogens that can be found in underground parking garages. In short, mechanical parking offers many advantages and may too often be dismissed as un-economical, given some of the potential benefits.

Benefits:

- Much lower exhaust pollution in parking areas
- Much lower ventilation, lighting, life safety, and mechanical requirements
- Most space efficient option

Disadvantages:

- Highest costs
- Limited parking rate (0.5 - 1 cars per minute per access point, compared to 6 or 7 for single lane ticket dispensing garage access) and therefore of limited applicability in high turnover programs, such as shopping malls, movie theatres, or event locations.
- Lack of familiarity

CONCLUSIONS:

Urban projects at modest densities can be caught between low density suburban developments, where relatively low land values make large, wasteful and unappealing surface parking lots economically attractive to many landowners and developers, and high rise, high density projects, where large revenues more than offset the costs of structured parking. Projects at mid-ranges of density need to thoughtfully consider parking in order to be competitive. In some cases, subsidies, either direct or in the form of tax incentives or favorable financing terms, could be considered.

Shared parking and reduction of parking space requirements should be explored to reduce the amount of parking necessary, but they cannot eliminate the need for it. For the bulk of the required spaces (excluding perhaps some number of spaces for short term stays and visitor parking, which may best be provided with limited surface parking) underground parking of a lim-

ited number of levels arguably provides the best combination of economy, land use efficiency, and urban amenity of all the types discussed. It does not intrude on the urban fabric, it can be heated, and it doesn't add to the bulk of the project. However, mechanical parking, while expensive and somewhat unfamiliar, bears at least more consideration. Of all types of parking, it is the most space efficient, requires less in terms of life safety systems and ventilations, and does not run the risk of exposing users to the unhealthy pollutants that can be found in underground parking garages. As with any technology, if mechanical parking becomes more widely adopted, prices could become more competitive with economies of scale and with increased competition.

In the end, of course, no one option is best in all cases, and combination of different approaches may be best. The aim here is not to prescribe rigid strategies but increase understanding of a financially important element of denser forms of dwelling.

ENDNOTES - APPENDIX 4

1. Urban Land Institute and National Parking Association, *The Dimensions of Parking*.
2. Ibid.
3. Waier, Ed. R.S. *Means Building Construction Cost Data: 69th Annual Edition*; Urban Land Institute and National Parking Association, *The Dimensions of Parking*.
4. Blais, "Smart Development for Smart Growth," p. B5 ; Urban Land Institute and National Parking Association, *The Dimensions of Parking*, p. 173
5. Glorennec et. al., "Is a quantitative risk assessment of air quality in underground parking garages possible?"
6. Spacesaver Parking Company, *Correspondence with Author* ; Urban Land Institute and National Parking Association, *The Dimensions of Parking*, p. 173

APPENDIX 5 - SCHEMATIC ENERGY SIMULATION IN EQUEST AND ENERGY 10

The energy simulations contained in this thesis are schematic in nature, and are meant to show, at a very rough quantitative level, how changes in form, massing, orientation, and basic envelope parameters, might affect the energy use of a building. Energy simulation can be highly complex, and indeed is a discipline of it's own. Projects that have the available design budget ought perhaps include skilled energy modellers periodically throughout the design project in order to receive feedback on the energy impact of design decisions. However, at the schmatic desing phase, on student projects, or projects with limited time and budget, use of simple simulation tools such as eQuest, at a schematic level, can arguably be helpful, even if these tools are operated by a non-specialist.

ENERGY SIMULATION PARAMETERS FOR SCHEMATIC TYPES, PART II CHAPTER FOUR

Some of the critical energy simulation parameters used in eQuest to model the schematic types in part II of chapter four are given on the right. Dimensions and glazing ratios varied for each type, but other parameters were held constant. Dimensions were taken from the models of the schematic types shown in chapter four. Where the types were stepped in form, the various stepped compartments of the building were modelled separately, with an adiabatic envelope where ground floors and roof areas intersected heated areas of the building. The results from the separate building compartments were then aggregated to produce energy intensity figures for the entire type. All simulation assumed residential occupancy. The eQuest files for the simulations are attached to this thesis on a CD.

