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Density Measures and Their Relation to Urban Form

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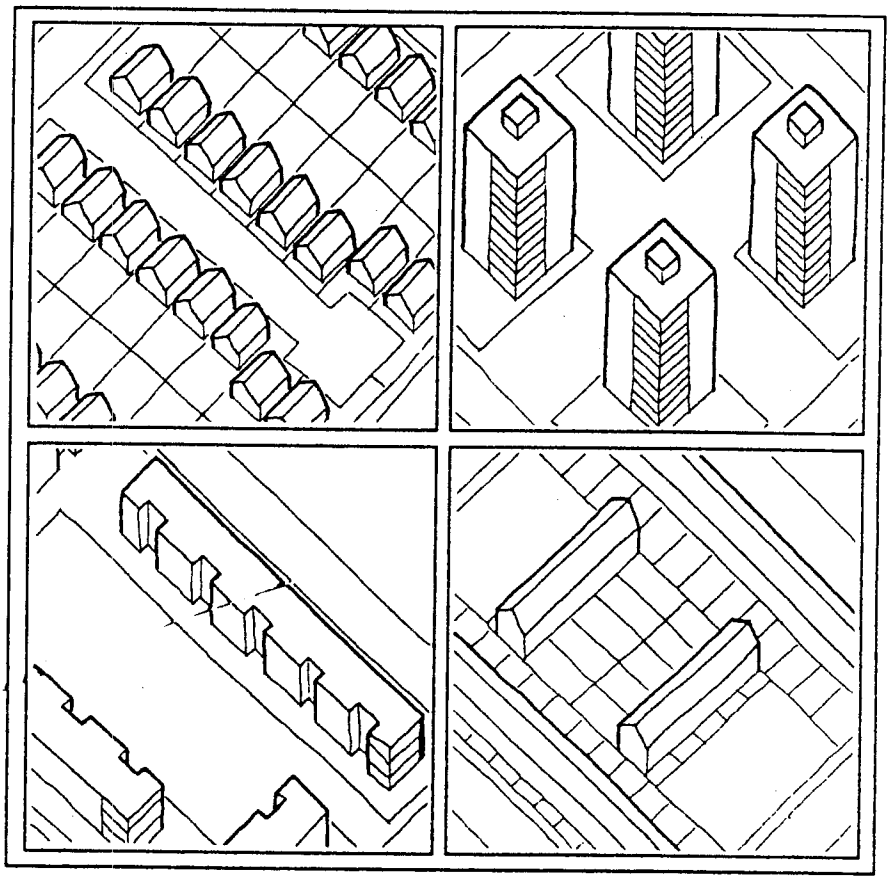

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Abstract:

The relationship between density and urban form is explored, using four dwelling types: single family detached housing, row housing, low- rise garden apartments, and high-rise multi-family housing. Preceding research is reviewed, presenting various concepts of density, and relating conflicting prior density measures to a set of clear definitions. 99 typical site layouts of the four dwelling types were developed by systematically changing variables including unit size, lot size, and block configuration. The relation between these variables and the resulting densities was analysed using regression and multiple correlation analysis. Examples of actual housing developments accompany the review, relating their physical and environmental characteristics to the densities generated in the abstract schemes. Conclusions include qualified support for the relationship between dwelling type and density range, specifically for single family and high-rise housing, but row housing and low-rise multifamily housing share a broad range of intermediate densities.

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Chapter 1:

Background and Concepts

Introduction

Density measures are an integral part of the design professional's vocabulary and "kit of tools". These measures include density indexes such as the number of people per hectare and the number of dwelling units per acre of land, and related measures of land use intensity, like coverage and floor area ratios. They are part of the conceptual vocabulary of architects, municipal engineers, land use planners, and urban designers, and affect applications ranging from the design of housing clusters to the zoning standards for entire cities.

The application of density measures is aimed at creating, changing, or otherwise affecting the form of the built environment. When they are invoked, it is because of their assumed relationship to urban form. The architect and her developer client, mulling over the optimal housing mix for their residential project, the urban planner submitting zoning modifications to his planning commission for approval, the engineer calibrating a land use model to project sewer capacities for the year 2000, or the urban designer sketching the layout of a neighborhood center, are all using density measures as a surrogate for something they want to acheive in the actual real-world environment of the city, suburb, or countryside.

In architectural design, urban and regional planning, municipal engineering infrastructure design and land use planning, and urban design, density measures are a constantly used tool. Yet few of the many users of these measures have a sound understanding of their true meaning. Though there is a fair body of research on densities, building intensity, and density measures (which is reviewed below) there is little convergence among these studies and even less diffusion of their results.

The application of density measures is suffused with a kind of "folklore" that relates densities within quite narrow ranges to specific dwelling types. Nearly twenty years ago some regulators realized that: "Because there is wide variation in the size of living

units and the number of occupants...density is a rather crude measure of the degree of land use." (FHA, 1971:6).

Yet, in an obvious attempt to estimate ultimate population densities and use intensities of proposed developments, the zoning ordinances of many cities still associate specific dwelling types with a sliding scale of "density points" depending on the number of bedrooms (League of Oregon Cities, 1977). Planning and design standards also frequently relate given housing types to specific densities (e.g. Lever, 1971).

Also open to considerable doubt is the precision of many density measures themselves. Ambiguity abounds regarding what is included under the "acres" or "hectares" in these measures' denominator. As a result, the association between the apparently regular increments of density expressed in these indexes and what may be experienced or perceived in the actual built environments that density measures are expected to express is much weaker than most users of these measures suspect.

The aim of this project is to promote peoples' understanding of the relation between density measures and the built environments of cities. A better appreciation of the complexities of this relationship will make more intelligent users of density measures out of the professionals who apply these measures in their daily tasks, and may assist those members of the public who encounter these measures in their interaction with the designers, planners, and regulators of the built urban environment.

The study consists of three parts:

* 1). A review and consolidation of previous research, focusing on the different definitions and measures of density that have been developed in the past, many of which are still in use. This analysis explores the differences between various density measures and exposes all the ambiguities that exist. In its conclusion a set of measures and definitions are presented that form the basis for the following sections.
* 2). A deductive exploration of the relationship between density measures and urban form. Four dwelling types: single family residence, row housing, low-rise "garden" apartments and high rise apartments are systematically analysed through a series of housing unit variations, lot sizes and block layouts, to see how these changes affect measured densities, and some of the physical characteristics of the perceived built environment.
* 3). An inductive empirical review of actual built environments, linked to the abstract exploration described above. Here

real-world examples of urban neighborhoods and housing developments are juxtaposed with their parallel diagrammatic variations. These examples illustrate better than the diagrams can the range of variation that is found, and the ambiguities of superficially similar numbers. Evaluation of the quality of these environments and their perceived characteristics suggests the uses and limits of density measures in designing and regulating the built environment.

A separate handbook is planned to summarize and illustrate the relationships between various measured densities and built environments presents the results of this study in a form that should be readily usable by practitioners and laypersons. This handbook is being designed to serve as a guide for the intelligent use of density measures and an accessory to design and planning guides and standards in the kinds of situations where these are consulted.

Concepts: Perceived, Physical and Measured Densities

In considering densities, it is important to distinguish between three different types of density which represent different phenomena and appear in different contexts though, as we shall see, they are intimately linked. They are: 1) Perceived Density; 2) Physical Density; and 3) Measured Density. As Rapoport (1975: 134-135) has said, "density itself is a perceived experience", made up of a physical system which is transformed into a perceived system and, when matched against personal and cultural norms, generates an "affective density" that communicates evaluative judgements like a sense of isolation, a feeling of comfort, or a perception of crowding.

This realization also enables us to distinguish between density and crowding. While closely linked to density, crowding is an appraisal relating perceived density to desired standards and norms, which may vary widely from one social group to another, and between different cultures (Rapoport, 1975: 134-141). Through crowding, density is related to environmental stress (Crothers, 1976; Krupat, 1985: 95-99).

We deal with density, then, in our roles as professional shapers of the built environment, or confront density as actual or potential users of an environment which is being moulded by some intervention. In any of these roles, we actually want to create environments that will have positive "affective" densities, stimulating positive evaluations on the part of their users. If we take social and cultural norms of desired levels of intensity of landuse, oc-

cupancy etc. as given, then what we are really trying to manipulate in each specific intervention is perceived density.

Perceived Density

Rapoport (1975: 138-140) identifies some of the factors contributing to perceived density. They include perceptual, associational-symbolic and physical aspects of the environment, temporal aspects of activities, and sociocultural aspects of actors and settings. In an attempt to systematize the way in which factors act together to generate perceived density, we suggest an interaction as shown in Figure 1-1.

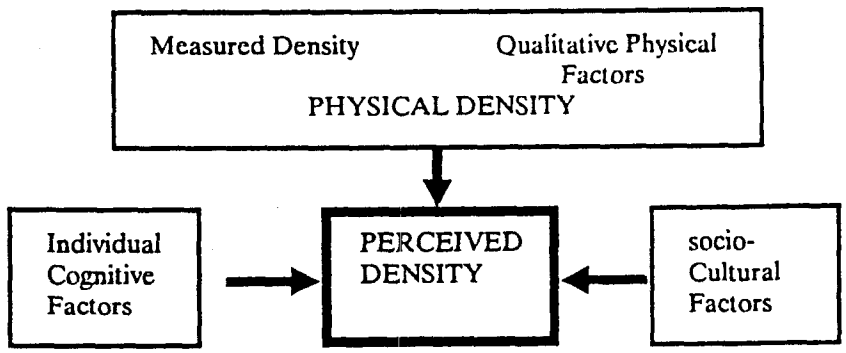


Figure 1-1: Perceived Density - Contributing Factors

Perceived density is the interaction between three major vectors, or combinations of factors: physical density, which itself contains both measured density and "qualitative density" made up of other relevant physical factors; individual cognitive factors; and social and cultural factors. The last two may contribute both to perceived density, and, in the sense that they incorporate norms and standards, to the "affective density" as well.

Physical density is discussed below. Individual cognitive factors can include feelings of control or lack of it (these may also be affected by physical stimuli, such as enclosure or openess), privacy, etc. Social and cultural factors include homogeneity or heterogenity of users of the environment, presence or absence of socioculturally regulated norms of interaction, levels of social interaction and the character of activites in relevant settings: their spatial and temporal dimensions (Rapoport, 1975), and their intensity (Lerup, 1971), etc.

We will not deal with individual-cognitive and socio-cultural factors any more in the course of this study, which, in focusing on density measures, approaches the outcome that is of interest: per-

ceived density, through the physical density vector. But it is important to remember, even when considering density measures, that the ultimate perceived density is not the result of physical density alone.

Physical Density

Physical density is made up of those objective and physical characteristics of the built environment and its users that contribute to the density that is perceived by people in an actual setting. Some of these characteristics are attributes of the built environment that are not included in density measures. These more qualitative factors are included in what we are calling:"qualitative density"in the component of physical density which we are calling "measured density".

This "qualitative" part of physical density expresses attributes of structures and buildings such as height and relative spacing (though these can be expressed in light, sun or shadow angles, e.g De Chiara and Koppelman, 1982:, conventional density measures fail to include them), massing, juxtaposition (e.g. openess or closure of a site layout) and diversity. Some other qualitative factors related to physical density are the character of buildings (e.g the intricacies of their elevations and materials, and diversity or homogeneity of color), lighting levels, and landscaping.

The "bounding" of an area -- i.e whether adjacent alternative locations are available for nonresidential uses (shops, streets, pubs, etc) or not, and the presence or absence of nonresidential landuses, and their mixture (Rapoport, 1975: 139), may also be an important factor. Another aspect of "bounding" that may contribute to physical density is scale: the sheer extent of an area of homogenous development, and the scale of the construction within an area. This aspect of density is often neglected (Boudon, 1981), but planners and designers ignore it at their peril.

Other characteristics can be expressed in the component of physical density which we are calling "measured density". These more quantitative attributes of the built environment include the number of potential occupants or users in an area, the number of dwellings in an area, the proportion of a site that is built upon, etc. These are the principal focus of this study.

The effects of different physical layouts within similar measured densities will be explored below. Previous such explorations (e.g Martin and March, 1966; Keeble, 1969; Holloway, 1971; Diamond, 1976) show clearly that measured density and other physical factors are quite independent of each other.

This study does not address the qualitative aspects of physical density, focusing as it does on measured density. But that does not mean that qualitative density can be ignored. The qualitative aspects of physical density may be just as important as the ones that can be quantified in measured densities, and warrant equal attention in research, planning and design.

Measured Density

Measured density is the focus of this study, though, as suggested above, other aspects of physical density combine with sociocultural and individual- cognitive factors to produce the perceived density which is the actual object of planning and design manipulations. A bewildering variety of measures exist to express density.

One way density measures have been grouped is by distinguishing between "molecular" and "molar" measures. Molecular measures reflect density within the dwelling unit: people per room, sq.ft. floor area per person,etc. Molar density refers to the space outside the dwelling: the site, neighborhood or community. These two may not be directly related; indeed, sometimes their relationship is inverse. In a wealthy urban area such as Manhattan, for example, luxury apartments may have low molecular densities (i.e low numbers of occupants per room), while the molar density (say, DUs/acre) is very high. Conversely, in a rural slum dwellings are crowded, while neighborhood densities are very low (Krupat, 1985: 100-102).

Many density measures are ratios of some "occupier" or user as the numerator (persons, rooms, households, dwelling units) and a unit of area as the denominator (acres of residential land, neighborhood area, city area in hectares etc.). As we shall see, definitions of the area used in the denominator are critical, but frequently absent. These density measures will be reviewed in detail below.

Another class of measures express the "bulk" components of physical density, i.e expression of the physical form and volume of buildings. These include the following:

* Floor Area Ratio (FAR) which is the ratio of built floor area (on all floors) to the area of the site; FAR is usually expressed as a % or a decimal fraction.
* Coverage: the ratio of the area covered by buildings (i.e the area of the ground floor "footprint") to the area of the site; Coverage is also expressed as a % or a decimal fraction.

* Angles such as light angles and shadow angles are additional measures that may be used to define a building envelope in relation to its site, street, or adjoining structures.
* Height and Setbacks: the combination of these measures determines the site- specific maximum permitted massing or building "envelope".

Given some assumptions about building capacity and usage (e.g how many dwelling units of a specific size "fit" into a particular volume, and how many persons make up the "average" household occupying a dwelling) all the other density measures can be derived from these basic units on a given site. However, at higher levels of aggregation, these units are usually unknown or indeterminate, hence the need for other measures of density like the ones discussed above.

In zoning and building regulations, these measures are frequently used in combination with other density ratio measures to approach an expression of the permitted maximum intensity of land use.

Finally, some more complex indexes of land use intensity have been developed, often from a sense of the limitations of the conventional density measures presented above. Probably the best known and most used of these is the Land Use Intensity Rating (LIR) of the Federal Housing Authority (FHA, 1971).

The FHA developed the LIR as a substitute for conventional measures of density because it is "more reliable because less variable" (p.6). The LIR takes FARs as its point of departure, and maps them onto an arbitrary interval scale, so that a LIR of 0= FAR of .0125, and a LIR of 8.0= FAR of 3.2. Given some assumptions of average sizes of dwelling units, equivalent densities (in DUs per "gross acre") can be deduced, so that if the housing unit is 1089 sq.ft. the LIR of 1.0 = 1.0 DUs/acre, and the LIR of 8.0= 128 DUs/acre, while if the dwelling is 871.2 sq.ft., then the LIR of 3.0= 5.0 DUs/acre, and the LIR of 6.0 = 40 DUs/acre, and so on. Adoption of the LIR outside the FHA itself was limited, probably because of its lack of intuitive transparency and its complexity. The FHA's claims for its index, as being a more "reliable" reflection of the actual physical density and the use intensity of a development, are also not really supported in practice.

Other complex density or land use intensity measures have been developed and received limited application, but their use never became widespread, probably for the same reasons as the LIR's lack of acceptance. With the LIR, the FHA developed a more complex measure, the Land Use Intensity Ratio (LUI) which com-

bines FAR with five other indexes: 1) an "Open Space Ratio" (OSR) expressing standards for minimum open space required per built floor area; 2) Living space ratio (LSR), expressing requirements for non-vehicular open space per sq.foot of living area; 3) Recreation Space Ratio (RSR): open recraetion space per sq.foot of floor area; 4) Total Car Ratio (TCR): minimum number of parking spaces per DU; 5) Occupant-Car Ratio (OCR): number of required unlimited time parking spaces per DU.(FHA, 1971; Hanke, 1966). This was also incorporated in the FHA's "densitometer" (Hanke, 1972). Besides their complexity, these measures are flawed because they build in a set of rigid and determinate standards upon which all the relationships are based.

Some cities developed their own measures, such as the system used in Eugene Oregon, where a scale of "density points" is related to dwelling type and number of bedrooms (League of Oregon Cities, 1977: 2). However, in spite of the prevailing disatifaction with conventional density measures, reflected in the development of these more complex indexes, none of the latter has gained general acceptance and all have fallen into disuse. In planning, design, and regulation of the built environment today, use of the conventional density ratios with all their oversimplification and their ambiguities is the norm, though they are usually combined with one or more of the other measures characterising building-land relationships that are described above (So and Getzels, 1988, p274).

Chapter 2:

Review: Density Measures and Research

Introduction and Definitions

All the density measures discussed here are ratios. The numerator may be the number of persons, families, households, habitable rooms, bedrooms, housing units or dwelling units (DUs).

Where one numerator unit is inferred from another, rather than being the direct unit of measurement, there is an explicit or implicit conversion factor. For example, the conversion of density measured in persons per acre to households per acre requires an assumption about average household or family size.

Similarly, to convert densities measured in population units (persons, families or households) to measurements using housing units (bedrooms or habitable rooms, DUs) assumptions about occupancy rates have to be made: the number of habitable rooms per household, or whether each household occupies one DU. Some of these assumptions may be robust in terms of reflecting the actual social and demographic characteristics of the relevant population. For example, for suburban U.S. communities one household usually does occupy one DU. Other assumptions may be less robust, and the resulting measurements may be correspondingly less accurate.

The denominator in all these density measure ratios is a unit of area. The unit of area may vary in two respects. One is the unit of measurement (acres, hectares, or square miles) and the other is the definition of the boundary. The unit of measurement does not raise any problem. Any unit of measurement can be transformed into any other by simple arithmetical conversion, though the extension in space of an "acre", a "hectare" or a "square mile" is not easily intuitively comprehended.

The definition of the boundary, on the other hand, has been the source of a great deal of ambiguity and fuzziness in much previous work on densities, as the review below will show. To avoid this a set of terms that will be used in this study, and their exact definitions, are presented below. These terms, or standard measures, will serve as points of reference for the review that follows.

Net Dwelling Density (NDD)
The numerator for the Net Dwelling Density (NDD) may be any of the units suggested above, ranging from persons to DUs. The denominator is the "net residential site area", defined as the "total land area devoted to residential facilities".

In single or two-family housing areas this will normally be the area of the dwelling lots, and can include driveways, front, back and side yards, private gardens, and ancilliary structures like garages, toolsheds, etc. In higher density developments the net residential site area includes private access drives and parking areas related to the dwellings, play spaces, gardens and adjacent landscaped areas directly related to the residential use. Excluded from this area are commercial and industrial areas, shopping and local business not directly beneath residential buildings, commercial garage space not directly below a dwelling structure, public parks and playgrounds, vacant land for future development, vacant unbuildable land, schools, churches and community facilities, institutions, and public streets and parking spaces (APHA, 1960: 73).

Gross Residential Density (GRD)
The Gross Residential Density (GRD) is the ratio of any of the above numerator units (persons, households, DUs) to the "gross residential site area". The gross residential site area is the net residential site area + half the area of the perimeter roads, + one quarter of the area of the intersections. If perimeter roads are over 100' wide, the gross residential area includes only up to 50' from the property line (APHA, 1960: 37, 74).

Neighborhood Density (ND)
Neighborhood Density is the number of persons, households, or DUs per acre, hectare, or square mile of total neighborhood land. Neighborhood land includes residential land, streets, and other landuses for neighborhood community purposes such as schools, recreation, religion, culture, and neighborhood retail shopping. Non- neighborhood landuses such as public and semipublic services, citywide business and commercial establishments, secondary and higher education, industry, major arterials and freeways, city, metropolitan or regional parks or recreation facilties, and vacant or unusable land are excluded (APHA, 1960: 63).

City Density (CD)
City density is the ratio of persons, households, rooms, or DUs to the entire area of the city, regardless of land use. This is the same as the British "town density" (James, 1967: 55). The numerators

DENSITY MEASURES

NUMERATOR UNITS	NDD Net Dwelling Density	GRD Gross Residential Density	ND Neighborhood Density	CD City Density
Persons		APHA(1960) gross res. density Gibberd(1967) nett neigh. density James (1967) net density (20' roads) Jensen(1966) net density Stevens(1960) housing area density	Gibberd(1967) gross neigh. density Keeble(1969) gross pop. density James(1967) gross density Jensen (1966) gross density	APHA(1960) district density Camerom (1980) James (1967) town density Jensen(1966) town density
Households		APHA(1960)		APHA(1960) district density
Rooms			Corvallis (League of Oregon Cities 1977)	
Dwelling Units	*APHA (1960) *FHA (1971) net density Keeble (1966) nett res.density Martin and March (1972) Hoffman(1967)	APHA(1960) gross dwelling density (50' roads) Cameron(1980) net housing density FHA(1971) gross density Martin and March (1972) Gibberd(1967) net neighborhood density	APHA (1960) net density Gibberd (1967) gross neighbor-hood density	APHA (1960) district density Keeble (1969)

Table 2-1: Comparative Density Measures.

most commonly used for this measure are persons or households. A remaining source of ambiguity is the delimitation of the land area included: it can be defined by a city's jurisdictional boundaries and then would include all vacant and undeveloped land within the city limits; or it can be limited to the urbanized or contiguous built-up area of the city. Since this study will not dwell much on city densities, this ambiguity is left unresolved.

Density Measures: A Review

Using the measures and definitions presented above as points of reference, we can explore the array of preceding density measures that have been developed and applied. These measures, for the most part, are remarkable for combining diverse names with relatively convergent definitions. At the same time, one has the impression of many authors, through the 1960s and 70s, each "reinventing the wheel" with little or no reference to their predecessors.

In Table 2-1, 28 density measures from 11 sources are arrayed by their relative correspondence to the "benchmark" measures we have defined above. Another four sources use density measures that are so vague and indeterminate that they cannot even be placed on this chart.

Five measures correspond or closely approximate to our NDD. The identical ones are the "net residential densities" of the APHA (1960), Hoffman (1967), Martin and March (1969), and Keeble (1971). The FHA's "net density" is more ambiguous about the street and parking areas that are included (FHA, 1965:8).

Nine measures are clustered around our GRD. Of these, five are identical. They include the APHA's "gross dwelling unit density" (1960), other "gross densities" (Martin and March 1969; FHA, 1971), Stevens' "housing area density" (1960), and Cameron's "net housing density" (1980). James' (1967) "net density" is very similar, the only difference being that he only includes up to 20' of peripheral roads. The APHA's (1960) "gross residential density", Jensen's (1966) "net density" and Gibberd's (1967) "net neighborhood density" veer towards our Neighborhood Density in being more inclusive in the range of landuses defined as belonging to a neighborhood rather than the city as a whole.

Seven measures roughly correspond to our Neighborhood Density. Identical are the APHA's (1960) neighborhood density, Gibberd's (1967) "gross neighborhood density" (using either persons or DUs in the numerator), and James' (1967) and Corvallis' (League of Oregon Cities, 1977) gross densities. Jensen's (1966)

and Keeble's (1971) density measures include in their denominators some landuses that our definition allocates to cities.

The APHA's (1960) "District Density" is nearly equivalent to our City Density. Four other measures (Jensen, 1966; James, 1967; Keeble, 1971; Cameron, 1980) are identical to the CD used here. This array suggests that the wide variety of terms used by different sources for the same measurement conceals a significant degree of convergence.

The density measures arrayed in Table 2-1 are the ones that are fairly well defined. Frequently in the literature there are references to density which are so indeterminate that they could not be placed anywhere on this chart with any confidence. Besides the many such references, several authors of studies relating to density have also used density measures with so little precision that they cannot be related to any one or other of the measures we have defined here. They include Crothers'(1976) "gross density", Diamond's (1976) use of DUs/acre (without specifying acres of what), Flachsbart's (1979) "residential density", and Windsor's (1979) "gross- and nett unit density".

Studies of Density and Urban Form

Considering the widespread applications of density measures in regulation, planning, and urban design, the relative lack of research into density measures is surprising. Even more surprising is the lack of convergence in this area of study. To avoid these errors we have reviewed all the previously developed density measures and applications we could find, and compared them to our measures as defined above. This review continues with a presentation of precedent research related to density measures and urban form.

This research can be grouped into several unequal categories:

* 1).Studies of density related to human perceptions and behavior: A considerable volume of work exists which relates density to perceptions of crowding, privacy, territoriality, and related behavior. An example is Gillis and Hagan's (1979) study relating density and delinquency. This body of research will not be reviewed here (a good review is provided by Krupat, 1985: 99-113, 176-184) because it is not central to our concerns. It is relevant, of course, to the ultimate concept this study is addressing: that of perceived density. But in relation to our immediate focus on measured densities, this work is peripheral. We consider this exclusion reasonable, since density in this sense is often used more as a broad

concept or indicator, without the precision implied by density as a measure of an observed or experienced phenomenon.

* 2).Density and land economics: Several studies relate density (with more or less exact measures) to economic variables such as housing prices and development costs. Urban form impacts are sometimes derived, including the shapes of buildings near the CBD and the costs and benefits of low-density suburban development.
* 3).Planning Prescriptions and Descriptions: Planning prescriptions for optimum densities are frequent. These studies sometimes arise out of description and analysis of historical and cultural prototypes, but often they are directly normative prescriptions where specific density ranges are associated with particular dwelling types.
* 4).Density measures -- applications and problems: A relatively sparse body of research presents examples of density measure applications and analyzes some of their related problems. Some of this work has already been referred to above, and it is highly relevant to our concerns.
* 5).Density and urban form: Several studies have shown a concern paralleling ours with the relation between density measures and urban form. Some resemble this one in their methodology, though none combine the deductive and inductive modes applied here. These studies are reviewed in detail below.

Density, Perceptions and Behavior

Representing the extensive body of research relating density,perception, and behavior, two specific studies can serve as examples. Lerup (1971) investigated the relationship between open space, access, and dwelling types and their densities. He concludes that courtyard type buildings use land more efficiently than pavillion type structures (cf. Martin and March, 1966, 1972). His concept of "intensity of activity" related to density is interesting and potentially useful, but the interaction between the two remains vague and underspecified.

Yeung (1977) is one of a long line of researchers basing their conclusions on the high rise housing experience of Hong Kong (see for example Mitchell, 1971). Distinguishing between internal density measures (occupancy) and external density measures (persons per unit area of land), he suggests that prevailing norms (e.g the U.N's suggestion of an average density of one person per room for privacy, with three or more persons suggesting undesirable crowding) are untenable. Yeung refutes two "myths" about high rise housing: it is not significantly more efficient, in

terms of producing higher external densities, nor does it necessarily result in less living space, i.e. higher internal densities.

Density and Land Economics

Several studies have explored the implications of low density suburban type development in terms of its economic efficiency. *The Costs of Sprawl* (RERC, 1974) suggested that this type of development was inefficient, and that substantial savings could result from the adoption of higher density cluster- type housing. This analysis used two scales of development, the first comparing five alternative housing types in standard developments of 1000 DUs each, the second showing five alternative mixed development patterns in communities of 10,000 DUs on a standard 6000 acre site. The density measures here (as in the succeeding studies) are incidental, and result from the housing units and site arrangements displayed. Density, then, (as is so often the case) is used almost anecdotally, and related to specific dwelling types and patterns of development.

Indeed, the loose use of density measures is one of the aspects of Windsor's (1979) critique of "The Costs of Sprawl". Exposing the previous study's assumptions, Windsor recomputes the occupancy (floor area per resident), net unit density (= our NDD), and gross unit density (= our GRD) for each of the alternative developments. He finds that while size and demographic composition of the population is held constant in the community prototypes, they are varied in the neighborhood prototypes, and that the floor areas of DUs change, with smaller units at higher densities. All these variations affect costs, so that density effects are inextricably confused with variations due to other factors. The reanalysis of RERC's data suggests different conclusions: private capital costs appear to be lowest for medium density development such as townhouses or low-rise apartments. Environmental impacts and population-dependent public costs seem to be lowest using planned single-family development as a form of growth management.

Resembling "The Costs of Sprawl" in its aims is Ottensmann's (1977) study which "proves" what is acknowledged as a truism: that denser development takes place on more expensive land. Density, however, is represented here by a surrogate measure: population, to which it is, in fact, only weakly related. Buttler (1981) comes to a similar conclusion, but his method is more sophisticated and incorporates several density attributes: population density, DUs per building, and FAR. His analysis finds that a competitive housing market in equilibrium will elicit narrow and

tall buildings close to the CBD, and that building heights and minimum areas tend to be determined by technology and codes.

Sanders' "Zero Lot Lines can Trim Costs" (1982) also makes a case for the greater economic efficencies for the higher net densities attainable through zero lot line zoning. Inadequately considered are the implications of the relation between NDD, GRD and ND, the latter two affecting development costs more than the former, but being much more marginally affected by changes in development patterns (cf., for example, Alexander 1968).

Planning - Descriptions and Prescriptions

55 years ago normative regulations involving density were already the subject of discussion and debate. Lanchester (1934) proposed a formula that would reward low density development by requiring a lower proportion of open space (including roads), and suggested a variation of conventional density measures to assess density at cubic feet of volume per acre. His proposals were accompanied (as was often the case later) by descriptions of prevailing densities and regulations elsewhere.

The set of subsequent proponents of density standards associated with specific dwelling types includes Segal (1964), Gibberd (1967) and de Chiara and Koppelman, whose *Urban Planning and Design Criteria* (4th. Edition, 1982) is probably the most widely used U.S. reference of its kind today. Reflecting current third world attitudes, Okpala (1978) reviews density patterns in Nigeria, and suggests a revision of prevailing regulations based on western norms to allow the higher densities more typical of his country's lifestyles.

Unlike Okpala's proposals, however, most normative work on residential densities does not rest on any descriptive or analytical base, or at least none is cited. We have to assume, then, that it reflects some kind of intuitive knowledge based on a body of experience. One exception is Keeble (1969, 1971) who proceeds from a set of precise definitions of density measures (see Fig.1 and following above) and analyzes the different density impacts of various combinations of dwelling types. Another is the FHA's (1971) development of its "Land Use Intensity (LUI) Scale", which was stimulated by a proper disenchantment with simplistic density measures, and is based on a complex set of indexes reflecting various dimensions of land use intensity.

Lever (1971) refers to "Positive Standards" (i.e density measures in practice) in his presentation of "Normative Standards". He correctly notes the lack of planning control over occupancy; thus building density measures (DUs/acre or Habitable rooms/acre)

are the only ones that are usable in planning and regulation. Sussna's (1973) study is primarily descriptive, presenting densities in some new planned communities in the U.S. and comparing population and density standards for ideal communities.

Applications and Problems

Applications of density measures in planning and regulation are described in Keeble (1971) and Lever (1971). A League of Oregon Cities (1977) study reviews practices in several municipalities, and includes substantial references to FHA standards. Cameron (1980) describes applications of density measures, focusing on practice in developing countries.

An early but useful review of norms and practice (Stevens, 1960) shows how other regulatory and environmental criteria e.g health standards and infrastructure capacities and requirements, may be affected by changes in density. Though our study that follows will not include these factors, they are worth bearing in mind.

Several studies address conceptual or practical problems involving density measures. Crothers (1976) raises the question of defining the area concerned, and how this raises problems of indeterminacy of density measures. The way such an area is bounded may affect its self-containment, in terms of the array of interdependent landuses that are included. This can certainly be a real issue in determining higher level densities -- ND or CD -- but for lower level density measures -- NDD and GRD -- it can safely be ignored.

Keeble's (1971) study critiques conventional density measures for their rigidity and aggregation (cf. Stein, 1978, below) and their imprecision (referring e.g. to the differences between the English, Scottish and Irish acre). He proposes to substitute performance standards involving space-height relationships, design quality, and parking provision for conventional density controls.

Stein (1978) discusses the weaknesses of several measures. "Accommodation density", or the number of habitable rooms/acre, is problematic because the number of persons per room is not taken into account, and the definition of "habitable" rooms is vague. Similar problems plague the habitable floor space/acre index. Population density fails to reflect concentrations of people (as in high-rise structures) but divided by accommodation density it can produce an occupancy rate (persons per habitable room). Stein notes that a common characteristic of all density measures is their inflexibility, both in reflecting spatial differences (concentration or dispersion) and temporal ones (e.g differences between daytime and nightime use). One cannot but agree, but then again,

this characteristic of all aggregated measures is inseparable from their usefulness and generalizability. Instead of rigid density standards, Stein (like Keeble, above) advocates performance zoning, suggesting a combination of population policies and "proxemics"-based criteria. This idea may warrant further development, but it might be of doubtful feasibility.

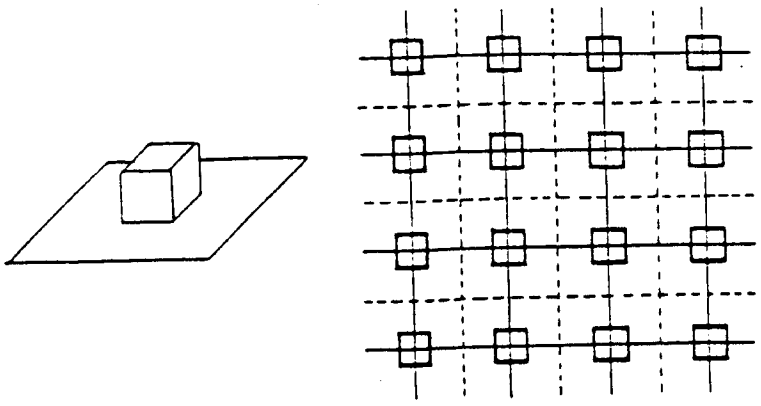
An interesting study by Flachsbart (1979) exposes the limitations of density measures in reflecting perceived densities. In relating observers' estimation of densities in several California cities to the measured densities he found a systematic tendency to underestimate physical densities, which is related to the frequency of streets and to block sizes. Flachsbart infers that areas with shorter blocks and more street intersections will seem to have lower densities than their actual objective densities, and thus will be perceived as more satisfying environments. His study is flawed, however, by lack of definition of density and a confusion between NDD, GRD, and ND. Consequently the "objective density" of the neighborhood layout he advocates may in fact be lower (in terms of GRD and ND) than that of an area with fewer streets (both areas sharing the same NDD); this makes the lower perceived density unsurprising.

Density and Urban Form

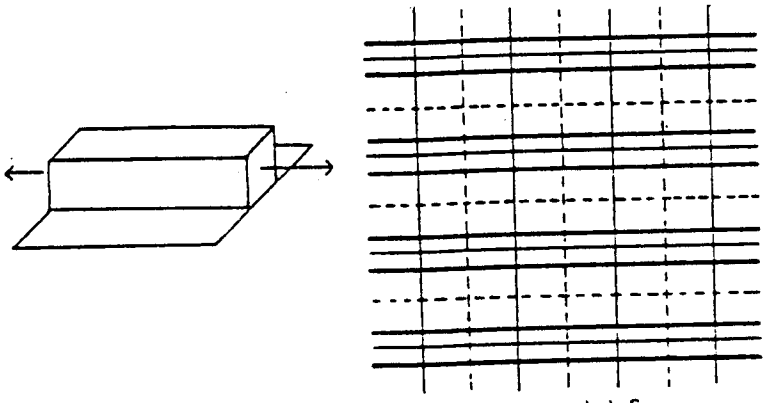
In the early 1960s Sir Leslie Martin and Lionel March were the first, in a series of studies at the Institute for Land Use and Built Form Studies, Cambridge University, to explore some of the relations between density and built environments. The impact of several alternative forms of structure and layout -- pavilion or tower, street, and court -- on various attributes of the environments created (coverage and FAR, called respectively the "site utilization factor" and "the built potential") was systematically analyzed (Figure 2-1). These types of structures were developed in prismatic (e.g. pyramidal), orthogonal, and combined forms, including some interesting "figure- ground" type contrasts and juxtapositions.

The conclusions were that court building forms were more efficient than pavillion or tower types in enabling higher density development while preserving site amenities (light penetration, open space, etc.), suggesting a reversal of conventional economic wisdom. They also found that the size of site, and the street systems are critical variables, suggesting that planning consideration be devoted to "loosening up" city texture so as to allow more effective development patterns (Martin and March, 1966; , 1972: 6-36).

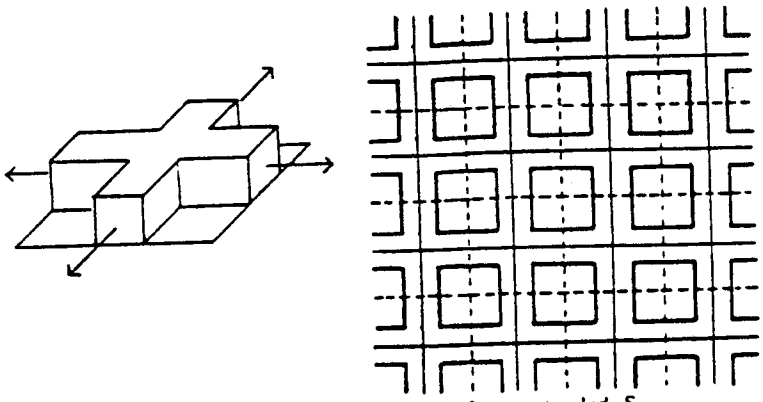
Martin and March's studies are a prototype for the deductive methodology used later (e.g. by Keeble, 1969 and Diamond, 1976,



2.0 Pavilion form extended. S.



2.1 Street form extended. S.



2.2 Court form extended. S.

Fig.2-1: Density & Built Form Analysis(Martin & March, 1972)

see below) and here. The relationships between density indicators and built forms are not taken for granted, nor are prevailing truisms accepted - for example, that high-rise towers enable higher densities and thus reduce development costs. Instead, these relationships are explored through systematic variation of building form.

A similarly deductive approach is adopted in the London County Council's analysis of theoretical new town plans, which systematically varies net densities and housing mixes while holding other variables constant (London County Council, 1961). This study exposes the "dampening" effects of GRD and ND on CD, so that even when the residential area increases in size dramatically as NDDs are reduced, the effect on the radius of a circular town is small. In contrast to Martin and March's, Diamond's, and our work, which is mainly at the microscale of the site and block, this study shows the feasible extension of this approach to the macroscale of the town or city. It suggests that there is a critical CD which

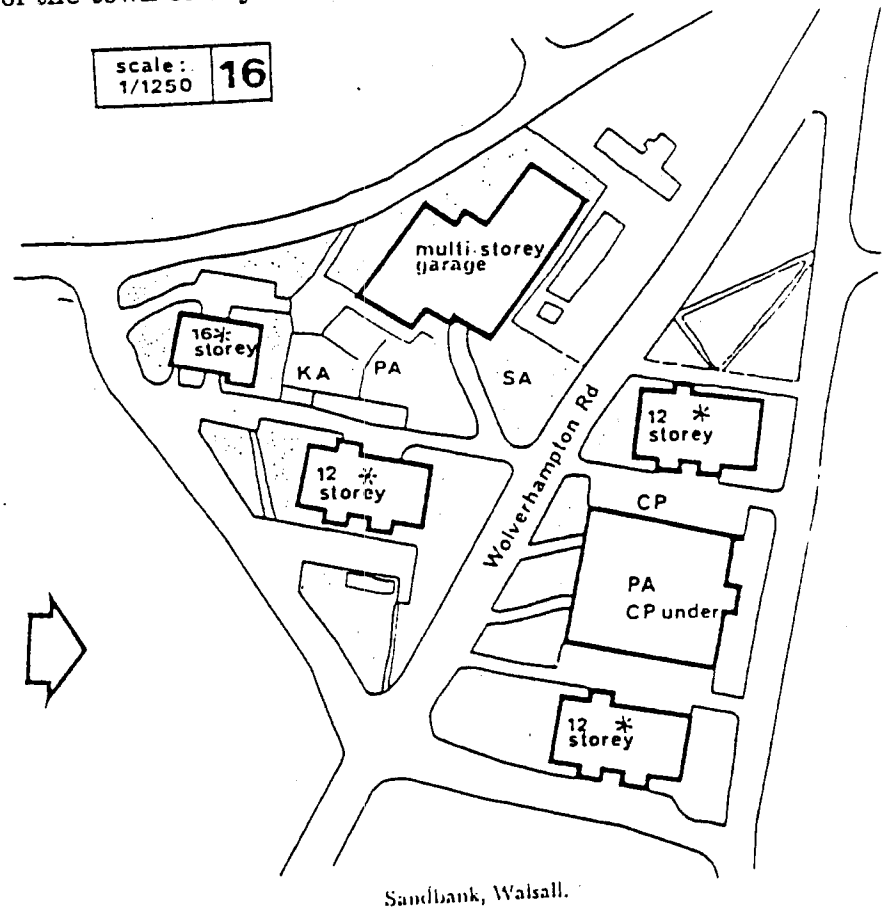
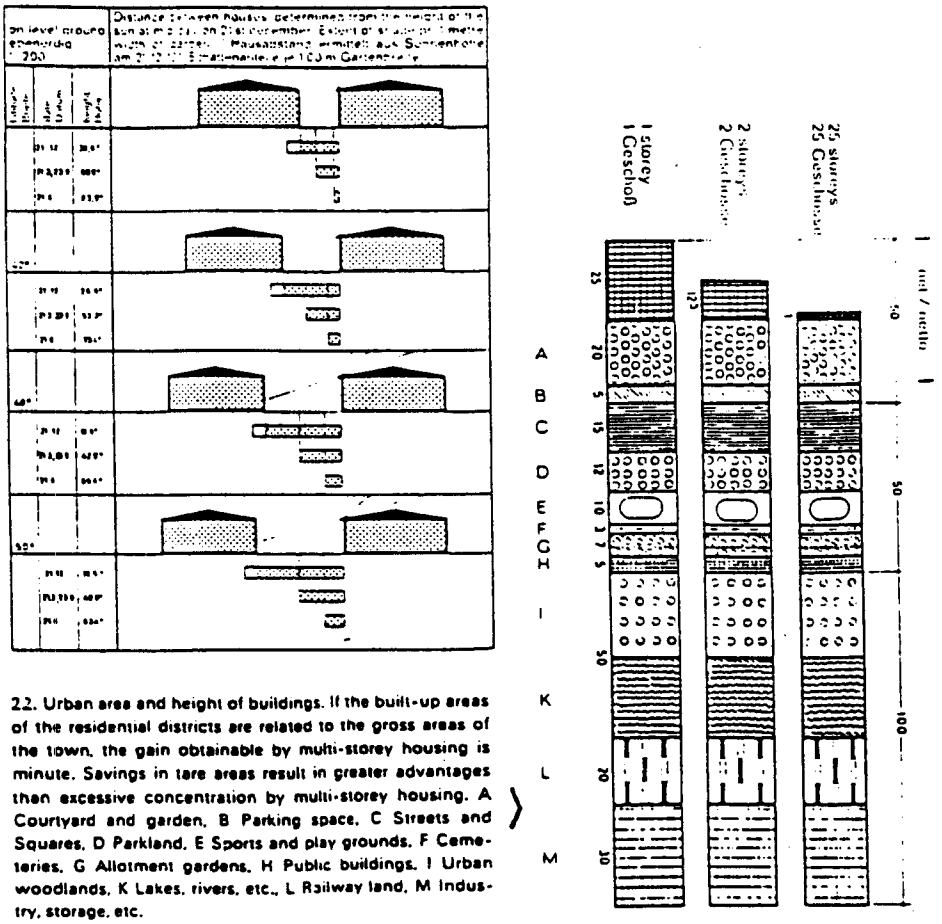


Figure 2-2: Neighborhood Density Analysis (James (1967).

can support local services without demanding unduly long trips. While this CD is compatible with a whole range of possible NDDs and alternative mixes of dwelling types, the study suggests that higher densities increase accessibility and choice.

James (1967) is also an important forerunner, especially in his precise definition of a range of density measures which closely parallel our own (though the names differ; see above). His analysis at the meso-scale (bridging Martin and March's work, which he cites, and the LCC's study) reviews the purported advantages of higher density residential development through an analysis of actual neighborhood layouts (Figure 2-2). His conclusions closely parallel his predecessors': he doubts the value of extremely high densities of around 70-80 persons per acre (ppa) and recommends more moderate gross densities (=ND) of 30-50 ppa which correspond to net densities (=GRD) of 30-50 ppa. He refers to other problems associated with high densities: design difficulties, and unresponsiveness to personal preferences for



2.2. Urban area and height of buildings. If the built-up areas of the residential districts are related to the gross areas of the town, the gain obtainable by multi-storey housing is minute. Savings in tare areas result in greater advantages than excessive concentration by multi-storey housing. A Courtyard and garden, B Parking space, C Streets and Squares, D Parkland, E Sports and play grounds, F Cemeteries, G Allotment gardens, H Public buildings, I Urban woodlands, K Lakes, rivers, etc., L Railway land, M Industry, storage, etc.

Fig.2-3: Housing Type & Density Relationships (Hoffman,1967)

private outdoor space.

In its combination of deductive and inductive-descriptive approaches our work closely parallels Hoffman's (1967) review of row and cluster housing. His descriptive analysis shows how density affects sunlight penetration, and arrives at appropriate housing typologies for different climates and geographic locations (Figure 2-3). His computations show the relationships between floor space index (FSI), cubic content of dwelling types, population densities, and building densities (which, however, are poorly defined).

Keeble (1969) analyzes the NRDs of neighborhoods made up of varying dwelling types and configurations. He shows how densities are a function of plot dimensions (given specific dwelling types) and how densities are associated with dwelling types, their heights and spacing (Figure 2-4). Keeble computes densities for a variety of mixed housing developments, going up to the scale of

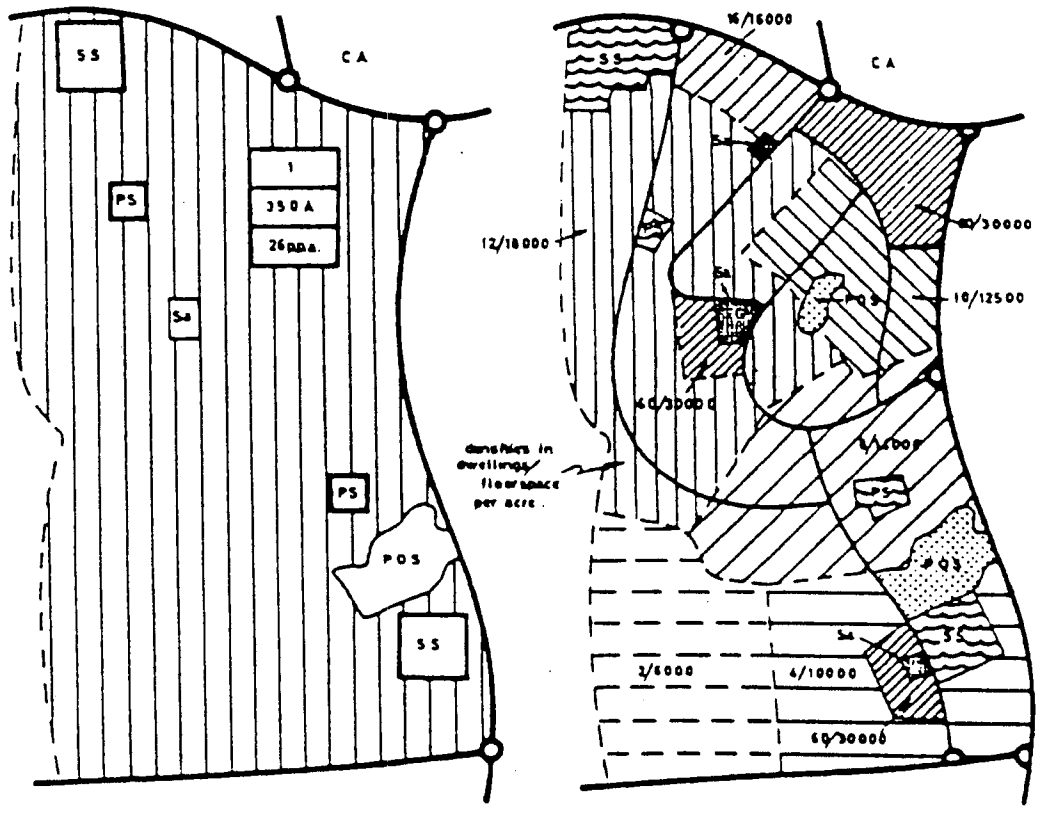


Figure 2-4: Density Analysis of Neighborhood (Keeble 1971)

a complete New Town. He confirms previous researchers' conclusions that the effect of increased NDDs on overall CD is negligible (p.267), and explores the interactions between density, cost and appearance. Both in this text and in his later (1971) study Keeble also combines the deductive and inductive approaches, illustrating his propositions with typical neighborhood layouts. Many of Keeble's conclusions are somewhat subjective, though well supported by his analysis, and his evaluations surmount the test of time; for example:

> "The LCC's Roehampton Housing Estate.. The net residential density is said to be 80 ppa. It is generally recognised to be visually a triumph...It is difficult to avoid the conclusion that, even at the cost of some loss of visual excellence...it would have been better to provide a considerably larger proportion of houses and to give them substantially larger plots." (p.281)

The deductive methodology of Diamond's (1976) analysis is also close to our own. He applies this analysis to make a case for middle level densities in residential development, as opposed to the conventional alternatives of high rise construction or low density single family housing. A graph of land required for a notional development of 3.0 persons per 1000 sq.ft. DU shows the required area increasing asymptotically as FARs go down. Associating specific FARs with dwelling types (single family = 0.25, row housing = 0.50, low-rise walkup apartments = 1.5) Diamond uses this to demonstrate the relative efficiency of mid-rise housing at intermediate densities. This argument is supported by a schematic diagram (Figure 2-5) showing a range of dwelling types and their associated layouts and density measures.

Diamond's analysis is somewhat simplistic, associating one FAR with each dwelling type. This implies not only the constant occupancy rate and dwelling size that Diamond assumes, but fixed densities as well. For example, the FAR of 0.25 he gives for single family housing generates a land requirement of 32 acres, presumably at a density of 8 DUs/acre (per his Fig.6). A FAR of 1.0 (mid- rise development of stacked row houses or garden apartments) for the same 256 DUs requires 8 acres only, i.e the average density is now 32 DUs/acre.

We know, however, that the association between dwelling types and densities is more complex. At the most elementary level, clearly single family detached housing can range in density from 0.2 DUs/acre (exurban large-lot development) to over 10 DUs/acre. These ranges of possible densities for different dwelling types will be one of the topics of our analysis later.

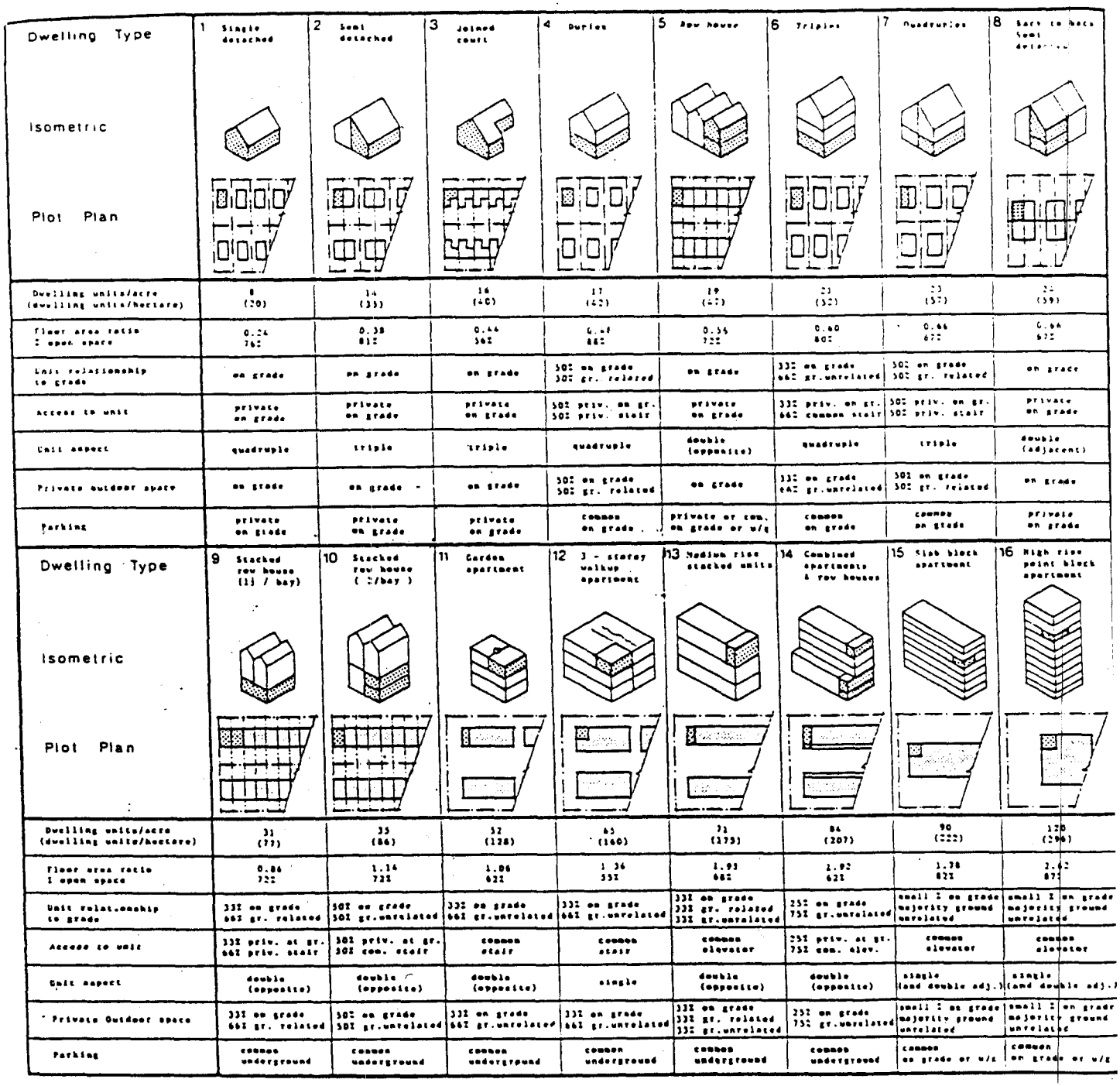


Figure 2-5: Deductive Density Schema (Diamond, 1976)

The schema Diamond develops is sometimes richer than his graph suggests, showing variations within dwelling types that can result from different prototypes; e.g stacked row houses at 31 and 35 DUs/acre, depending on the plan arrangements and number of storeys. For many dwelling types, however, this schema shows only one (perhaps "typical"?) density, or a narrow range, e.g row house, "slab" and "point" block high rise apartments. A more complete analysis, such as the one developed here later, will include the effects on density of other variables, such as lot sizes and proportions (cf.Keeble, above), and block layouts.

Summary and Conclusions:

The preceding research on density measures that is reviewed above reveals a strange paradox. The normative use of density measures continues, and several of the studies are devoted to the development of planning and design prescriptions. At the same time, many of the analyses expose problems with density measures and their applications. These problems include indeterminacy and ambiguity, oversimplification and overaggregation, and possibly a weak relationship with perceived density, which, after all, is what measured densities are ultimately about.

In response some attempts have been made to develop indexes of land use intensity that are richer and more discriminating than conventional density measures, used singly or in combination. These indexes have not gained widespread acceptance, and conventional density measures are still the norm. Several analyses of the relations between density and built form suggest that their interaction is richer and more complex than generally appreciated. Some previously conventional wisdom, e.g that higher densities save land and reduce development costs, has already been exploded. But density measures continue to be used in a very simple way, and even some preceding studies imply simple and relatively fixed relations between densities and dwelling types. It is this assumption that the following analysis will test.

Chapter 3:
Deductive Analysis

Conceptual Approach

The basic conceptual approach of our analysis has been used before (e.g. Martin and March, 1966; Keeble, 1969; Diamond, 1976). It is to combine a number of factors systematically in the development of a range of layouts, and analyze the effects of these factors on the resulting densities and urban patterns. Several factors may affect densities; these are incorporated into our analysis as the following independent variables.

Dwelling Form:
The most important factor is obviously the dwelling form. Consequently, the dwelling form is the first and main variable in our analysis. The range of possible dwelling forms we could have explored is quite large, from simple single family detached housing, through semi- detached and variations of duplex and quadruplex combinations, cluster housing, row housing, a wide range of low-rise multifamily housing types, to the many existing variations of high rise dwelling complexes. Within these types variations in floor plan characteristics and number of storeys could of course also have significant effects on densities and the resulting layout patterns.

Constraints of time and resources limited our ability to address the full range of possible dwelling forms. Therefore we selected for investigation four basic types which represent the polar and some intermediate points on this range: single family detached housing, single family row housing, low rise multi-family garden apartments, and high-rise multi-family apartments. Within each basic dwelling form, a few major variations in configuration were tested; these are the results of combining differences in form (e.g. indentations or projections) with other physical variables as shown in Figure 3-1.

Dwelling Size:
Within each dwelling form, variations in size are possible, which could have density effects (see, e.g. Windsor, 1979). Our analysis includes systematic variation in dwelling size, as a result of chan-

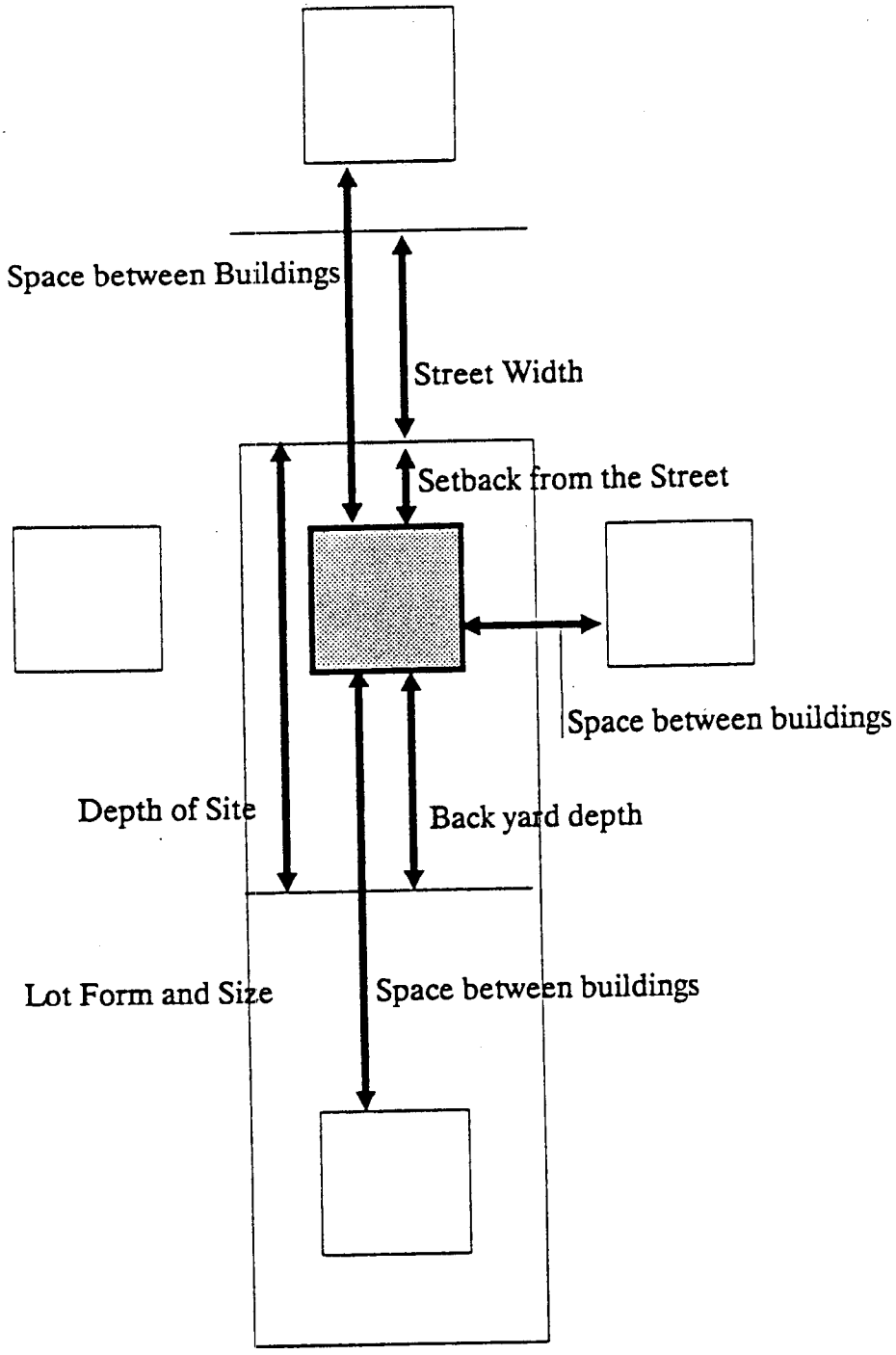


Figure 3-1: Physical Variables.

ges in floor plan area and in height. Thus single family detached dwellings are represented in 25'x40' and 30'x40' floor plans and in single storey and double storey versions. Row housing comes in 18'x22', 18'x30', floor plans, and in 2-floor and 3-floor heights. Garden apartments come in 3- and 4-floor variations, and range in area from 800 to 1650 square feet. High rise apartment complexes range from 8-12 floors (while this does not affect layouts necessarily, it interacts with density through the impact on parking requirements) and include apartments ranging from 500 to 1200 square feet.

The combinations of size, height and configuration were developed to be representative of a realistic range of residential dwelling arrangements, responding to market characteristics and the needs of a diverse population. Thus single family housing might be more compact for smaller families buying their "starter" home, while larger dwellings house larger and more mature households, and in multifamily complexes, small "studio" apartments appealing to the young single person or couple may be combined with larger apartments for older small families.

Lot Size:
Within each dwelling type, lot sizes vary too. For row housing this is the direct result of variation in dwelling plan; in other dwelling types, lot sizes were systematically varied in association with housing size and configuration to produce reasonable combinations. Thus, for single family housing, lots were changed in combinations of width and depth ranging from 36' to 133' width and 100' to 350' depth. Row house lot widths varied with the dwelling widths, from 12'to 35', and depths ranged from 60'to 125'.

Lots for multifamily housing are identical to their blocks; these were also systematically varied (see below). For multifamily dwelling forms another factor affecting what might be analogous to the single family dwelling's lot is the configuration of dwelling units on the building's floor plan. Possible configurations which were tested in apartment housing layouts are the "point" (a small number of units grouped around a common core), single and double loaded corridor plans, single and double loaded "core" plans (i.e where apartments are served by separate vertical circulation cores) and complex configurations involving combinations of the above. For low-rise apartment housing blocks were varied from 210' to 440' width and from 400' to 650' depth. High rise housing blocks ranged from 200' to 400' wide, and from 250' to 550' deep.

Block Configuration:
The block is the uninterrupted area of land bounded by streets. Block sizes and configurations can also affect GRD (cf. Flachsbart,

1979). There is obviously a close relationship between dwelling form and lot size, site layout, and block size and configuration. In terms of architectural design, block size and configuration are usually given. However, in development and site planning and urban design the block, as a result of the layout of streets and the disposition of buildings, is also a variable under the designer's control.

In this analysis, block sizes and configurations were systematically varied. Variations consisted of permutations of block sizes and three "block variables". The "block variable" represents the combination of the disposition of the surrounding streets and of the building masses in the block. In "parallel" blocks the block is a simple rectangle and the buildings are massed parallel to its long or short sides. In the "perimeter" block the building masses follow the perimeter of the rectangular block. The "penetrating" block diverges from the simple rectangles of the two former types, and includes "dead end" streets (often serving parking areas) penetrating the block.

Block sizes were the result of the interaction between the disposition of dwelling types and the "block variables". For single family detached dwellings block sizes ranged through a minimum of 360'x 250' to a maximum of 700'x 400'. Row housing occupied blocks ranging from 380'x 120' to 440'x 480'. Garden apartment blocks ranged from 210'x 400' to 440'x 800', while high rise apartment housing blocks ranged from 225'x 250' to 400'x 460'. Since the block area provides the denominator for the density measures, the variation in block sizes does not affect the analysis' results, and is simply included as a design factor.

Density Measures:
The dependent variables in this analysis are the density measures which we defined and reviewed above: NDD and GRD. Neighborhood Density and City Density are beyond the scope of this analysis, related as they are to the two former by another factor: the allocation of land for nonresidential neighborhood and citywide uses. In addition to NDD and GDD two other measures are computed for each of the schemes generated by the combinations of the variables described above. They are the Coverage and the Floor Area Ratio (FAR).

Method

Ninety nine schemes were developed combining the variables described above. Designs for the schemes reflect accepted or standard configurations and requirements of access, space between buildings, parking requirements etc. They are analytical

"ideal types", so they do not aspire to architectural or design excellence, originality, diversity or stimulation. Obviously real-world designs will differ from these schematic layouts; the similarities and differences are explored later (see Chapter 4).

These schemes are shown in Appendix A. There are 24 variations of single family detached housing, 28 schemes of row housing, 37 garden apartment layouts, and 10 arrangements of high-rise multifamily housing. Table 3-1 presents a summary description of all these variations.

The information yielded by these schemes was the subject of two kinds of analysis. First, we are interested in the relation between dwelling forms and density measures. Since dwelling forms are nominal categories, this is not a relationship that is suited to statistical analysis. A simple array of the observed densities by dwelling form and subtype is sufficient to display whatever relationship may exist. This is shown in Figure 3-2.

Second, any relationships between any of the above variables, and the density measures related to the schemes resulting from their combination, would be of interest. Parametric statistical analysis

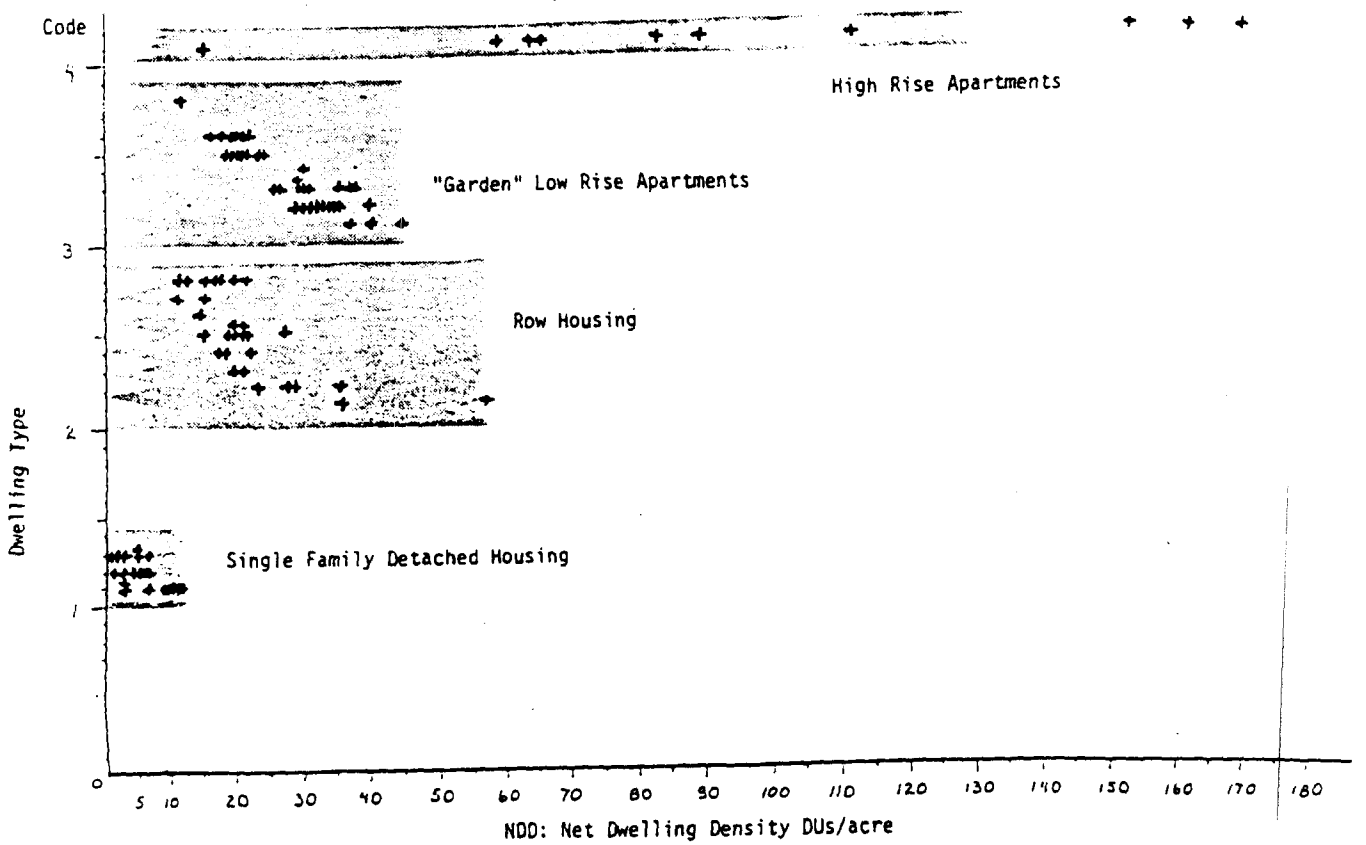


Figure 3-2: Distribution of NDD by Dwelling Types.

Code	Lot size 1	Lot size 2	Lot size 3	Block size	Block area	GRA acres	NDD	GRD	Cover (net)	FAR
1111	20 @ 36'x 125'			250' x 360'	2.10	2.70	9.700	7.400	0.27	0.27
1112	14 @ 50' x 100'	4 @ 62.5'x 100'		200' x 475'	2.20	2.80	8.300	6.300	0.23	0.23
1112	12 @ 66.7x 175'			350' x 400'	3.20	3.90	3.750	3.100	0.10	0.10
1121	4 @ 54' x 100'	8 @ 36' x 100'	8 @ 36' x 126'	252' x 364'	2.000	2.600	10.10	7.80	0.28	0.28
1122	10@ 70' x 150'	2 @ 100' x 175'		350' x 400'	3.200	3.900	3.750	3.100	0.100	0.100
1123	8 @ 50' x 100'	8 @ 50'x 137.5		200' x 475'	2.200	2.800	7.300	5.600	0.200	0.200
1131	40' x 90' (typ)			420' x 420'	3.600	4.400	10.60	8.700	0.300	0.300
1131	26 @ 50' x 90'			350' x 400'	2.850	3.900	9.100	6.600	0.250	0.250
1131/3	22 @ 40' x 100'	8 @ 53' x 100'	2 @ 40' x 87'	440' x 350'	3.500	4.300	9.000	7.400	0.250	0.250
1212/3	6 @ 133'x 175'			350' x 400'	3.200	3.900	1.900	1.500	0.060	0.080
1212/3	12 @ 60'x 125'			250' x 360'	2.100	2.700	5.800	4.400	0.180	0.180
1213	14 @ 70' x 100'			200' x 490'	2.250	2.900	6.200	4.800	0.190	0.280
1222	6 @ 83.3'x 95'	4 @ 80' x 125'		250' x 350'	2.000	2.600	5.000	3.850	0.150	0.250
1223	8 @ 70' x 100'	6 @ 66.7'x97.5		200' x 475'	2.200	2.800	6.400	4.900	0.200	0.290
1223	8 @ 87.5'x 150'	2 @100'x 175'		350' x 400'	3.200	3.900	3.125	2.500	0.090	0.140
1233	20 @ 70' x 115'(typ)			520' x 350'	3.800	4.800	5.200	4.200	0.170	0.300
1312/3	6 @ 130'x 350'			700' x 400'	6.400	0.000	1.000	1.000	0.020	0.040
1313	12 @ 55' x 125'			250' x 330'	1.900	2.500	6.400	4.900	0.150	0.300
1313	12 @ 79.2x 100'			200' x 475'	2.200	2.800	5.500	4.200	0.130	0.260
1321	8 @ 60' x 100'	6 @ 55' x 120'		240' x 365'	2.000	2.600	7.000	5.400	0.160	0.320
1321/3	6@ 75' x 100'	6@ 66.7'x 125'		200' x 475'	2.200	2.800	5.500	4.200	0.130	0.260
1323	6@ 116.7 x 150'	2@ 100' x 175'		350' x 400'	3.200	3.900	2.500	2.000	0.060	0.110
1331/3	6 @ 70' x 90'	22@ 45' x 90'(typ)		420' x 530'	4.700	6.000	6.400	5.000	0.150	0.300
1333	16@ 87.5'x 115'			520' x 350'	3.800	4.800	4.200	3.300	0.100	0.190
2112	56 @ 12' x 60'	4 @ 21' x 60'		120' x 380'	1.100	1.500	57.10	39.00	0.470	1.400
2123	66 @ 12' x 70'	4 @ 32' x 70'		220' x 380'	1.900	2.500	36.50	28.00	0.300	0.900
2212	34 @ 18' x 60'	4 @ 28' x 60'		120' x 380'	1.100	1.500	36.20	25.30	0.330	0.660
2222	46 @ 18' x 60'	4 @ 38' x 60'		256' x 354'	2.100	2.700	24.00	18.70	0.220	0.440
2232	76 @ 18' x 60'	4 @ 38' x 60'		300' x 400'	2.750	3.400	29.10	23.30	0.260	0.520
2233	86 @ 18' x 80'	6 @ 28' x 80'	2 @ 28' x 80'	380' x 470'	3.400	4.200	27.90	22.40	0.250	0.500
2313	46 @ 18' x 100'	4 @ 38' x 100'		200' x 490'	2.250	2.900	22.20	17.10	0.280	0.560
2322	46 @ 18' x 110'	4 @ 38' x 110'		220' x 490'	2.500	3.200	20.20	15.80	0.250	0.500
2412	40 @ 18' x 120'	4 @ 43' x 120'		240' x 446'	2.500	3.100	17.90	14.10	0.300	0.600
2423	48 @ 18' x 120'	4 @ 39' x 120'		240' x 510'	2.800	3.500	18.50	14.70	0.310	0.620
2432	88 @ 18' x 90'	10 @ 38' x 90'	2 @ 28' x 90'	455' x 490'	4.300	6.000	23.00	16.70	0.380	0.760
2512	36 @ 20' x 75'	4 @ 30' x 75'		150' x 420'	1.450	2.000	27.60	20.00	0.380	0.760
2512	42 @ 20' x 100'	4 @ 30' x 100'		200' x 480'	2.200	2.900	20.90	16.00	0.312	0.625
2522	38 @ 20' x 80'	4 @ 30' x 80'		240' x 360'	1.900	2.600	21.20	16.30	0.290	0.580
2522	42 @ 20' x 100'	4 @ 30' x 100'		200' x 480'	2.200	2.870	20.90	16.00	0.290	0.580
2522	48 @ 20' x 100'	4 @ 30' x 100'		360' x 400'	3.300	4.000	15.80	12.90	0.220	0.440
2532	38 @ 20' x 75'	4 @ 30' x 75'		250' x 340'	1.950	2.500	21.50	16.60	0.300	0.600
2532	60 @ 20' x 80'	8 @ 40' x 80'		380' x 400'	3.490	4.200	19.50	16.00	0.270	0.540
2532	78 @ 20' x 90'	10 @ 30' x 90'		440' x 480'	3.900	5.700	22.40	15.40	0.310	0.620
2612	30 @ 20' x 125'	4 @ 40' x 125'		250' x 380'	2.200	2.800	15.60	12.10	0.290	0.580
2723	38 @ 25' x 100'	4 @ 35' x 100'		370' x 395'	3.400	4.100	12.50	10.30	0.220	0.440
2732	22 @ 25' x 80'	10 @ 25' x 93'	4 @ 35' x 80'	285' x 345'	2.300	2.900	15.90	12.50	0.270	0.540
2812	24 @ 25' x 75'	4 @ 35' x 75'		150' x 360'	1.200	1.700	22.60	16.10	0.470	0.940
2812	24 @ 25' x 125'	4 @ 35' x 125'		250' x 370'	2.100	2.700	13.20	10.30	0.270	0.540
2813	32 @ 25' x 100'	4 @ 35' x 100'		200' x 460'	2.100	2.750	17.10	13.10	0.290	0.580
2822	34 @ 25' x 85"	4 @ 35' x 85'		170' x 485'	1.900	2.500	20.10	15.00	0.410	0.820
2823	24 @ 25' x 110'	4 @ 35' x 110'		220' x 350'	1.800	2.300	15.80	12.10	0.330	0.660
2833	64 @ 25' x 90'	8 @ 35' x 90'		450' x 470'	4.100	5.700	17.40	12.50	0.360	0.720

Table 3-1: Density Layout Schemes.

Code	Lot size 1	Lot size 2	Lot size 3	Block size	Block area	GRA acres	NDD	GRD	Cover (net)	FAR
3115				385' x 400'	3.500	4.300	40.70	33.60	0.250	0.750
3125				390' x 530'	4.750	5.600	45.50	38.40	0.280	0.840
3135				240' x 580'	3.200	4.000	37.50	30.10	0.210	0.620
3215				325' x 500'	3.400	4.200	35.00	28.60	0.340	1.020
3222				310' x 460'	3.300	4.020	33.00	26.90	0.320	0.950
3223				440' x 800'	5.250	6.200	32.00	27.20	0.450	1.350
3226				380' x 460'	4.000	4.800	35.90	29.90	0.340	1.030
3226				380' x 410'	3.600	4.300	40.20	33.20	0.350	1.040
3233				290' x 550'	3.700	4.500	29.50	24.20	0.280	0.840
3234				290' x 570'	3.800	4.600	34.80	28.60	0.330	1.000
3236				300' x 460'	3.200	3.900	30.30	24.60	0.300	0.890
3236				340' x 460'	3.600	4.400	33.40	27.50	0.290	0.870
3311				350' x 400'	3.200	3.900	30.00	28.00	0.320	0.960
3314				210' x 400'	1.930	2.500	37.30	28.50	0.310	0.940
3315				330" x 440'	3.300	4.100	36.00	29.40	0.300	0.900
3321				300' x 400'	2.750	3.400	26.20	21.00	0.240	0.720
3324				270' x 450'	2.800	3.500	30.10	24.10	0.250	0.760
3325				530' x 570'	4.300	5.200	38.90	32.40	0.330	0.990
3334				350' x 500'	4.000	4.800	26.90	22.50	0.230	0.680
3335				240' x 500'	2.750	3.500	30.50	24.20	0.280	0.840
3335				280' x 560'	3.600	4.400	30.00	24.50	0.250	0.750
3335				300' x 460'	3.200	3.900	30.30	24.60	0.300	0.890
3412				250' x 370'	2.100	2.700	31.10	24.20	0.360	1.100
3513				285' x 300'	1.900	2.500	24.50	18.90	0.360	1.100
3522				300' x 440'	3.100	3.750	23.80	19.20	0.320	0.950
3523				450' x 450'	4.700	5.500	20.70	17.50	0.310	0.930
3526				430' x 440'	4.300	5.200	22.10	18.50	0.300	0.910
3533				320' x 450'	3.300	4.100	21.80	17.80	0.250	0.750
3534				375' x 510'	4.400	5.200	20.50	17.20	0.270	0.820
3536				440' x 500'	5.100	5.950	19.00	16.10	0.270	0.810
3611				380' x 390'	3.400	4.200	21.00	17.35	0.280	0.840
3614				250' x 460'	2.600	3.300	22.70	18.00	0.350	1.040
3614				300' x 480'	3.300	4.100	21.75	17.70	0.275	0.825
3621				370' x 500'	4.250	5.100	16.90	14.20	0.230	0.680
3624				320' x 530'	3.900	4.700	21.60	17.80	0.270	0.810
3634				410' x 580'	5.500	6.400	19.80	16.88	0.250	0.750
3635				300' x 650'	4.500	5.400	18.75	15.60	0.250	0.750
4122				200' x 230'	1.600	1.500	113.0	80.00	0.210	2.470
4222				250' x 150'	0.860	1.130	58.00	44.00	0.200	2.080
4321				340' x 340'	2.700	3.300	59.30	48.50	0.120	1.250
4323				225' x 250'	1.290	1.760	163.0	119.0	0.420	2.990
4334				250' x 400'	2.300	2.900	83.50	66.20	0.250	1.430
4413				290' x 400'	2.700	3.300	154.0	126.0	0.120	3.230
4424				350' x 375'	3.010	3.700	65.80	53.50	0.250	1.310
4521				400' x 460'	4.200	5.100	171.0	141.0	0.120	3.640
4621				225' x 325'	0.510	1.670	90.00	36.00	0.300	4.600
4713				280' x 350'	2.250	2.900	64.00	49.70	0.150	1.760

Table 3-1: (continued)

was used to seek relationships between variables that could be expressed in quantitative data. On the assumption that the dwelling form as a nominal variable might introduce spurious relationships or confuse relationships that might exist, all the analyses were either done or repeated with observations (the 99 schemes) sorted by dwelling form.