Note that infiltration rates were kept the same for all types to follow the prescribed air change rates listed in part I of chapter four. In

FIG 12.1 EQUEST ENERGY SIMULATION PARAMETERS FOR SCHEMATIC TYPES

Location	Ottawa				
Floor to Floor height (ft)	10				
Building Type	Multif-Family Mid-Rise, single zone per floor				
Building Dimensions	Varied by type				
Ground Floor Exposure	Over Parking Garage				
Opaque Envelope					
Wall construction	2x6 Wood frame with R-15 batts, R 21 polyiso exterior insulation, brick veneer				
Roof R Value ((h ft ² °F)/Btu)	42				
Wall R Value ((h ft ² °F)/Btu)	36				
Below grade Wall R Value ((h ft ² °F)/Btu)	18				
Windows					
Window U factor (Btu/(h ft ² °F))	0.2				
SHGC (South windows)	0.81				
SHGC (Other windows)	0.5				
Fixed overhangs on south windows (ft of overhang)	3 (larger on types D and E to model deep balconies)				
WWR (Varied with type and facade)	40-20 Depends on facade				
Infiltration (ACH at normal pressure)	0.25				
Building operation schedule (Standard eQuest schedule)					
Daytime unoccupied, typical use					
Occupancy					
	Percent floor area	Design Max Occupancy (ft²/person)	Design ventilation (CFM/person)	Lighting Loads (W/ft²)	Misc electric loads (W/ft²)
Residential (Multi-family)	83	450	30	0.3	0.3
Corridor	10	1000	50	0.3	0
Storage (conditioned)	7	500	75	1.2	0
Exterior Lighting					
None					
Thermostat Setpoints					
Occupied (°F)	Cool	Heat			
Unoccupied (°F)	79	68			
	80	66.5			
Heating System					
Furnace – single zone - < 225 kBtuh					
Efficiency	0.85				
Cooling System					
DX coils - < 65 kBtuh or 5.4 Tons					
Air-cooled condenser					
SEER	9.7				
Fan operation	Intermittent, no night cycling				
Domestic Hot Water					
Natural gas storage Heater					
Thermal efficiency	0.85				
Tank R Value (imperial)	20				
Standby loss (%/hour)	2.13				
138 Gal Tank					
Hot water Use (Gallon/peron/day)	19.2				

reality, envelopes with identical or similar airtightness would result in different air change rates for the different types, as each type has differing ratios of exterior envelope surface area to floor area. Thus, the effect that various surface area to floor area ratios may have on the types may be slightly understated in the energy simulations. Nevertheless, as infiltration has been shown to account for approximately one-quarter of heat loss in multi-unit residential buildings.

ENERGY SIMULATION PARAMETERS FOR FIG. 4.4 - ENERGY USE VS. BUILDING FORM AND ORIENTATION

The values used to model the results shown in FIG. 4.4 in chapter four are shown on the right. The only variables that are changed for each building type are the dimensions of the building. Envelopes, window to wall ratios, infiltration rates through the envelope, occupancy rates, interior loads, etc. are all kept the same - even if some of these will likely differ from type to type. This is to examine the effects of massing and orientation *only*. Efforts were made to re-create these parameters rather closely in Energy 10, to provide some corroboration from another simulation program, however the way in which various parameters are measured and entered differs in each program, resulting in somewhat different simulation outputs.