Two kinds of analysis were done. A set of simple regressions analyzed the relationship of each variable with NDD and GRD as the dependent variables. Four sets of partial correlations (each set for a different dwelling form) analyzed the association between NDD and GRD and selected variables, controlling for several other factors at the same time. Table 3-2 describes all these analyses.

Findings

Density Measures and Dwelling Form:
Review of the array of densities produced by the 99 schemes which make up our "observations" offers a mixture of support for and contradiction of the proposition that densities are highly associated with dwelling forms or housing types. Figure 3-2 shows these observations, which are, of course, only intermediate points of the complete set of observations which we would see if all possible combinations of the variables had been explored.

The densities generated by the schemes developed here are highly suggestive at their upper limits. At their lower limits, of course, they simply represent a deliberate cutoff in terms of reasonable design configurations. However, other schemes could be developed that could produce densities arbitrarily as low as desired. Thus the range of densities for each dwelling form is intrinsically open-ended towards the low end of the scale, but is limited upwards by constraints involving the nature of the dwelling form and its possible configurations, design, access and space requirements, and parking needs. Development of the schemes used here has fulfilled its purpose in showing how these factors, when incorporated into realistic layout designs, affect residential densities and limit the densities at which development of various dwelling forms is possible.

Figure 3-2 offers some confirmation of popular wisdom, and some surprizes. Accepted stereotypes are supported by the finding that conventional single family detached housing is subject to a clear maximum density limit: this is around 12 units per acre (naturally, this can be exceeded by "unconventional" development such as "carpet" layouts with enclosed patios or "zero-lot-line" development).

Simple Regressions

Variables	Adj.r^2	Sign.F	B (slope)	B const. (Y inter.)	B 95% Conf. Interval
ALL SCHEMES:					
NDD-GRD	0.77	0.0000	1.17	3.88	1.04-1.30
NDD-LOTAREA	0.12*	0.0003	*see Figure 3-2A		
NDD-FAR	0.81	0.0000	45.28	-5.35	40.85-49.71
GRD-FAR	0.77	0.0000	33.19	-3.81	29.58-36.81
SINGLE FAMILY DETACHED HOUSING ONLY:					
NDD-GRD	0.99	0.0000	1.29	-0.06	1.24-1.35
NDD-LOTAREA	0.56*	0.0000	*see Figure 3-2B		
NDD-NCOVER	0.95	0.0000	34.00	0.43	30.69-37-37
NDD-FAR	0.54	0.0000	23.60	0.79	14.40-32.80
GRD-LOTAREA	0.53	0.0000	(like Figure 3-2B)		
GRD-GCOVER	0.94	0.0000	34.11	0.26	30.27-37.95
GRD-FAR	0.52	0.0000	17.84	0.75	30.27-37.95
ROW HOUSING ONLY:					
NDD-GRD	0.98	0.0000	1.47	-2.43	1.38-1.55
NDD-LOTAREA	0.65	0.0000	-0.13	46.00	-0.16-9.05
NDD-FAR	0.53	0.0000	33.82	0.82	21.33-46.30
GRD-LOTAREA	0.71	0.0000	-0.001	33.58	-0.011- -0.006
GRD-FAR	0.45	0.0001	20.85	4.50	11.61-30.09
GARDEN APARTMENTS ONLY:					
NDD-GRD	0.69	0.0000	1.11	8.90	0.87-1.30
NDD-FAR	0.75	0.0000	46.58	-6.73	38.61-54.55
NDD-PKRQD	0.29	0.0001	-0.00094	0.0021	-0.0014- -0.00051
NDD-UNITSIZE	0.32	0.0000	-0.06	122.50	-0.39-0.577
GRD-FAR	0.71	0.0000	34.70	-5.74	28.17-41.22
GRD-UNISIZE	0.19	0.0013	-0.04	79.74	-0.07- -0.45
HIGH-RISE APARTMENTS ONLY:					
NDD-GRD	0.51	0.0124	0.74	52.49	0.21-1.27
NDD-FAR	0.72	0.0011	35.14	34.41	18.82-51.45

Partial Correlations (by Dwelling Types) for the following variables:

NDD on NRASQFT/UNITSIZE	GRD on GRASQFT/UNITSIZE
NDD on LOTAREA/NRASQFT	GRD on LOTAREA/GRASQFT
NDD on LOTAREA/UNITSIZE	GRD on LOTAREA/UNITSIZE
NDD on LOTAREA/FAR	GRD on LOTAREA/FAR
NDD on UNITSIZE/NRASQFT	GRD on UNITSIZE/GRASQFT
NDD on UNITSIZE/NCOVER	GRD on UNITSIZE/GCOVER
NDD on UNITSIZE/FAR	GRD on UNITSIZE/FAR
NDD on NCOVER/LOTAREA	GRD on GCOVER/LOTAREA
NDD on NCOVER/FAR	GRD on GCOVER/FAR
NDD on FAR/LOTAREA	GRD on FAR/LOTAREA

Key: NDD = Net Dwelling Density (DUs/Net Residential Area)
GRD = Gross Residential Density (DUs/Gross Residential Area)
NRASQFT = Net Residential Area in Sq. Feet
GRASQFT = Gross Residential Area in Sq. Feet
LOTAREA = Area of Lot in Sq. Feet
UNITSIZE = Total Floor Area of Dwelling Unit in Sq. Ft.
FAR = Floor Area Ratio (Tot. Built Floor Area/Net Res. Area)
NCOVER = Net Coverage (Ground Floor Area/Net Res. Area - %)

Table 3-2: Analysis of Density Related Variables.

Row housing offers a range of densities that may be surprizing: the upper limit is around 57 units per acre. This is higher than the limit we found for garden apartments. Contrary to prevailing images, perhaps, these two dwelling forms overlap over almost their entire range of densities: from about 13 units per acre at the low end to the 46 units per acre which is the upper limit for low rise multifamily housing.

The upper part of the range of residential densities, from 60 to 170 units per acre, is occupied exclusively by high rise multifamily housing. This finding again confirms the rules-of-thumb that prevail among architectural, urban design and planning practitioners. It supports the implication that for developments seeking average NDDs of 60 units per acre or higher, a mixture of housing types including a proportion of high-rise apartments will be required.

In summary, this analysis reveals a clear association of certain parts of the range of possible residential densities with specific dwelling forms. This association is not as exclusive, however, as often supposed. The bottom end of the range, up to 12 units per acre, is the domain of single family detached housing. The middle portion includes much higher NDDs than expected, and occupies the range from 13 to 59 units per acre. This area is associated with single family row housing and (up to 45 DUs per acre) low rise multifamily housing. High-rise multifamily housing monopolizes the upper part of the range, from 60 to 170 DUs per acre.

Relations Between Variables:
The variables included in this analysis are shown in Table 3-2 above. Several did not show any significant relationships. The ones of interest are the following (except where indicated, their significance always = 0.000).

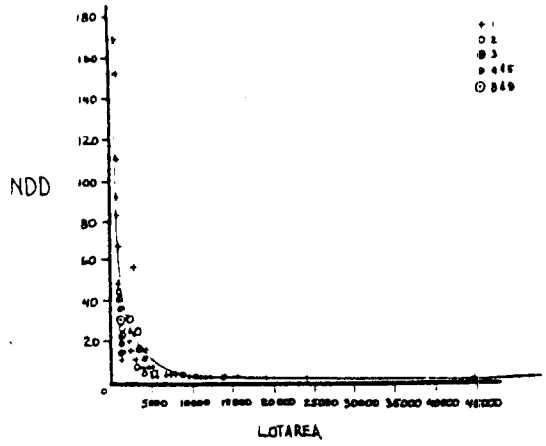
Net Dwelling Density (NDD) - Gross Residential Density (GRD).
The relationship between NDD and GRD revealed by the analysis was expected. A strong association exists throughout the entire range of cases (the overall adjusted r^2 = 0.77); the slope of the function is just over one (b = 1.17). Sorted by dwelling types, this relationship varies somewhat: it is strongest for single family housing (r^2 = 0.99) and gradually weakens for multifamily housing; for the highrise apartments it is much weaker (r^2 = 0.51; sig.F = 0.12). This change is also predictable: as the size of developments increases, the gap between NDD and GRD will grow.

Floor Area Ratio (FAR). Overall, there is a significant association between density (NDD and GRD) and FAR (adj. $r^2 = 0.81$); this is also expected. The slope of the linear regression ($b = 45.28$) suggests that each increase of 100% in FAR would produce a 45 DU/acre rise in NDD. However, this finding is somewhat of an oversimplification, a statistical artefact resulting from the large number of cases. When sorted by dwelling type, the relationship between density and FAR is much less consistent. It is weak for single family housing (adj. $r^2 = 0.54$); this could also be expected, since here there is much less variance in number of storeys. The results for row housing are similar. But it is stronger for multi-family housing (e.g. for NDD adj.$r^2 = 0.72$).

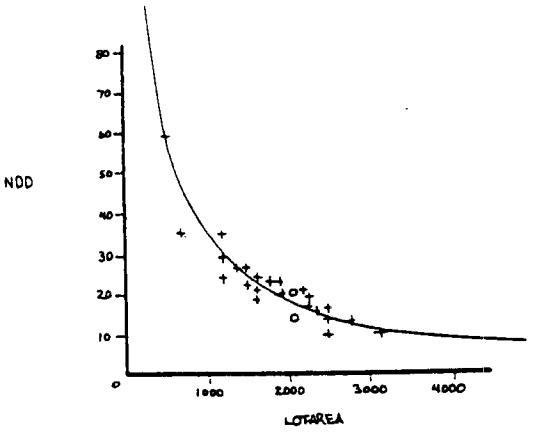
The partial correlation analysis confirms that FAR can be a significant factor, but with some qualifications. For single family detached housing, FAR is correlated with density (0.86) when controlling for unit size and for net or gross area of the block (0.73), but when controlled for coverage and lot area the association disappears. For row housing the relationship is strong, even when controlled for other variables (from 0.84 for FAR-GRD controlling for unit size, to 0.77 for FAR-NDD controlling for net coverage). For garden apartment housing, however, when controlled for other variables, the relationship between density and FAR disappears. It reappears strongly in high rise housing (this is not unexpected) where it is the only factor, indeed, to show any significant association with densities (with NDD: 0.91 controlling for block area, and 0.84 controlling for net coverage; with GRD: 0.81 controlling for gross residential land area, and 0.75 controlling for coverage).

We can conclude that there is an evident association between FAR and densities. Viewed in the aggregate, it could be expressed like our overall regression in a simple multiplier, confirming what is intuitively obvious: increases in FAR will produce higher densities. But in fact it is a more complex interaction which varies by dwelling type, and may be mediated by other factors.

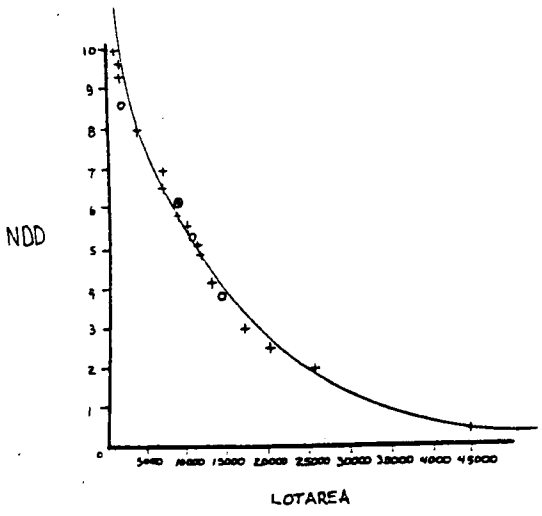
Coverage (net and gross). Regression analysis of all the cases shows no relationship between densities and coverage. This was a bit unexpected, but is explained when the cases are sorted by dwelling type. Single family detached housing does exhibit a strong relationship (adj. $r^2 = 0.95$); this is confirmed by the partial correlations, which are strong (0.94 to 0.97) even when controlled for other variables. For this type of housing the relationship between density and coverage can be expressed in a simple multiplyer: a 10% increase in coverage will add 3.4 DUs/acre to the NDD.



A: ALL DWELLING TYPES



B. SINGLE FAMILY DETACHED HOUSING



C. ROW HOUSING

Figure 3-3: Density-Lot Area Relationships.

This is clearly not a necessary arithmetical function. Rather, it seems to be the expression of a constant design relationship. This relationship is difficult to account for, since obvious possible connections to lot sizes or unit sizes are excluded by the results of the partial correlation analysis. In the other dwelling types multiple storeys reduce the effect of coverage on density to insignificance.

Lot Area. The relationship between densities and lot area is complex. The overall linear regression (for NDD: adj. $r^2=0.12$, sign.F = 0.0003) fails to express the strong relationship (see Fig. 3-3.A) which, as the separate analyses show, is mediated by dwelling types. The first dwelling type, single family detached housing, exhibits an exponential function (Fig. 3-3.B) which, as expected, indicates an inverse relationship between lot size and density (i.e as lot area increases, densities fall). A similar, though flatter and more diffuse, relationship appears for row housing (Fig. 3-3.C). The partial correlations confirm the relationship between densities and lot area, though it is weaker (-0.67, -0.73) when controlled for unit size and block area. For the multifamily housing, lot area drops out as a relevant variable.

Dwelling Unit Size. Since the sizes of dwelling units in the designed cases do not vary continuously, linear regression analysis fails to reveal any association between them and densities (the results for lot areas are similar, for the same reason). The partial correlations show a weak negative association, however, for single family detached housing, which is much stronger (-0.85 to -0.90) for row and multifamily housing, even when controlled for other variables. This suggests that larger dwelling units are associated with lower densities, confirming what we have intuitively known all along. It is only surprising that the association is stronger for multifamily than for single family housing, since the reverse would be expected.

Conclusions

The following conclusions emerge from the findings of the deductive analysis:

* Dwelling form is almost as important in relation to density measures and their effects on urban form as has generally been supposed. All variables affecting residential densities are mediated by dwelling form, and some dwelling forms are closely associated with specific ranges of net dwelling densities and gross residential densities (see below).

* The relationship between dwelling form and density measures is not completely determinate, but some dwelling types are associated with particular parts of the entire range of residential densities. Among the dwelling types included in this study, the following rellationships appear:

  - single family detached housing occupies the NDD range from less than one to 12 DU/acre;

  - row housing and low-rise garden apartments share the middle densities in the range, with maximum NDD of 59 DU/acre and 46 DU/acre respectively;

  - high rise apartment housing claims the high end of the range, from 60- 170 DU/acre.

* Several variables are associated with density, but in complex relationships which are not simple mathematical functions. Usually these associations are the result of design considerations reflected in site development schemes, and a complex interaction of site and dwelling unit related variables. Variables which are associated with NDD and GRD are:

  - floor area ratio (FAR), for which overall regression analysis shows a multiplyer of 45 DU/acre for each 100% increase in FAR; however, this relationship is less consistent when disaggregated by dwelling form.

  - coverage is significantly related to NDD and GRD for single family detached housing only; here the multiplyer is a 3.4 DU/acre increase in NDD for every 10% rise in coverage.

  - dwelling unit size and lot area are sometimes related to NDD and GRD in a complex and variable fashion; these associations are too inconsistent to be of much significance for practical purposes.

Chapter 4:
Inductive Analysis

Previous chapters have shown the many different measures of density and indicated a lack of common accord on what to call the various measures. This divergence is further aggravated by the difficulty in mentally conceptualizing the areal measure of the denominator in the density equation - the acre or hectare. Ask the question "how big is an acre?" or "how many acres is this particular plot of land?" and the answers are as numerous as the respondents.

The inductive section of this study sets out to present an array of visual images of various densities to help people to conceptualize the physical ramifications of specific densities within the range of one unit per acre to approximately 170 units per acre.

Each case study, set out in Appendix A, shows a housing pattern: a particular dwelling type organized on a site, conforming to a set of site dimensions and constraints. Each such pattern is il-

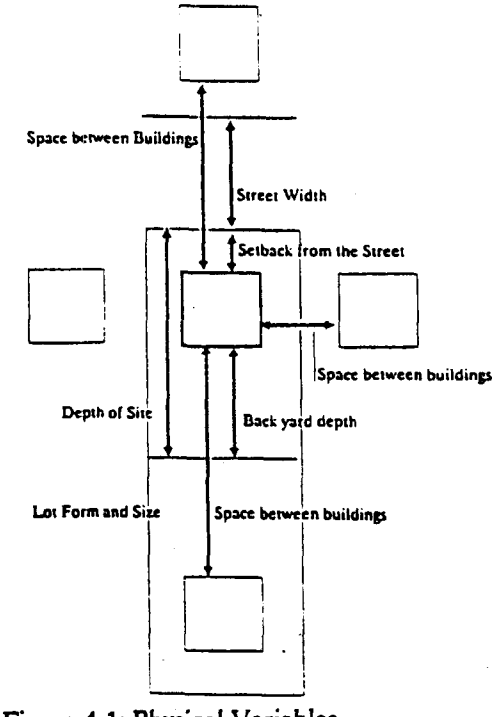


Figure 4-1: Physical Variables.

lustrated by plan and axonometric layouts of the abstracted conditions.

In putting these patterns together the complexity of the interplay of the many dimensional variables that affect housing density became quickly apparent. Some of these have been discussed in Chapter 3 and illustrated in Figure 3-1. (For convenience this Figure is repeated in Figure 4-1.)

The dimensional variables identified in Figure 4-1 represent design factors that can vary in a residential environment to produce a particular pattern of development and, in turn, have an impact on urban form. While some of these variables affect housing density, some do not and it is important to differentiate between these two categories, particularly with regard to their impact on the urban form. Table 4-1 shows these two categories.

Key Density Factors:	Other Critical Design Factors:
Dwelling Type	Access
Lot Size	Daylighting/Sunlighting
Block Variables	Privacy
Building Size	The Nature of the Street
	Orientation
	Relationship to Parking

Table 4-1: Critical Design Factors.

Dwelling type:
Within each of the four dwelling types used in this study are a number of variables that are typical to each type. These variables have their own particular set of demands on the site and on the arrangement of the units on the site and consequently affect the density of particular layouts in subtle ways. The variables used in this study are summarized below.

Single family detached housing.
The single family detached housing case studies illustrate a variety of floor plan characteristics. Clearly the number of variations in plan and organization are considerable. Within the scope of this study we have illustrated three single family detached house plans that typically appear in new housing developments:

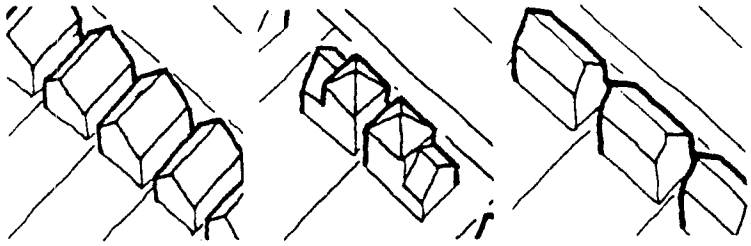


Figure 4-2: Single Family Detached Housing Types.

the one-level "bungalow", the "split level", and the two storey "colonial". (Figure 4-2)

The densities illustrated range from a low of one unit/acre (NDD) to a high of 10.6 units /acre (NDD). The low end of this scale, the one acre lot, represents typical suburban development in many parts of the country. Less prevalent but still obvious in many parts are densities lower than this but at anything less than one unit/acre the overall character of development has clearly switched from urban to rural - in fact this may also be true at one unit/acre. The upper end of the scale, about 10 units/acre represents the density found in more urban developments that employ single family housing. The overall environmental character at this density is now shaped by the relationships that exist between the housing units and each of the lot variables set out in Figure 4-1 becomes significant in determining that character.

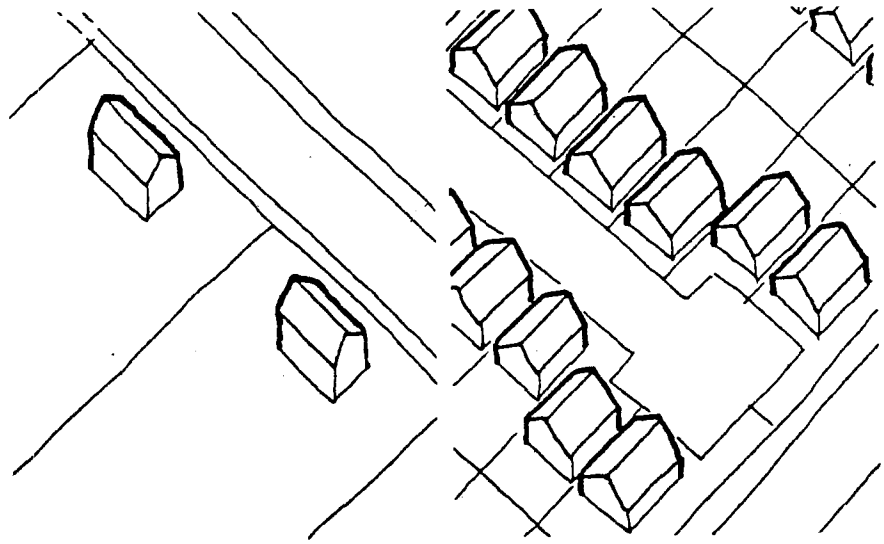


Figure 4-3: Single Family Detached Housing:The Density Range

Row Housing

The range of density within the row housing type is principally controlled by the width of the lot. We have chosen an extremely narrow lot by American standards of 12 feet as the narrowest lot and have increased this to 18 feet, 20 feet, and 25 feet. Two and three storey units are illustrated in a variety of configurations. (Figure 4-4)

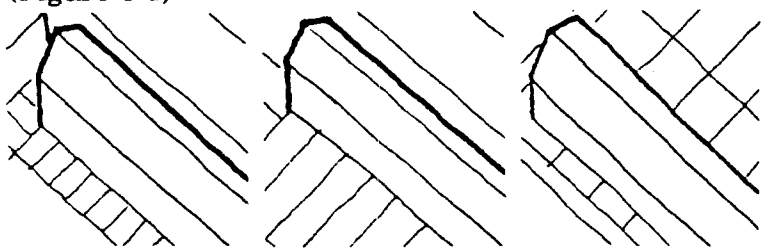


Figure 4-4: Row Housing Types.

Densities range from a low of 12.5 units/acre (NDD) to a high of 57 units/acre (NDD) (Figure 4-5). The character of the urban form can be more significantly manipulated and controlled at these higher densities and the consolidation of the individual dwelling unit into a large building unit adds to the control of the housing environment available to the designer. This is true for both the design of the private space within the block and the design of the public zone, the street side of the units. As is noted later the relationship between the housing unit and the parking arrangements becomes a critical element of the site design and the integration of landscape into the design can be a prime factor in determining the overall character of the housing environment. The case studies explore a number of alternative layouts that illustrate some of the many possible configurations.

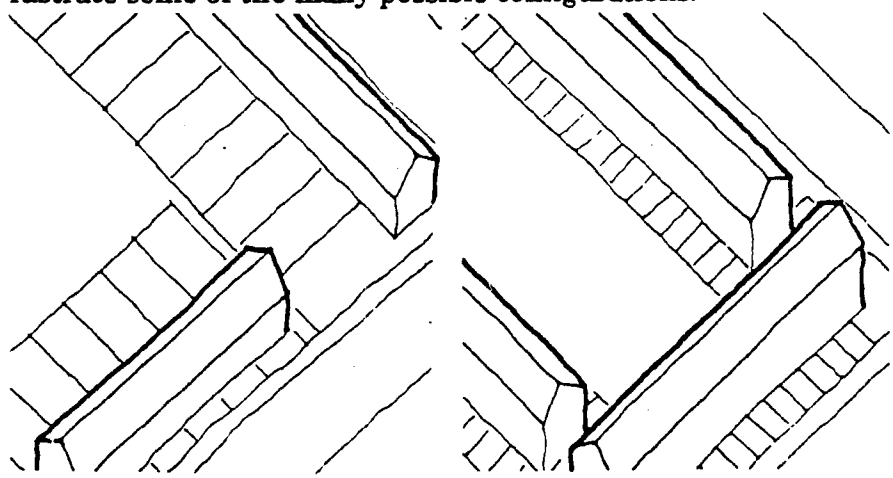


Figure 4-5: Row Housing: The Density Range.

Low-rise "Garden" Apartments.
With single family and row house dwelling units the key variable that affected density was the lot size. With garden apartments this is clearly not the case as the lot as an identifiable element has disappeared from the layout. Other site factors now take over as the significant lot variables with the dwelling type, the site organization, and the relationship to parking being among the most important. The dwelling types that we have represented are three and four storey buildings with double- and single- loaded corridor plan arrangements or with single or multiple cores (Figure 4-6).

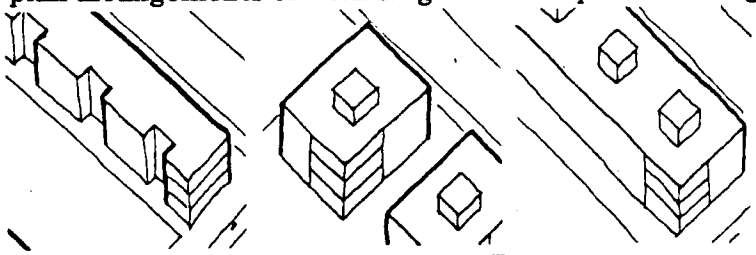


Figure 4-6: Low-rise "Garden" Apartments Types.

The density range illustrated is from a low of 12.6 units/acre (NDD) to a high of 45.5 units/ acre (NDD) (Figure 4-7). As with the row housing type, the character of the urban form can be manipulated and controlled at these higher densities to create both an "internal" private environment and an "external" public environment with both landscaping and parking playing key roles in determining the particular urban character of the urban environment. Discussed later is the issue of the orientation of the individual units within each building block which, while not affecting density, is often ignored in apartment layout.

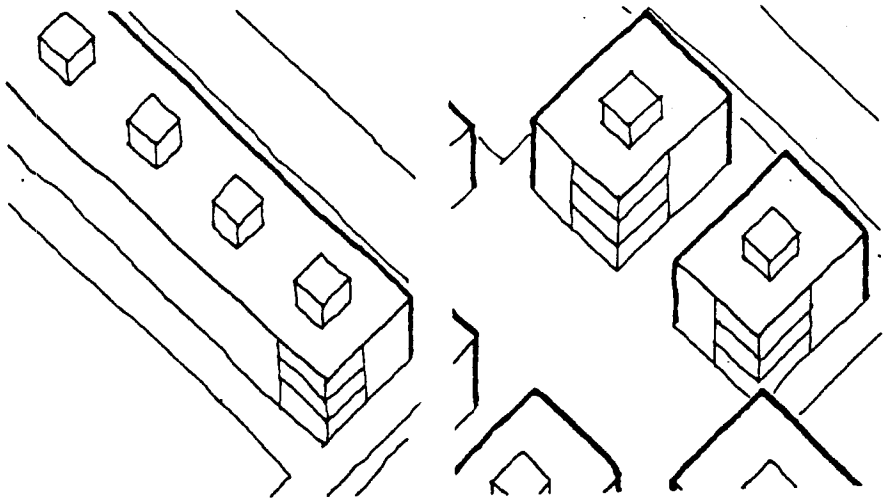


Figure 4-7: Low-rise "Garden" Apartments: The Density Range.

High-rise Apartments. As with the low-rise apartment dwelling types, the high-rise dwelling types that we have represented are buildings with double- and single- loaded corridor plan arrangements or with single or multiple cores. The height of the buildings range from 7 to 30 storeys. (Figure 4-8). Also included with this group are a number of schemes that combine both high-rise and low-rise buildings to create a variety of opportunities within the site. Problems of overlooking, referred to later in this chapter, take on a particular significance with this complex arrangement.

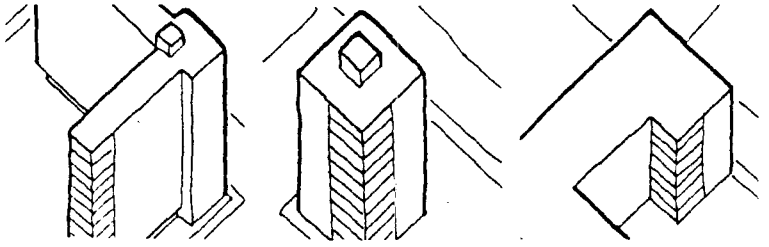


Figure 4-8: High-rise Apartment Types.

High-rise Apartments.

High-rise aparment developments are illustrated with a density range from as low as 15 units/acre (NDD) to a high of 171 units/acre (NDD) (Figure 4-9). At these high levels other design determinants become key factors with perhaps parking being the most significant one. Above about 150 units per acre and with the liberal requirement of one car parking space per unit, one acre of parking must be created. For high densities to be maintained this parking must be in a structured facility either above or below ground. Either way the parking and its access both to the street and to the dwelling unit become key factors in design.

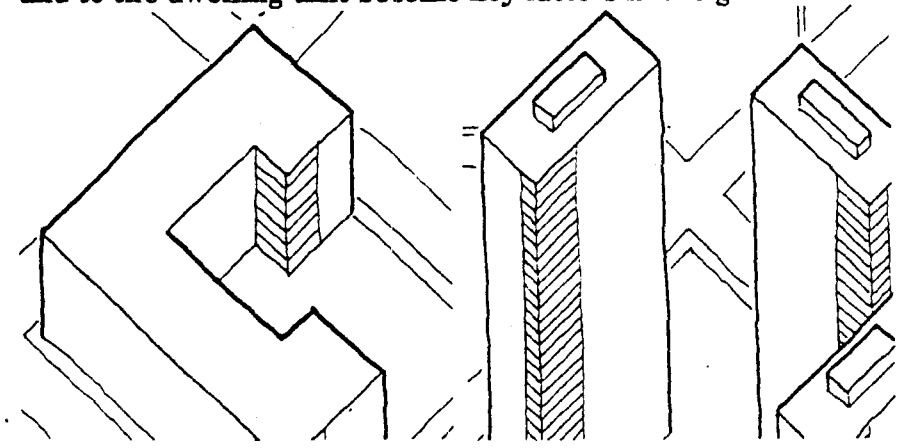


Figure 4-9: High-rise Apartments: The Density Range.

Lot Size:

The lots on which these buildings are sited can vary through a considerable range though the method of describing the unit in relation to the lot size changes with the type of unit. Clearly there is a direct relationship between the size of the lot and the number of units able to be accommodated in an acre. Yet, while the lot size is usually thought of in terms of area, it is equally important to understand the impact on urban form of the relationship between the site depth and the site width - short, wide lots are a very different proposition than long, narrow lots although they can produce the same density.

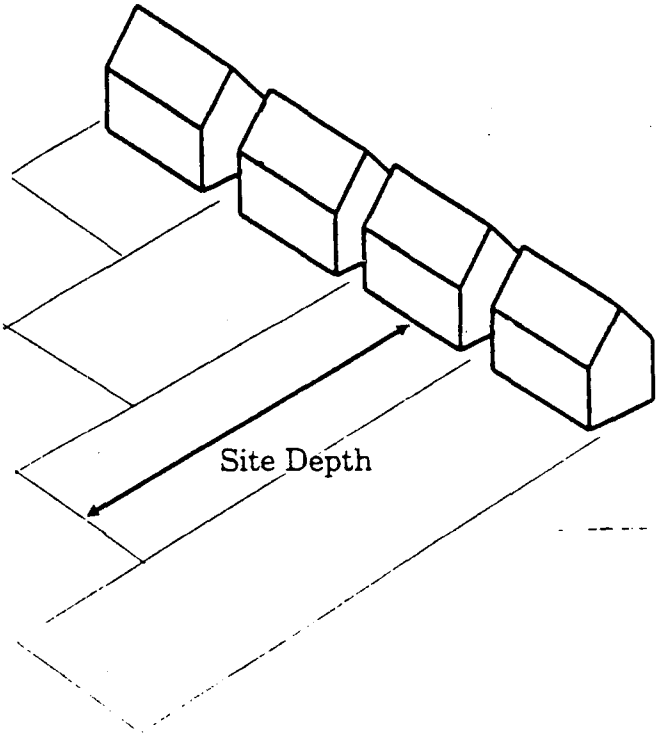


Figure 4-10: Lot Size.

Block variables:

All of the block diagrams are illustrated as if they were regular rectilinear blocks although this is not always true of the photographic illustrations that accompany the diagrams. This is an abstraction for calculation purposes and each of the patterns could be illustrated by a curvilinear pattern substituted for the rectilinear pattern. The road pattern also has a decisive effect on the development potential of the site determining the shape and

character of the individual plots, the easy of development, and, in concert with the contours of the site, the ease of building in relation to the road. Again the density measures would remain constant but the urban form would be different and in some cases the impact of the change would be considerable.

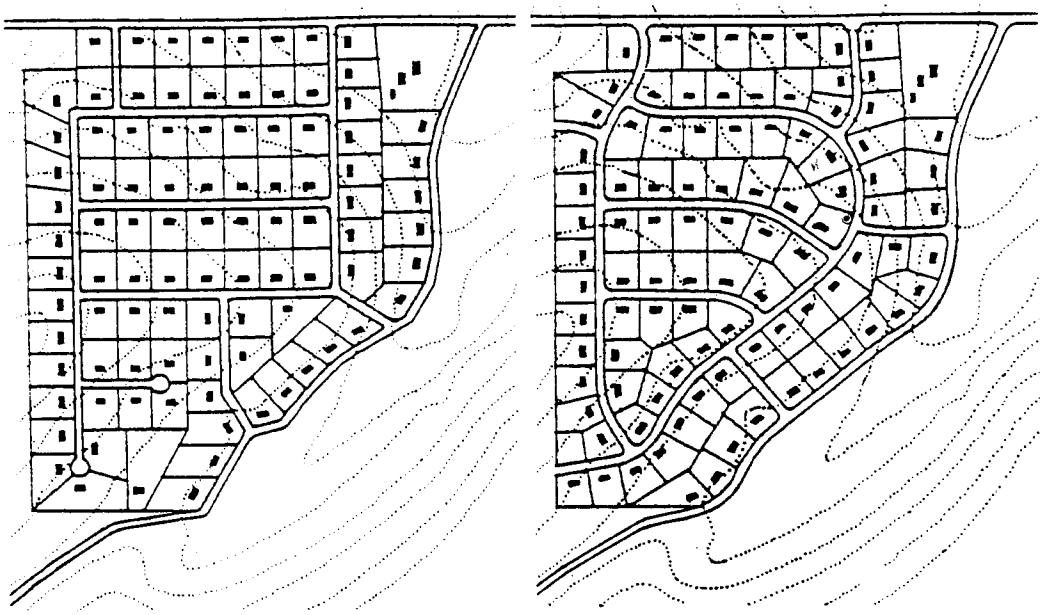


Figure 4-11: Block Variables (Tunnard, 1963).

Figure 4-11

Building size:

There is an assumed relationship between building size and the lot size. This is a natural assumption with minimum lot dimensions that add on front yard, side yard, and back yard requirements to the unit size to obtain the lot size. Here the relationship with density is direct.

Different attitudes to the site dimensions as they relate to the house size can produce considerably different urban form conditions without changing the density. This is perhaps best illustrated in relation to the front yard or setback dimension. A change of setback with the building dimension and the lot size remaining the same can produce a considerably different urban environment with no impact on the density measure.

The extension of this thinking can have an even greater impact on urban form. In a study carried out in England, the following sequence of logic is outlined - less set back requirement can result

in smaller lots which means more houses on the site (and hence a higher density) which, in turn, produces a greater return to the builder (Essex County Council, 1973). The use of this option then gives the planning authority greater leverage with the developer to demand higher standards of finishes and detailing in the urban realm. Clearly this kind of thinking produces a significant relationship between setback, density, and urban form.

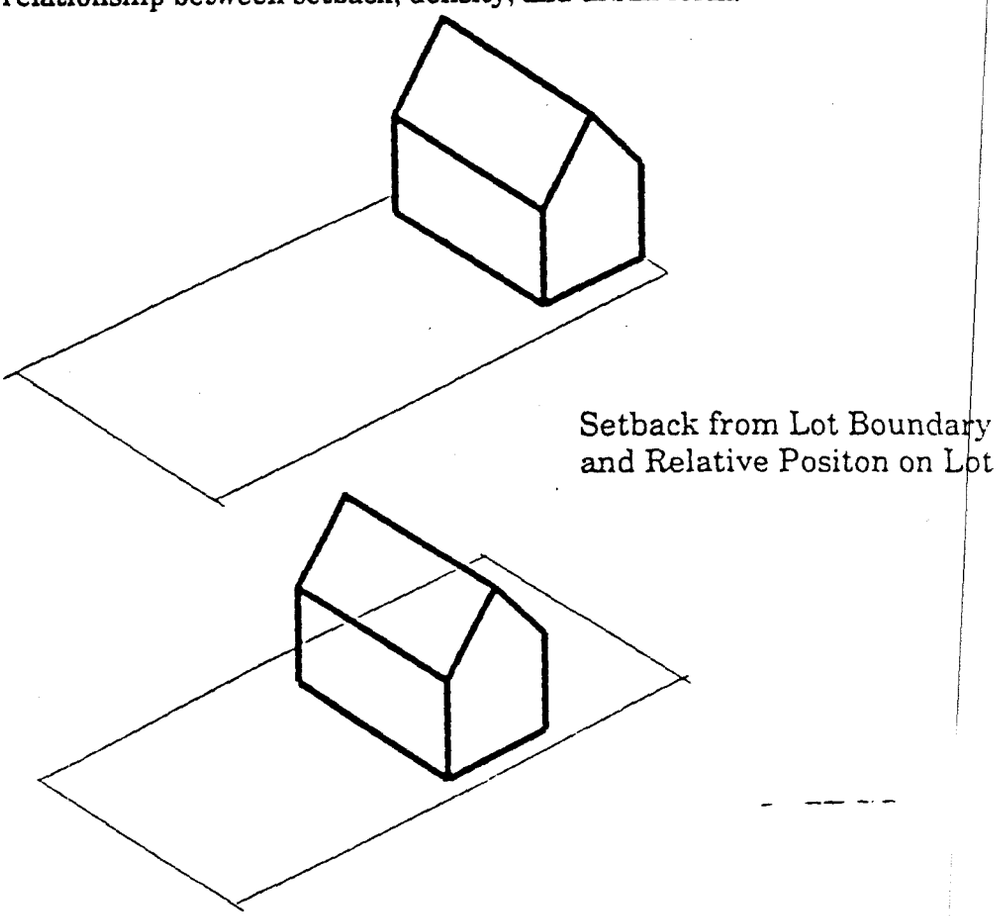


Figure 4:12: Variation in Setback from the Street.

Other urban form issues:

Other consideration of housing layout must include the needs for access, adequate daylighting and sunlighting, and privacy, both visual and auditory.

Housing design standards have tended to incorporate these requirements into two prime concerns that can be defined as: a) the problems of accessibility, and b) the problem of achieving a physically satisfactory environment for people within their own site.

These standards have proven to be particularly ineffective in shaping the urban form, particularly as they have affected the issues of privacy and of the nature of the street. In relation to these issues, any inter-relationship between density and urban form is a secondary consideration.

Privacy:

The private yard is an important use of the ground in a family housing site (Lynch and Hack, 1984). The responses to achieving privacy within the building lot can be categorized into three groups:

a). The enclosure within the building lot of part of the site to ensure privacy from the street. This can be achieved by the use of the building itself as a screen or be using other physical devices (fences, planting, etc.) to obtain privacy (Figure 4-13)

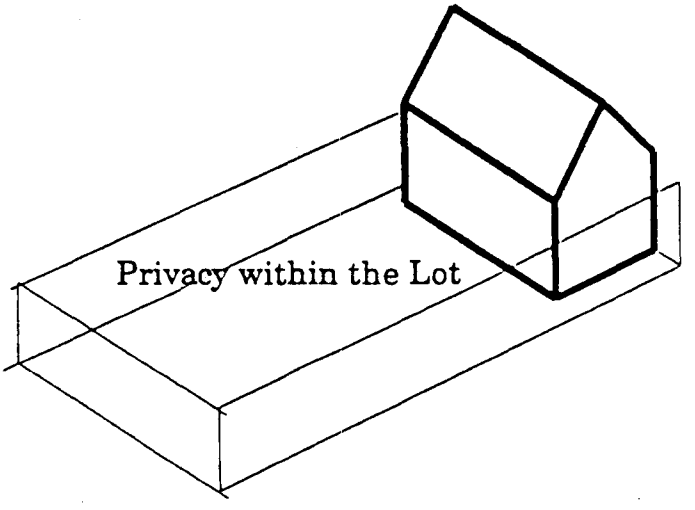


Figure 4-13: Privacy within the Building Lot.

b). A relationship between the organization and design of the housing unit and the public zone of the street to ensure privacy within the house. This can take several forms - increase the distance, organize the unit in a suitable way to avoid problems, or provide barriers. The logic of the same study referred to above is interesting in this regard. (Figure 4-14)

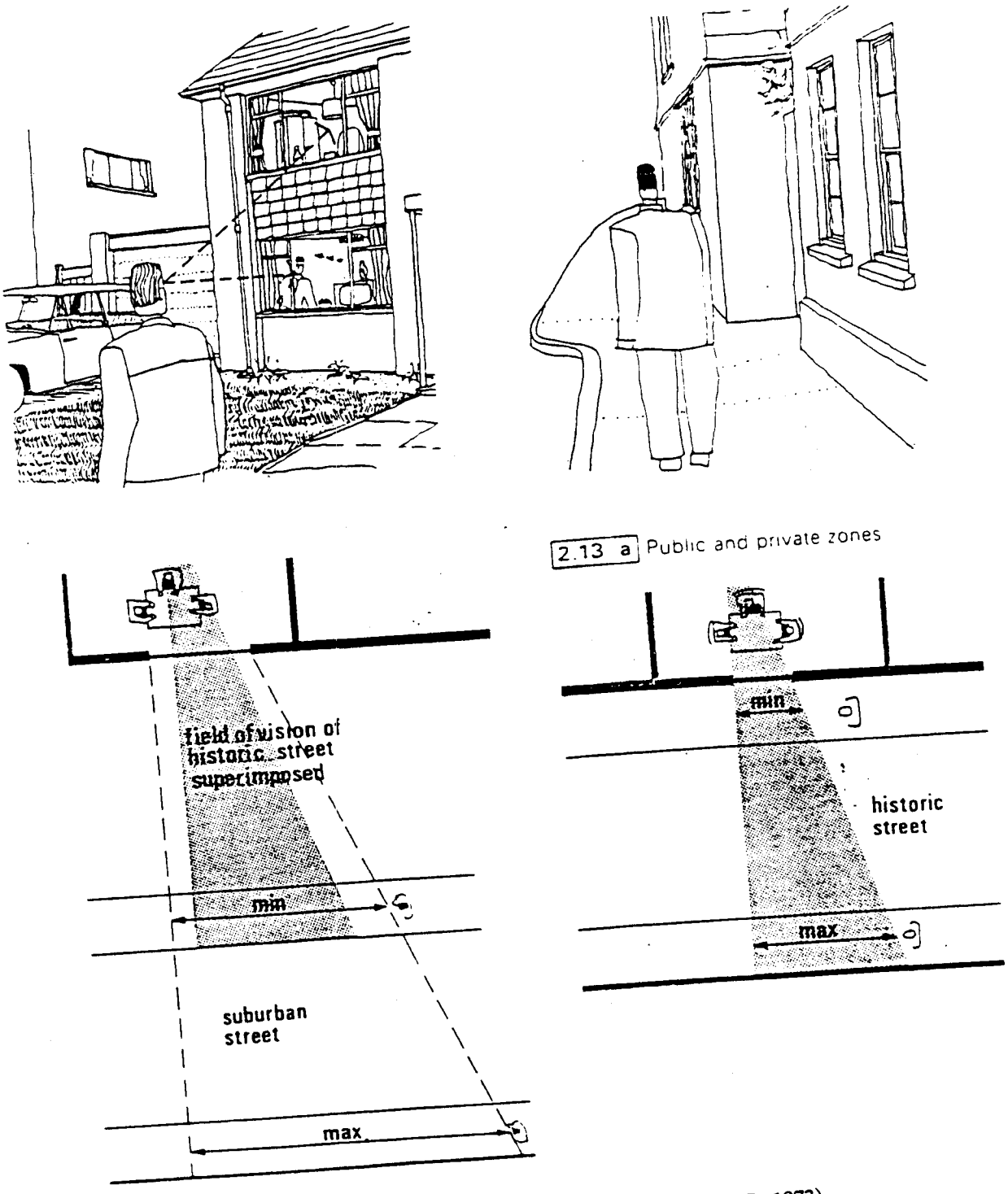
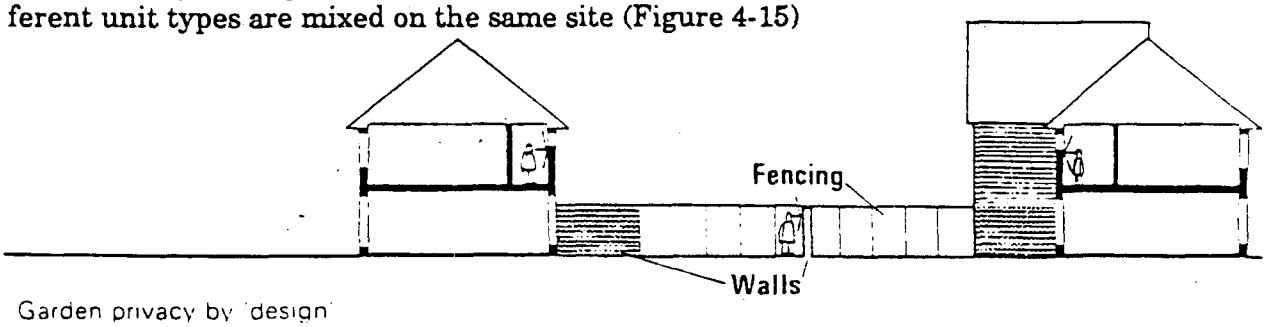


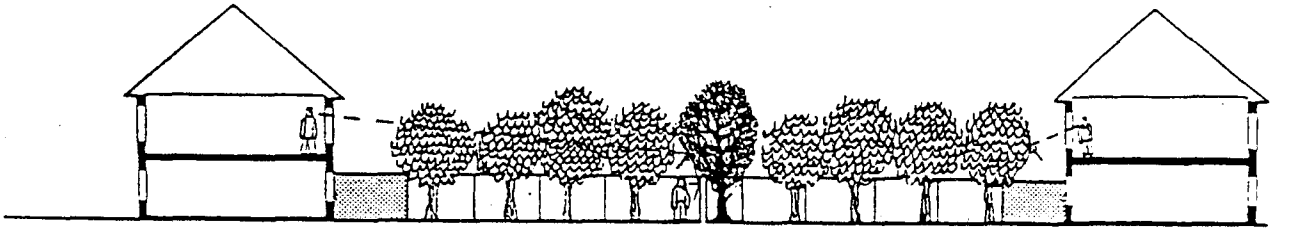
Figure 4-14: Privacy from the Street (Essex C.C., 1973).

c). Organization of the relationship between adjacent units, both back to back and side to side, to ensure a privacy from overlooking from neighboring units. This is particularly difficult when different unit types are mixed on the same site (Figure 4-15)



Garden privacy by 'design'

Overlooking from surrounding gardens and ground floor windows can be effectively prevented by above eye-level screens
Overlooking from upper floor windows, with conventional cill levels, will still occur unless the view from them is very oblique, they are sufficiently remote, or screened by buildings or trees. Fig 2 21b



Screen planting effectively blocks first floor overlooking

Private zone

Figure 4-15: Privacy from Overlooking (Essex C.C., 1973).

The Nature of the Street:

Of particular significance to the question of urban form is the relationship that exists between the housing units and the public zone - the street. The public street is a significant component of urban form - a community space under public control. At the lower density scale, the space between the units both along the street and across the street greatly affects the overall urban character and form of the residential neighborhood. Gordon Cullen's (1962) treatise of Townscape and Ian Nairn's (1964) critique of suburban layout have had little effect in bringing about a change to the urban form of housing developments. Most continue to perpetuate the barren prairie approach.

At higher densities, buildings are often designed as object buildings with little consideration for the design of the space between buildings, the relationship that determines the quality of the urban form. Parking and access needs further complicate the problem at the higher density scale and poor relationships between parking areas and buildings contribute to the further reduction of the quality of the urban environment.

The relationships that shape the street, the proportions that are achieved, and the resulting sense of enclosure or openness are critical components of urban form (Figure 4-16). Consideration of the nature of the street obviously affect, or are affected by, density concerns but at a secondary level. The two factors are seldom considered together.

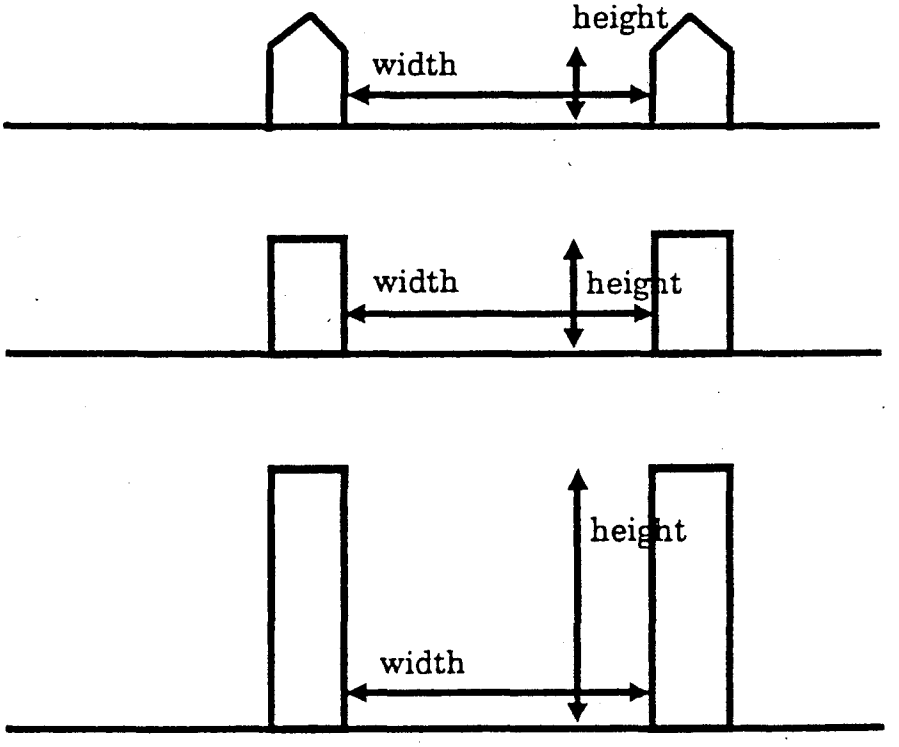


Figure 4-16: Street Proportions.

Orientation:

Two further issues need to be touched upon. The patterns illustrated in Appendix A do not include any consideration of orientation. As is often true with built projects, individual housing units are freely rotated through 360 degrees with little regard to the energy or lighting needs of the unit. Similarly, individual

units in the multi-unit complexes are simply related to the outside wall with no regard to orientation. Orientation is more of a problem as density increases and units have fewer open sides. Conventional wisdom is that the best orientation for double-loaded corridor buildings is with the corridor oriented north/south to afford east or west facing apartments - but examples that pay little heed to such guidelines are numerous, and the virtue of west facing units that potentially suffer from heat and glare still remains an open question (Figure 4-17)

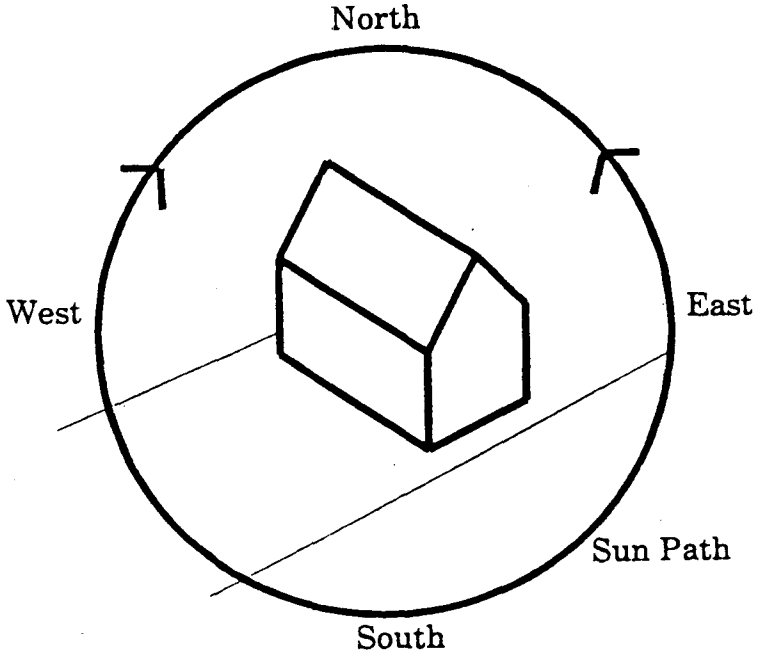


Figure 4-17: Orientation Considerations.

Orientation per se has little effect on density. Consideration of housing layout and urban form that responds to orientation as a critical issue will have an affect on density.

Parking

The final issue that needs to be discussed concerns the issue of parking and the relationship that exists between parking and the housing unit (Figure 4-19).

At low densities this is not generally considered a problem with the access provided to a point immediately adjacent to the house. At higher densities such an arrangement is not so feasible and alternative organizational arrangements have to be made. Choices must be made between surface parking, underground parking,

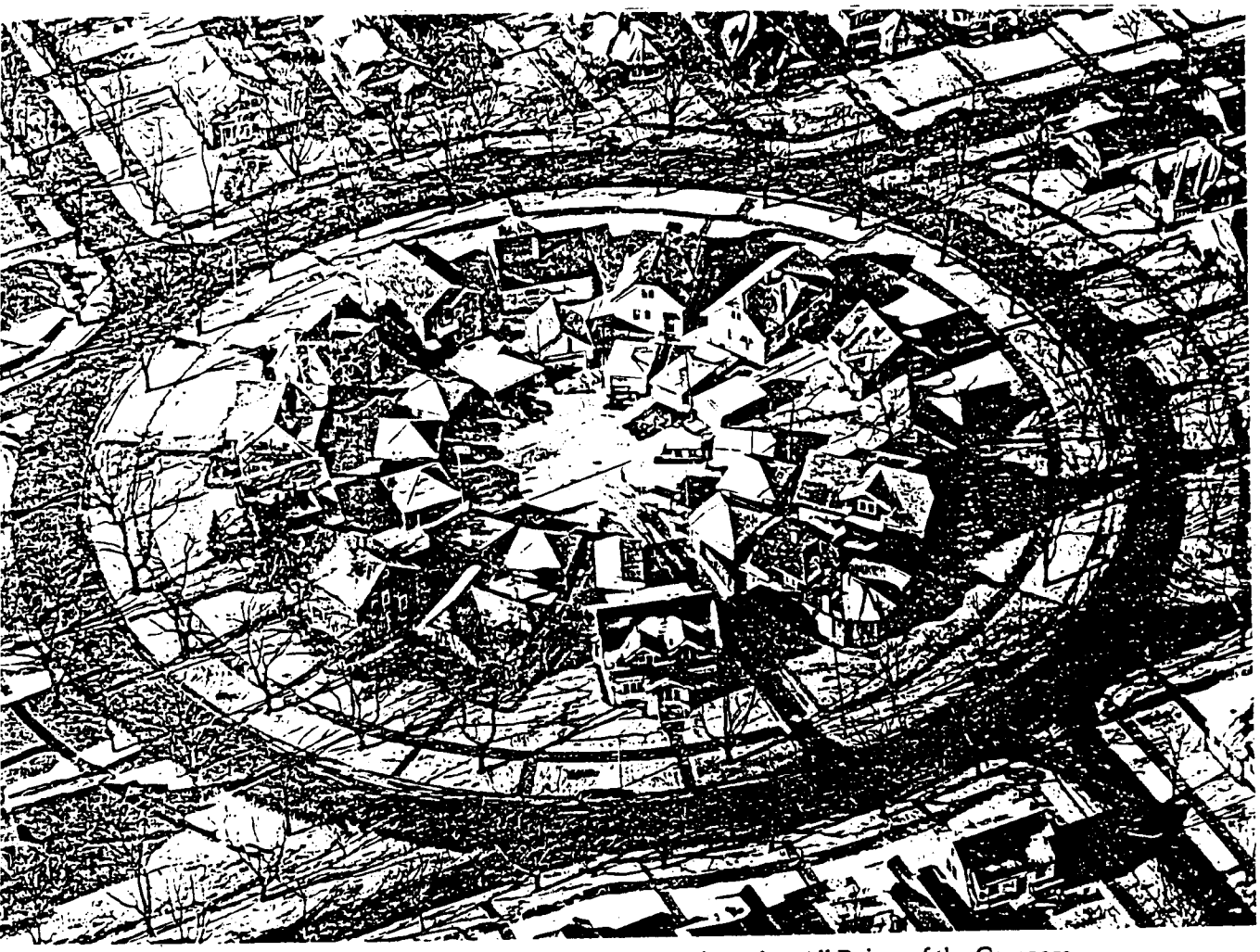


Figure 4-18: Housing Oriented to All Points of the Compass.

and structured parking; between large parking areas and a number of smaller parking areas; and between covered or uncovered parking. At the same time decisions need to be made about the relationship between car parking areas and other landscaped spaces, and about the ratio of housing units to parking spaces. These decisions hinge upon a complex set of relationships that exist between issues of access, cost, image, urban form, and, of course, ultimately, density. The patterns illustrated have attempted to incorporate parking requirements into the layout although this has often been at the expense of land for other uses such as play space or passive landscaped areas.

Such considerations will further moderate the densities achieved in any particular development. What we present is a range of 99 patterns from a density of one unit per acre to the highest of 171

units per acre. Of course, any pattern can be built at lower densities than those shown, although it may be difficult to economically justify much lower figures. In between the extremes thresholds of different housing types can be seen, areas of overlap between similar densities with different housing types can be found, and the image of density measures can be discovered.

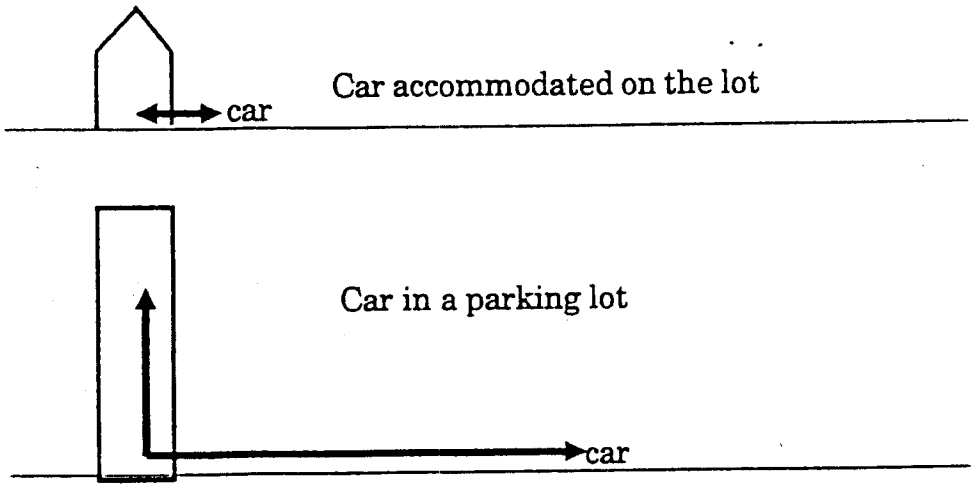


Figure 4-19: Relation of Parking to the Dwelling Unit.

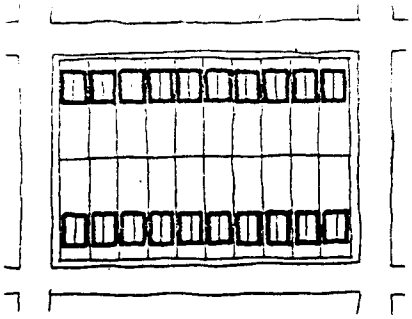
Appendix A:

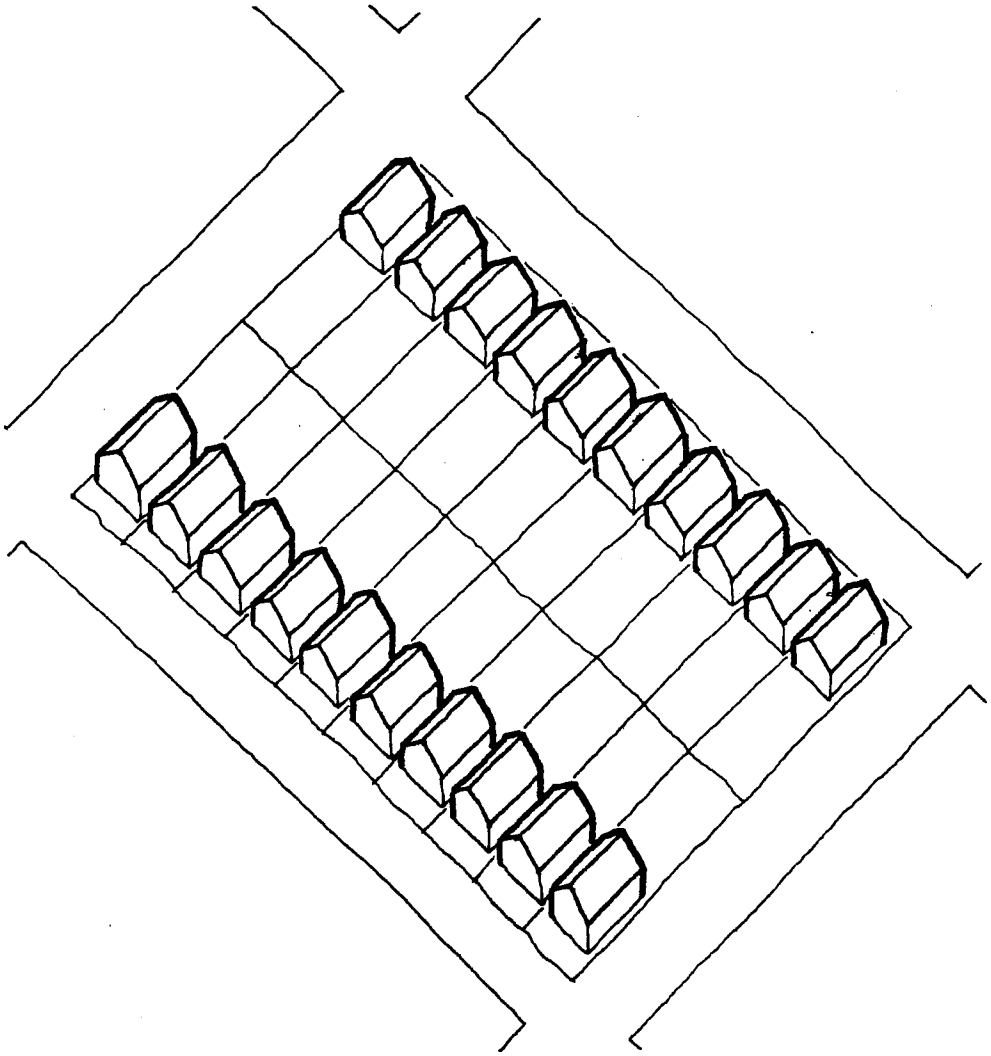
Housing Density Case Studies

1.1.1.1 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 30' x 40' (bungalow)	- parallel	- space between bldgs
- row housing	- 25' x 40' (split level)	- perimeter	- site depth
- garden apartments	- 25' x 40' (two story)	- penetrating	- site width
- high-rise apartments			

Block Size:
250' x 360'
90,000 sq.ft.
2.1 acres
Gross Residential Area:
116,000 sq.ft.
2.7 acres
Lot Dimensions:
20 @ 36'x 125'
4,500 sq.ft.
Number of Units:
20 @ 30' x 40'
Net Dwelling Density:
9.7 dwelling units/acre
Gross Residential Density:
7.4 dwelling units/acre
Coverage:
Net area = 0.27
Gross area = 0.21
Floor Area Ratio:
FAR = 0.27

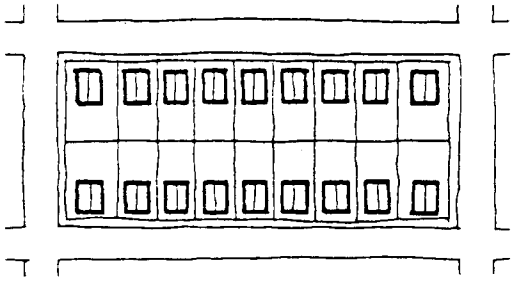


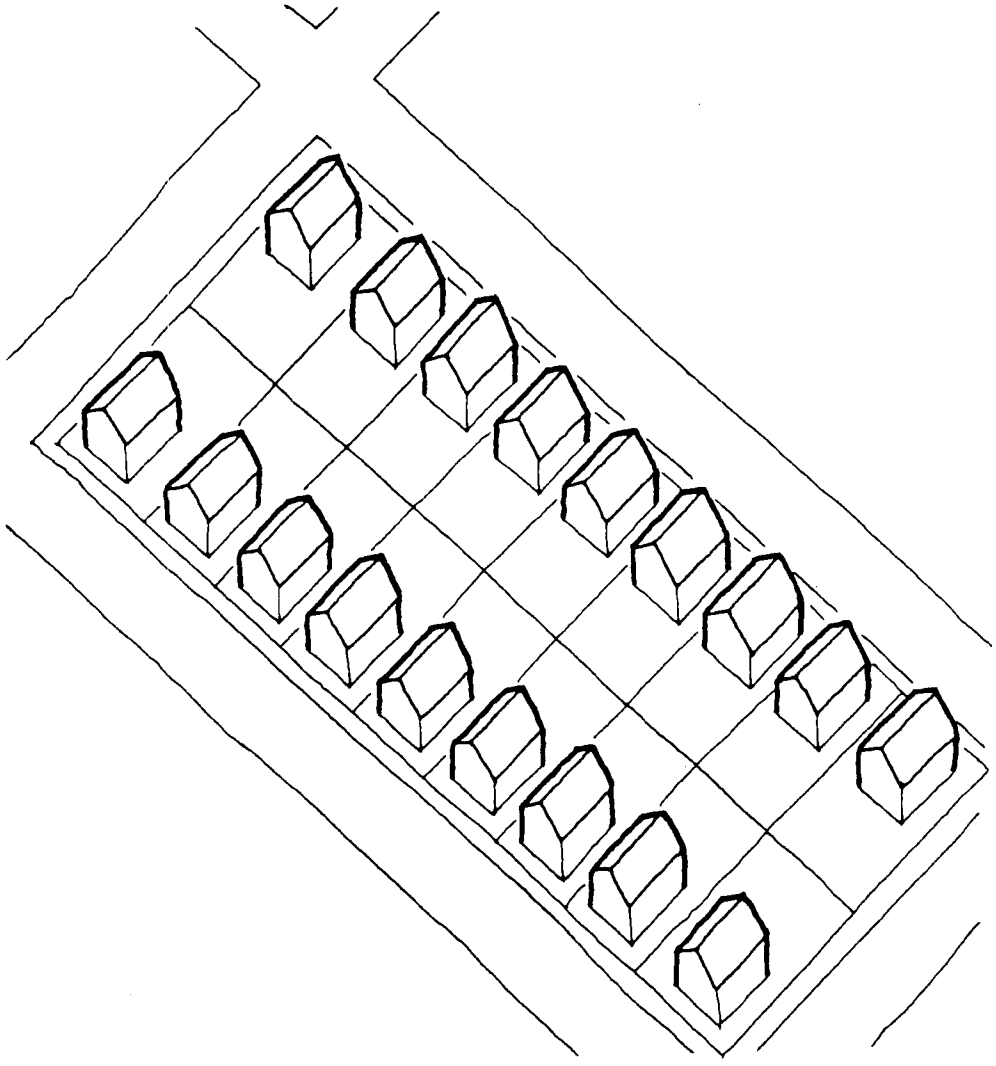


1.1.1.2 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- **30' x 40' (bungalow)**	- **parallel**	- space between blgs
- row housing	- 25' x 40' (split level)	- perimeter	- **site depth**
- garden apartments	- 25' x 40' (two story)	- penetrating	- site width
- high-rise apartments			

Block Size
200' x 475' 95,000 sq.ft.
2.2 acres
Gross Residential Area:
123,600 sq.ft. 2.8 acres
Lot Dimensions:
14 @ 50' x 100'
4 @ 62.5'x 100'
5,278 (average) sq.ft.
Number of Units:
18 @ 30' x 40'
Net Dwelling Density:
8.3 dwelling units/acre
Gross Residential Density:
6.3 dwelling units/acre
Coverage:
Net area = 0.23
Gross area = 0.17
Floor Area Ratio:
FAR = 0.23

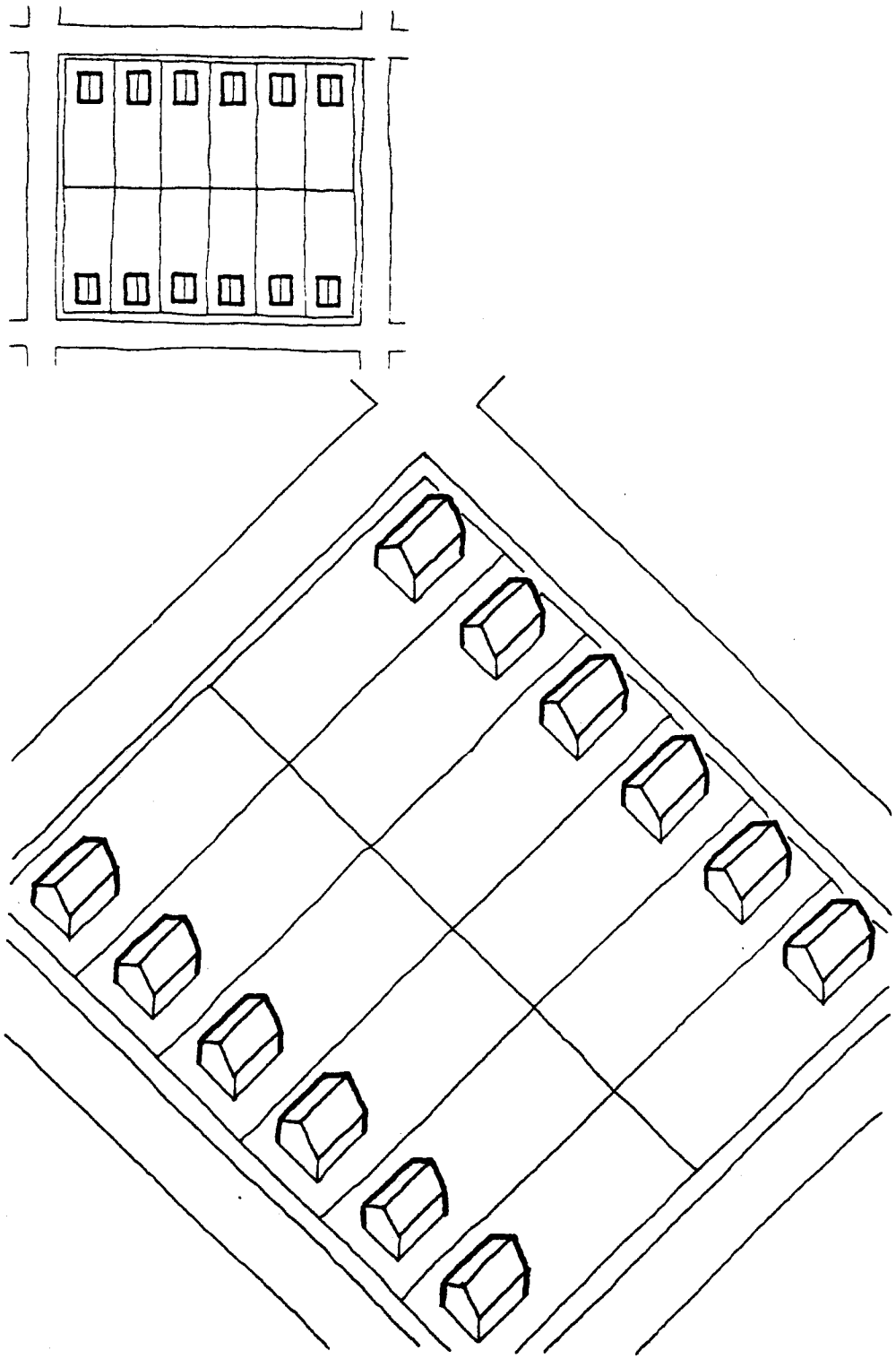




1.1.1.2 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- **single family**	- **30' x 40' (bungalow)**	- **parallel**	- space between blgs
- row housing	- 25' x 40' (split level)	- perimeter	- **site depth**
- garden apartments	- 25' x 40' (two story)	- penetrating	- site width
- high-rise apartments			

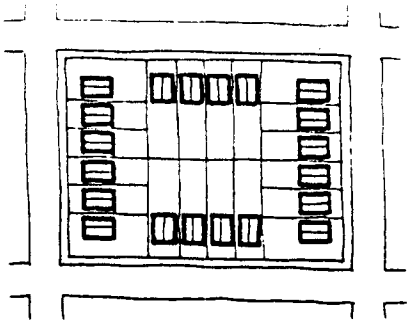
Block Size
350' x 400'
140,000 sq.ft.
3.2 acres
Gross Residential Area:
171,600 sq.ft.
3.9 acres
Lot Dimensions:
12 @ 66.7x 175'
11,667 sq.ft.
Number of Units:
12 @ 30' x 40'
Net Dwelling Density:
3.75 dwelling units/acre
Gross Residential Density:
3.1 dwelling units/acre
Coverage:
Net area = 0.10
Gross area = 0.08
Floor Area Ratio:
FAR = 0.10

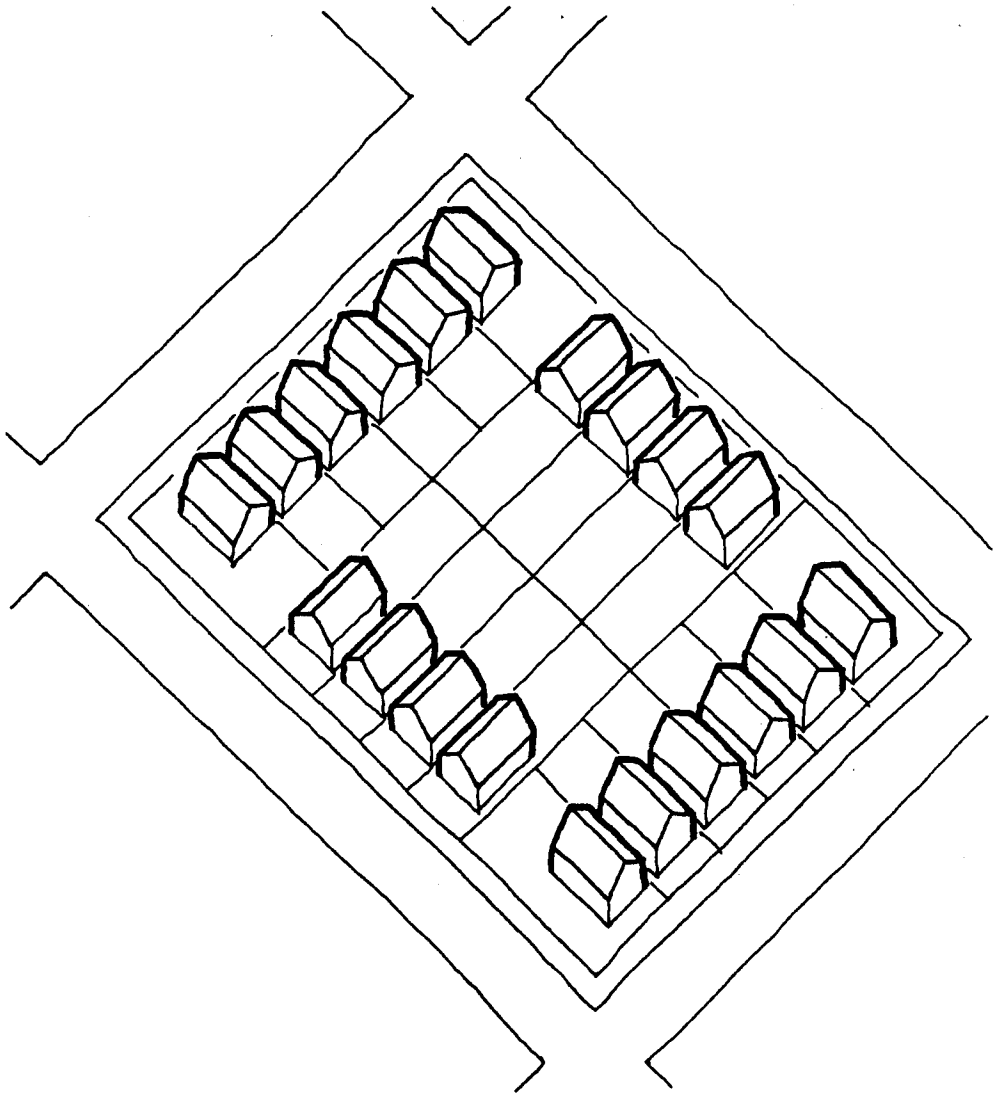


1.1.2.1 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- **single family**	- **30' x 40' (bungalow)**	- parallel	- **space between blgs**
- row housing	- 25' x 40' (split level)	- **perimeter**	- site depth
- garden apartments	- 25' x 40' (two story)	- penetrating	- site width
- high-rise apartments			

Block Size
252' x 364'
86,688 sq.ft.
2.0 acres
Gross Residential Area:
112,128 sq.ft.
2.6 acres
Lot Dimensions:
4 @ 54' x 100'
8 @ 36' x 100'
8 @ 36' x 126'
4,334 (average) sq.ft.
Number of Units:
20 @ 30' x 40'
Net Dwelling Density:
10.1 dwelling units/acre
Gross Residential Density:
7.8 dwelling units/acre
Coverage:
Net area = 0.28
Gross area = 0.21
Floor Area Ratio:
FAR = 0.28

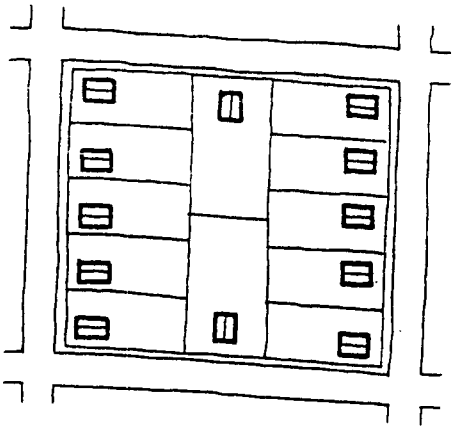


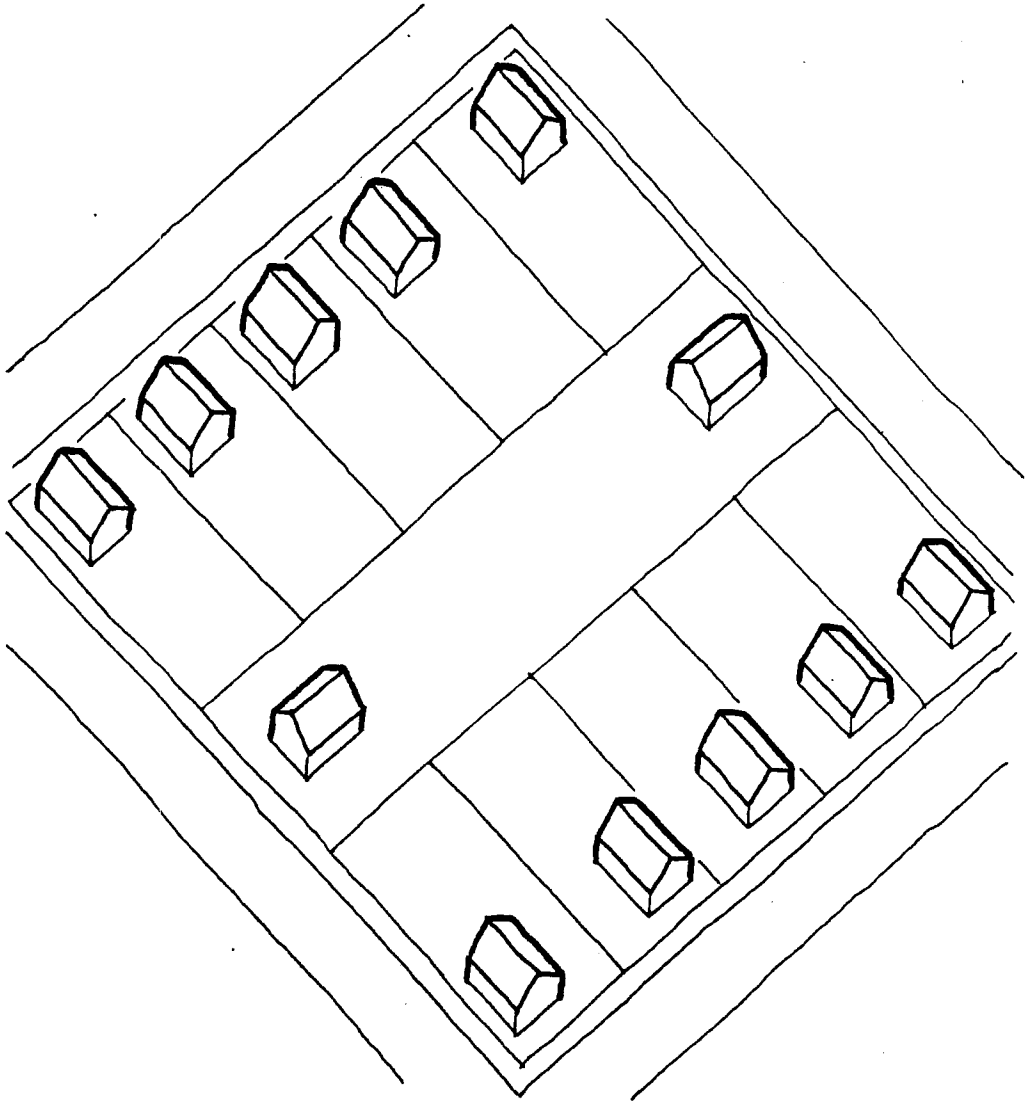


1.1.2.2 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- **single family**	- **30' x 40' (bungalow)**	- parallel	- space between blgs
- row housing	- 25' x 40' (split level)	- **perimeter**	- **site depth**
- garden apartments	- 25' x 40' (two story)	- penetrating	- site width
- high-rise apartments			

Block Size
350' x 400'
140,000 sq.ft.
3.2 acres
Gross Residential Area:
171,600 sq.ft.
3.9 acres
Lot Dimensions:
10@ 70' x 150'
2 @ 100' x 175'
11,667 (average) sq.ft.
Number of Units:
12 @ 30' x 40'
Net Dwelling Density:
3.75 dwelling units/acre
Gross Residential Density:
3.1 dwelling units/acre
Coverage:
Net area = 0.10
Gross area = 0.08
Floor Area Ratio:
FAR = 0.10

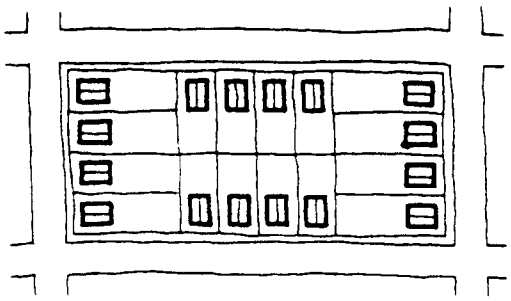


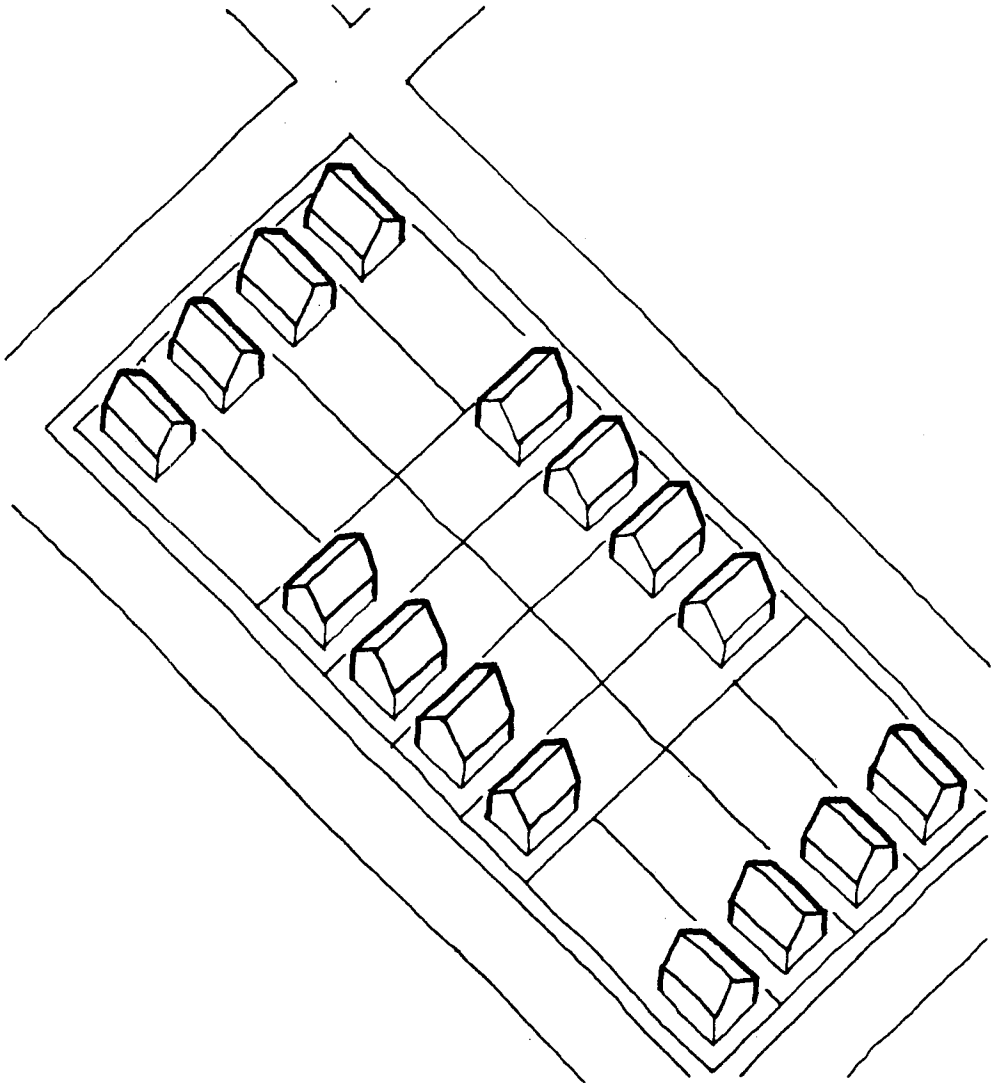


1.1.2.3 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- **single family**	- **30' x 40' (bungalow)**	- parallel	- space between blgs
- row housing	- 25' x 40' (split level)	- **perimeter**	- site depth
- garden apartments	- 25' x 40' (two story)	- penetrating	- **site width**
- high-rise apartments			

Block Size
200' x 475'
95,000 sq.ft.
2.2 acres
Gross Residential Area:
123,600 sq.ft.
2.8 acres
Lot Dimensions:
8 @ 50' x 100'
8 @ 50'x 137.5
5,938 (average) sq.ft.
Number of Units:
16 @ 30' x 40'
Net Dwelling Density:
7.3 dwelling units/acre
Gross Residential Density:
5.6 dwelling units/acre
Coverage:
Net area = 0.20
Gross area = 0.16
Floor Area Ratio:
FAR = 0.20

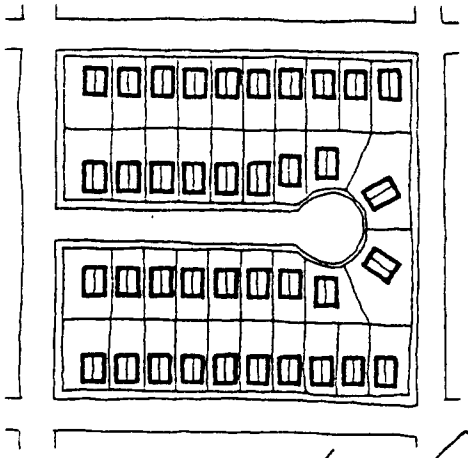


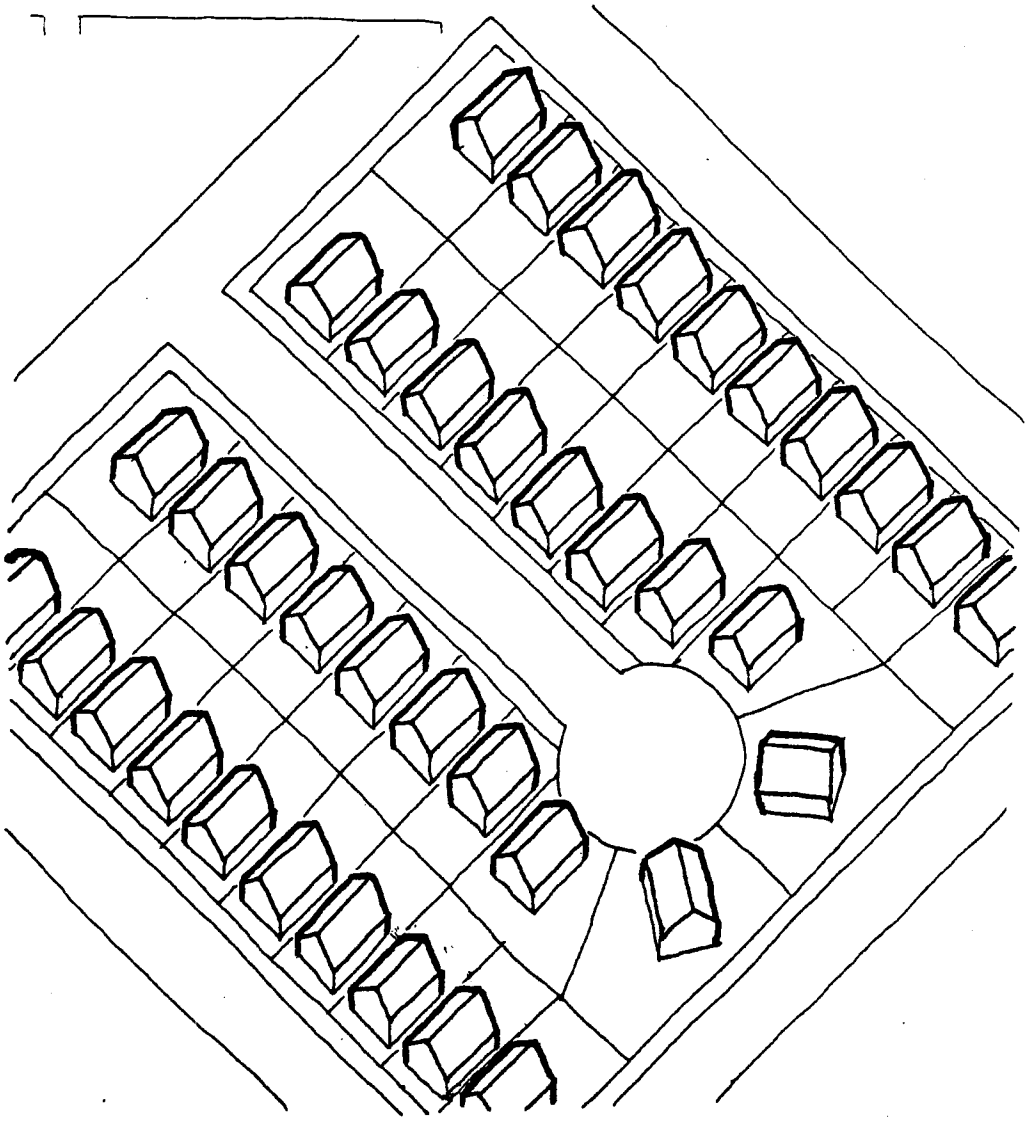


1.1.3.1/3 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- **single family**	- **30' x 40' (bungalow)**	- parallel	- **space between bldgs**
- row housing	- 25' x 40' (split level)	- perimeter	- site depth
- garden apartments	- 25' x 40' (two story)	- **penetrating**	- **site width**
- high-rise apartments			

Block Size
350' x 400'
124,146 sq.ft.
2.85acres
Gross Residential Area:
171,600 sq.ft.
3.9 acres
Lot Dimensions:
26 @ 50' x 90' (typical).
4,500 (typical) sq.ft.
Number of Units:
26 @ 1,200 s.f.
Net Dwelling Density:
9.1 dwelling units/acre
Gross Residential Density:
6.6 dwelling units/acre
Coverage:
Net area = 0.25
Gross area = 0.18 **Floor Area Ratio:**
FAR = 0.25

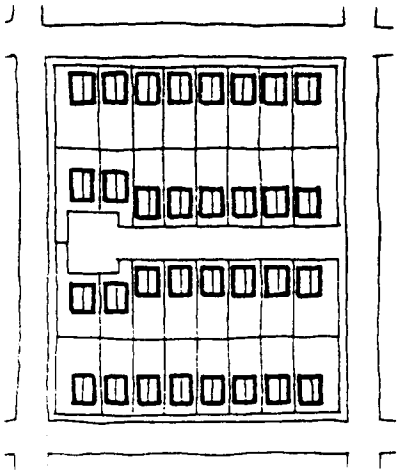


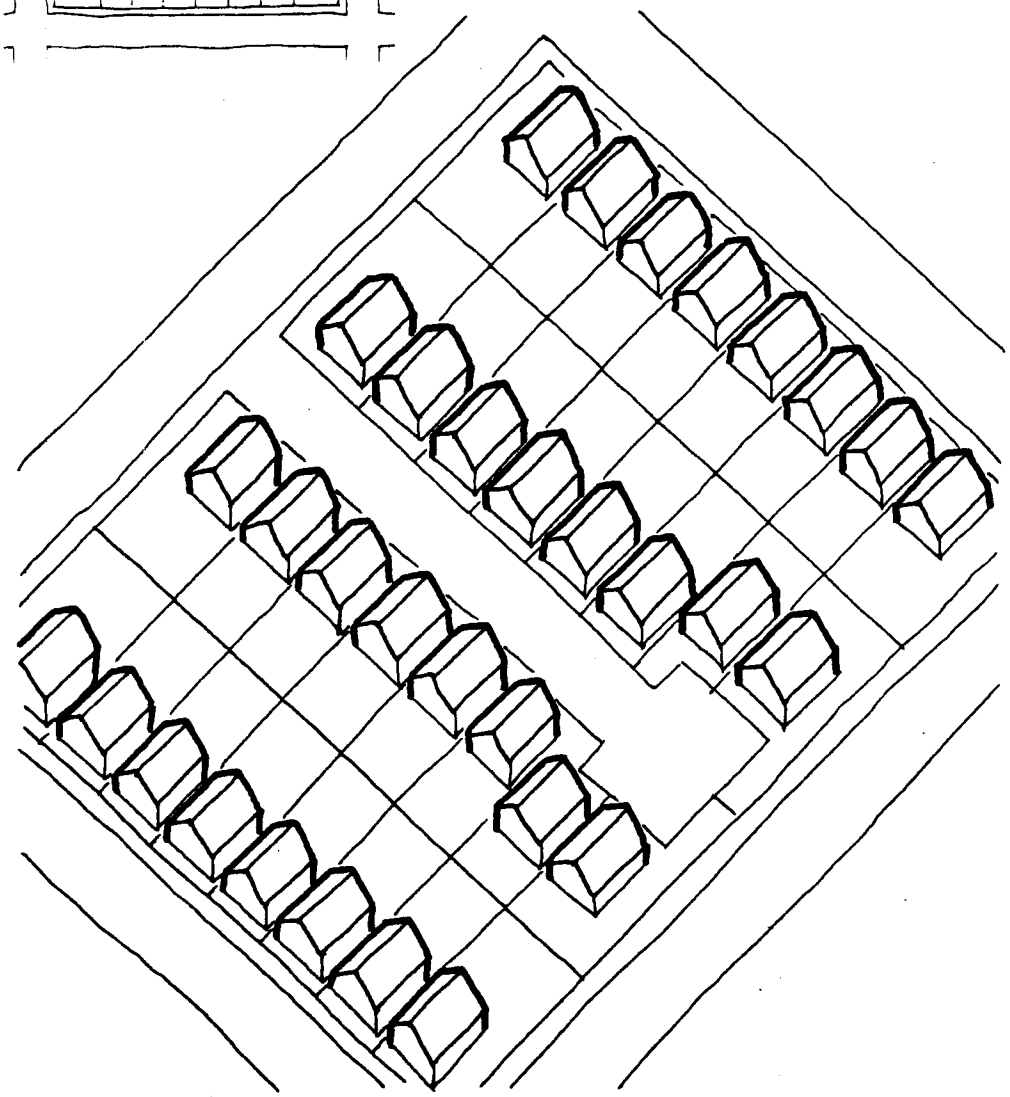


1.1.3.1 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- **single family**	- **30' x 40' (bungalow)**	- **parallel**	- **space between blgs**
- row housing	- 25' x 40' (split level)	- perimeter	- site depth
- garden apartments	- 25' x 40' (two story)	- penetrating	- site width
- high-rise apartments			

Block Size
420' x 420'
152,346 sq.ft.
3.6 acres
Gross Residential Area:
190,846 sq.ft.
4.4 acres
Lot Dimensions:
40' x 90' (typical)
4,010 (average) sq.ft.
Number of Units:
38 @ 1,200 sq.ft.
Net Dwelling Density:
10.6 dwelling units/acre
Gross Residential Density:
8.7 dwelling units/acre
Coverage:
Net area = 0.30
Gross area = 0.24
Floor Area Ratio:
FAR = 0.30

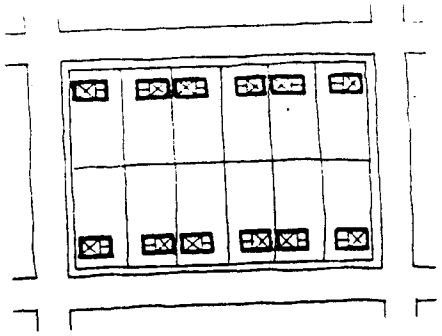


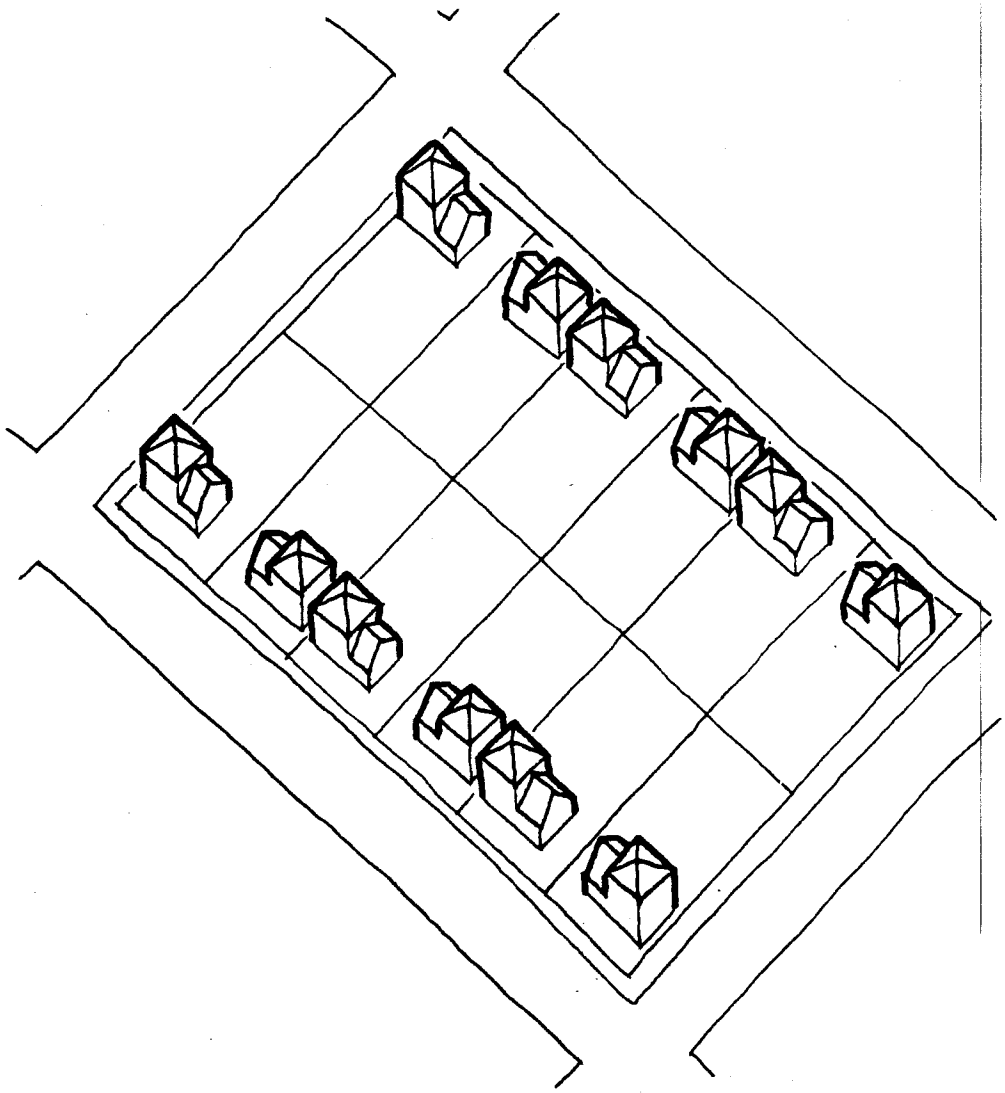


1.2.1.2/3 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- **single family** - row housing - garden apartments - high-rise apartments	- 30' x 40' (bungalow) - **25' x 40' (split level)** - 25' x 40' (two story)	- **parallel** - perimeter - penetrating	- space between blgs - **site depth** - **site width**

Block Size:
250' x 360'
90,000 sq.ft.
2.1 acres
Gross Residential Area:
116,000 sq.ft.
2.7 acres
Lot Dimensions:
12 @ 60'x 125'
7,500 sq.ft.
Number of Units:
12 @ 25' x 40'
Net Dwelling Density:
5.8 dwelling units/acre
Gross Residential Density:
4.4 dwelling units/acre
Coverage:
Net area = 0.18
Gross area = 0.14
Floor Area Ratio:
FAR = 0.18

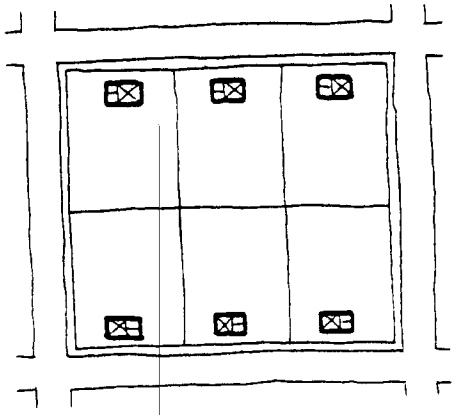


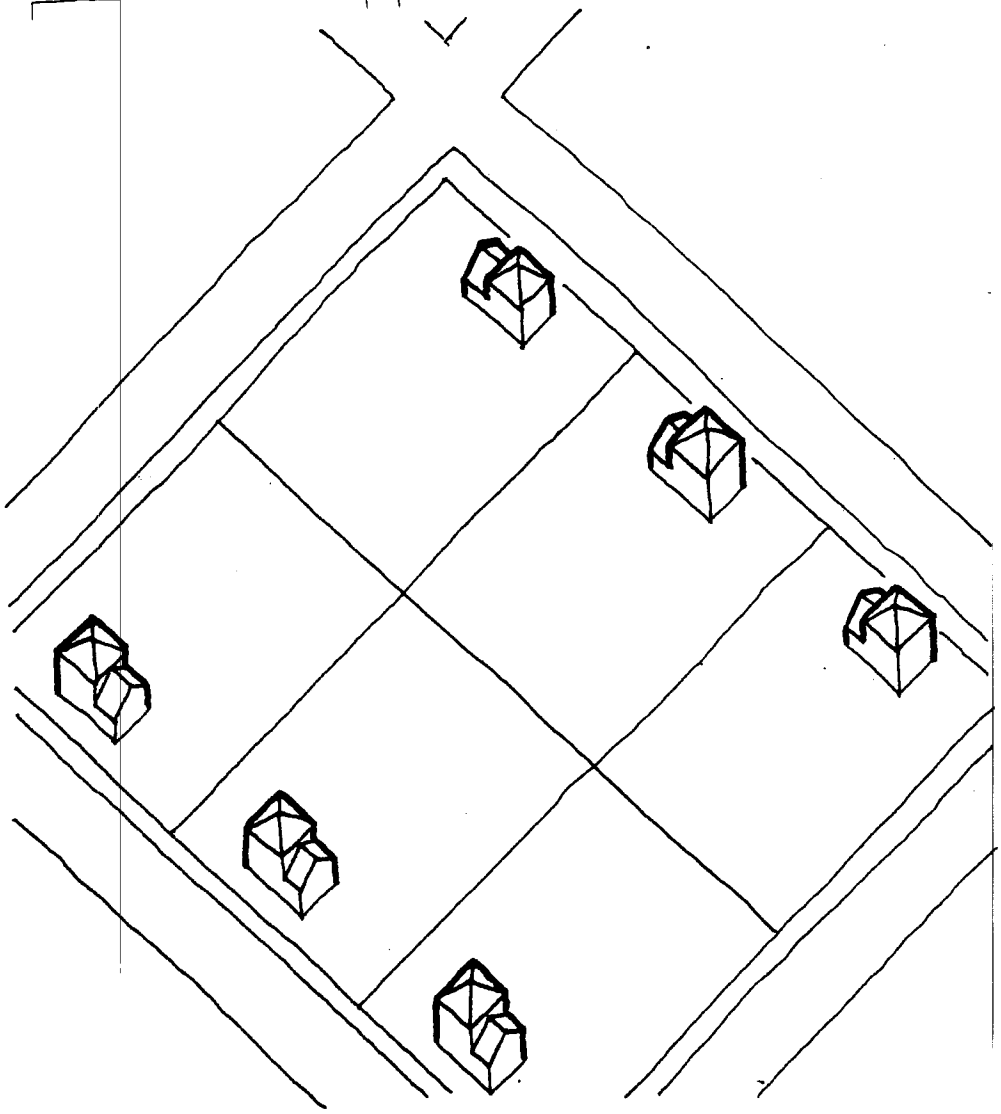


1.2.1.2/3 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- **single family** - row housing - garden apartments - high-rise apartments	- 30' x 40' (bungalow) - **25' x 40' (split level)** - 25' x 40' (two story)	- **parallel** - perimeter - penetrating	- space between blgs - **site depth** - **site width**

Block Size
350' x 400'
140,000 sq.ft.
3.2 acres
Gross Residential Area:
171,600 sq.ft.
3.9 acres
Lot Dimensions:
6 @ 133'x 175'
23,328 sq.ft.
Number of Units:
6 @ 25' x 40'
Net Dwelling Density:
1.9 dwelling units/acre
Gross Residential Density:
1.5 dwelling units/acre
Coverage:
Net area = 0.06
Gross area = 0.05
Floor Area Ratio:
FAR = 0.08

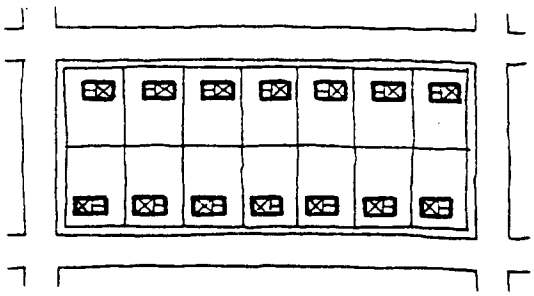


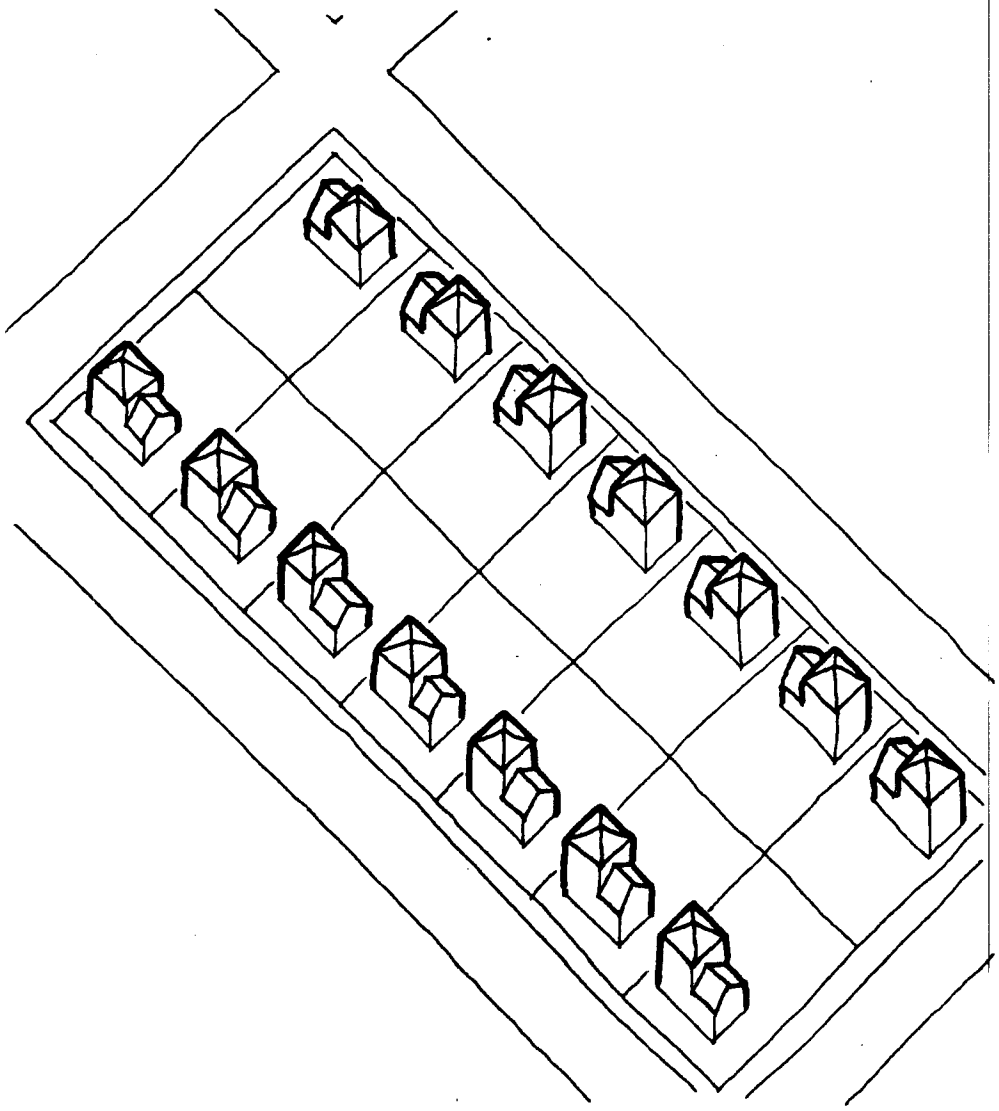


1.2.1.3 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- **single family**	- 30' x 40' (bungalow)	- **parallel**	- space between blgs
- row housing	- **25' x 40' (split level)**	- perimeter	- site depth
- garden apartments	- 25' x 40' (two story)	- penetrating	- **site width**
- high-rise apartments			

Block Size
200' x 490'
98,000 sq.ft.
2.25 acres
Gross Residential Area:
127,200 sq.ft.
2.9 acres
Lot Dimensions:
14 @ 70' x 100'
7,000 sq.ft.
Number of Units:
14 @ 25' x 40'
Net Dwelling Density:
6.2 dwelling units/acre
Gross Residential Density:
4.8 dwelling units/acre
Coverage:
Net area = 0.19
Gross area = 0.15
Floor Area Ratio:
FAR = 0.28

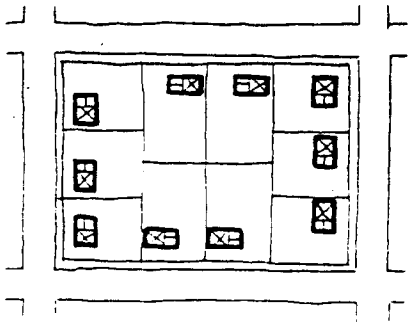


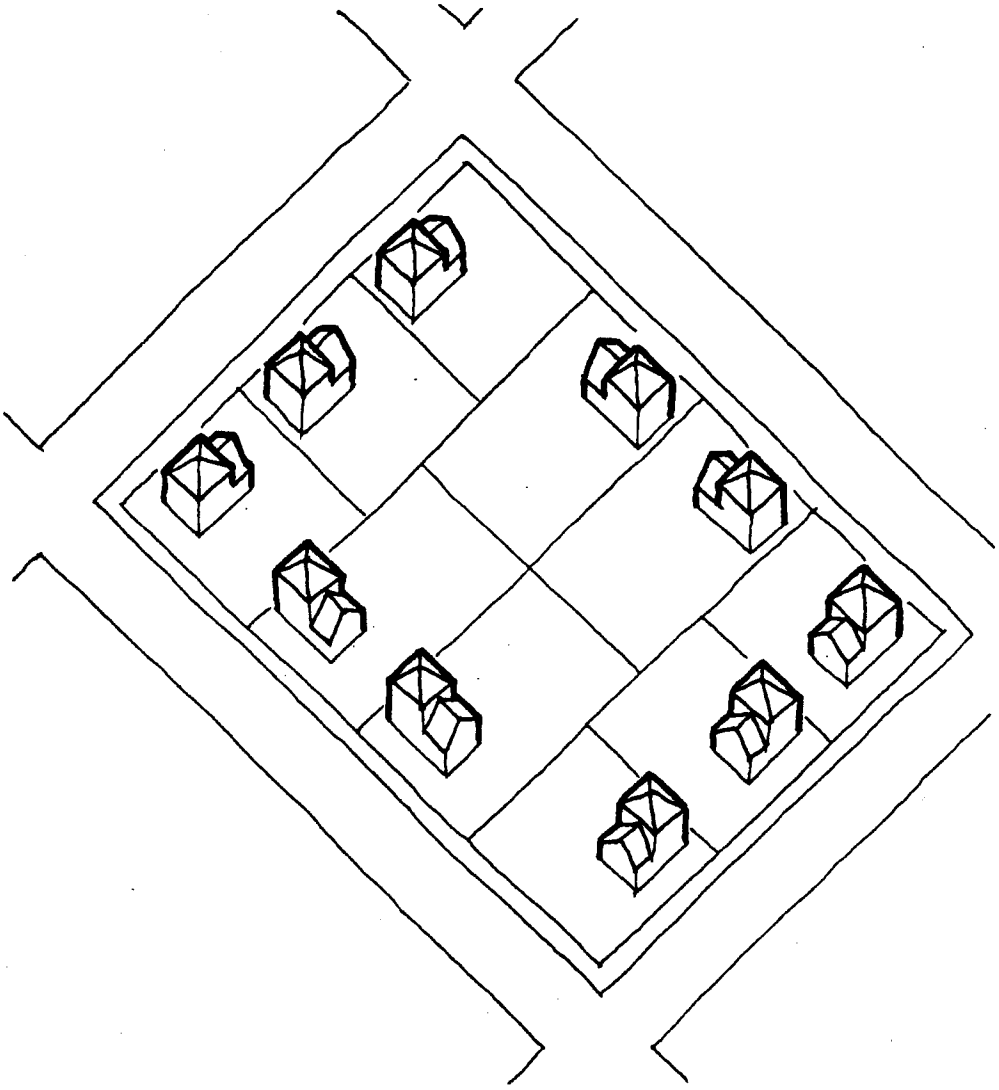


1.2.2.2 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- **single family**	- 30' x 40' (bungalow)	- *parallel*	- space between blgs
- row housing	- **25' x 40' (split level)**	- **perimeter**	- **site depth**
- garden apartments	- 25' x 40' (two story)	- penetrating	- site width
- high-rise apartments			

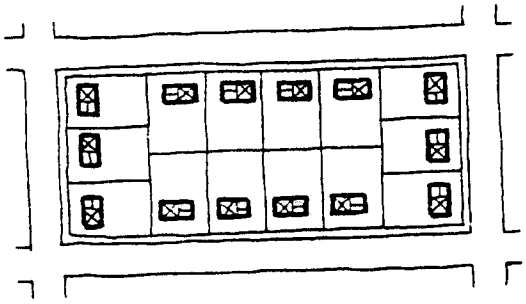
Block Size:
250' x 350'
87,500 sq.ft.
2.0 acres
Gross Residential Area:
113,000 sq.ft.
2.6 acres
Lot Dimensions:
6 @ 83.3'x 95'
4 @ 80' x 125'
8,750 (average) sq.ft.
Number of Units:
10 @ 25' x 40'
Net Dwelling Density:
5.0 dwelling units/acre
Gross Residential Density:
3.85 dwelling units/acre
Coverage:
Net area = 0.15
Gross area = 0.12
Floor Area Ratio:
FAR = 0.25



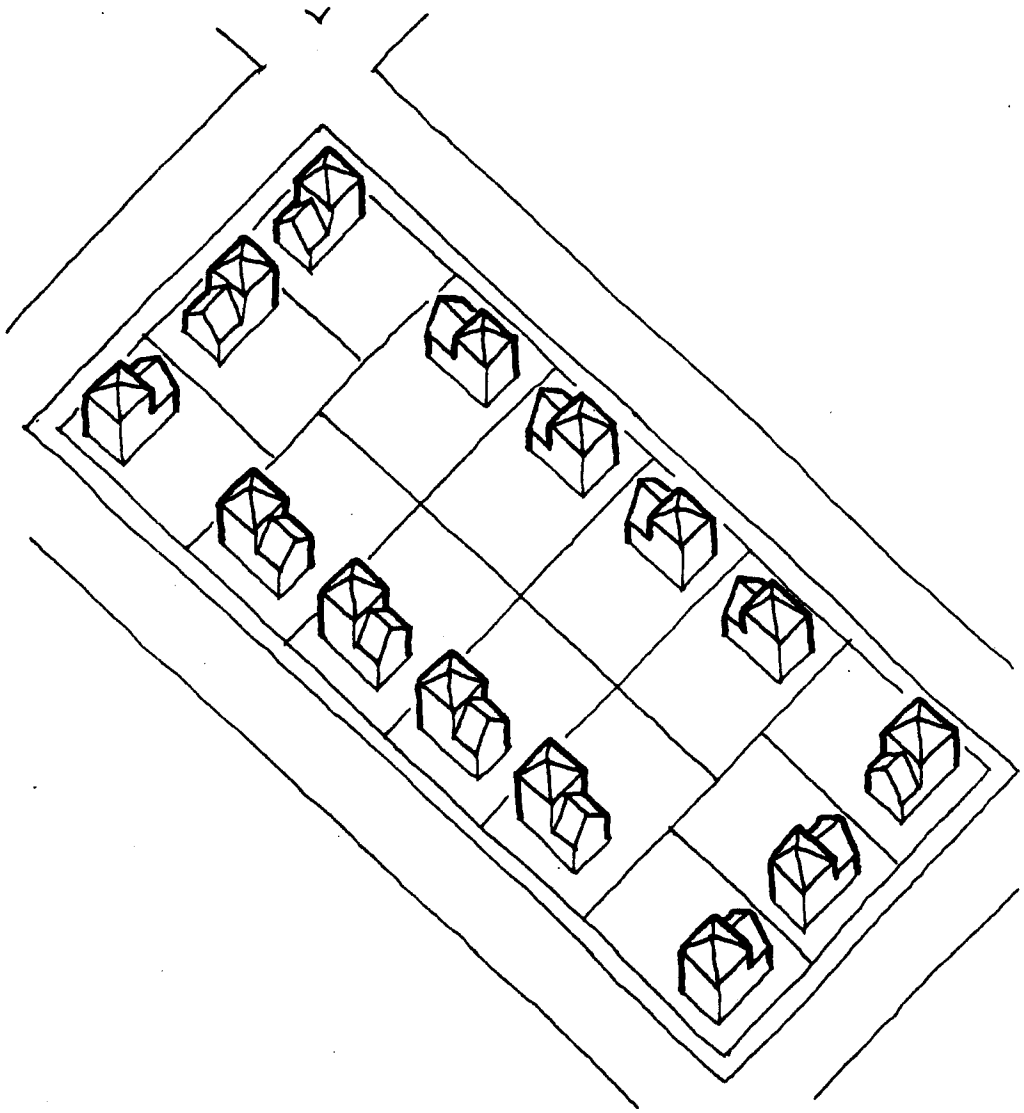


1.2.2.3 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable D*	*Lot Variable*
- **single family**	- 30' x 40' (bungalow)	- *parallel*	- space between blgs
- row housing	- **25' x 40' (split level)**	- **perimeter**	- site depth
- garden apartments	- 25' x 40' (two story)	- penetrating	- **site width**
- high-rise apartments			



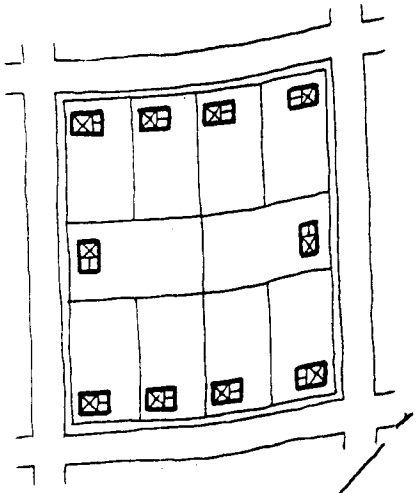
Block Size
200' x 475'
95,000 sq.ft.
2.2 acres
Gross Residential Area:
123,600 sq.ft.
2.8 acres
Lot Dimensions:
8 @ 70' x 100'
6 @ 66.7'x 97.5'
6,786 (average) sq.ft.
Number of Units:
14 @ 25' x 40'
Net Dwelling Density:
6.4 dwelling units/acre
Gross Residential Density:
4.9 dwelling units/acre
Coverage:
Net area = 0.20
Gross area = 0.15
Floor Area Ratio:
FAR = 0.29

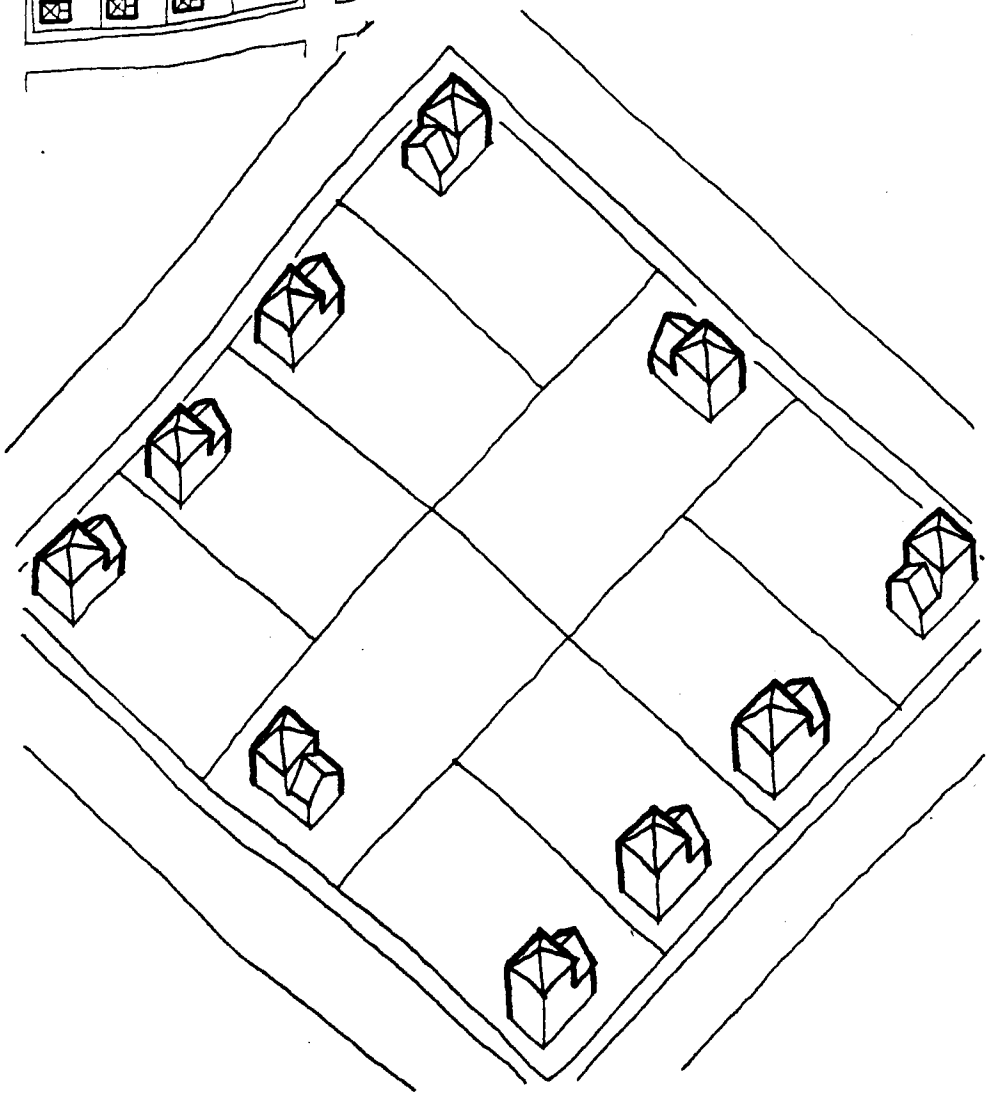


1.2.2.3 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- **single family**	- 30' x 40' (bungalow)	- parallel	- space between blgs
- row housing	- **25' x 40' (split level)**	- **perimeter**	- site depth
- garden apartments	- 25' x 40' (two story)	- penetrating	- **site width**
- high-rise apartments			

Block Size
350' x 400'
140,000 sq.ft.
3.2 acres
Gross Residential Area:
171,600 sq.ft.
3.9 acres
Lot Dimensions:
8 @ 87.5"x 150'
2 @ 100" x 175"
14,000 (average) sq.ft.
Number of Units:
10 @ 25' x 40'
Net Dwelling Density:
3.125 dwelling units/acre
Gross Residential Density:
2.5 dwelling units/acre
Coverage:
Net area = 0.09
Gross area = 0.08
Floor Area Ratio:
FAR = 0.14

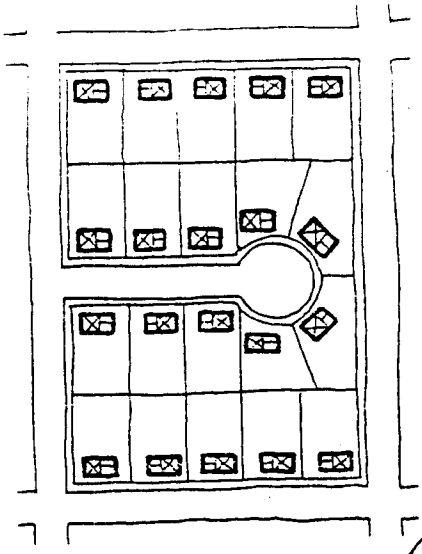


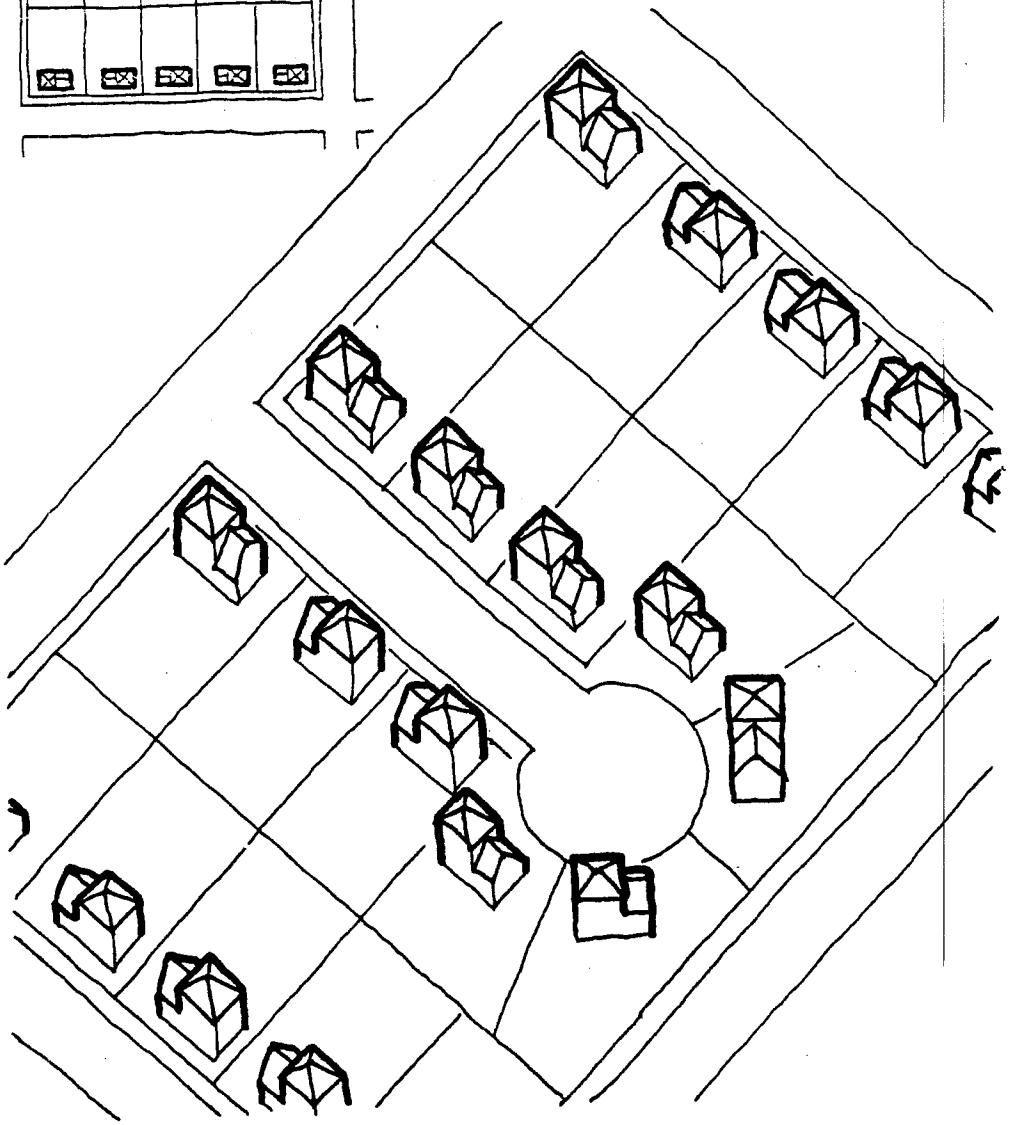


1.2.3.3 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- **single family**	- 30' x 40' (bungalow)	- parallel	- **space between blgs**
- row housing	- **25' x 40' (split level)**	- perimeter	- site depth
- garden apartments	- 25' x 40' (two story)	- **penetrating**	- site width
- high-rise apartments			

Block Size
520' x 350'
165,746 sq.ft.
3.8 acres
Gross Residential Area:
209,000 sq.ft.
4.8 acres
Lot Dimensions:
20 @ 70' x 115' (typical)
8,050 sq.ft. (typical)
Number of Units:
20 @ 25' x 40'
Net Dwelling Density:
5.2 dwelling units/acre
Gross Residential Density:
4.2 dwelling units/acre
Coverage:
Net area = 0.17
Gross area = 0.13
Floor Area Ratio:
FAR = 0.30

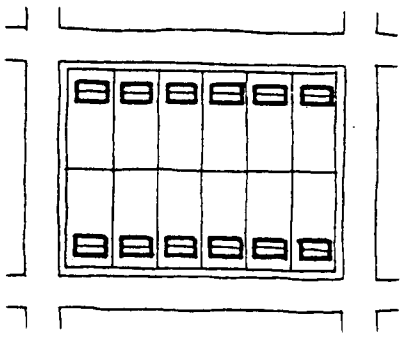


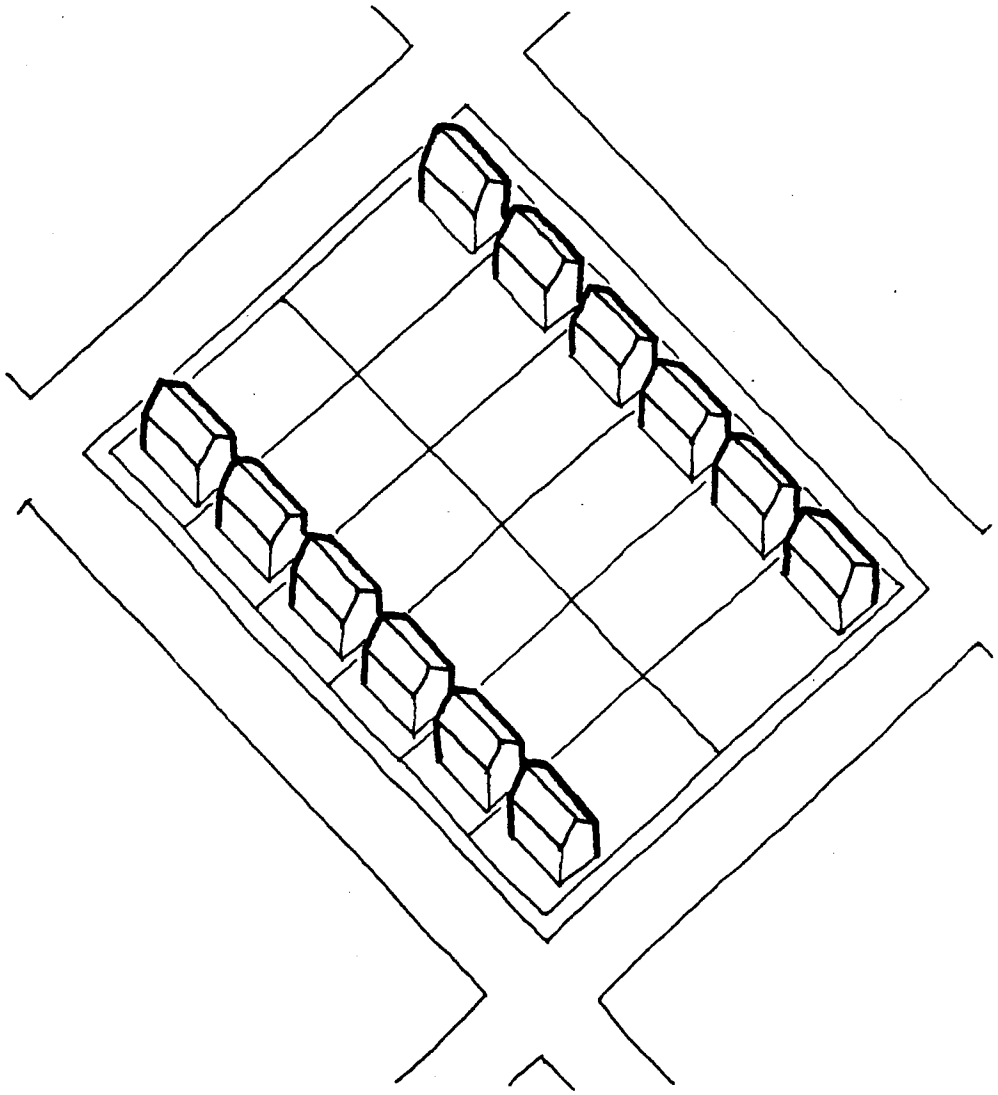


1.3.1.3 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family - **row housing** - garden apartments - high-rise apartments	- 30' x 40' (bungalow) - 25' x 40' (split level) - **25' x 40' (two story)**	- **parallel** - perimeter - penetrating	- space between blgs - site depth - **site width**

Block Size:
250' x 330'
82,500 sq.ft.
1.9 acres
Gross Residential Area:
107,300 sq.ft.
2.5 acres
Lot Dimensions:
12 @ 55' x 125'
6,875 sq.ft.
Number of Units:
12 @ 25' x 40'
Net Dwelling Density:
6.4 dwelling units/acre
Gross Residential Density:
4.9 dwelling units/acre
Coverage:
Net area = 0.15
Gross area = 0.11
Floor Area Ratio:
FAR = 0.30

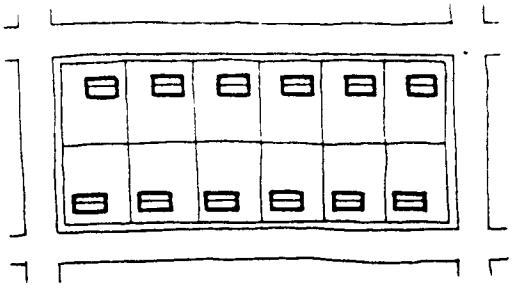


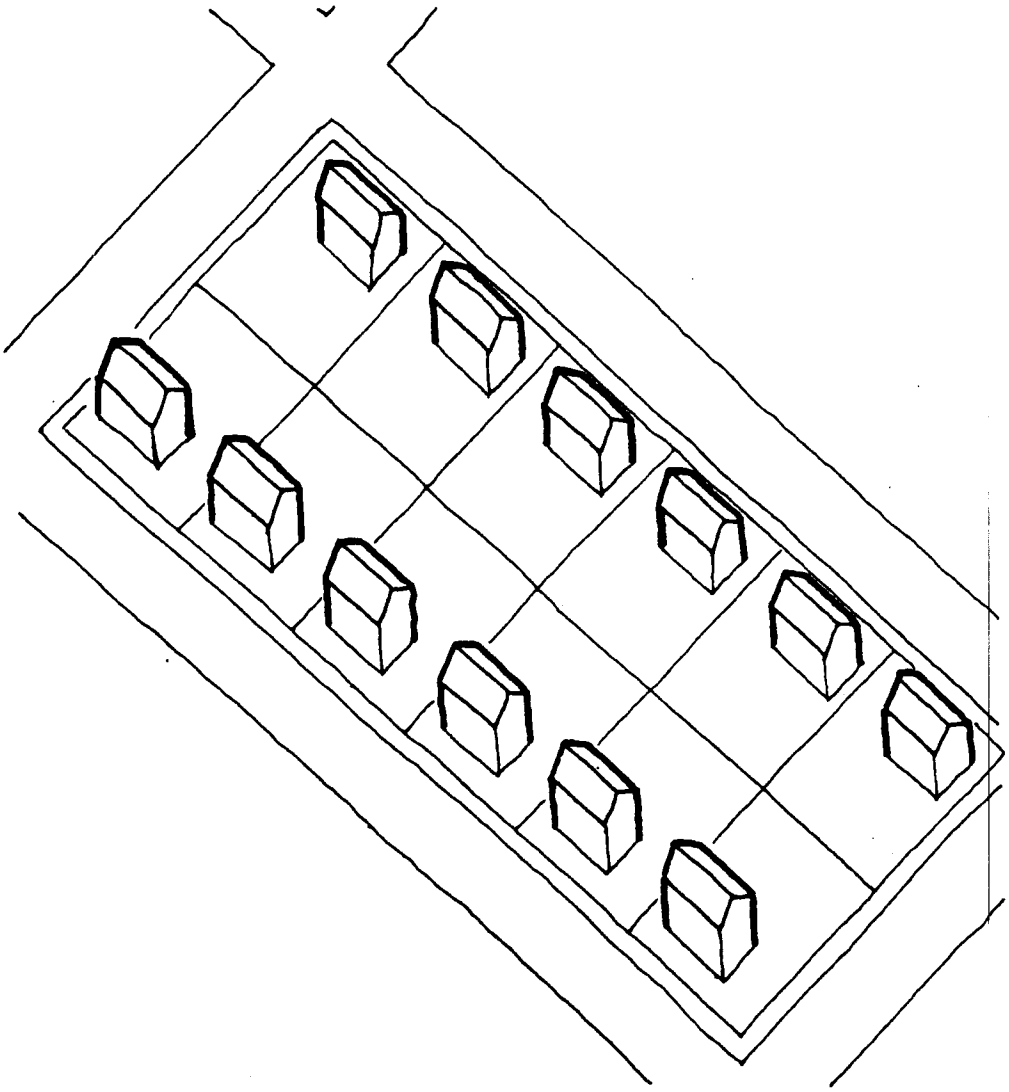


1.3.1.3 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- **single family**	- 30' x 40' (bungalow)	- **parallel**	- space between blgs
- row housing	- 25' x 40' (split level)	- perimeter	- site depth
- garden apartments	- **25' x 40' (two story)**	- penetrating	- **site width**
- high-rise apartments			

Block Size
200' x 475'
95,000 sq.ft.
2.2 acres
Gross Residential Area:
123,600 sq.ft.
2.8 acres
Lot Dimensions:
12 @ 79.2x 100'
7,920 sq.ft.
Number of Units:
12 @ 25' x 40'
Net Dwelling Density:
5.5 dwelling units/acre
Gross Residential Density:
4.2 dwelling units/acre
Coverage:
Net area = 0.13
Gross area = 0.1
Floor Area Ratio:
FAR = 0.26

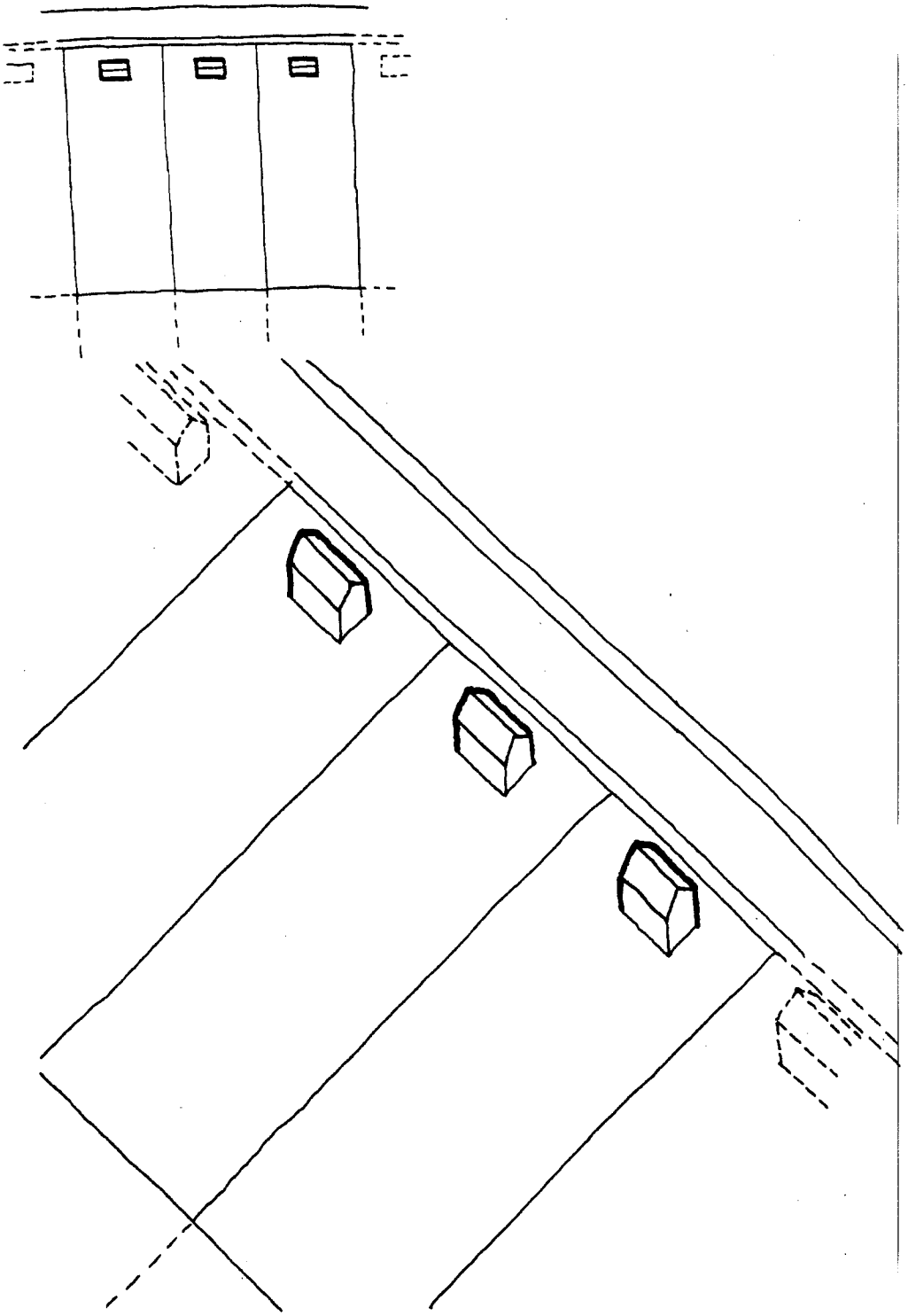




1.3.1.2/3 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- **single family** - row housing - garden apartments - high-rise apartments	- 30' x 40' (bungalow) - 25' x 40' (split level) - **25' x 40' (two story)**	- **parallel** - perimeter - penetrating	- space between blgs - **site depth** - **site width**

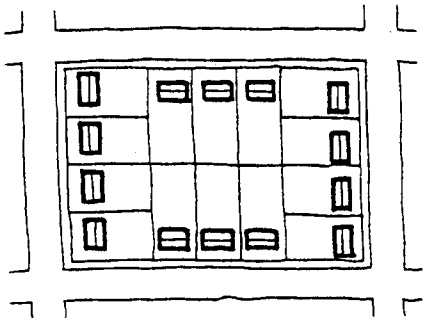
Block Size
700' x 400' +
280,000 sq.ft.
6.4 acres
Gross Residential Area:
n/a
Lot Dimensions:
6 @ 130'x 350'
45,500 sq.ft.
Number of Units:
6 @ 25' x 40'
Net Dwelling Density:
1.0 dwelling units/acre
Gross Residential Density:
1.0 dwelling units/acre
Coverage:
Net area = 0.02
Gross area = 0.02
Floor Area Ratio:
FAR = 0.04

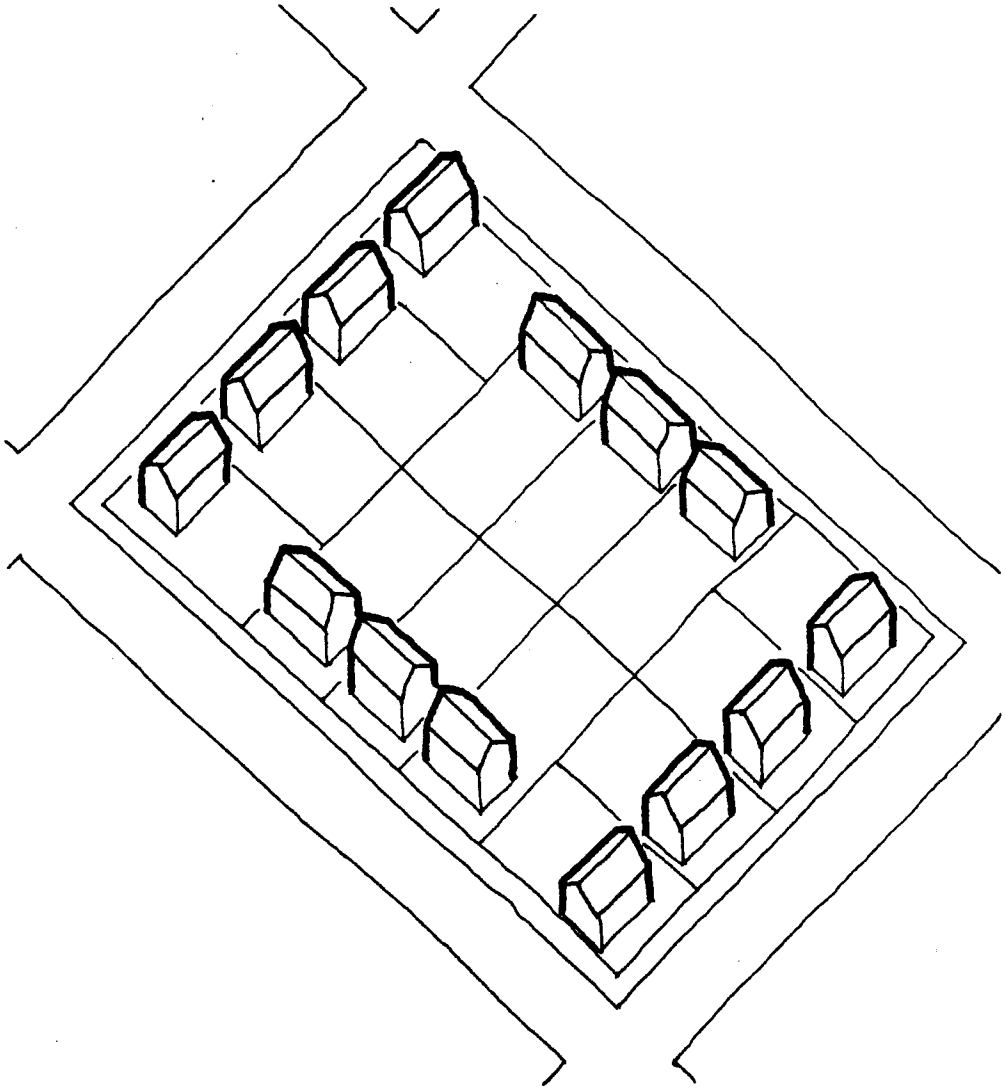


1.3.2.1 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- **single family** - row housing - garden apartments - high-rise apartments	- 30' x 40' (bungalow) - 25' x 40' (split level) - **25' x 40' (two story)**	- parallel - **perimeter** - penetrating	- space between blgs - site depth - site width

Block Size
240' x 365'
87,600 sq.ft.
2.0 acres
Gross Residential Area:
113,400 sq.ft.
2.6 acres
Lot Dimensions:
8 @ 60' x 100'
6 @ 55' x 120'
6,257 (average) sq.ft.
Number of Units:
14 @ 25' x 40'
Net Dwelling Density:
7.0 dwelling units/acre
Gross Residential Density:
5.4 dwelling units/acre
Coverage:
Net area = 0.16
Gross area = 0.12
Floor Area Ratio:
FAR = 0.32

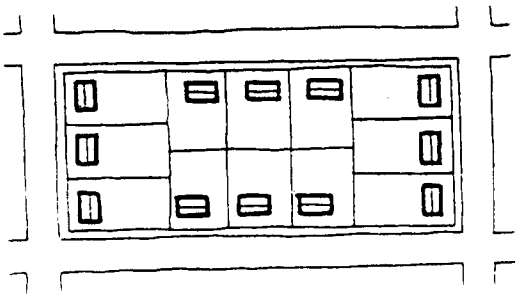


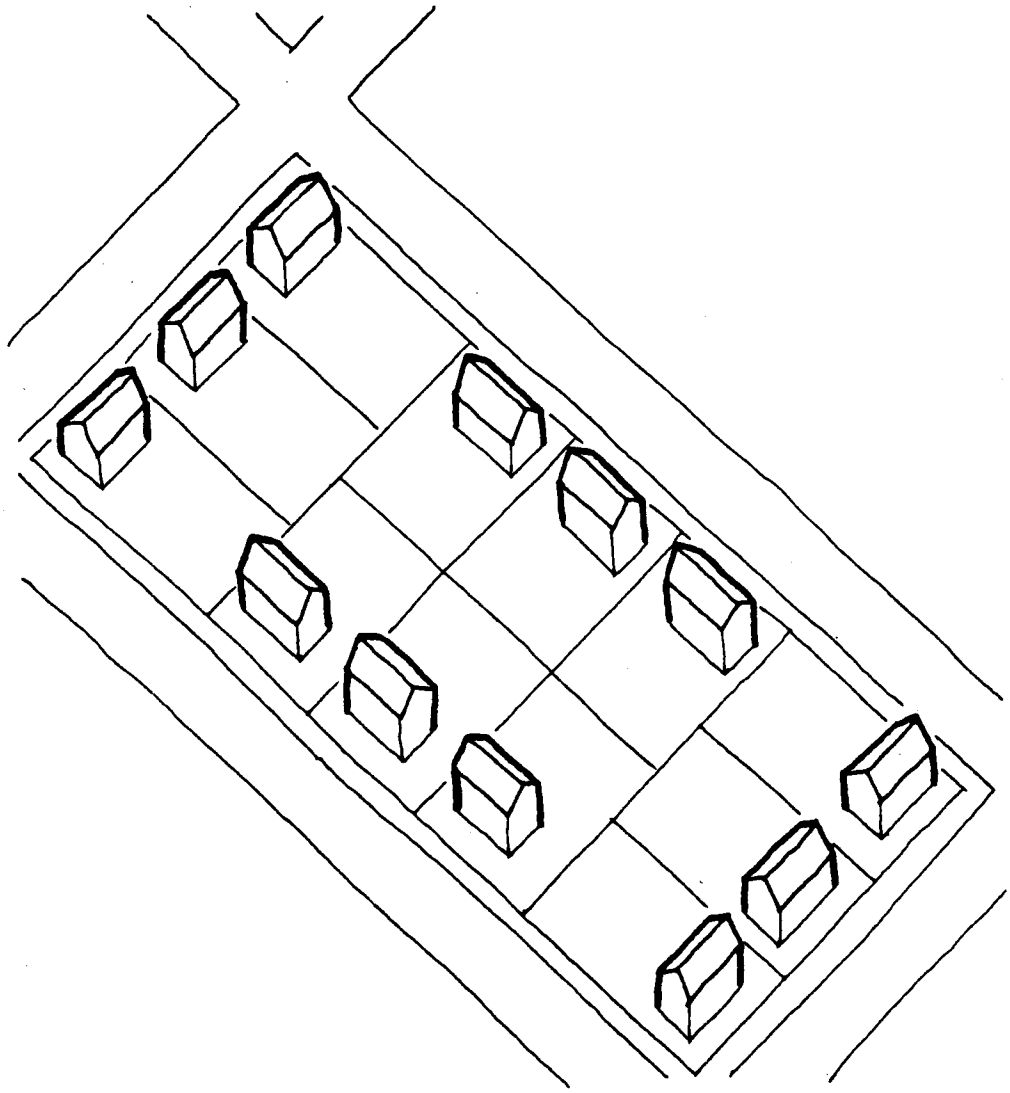


1.3.2.1/2 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- **single family**	- 30' x 40' (bungalow)	- parallel	- **space between blgs**
- row housing	- 25' x 40' (split level)	- **perimeter**	- site depth
- garden apartments	- **25' x 40' (two story)**	- penetrating	- **site width**
- high-rise apartments			

Block Size
200' x 475'
95,000 sq.ft.
2.2 acres
Gross Residential Area:
123,600 sq.ft.
2.8 acres
Lot Dimensions:
6@ 75' x 100'
6@ 66.7'x 125'
7,917 (average) sq.ft.
Number of Units:
12 @ 25' x 40'
Net Dwelling Density:
5.5 dwelling units/acre
Gross Residential Density:
4.2 dwelling units/acre
Coverage:
Net area = 0.13
Gross area = 0.10
Floor Area Ratio:
FAR = 0.26