FIG 12.2 - EQUEST ENERGY SIMULATION PARAMETERS FOR FIG 4.4
(Similar values in Energy 10)

Location	Ottawa					
Floor to Floor height (ft)	9					
Building Type	Multi-Family Mid-Rise, single zone per floor					
Building Dimensions	Varied by type					
Ground Floor Exposure	Over unconditioned space					
Opaque Envelope						
Wall construction	Steel studs with R-21 Polyiso exterior insulation and brick veneer					
Roof R Value ((h ft ² °F)/Btu)	30					
Wall R Value ((h ft ² °F)/Btu)	21					
Below grade Wall R Value ((h ft ² °F)/Btu)	14					
Windows						
Window U factor (Btu/(h ft ² °F))	0.25					
SHGC – all windows	0.63					
Shading	None					
WWR – all facades	30					
Infiltration (CFM/ft² exterior wall area, core and perimeter)	0.039					
Building operation schedule (Standard eQuest schedule)	Daytime unoccupied, typical use					
Occupancy	Percent floor area	Design Max Occupancy (ft²/person)	Design ventilation (CFM/person)	Lighting Loads (W/ft²)	Misc electric loads (W/ft²)	
Residential (Multi-family)	85	624	30	0.5	0.5	
Corridor	9	1000	50	0.57	0	
Storage (conditioned)	4	500	75	1.19	0	
Laundry	2	200		1.28	0.15	
Occupancy Profile	Occup Profile (s1)					
Exterior Lighting	None					
Thermostat Setpoints	Cool	Heat				
Occupied (°F)	78	68				
Unoccupied (°F)	78	68				
Heating System						
Furnace – single zone – autosized - < 225 kBtuh						
Efficiency (AFUE)	0.78					
Ducted return air						
Cooling System						
DX coils – Autosized - < 65 kBtuh or 5.4 Tons						
Air-cooled condenser						
SEER	9.7					
Fan operation	Intermittent, no night cycling					
Domestic Hot Water						
Natural gas storage Heater						
Tank R Value (imperial)	12					
Energy Factor	0.56					
30 Gal Tank						
Hot water Use (Gallon/peron/day)	20					

ENERGY SIMULATION PARAMETERS FOR FIG. 4.12, ORIENTATION VS ANNUAL ENERGY USE

This simulation was on a very simple, one zone non-residential building (FIG.12.4). The simulations shown were carried out in Energy 10, though simulations were carried out on the same building with a number of other simulation programs for a reading elective with Prof. Meyer-Boake, with similar results. Some of the parameters in Energy 10 are shown to the right (in metric values), along with drawings of the sample building.

FIG 12.3 - ENERGY-10 SUMMARY

Energy-10 Summary Page
Project: Test building - reading elect Project Director

```

Description: MRG_BASE_BUILDING
Scheme Number: 21 / Not Saved
Library Name: MRG_LIB_READING_ELECTIVELI
Simulation status, Thermal/DL out of date/NA
Weather file: Ottawa.etl
Floor Area, m² 83.6
Surface Area, m² 292.2
Volume, m³ 275.3
Total Conduction UA, W/K 119.3
Average U-value, W/m²K 0.408
Wall Construction _uw_abv_grd_ext, R=5.6
Roof Construction _uw-roof1, R=10.9
Floor type, insulation Slab on Grade, Reff=1.4
Window Construction _uw d1b low-e pvc frame -
Window Shading 40 deg latitude
Wall total gross area, m² 125
Roof total gross area, m² 84
Ground total gross area, m² 84
Window total gross area, m² 14
Windows (N/E/S/W:Roof) 2/1/1/1:0
Glazing name double low-e mrg, U=1.98
    
```

```

Operating parameters for zone 1
HVAC system DX Cooling with Gas Furnace
Rated Output (Heat/SCool/TCool), kW 7/5/6
Rated Air Flow/MOOA, L/s 391/0
Heating thermostat 21.0 °C, setback to 13.0 °C
Cooling thermostat 24.0 °C, setup to 30.0 °C
Heat/cool performance eff=80, COP=2.6
Economizer?/type no/NA
Duct leaks/conduction losses, total % 2/0
Peak Gains; IL,EL,HW,OT; W/m² 24.75/0.43/7.10/2.69
Added mass? none
Daylighting? no
Infiltration, cm³ ACH=0.2
    
```