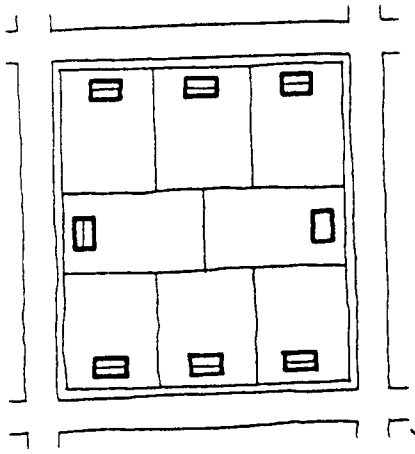


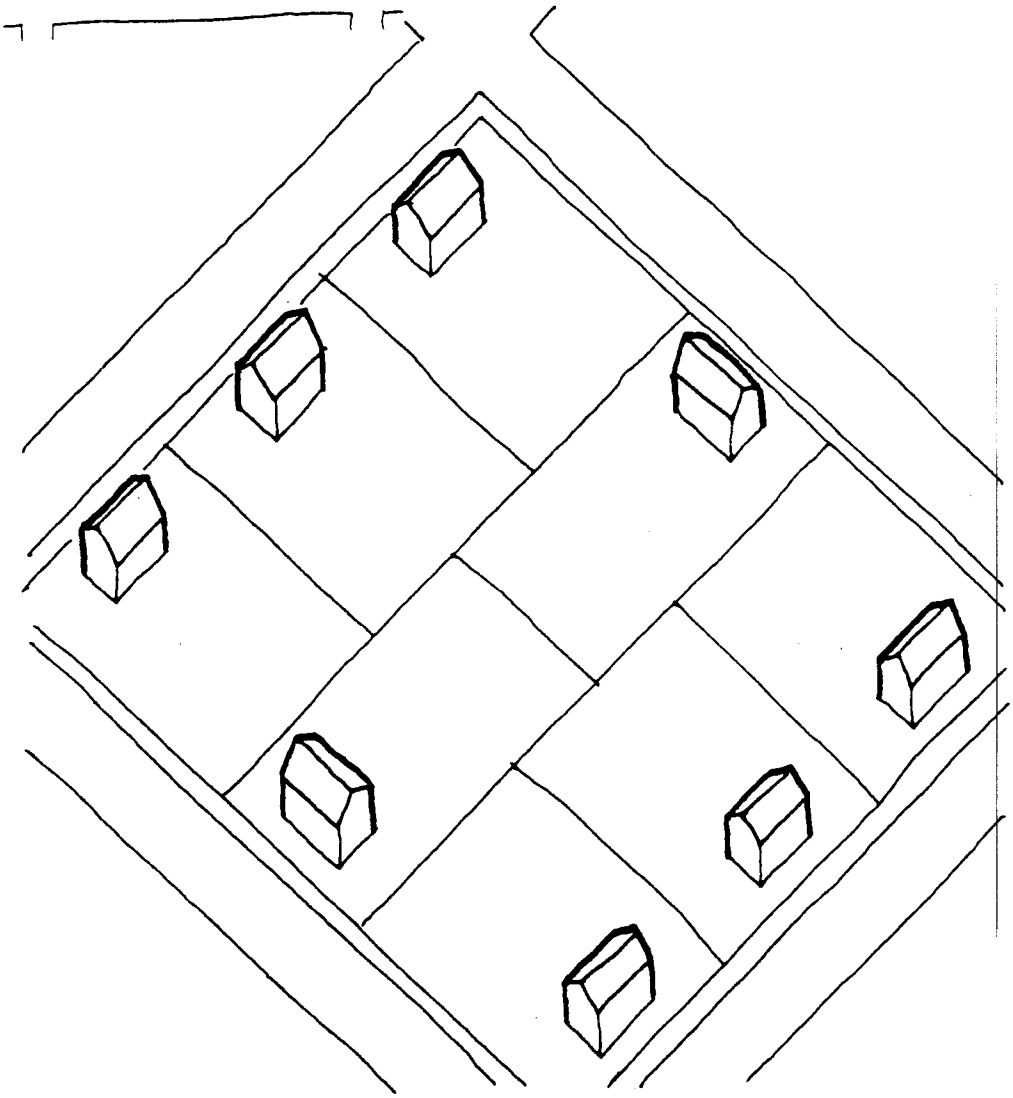


1.3.2.3 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- **single family**	- 30' x 40' (bungalow)	- parallel	- space between blgs
- row housing	- 25' x 40' (split level)	- **perimeter**	- site depth
- garden apartments	- **25' x 40' (two story)**	- penetrating	- **site width**
- high-rise apartments			

Block Size
350' x 400'
140,000 sq.ft.
3.2 acres
Gross Residential Area:
171,600 sq.ft.
3.9 acres
Lot Dimensions:
6 @ 116.7 x 150'
2 @ 100' x 175'
17,500 (average) sq.ft.
Number of Units:
8 @ 25' x 40'
Net Dwelling Density:
2.5 dwelling units/acre
Gross Residential Density:
2.0 dwelling units/acre
Coverage:
Net area = 0.06
Gross area = 0.05
Floor Area Ratio:
FAR = 0.11

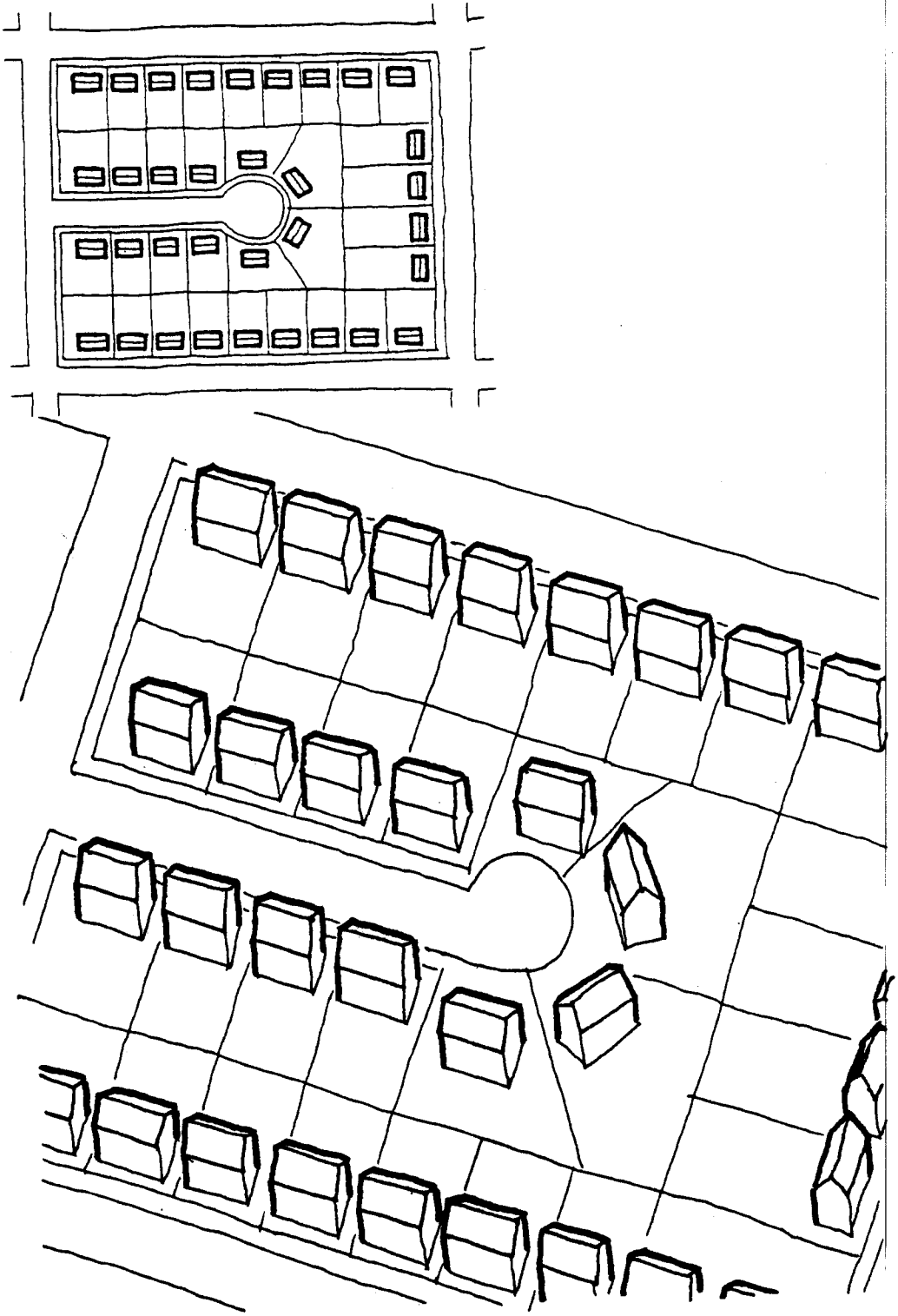




1.3.3.1/3 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- **single family** - row housing - garden apartments - high-rise apartments	- **30' x 40' (bungalow)** - 25' x 40' (split level) - 25' x 40' (two story)	- **parallel** - perimeter - penetrating	- **space between blgs** - site depth - site width

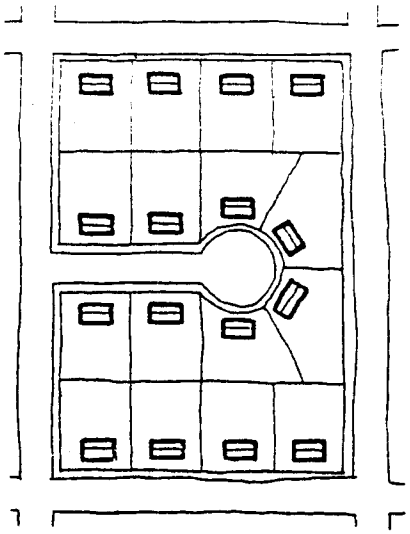
Block Size
420' x 530'
205,146 sq.ft.
4.7 acres
Gross Residential Area:
262,200 sq.ft.
6.0 acres
Lot Dimensions:
22 @ 45' x 90' (typical)
6@ 70' x 90'
6,838 (average) sq.ft.
Number of Units:
32 @ 25' x 40'
Net Dwelling Density:
6.4 dwelling units/acre
Gross Residential Density:
5.0 dwelling units/acre
Coverage:
Net area = 0.15
Gross area = 0.11
Floor Area Ratio:
FAR = 0.30

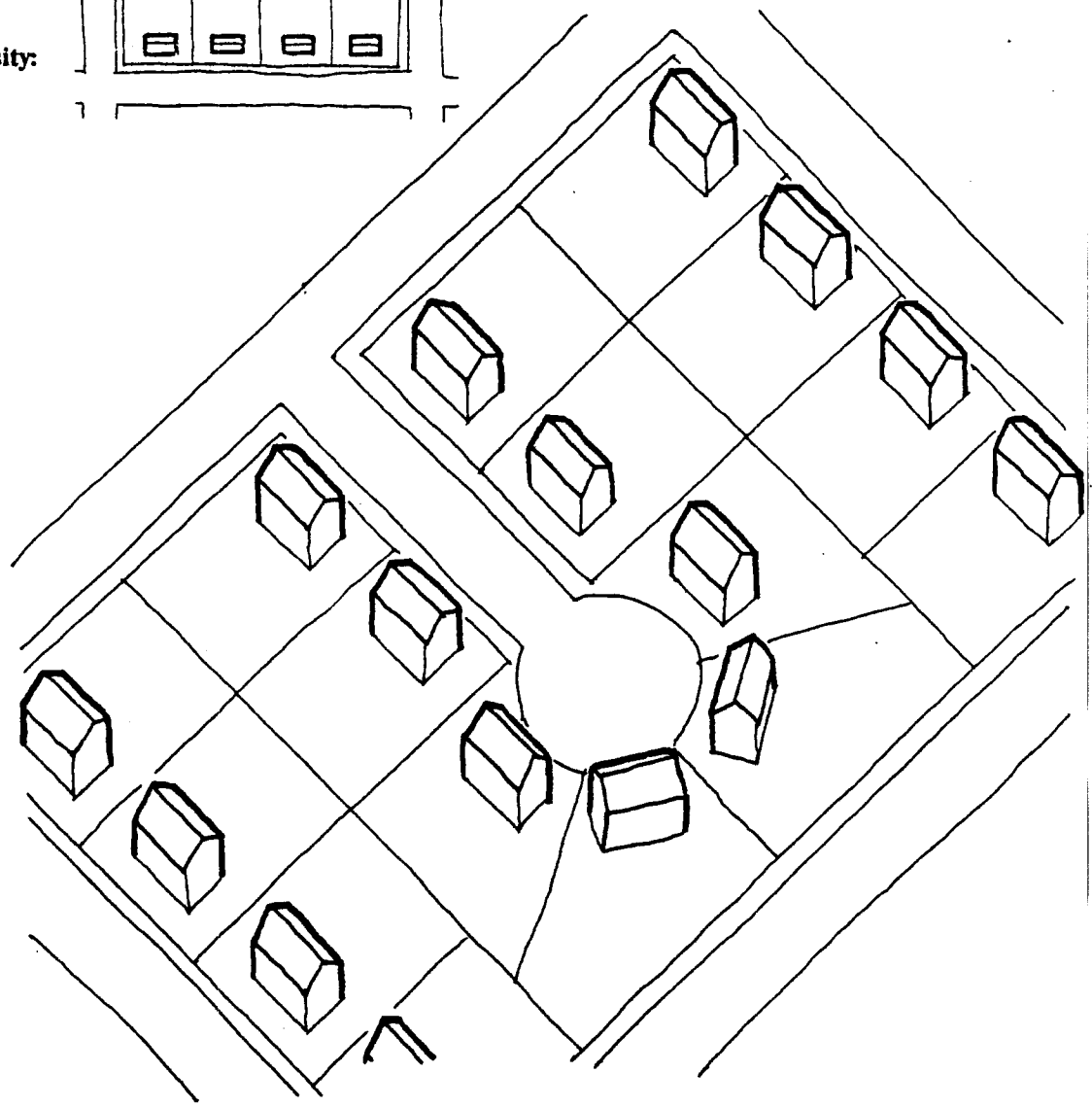


1.3.3.3 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- **single family**	- **30' x 40' (bungalow)**	- **parallel**	- space between blgs
- row housing	- 25' x 40' (split level)	- perimeter	- site depth
- garden apartments	- 25' x 40' (two story)	- penetrating	- **site width**
- high-rise apartments			

Block Size
520' x 350'
167,346 sq.ft.
3.8 acres
Gross Residential Area:
208,000 sq.ft.
4.8 acres
Lot Dimensions:
16@ 87.5'x 115'
10,063 (typical) sq.ft.
Number of Units:
20 @ 25' x 40'
Net Dwelling Density:
4.2 dwelling units/acre
Gross Residential Density:
3.3 dwelling units/acre
Coverage:
Net area = 0.10
Gross area = 0.08
Floor Area Ratio:
FAR = 0.19

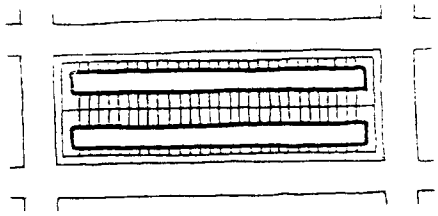


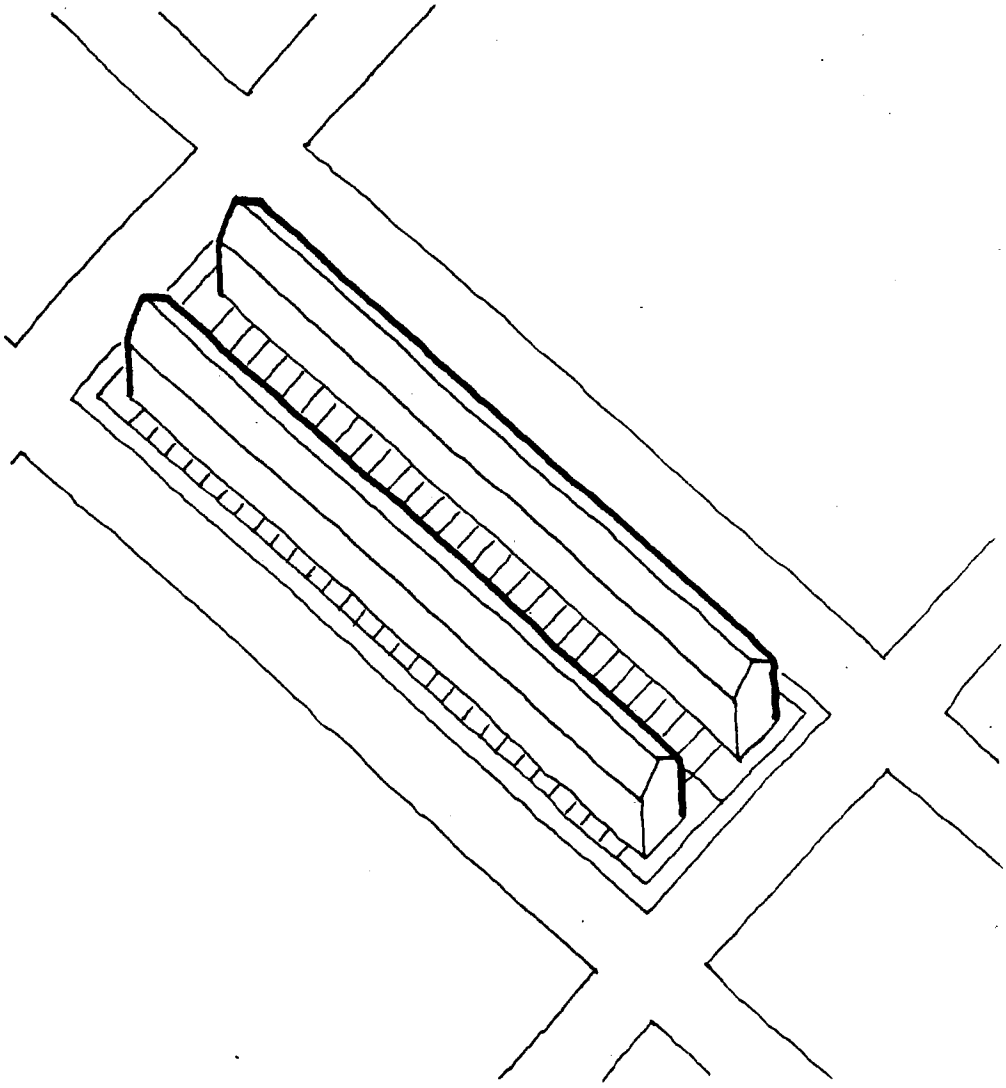


2.1.1.2 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family - **row housing** - garden apartments - high-rise apartments	- **12' x 30' (three story)** - 18' x 22' (three story) - 18' x 30' (two story) - 18' x 40' (two story) - 20' x 30' (two story) - 20' x 40' (two story) - 25' x 30' (two story) - 25' x 36'(two story)	- **parallel** - perimeter - penetrating	- space between blgs - **site depth** - site width

Block Size
120' x 380'
45,600 sq.ft.
1.1 acres
Gross Residential Area:
67,200 sq.ft.
1.5 acres
Lot Dimensions:
56 @ 12' x 60'
4 @ 21' x 60'
720 (typical) sq.ft.
Number of Units:
60 @ 1,080 s.f.
Net Dwelling Density:
57.1 dwelling units/acre
Gross Residential Density:
39.0 dwelling units/acre
Coverage:
Net area = 0.47
Gross area = 0.32
Floor Area Ratio:
FAR = 1.4

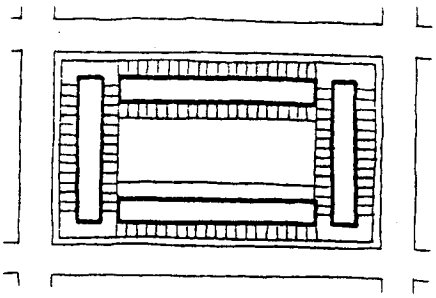


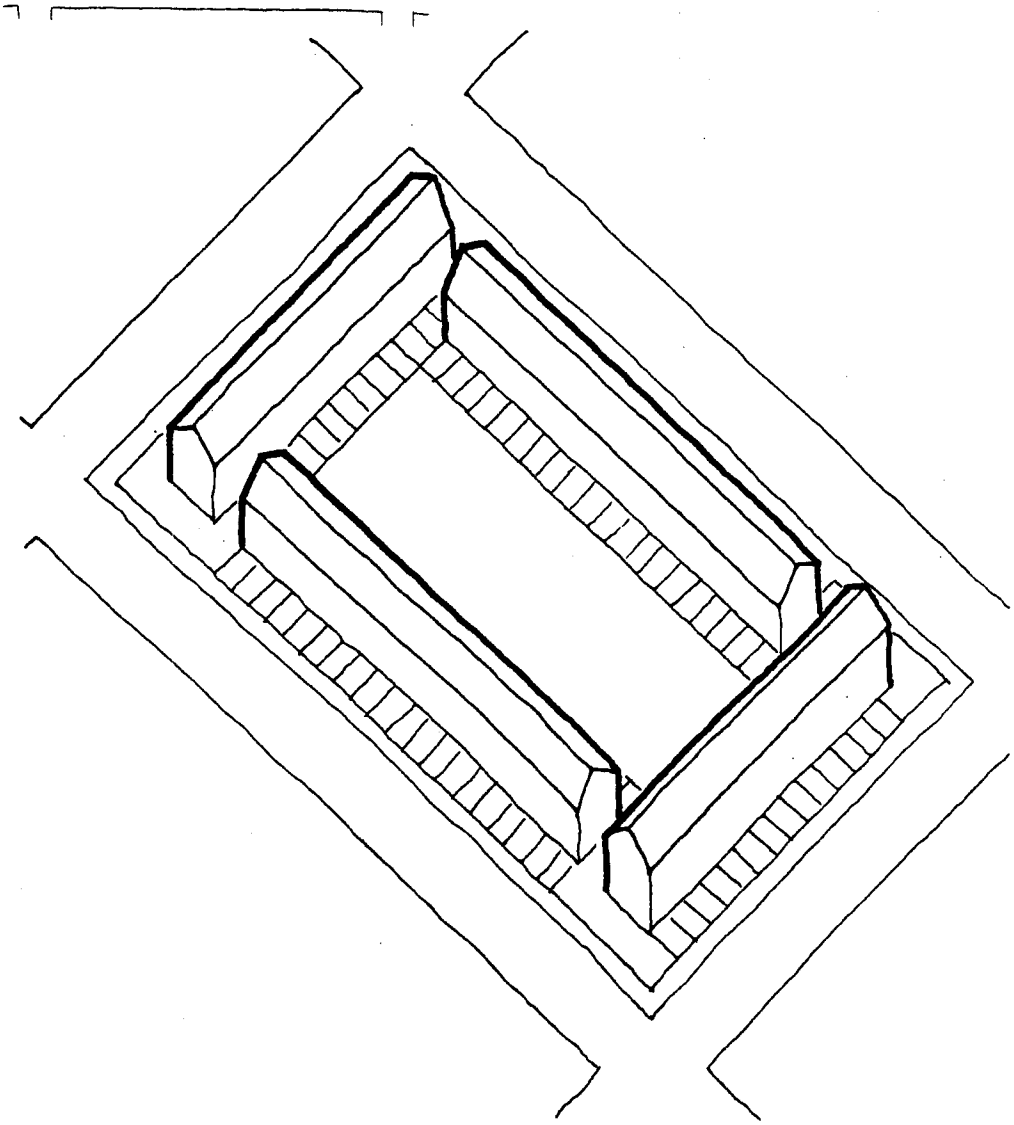


2.1.2.3 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- **12' x 30' (three story)**	- parallel	- space between blgs
- **row housing**	- 18' x 22' (three story)	- **perimeter**	- site depth
- garden apartments	- 18' x 30' (two story)	- penetrating	- **site width**
- high-rise apartments	- 18' x 40' (two story)		
	- 20' x 30' (two story)		
	- 20' x 40' (two story)		
	- 25' x 30' (two story)		
	- 25' x 36'(two story)		

Block Size
220' x 380'
83,600 sq.ft.
1.9 acres
Gross Residential Area:
109,200 sq.ft.
2.5 acres
Lot Dimensions:
66 @ 12' x 70'
4 @ 32' x 70'840 (typical)
sq.ft.
Number of Units:
70 @ 1,080 sq.ft.
Net Dwelling Density:
36.5 dwelling units/acre
Gross Residential Density:
28.0 dwelling units/acre
Coverage:
Net area = 0.30
Gross area = 0.23
Floor Area Ratio:
FAR = 0.90

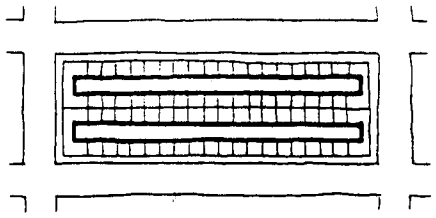


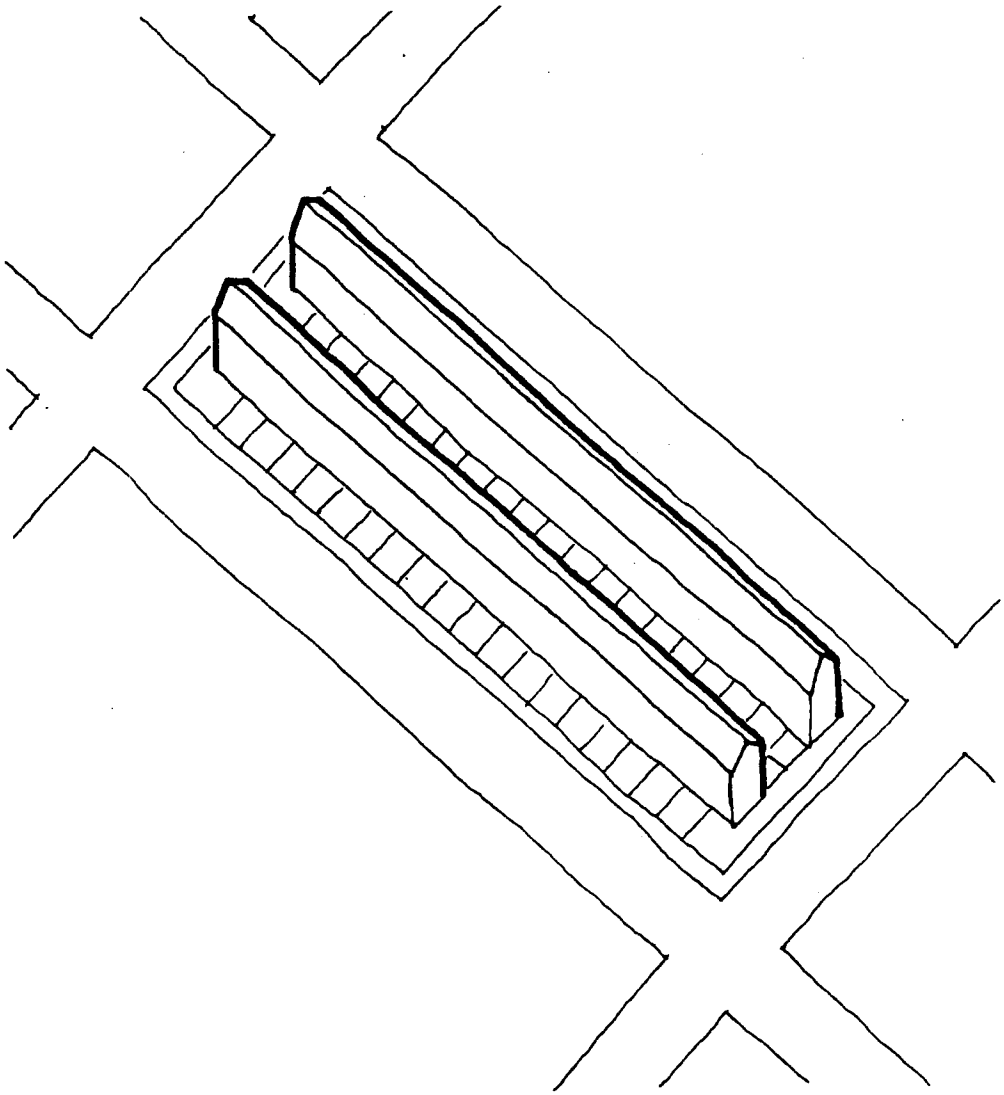


2.2.1.2 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 12' x 30' (three story)	- **parallel**	- space between blgs
- **row housing**	- **18' x 22' (three story)**	- perimeter	- **site depth**
- garden apartments	- 18' x 30' (two story)	- penetrating	- site width
- high-rise apartments	- 18' x 40' (two story)		
	- 20' x 30' (two story)		
	- 20' x 40' (two story)		
	- 25' x 30' (two story)		
	- 25' x 36'(two story)		

Block Size
120' x 380'
45,600 sq.ft.
1.1 acres
Gross Residential Area:
67,200 sq.ft.
1.5 acres
Lot Dimensions:
34 @ 18' x 60'
4 @ 28' x 60'
1,080 sq.ft.
Number of Units:
38 @ 792 sq.ft.
Net Dwelling Density:
36.2 dwelling units/acre
Gross Residential Density:
25.3 dwelling units/acre
Coverage:
Net area = 0.33
Gross area = 0.22
Floor Area Ratio:
FAR = 0.66

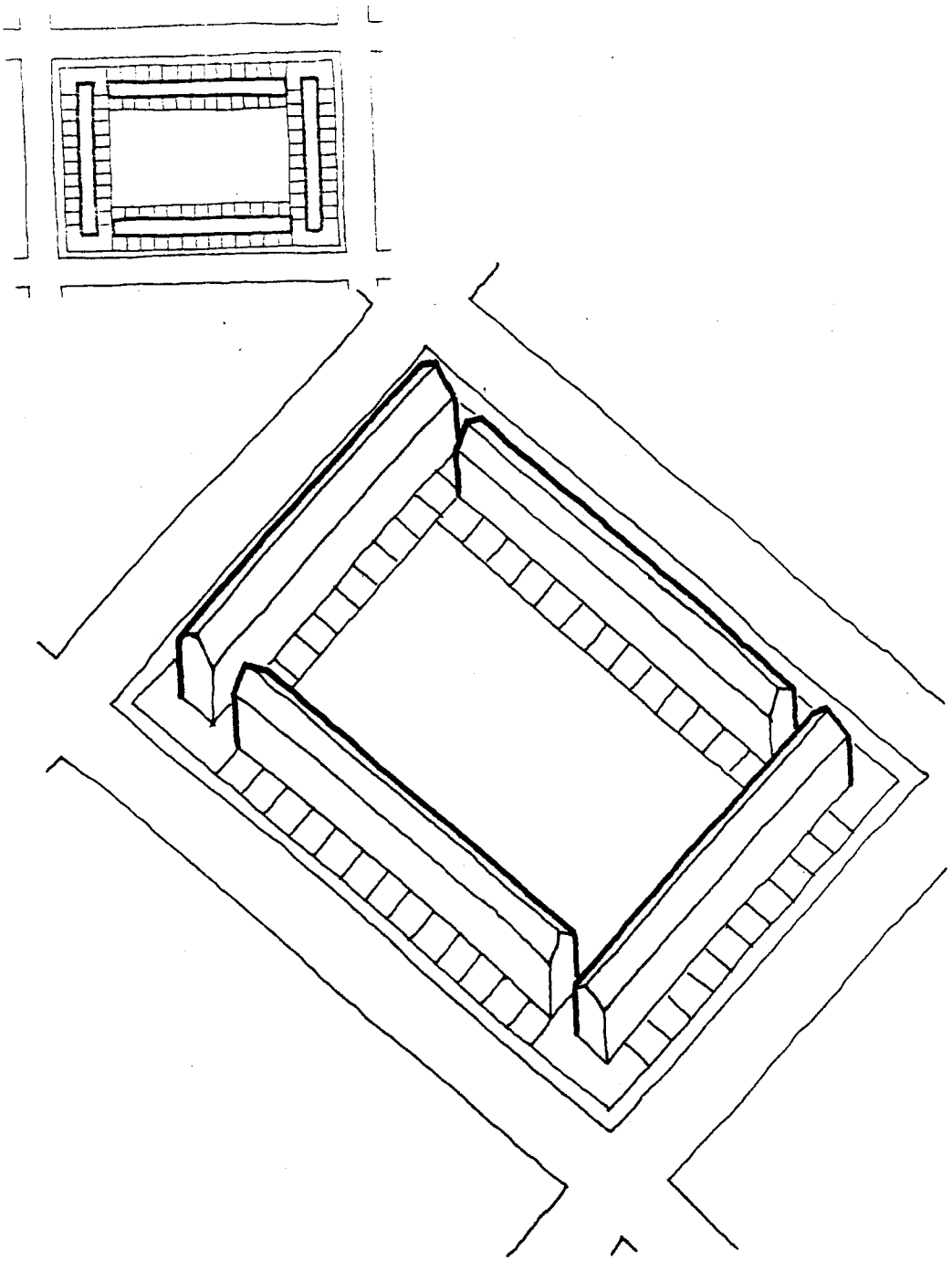




2.2.2.2 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 12' x 30' (three story)	- parallel	- space between blgs
- **row housing**	- **18' x 22' (three story)**	- **perimeter**	- **site depth**
- garden apartments	- 18' x 30' (two story)	- penetrating	- site width
- high-rise apartments	- 18' x 40' (two story)		
	- 20' x 30' (two story)		
	- 20' x 40' (two story)		
	- 25' x 30' (two story)		
	- 25' x 36'(two story)		

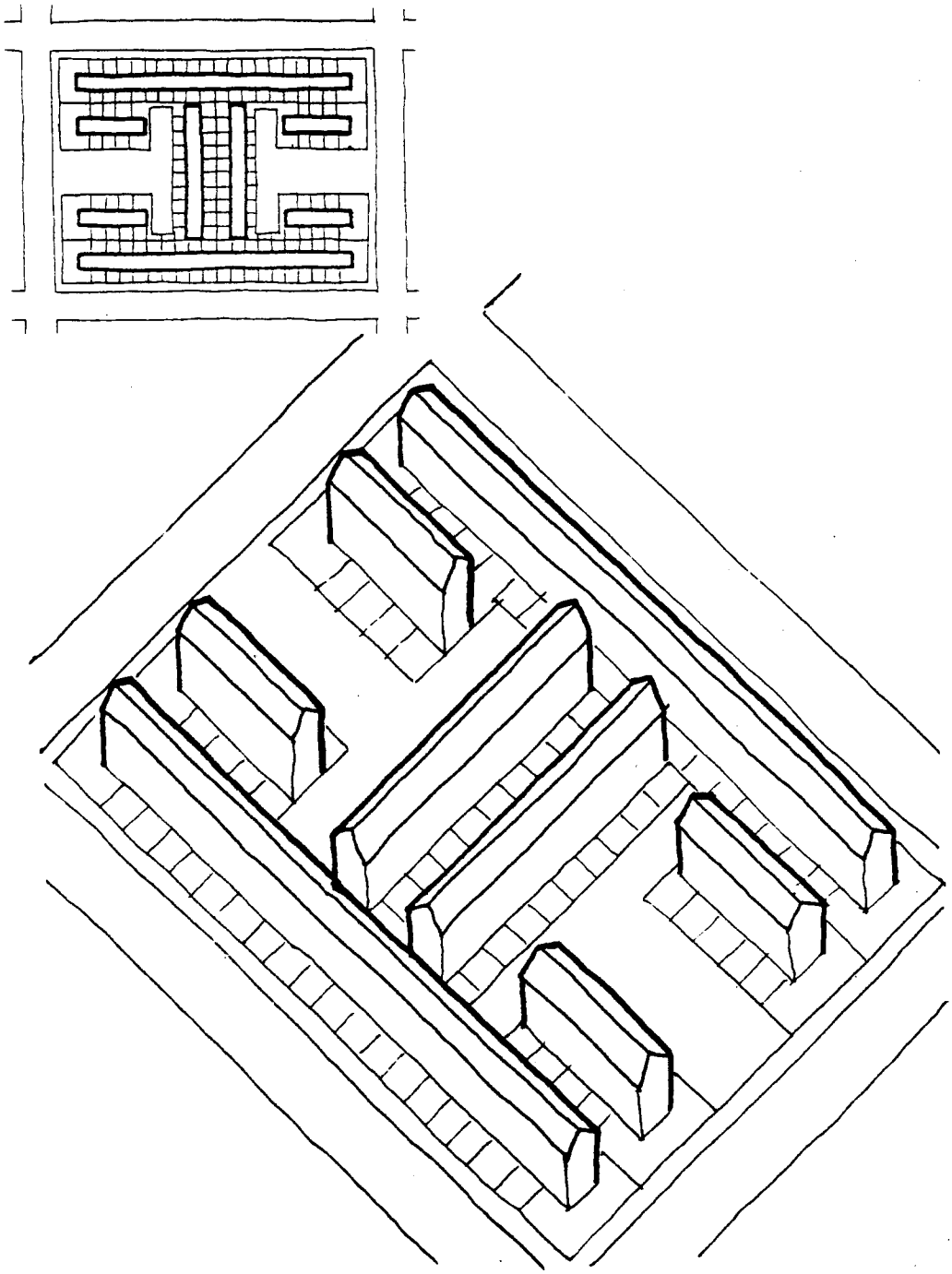
Block Size
256' x 354'
90,624 sq.ft.
2.1 acres
Gross Residential Area:
116,624 sq.ft.
2.7 acres
Lot Dimensions:
46 @ 18' x 60'
4 @ 38' x 60'
1,080 (typical) sq.ft.
Number of Units:
50 @ 792 sq.ft.
Net Dwelling Density:
24.0 dwelling units/acre
Gross Residential Density:
18.7 dwelling units/acre
Coverage:
Net area = 0.22
Gross area = 0.17
Floor Area Ratio:
FAR = 0.44



2.2.3.2 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 12' x 30' (three story)	- parallel	- space between blgs
- **row housing**	- **18' x 22' (three story)**	- perimeter	- **site depth**
- garden apartments	- 18' x 30' (two story)	- **penetrating**	- site width
- high-rise apartments	- 18' x 40' (two story)		
	- 20' x 30' (two story)		
	- 20' x 40' (two story)		
	- 25' x 30' (two story)		
	- 25' x 36'(two story)		

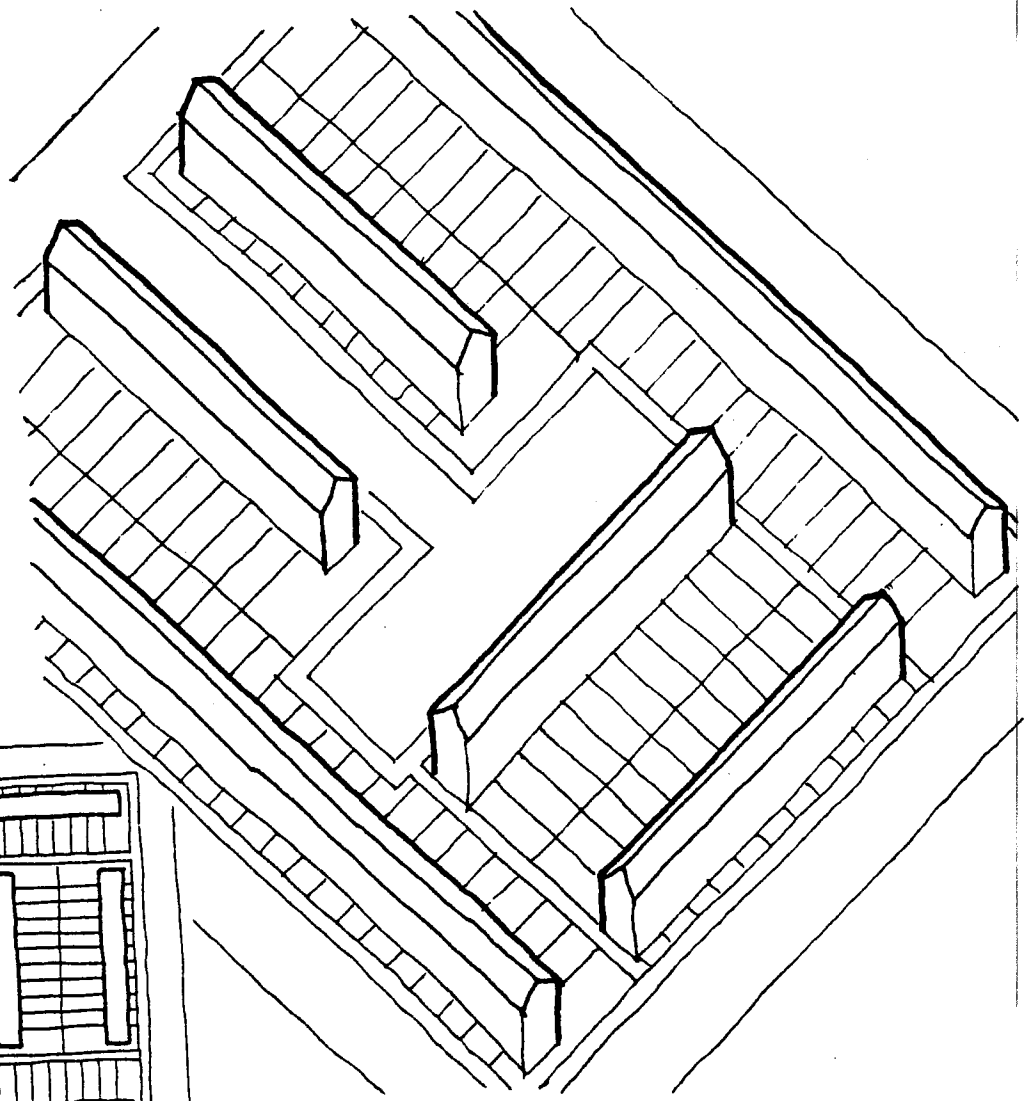
Block Size
300' x 400'
120,000 sq.ft.
2.75 acres
Gross Residential Area:
149,600 sq.ft.
3.4 acres
Lot Dimensions:
76 @ 18' x 60'
4 @ 38' x 60'
1,080 (typical) sq.ft.
Number of Units:
80 @ 792 sq.ft.
Net Dwelling Density:
29.1 dwelling units/acre
Gross Residential Density:
23.3 dwelling units/acre
Coverage:
Net area = 0.26
Gross area = 0.21
Floor Area Ratio:
FAR = 0.52

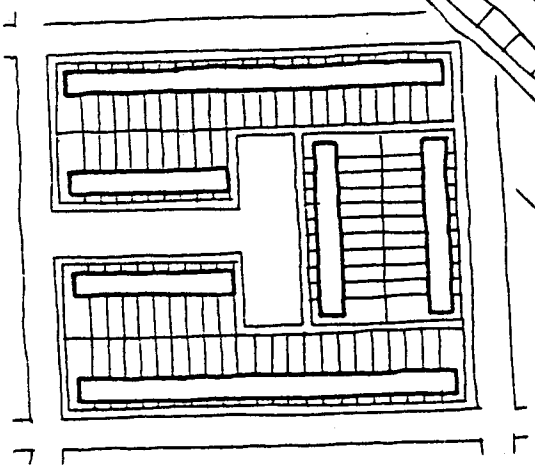


2.2.3.3 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family - **row housing** - garden apartments - high-rise apartments	- 12' x 30' (three story) - **18' x 22' (three story)** - 18' x 30' (two story) - 18' x 40' (two story) - 20' x 30' (two story) - 20' x 40' (two story) - 25' x 30' (two story) - 25' x 36'(two story)	- parallel - perimeter - **penetrating**	- space between blgs - site depth - **site width**

Block Size:
380' x 470'
146,880 sq.ft.
3.4 acres
Gross Residential Area:
182,480 sq.ft.
4.2 acres
Lot Dimensions:
86 @ 18' x 80'
6 @ 28' x 80'
2 @ 28' x 80'
1,440 (typical) sq.ft.
Number of Units:
94 @ 792 sq.ft.
Net Dwelling Density:
27.9 dwelling units/acre
Gross Residential Density:
22.4 dwelling units/acre
Coverage:
Net area = 0.25
Gross area = 0.20
Floor Area Ratio:
FAR = 0.5

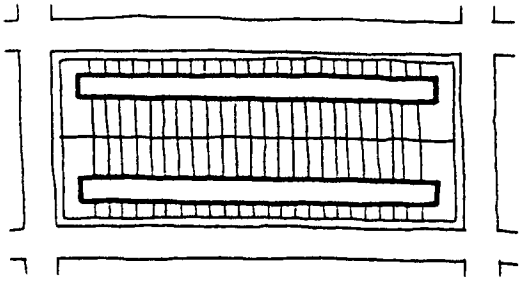


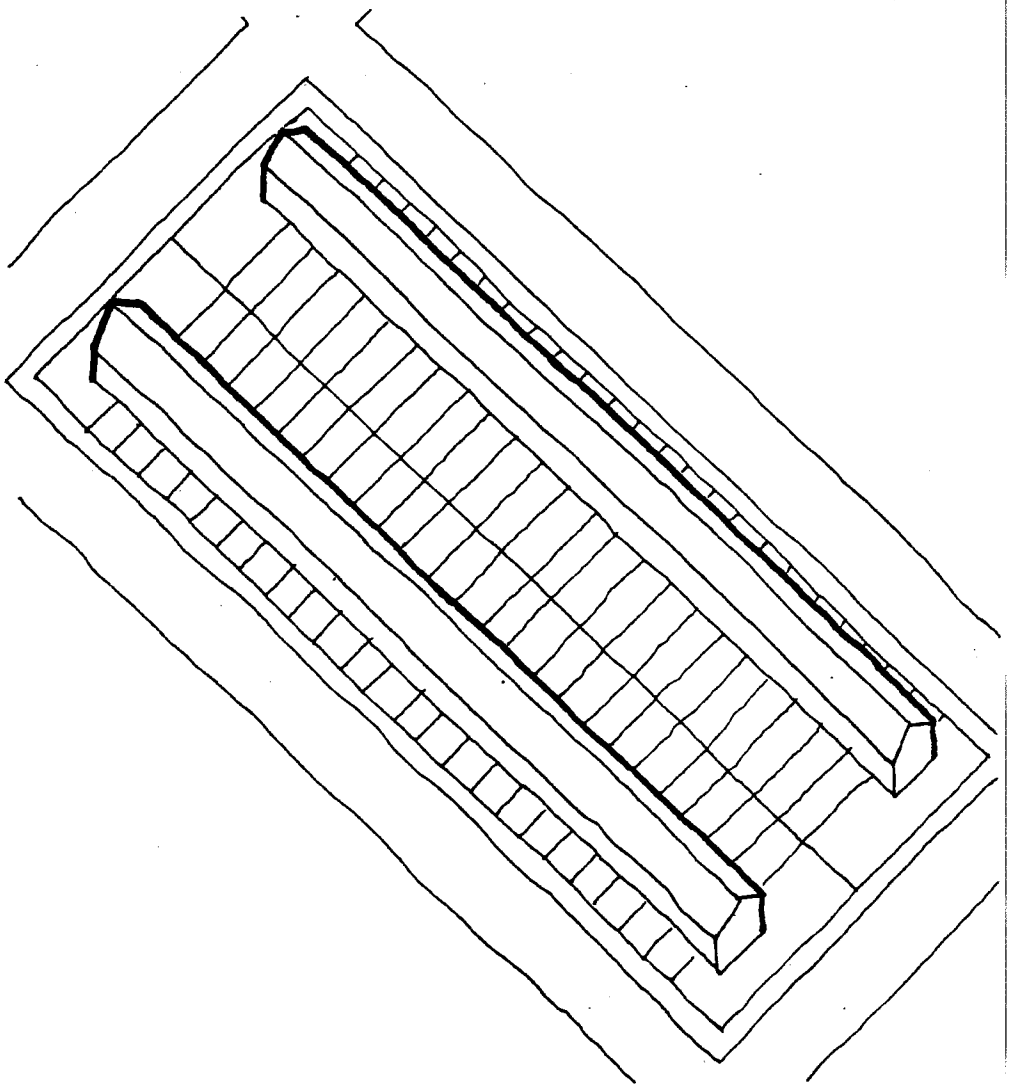


2.3.1.3 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family - **row housing** - garden apartments - high-rise apartments	- 12' x 30' (three story) - 18' x 22' (three story) - **18' x 30' (two story)** - 18' x 40' (two story) - 20' x 30' (two story) - 20' x 40' (two story) - 25' x 30' (two story) - 25' x 36'(two story)	- **parallel** - perimeter - penetrating	- space between blgs - site depth - **site width**

Block Size
200' x 490'
98,000 sq.ft.
2.25 acres
Gross Residential Area:
127,200 sq.ft.
2.9 acres
Lot Dimensions:
46 @ 18' x 100'
4 @ 38' x 100'
1,800 (typical) sq.ft.
Number of Units:
50 @ 1,080 s.f.
Net Dwelling Density:
22.2 dwelling units/acre
Gross Residential Density:
D17.1 dwelling units/acre
Coverage:
Net area = 0.28
Gross area = 0.21
Floor Area Ratio:
FAR = 0.56

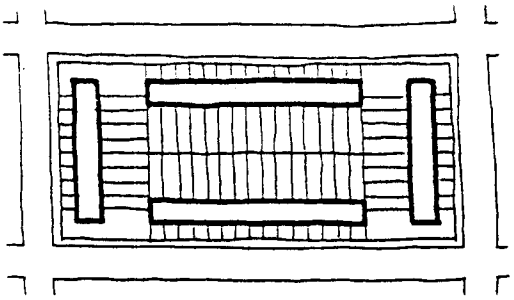


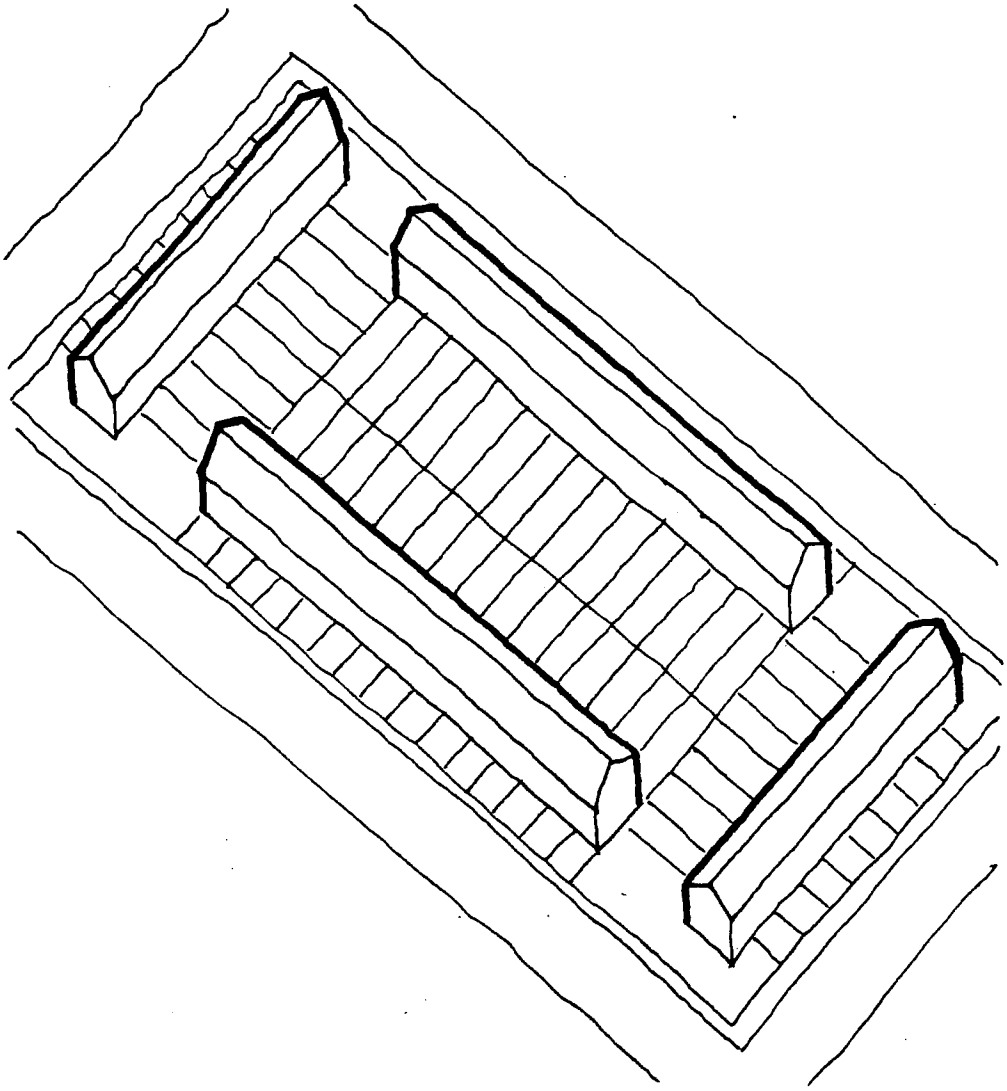


2.3.2.2 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family - **row housing** - garden apartments - high-rise apartments	- 12' x 30' (three story) - 18' x 22' (three story) - **18' x 30' (two story)** - 18' x 40' (two story) - 20' x 30' (two story) - 20' x 40' (two story) - 25' x 30' (two story) - 25' x 36'(two story)	- parallel - **perimeter** - penetrating	- space between blgs - **site depth** - site width

Block Size
220' x 490'
107,800 sq.ft.
2.5 acres
Gross Residential Area:
137,800 sq.ft.
3.2 acres
Lot Dimensions:
46 @ 18' x 110'
4 @ 38' x 110'
1,980 sq.ft.
Number of Units:
50 @ 1080 sq.ft.
Net Dwelling Density:
20.2 dwelling units/acre
Gross Residential Density:
15.8 dwelling units/acre
Coverage:
Net area = 0.25
Gross area = 0.20
Floor Area Ratio:
FAR = 0.50

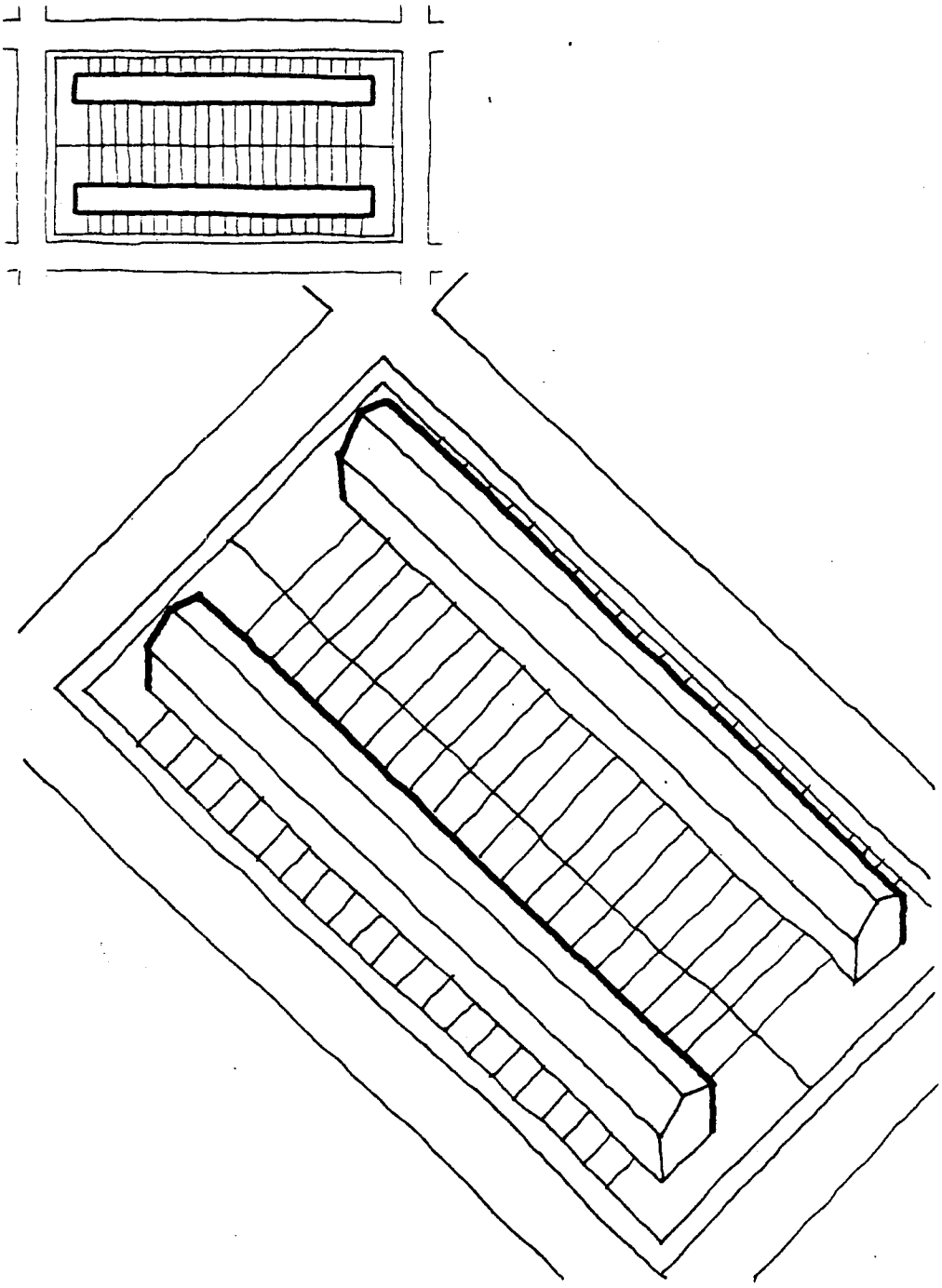




2.4.1.2 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 12' x 30' (three story)	- **parallel**	- space between blgs
- **row housing**	- 18' x 22' (three story)	- perimeter	- **site depth**
- garden apartments	- 18' x 30' (two story)	- penetrating	- site width
- high-rise apartments	- **18' x 40' (two story)**		
	- 20' x 30' (two story)		
	- 20' x 40' (two story)		
	- 25' x 30' (two story)		
	- 25' x 36'(two story)		

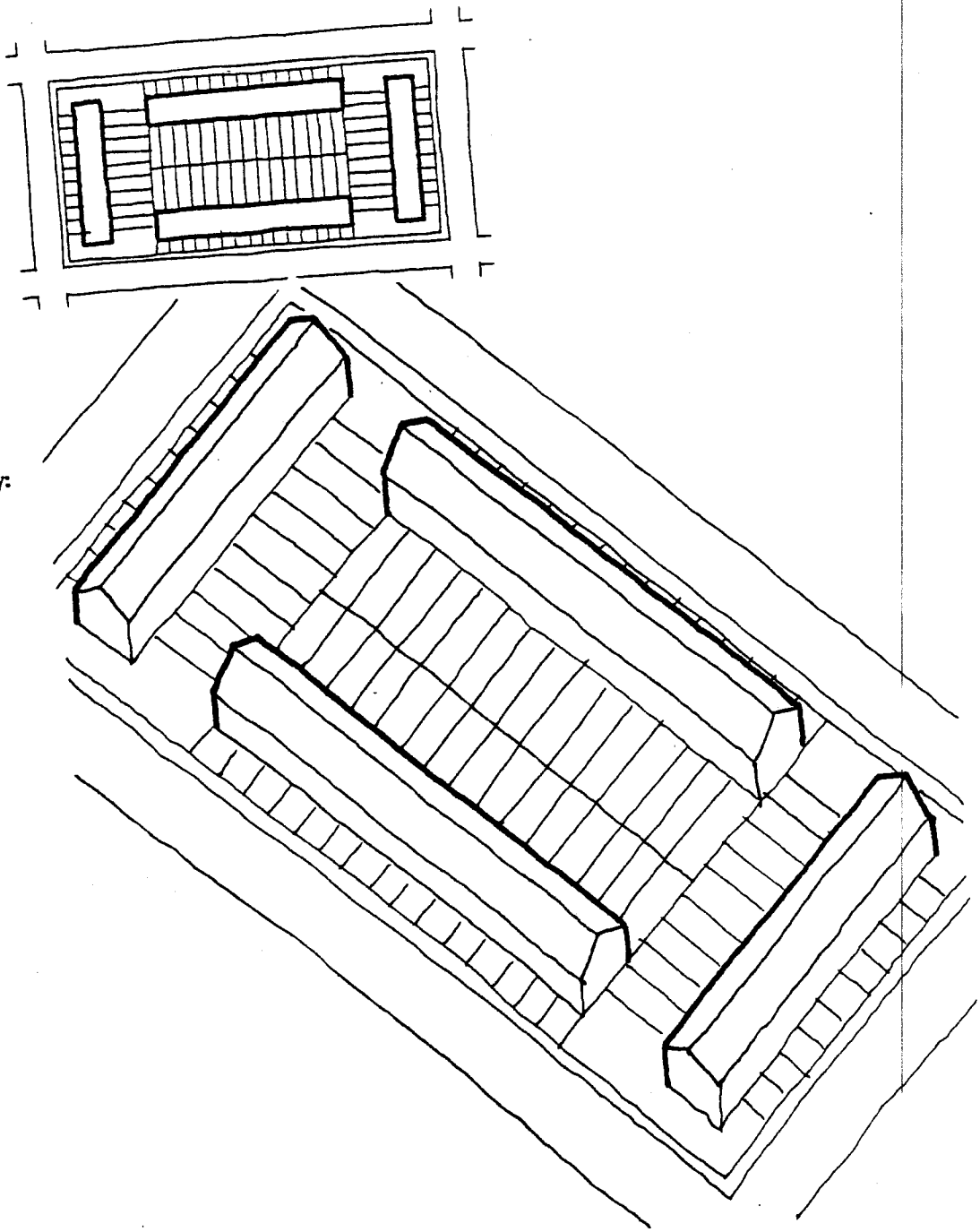
Block Size
240' x 446'
107,040 sq.ft.
2.5 acres
Gross Residential Area:
136,000 sq.ft.
3.1 acres
Lot Dimensions:
40 @ 18' x 120'
4 @ 43' x 120'
2,160 (typical) sq.ft.
Number of Units:
44 @ 1,440 sq.ft.
Net Dwelling Density:
17.9 dwelling units/acre
Gross Residential Density:
14.1 dwelling units/acre
Coverage:
Net area = 0.30
Gross area = 0.23
Floor Area Ratio:
FAR = 0.60



2.4.2.3 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family - **row housing** - garden apartments - high-rise apartments	- 12' x 30' (three story) - 18' x 22' (three story) - 18' x 30' (two story) - **18' x 40' (two story)** - 20' x 30' (two story) - 20' x 40' (two story) - 25' x 30' (two story) - 25' x 36'(two story)	- parallel - **perimeter** - penetrating	- space between blgs - site depth - **site width**

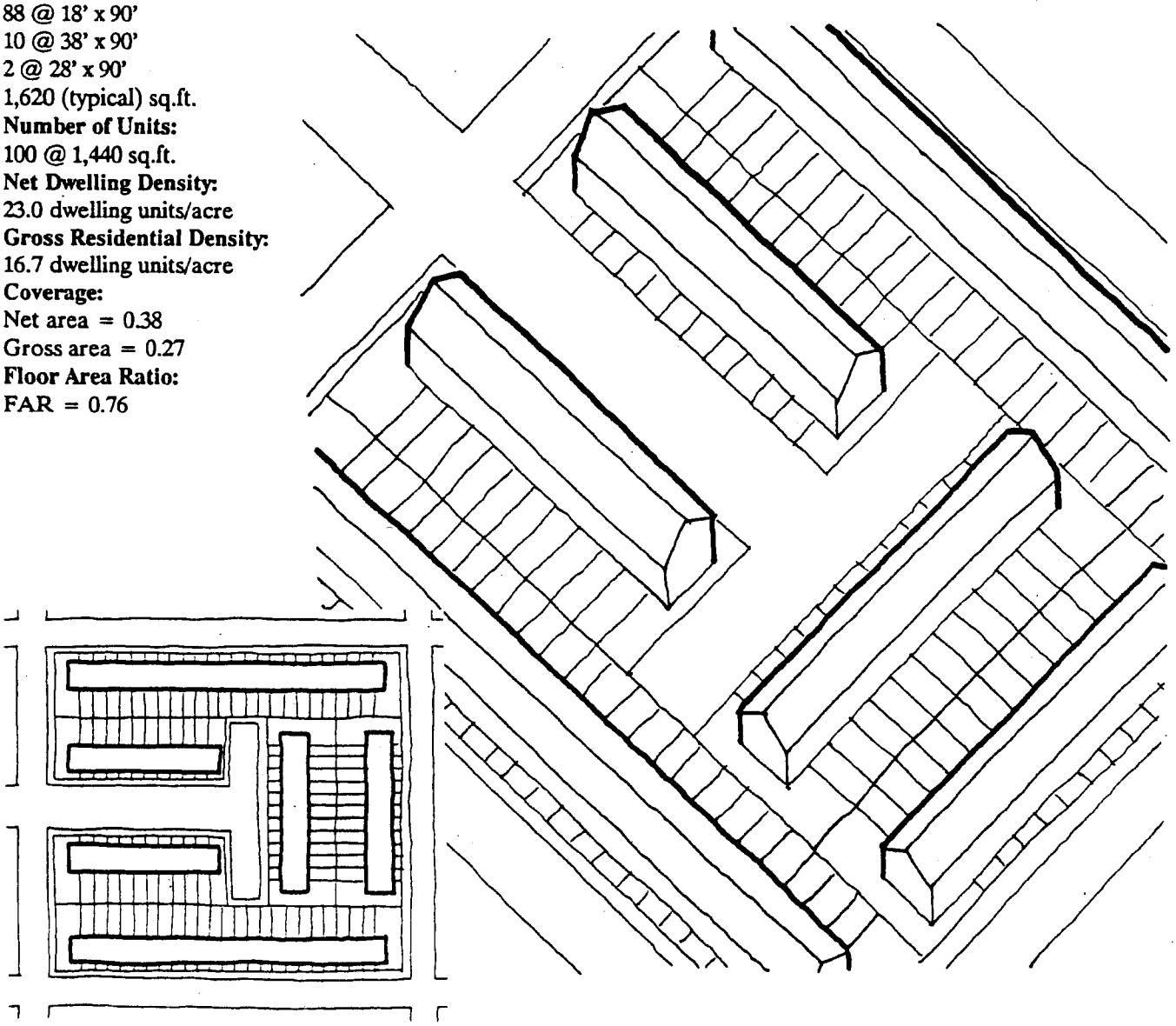
Block Size
240' x 510'
122,400 sq.ft.
2.8 acres
Gross Residential Area:
154,000 sq.ft.
3.5 acres
Lot Dimensions:
48 @ 18' x 120'
4 @ 39' x 120'
2,160 (typical) sq.ft.
Number of Units:
52 @ 1,440 sq.ft.
Net Dwelling Density:
18.5 dwelling units/acre
Gross Residential Density:
14.7 dwelling units/acre
Coverage:
Net area = 0.31
Gross area = 0.24
Floor Area Ratio:
FAR = 0.62



2.4.3.2 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 12' x 30' (three story)	- parallel	- space between blgs
- **row housing**	- 18' x 22' (three story)	- perimeter	- **site depth**
- garden apartments	- 18' x 30' (two story)	- **penetrating**	- site width
- high-rise apartments	- **18' x 40' (two story)**		
	- 20' x 30' (two story)		
	- 20' x 40' (two story)		
	- 25' x 30' (two story)		
	- 25' x 36'(two story)		

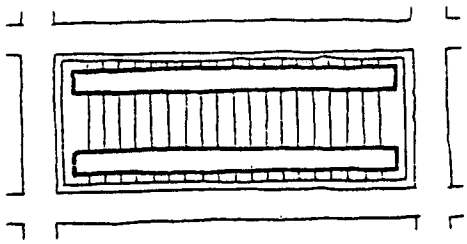
Block Size
455' x 490'
189,218 sq.ft.
4.3 acres
Gross Residential Area:
262,350 sq.ft.
6.0 acres
Lot Dimensions:
88 @ 18' x 90'
10 @ 38' x 90'
2 @ 28' x 90'
1,620 (typical) sq.ft.
Number of Units:
100 @ 1,440 sq.ft.
Net Dwelling Density:
23.0 dwelling units/acre
Gross Residential Density:
16.7 dwelling units/acre
Coverage:
Net area = 0.38
Gross area = 0.27
Floor Area Ratio:
FAR = 0.76

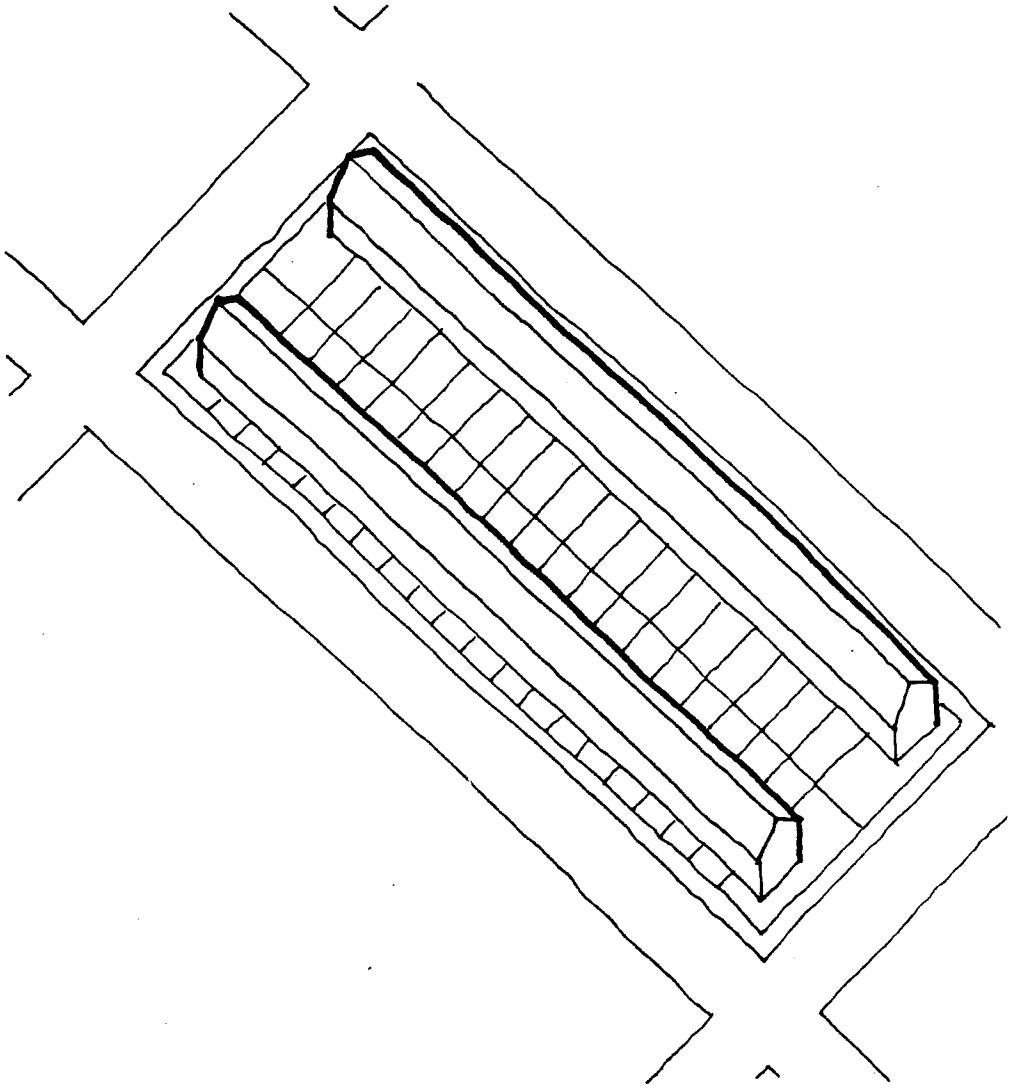


2.5.1.2 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family - **row housing** - garden apartments - high-rise apartments	- 12' x 30' (three story) - 18' x 22' (three story) - 18' x 30' (two story) - 18' x 40' (two story) - **20' x 30' (two story)** - 20' x 40' (two story) - 25' x 30' (two story) - 25' x 36'(two story)	- **parallel** - perimeter - penetrating	- space between blgs - **site depth** - site width

Block Size
150' x 420'
63,000 sq.ft.
1.45 acres
Gross Residential Area:
87,400 sq.ft.
2.0 acres
Lot Dimensions:
36 @ 20' x 75'
4 @ 30' x 75'
1,500 (typical) sq.ft.
Number of Units:
40 @ 1,200 sq.ft.
Net Dwelling Density:
27.6 dwelling units/acre
Gross Residential Density:
20.0 dwelling units/acre
Coverage:
Net area = 0.38
Gross area = 0.27
Floor Area Ratio:
FAR = 0.76

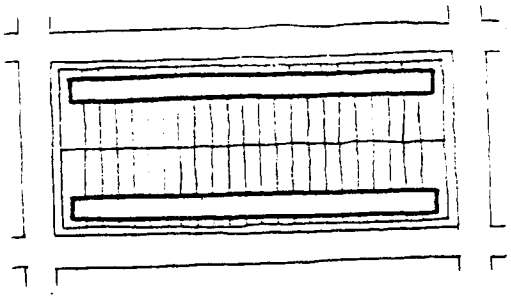


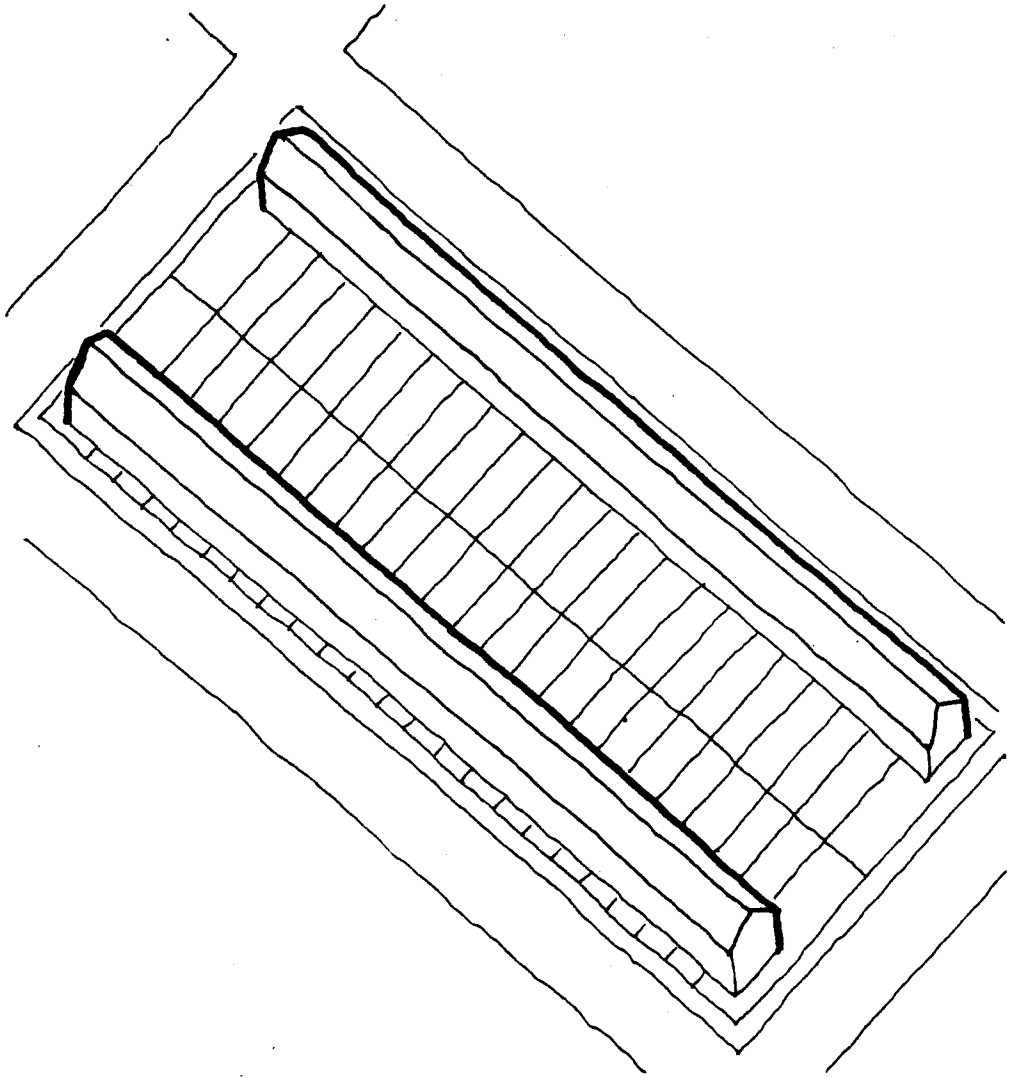


2.5.1.2/3 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family - **row housing** - garden apartments - high-rise apartments	- 12' x 30' (three story) - 18' x 22' (three story) - 18' x 30' (two story) - 18' x 40' (two story) - **20' x 30' (two story)** - 20' x 40' (two story) - 25' x 30' (two story) - 25' x 36'(two story)	- **parallel** - perimeter - penetrating	- space between blgs - **site depth** - **site width**

Block Size
200' x 480'
96,000 sq.ft.
2.2 acres
Gross Residential Area:
124,800 sq.ft.
2.87acres
Lot Dimensions:
42 @ 20' x 100'
4 @ 30' x 100'
2,000 sq.ft.
Number of Units:
46 @ 1,200 sq.ft.
Net Dwelling Density:
20.9 dwelling units/acre
Gross Residential Density:
16.0 dwelling units/acre
Coverage:
Net area = 0.29
Gross area = 0.22
Floor Area Ratio:
FAR = 0.58

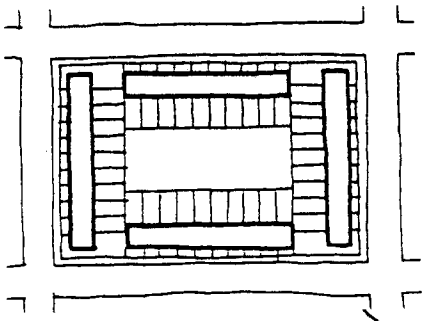


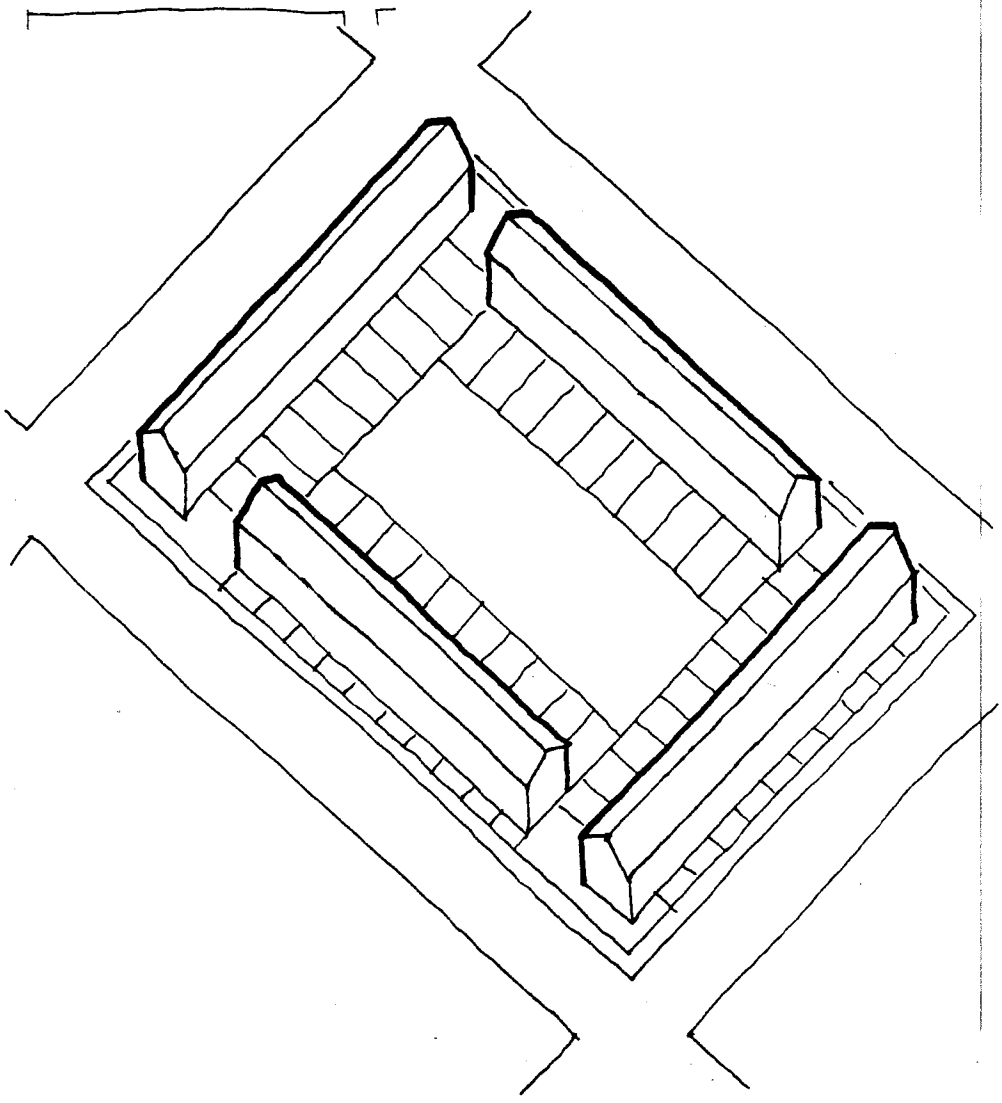


2.5.2.2 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family - **row housing** - garden apartments - high-rise apartments	- 12' x 30' (three story) - 18' x 22' (three story) - 18' x 30' (two story) - 18' x 40' (two story) - **20' x 30' (two story)** - 20' x 40' (two story) - 25' x 30' (two story) - 25' x 36'(two story)	- parallel - **perimeter** - penetrating	- space between blgs - **site depth** - site width

Block Size
240' x 360'
86,400 sq.ft.
1.9 acres
Gross Residential Area:
112,000 sq.ft.
2.6 acres
Lot Dimensions:
38 @ 20' x 80'
4 @ 30' x 80'
1,600 (typical) sq.ft.
Number of Units:
42 @ 1,200 sq.ft.
Net Dwelling Density:
21.2 dwelling units/acre
Gross Residential Density:
16.3 dwelling units/acre
Coverage:
Net area = 0.29
Gross area = 0.22
Floor Area Ratio:
FAR = 0.58

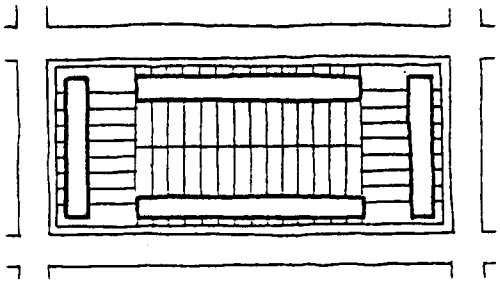


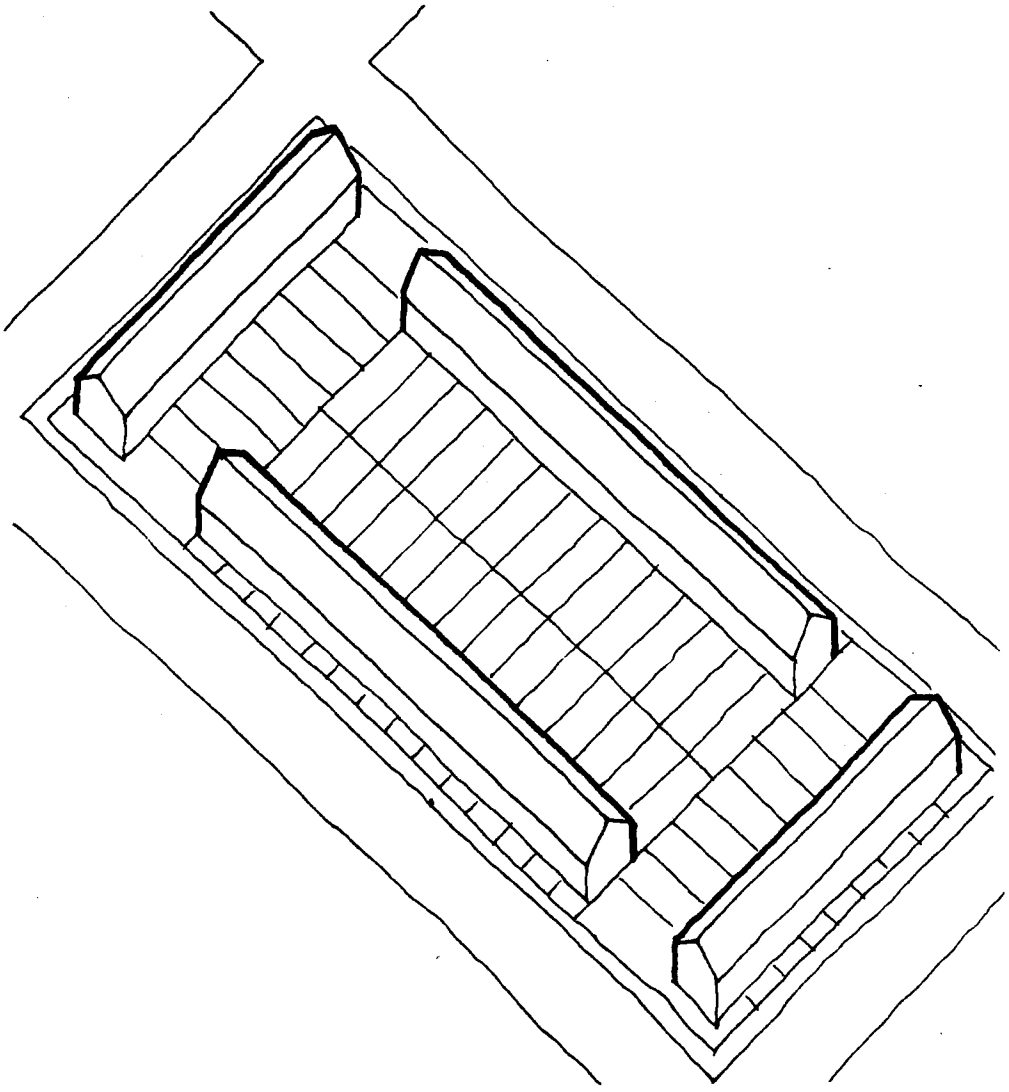


2.5.2.2/3 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 12' x 30' (three story)	- parallel	- space between blgs
- **row housing**	- 18' x 22' (three story)	- **perimeter**	- **site depth**
- garden apartments	- 18' x 30' (two story)	- penetrating	- **site width**
- high-rise apartments	- 18' x 40' (two story)		
	- **20' x 30' (two story)**		
	- 20' x 40' (two story)		
	- 25' x 30' (two story)		
	- 25' x 36'(two story)		

Block Size
200' x 480'
96,000 sq.ft.
2.2 acres
Gross Residential Area:
124,800 sq.ft.
2.9 acres
Lot Dimensions:
42 @ 20' x 100'
4 @ 30' x 100'
2,000 (typical) sq.ft.
Number of Units:
46 @ 1,200 sq.ft.
Net Dwelling Density:
20.9 dwelling units/acre
Gross Residential Density:
16.0 dwelling units/acre
Coverage:
Net area = 0.31
Gross area = 0.24
Floor Area Ratio:
FAR = 0.62

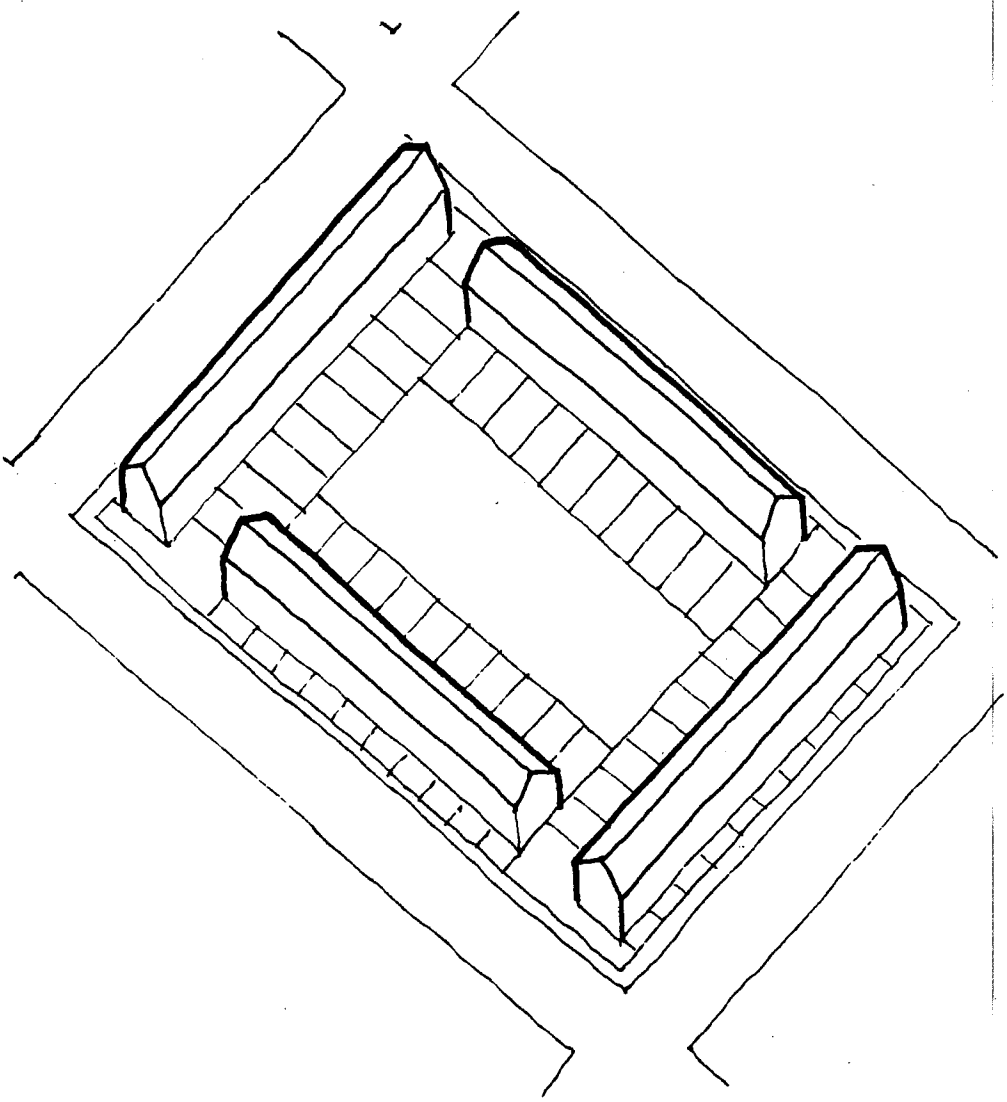




2.5.2.2/3 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family - **row housing** - garden apartments - high-rise apartments	- 12' x 30' (three story) - 18' x 22' (three story) - 18' x 30' (two story) - 18' x 40' (two story) - **20' x 30' (two story)** - 20' x 40' (two story) - 25' x 30' (two story) - 25' x 36'(two story)	- parallel - **perimeter** - penetrating	- space between blgs - **site depth** - **site width**

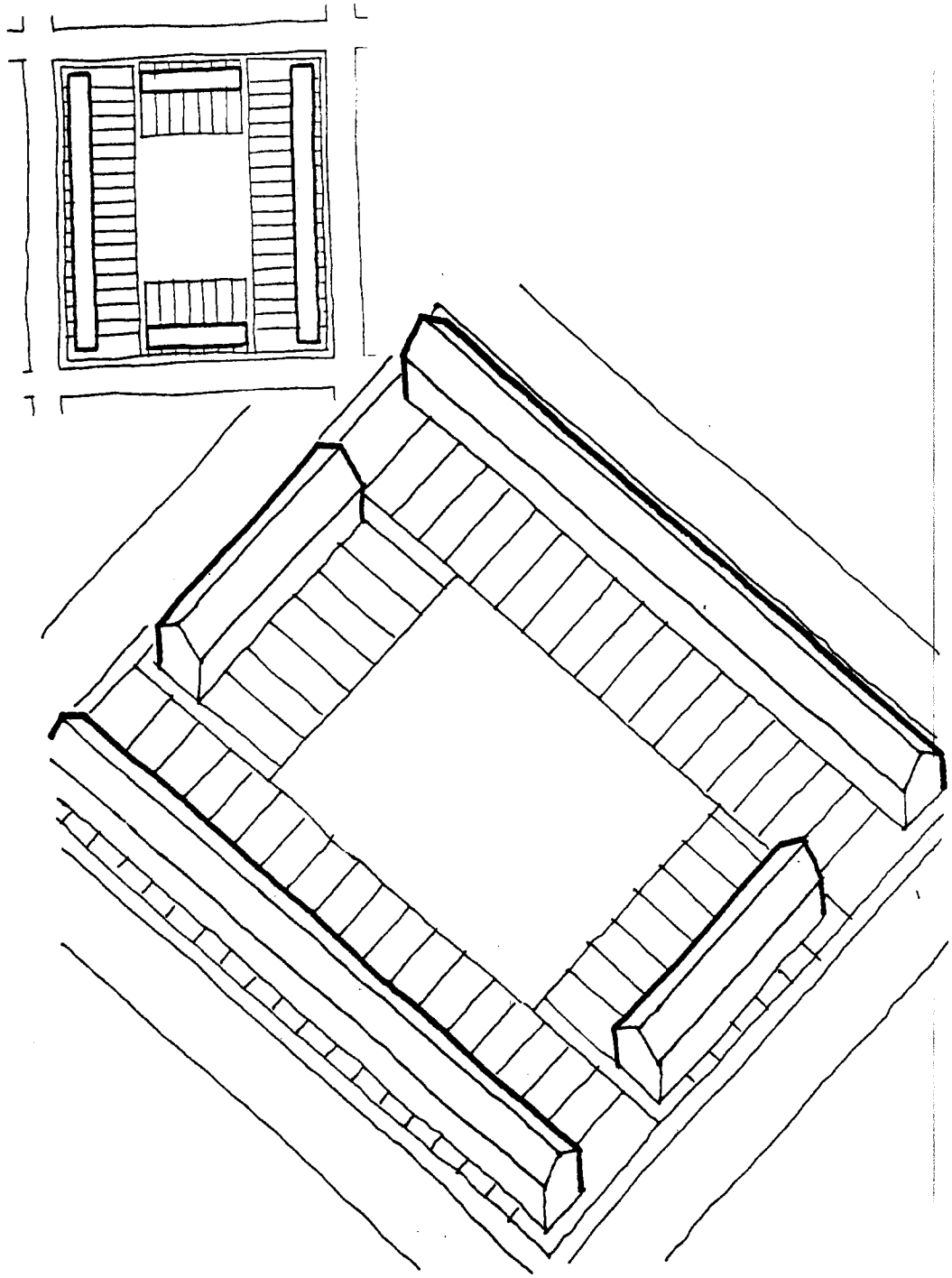
Block Size
360' x 400'
144,000 sq.ft.
3.3 acres
Gross Residential Area:
176,000 sq.ft.
4.0 acres
Lot Dimensions:
48 @ 20' x 100'
4 @ 30' x 100'
2,000 (typical) sq.ft.
Number of Units:
52 @ 1,200 sq.ft.
Net Dwelling Density:
15.8 dwelling units/acre
Gross Residential Density:
12.9 dwelling units/acre
Coverage:
Net area = 0.22
Gross area = 0.18
Floor Area Ratio:
FAR = 0.44



2.5.3.2/3 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family - **row housing** - garden apartments - high-rise apartments	- 12' x 30' (three story) - 18' x 22' (three story) - 18' x 30' (two story) - 18' x 40' (two story) - **20' x 30' (two story)** - 20' x 40' (two story) - 25' x 30' (two story) - 25' x 36'(two story)	- parallel - perimeter - **penetrating**	- space between blgs - site depth - site width

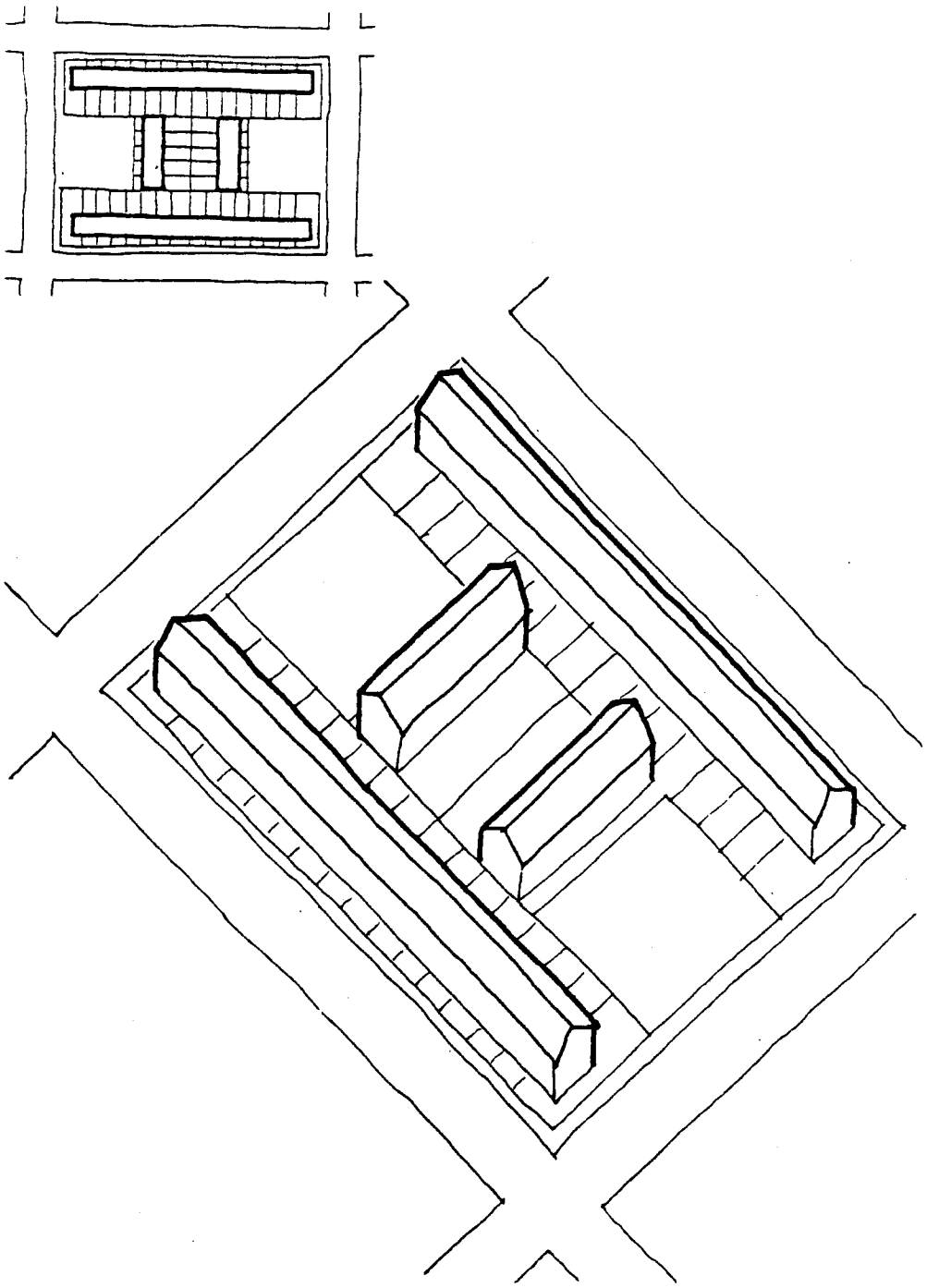
Block Size
440'x 480'
171,000 sq.ft.
3.9 acres
Gross Residential Area:
249,600 sq.ft.
5.7 acres
Lot Dimensions:
78 @ 20' x 90'
10 @ 30' x 90'
1,800 (typical) sq.ft.
Number of Units:
88 @ 1,200 sq.ft.
Net Dwelling Density:
22.4 dwelling units/acre
Gross Residential Density:
15.4 dwelling units/acre
Coverage:
Net area = 0.31
Gross area = 0.21
Floor Area Ratio:
FAR = 0.62



2.5.3.2 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 12' x 30' (three story)	- parallel	- space between blgs
- **row housing**	- 18' x 22' (three story)	- perimeter	- **site depth**
- garden apartments	- 18' x 30' (two story)	- **penetrating**	- site width
- high-rise apartments	- 18' x 40' (two story)		
	- **20' x 30' (two story)**		
	- 20' x 40' (two story)		
	- 25' x 30' (two story)		
	- 25' x 36'(two story)		

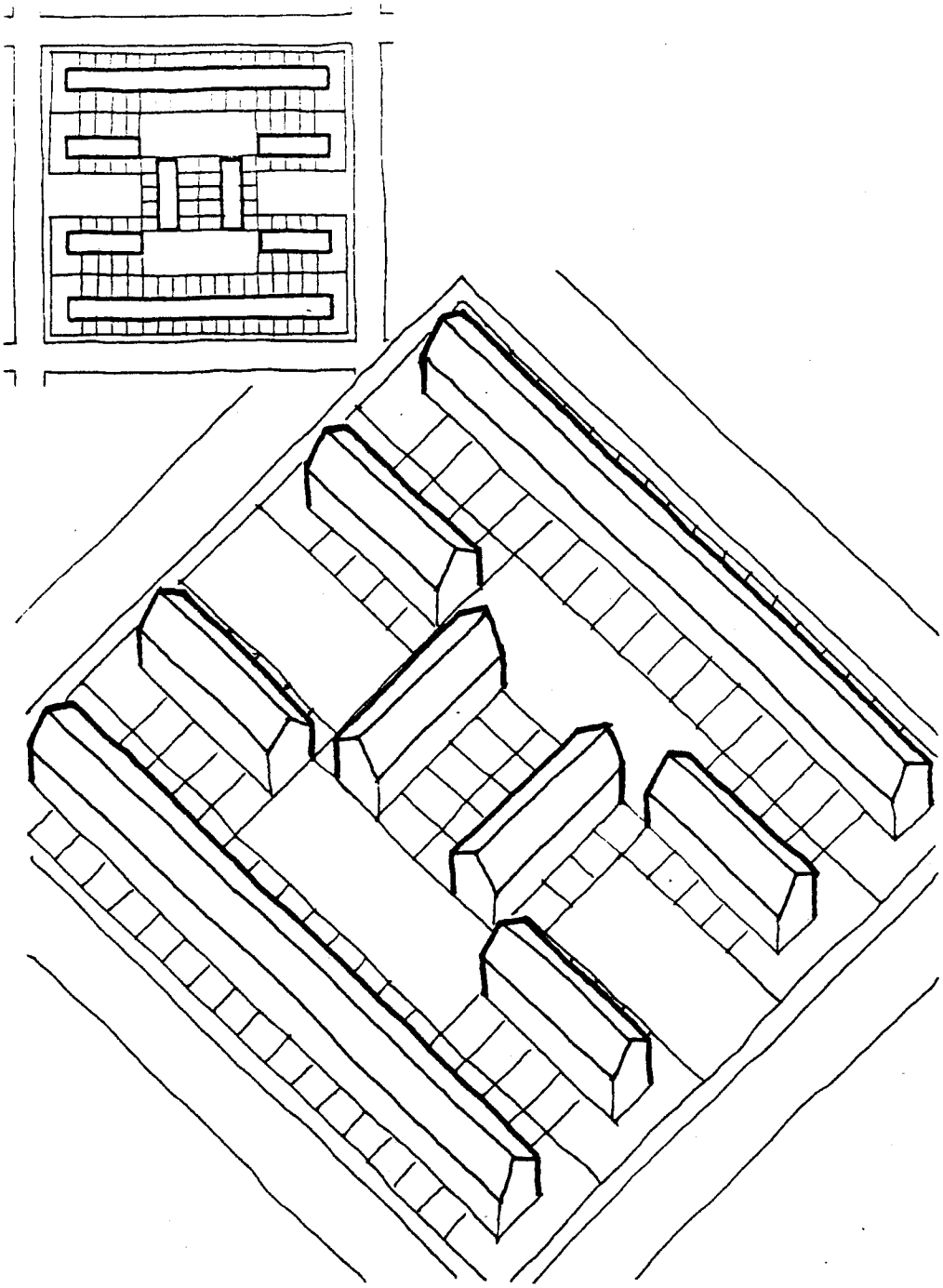
Block Size:
250' x 340'
85,000 sq.ft.
1.95 acres
Gross Residential Area:
110,200 sq.ft.
2.5 acres
Lot Dimensions:
38 @ 20' x 75'
4 @ 30' x 75'
1,500 (typical) sq.ft.
Number of Units:
42 @ 1,200 sq.ft.
Net Dwelling Density:
21.5 dwelling units/acre
Gross Residential Density:
16.6 dwelling units/acre
Coverage:
Net area = 0.30
Gross area = 0.23
Floor Area Ratio:
FAR = 0.60



2.5.3.2 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 12' x 30' (three story)	- parallel	- space between blgs
- **row housing**	- 18' x 22' (three story)	- perimeter	- **site depth**
- garden apartments	- 18' x 30' (two story)	- **penetrating**	- site width
- high-rise apartments	- 18' x 40' (two story)		
	- **20' x 30' (two story)**		
	- 20' x 40' (two story)		
	- 25' x 30' (two story)		
	- 25' x 36'(two story)		

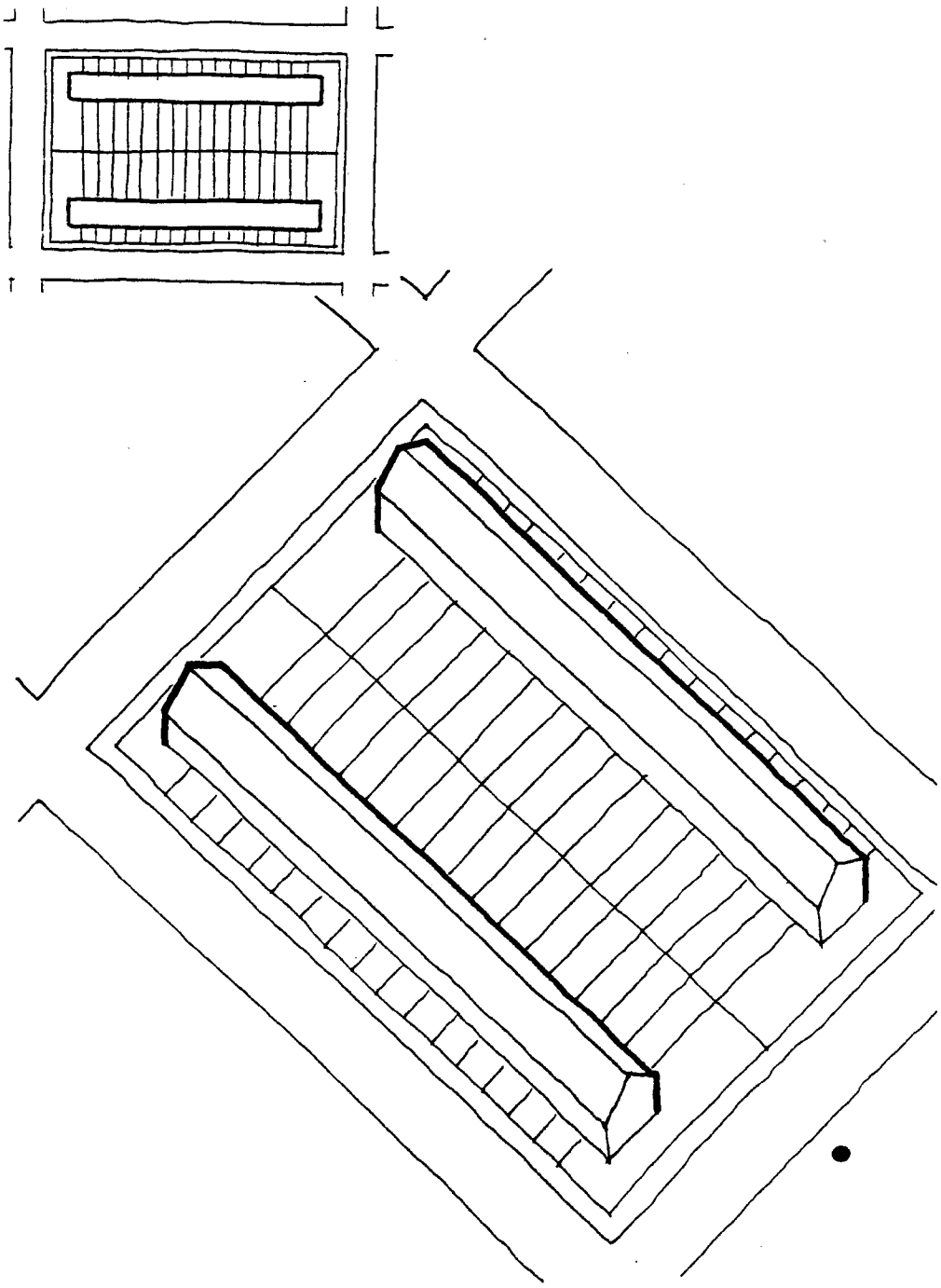
Block Size
380' x 400'
152,000 sq.ft.
3.49 acres
Gross Residential Area:
184,800 sq.ft.
4.2 acres
Lot Dimensions:
60 @ 20' x 80'
8 @ 40' x 80'
1,600 (typical) sq.ft.
Number of Units:
68 @ 1200 sq.ft.
Net Dwelling Density:
19.5 dwelling units/acre
Gross Residential Density:
16.0 dwelling units/acre
Coverage:
Net area = 0.27
Gross area = 0.22
Floor Area Ratio:
FAR = 0.54



2.6.1.2 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 12' x 30' (three story)	- **parallel**	- space between blgs
- **row housing**	- 18' x 22' (three story)	- perimeter	- **site depth**
- garden apartments	- 18' x 30' (two story)	- penetrating	- site width
- high-rise apartments	- 18' x 40' (two story)		
	- 20' x 30' (two story)		
	- **20' x 40' (two story)**		
	- 25' x 30' (two story)		
	- 25' x 36'(two story)		

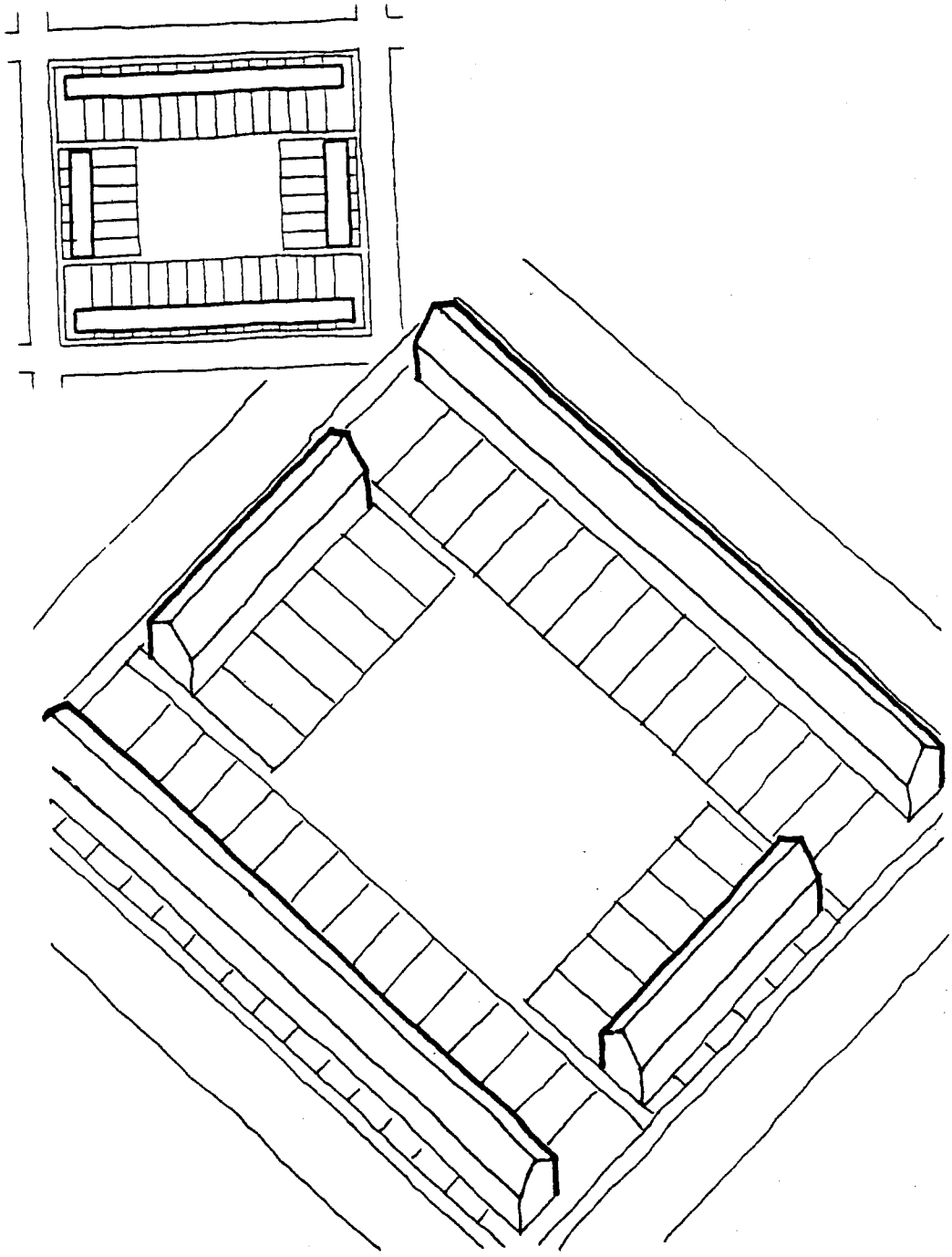
Block Size
250' x 380'
95,000 sq.ft.
2.2 acres
Gross Residential Area:
121,800 sq.ft.
2.8 acres
Lot Dimensions:
30 @ 20' x 125'
4 @ 40' x 125'
2,500 (typical) sq.ft.
Number of Units:
34 @ 1,600 s.f.
Net Dwelling Density:
15.6 dwelling units/acre
Gross Residential Density:
12.1 dwelling units/acre
Coverage:
Net area = 0.29
Gross area = 0.22
Floor Area Ratio:
FAR = 0.58



2.7.2.3 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family - **row housing** - garden apartments - high-rise apartments	- 12' x 30' (three story) - 18' x 22' (three story) - 18' x 30' (two story) - 18' x 40' (two story) - 20' x 30' (two story) - 20' x 40' (two story) - **25' x 30' (two story)** - 25' x 36'(two story)	- parallel - **perimeter** - penetrating	- space between blgs - site depth - **site width**

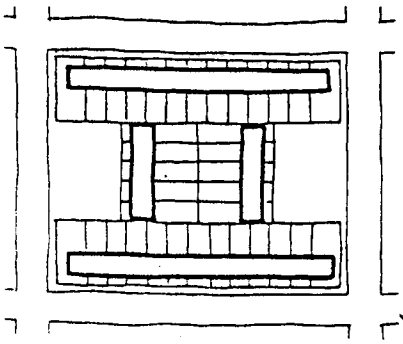
Block Size
370' x 395'
146,150 sq.ft.
3.4 acres
Gross Residential Area:
178,350 sq.ft.
4.1 acres
Lot Dimensions:
38 @ 25' x 100'
4 @ 35' x 100'
2,500 (typical) sq.ft.
Number of Units:
42 @ 1,500 sq.ft.
Net Dwelling Density:
12.5 dwelling units/acre
Gross Residential Density:
10.3 dwelling units/acre
Coverage:
Net area = 0.22
Gross area = 0.18
Floor Area Ratio:
FAR = 0.44

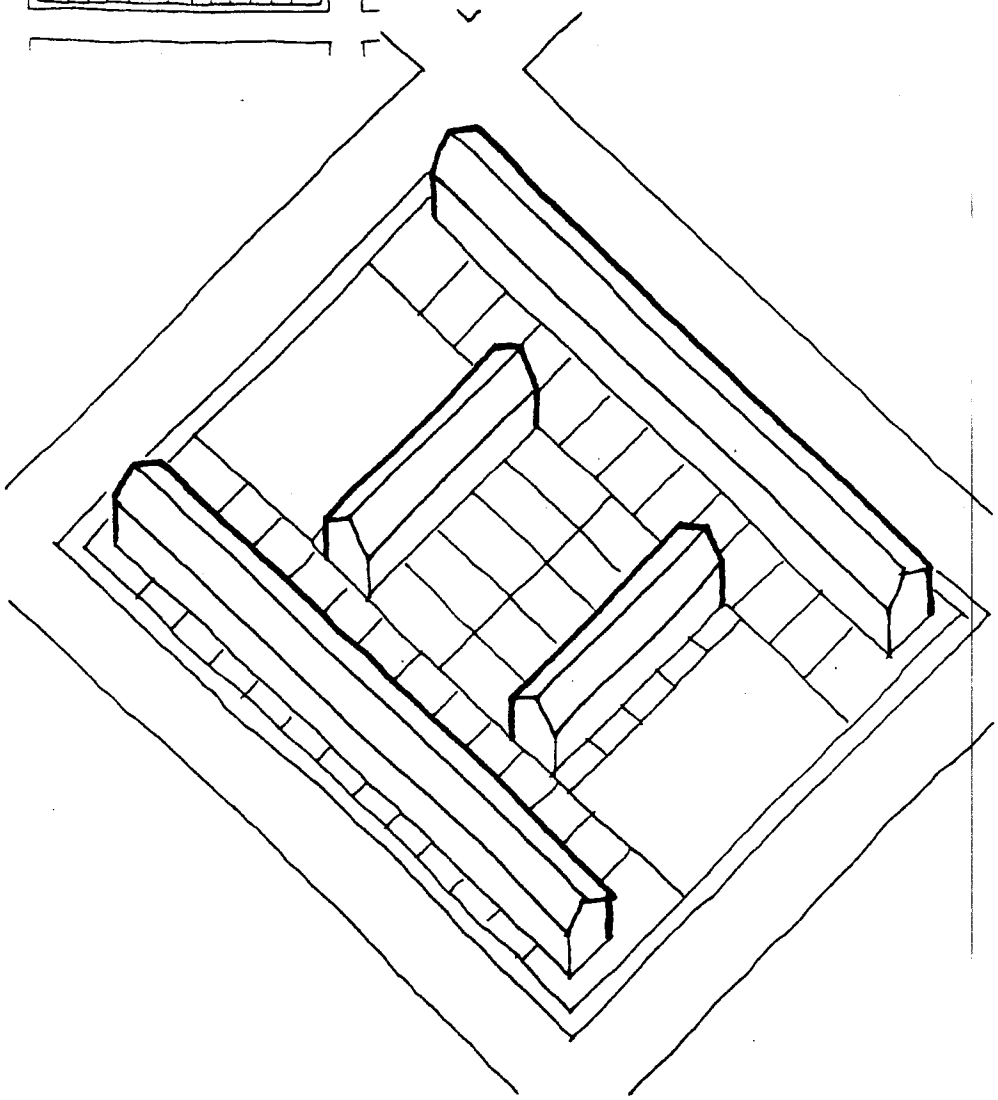


2.7.3.2/3 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 12' x 30' (three story)	- parallel	- space between blgs
- **row housing**	- 18' x 22' (three story)	- perimeter	- **site depth**
- garden apartments	- 18' x 30' (two story)	- **penetrating**	- **site width**
- high-rise apartments	- 18' x 40' (two story)		
	- 20' x 30' (two story)		
	- 20' x 40' (two story)		
	- **25' x 30' (two story)**		
	- 25' x 36'(two story)		

Block Size
285' x 345'
98,325 sq.ft.
2.3 acres
Gross Residential Area:
125,125 sq.ft.
2.9 acres
Lot Dimensions:
22 @ 25' x 80'
10 @ 25' x 93'
4 @ 35' x 80'
2,000 (typical) sq.ft.
Number of Units:
36 @ 1,500 sq.ft.
Net Dwelling Density:
15.9 dwelling units/acre
Gross Residential Density:
12.5 dwelling units/acre
Coverage:
Net area = 0.27
Gross area = 0.22
Floor Area Ratio:
FAR = 0.54

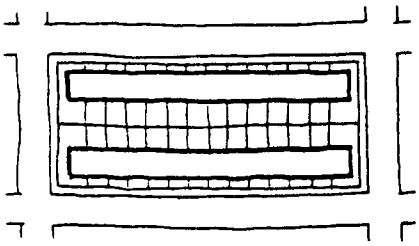


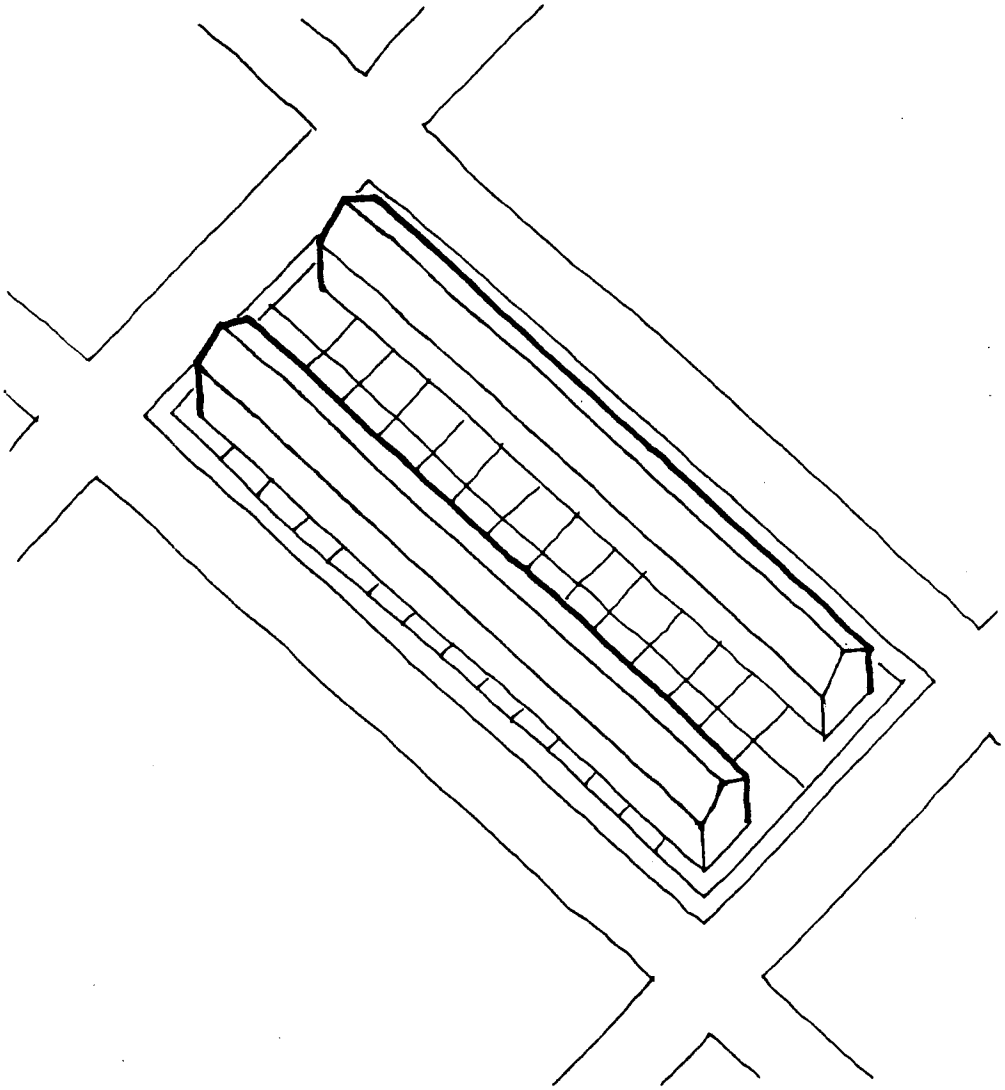


2.8.1.2 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 12' x 30' (three story)	- **parallel**	- space between blgs
- **row housing**	- 18' x 22' (three story)	- perimeter	- **site depth**
- garden apartments	- 18' x 30' (two story)	- penetrating	- site width
- high-rise apartments	- 18' x 40' (two story)		
	- 20' x 30' (two story)		
	- 20' x 40' (two story)		
	- 25' x 30' (two story)		
	- **25' x 36'(two story)**		

Block Size
150' x 360'
54,000 sq.ft.
1.2 acres
Gross Residential Area:
76,000 sq.ft.
1.7 acres
Lot Dimensions:
24 @ 25' x 75'
4 @ 35' x 75'
1,875 (typical) sq.ft.
Number of Units:
28 @ 1,800 sq.ft.
Net Dwelling Density:
22.6 dwelling units/acre
Gross Residential Density:
16.1 dwelling units/acre
Coverage:
Net area = 0.47
Gross area = 0.33
Floor Area Ratio:
FAR = 0.94

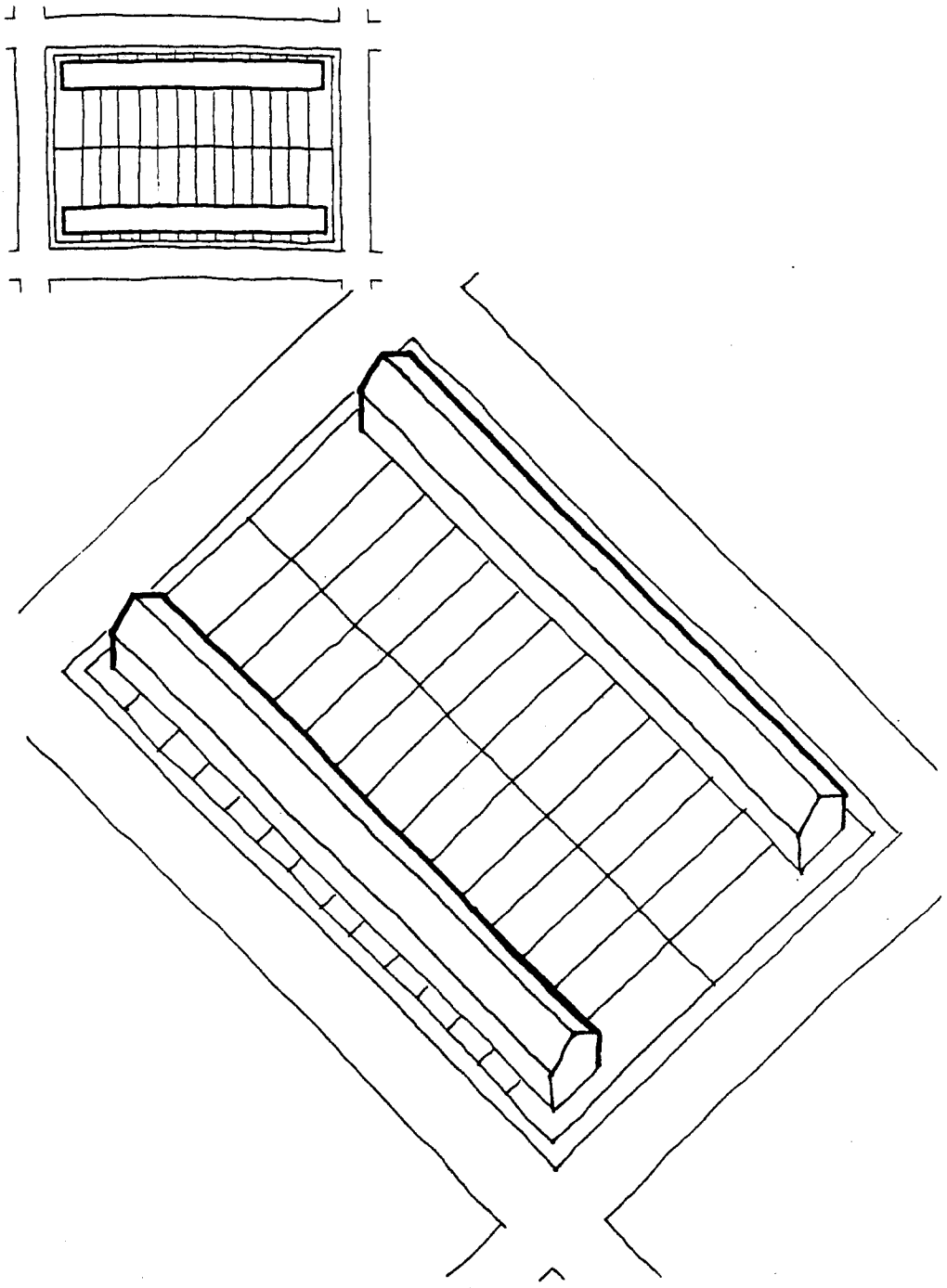




2.8.1.2/3 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family - **row housing** - garden apartments - high-rise apartments	- 12' x 30' (three story) - 18' x 22' (three story) - 18' x 30' (two story) - 18' x 40' (two story) - 20' x 30' (two story) - 20' x 40' (two story) - 25' x 30' (two story) - **25' x 36'(two story)**	- **parallel** - perimeter - penetrating	- space between blgs - **site depth** - **site width**

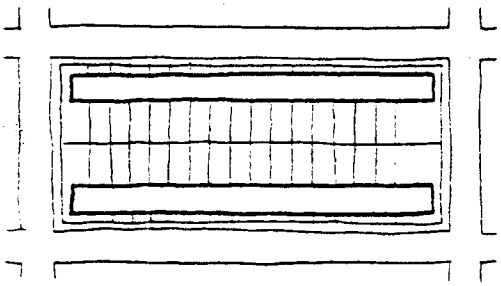
Block Size
250' x 370'
92,500 sq.ft.
2.1 acres
Gross Residential Area:
118,900 sq.ft.
2.7 acres
Lot Dimensions:
24 @ 25' x 125'
4 @ 35' x 125'
3,125(typical)sq.ft.
Number of Units:
28 @ 1,800 sq.ft.
Net Dwelling Density:
13.2 dwelling units/acre
Gross Residential Density:
10.3 dwelling units/acre
Coverage:
Net area = 0.27
Gross area = 0.21
Floor Area Ratio:
FAR = 0.54

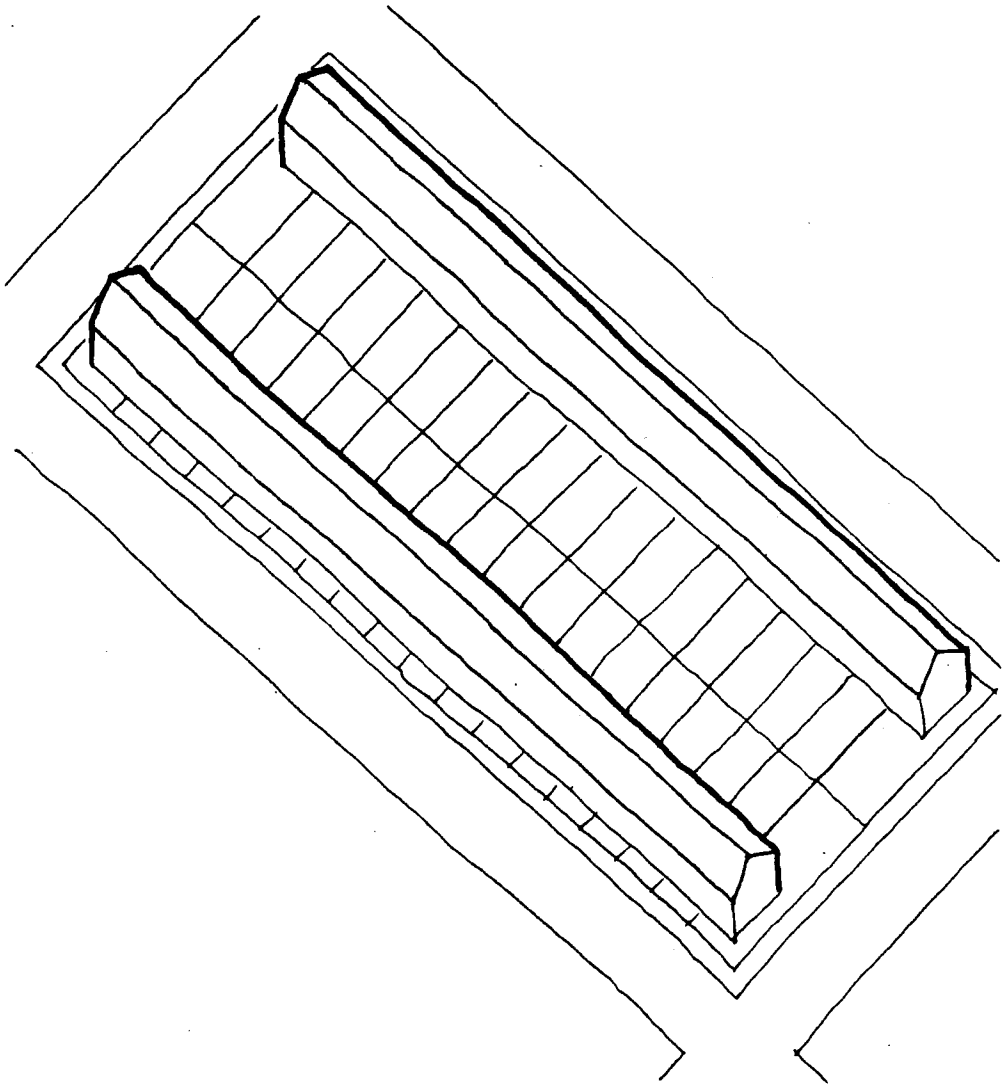


2.8.1.3 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 12' x 30' (three story)	- **parallel**	- space between blgs
- **row housing**	- 18' x 22' (three story)	- perimeter	- site depth
- garden apartments	- 18' x 30' (two story)	- penetrating	- **site width**
- high-rise apartments	- 18' x 40' (two story)		
	- 20' x 30' (two story)		
	- 20' x 40' (two story)		
	- 25' x 30' (two story)		
	- **25' x 36'(two story)**		

Block Size
200' x 460'
92,000 sq.ft.
2.1 acres
Gross Residential Area:
120,000 sq.ft.
2.75 acres
Lot Dimensions:
32 @ 25' x 100'
4 @ 35' x 100'
2,500 (typical) sq.ft.
Number of Units:
36 @ 1,800 sq.ft.
Net Dwelling Density:
17.1 dwelling units/acre
Gross Residential Density:
13.1 dwelling units/acre
Coverage:
Net area = 0.29
Gross area = 0.22
Floor Area Ratio:
FAR = 0.58

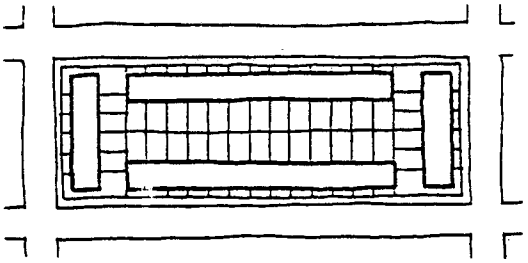


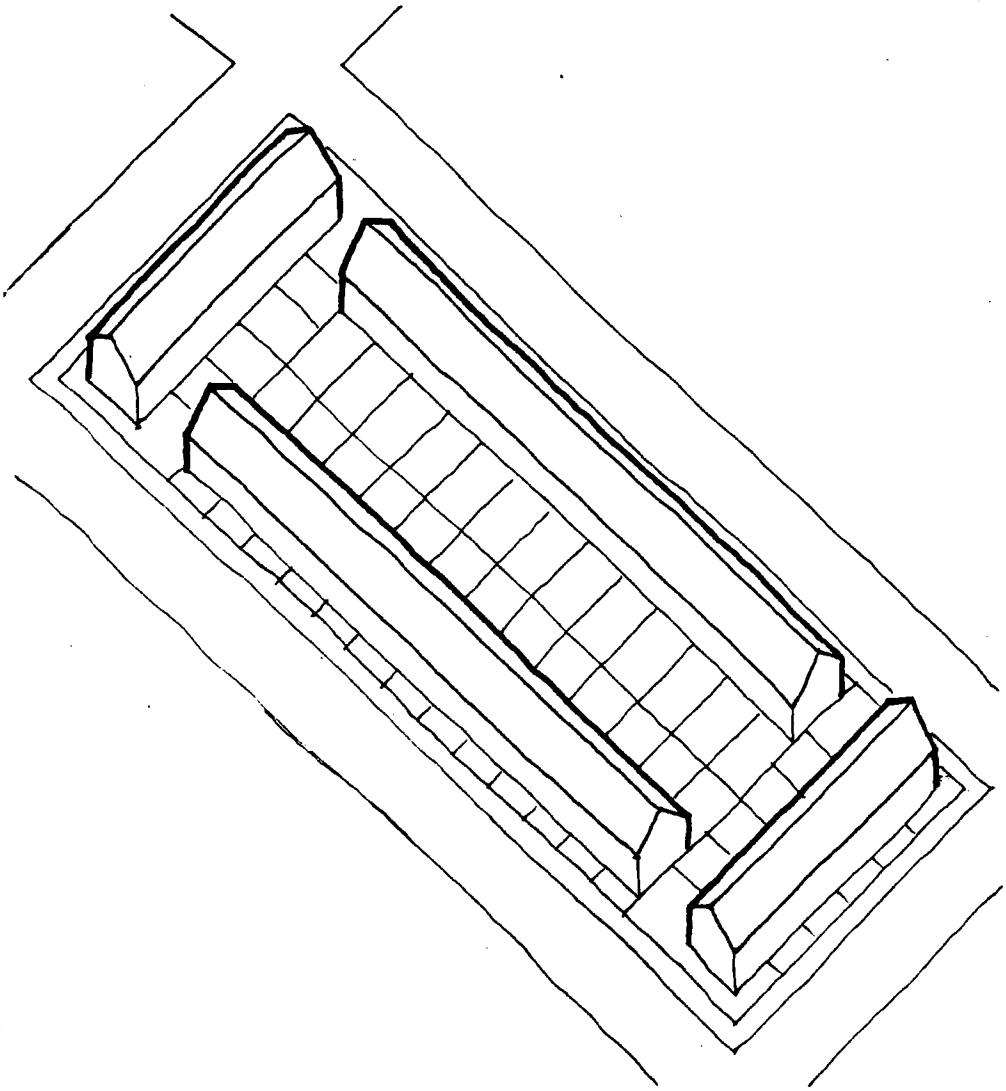


2.8.2.2/3 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family - **row housing** - garden apartments - high-rise apartments	- 12' x 30' (three story) - 18' x 22' (three story) - 18' x 30' (two story) - 18' x 40' (two story) - 20' x 30' (two story) - 20' x 40' (two story) - 25' x 30' (two story) - **25' x 36'(two story)**	- parallel - **perimeter** - penetrating	- space between blgs - **site depth** - **site width**

Block Size
170' x 485'
82,450 sq.ft.
1.9 acres
Gross Residential Area:
110,250 sq.ft.
2.5 acres
Lot Dimensions:
34 @ 25' x 85"
4 @ 35' x 85'
2,125 (typical) sq.ft.
Number of Units:
38 @ 1,800 sq.ft.
Net Dwelling Density:
20.1 dwelling units/acre
Gross Residential Density:
15.0 dwelling units/acre
Coverage:
Net area = 0.41
Gross area = 0.31
Floor Area Ratio:
FAR = 0.82

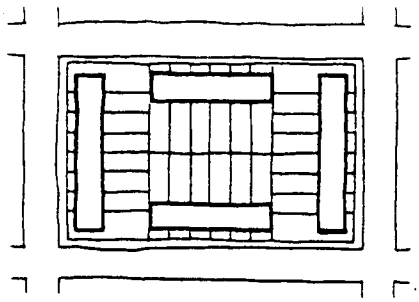


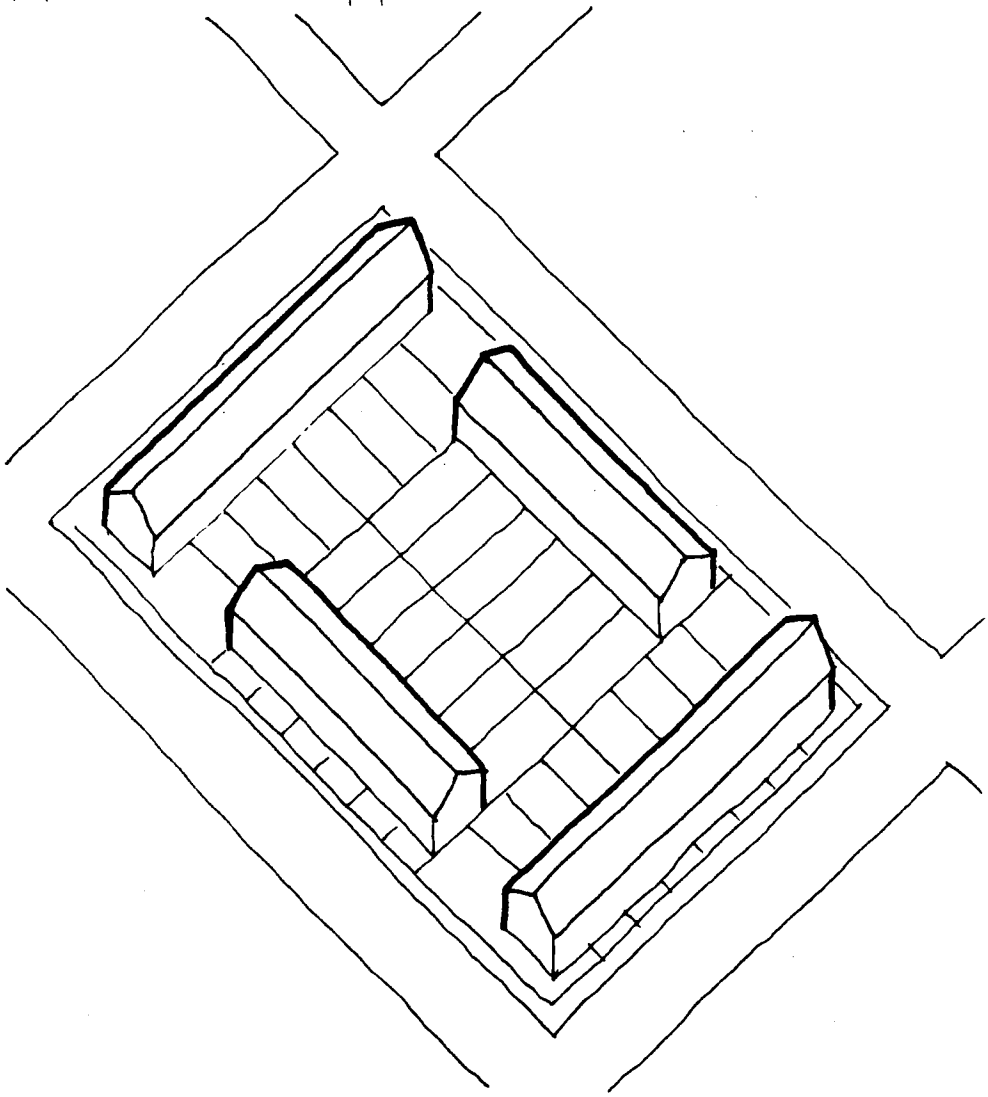


2.8.2.3 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 12' x 30' (three story)	- parallel	- space between blgs
- **row housing**	- 18' x 22' (three story)	- **perimeter**	- site depth
- garden apartments	- 18' x 30' (two story)	- penetrating	- **site width**
- high-rise apartments	- 18' x 40' (two story)		
	- 20' x 30' (two story)		
	- 20' x 40' (two story)		
	- 25' x 30' (two story)		
	- **25' x 36'(two story)**		

Block Size
220' x 350'
77,000 sq.ft.
1.8 acres
Gross Residential Area:
101,400 sq.ft.
2.3 acres
Lot Dimensions:
24 @ 25' x 110'
4 @ 35' x 110'
2,750 (typical) sq.ft.
Number of Units:
28 @ 1,800 sq.ft.
Net Dwelling Density:
15.8 dwelling units/acre
Gross Residential Density:
12.1 dwelling units/acre
Coverage:
Net area = 0.33
Gross area = 0.25
Floor Area Ratio:
FAR = 0.66

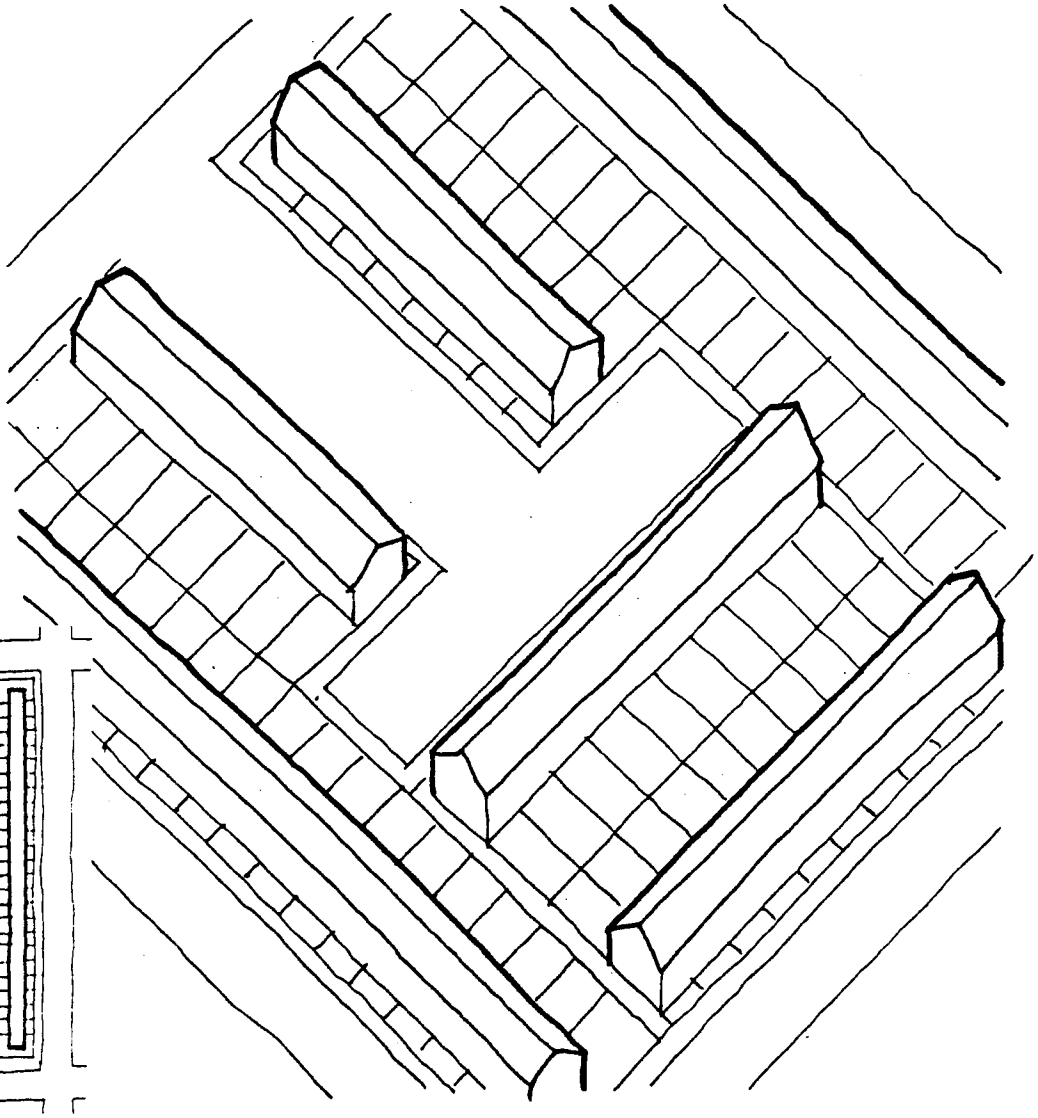


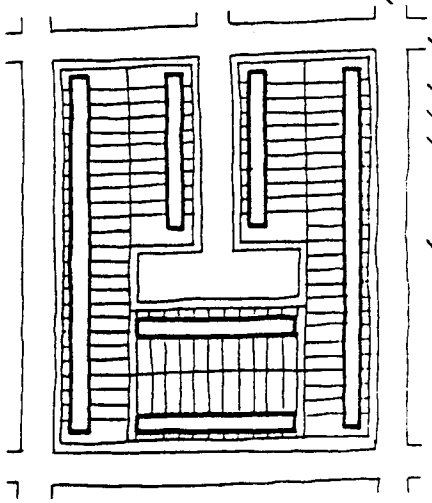


2.8.3.3 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 12' x 30' (three story)	- parallel	- space between blgs
- **row housing**	- 18' x 22' (three story)	- perimeter	- site depth
- garden apartments	- 18' x 30' (two story)	- **penetrating**	- **site width**
- high-rise apartments	- 18' x 40' (two story)		
	- 20' x 30' (two story)		
	- 20' x 40' (two story)		
	- 25' x 30' (two story)		
	- **25' x 36' (two story)**		

Block Size
450' x 470'
179,900 sq.ft.
4.1 acres
Gross Residential Area:
249,900 sq.ft.
5.7 acres
Lot Dimensions:
64 @ 25' x 90'
8 @ 35' x 90'
2,250 (typical) sq.ft.
Number of Units:
72 @ 1,800 sq.ft.
Net Dwelling Density:
17.4 dwelling units/acre
Gross Residential Density:
12.5 dwelling units/acre
Coverage:
Net area = 0.36
Gross area = 0.26
Floor Area Ratio:
FAR = 0.72

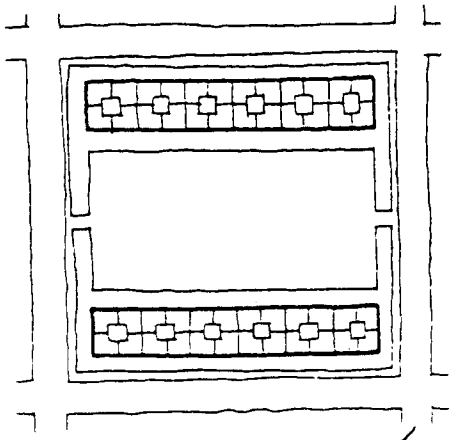


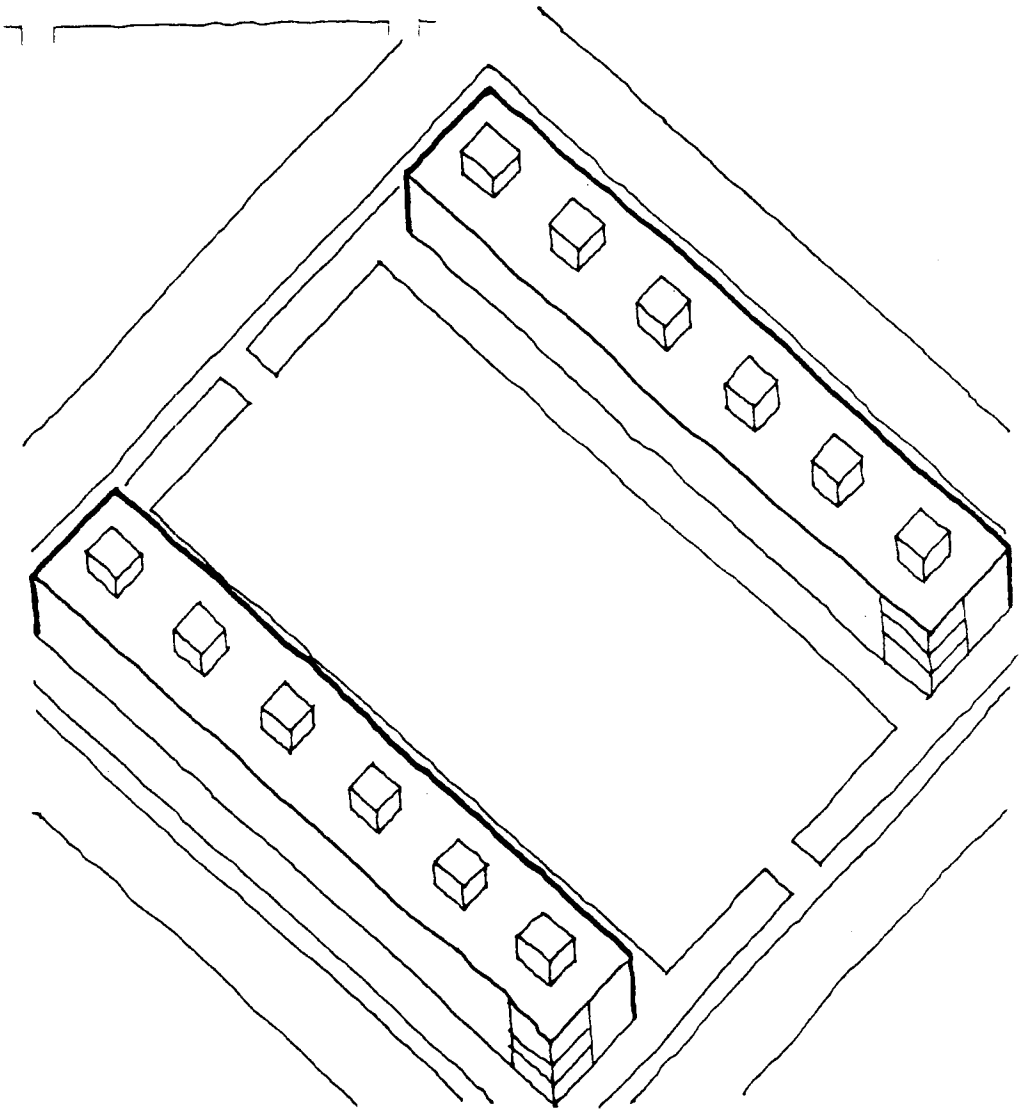


3.1.1.5 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- **800 sq.ft.**	- **parallel**	- point
- row housing	- 1000 sq.ft.	- perimeter	- single loaded corridor
- **garden apartments**	- 1100 sq.ft.	- penetrating	- double loaded corridor
- high-rise apartments	- 1200 sq.ft.		- single loaded core
	- 1500sq.ft.		- **double loaded core**
	- 1650 sq.ft.		- complex

Block Size
385' x 400'
154,000 sq.ft.
3.5 acres
Gross Residential Area:
187,000 sq.ft.
4.3 acres
Number of Units:
144 @ 800 sq.ft.
Net Dwelling Density:
40.7 dwelling units/acre
Gross Residential Density:
33.6 dwelling units/acre
Coverage:
Net area = 0.25
Gross area = 0.21
Floor Area Ratio:
FAR = 0.75

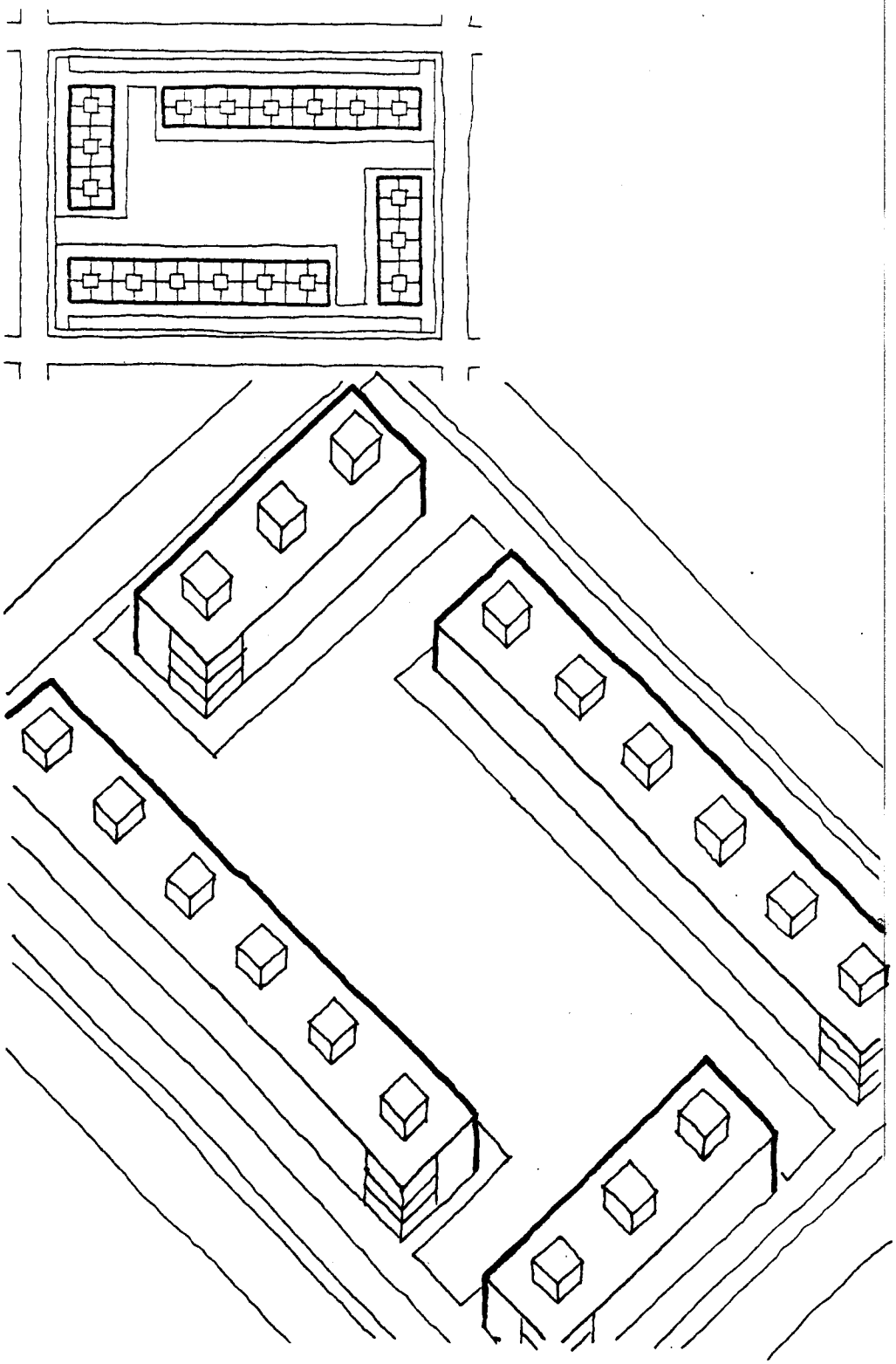




3.1.2.5 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- **800 sq.ft.**	- parallel	- point
- row housing	- 1000 sq.ft.	- **perimeter**	- single loaded corridor
- **garden apartments**	- 1100 sq.ft.	- penetrating	- double loaded corridor
- high-rise apartments	- 1200 sq.ft.		- single loaded core
	- 1500sq.ft.		- **double loaded core**
	- 1650 sq.ft.		- complex

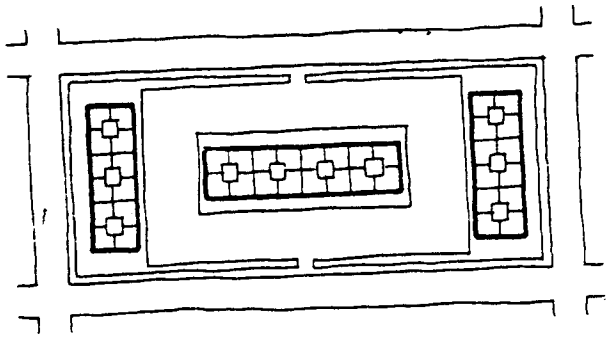
Block Size
390' x 530'
206,700 sq.ft.
4.75 acres
Gross Residential Area:
245,100 sq.ft.
5.6 acres
Number of Units:
216@ 800 sq.ft.
Net Dwelling Density:
45.5 dwelling units/acre
Gross Residential Density:
38.4 dwelling units/acre
Coverage:
Net area = 0.28
Gross area = 0.24
Floor Area Ratio:
FAR = 0.84

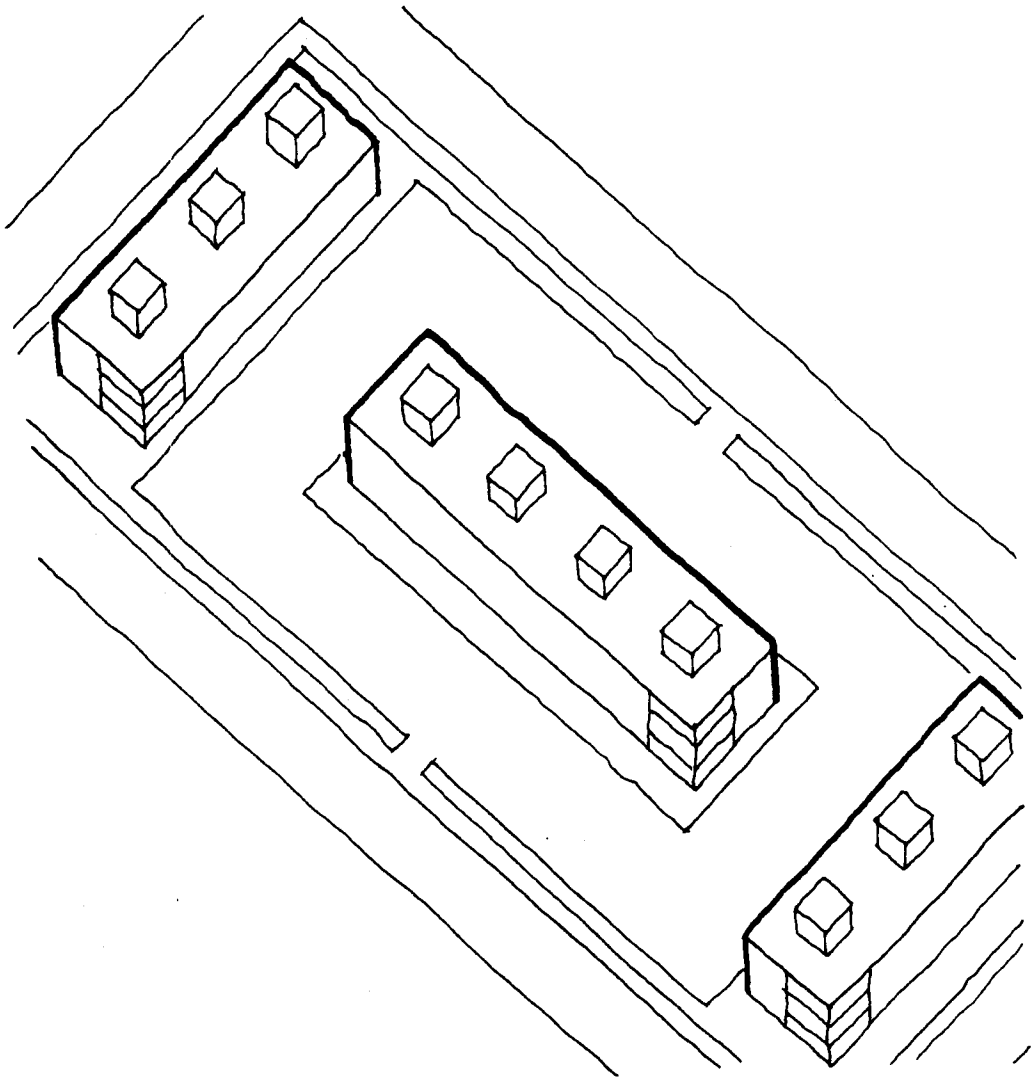


3.1.3.5 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- **800 sq.ft.**	- parallel	- point
- row housing	- 1000 sq.ft.	- perimeter	- single loaded corridor
- **garden apartments**	- 1100 sq.ft.	- **penetrating**	- double loaded corridor
- high-rise apartments	- 1200 sq.ft.		- single loaded core
	- 1500sq.ft.		- **double loaded core**
	- 1650 sq.ft.		- complex

Block Size
240' x 580'
139,200 sq.ft.
3.2 acres
Gross Residential Area:
173,600 sq.ft.
4.0 acres
Number of Units:
120 @ 800 sq.ft.
Net Dwelling Density:
37.5 dwelling units/acre
Gross Residential Density:
30.1 dwelling units/acre
Coverage:
Net area = 0.21
Gross area = 0.17
Floor Area Ratio:
FAR = 0.62

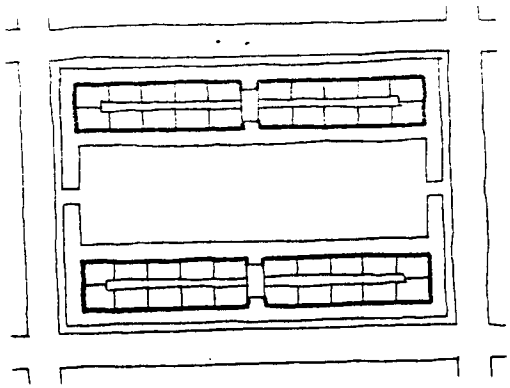


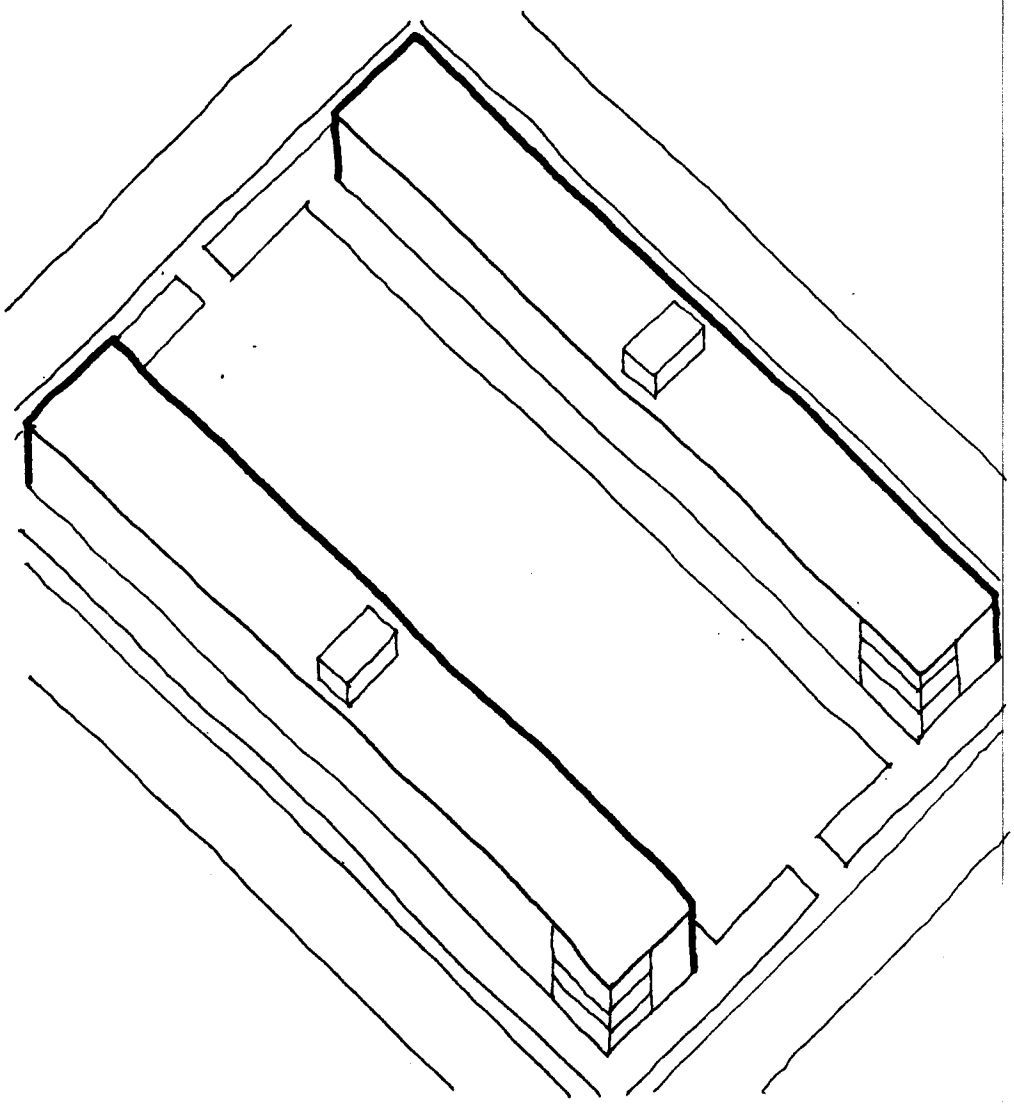


3.2.1.3 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 800 sq.ft.	- **parallel**	- point
- row housing	- **1000 sq.ft.**	- perimeter	- single loaded corridor
- **garden apartments**	- 1100 sq.ft.	- penetrating	- **double loaded corridor**
- high-rise apartments	- 1200 sq.ft.		- single loaded core
	- 1500sq.ft.		- double loaded core
	- 1650 sq.ft.		- complex

Block Size
325' x 500'
149,500 sq.ft.
3.4 acres
Gross Residential Area:
182,500 sq.ft.
4.2 acres
Number of Units:
120 @ 1,000 sq.ft.
Net Dwelling Density:
35.0 dwelling units/acre
Gross Residential Density:
28.6 dwelling units/acre
Coverage:
Net area = 0.34
Gross area = 0.28
Floor Area Ratio:
FAR = 1.02

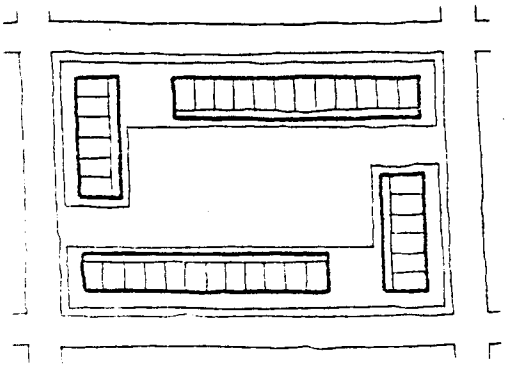


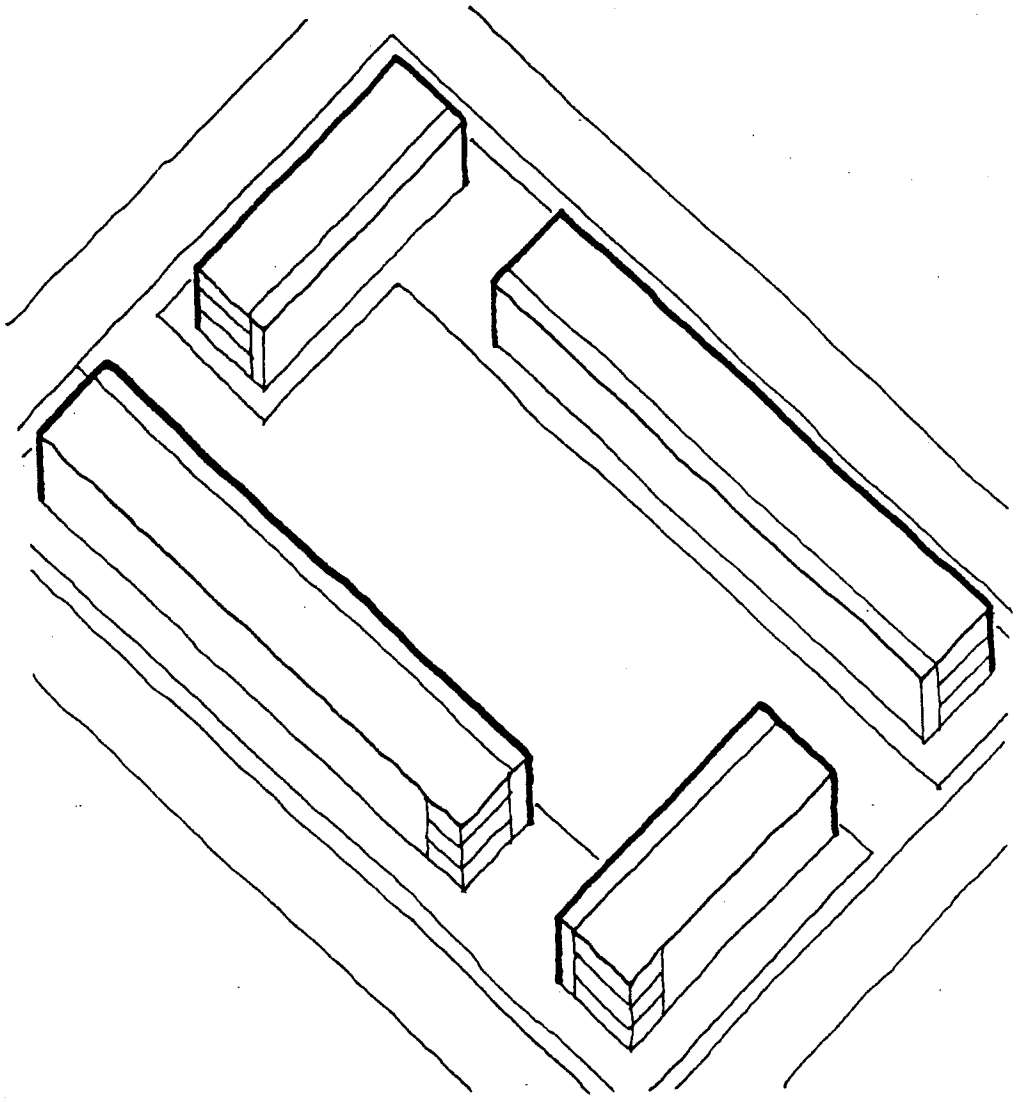


3.2.2.2 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 800 sq.ft.	- parallel	- point
- row housing	- **1000 sq.ft.**	- **perimeter**	- **single loaded corridor**
- **garden apartments**	- 1100 sq.ft.	- penetrating	- double loaded corridor
- high-rise apartments	- 1200 sq.ft.		- single loaded core
	- 1500sq.ft.		- double loaded core
	- 1650 sq.ft.		- complex

Block Size
310' x 460'
142,600 sq.ft.
3.3 acres
Gross Residential Area:
175,000 sq.ft.
4.02 acres
Number of Units:
108 @ 1,000 sq.ft.
Net Dwelling Density:
33.0 dwelling units/acre
Gross Residential Density:
26.9 dwelling units/acre
Coverage:
Net area = 0.32
Gross area = 0.26
Floor Area Ratio:
FAR = 0.95

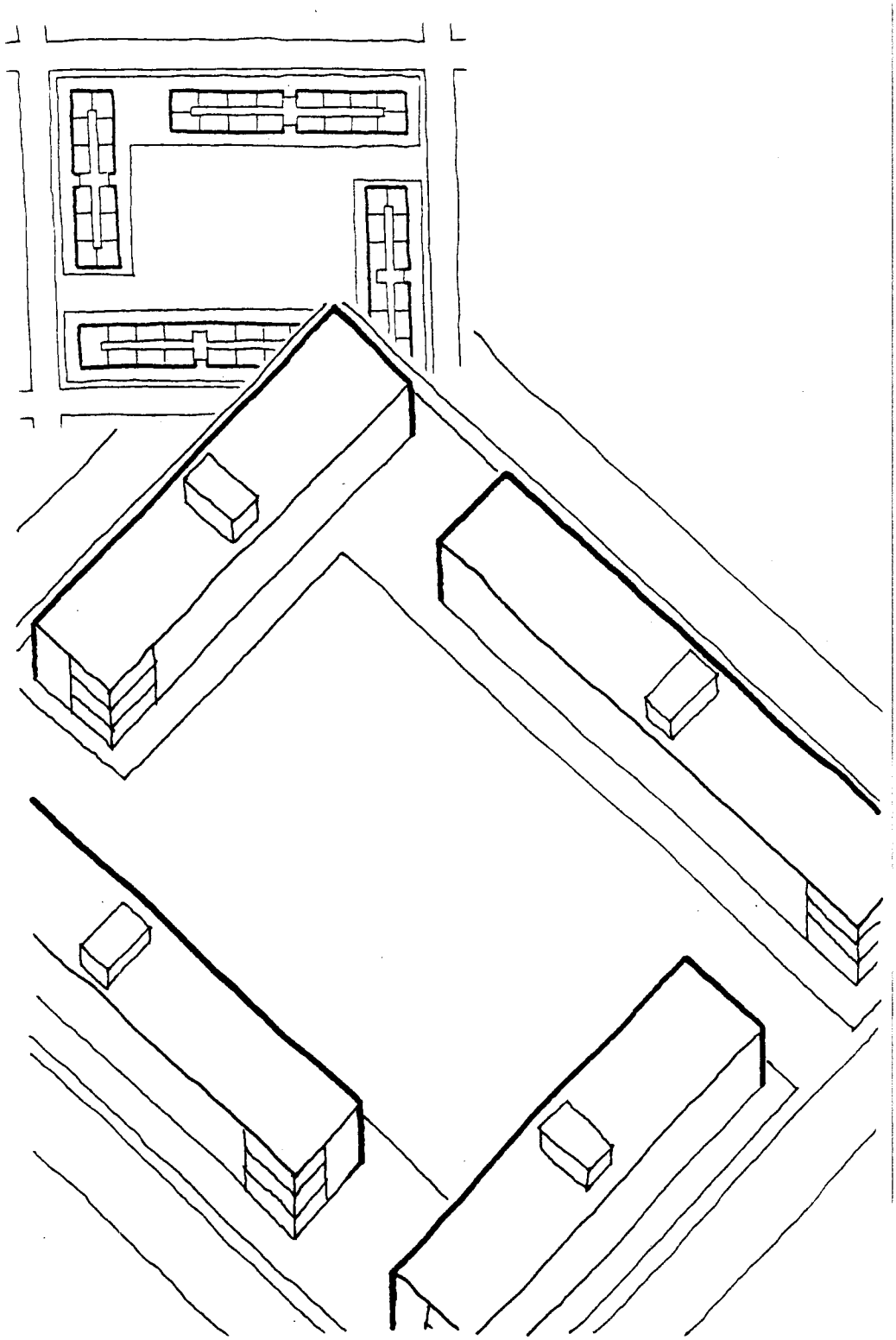




3.2.2.3 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 800 sq.ft.	- parallel	- point
- row housing	- **1000 sq.ft.**	- **perimeter**	- single loaded corridor
- **garden apartments**	- 1100 sq.ft.	- penetrating	- **double loaded corridor**
- high-rise apartments	- 1200 sq.ft.		- single loaded core
	- 1500sq.ft.		- double loaded core
	- 1650 sq.ft.		- complex

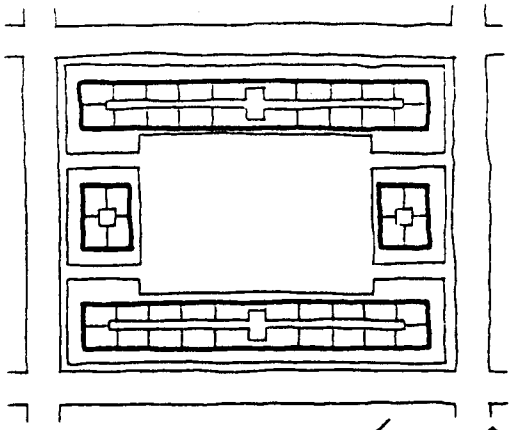
Block Size
440' x 800'
228,800 sq.ft.
5.25 acres
Gross Residential Area:
268,800 sq.ft.
6.2 acres
Number of Units:
168 @ 1,000 sq.ft.
Net Dwelling Density:
32.0 dwelling units/acre
Gross Residential Density:
27.2 dwelling units/acre
Coverage:
Net area = 0.45
Gross area = 0.38
Floor Area Ratio:
FAR = 1.35

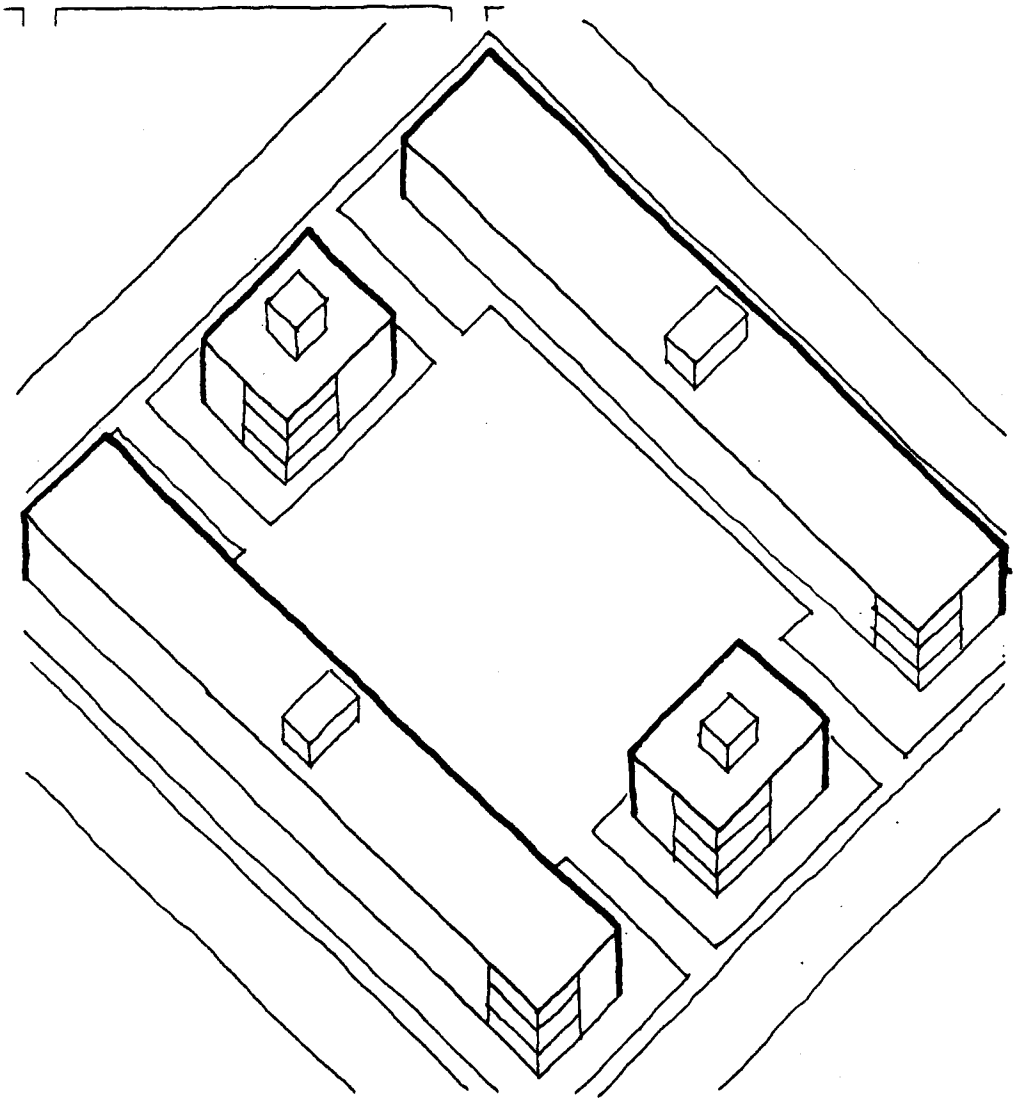


3.2.2.6 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 800 sq.ft.	- parallel	- point
- row housing	- **1000 sq.ft.**	- **perimeter**	- single loaded corridor
- **garden apartments**	- 1100 sq.ft.	- penetrating	- double loaded corridor
- high-rise apartments	- 1200 sq.ft.		- single loaded core
	- 1500sq.ft.		- double loaded core
	- 1650 sq.ft.		- **complex**

Block Size
380' x 410'
155,800 sq.ft.
3.6 acres
Gross Residential Area:
189,000 sq.ft.
4.3 acres
Number of Units:
24 @ 1,000 sq.ft.
24 @ 1,100 sq.ft.
Net Dwelling Density:
40.2 dwelling units/acre
Gross Residential Density:
33.2 dwelling units/acre
Coverage:
Net area = 0.35
Gross area = 0.29
Floor Area Ratio:
FAR = 1.03

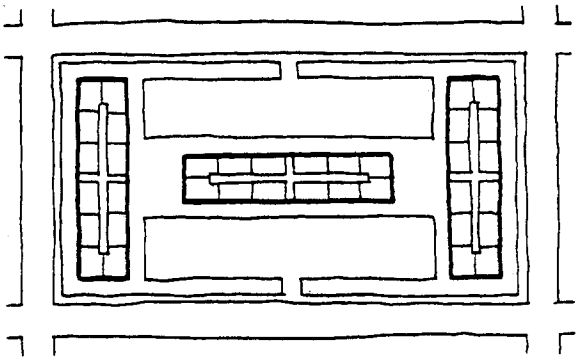


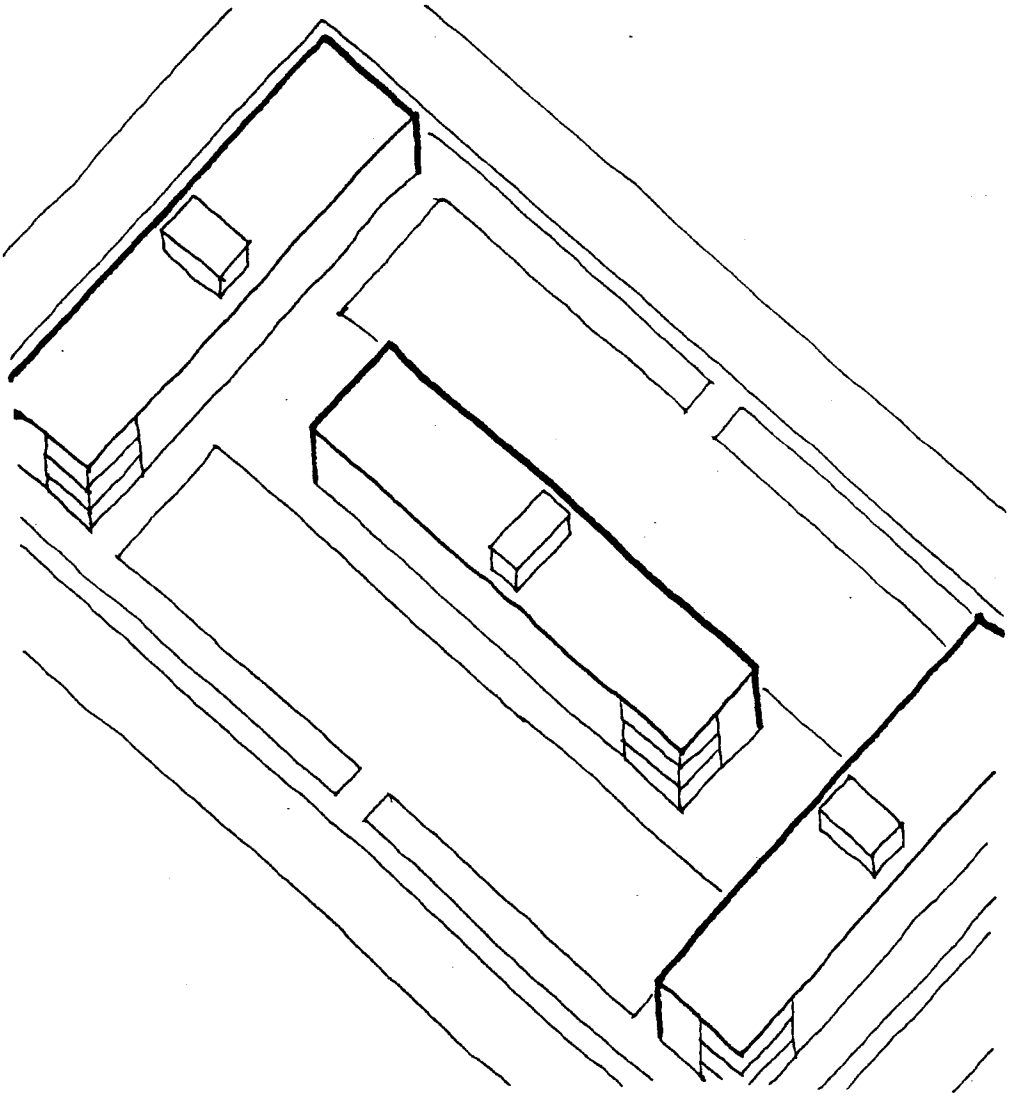


3.2.3.3 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 800 sq.ft.	- parallel	- point
- row housing	- **1000 sq.ft.**	- perimeter	- single loaded corridor
- **garden apartments**	- 1100 sq.ft.	- **penetrating**	- **double loaded corridor**
- high-rise apartments	- 1200 sq.ft.		- single loaded core
	- 1500sq.ft.		- double loaded core
	- 1650 sq.ft.		- complex

Block Size
290' x 550'
159,500 sq.ft.
3.7 acres
Gross Residential Area:
194,700 sq.ft.
4.5 acres
Number of Units:
108@1,000 sq.ft.
Net Dwelling Density:
29.5 dwelling units/acre
Gross Residential Density:
24.2 dwelling units/acre
Coverage:
Net area = 0.28
Gross area = 0.23
Floor Area Ratio:
FAR = 0.84

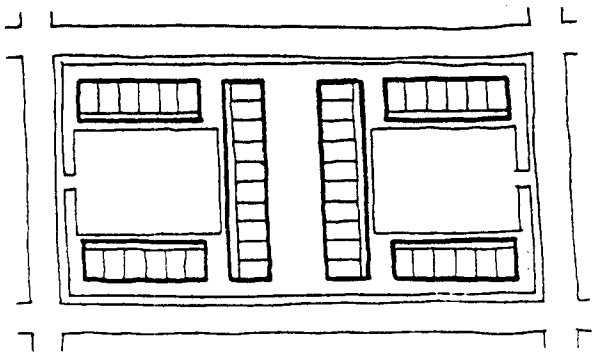


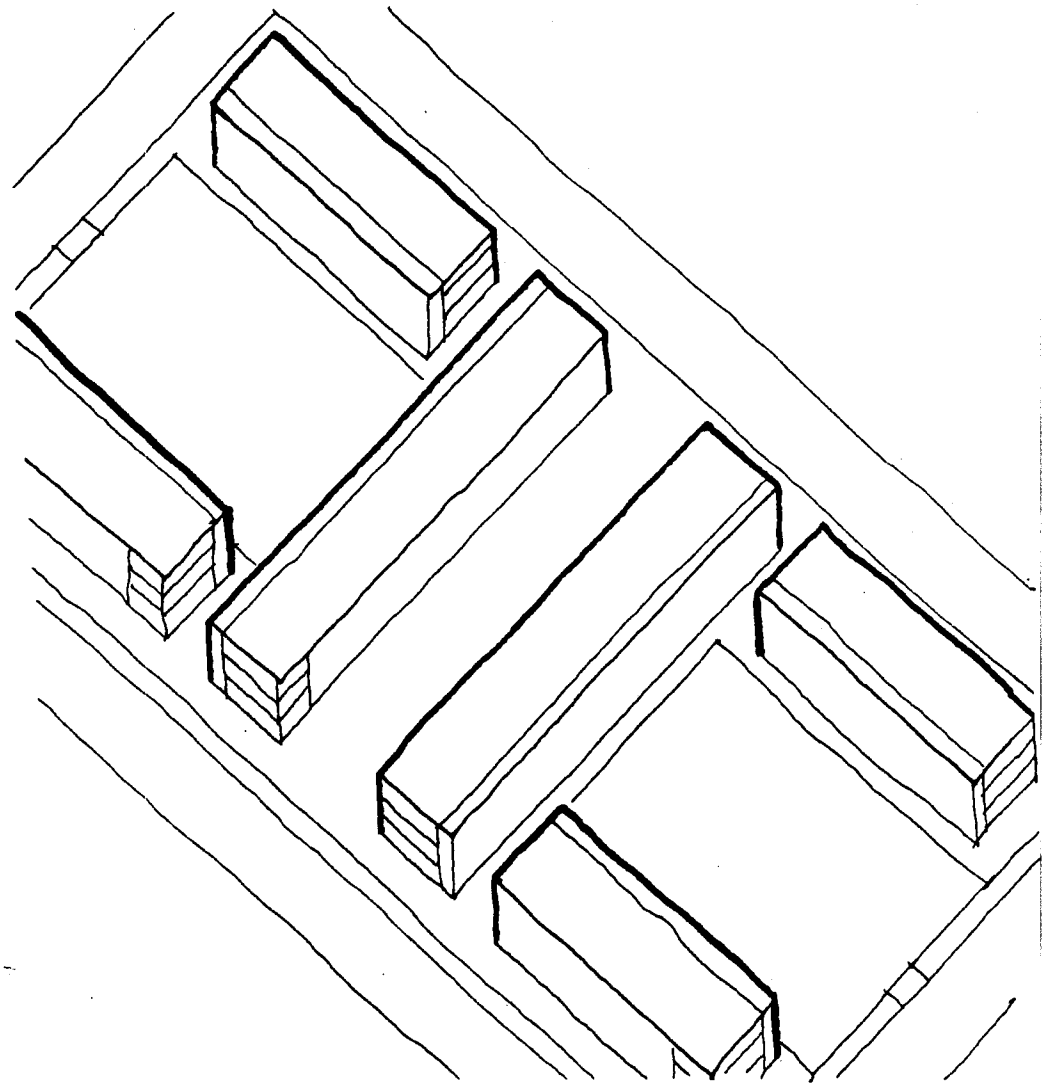


3.2.3.4 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 800 sq.ft.	- parallel	- point
- row housing	- **1000 sq.ft.**	- perimeter	- single loaded corridor
- **garden apartments**	- 1100 sq.ft.	- **penetrating**	- double loaded corridor
- high-rise apartments	- 1200 sq.ft.		- **single loaded core**
	- 1500sq.ft.		- double loaded core
	- 1650 sq.ft.		- complex

Block Size
290' x 570'
165,300 sq.ft.
3.8 acres
Gross Residential Area:
201,300 sq.ft.
4.6 acres
Number of Units:
132 @ 1,000 sq.ft.
Net Dwelling Density:
34.8 dwelling units/acre
Gross Residential Density:
28.6 dwelling units/acre
Coverage:
Net area = 0.33
Gross area = 0.27
Floor Area Ratio:
FAR = 1.00

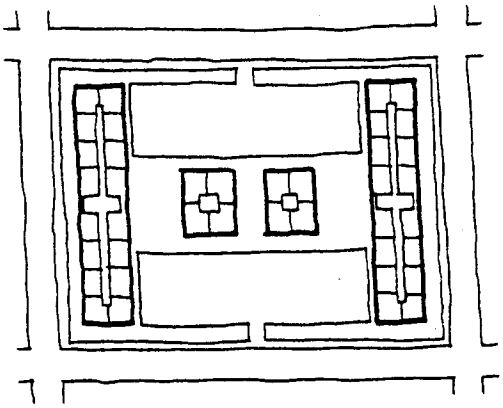


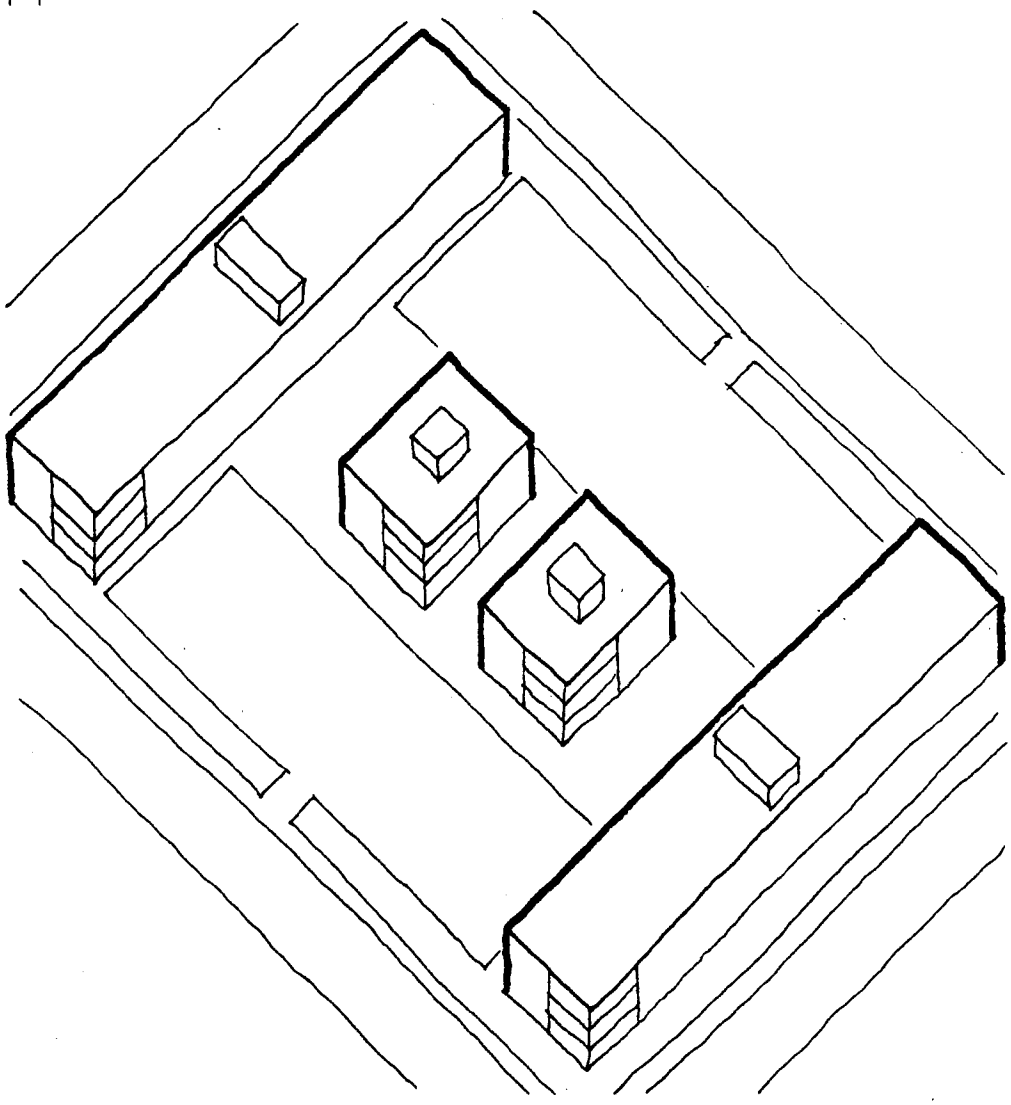


3.2.3.6 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 800 sq.ft.	- parallel	- point
- row housing	- **1000 sq.ft.**	- perimeter	- single loaded corridor
- **garden apartments**	- 1100 sq.ft.	- **penetrating**	- double loaded corridor
- high-rise apartments	- 1200 sq.ft.		- single loaded core
	- 1500sq.ft.		- double loaded core
	- 1650 sq.ft.		- **complex**

Block Size
340' x 460'
156,400 sq.ft.
3.6 acres
Gross Residential Area:
190,000 sq.ft.
4.4 acres
Number of Units:
120 @ approx 1,000 sq.ft.
Net Dwelling Density:
33.4 dwelling units/acre
Gross Residential Density:
27.5 dwelling units/acre
Coverage:
Net area = 0.29
Gross area = 0.24
Floor Area Ratio:
FAR = 0.87

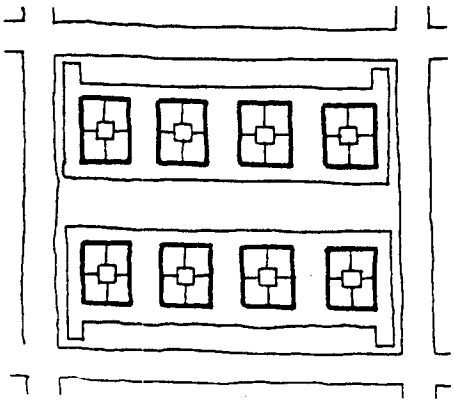


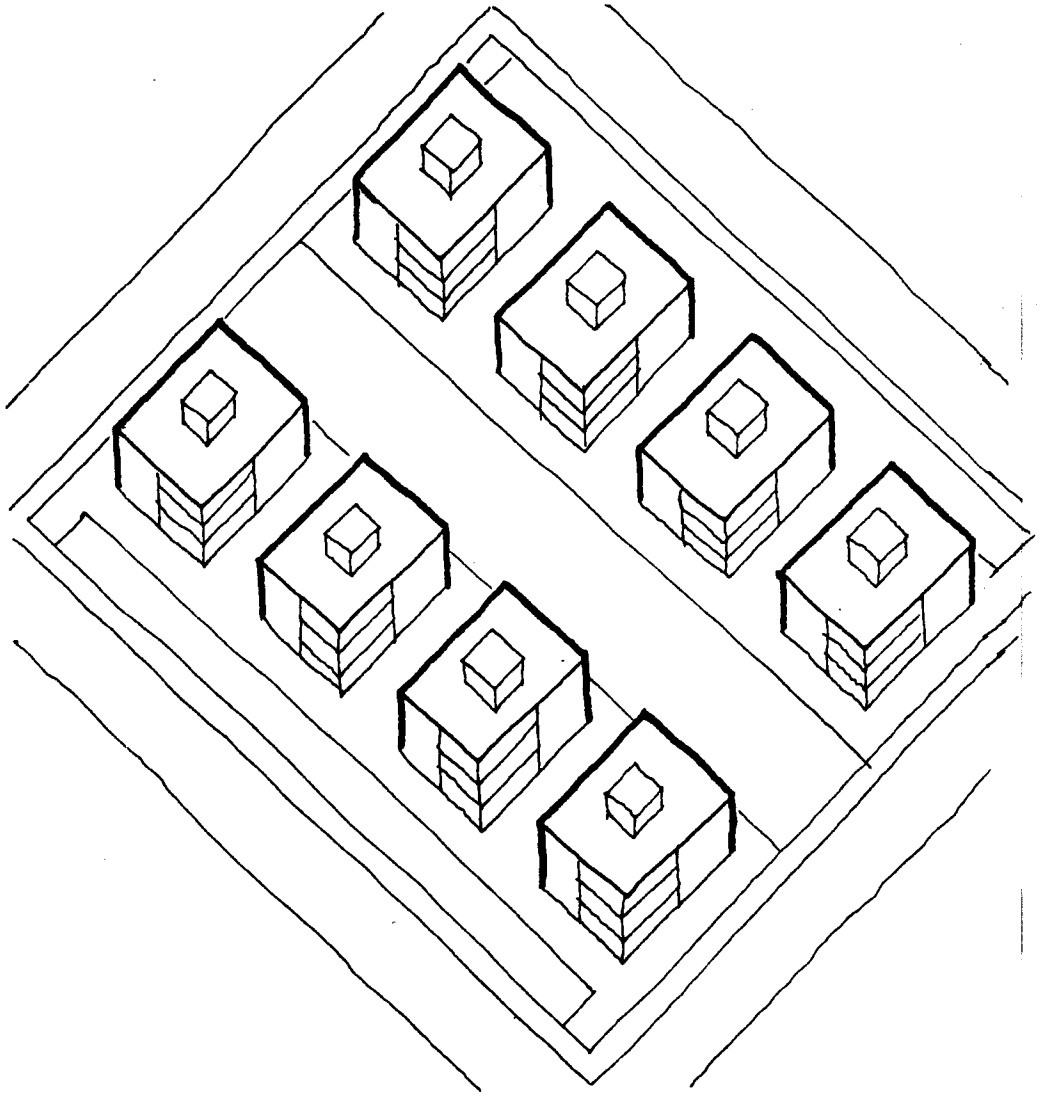


3.3.1.1 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 800 sq.ft.	- **parallel**	- **point**
- row housing	- 1000 sq.ft.	- perimeter	- single loaded corridor
- **garden apartments**	- **1100 sq.ft.**	- penetrating	- double loaded corridor
- high-rise apartments	- 1200 sq.ft.		- single loaded core
	- 1500sq.ft.		- double loaded core
	- 1650 sq.ft.		- complex

Block Size
350' x 400'
140,000 sq.ft.
3.2 acres
Gross Residential Area:
171,600 sq.ft.
3.9 acres
Number of Units:
96 @ 1,100 sq.ft.
Net Dwelling Density:
30.0 dwelling units/acre
Gross Residential Density:
28.0 dwelling units/acre
Coverage:
Net area = 0.32
Gross area = 0.26
Floor Area Ratio:
FAR = 0.96

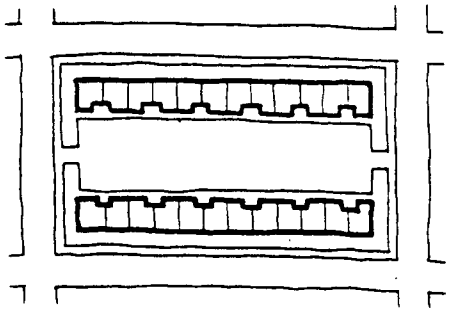


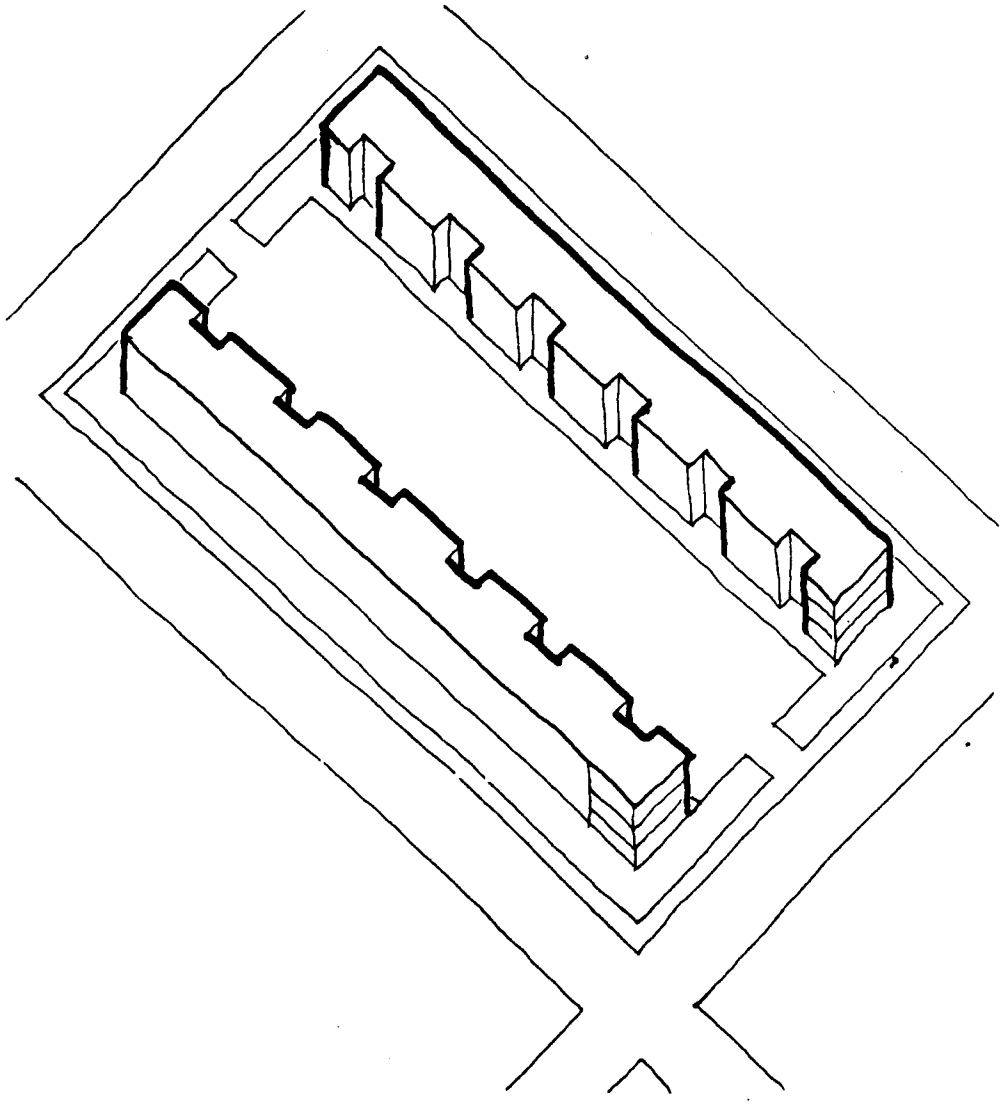


3.3.1.4 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 800 sq.ft.	- **parallel**	- point
- row housing	- 1000 sq.ft.	- perimeter	- single loaded corridor
- **garden apartments**	- **1100 sq.ft.**	- penetrating	- double loaded corridor
- high-rise apartments	- 1200 sq.ft.		- **single loaded core**
	- 1500sq.ft.		- double loaded core
	- 1650 sq.ft.		- complex

Block Size
210' x 400'
84,000 sq.ft.
1.93 acres
Gross Residential Area:
110,000 sq.ft.
2.5 acres
Number of Units:
72 @ 1,100 sq.ft.
Net Dwelling Density:
37.3 dwelling units/acre
Gross Residential Density:
28.5 dwelling units/acre
Coverage:
Net area = 0.31
Gross area = 0.27
Floor Area Ratio:
FAR = 0.94

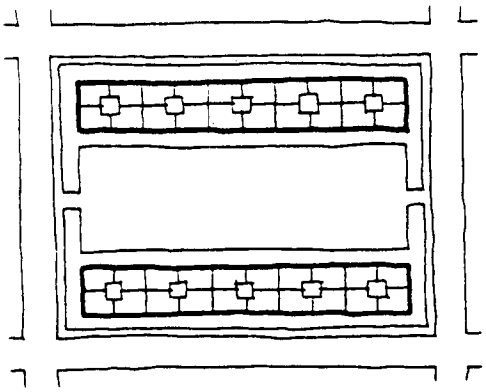


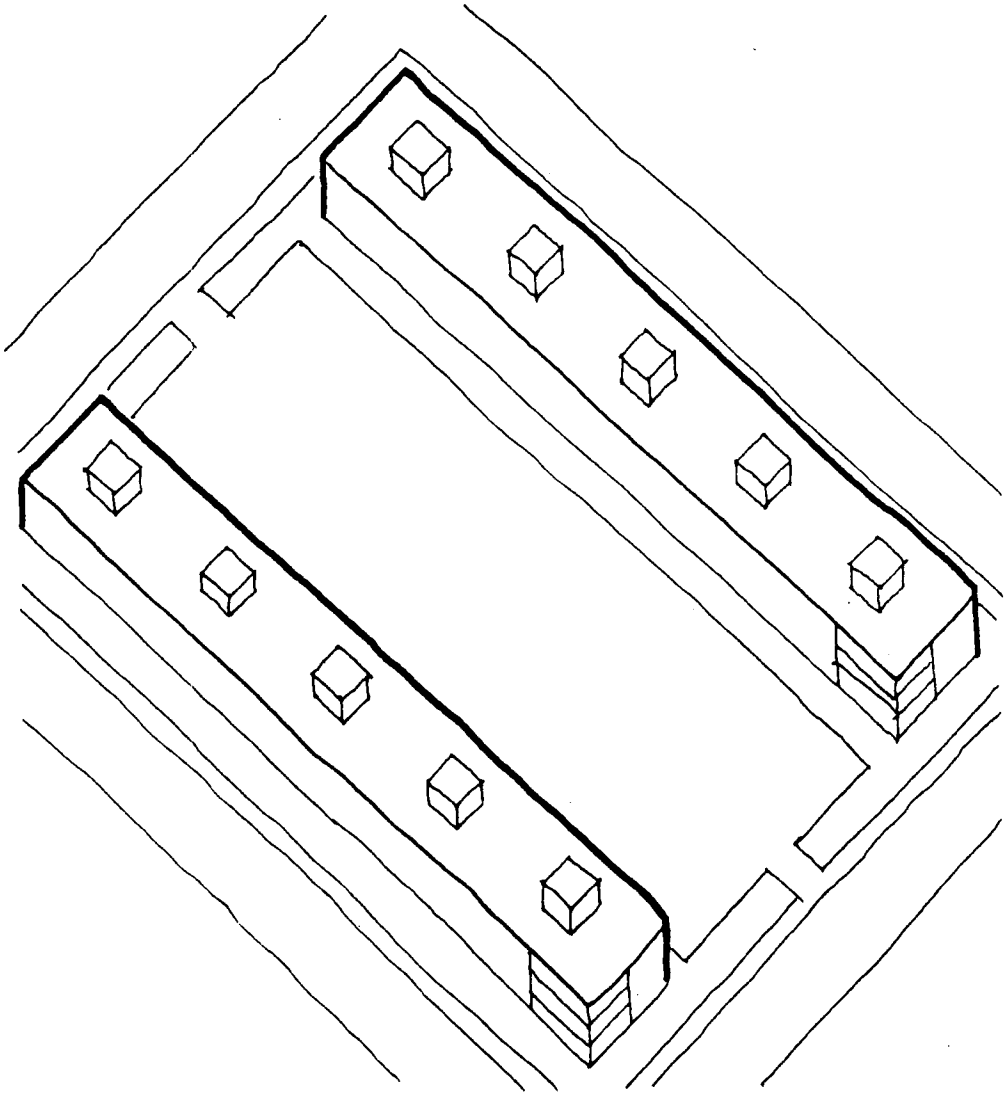


3.3.1.5 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 800 sq.ft.	- **parallel**	- point
- row housing	- 1000 sq.ft.	- perimeter	- single loaded corridor
- **garden apartments**	- **1100 sq.ft.**	- penetrating	- double loaded corridor
- high-rise apartments	- 1200 sq.ft.		- single loaded core
	- 1500sq.ft.		- **double loaded core**
	- 1650 sq.ft.		- complex

Block Size
330' x 440'
145,200 sq.ft.
3.3 acres
Gross Residential Area:
177,600 sq.ft.
4.1 acres
Number of Units:
120@ 1,100 sq.ft.
Net Dwelling Density:
36.0 dwelling units/acre
Gross Residential Density:
29.4 dwelling units/acre
Coverage:
Net area = 0.30
Gross area = 0.25
Floor Area Ratio:
FAR = 0.90

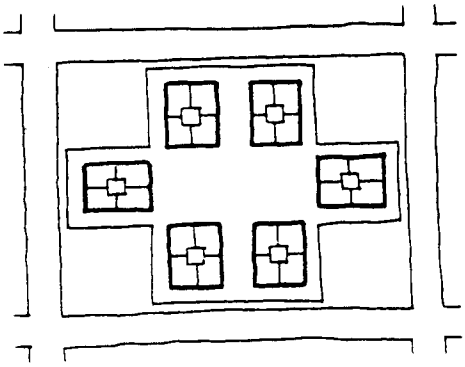


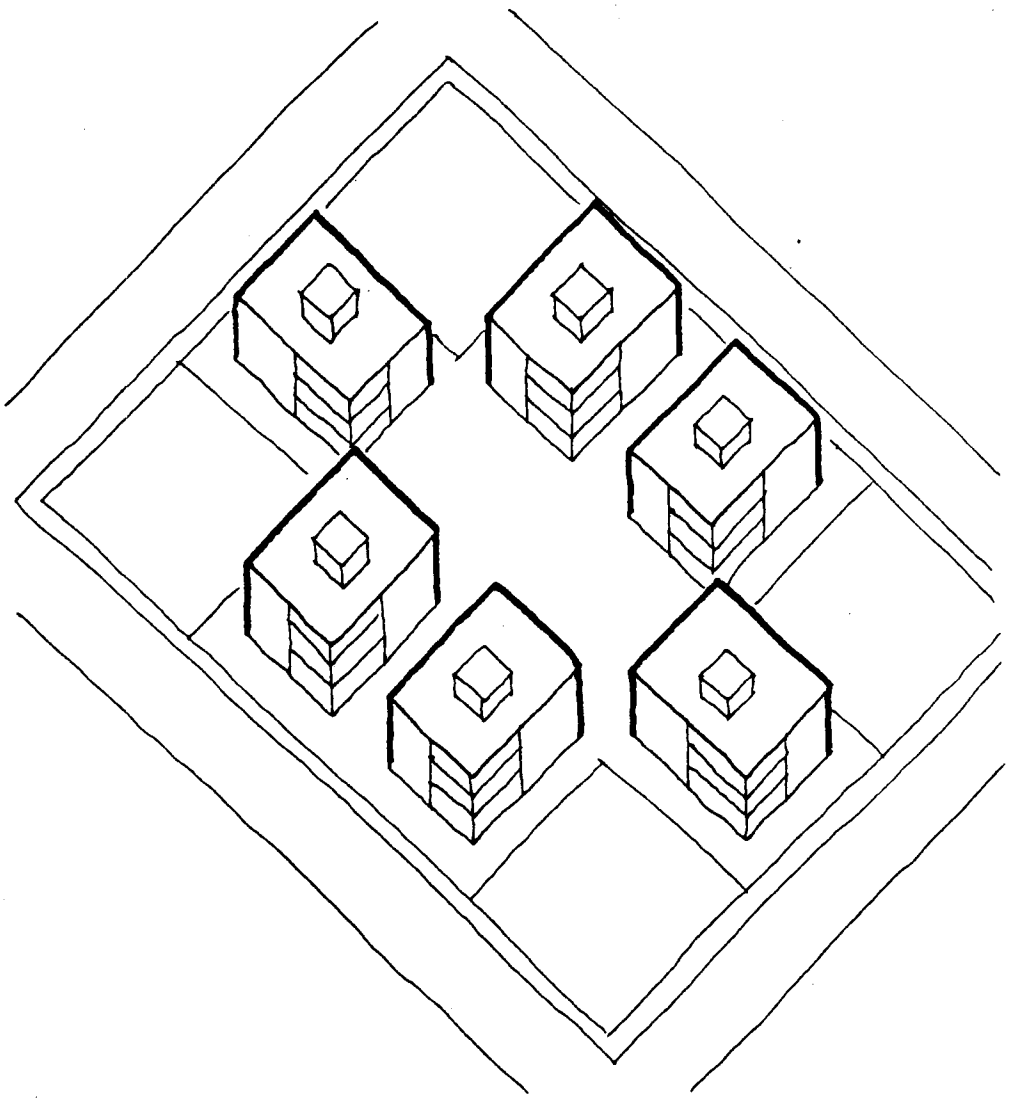


3.3.2.1 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 800 sq.ft.	- parallel	- **point**
- row housing	- 1000 sq.ft.	- **perimeter**	- single loaded corridor
- **garden apartments**	- **1100 sq.ft.**	- penetrating	- double loaded corridor
- high-rise apartments	- 1200 sq.ft.		- single loaded core
	- 1500sq.ft.		- double loaded core
	- 1650 sq.ft.		- complex

Block Size
300' x 400'
120,000 sq.ft.
2.75 acres
Gross Residential Area:
149,600 sq.ft.
3.4 acres
Number of Units:
72 @ 1,100 sq.ft.
Net Dwelling Density:
26.2 dwelling units/acre
Gross Residential Density:
21.0 dwelling units/acre
Coverage:
Net area = 0.24
Gross area = 0.19
Floor Area Ratio:
FAR = 0.72

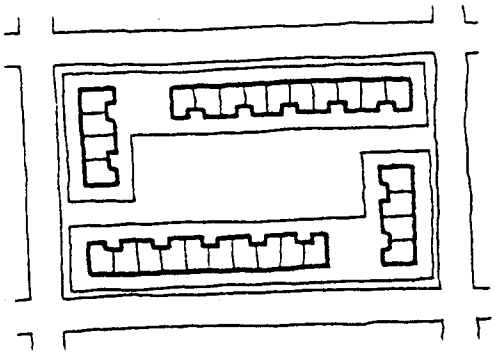


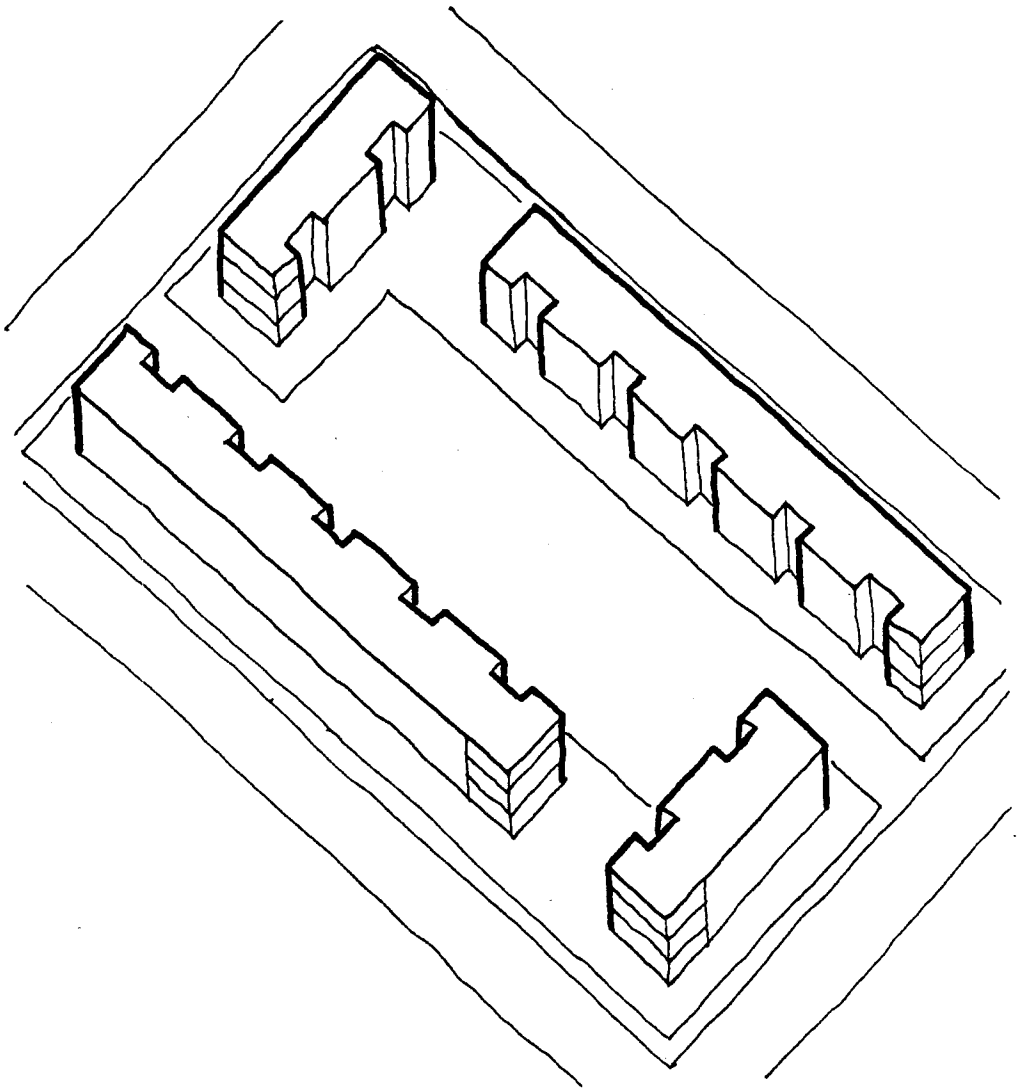


3.3.2.4 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 800 sq.ft.	- parallel	- point
- row housing	- 1000 sq.ft.	- **perimeter**	- single loaded corridor
- **garden apartments**	- **1100 sq.ft.**	- penetrating	- double loaded corridor
- high-rise apartments	- 1200 sq.ft.		- **single loaded core**
	- 1500sq.ft.		- double loaded core
	- 1650 sq.ft.		- complex

Block Size
270' x 450'
121.500 sq.ft.
2.8 acres
Gross Residential Area:
151,900 sq.ft.
3.5 acres
Number of Units:
84 @ 1,100 sq.ft.
Net Dwelling Density:
30.1 dwelling units/acre
Gross Residential Density:
24.1 dwelling units/acre
Coverage:
Net area = 0.25
Gross area = 0.20
Floor Area Ratio:
FAR = 0.76

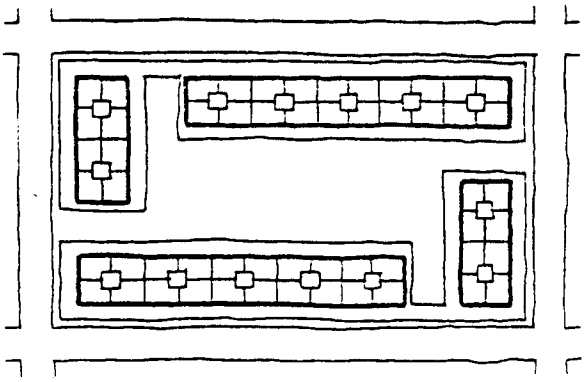


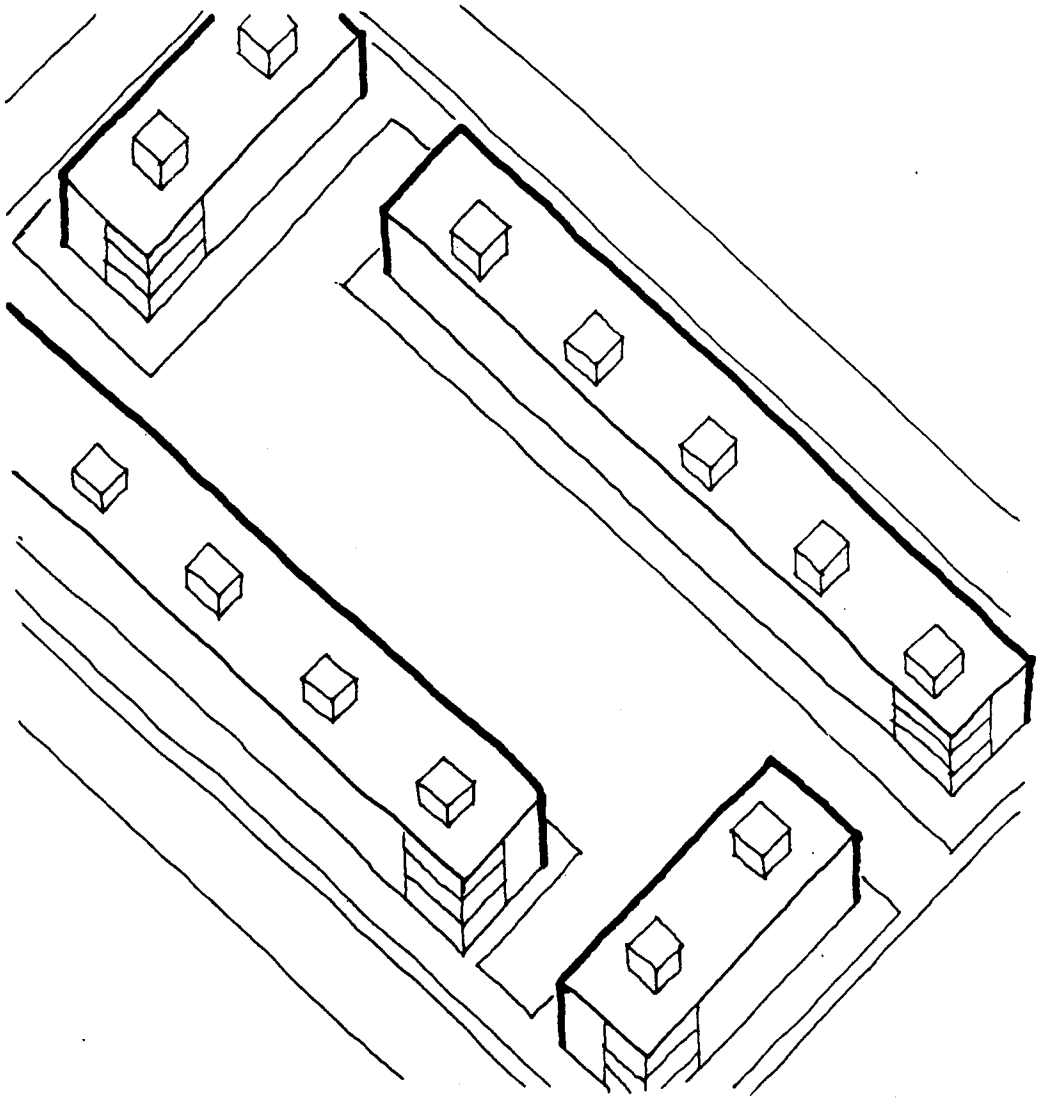


3.3.2.5 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 800 sq.ft.	- parallel	- point
- row housing	- 1000 sq.ft.	- **perimeter**	- single loaded corridor
- **garden apartments**	- **1100 sq.ft.**	- penetrating	- double loaded corridor
- high-rise apartments	- 1200 sq.ft.		- single loaded core
	- 1500sq.ft.		- **double loaded core**
	- 1650 sq.ft.		- complex

Block Size
530' x 570'
188,100 sq.ft.
4.3 acres
Gross Residential Area:
225,700 sq.ft.
5.2 acres
Number of Units:
168@ 1,100 sq.ft.
Net Dwelling Density:
38.9 dwelling units/acre
Gross Residential Density:
32.4 dwelling units/acre
Coverage:
Net area = 0.33
Gross area = 0.27
Floor Area Ratio:
FAR = 0.99

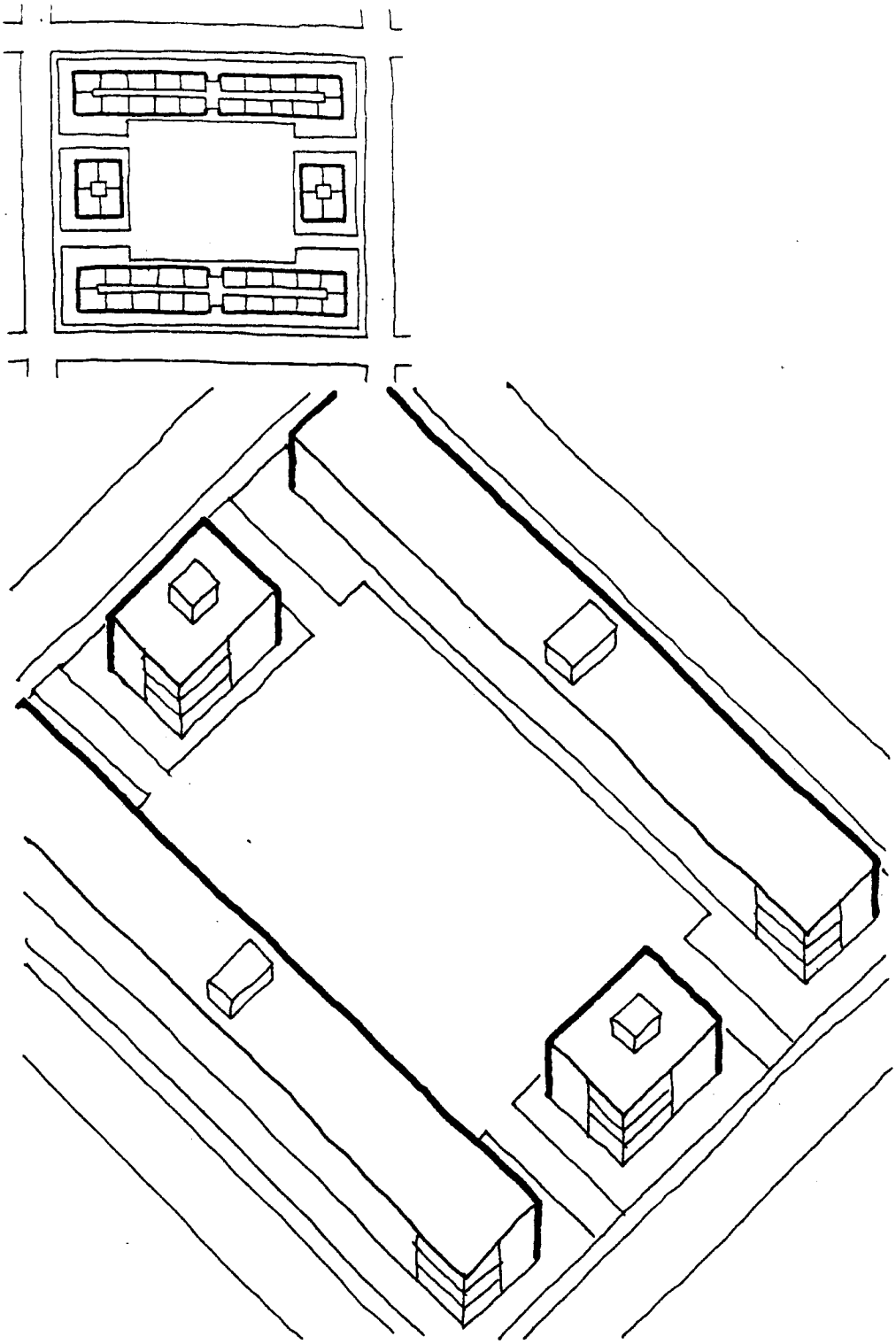




3.3.2.6 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 800 sq.ft.	- parallel	- point
- row housing	- 1000 sq.ft.	- **perimeter**	- single loaded corridor
- **garden apartments**	- **1100 sq.ft.**	- penetrating	- double loaded corridor
- high-rise apartments	- 1200 sq.ft.		- single loaded core
	- 1500sq.ft.		- double loaded core
	- 1650 sq.ft.		- **complex**

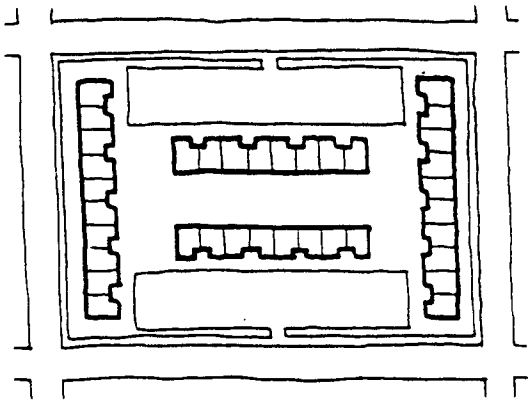
Block Size
380' x 460'
174,800 sq.ft.
4.0 acres
Gross Residential Area:
210,000 sq.ft.
4.8 acres
Number of Units:
48 @ 1,100 sq.ft.
Net Dwelling Density:
35.9 dwelling units/acre
Gross Residential Density:
29.9 dwelling units/acre
Coverage:
Net area = 0.34
Gross area = 0.29
Floor Area Ratio:
FAR = 1.03

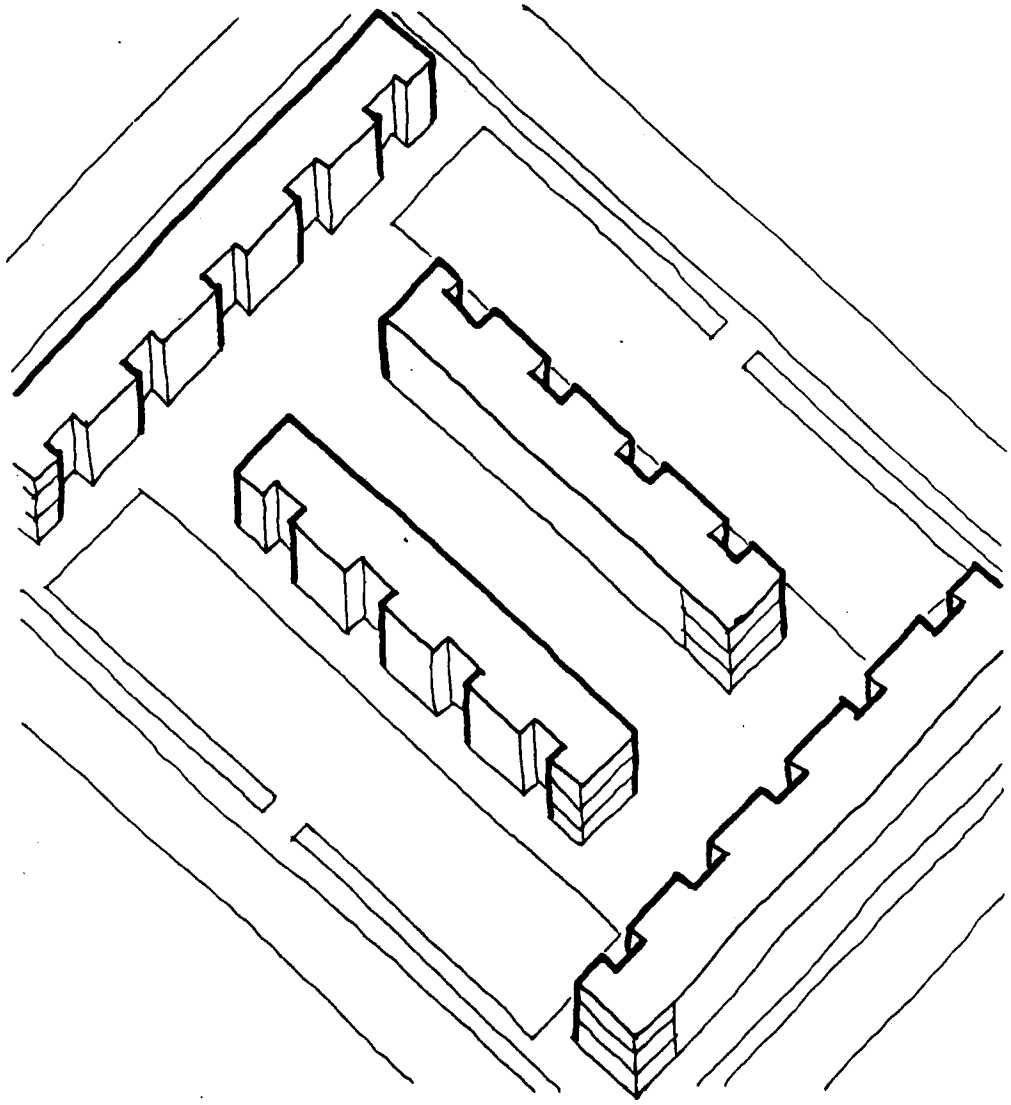


3.3.3.4 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 800 sq.ft.	- parallel	- point
- row housing	- 1000 sq.ft.	- perimeter	- single loaded corridor
- **garden apartments**	- **1100 sq.ft.**	- **penetrating**	- double loaded corridor
- high-rise apartments	- 1200 sq.ft.		- **single loaded core**
	- 1500sq.ft.		- double loaded core
	- 1650 sq.ft.		- complex

Block Size
350' x 500'
175,000 sq.ft.
4.0 acres
Gross Residential Area:
209,160 sq.ft.
4.8 acres
Number of Units:
108@ 1,100 sq.ft.
Net Dwelling Density:
26.9 dwelling units/acre
Gross Residential Density:
22.5 dwelling units/acre
Coverage:
Net area = 0.23
Gross area = 0.19
Floor Area Ratio:
FAR = 0.68

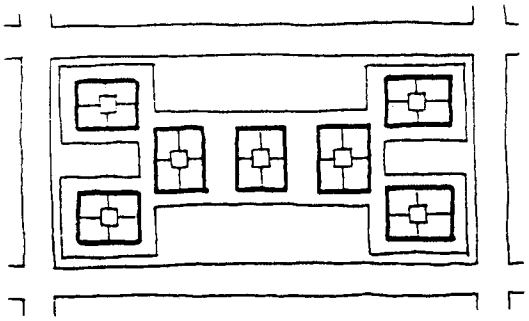


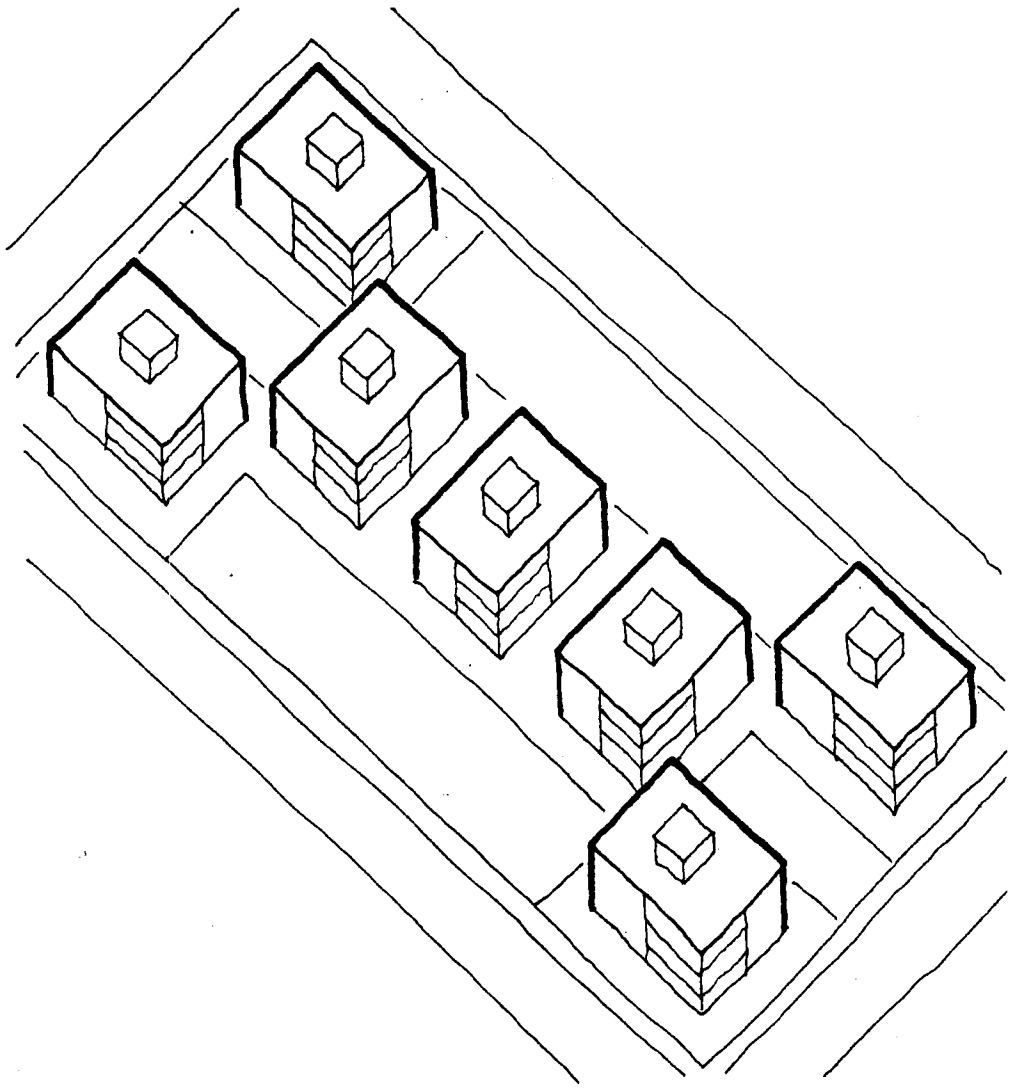


3.3.3.5 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 800 sq.ft.	- parallel	- point
- row housing	- 1000 sq.ft.	- perimeter	- single loaded corridor
- **garden apartments**	- **1100 sq.ft.**	- **penetrating**	- double loaded corridor
- high-rise apartments	- 1200 sq.ft.		- single loaded core
	- 1500sq.ft.		- **double loaded core**
	- 1650 sq.ft.		- complex

Block Size
240' x 500'
120,000 sq.ft.
2.75 acres
Gross Residential Area:
151,200 sq.ft.
3.5 acres
Number of Units:
84 @ 1,100 sq.ft.
Net Dwelling Density:
30.5 dwelling units/acre
Gross Residential Density:
24.2 dwelling units/acre
Coverage:
Net area = 0.28
Gross area = 0.22
Floor Area Ratio:
FAR = 0.84

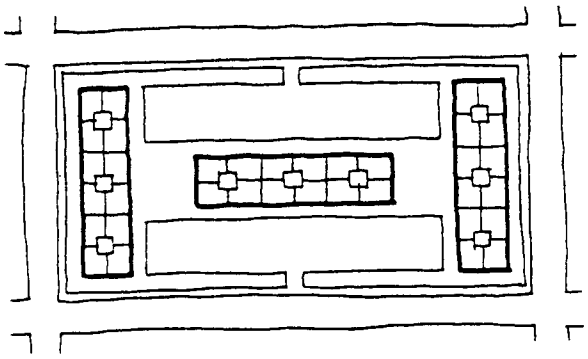


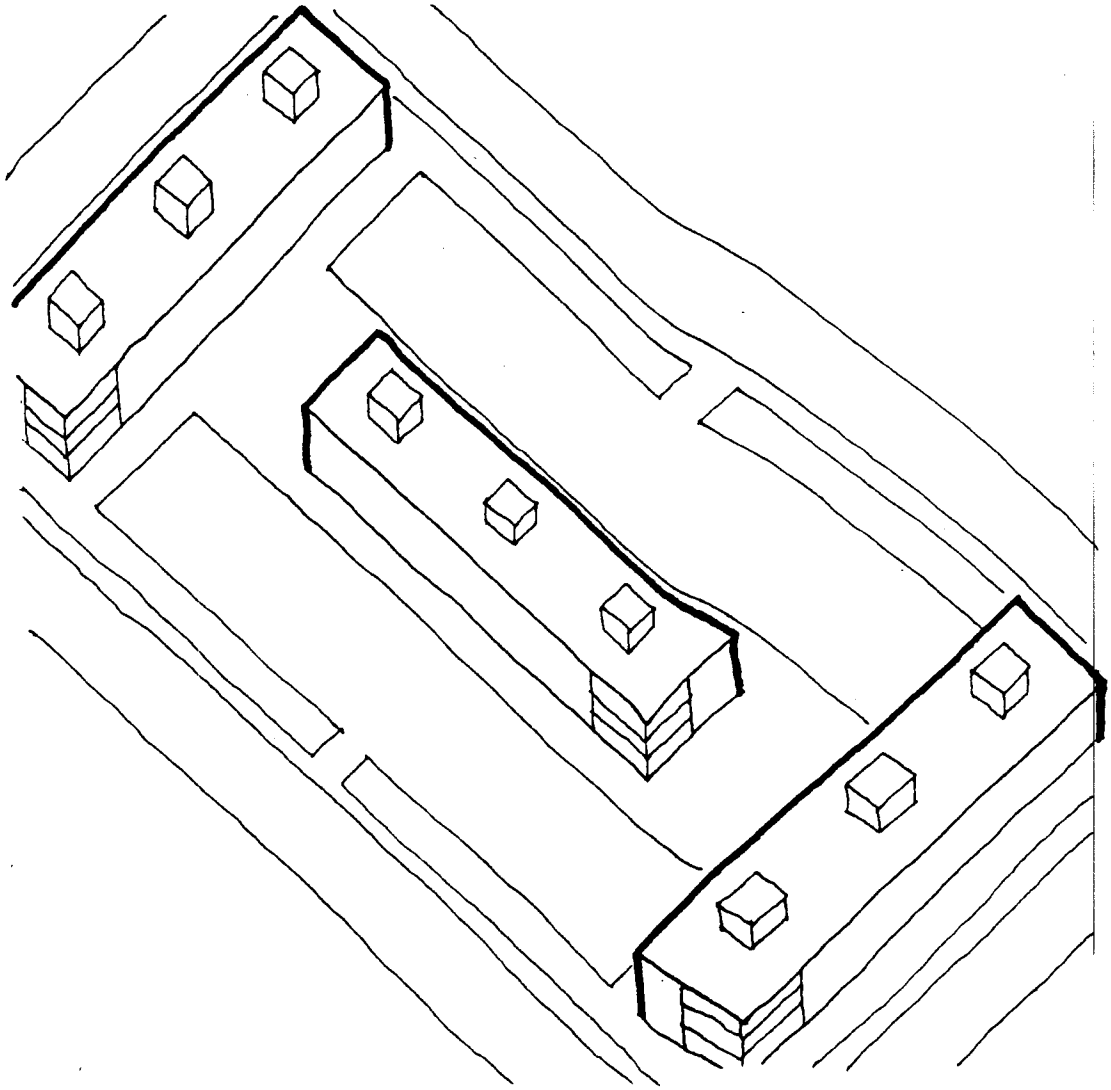


3.3.3.5 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 800 sq.ft.	- parallel	- point
- row housing	- 1000 sq.ft.	- perimeter	- single loaded corridor
- **garden apartments**	- **1100 sq.ft.**	- **penetrating**	- double loaded corridor
- high-rise apartments	- 1200 sq.ft.		- single loaded core
	- 1500sq.ft.		- **double loaded core**
	- 1650 sq.ft.		- complex

Block Size
280' x 560'
156,800 sq.ft.
3.6 acres
Gross Residential Area:
192,000 sq.ft.
4.4 acres
Number of Units:
108@ 1,100 sq.ft.
Net Dwelling Density:
30.0 dwelling units/acre
Gross Residential Density:
24.5 dwelling units/acre
Coverage:
Net area = 0.25
Gross area = 0.21
Floor Area Ratio:
FAR = 0.75

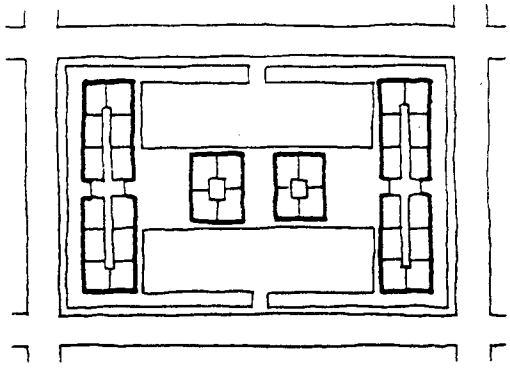


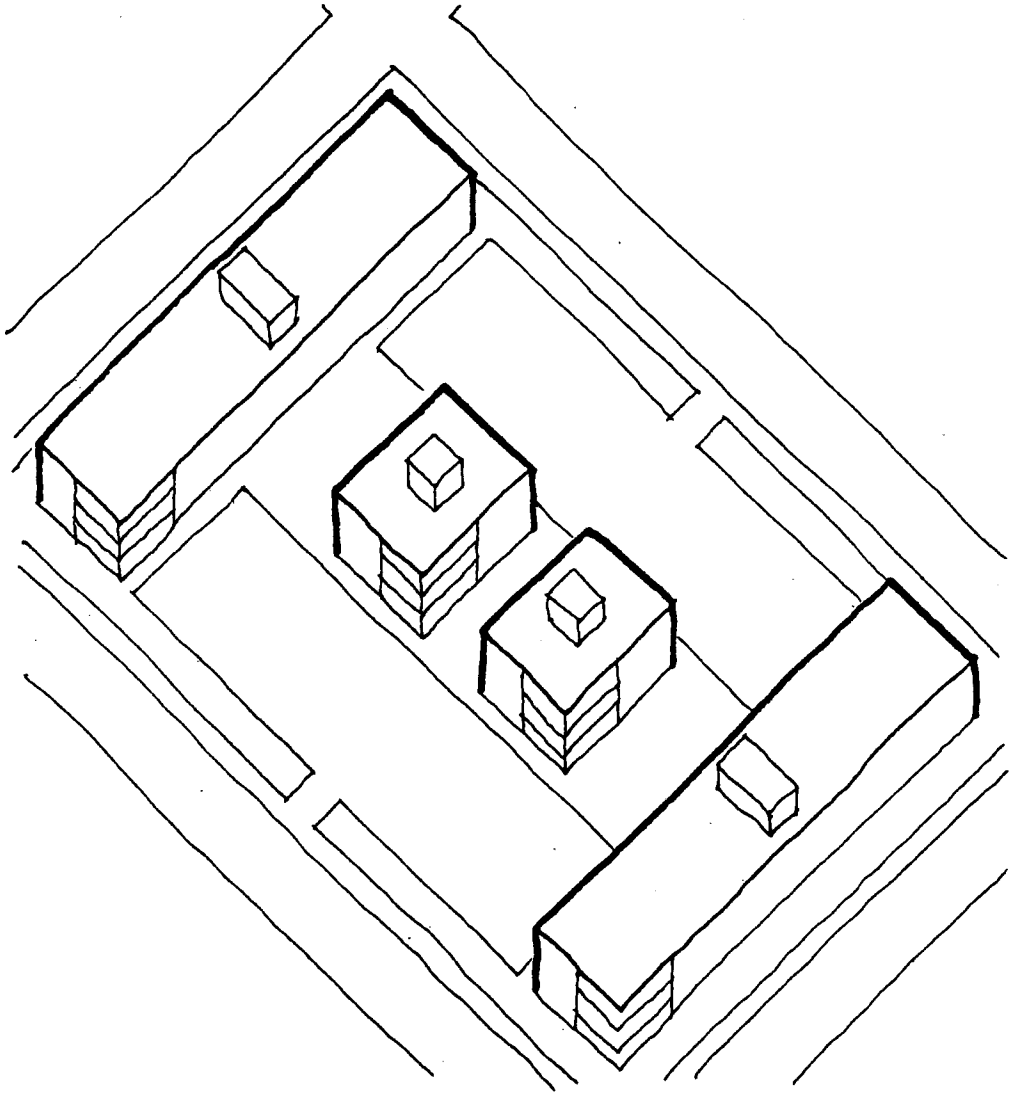


3.3.3.6 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 800 sq.ft.	- parallel	- point
- row housing	- **1000 sq.ft.**	- perimeter	- single loaded corridor
- **garden apartments**	- 1100 sq.ft.	- **penetrating**	- double loaded corridor
- high-rise apartments	- 1200 sq.ft.		- single loaded core
	- 1500sq.ft.		- double loaded core
	- 1650 sq.ft.		- **complex**

Block Size
300' x 460'
138,000 sq.ft.
3.2 acres
Gross Residential Area:
170,000 sq.ft.
3.9 acres
Number of Units:
48 @ 1,100 sq.ft.
Net Dwelling Density:
30.3 dwelling units/acre
Gross Residential Density:
24.6 dwelling units/acre
Coverage:
Net area = 0.30
Gross area = 0.24
Floor Area Ratio:
FAR = 0.89

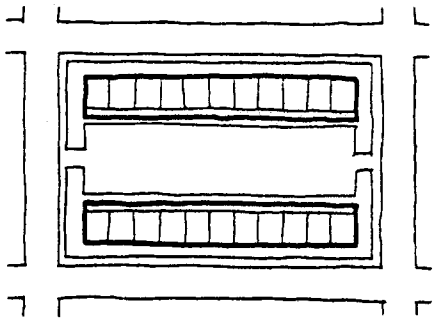


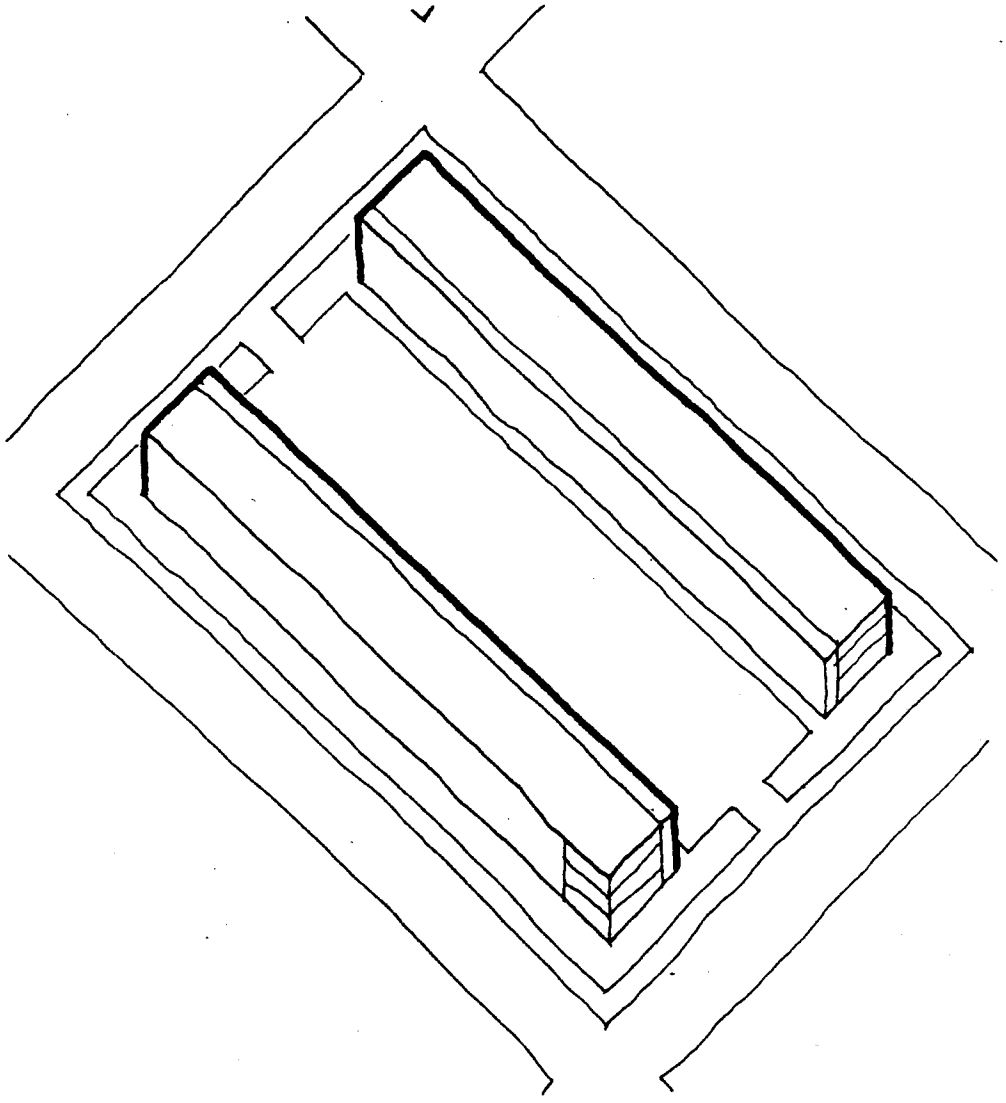


3.4.1.2 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 800 sq.ft.	- **parallel**	- point
- row housing	- 1000 sq.ft.	- perimeter	- **single loaded corridor**
- **garden apartments**	- 1100 sq.ft.	- penetrating	- double loaded corridor
- high-rise apartments	- **1200 sq.ft.**		- single loaded core
	- 1500sq.ft.		- double loaded core
	- 1650 sq.ft.		- complex

Block Size
250' x 370'
92,500 sq.ft.
2.1 acres
Gross Residential Area:
118,900 sq.ft.
2.7 acres
Number of Units:
66 @ 1,200 sq.ft.
Net Dwelling Density:
31.1 dwelling units/acre
Gross Residential Density:
24.2 dwelling units/acre
Coverage:
Net area = 0.36
Gross area = 0.28
Floor Area Ratio:
FAR = 1.1

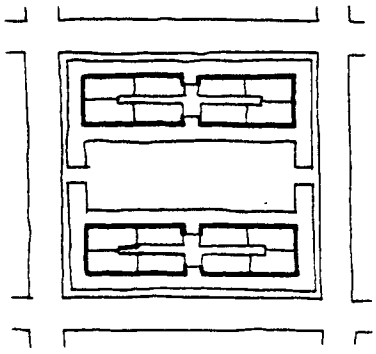


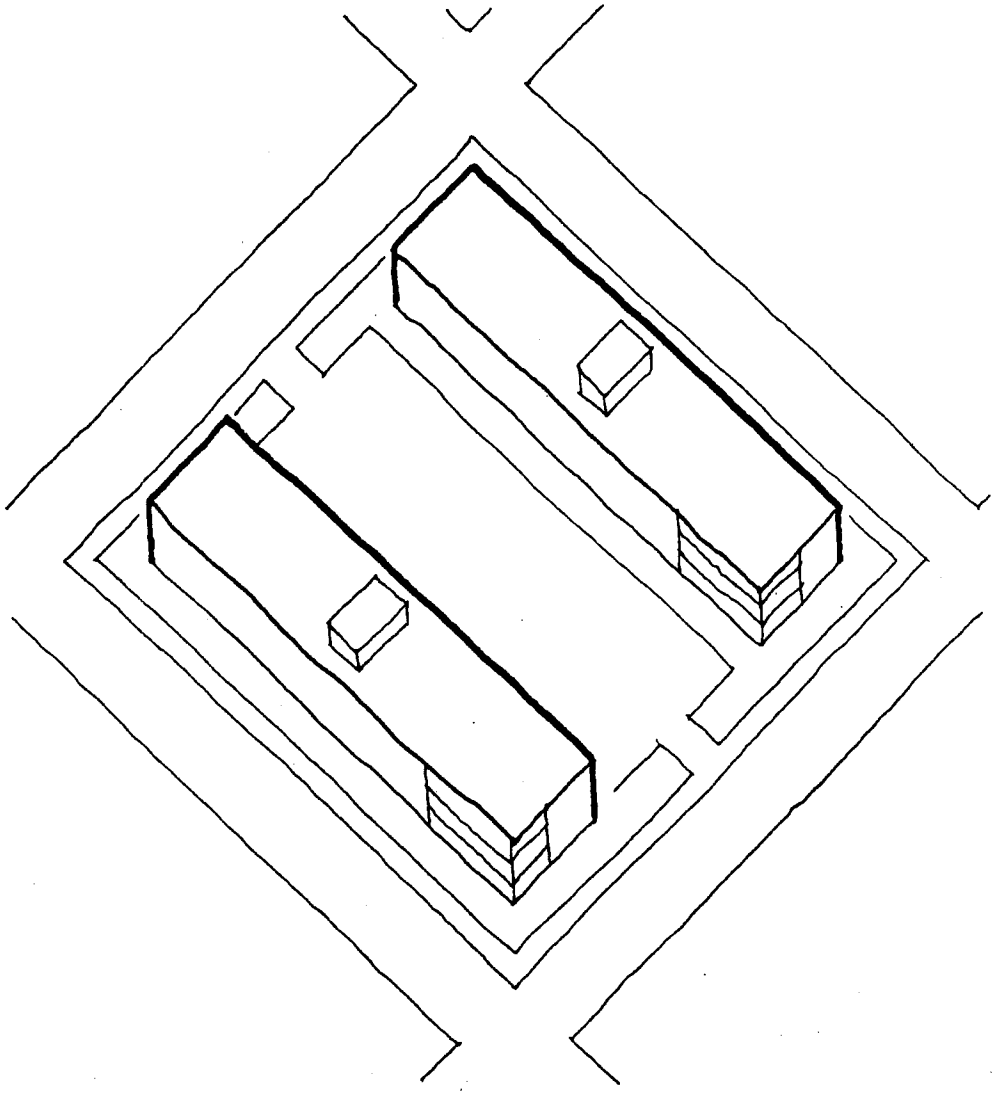


3.5.1.3 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 800 sq.ft.	- **parallel**	- point
- row housing	- 1000 sq.ft.	- perimeter	- single loaded corridor
- **garden apartments**	- 1100 sq.ft.	- penetrating	- **double loaded corridor**
- high-rise apartments	- 1200 sq.ft.		- single loaded core
	- **1500sq.ft.**		- double loaded core
	- 1650 sq.ft.		- complex

Block Size
285' x 300'
85,500 sq.ft.
1.9 acres
Gross Residential Area:
110,500 sq.ft.
2.5 acres
Number of Units:
48 @ 1,500 sq.ft.
Net Dwelling Density:
24.5 dwelling units/acre
Gross Residential Density:
18.9 dwelling units/acre
Coverage:
Net area = 0.36
Gross area = 0.28
Floor Area Ratio:
FAR = 1.1

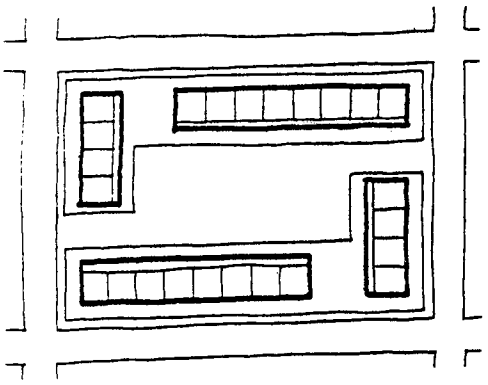


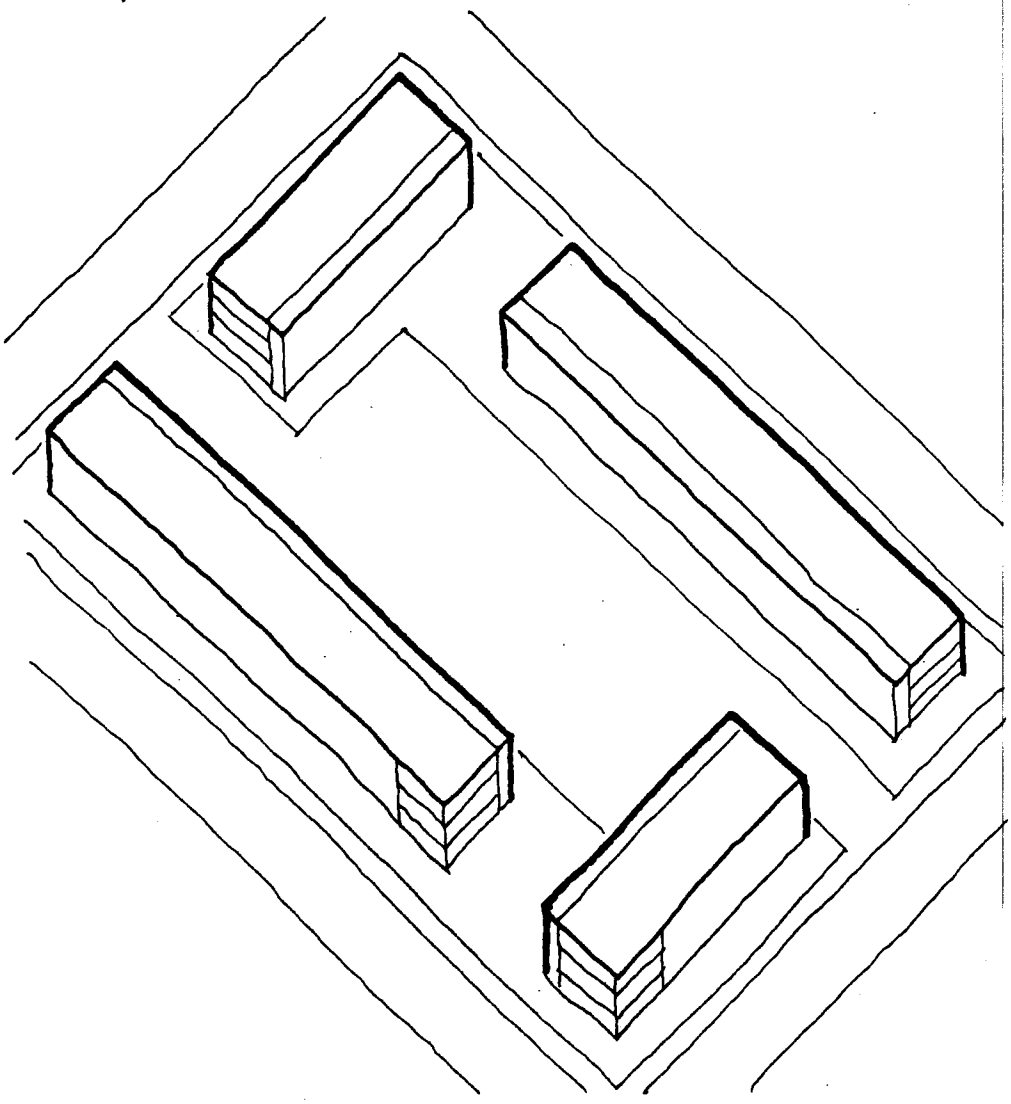


3.5.2.2 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 800 sq.ft.	- parallel	- point
- row housing	- 1000 sq.ft.	- **perimeter**	- **single loaded corridor**
- **garden apartments**	- 1100 sq.ft.	- penetrating	- double loaded corridor
- high-rise apartments	- 1200 sq.ft.		- single loaded core
	- **1500sq.ft.**		- double loaded core
	- 1650 sq.ft.		- complex

Block Size
300' x 440'
132,000 sq.ft.
3.1 acres
Gross Residential Area:
163,200 sq.ft.
3.75 acres
Number of Units:
72 @ 1,500 sq.ft.
Net Dwelling Density:
23.8 dwelling units/acre
Gross Residential Density:
19.2 dwelling units/acre
Coverage:
Net area = 0.27
Gross area = 0.22
Floor Area Ratio:
FAR = 0.81

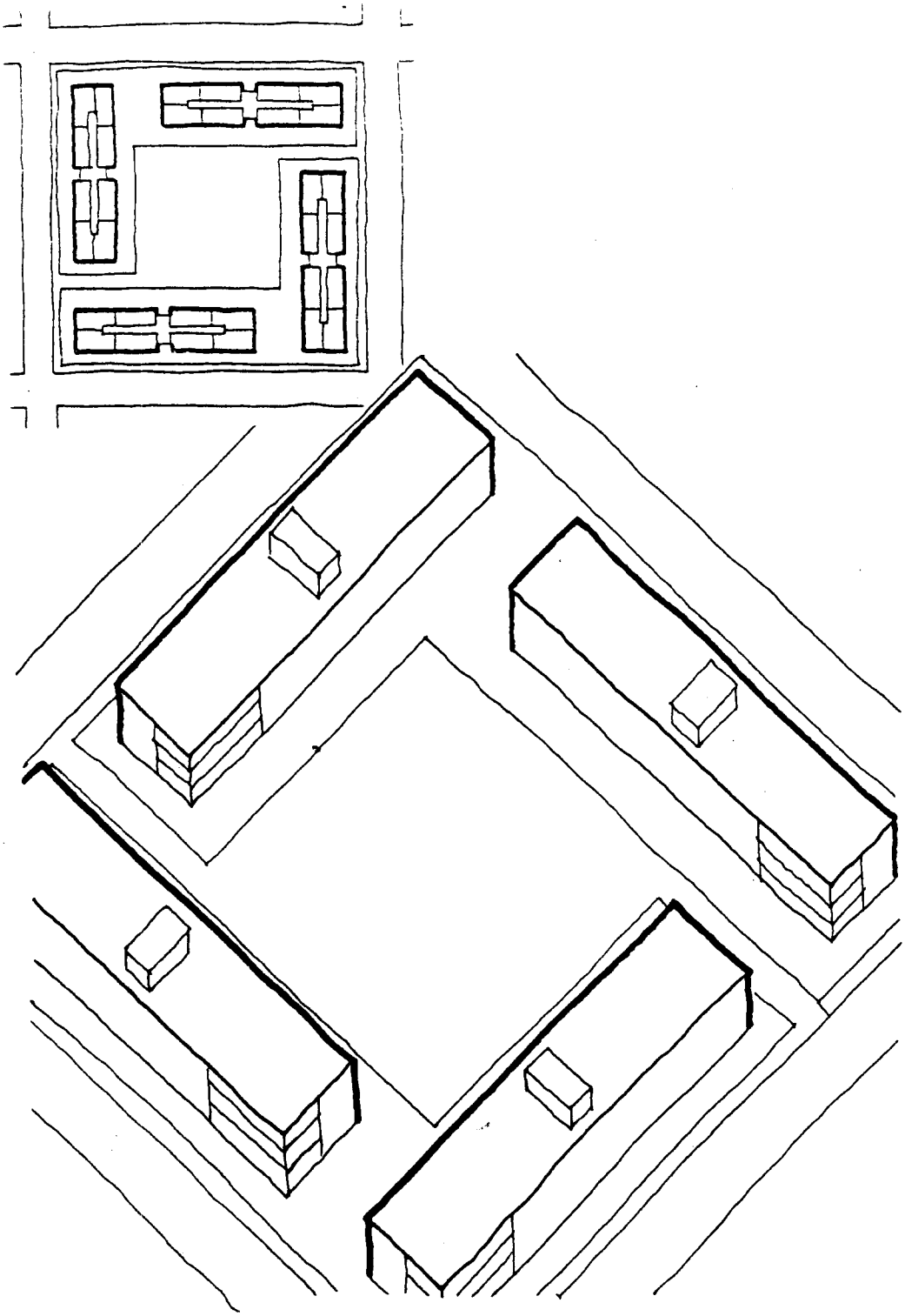




3.5.2.3 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 800 sq.ft.	- parallel	- point
- row housing	- 1000 sq.ft.	- **perimeter**	- single loaded corridor
- **garden apartments**	- 1100 sq.ft.	- penetrating	- **double loaded corridor**
- high-rise apartments	- 1200 sq.ft.		- single loaded core
	- **1500sq.ft.**		- double loaded core
	- 1650 sq.ft.		- complex

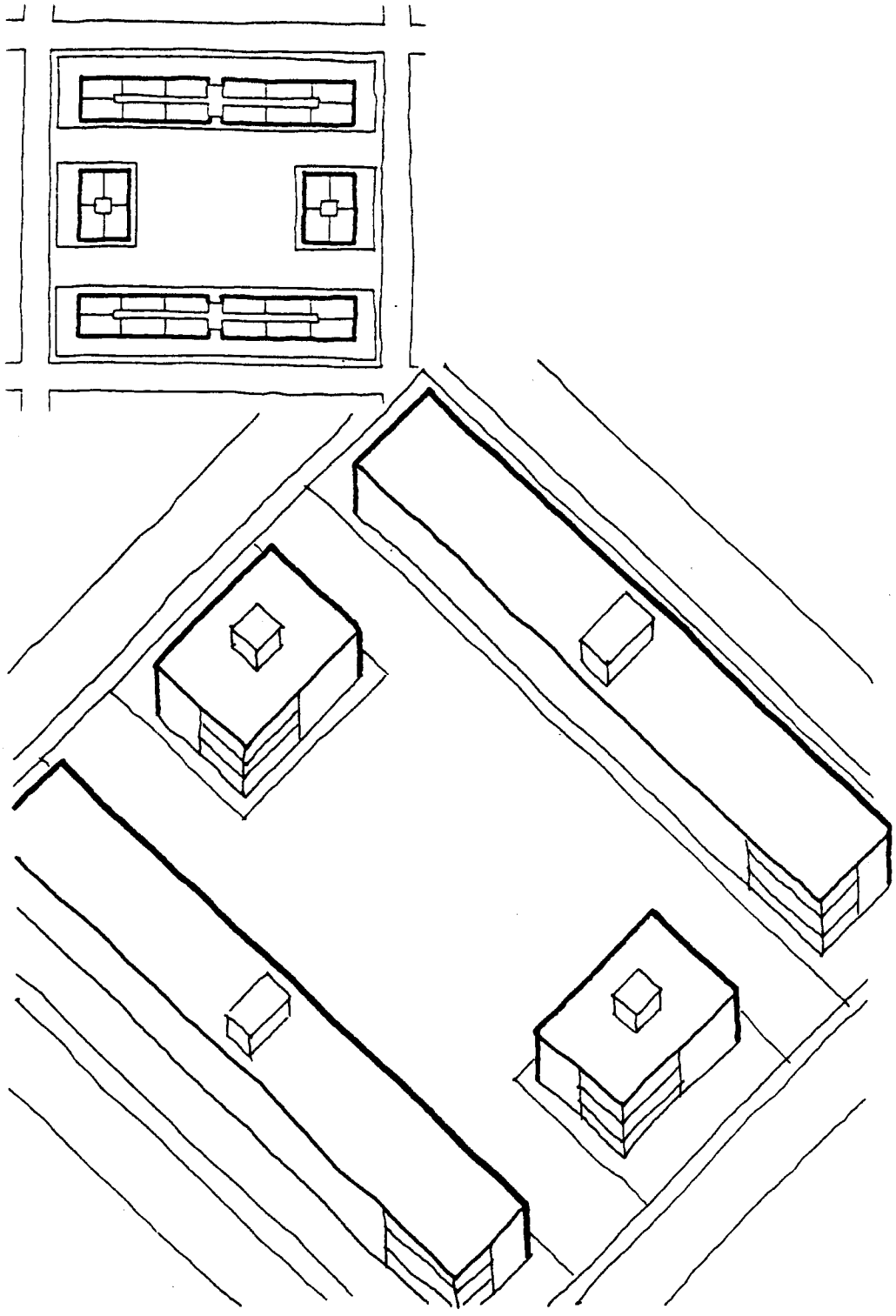
Block Size
450' x 450'
202,500 sq.ft.
4.7 acres
Gross Residential Area:
240,100 sq.ft.
5.5 acres
Number of Units:
96 @ 1,500 sq.ft.
Net Dwelling Density:
20.7 dwelling units/acre
Gross Residential Density:
17.5 dwelling units/acre
Coverage:
Net area = 0.31
Gross area = 0.26
Floor Area Ratio:
FAR = 0.93



3.5.2.6 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 800 sq.ft.	- parallel	- point
- row housing	- 1000 sq.ft.	- **perimeter**	- single loaded corridor
- **garden apartments**	- 1100 sq.ft.	- penetrating	- double loaded corridor
- high-rise apartments	- 1200 sq.ft.		- single loaded core
	- **1500sq.ft.**		- double loaded core
	- 1650 sq.ft.		- **complex**

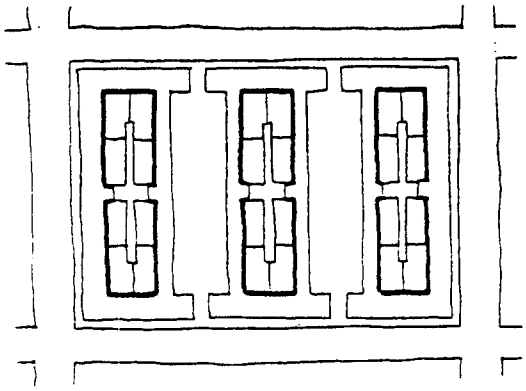
Block Size
430' x 440'
189,200 sq.ft.
4.3 acres
Gross Residential Area:
225,600 sq.ft.
5.2 acres
Number of Units:
96 @ approx. 1,650 sq.ft.
Net Dwelling Density:
22.1 dwelling units/acre
Gross Residential Density:
18.5 dwelling units/acre
Coverage:
Net area = 0.30
Gross area = 0.26
Floor Area Ratio:
FAR = 0.91

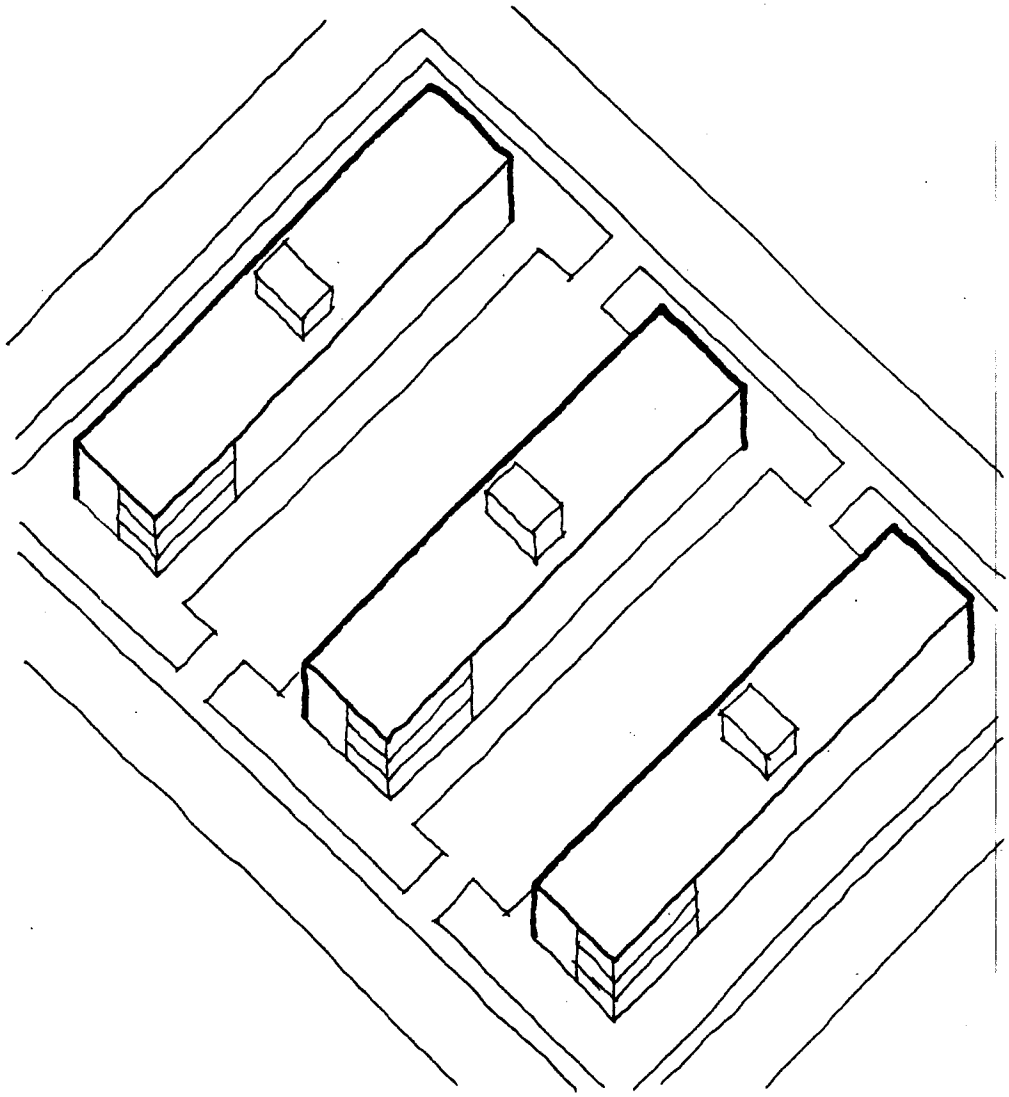


3.5.3.3 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 800 sq.ft.	- parallel	- point
- row housing	- 1000 sq.ft.	- perimeter	- single loaded corridor
- **garden apartments**	- 1100 sq.ft.	- **penetrating**	- **double loaded corridor**
- high-rise apartments	- 1200 sq.ft.		- single loaded core
	- **1500sq.ft.**		- double loaded core
	- 1650 sq.ft.		- complex

Block Size:
320' x 450'
144,000 sq.ft.
3.3 acres
Gross Residential Area:
176,400 sq.ft.
4.1 acres
Number of Units:
72 @ 1,500 sq.ft.
Net Dwelling Density:
21.8 dwelling units/acre
Gross Residential Density:
17.8 dwelling units/acre
Coverage:
Net area = 0.25
Gross area = 0.20
Floor Area Ratio:
FAR = 0.75

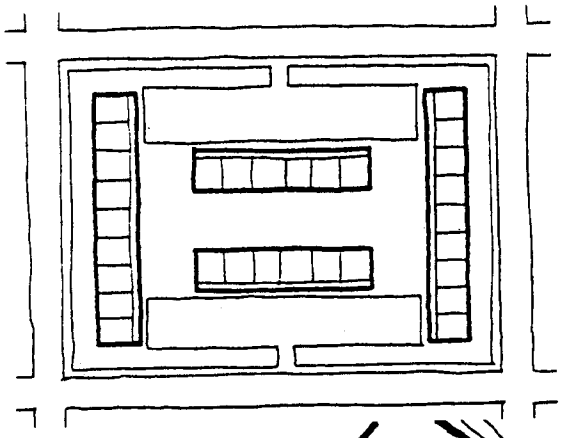


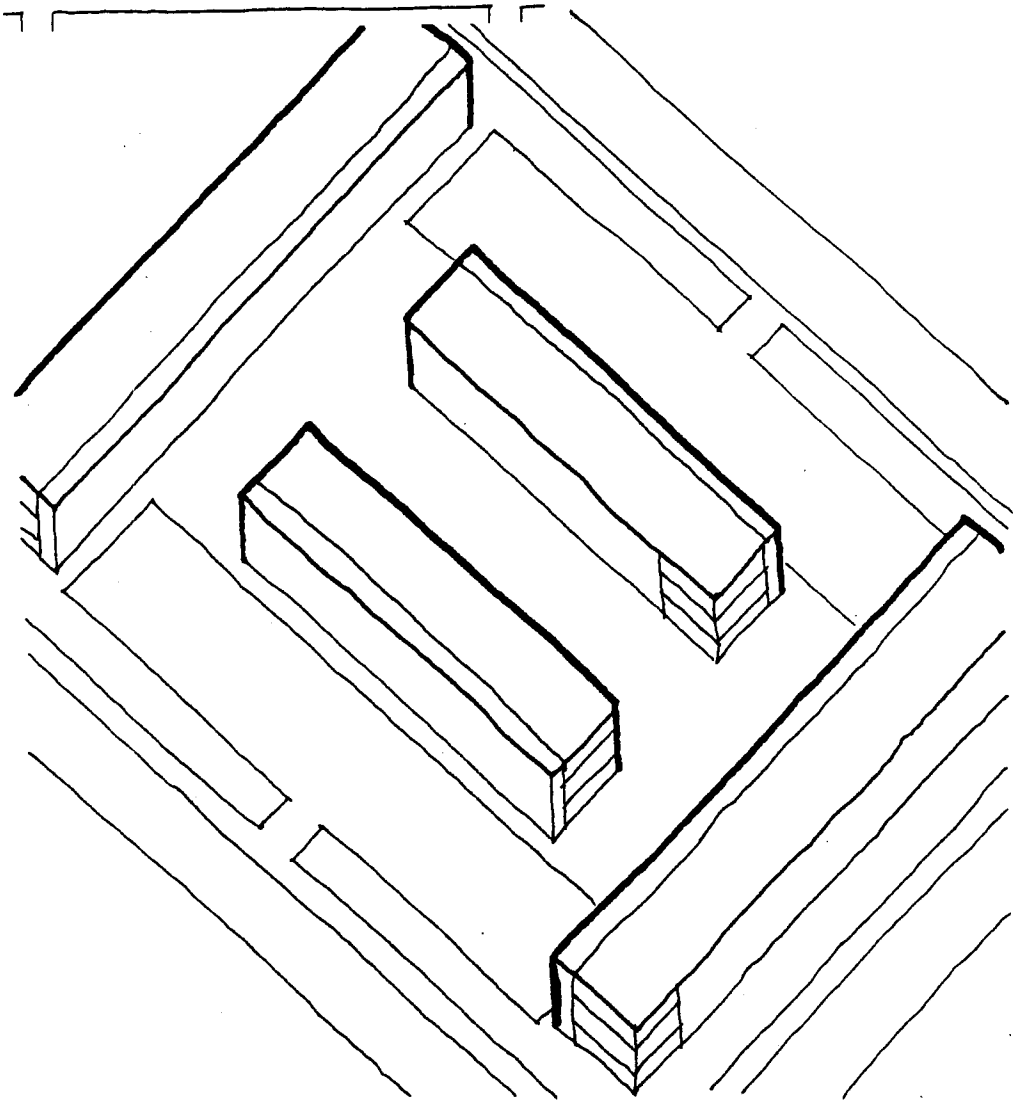


3.5.3.4 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 800 sq.ft.	- parallel	- point
- row housing	- 1000 sq.ft.	- perimeter	- single loaded corridor
- **garden apartments**	- 1100 sq.ft.	- **penetrating**	- double loaded corridor
- high-rise apartments	- 1200 sq.ft.		- **single loaded core**
	- **1500sq.ft.**		- double loaded core
	- 1650 sq.ft.		- complex

Block Size
375' x 510'
191,250 sq.ft.
4.4 acres
Gross Residential Area:
228,250 sq.ft.
5.2 acres
Number of Units:
90 @ 1,500 sq.ft.
Net Dwelling Density:
20.5 dwelling units/acre
Gross Residential Density:
17.2 dwelling units/acre
Coverage:
Net area = 0.24
Gross area = 0.20
Floor Area Ratio:
FAR = 0.72

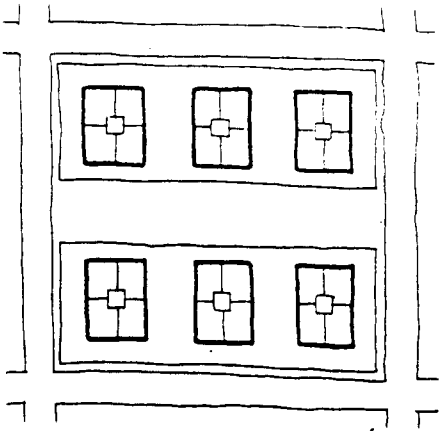


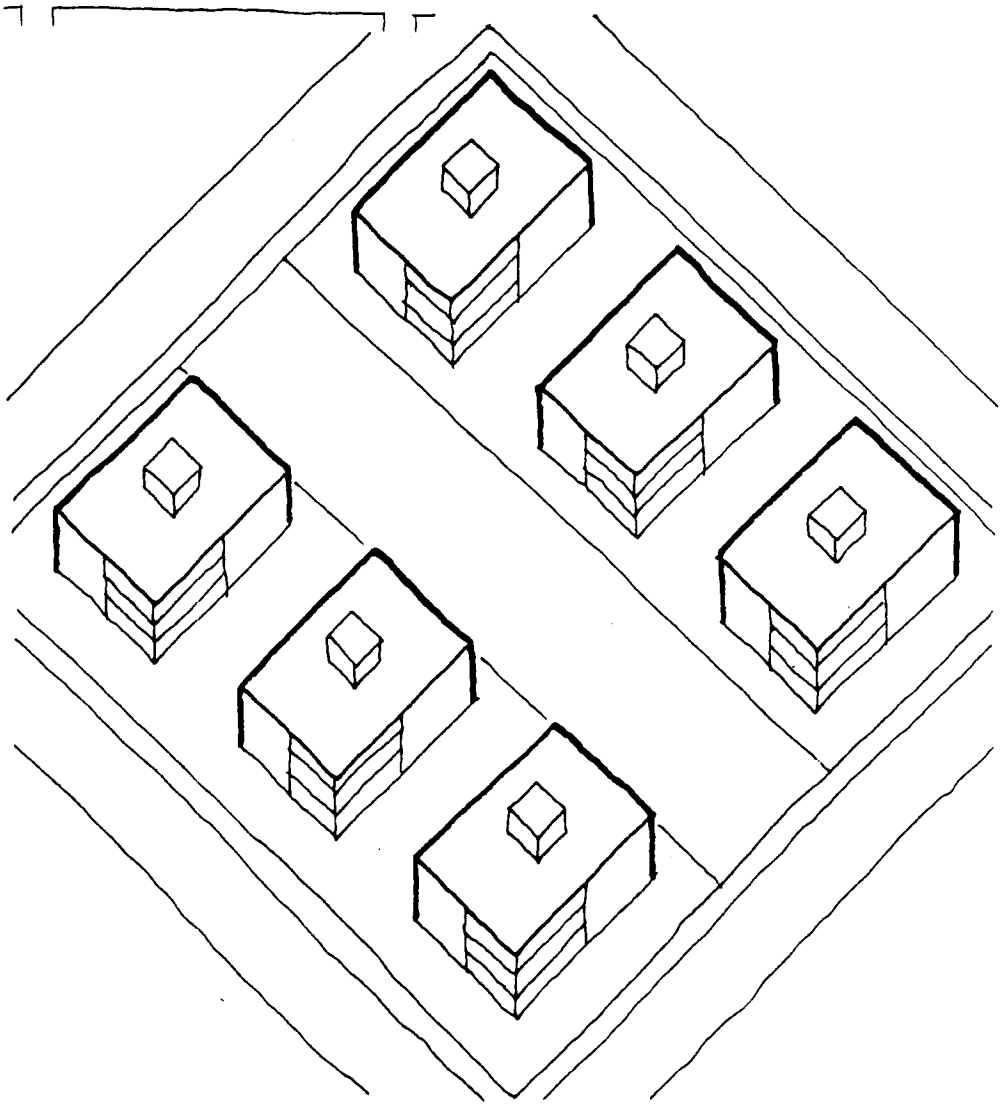


3.6.1.1 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 800 sq.ft.	- **parallel**	- **point**
- row housing	- 1000 sq.ft.	- perimeter	- single loaded corridor
- **garden apartments**	- 1100 sq.ft.	- penetrating	- double loaded corridor
- high-rise apartments	- 1200 sq.ft.		- single loaded core
	- 1500sq.ft.		- double loaded core
	- **1650 sq.ft.**		- complex

Block Size
380' x 390'
148,200 sq.ft.
3.4 acres
Gross Residential Area:
180,600 sq.ft.
4.2 acres
Number of Units:
72 @ 1,650 sq.ft.
Net Dwelling Density:
21.0 dwelling units/acre
Gross Residential Density:
17.35 dwelling units/acre
Coverage:
Net area = 0.28
Gross area = 0.23
Floor Area Ratio:
FAR = 0.84

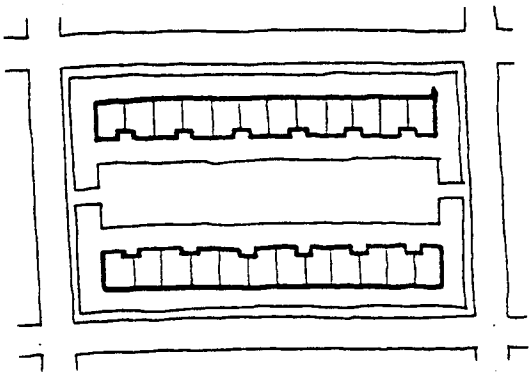


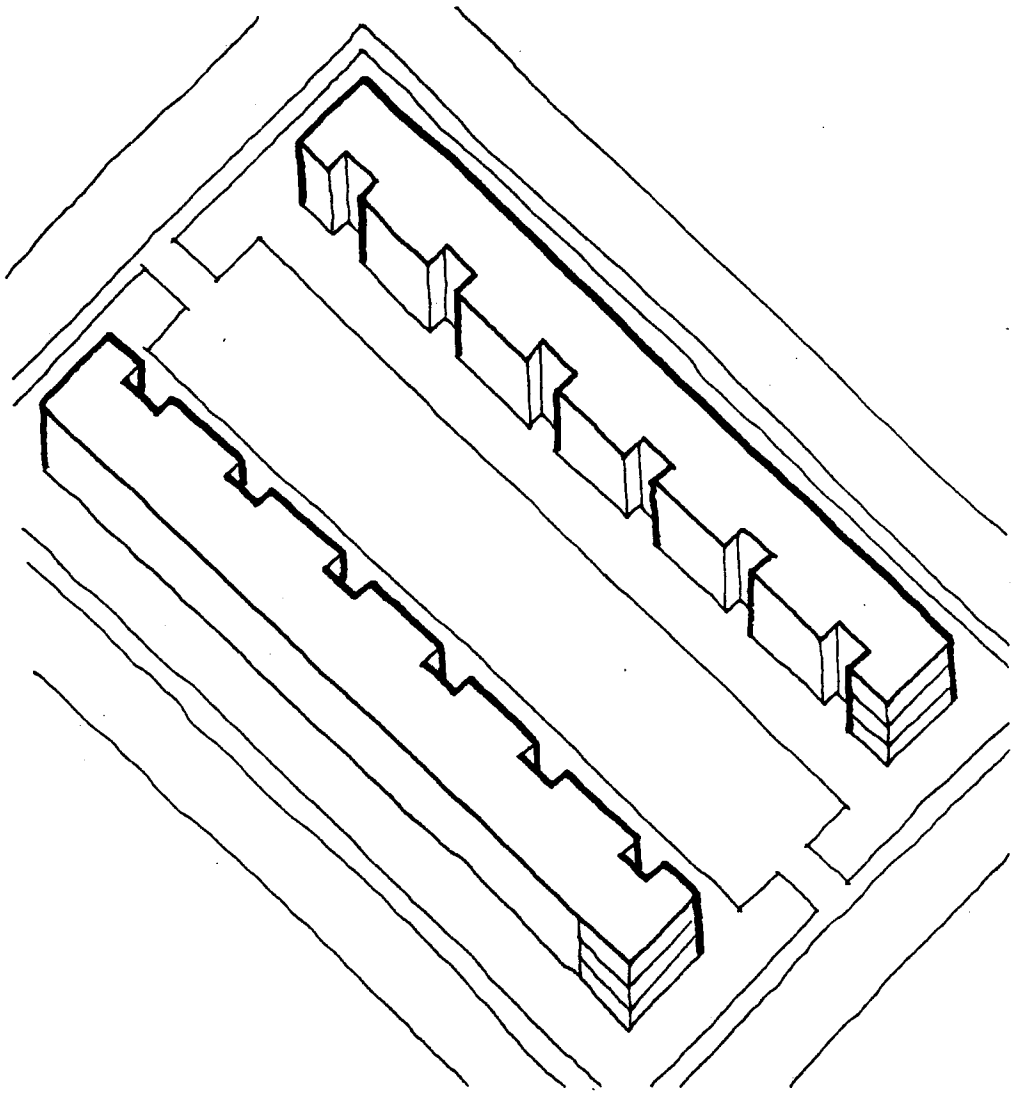


3.6.1.4 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 800 sq.ft.	- **parallel**	- point
- row housing	- 1000 sq.ft.	- perimeter	- single loaded corridor
- **garden apartments**	- 1100 sq.ft.	- penetrating	- double loaded corridor
- high-rise apartments	- 1200 sq.ft.		- **single loaded core**
	- 1500sq.ft.		- double loaded core
	- **1650 sq.ft.**		- complex

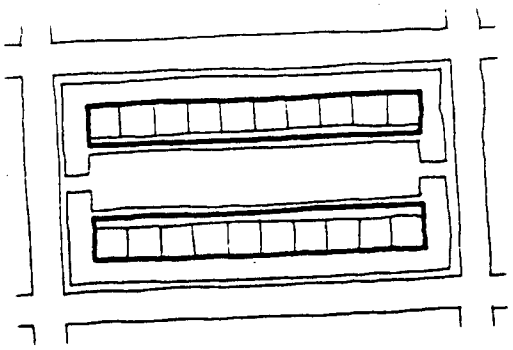
Block Size
300' x 480'
144,000 sq.ft.
3.3 acres
Gross Residential Area:
176,800 sq.ft.
4.1 acres
Number of Units:
72 @ 1,650 sq.ft.
Net Dwelling Density:
21.75 dwelling units/acre
Gross Residential Density:
17.7 dwelling units/acre
Coverage:
Net area = 0.27
Gross area = 0.22
Floor Area Ratio:
FAR = 0.82



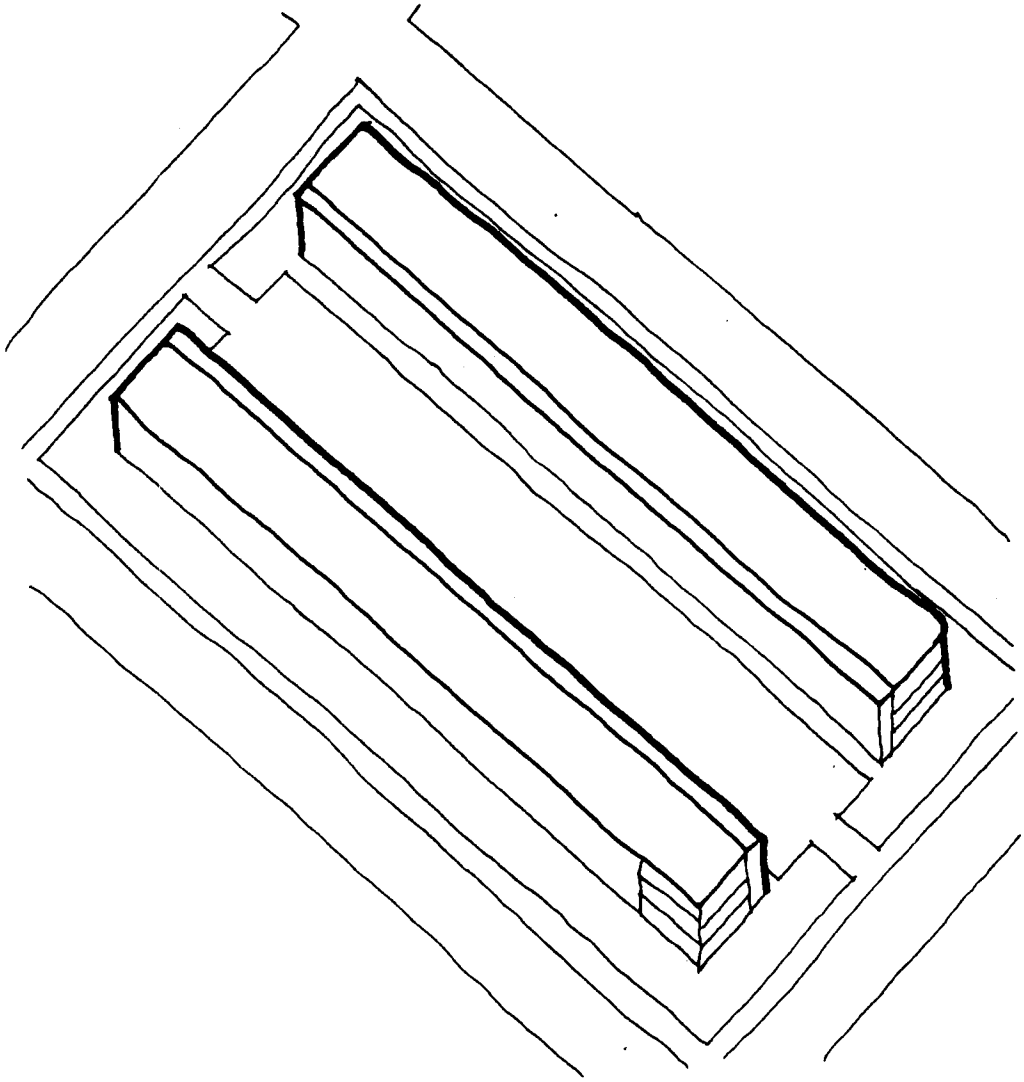


3.6.1.4 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 800 sq.ft.	- **parallel**	- point
- row housing	- 1000 sq.ft.	- perimeter	- single loaded corridor
- **garden apartments**	- 1100 sq.ft.	- penetrating	- double loaded corridor
- high-rise apartments	- 1200 sq.ft.		- **single loaded core**
	- 1500sq.ft.		- double loaded core
	- **1650 sq.ft.**		- complex



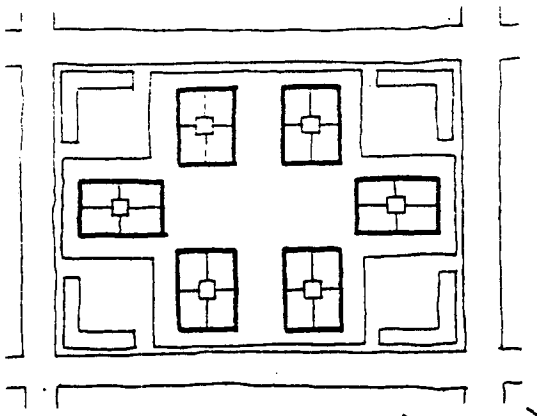
Block Size
250' x 460'
115,000 sq.ft.
2.6 acres
Gross Residential Area:
145,000 sq.ft.
3.3 acres
Number of Units:
60 @ 1,650 sq.ft.
Net Dwelling Density:
22.7 dwelling units/acre
Gross Residential Density:
18.0 dwelling units/acre
Coverage:
Net area = 0.35
Gross area = 0.28
Floor Area Ratio:
FAR = 1.04

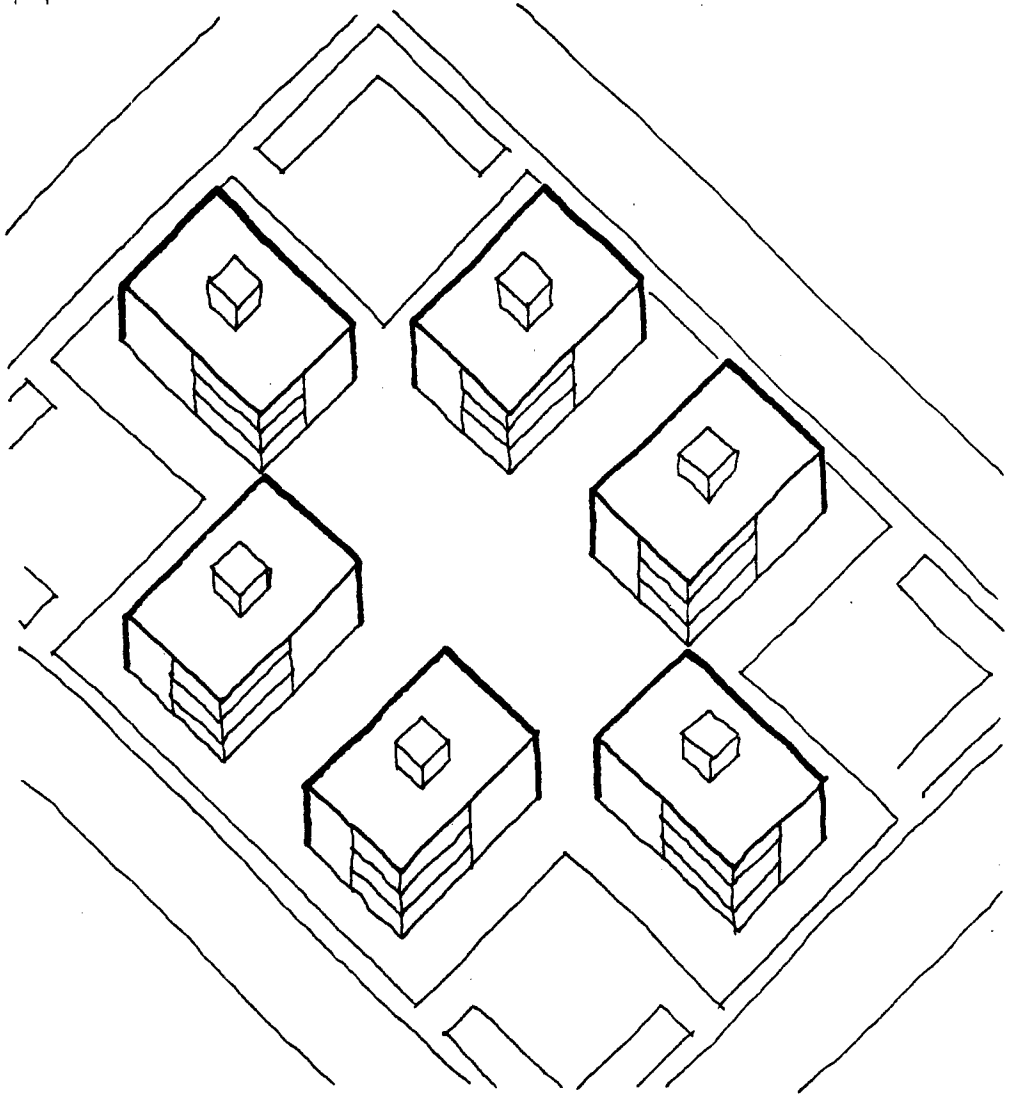


3.6.2.1 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 800 sq.ft.	- parallel	- **point**
- row housing	- 1000 sq.ft.	- **perimeter**	- single loaded corridor
- **garden apartments**	- 1100 sq.ft.	- penetrating	- double loaded corridor
- high-rise apartments	- 1200 sq.ft.		- single loaded core
	- 1500sq.ft.		- double loaded core
	- **1650 sq.ft.**		- complex

Block Size
370' x 500'
185,000 sq.ft.
4.25 acres
Gross Residential Area:
221,400 sq.ft.
5.1 acres
Number of Units:
72 @ 1,650 sq.ft.
Net Dwelling Density:
16.9 dwelling units/acre
Gross Residential Density:
14.2 dwelling units/acre
Coverage:
Net area = 0.23
Gross area = 0.19
Floor Area Ratio:
FAR = 0.68

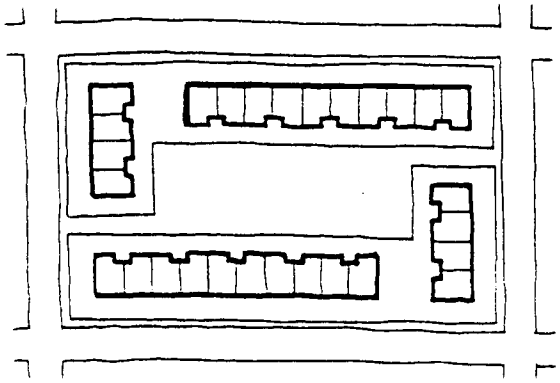


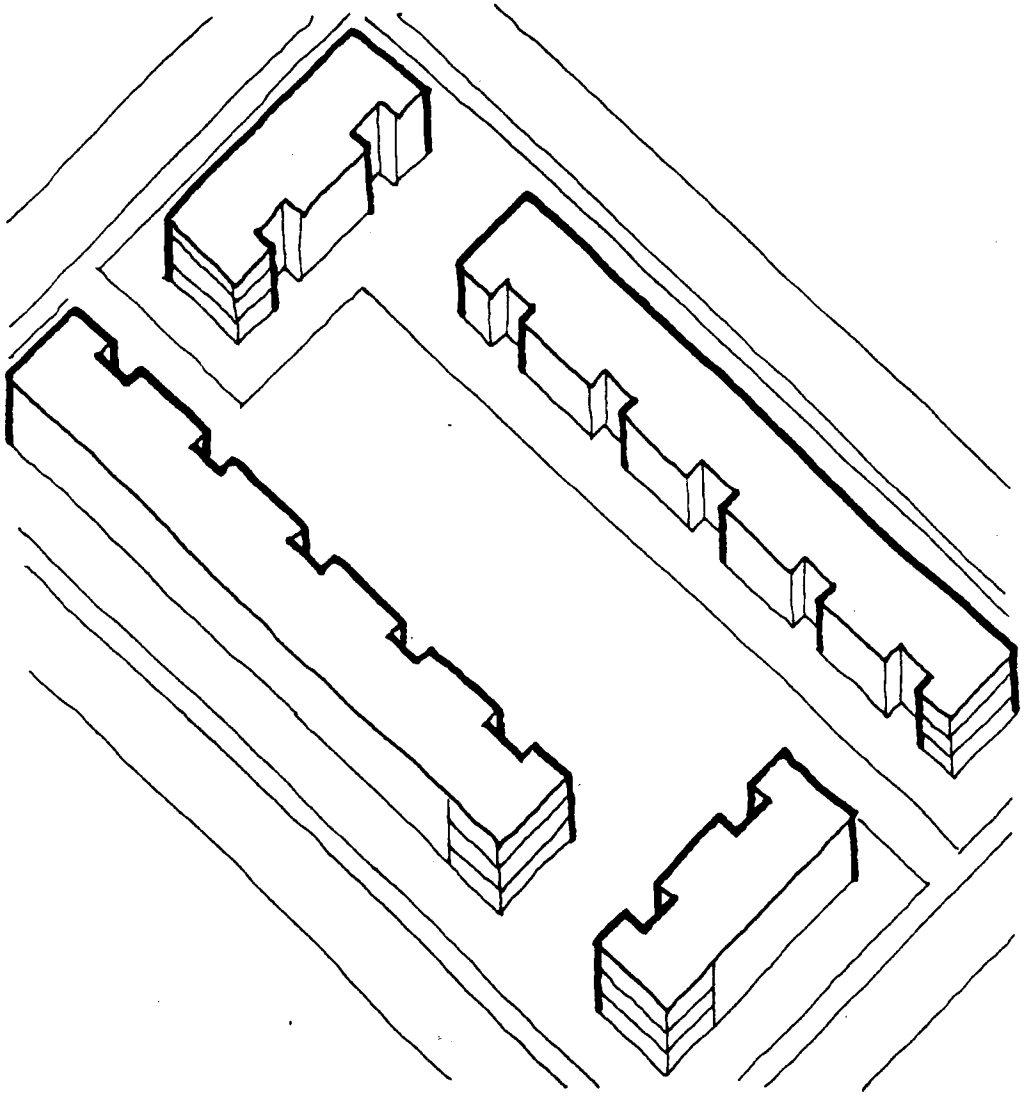


3.6.2.4 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 800 sq.ft.	- parallel	- point
- row housing	- 1000 sq.ft.	- **perimeter**	- single loaded corridor
- **garden apartments**	- 1100 sq.ft.	- penetrating	- double loaded corridor
- high-rise apartments	- 1200 sq.ft.		- **single loaded core**
	- 1500sq.ft.		- double loaded core
	- **1650 sq.ft.**		- complex

Block Size
320' x 530'
169,600 sq.ft.
3.9 acres
Gross Residential Area:
205,200 sq.ft.
4.7 acres
Number of Units:
84 @ 1,650 sq.ft.
Net Dwelling Density:
21.6 dwelling units/acre
Gross Residential Density:
17.8 dwelling units/acre
Coverage:
Net area = 0.27
Gross area = 0.23
Floor Area Ratio:
FAR = 0.81

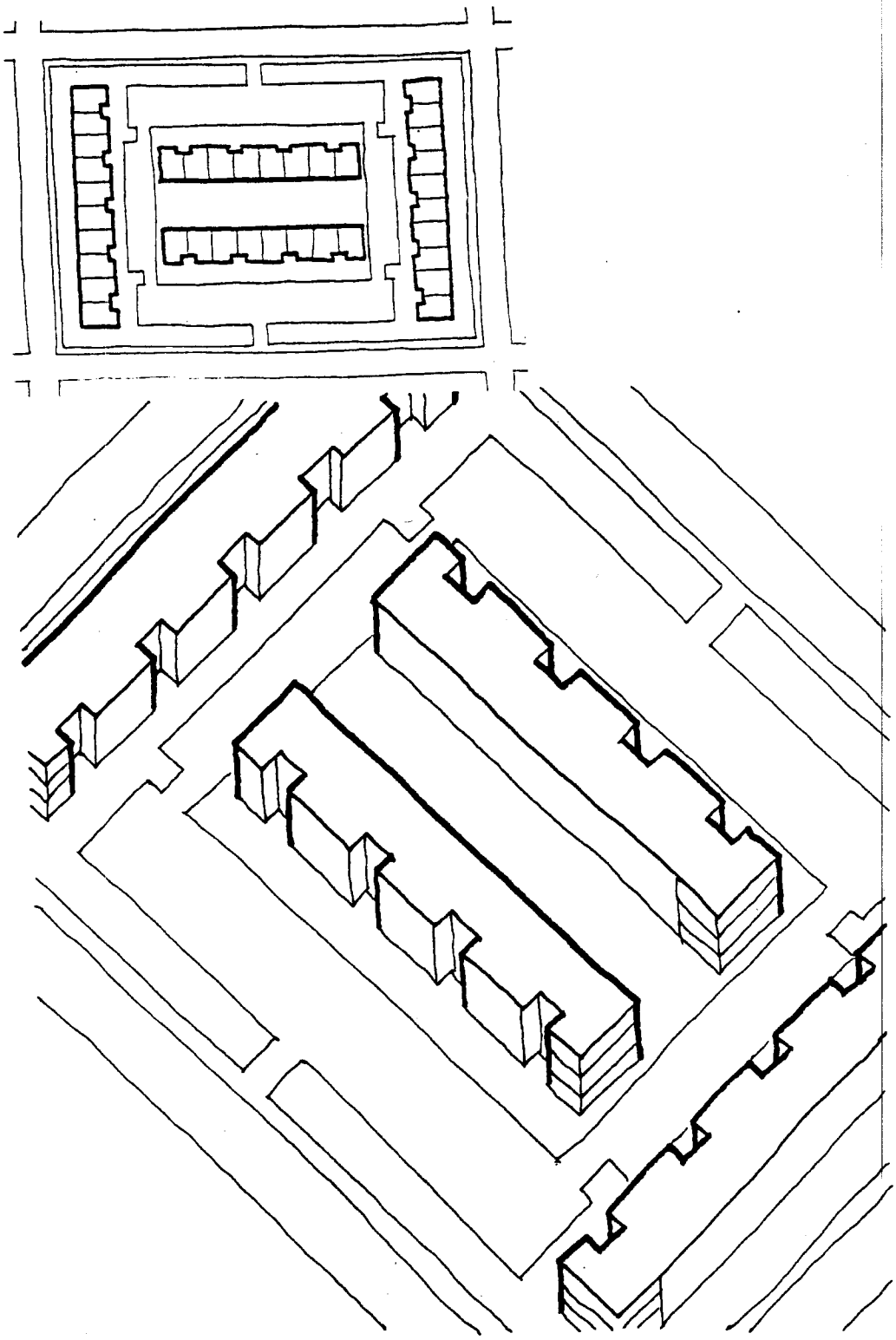




3.6.3.4 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 800 sq.ft.	- parallel	- point
- row housing	- 1000 sq.ft.	- perimeter	- single loaded corridor
- **garden apartments**	- 1100 sq.ft.	- **penetrating**	- double loaded corridor
- high-rise apartments	- 1200 sq.ft.		- **single loaded core**
	- 1500sq.ft.		- double loaded core
	- **1650 sq.ft.**		- complex

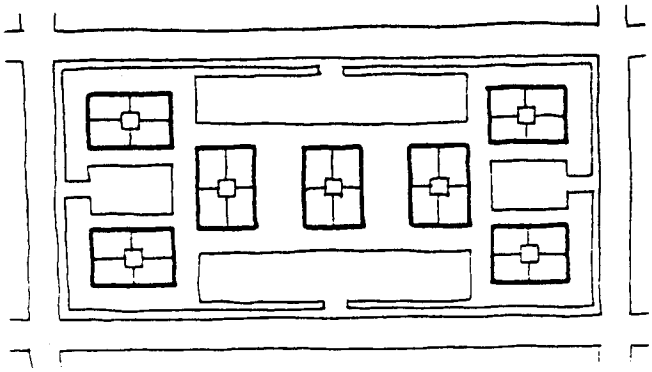
Block Size
410' x 580'
237,800 sq.ft.
5.5 acres
Gross Residential Area:
279,000 sq.ft.
6.4 acres
Number of Units:
108@ 1,650 sq.ft.
Net Dwelling Density:
19.8 dwelling units/acre
Gross Residential Density:
16.8 dwelling units/acre
Coverage:
Net area = 0.25
Gross area = 0.21
Floor Area Ratio:
FAR = 0.75

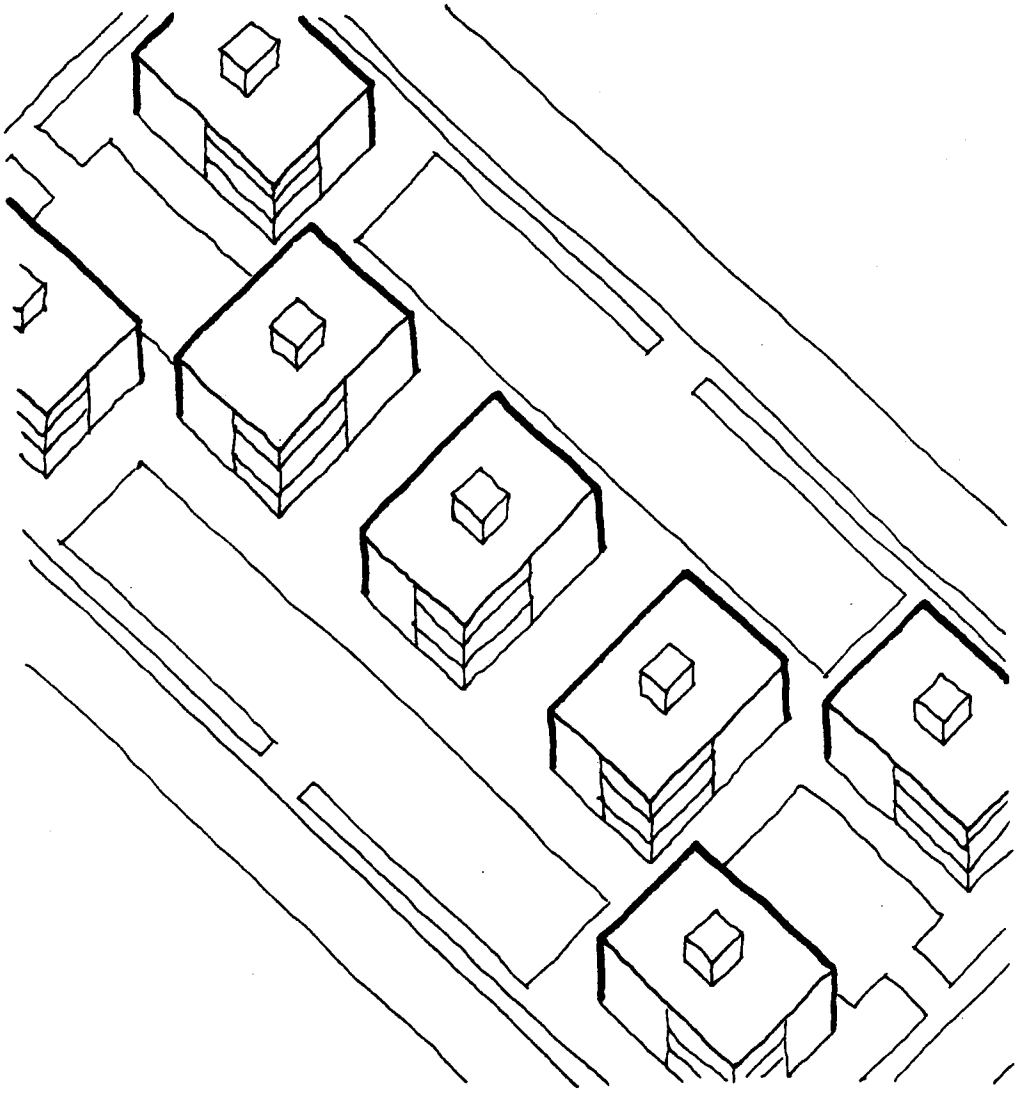


3.6.3.5 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 800 sq.ft.	- parallel	- point
- row housing	- 1000 sq.ft.	- perimeter	- single loaded corridor
- **garden apartments**	- 1100 sq.ft.	- **penetrating**	- double loaded corridor
- high-rise apartments	- 1200 sq.ft.		- single loaded core
	- 1500sq.ft.		- **double loaded core**
	- **1650 sq.ft.**		- complex

Block Size
300' x 650'
195,000 sq.ft.
4.5 acres
Gross Residential Area:
234,600 sq.ft.
5.4 acres
Number of Units:
84 @ 1,650 sq.ft.
Net Dwelling Density:
18.75 dwelling units/acre
Gross Residential Density:
15.6 dwelling units/acre
Coverage:
Net area = 0.25
Gross area = 0.21
Floor Area Ratio:
FAR = 0.75

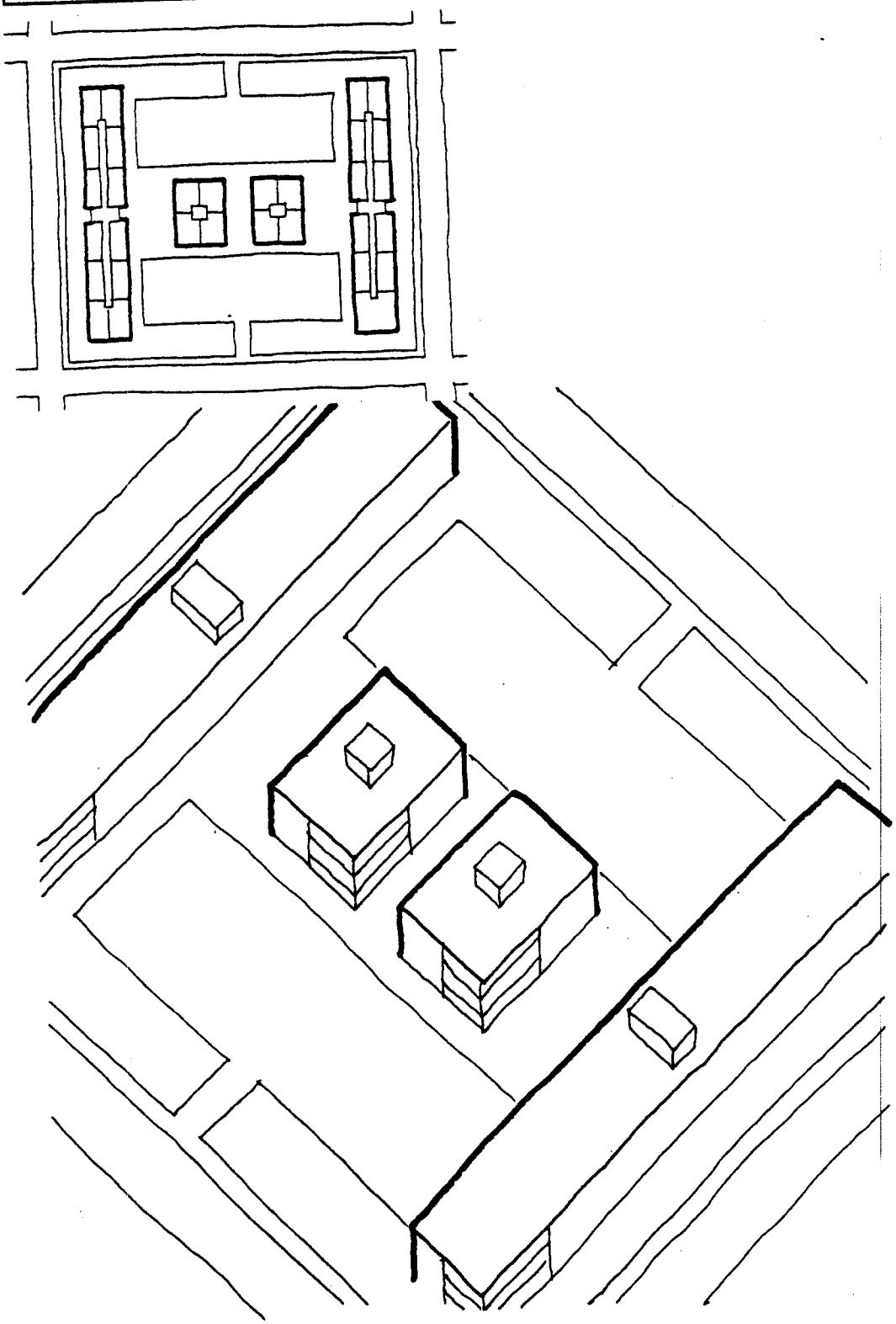




3.6.3.6 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 800 sq.ft.	- parallel	- point
- row housing	- 1000 sq.ft.	- perimeter	- single loaded corridor
- **garden apartments**	- 1100 sq.ft.	- **penetrating**	- double loaded corridor
- high-rise apartments	- 1200 sq.ft.		- single loaded core
	- 1500sq.ft.		- double loaded core
	- **1650 sq.ft.**		- **complex**

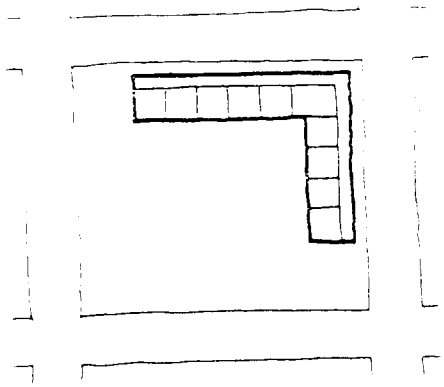
Block Size
440' x 500'
220,000 sq.ft.
5.1 acres
Gross Residential Area:
259,200 sq.ft.
5.95acres
Number of Units:
96 @ approx. 1,650 sq.ft.
Net Dwelling Density:
19.0 dwelling units/acre
Gross Residential Density:
16.1 dwelling units/acre
Coverage:
Net area = 0.27
Gross area = 0.23
Floor Area Ratio:
FAR = 0.81

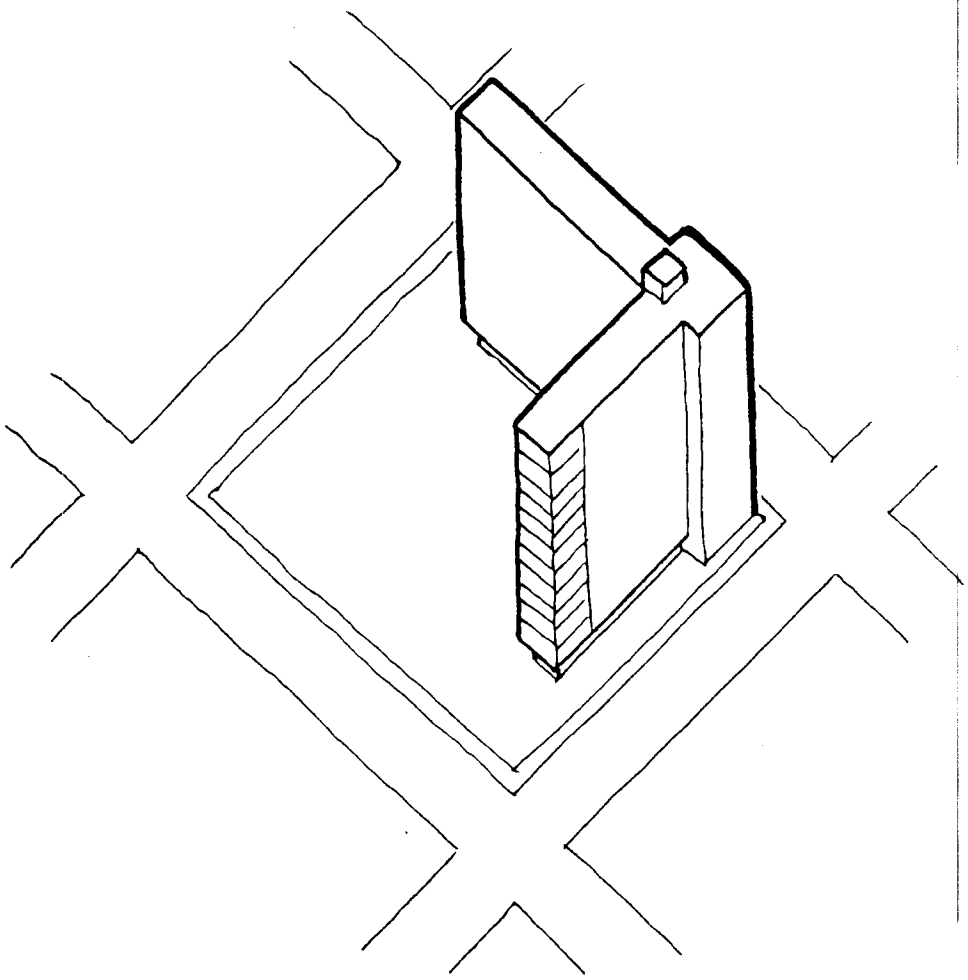


4.1.2.2 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family - row housing - garden apartments - **high-rise apartments**	- **600sq.ft.** - 700sq.ft. - 800sq.ft. - 900sq.ft. - 1000sq.ft. - 1100sq.ft. - 1200sq.ft.	- parallel - **perimeter** - penetrating	- point - single loaded corridor - double loaded corridor - complex

Block Size
200' x 230'
46,000 sq.ft.
1.06 acres
Gross Residential Area:
64,800 sq.ft.
1.5 acres
Number of Units:
120 @ 600 sq.ft.
Net Dwelling Density:
113 dwelling units/acre
Gross Residential Density:
80 dwelling units/acre
Coverage:
Net area = 0.21
Gross area = 0.15
Floor Area Ratio:
FAR = 2.47

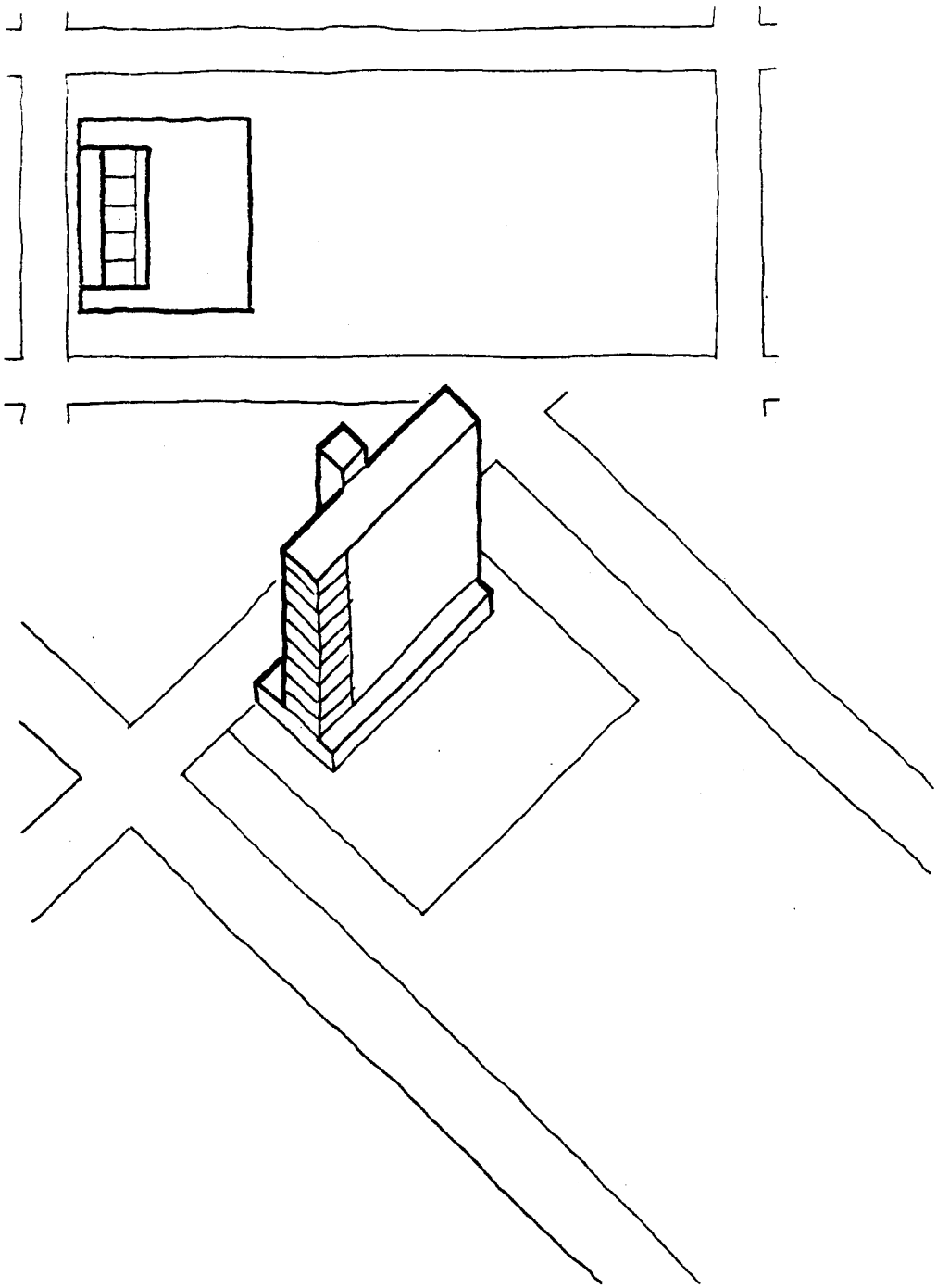




4.2.2.2 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 600sq.ft.	- parallel	- point
- row housing	- **700sq.ft.**	- **perimeter**	- **single loaded corridor**
- garden apartments	- 800sq.ft.	- penetrating	- double loaded corridor
- **high-rise apartments**	- 900sq.ft.		- complex
	- 1000sq.ft.		
	- 1100sq.ft.		
	- 1200sq.ft.		

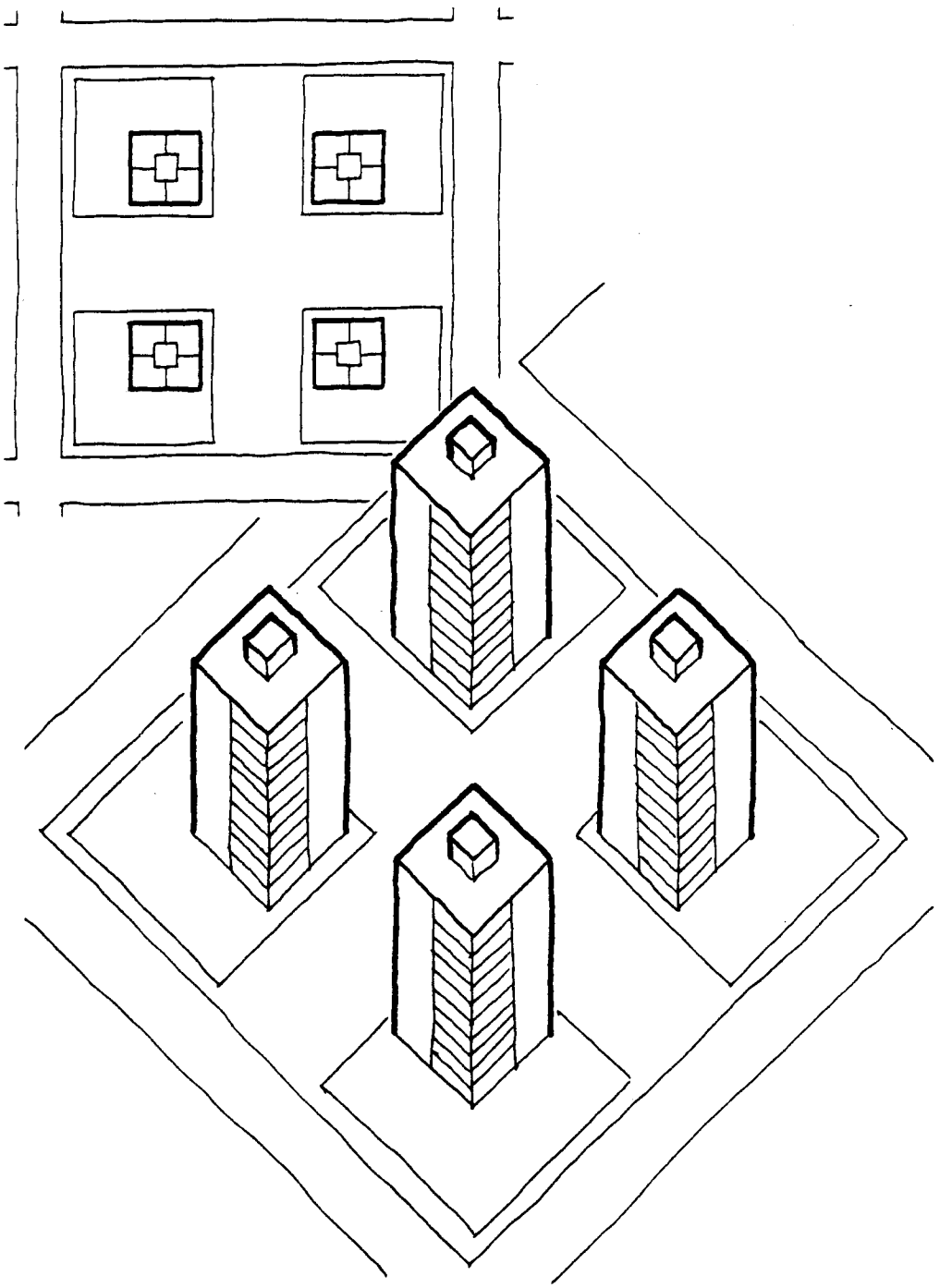
Block Size
250' x 150'
37,500 sq.ft.
0.86 acres
Gross Residential Area:
49,300 sq.ft.
1.13 acres
Number of Units:
5 x 10 stories @ 700 sq.ft.
Net Dwelling Density:
58.0 dwelling units/acre
Gross Residential Density:
44.0 dwelling units/acre
Coverage:
Net area = 0.20
Gross area = 0.16
Floor Area Ratio:
FAR = 2.40



4.3.2.1 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 600sq.ft.	- parallel	- **point**
- row housing	- 700sq.ft.	- **perimeter**	- single loaded corridor
- garden apartments	- **800sq.ft.**	- penetrating	- double loaded corridor
- **high-rise apartments**	- 900sq.ft.		- complex
	- 1000sq.ft.		
	- 1100sq.ft.		
	- 1200sq.ft.		

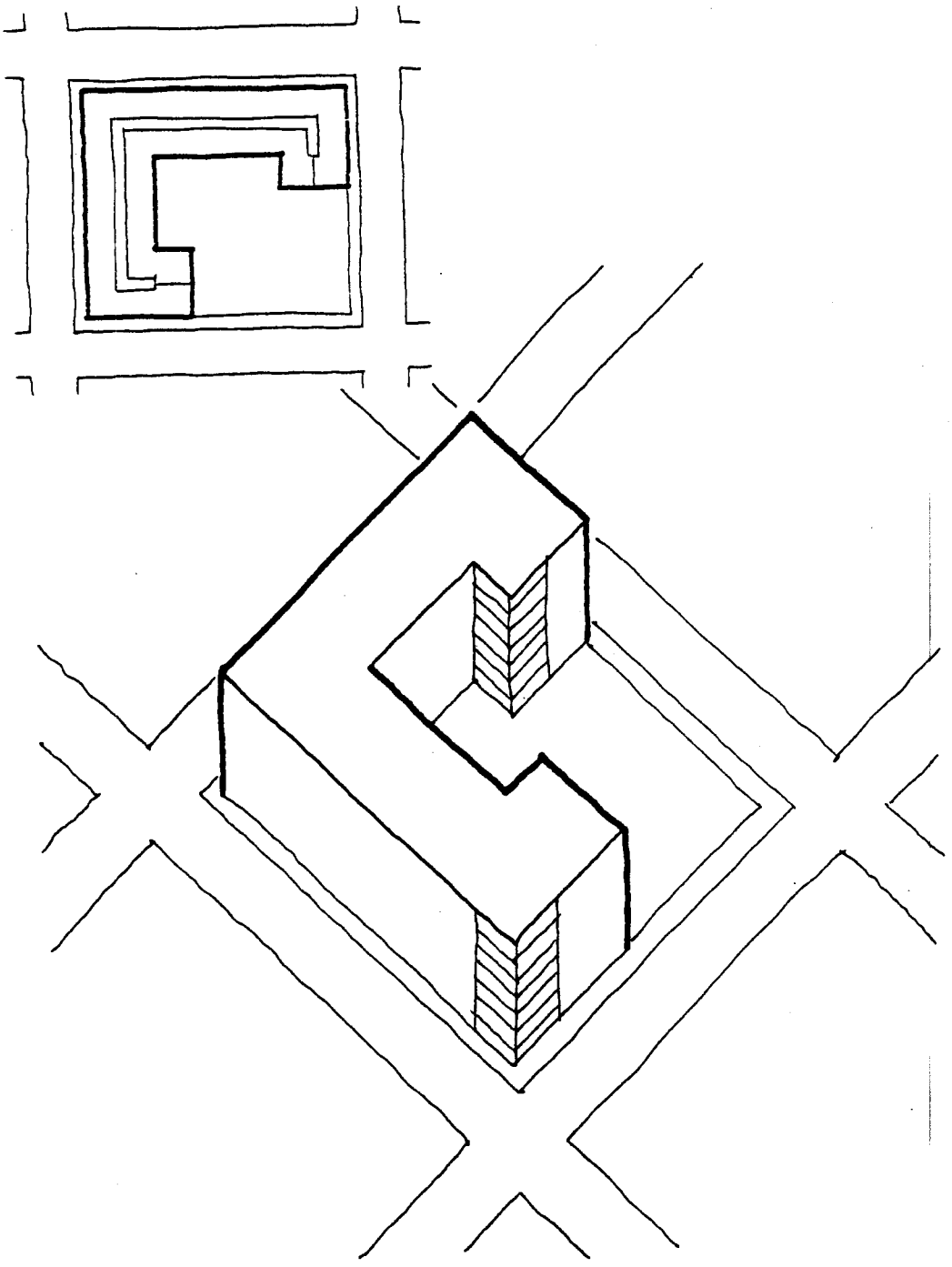
Block Size
340' x 340'
115,600 sq.ft.
2.7 acres
Gross Residential Area:
144,400 sq.ft.
3.3 acres
Number of Units:
120 @ 800 sq.ft.
Net Dwelling Density:
59.3 dwelling units/acre
Gross Residential Density:
48.5 dwelling units/acre
Coverage:
Net area = 0.12
Gross area = 0.10
Floor Area Ratio:
FAR = 1.25



4.3.2.3 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 600sq.ft.	- parallel	- point
- row housing	- 700sq.ft.	- **perimeter**	- single loaded corridor
- garden apartments	- **800sq.ft.**	- penetrating	- **double loaded corridor**
- **high-rise apartments**	- 900sq.ft.		- complex
	- 1000sq.ft.		
	- 1100sq.ft.		
	- 1200sq.ft.		

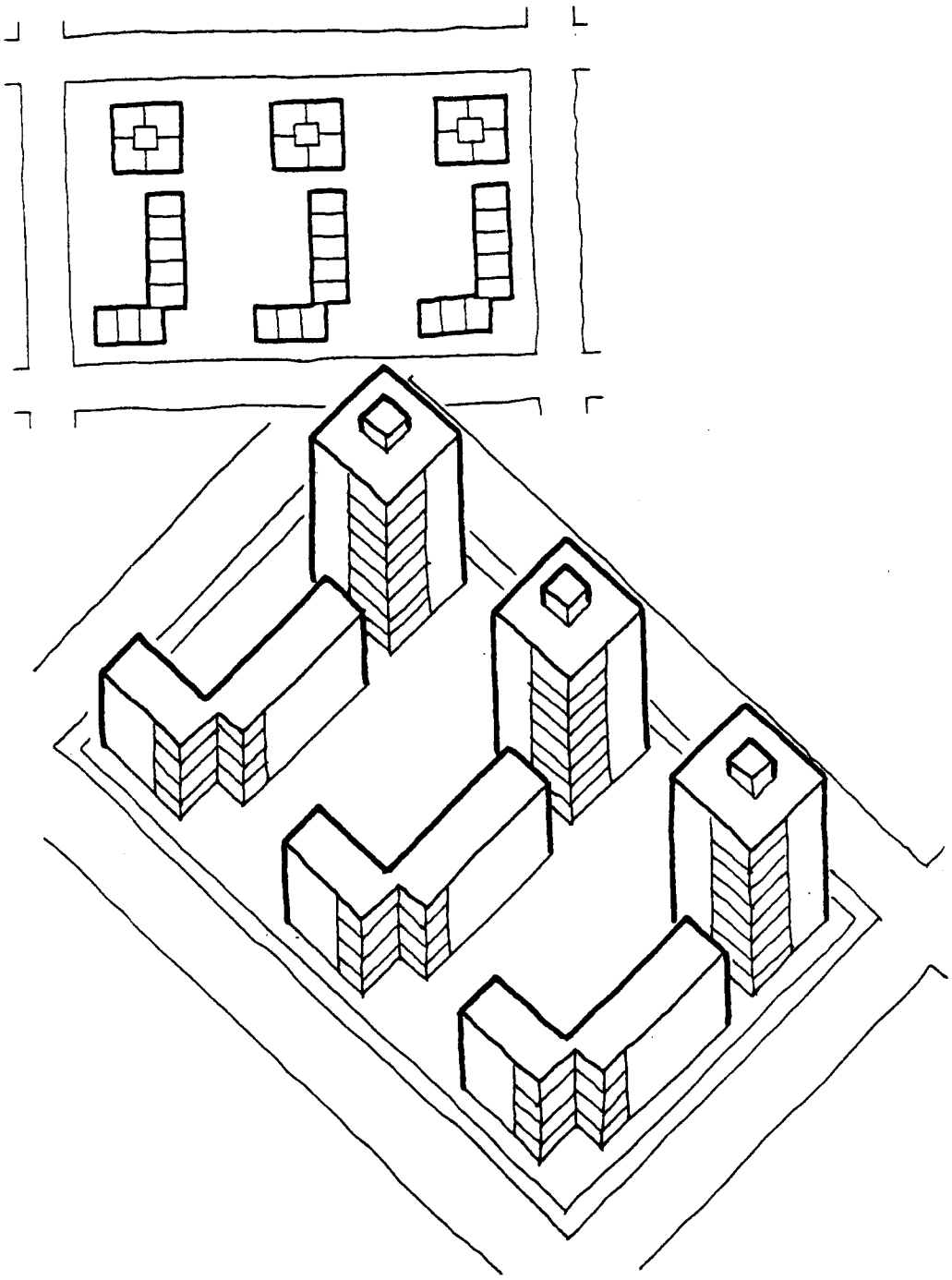
Block Size
225' x 250'
56,250 sq.ft.
1.29 acres
Gross Residential Area:
78,850 sq.ft.
1.76 acres
Number of Units:
210 @ 800 sq.ft.
Net Dwelling Density:
163 dwelling units/acre
Gross Residential Density:
119 dwelling units/acre
Coverage:
Net area = 0.42
Gross area = 0.30
Floor Area Ratio:
FAR = 2.99



4.3.3.4 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family - row housing - garden apartments - **high-rise apartments**	- 600sq.ft. - 700sq.ft. - **800sq.ft.** - 900sq.ft. - 1000sq.ft. - 1100sq.ft. - 1200sq.ft.	- parallel - perimeter - **penetrating**	- point - single loaded corridor - double loaded corridor - **complex**

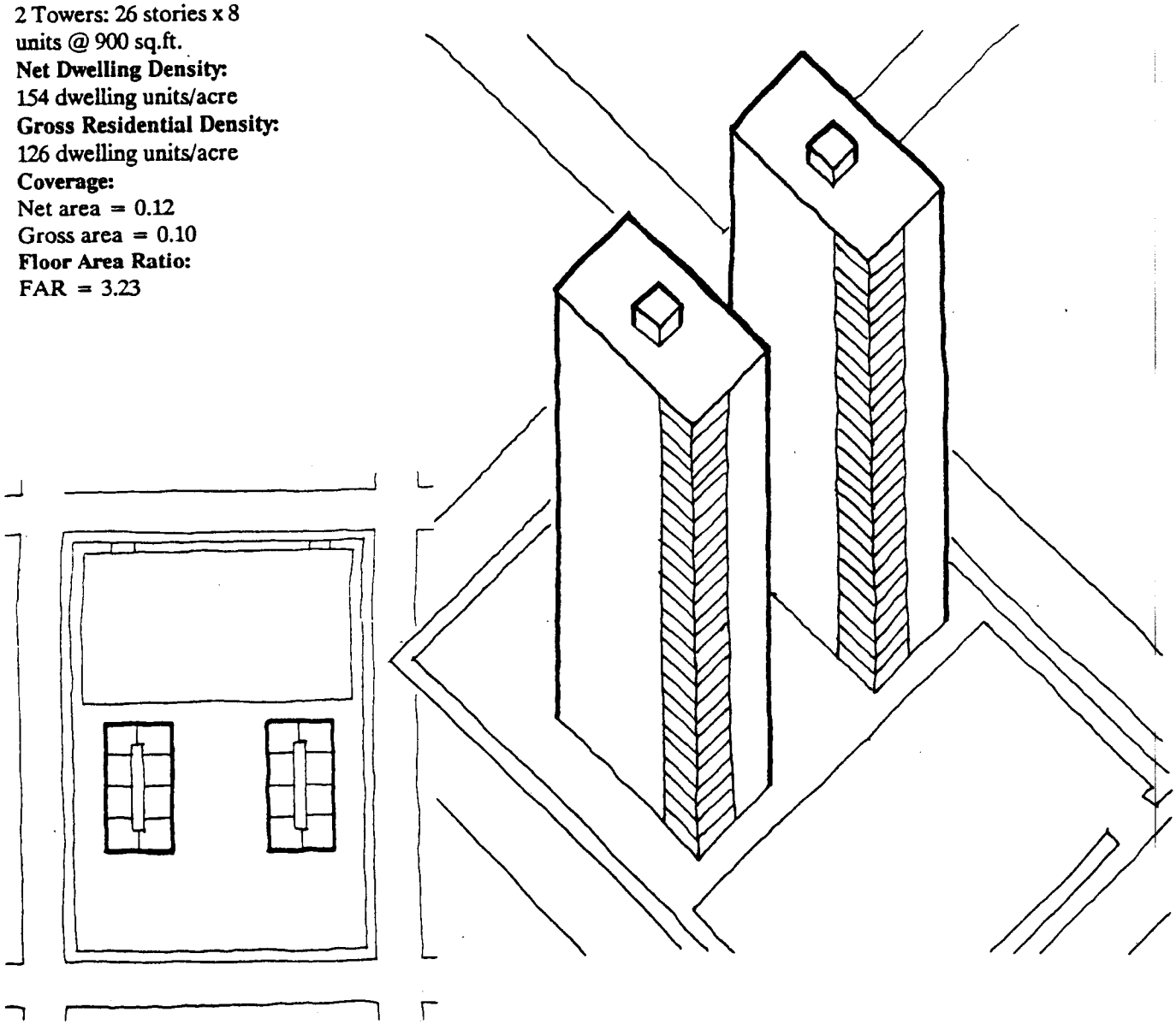
Block Size
250' x 400'
100,000 sq.ft.
2.3 acres
Gross Residential Area:
127,000 sq.ft.
2.9 acres
Number of Units:
192 @ 800 sq.ft.
Net Dwelling Density:
83.5 dwelling units/acre
Gross Residential Density:
66.2 dwelling units/acre
Coverage:
Net area = 0.25
Gross area = 0.20
Floor Area Ratio:
FAR = 1.43



4.4.1.3 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family - row housing - garden apartments - **high-rise apartments**	- 600sq.ft. - 700sq.ft. - 800sq.ft. - **900sq.ft.** - 1000sq.ft. - 1100sq.ft. - 1200sq.ft.	- **parallel** - perimeter - penetrating	- point - single loaded corridor - **double loaded corridor** - complex

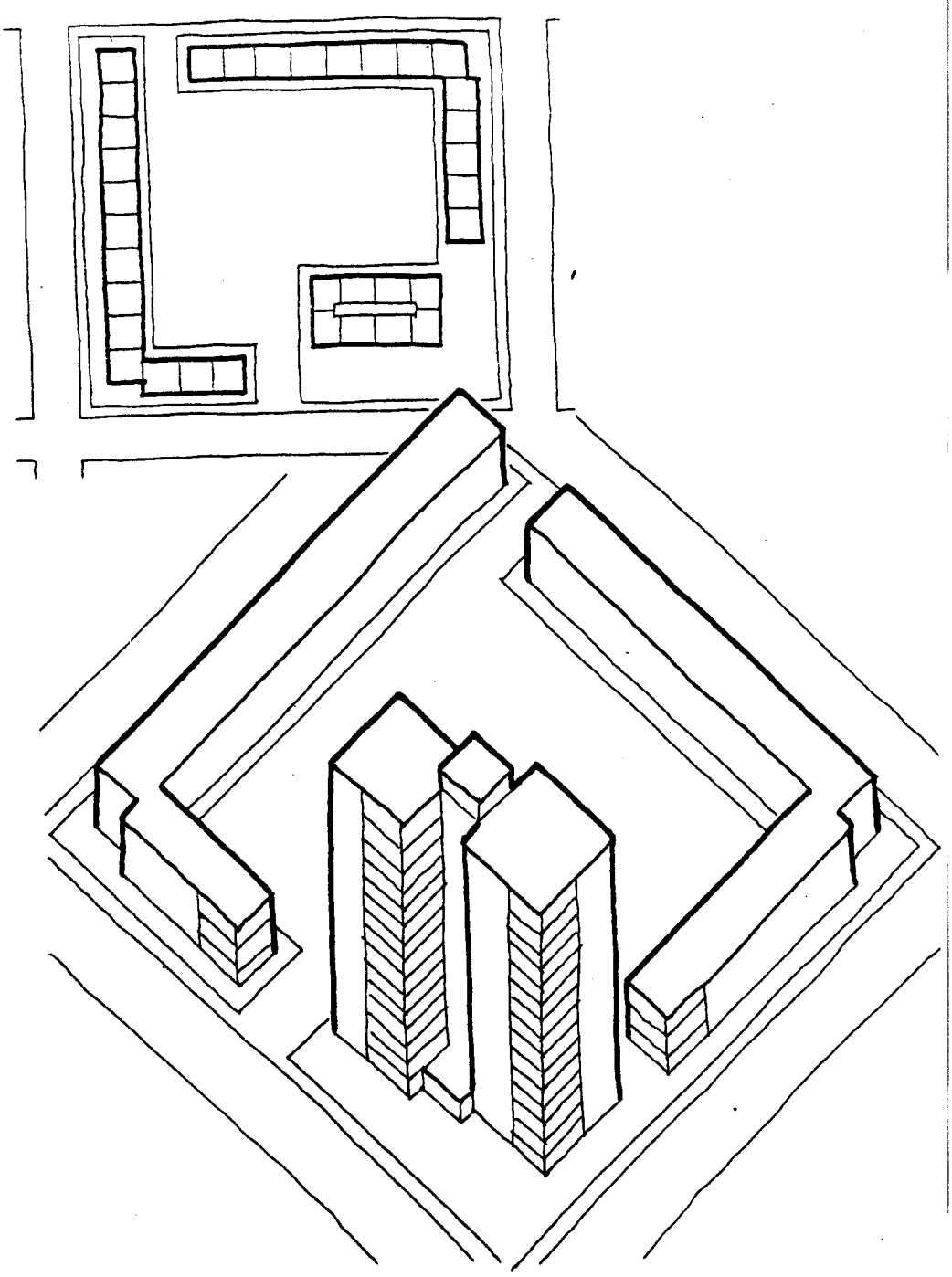
Block Size
290' x 400'
116,000 sq.ft.
2.7 acres
Gross Residential Area:
145,200 sq.ft.
3.3 acres
Number of Units:
2 Towers: 26 stories x 8 units @ 900 sq.ft.
Net Dwelling Density:
154 dwelling units/acre
Gross Residential Density:
126 dwelling units/acre
Coverage:
Net area = 0.12
Gross area = 0.10
Floor Area Ratio:
FAR = 3.23



4.4.2.4 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family - row housing - garden apartments - **high-rise apartments**	- 600sq.ft. - 700sq.ft. - 800sq.ft. - **900sq.ft. (average)** - 1000sq.ft. - 1100sq.ft. - 1200sq.ft.	- parallel - perimeter - penetrating	- point - single loaded corridor - double loaded corridor - **complex**

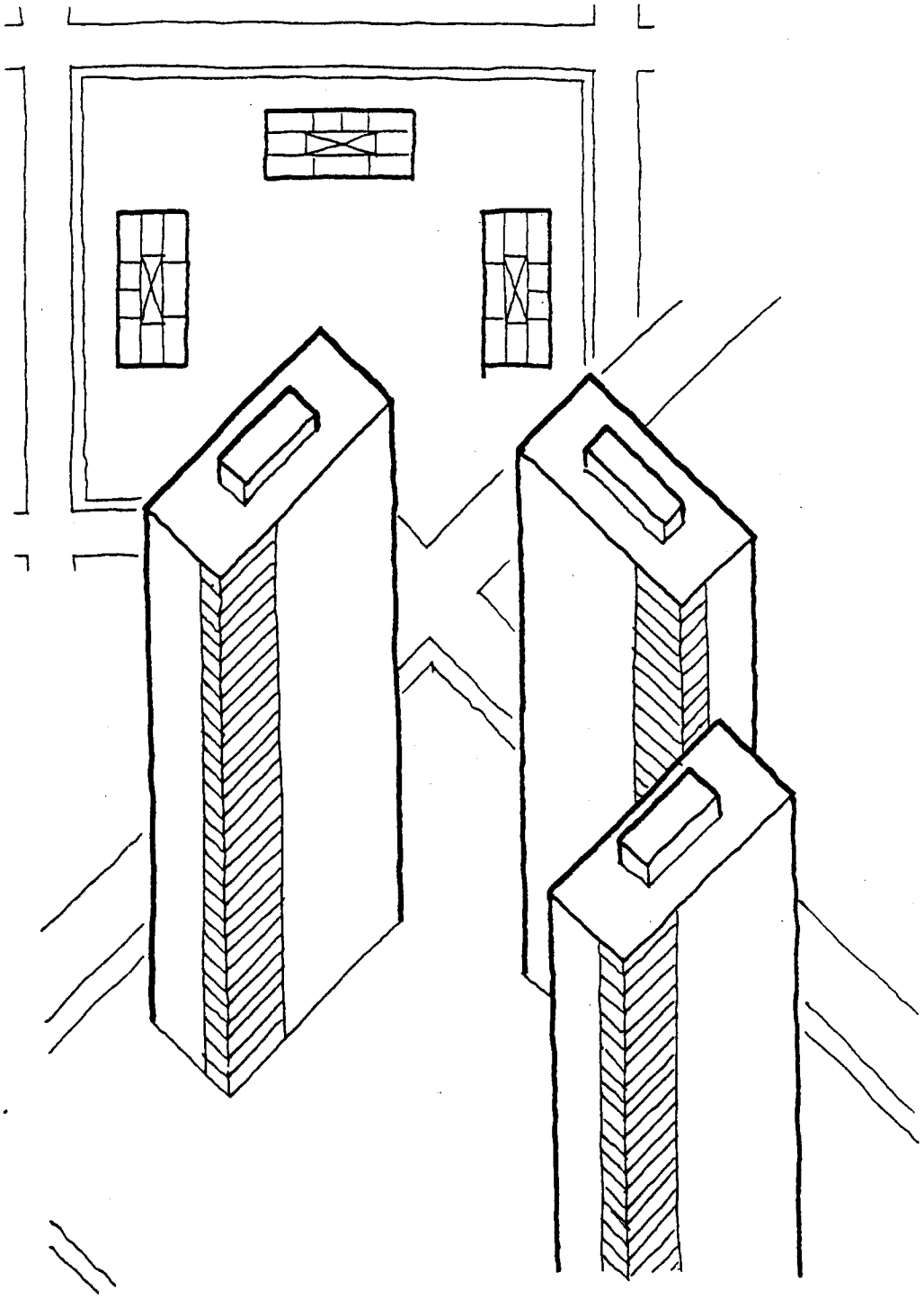
Block Size
350' x 375'
131,250 sq.ft.
3.01 acres
Gross Residential Area:
161,850 sq.ft.
3.7 acres
Number of Units:
Tower: 15 stories x 8 units @ 800 sq.ft.
Block: 3 stories x 26 units @ 1000 sq.ft.
Net Dwelling Density:
65.8 dwelling units/acre
Gross Residential Density:
53.5 dwelling units/acre
Coverage:
Net area = 0.25
Gross area = 0.20
Floor Area Ratio:
FAR = 1.31



4.5.2.1 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 600sq.ft.	- parallel	- **point**
- row housing	- 700sq.ft.	- **perimeter**	- single loaded corridor
- garden apartments	- 800sq.ft.	- penetrating	- double loaded corridor
- **high-rise apartments**	- 900sq.ft.		- complex
	- **1000sq.ft.**		
	- 1100sq.ft.		
	- 1200sq.ft.		

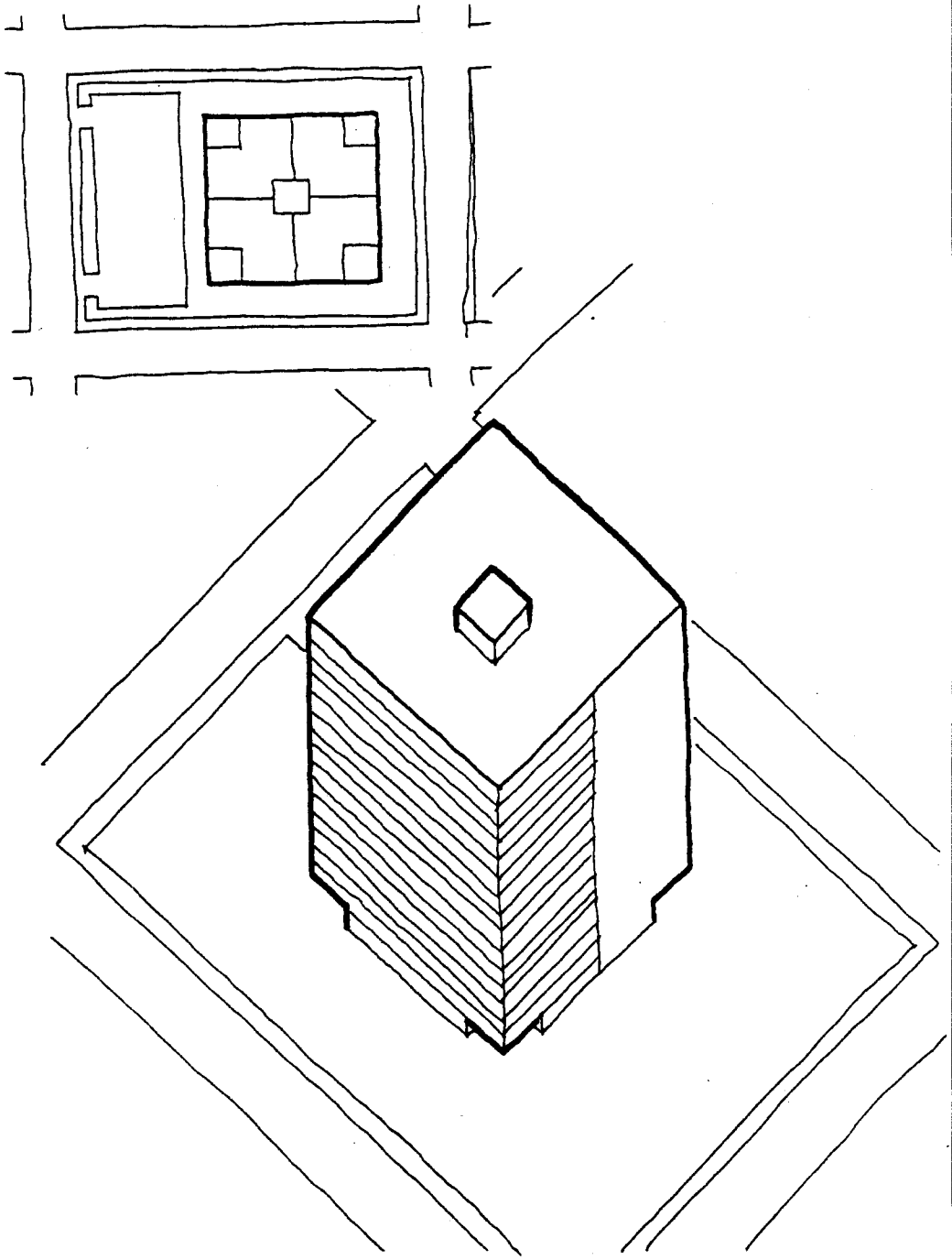
Block Size
400' x 460'
184,000 sq.ft.
4.2 acres
Gross Residential Area:
220,000 sq.ft.
5.1 acres
Number of Units:
30 stories x 8 units @ 1000 sq.ft.
Net Dwelling Density:
171 dwelling units/acre
Gross Residential Density:
141 dwelling units/acre
Coverage:
Net area = 0.12
Gross area = 0.10
Floor Area Ratio:
FAR = 3.64



4.6.2.1 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 600sq.ft.	- parallel	- **point**
- row housing	- 700sq.ft.	- **perimeter**	- single loaded corridor
- garden apartments	- 800sq.ft.	- penetrating	- double loaded corridor
- **high-rise apartments**	- 900sq.ft.		- complex
	- 1000sq.ft.		
	- **1100sq.ft.**		
	- 1200sq.ft.		

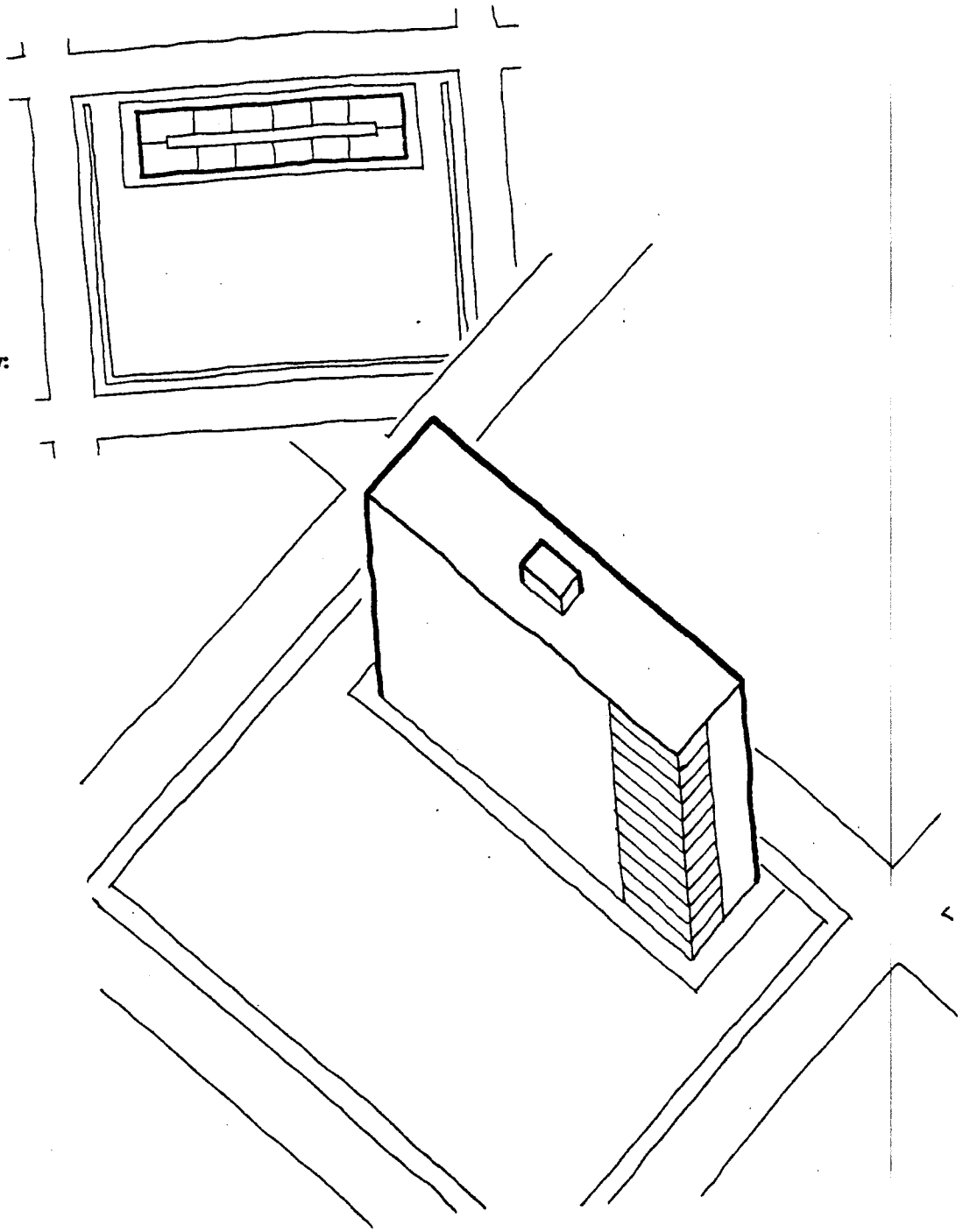
Block Size
225' x 325'
73,125 sq.ft.
1.67 acres
Gross Residential Area:
97,200 sq.ft.
2.23 acres
Number of Units:
60 @ 1100 sq.ft (15 stories)
Net Dwelling Density:
36 dwelling units/acre
Gross Residential Density:
27 dwelling units/acre
Coverage:
Net area = 0.30
Gross area = 0.23
Floor Area Ratio:
FAR = 4.60



4.7.1.3 housing density: case studies

Dwelling Form	*Unit Variable*	*Block Variable*	*Lot Variable*
- single family	- 600sq.ft.	- **parallel**	- point
- row housing	- 700sq.ft.	- perimeter	- single loaded corridor
- garden apartments	- 800sq.ft.	- penetrating	- **double loaded corridor**
- **high-rise apartments**	- 900sq.ft.		- complex
	- 1000sq.ft.		
	- 1100sq.ft.		
	- **1200sq.ft.**		

Block Size
280' x 350'
98,000 sq.ft.
2.25 acres
Gross Residential Area:
124,800 sq.ft.
2.9 acres
Number of Units:
144 @ 1200 sq.ft.
Net Dwelling Density:
64 dwelling units/acre
Gross Residential Density:
49.7 dwelling units/acre
Coverage:
Net area = 0.15
Gross area = 0.17
Floor Area Ratio:
FAR = 1.76



Appendix B:

Annotated Bibligraphy

Aiello, J. R. and A. Baum, eds., *Residential Crowding and Design*, New York, Plenum, 1979.

Alexander, Ernest R., *Building in Hill Areas: A Survey of Housing Types at Various Slopes,* Tel Aviv, Institute for Planning and Development Ltd (IPD), 1968. (Hebrew)

American Society of Planning Officials, *Apartment Densities for Medium Sized Cities*, ASPO Information Report No. 166, January 1963.

American Public Health Association, Committee on the Hygiene of Housing, *Planning the Neighborhood*, Chicago, Public Administration Service, 1960.

* An excellent source for density definitions.

Net residential site area: the total land area devoted to residential facilities. Uses excluded: commercial and industrial areas, shopping and local business not directly beneath buildings, commercial garage space, public parks and playgrounds, vacant land reserved for future development, vacant unbuildable land, schools, churches, community facilities, etc.

District density: The number of persons, families, or dwellings per acre of land within a whole distirct, regardless of land use. District density corresponds to the term "gross density" as used by many city planners.

Net dwelling density: the number of dwelling units per acre of net residential land (land devoted to residential buildings and accessory uses on the same lots i.e. informal open space, drives, service areas, but excluding land for streets, public parking, playgrounds and nonresidential buildings).

Building coverage: the proportion of net or gross residential land taken up by buildings.

Neighborhood density: the number of dwelling units per acre of total neighborhood land (net residential land plus streets and land used for schools, recreation, shopping and other neighborhood community purposes); neighborhood land excludes non-neighborhood uses and unusable land within the neighborhood boundaries.

Gross dwelling density: defined as an outmoded term; defined here as the number of dwelling units per acre of gross residential land including 1/2 bordering streets. Recommends that the term gross residential density be replaced by over-all neighborhood density, usually expressed as families or persons per acre of total neighborhood land.

Gross residential density: The number of persons, families or dwellings per acre of gross residential site area.

Net residential density: The number of persons, families or dwellings per acre of net residential site area.

Amick, Daniel, and Frederick J. Kviz. "Density, Building Type, and Social Integration in Public Housing Projects," *Man-Environment Systems* 4:3 (May, 1974) pp.187-190.

Baer, W.C. "Housing Indicators and Standards in the USA." *Ekistics* 44, no. 26 (1977) pp. 71-78.

Bargel, Egon Ernest. "Size, Density, Spatial Types," *Urban Sociology*, ch. 7: 117-144, 1955.

Boudon, P. et al. "High Density Housing." *Architecture d'Aujourd'hui* 215 (1981) pp. 1-92.

* A paper about scale--a topic which is important--well illustrated but so poorly written and conceptualized that it hardly serves any purpose other than consciousness-raising.

Buttler, H.-J. "Equilibrium of a Residential City, attributes of Housing, and Land-Use Zoning." *Urban Studies*: 18(1):23-40, February, 1981.

* Interesting example of disaggregation of density: population density, DUs per building, and FAR. He shows mathematically how zoning constraints in FAR, coverage, and height can affect housing prices and design. An interesting us: example of application, and proof of importance of understanding density measures for regulation, since regulation affects so much of what is built.

Aspects of housing considered: floor area, finishing cost of a dwelling unit, garden space, building height. Page 37,Fig.6: Demonstrates a competitive housing market with technical restraints. States in conclusion that a "competitive housing market in equilibrium requires narrow and tall buildings which lie close to the CBD. While the maximum building height is determined by either material properties or building codes, the minimum building area is determined by either technical considerations or building codes."

Cameron, George. "Housing Densities for Developing Countries: A Discussion Paper." *Third World Planning Review* 2, no. 1 (1980) pp. 45-52.

* Relationships between population densities, land use and housing in developing countries are considered. Defines overall gross density (p. 47) as persons/hectare. Measure for net density = net housing area i.e. "one hectare bounded by two parallel service roads linked by pedestrian ways between the housing, without any other significant land use whatever. Net housing density would relate to the total of the built areas, private open spaces, if any, and any local public open space including the footpaths and half the local road widths.

  Cites three principal land uses: 1. farming and farm buildings 2. all other physical development than housing 3. net housing areas.

  "Other physical uses include: play fields and parks, shops and offices, municipal and health buildings, industry, transport facilities, educational buildings." p. 48.

Cooperman, D. "Density, Design, and Social Organization" *EDRA 5, VI: Man-Environment Interactions,* D.H. Carson, ed., 1976.

Crothers, Charles. "Three Problems With Density Indices," *The Australian and New Zealand Journal of Sociology* 12:2 (June, 1976) pp. 152-153.

* Short, general essay; problems discussed are most relevant to New Zealand, but may have more general implications. Raises the question of the most appropriate measurement of residential density. Discussion focuses primarily on relationship between density and environmental stress, but raises one other issue: the extent to which communities are self-contained. What is the role (if any) of suburbs in density measures? Makes no distinction between net and gross densities; states that the most relevant measure (for measuring stress) would be in the residential environment i.e. the density of the population living in housing estates. Measures density in acres per 1000 population and the residential area as a percentage of the total area (these distinctions remain unclear).

Cullen, Gordon, *Townscape*. London, Architectural Press, 1962.

Davis, G.E. "Designing for Residential Density." *Human Response to Crowding*, A. Baum and Y. M. Epstein, eds. Hillsdale, NJ: Erlbaum, 1978, pp. 357-71.

De Chiara and L. Koppelman *Site Planning Standards* New York: McGraw-Hill, 1978.

De Chiara and L. Koppelman. *Urban Planning and Design Criteria* New York: Van Nostrand Reinhold, 1982.

* p 516: Comparison of densities for ideal communities: E. Howard, Le Corbusier, Wright, Perry, Sert, Gropius, Goodman & Goodman. Measures density using DU/gross acre (although Corbu uses ppa). p. 598: Recommended housing types based on gross area per family and ppa. Ranges from 4 ppa to 1600 ppa

Diamond, Jack. "Residential Density and Housing Form," *Journal of Architectural Education* 29:3 (February 1976) pp.15-17.

* Discusses in Canadian context- many housing forms shown on p. 16 rather unusual- not common to American experience. Gives some ideas for possible generic prototypes and ground plans for various unit layouts. Stresses need to allow planning and construction of housing in "middle ranges of density" (i.e non- high rise and non-single family housing) and points out that housing with FAR of .75 to 1.5 provides efficient alternative to high rise living accommodations. Refers to several density measures: DU/acre or hectare, FAR; does not clearly distinguish between net and gross density measures.

Erb, Richard David. *Postwar Developments in Urban Residential Density* Ph.D. Dissertation, Stanford Univ., 1968.

Essex County Council, *A Design Guide for Residential Areas.* Chelmsford, Essex, Essex County Council, December 1973.

Fan, Yaobang "Some Opinions About Rational Density of Residential Quarters," *Architectural Journal* 3 (1980) pp. 20-23.

Federal Housing Administration. *Land Use Intensity.* Land Planning Bulletin, no.7. Washington, D.C.: U.S. Government Printing Office, 1971.

* Land Use Intensity (LUI) defined here (as it was in Minimum Property Standards for Multifamily Housing, Washington, D.C.: FHA 1963) as a measurement of the over-all structural mass and open space relationship in a developed property. Density measures are unresponsive to wide variables in living unit size and household size, and density measures can only be compared to LUI ratios in very general terms, with the possibility of gross error. Compared to density measures, LUI is more reliable because it there are fewer variations. Some comparison can be made if living unit size or household size is kept constant.

  Gross density: Gross land area (gross acreage) defined here as living units related to all land which benefits or is used by the development; less streets, we have net density. This report acknowledges ambivalence and confusion regarding the definition of net density. Does net density include paved parking areas in bays along streets?

What about privately owned streets? etc., etc.

Intensity rating scale refers to the gross acres of all land benefiting a project, with land area including 1/2 abutting street right-of-way, 1/2 abutting river or park; claims that land use intensity measures are more realistic and reliable by measuring gross acreage rather than net.

LUI scale begins with FAR. Other variables included in the measure are open space ratio, livability space ratio, and recreation space ratio. The denominator in each case is the total floor area.

Flachsbart, P.G. "Residential Site Planning and Perceived Density, "*Journal of Urban Planning and Development Division* 105, no.2 (1979), pp. 103-18.

* This book includes a good review of literature.
Empirical study limited but provocative: relation between block sizes and street frequencies in selected California cities and underestimation of net residential densities suggests relationship between net and neighborhood (and maybe even gross) densities affecting perceptions. Methodology: believes that subjects would not be able to relate DU/acre or persons per acre measures of density; developed 7 categories of perceived residential density:
1.less than 10 households/block,
2. 10-25 households/block,
3. 25-35 households/block,
4. 35-60 households/block,
5. 60-100 households/block,
6. 100-200 households/block,
7. 200+ households/block.
Shows no association between magnitude of actual density and correct perceptual density. Cites Jane Jacobs: visual breaks with shorter blocks and many intersections would cause objective density to appear lower than it actually is and thus increase density underestimates and lead to higher satisfaction scores. Another variable which could affect perceived density levels: topography.

Gellen, M.G. *Accessory Apartments and Single Family Zoning* Working Paper #406. Berkeley: Institute of Urban And Regional Development, University of California, 1983.

Gibberd, Frederick *Town Design*. London: Architectural Press, 1967.

* Neighborhood density: calculated on the number of people living in a housing area per area of land (NET DENSITY) - distinguishes people per acre living over the whole neighborhood which would equal GROSS DENSITY. The area includes "all the small open spaces and gardens about which the buildings may be grouped, and the residential roads, but excludes school sites, the neighborhood center, and playing fields for the area as a whole." p. 256. Problem with expressing density in dwellings/acre: OK when development was limited to one kind of dwelling, but now that mixed developments are common, the measure

becomes useless. More appropritate to express density as the number of persons living on an area of land, or the number of habitable rooms. Converts population figures to dwelling numbers by diving by 3.3 ("safe average family size, 3.5 being the national [British] average") or can be converted to number of rooms (usually 1 person/habitable room--outdated--recommends 0.9 as more appropriate for shrinking family sizes). Most common density for housing developments: 30 to 40 ppa, with 9 to 12 semi-detached houses with small gardens. But the results from using this arrangement produced such wasteful and monontonous results that the trend is now towards higher densities. The limit for that type of arrangement would be about 50 ppa, but above that figure, narrower frontages would be required. With the extensive use of terrace houses (and economical garden planning), densities can be increased to about 70 ppa.

Gillis, A.R. And J. Hagan. *Density, Delinquency and Design: Formal and Informal Control and the Built Environment.* Research Paper no. 109, Toronto, Canada: Centre for Urban and Community Studies, 1979.

Goodman, W.I. and E.C. Freund, eds. *Principles and Practices of Urban Planning*. Washington, D.C.: International City Managers' Association (1968).

Guest, A. M. "Urban History, Population Densities and Higher Status Residential Location," *Economic Geography* 48, no. 4 (1972) pp.375-87.

Hanke, B.R. *Land Use Intensity Standards: The LUI Scale and Zoning* Dept. of Housing and Urban Development, Federal Housing Administration. Paper presented at 1965-66 conference of the American Institute of Planners, American Society of Civil Engineers, American Society of Planning Officials, and National Association of Home Builders, 1966.

Hanke, Byron R. "Urban Densities in the U.S. and Japan" in *Density: Five Perspectives*. Washington, D.C.: ULI, 1972.

* p. 42: "Densitometer" measures relationship between various communities in the US and Japan using living units per gross acre as the standard. Hard for accurate comparative purposes: densitometer requires difficult and approximte conversions of limited data. pp.55, 56, 58, 59: Examples of HUD's Land Use Intensity Scale; definitions outlined on bottom of p. 59:

FAR: Floor Area Ratio: sq. ft. of total floor area for each sq. ft. of land use.

OSR: Open Space Ratio: sq. ft of open space for each sq. ft. of floor area.

LSR: Living Space Ratio: sq. ft. of non-vehicular outdoor space for each sq. ft. of floor area.

RSR: Recreation Space Ratio: sq. ft. of recreation space for each sq. ft. of living space.

OCR: Occupant Car Ratio: number of parking spaces without parking time limits for each living unit.

TCR: Total Car Ratio: minimum number of parking spaces for each living unit.

Hanke states that Japan uses only FAR and not these perhaps more meaningful ratios to examine density. Recommends adoption of standard system of data collection and concept testing for measuring density, such as HUD's land use intensity system. This system could serve as a starting point for further refinements in density measurement. Inclusion of the Recreation Space Ratio seems to suggest that the LUI scale combines elements of net and neighborhood density measures. Hanke develops a "Densitometer" which measures living units per gross acre.

Hoffman, Hubert. *Row Houses and Cluster Houses: An International Survey.* New York: Praeger, 1967.

* Important analysis of housing densities in relation to these typologies. p.18: Geographical position (sunlight access) affects housing density-shows maximum net densities for residential areas in various cities (London, Berlin, Vienna, Naples, Barcelona). Steeper angle of the sun in southern regions allows for higher buildings and higher floor space index. Because of cloudier weather in northern cities, differences in sunlight intensities are increased. States that if floor space index is used to calculated density base on access to sunlight, New York could have a FSI of 10.00- same latitude as Naples, Italy. p. 24: Important tables showing relationships between FSI, population densities, dwellings/hectare, cubic content, range of possible typologies and appropriate climatic regions for each of the measures.

Holloway, D.R. "Some Comparative Measurements for Low-Rise Medium-Density Housing," *Ekistics* 31, no. 183 (1971) pp. 179-83.

* Excellent example of development and application of prototypes. Advantages of low-rise, medium density housing over high rise discussed on p 179 in context of displaced families in Britain who lost "subtle environmental amenities" when moved to high rise develoments. P.180: Systematically classifies housing sections with various combinations of modules and analyzes spatial densities (p.181); variables considered: number of floors, maximum density ranges (bpa), average maximum density, percentage of car provision, percentage of residences with one access, percentage of residences with access first floor or above, etc. Figures 4 & 5, (p. 182) diagram relationships between maximum densities and number of floors as well as exterior private space versus number of floors.

Ingberman, S. "Normative and Evolutionary Housing Prototypes in Germany and Austria: The Viennese Superblocks, 1919-1934," *Oppositions*, no. 13 (Summer, 1978) pp.76-111.

James, J.R. "Residential Densities and Housing Layouts," *Town and Country Planning* 35:11 (December, 1967) pp. 552-561.

* Important for density definitions: town density, net residential density, gross density. Provides examples of prototypical layouts. Town density: "provides a standard against which to check existing towns." Town density = "population realted to all the urban activities and uses for the whole town" Net Density: what is measured: population in residential areas; includes dwellings and gardens, "incidental open space" (play areas, visitors' parking), 1/2 surrounding roads (up to 20'); excludes: shops, primary schools, most open space, all other developments. Gross Density: also measures population but includes wider mix of activities. Includes: land covered by housing, gardens, roads, shops, primary schools, most open spaces. Excludes: indutrial lands, secondary schools, town parks and centers. Covers a whole sector/district of a town. Goals of high density development: economical use of land, preventing sprawl. Increases in gross densities save relatively little land while net densities increase disproportionately. Doubts value of raising densities to 70-80 ppa; recommends medium gross densities of 30-50 ppa whcih corresponds to net densities of 40 to 80 persons per acre. Other problems w/ high densities: personal preferences for private outdoor space, difficulty/commplexity of designing at high densities, both from physical and intellectual perspectives. Cites Lionel March's concept of returning to peripheral buildings around a central court as an appropriate solution. Can achieve fairly high densities w/ low well lit buildings.

Jantzen, E.B. and H. Kaaris. "Danish Low-Rise Housing." *Scandinavian Housing and Planning Research* 1(1):27-42, February, 1984.

* Mentions change from building high rises to low rise housing projects as being influenced by sociological studies and other criticisms lodged against high rise developments. By the early 1970s, building industry evolved to such an extent that it became profitable for the building industry to develop low rise housing- became more widely seen esp. in smaller towns. Allowed greater variety in dwelling types- allowed residents' input into design and use of the evironment. Notes increasing popularity in recent years of houses w/ very small lots (250 square meters)-a more traditional approach to housing. Developers looked to Danish traditions in housing when building newer housing estates. Findings based on research done in the 1970s are interesting from a behavioral point of view.

Jensen, R. *High Density Living*. New York: Praeger (1966).

* Excellent source for high-density prototypes from around the world. Defines net density as number of persons accommodated on a given site, usually including perimeter roads. Gross density as defined here includes whole neighborhood area, with housing area, primary schools, local shops, community buildings and churches, service industry and workshops, provision for local roads and parking areas. Town density relates population of the town to the whole area of the town, including residential area plus central commercial district, industries, business and shopping areas, educational facilities, open spaces, playing fields, railways, etc.

Keeble, Lewis *Principles and Practices of Town and Country Planning* London: Estates Gazette (1969).

* An excellent source for definitions (compare definitions here with James (1967)), particularly Chapter 18, pp251-285.: Definitions include Net Residential Density, Habitable Rooms per acre, and Number of Dwellings per acre (calculated by NRD in habitable rooms per acre divided by average number of habitable rooms per dwelling. NRD also used as an indication of garden space or private space per acre. Little connection between size of house and size of garden or open space required. Other measures include net population density and gross population density. Analyzes NRD requirements for neigborhoods of various sizes, pp. 257-258.

  Table, p.261: Typical densities, plot dimensions and house types: could be very useful for detached/semi-detached housing types.

  Figure 113 p. 262: Examples of plot shapes and sizes which produce various densities; ranges from 1/20 acre to 1/2 acre.

  Figure 114, p. 263: Density chart; shows relationship between length and width of plots and the resulting number of plots per acre.

  Figure 115, p. 264: The inter-relationship of building height and density; shows cross sections of space required for same building volumes. Ranges from 2 story buildings 60 and 120 ft apart to 12 story buildings 240 ft apart. Densities and habitable rooms/acre increase dramatically w/ each succeeding variation.

  Table, p. 266: Effects on NRD and Town Size of variations in density of different types of dwelling occupancy rate. Shows how various combinations of houses and flats can be used to achieve different density ratios, in HRPA, PPA, density in HRPA and total residential acreage of town and total acreage of town.

  pp.276-284: several examples of residential neighborhood layouts, both generic and actual communities (British prototypes).

  Measures cited: Habitable rooms/acre, net population density, gross

population density, average number of DUs/acre, average number of persons/DU, average number of persons/acre.

Keeble, Lewis "Residential Density and Layouts," *Royal Australian Planning Institute Journal* (July, 1971) pp. 82-88.

* Measures of density: DU/acre and floor space/acre. Using these two measurements, one can determine how many people can come to live in an area and a particular type of development can be prescribed. Opposes the Floor Space Index/Plot Ratio as well as Site Coverage: "left over from the days when planning control tried to modify itself on building regulation methods." States that by using DU/acre and floor space per acre "density should be regulated by prescribing a permitted number of dwellings and a permitted floor space per acre as a design control to ensure conformity with a preconceived plan for each residential neighborhood."

Krupat, Edward. *People in Cities: The Urban Environment and Its Effects*, Cambridge, Cambridge University Press, 1985.

* Review of literature on crowding and stress (pp. 95-113), including "Characteristics of the Environment (objective physical conditions)" as contributing to stress through "experience of the environment" (p.96). Crowding is defined and related to "high density situations", and "molar" (i.e. within dwelling units) and "molar" (i.e. outside, or among, dwelling units) density measures are distinguishe (pp. 101-102). Crowding research and its inplications are reviewed (pp. 102-112). It is concluded that density can be stressful, but that other factors (e.g. poverty, social class) are corelated with high densities and crowding, and are aqually or more responsible for negative effects. Also included is a review of research on "defenible space" and the reponses to Oscar Newman's studies.

Klaber, Eugene Henry. *Housing Design* (Coverage and Density) c1954, pp.171-176.

Lanchester, H.V. "Height and Bulk of Buildings in Relation to their Requirements and Surroundings," *Journal of the Town Planning Institute*, 20:8 (June, 1934) pp. 213-222.

* Interesting from an historic point of view-p.214: discusses the proportion of open space to residential lands. Standards have most likely changed, but it is interesting to note that the formulae seem to (slightly) favor lower density developments. Recommends that the proportion of open space in residential areas (inclusive of raods) be 8% + 1.5% per house per acre. e.g. 6 houses/acre = 8%+9%= 17% Advantages of this system would include: 1. Roads would be kept to a minimum by virtue of their added expense; more space for play, parks, etc. 2. Balance related to density of population; 3. Cost of reserving traffic routes would be reduced- could be included in ratio; 4. Formula favors slightly lower density ratios; 5. Greater freedom in planning in place of restrictive regulations. Speaks in terms of CUBIC FEET PER ACRE. e.g. if typical house = 10,000 cubic feet, 16 DU/acre = 160,000 cubic feet. Under old laws it was possible to build houses 300,000 to

400,000 cubic feet/acre. Vertical controls implied, and cites (outdated?) laws in Calcutta that restrict the height of buildings by drawing a 45 degree angle from the middle of the road. Results of Lanchester's recommendations challenged in discussion following paper (pp.217 ff).

League of Oregon Cities, Urban Service Program; and University of Oregon, Bureau of Governmental Research and Service. *Residential Density Standards.* Local Government Notes and Information, Policy and Practice no. 40. Eugene: University of Oregon. Bureau of Governmental Research and Service, October, 1977.

* The most common method in Oregon for measuring densities: base standards on lot area; "Minimum Lot Area" would be designated for each zone or type of housing in residential zone. Usually this would include 1. lot area and width and sometimes lot depth; 2. maximum percentage coverage; 3. specified amount of lot areas for each DU in areas where multifamily DUs are authorized. In Eugene, Planned Unit Development standards are based on density point calculations correlated to DUs and the number of bedrooms. Maximum densities within PUDs are derived by comparing points assigned by DU type for maximum density points assigned per gross acre for the zoning district. Density points are determined according to the size of the DU and the number of bedrooms. A bedroom is defined as an enclosed room containing the minimum square footage of floor space required by commonly used ordinances or a room that is easily converted to sleeping quarters. Included are family rooms and dens if they fit the definition, are separated from other areas by doors and walls and have access to bath without passing through another bedroom. Density points are added and can't exceed a maximum set up in table (see p. 2) Gross Area is defined as an entire area internal to PUD including streets within the development and abutting streets provided by the developer. In Corvallis, the density measure is calculated according to the number of bedrooms per DU in residential districts. 2 classifications: R-M = Multiple family residential medium density district; R-H = High density multiple family residential district. FAR (# floors x coverage) used in conjunction with minimum lot area (width and depth) and building height regulations to obtain desired maximum density standard. Typical one family FAR = 0.3; multi-story, multi-family: 1.0. FAR usually includes off-street parking which increases the gross floor area per DU.

  The Land Use Intensity Ratio developed by HUD is designed to limit the amount of activity on a given unit of land area i.e. limiting density. Need to differentiate between intensity and structural requirements (e.g. setbacks) Some density controls affect both: height restrictions (in stories, multiples of street width, etc.) percent coverage and FAR. LUI uses 6 measures: 1. "open space ratio" which is the minimum open space for each square foot of floor area- expressed as a % of the total floor space. 2. FAR = basic density control while OSR allows

increasing open space at ground level as the total floor area increases. 3. Living space ratio = minimum sqaure footage of non-vehicular outdoor space required for each swaure foot of floor area 4. Recreation space ratio = minimum square footage of recreation space required for each square foot of floor area - a component of "living space" 5. Total car ratio = minimum number of parking space per DU. 6. Ocupant car ratio = minimum number of parking spaces without time limits required for each DU. LUI scale based on gross acreage, not net acreage. Scale ranges from 0.00 (actually 0.0125) for low rural land use to 3.0 for suburban type land use for "modest" DUs/gross acre to 8.0 for high intensity land use (high rise apartments)

Lerup, Lars, "Suburban Residential Environments: Analysis, Evaluation and Selection", *Ekistics* 183, (February 1971)

* Methodology; relation of land use areas; some concepts; intensity of activity, etc. Uses one acre as the unit of analysis. Considers only the relationship between DU, immediate open space, access roads, utility systems. "TO my dismay, little real concern for the actual differences between densities exists; the arguments seem simply rhetorical." (pp.184-85). Uses FAR; plots land use as a percentage of the total area plotted against density (persons per acre) using single famlity detached, semi-detached, multi- family 2 story walk-ups. Court buildings use land more efficiently than pavilions- same conclusion as Martin and March, et. al. States that intensity of activity is deduced from density--but how?

Lever, W. F. "Planning Standards and Residential Densities," *Journal of the Town Planning Institute* (November, 1971) pp. 400-403.

* Useful to show density measures. Distinguishes between Normative Standards (refer to recommended practice) and Positive Standards (refer to actual practice). 1969: studied how important residential density standards actually were in guiding planners. Ministry of Housing and Local Government (1962,63) stated that under 12 DU/acre was wasteful- need higher densities--up to 20 DUs/acre. Above 20 DUs/acre, increasing construction costs outweighed savings on land costs. In addition, above 20 DUs/acre, buildings larger than two story terraced development would have to be introduced. Used 4 residential density measures in his study: DUs, persons, habitable roms and bedspaces, all per acre. Stated that DUs/acre and persons/acre were most commonly used measures (by planners) However, DUs/acre and Habitable rooms/acre were the only two measures over which planners had control--after buildings are occupied, no control over persons/acre or bedspaces/acre.

London County Council, Hubert Bennett (Architect to the Council) *The Planning of a New Town* London: The Council (1961).

* p. 28: Develops theorical combinations of town designs, ranging from 100 ppa to 70 ppa to 40 ppa when varying sizes of residential areas are placed in relation to a constant combination of industry, open spaces, main roads, public utility services, hospital, town center, and

educational buildings. The NET DENSITY is the variable within a constant. The overall effect of these changes is that while the residential area increases in size dramatically, the effect on the radius of a circular town is small. There is a critical density at which services (e.g. schools) can be adequately supported without long journeys to and from places. Higher densities allow choice.

Lynch, Kevin and Hack, Gary, *Site Planning.* Cambridge, Mass., MIT, 1984 (Third Edition).

Macsai, John. *Housing* New York: Wiley, 1982.

* Excellent source for typologies- wide range of housing types, sizes and combinations.

Martin, Leslie and Lionel March. "Land Use and Built Forms," *Cambridge Research* (April, 1966) pp.8-14.

* Discusses two measures traditionally used in measuring density: floor space index (plot ratio) and daylight considerations.
Floor Space