CASUAL LOADS + INFILTRATION

	Main Room
Lighting Power Density at 100% use (W/sq.m)	16
People per sq m at 100% capacity	0.036
Misc equipment loads at 100% use (W/sq.m)	2.69
Max Infiltration Flow (ACH)	0.17

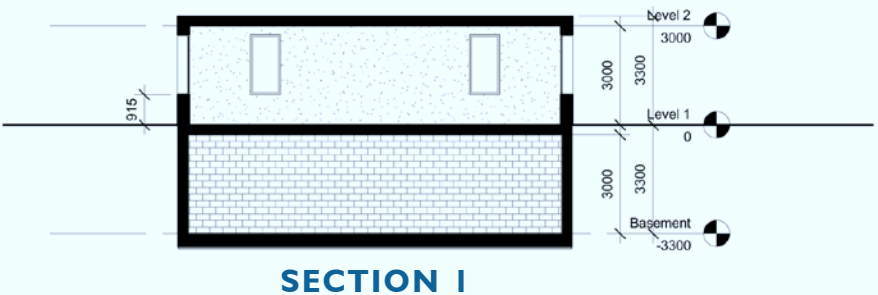
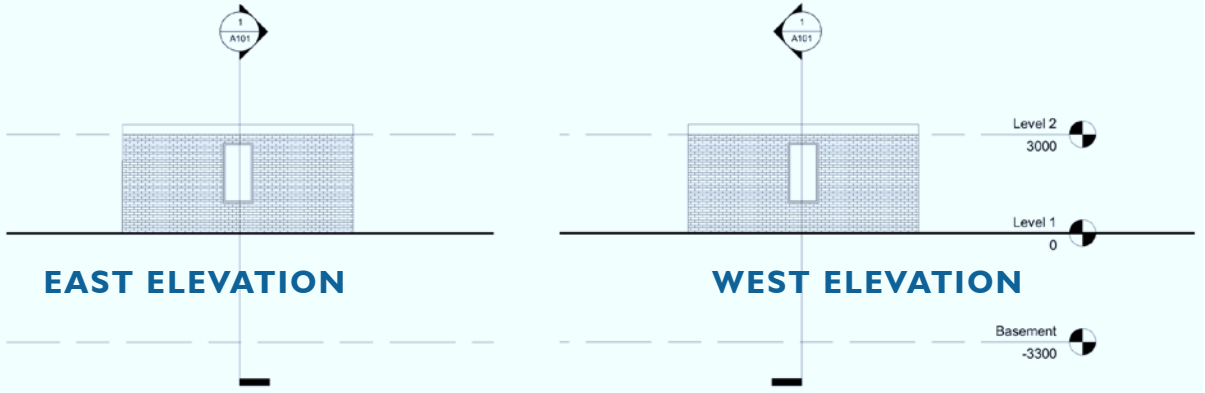
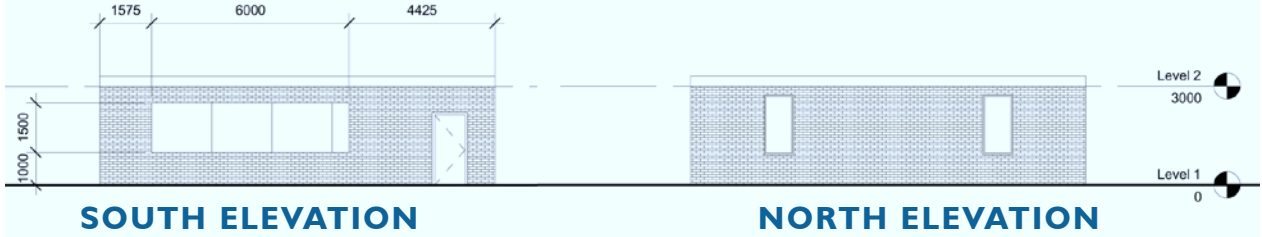


FIG 12.4 ORIENTATION TEST BUILDING

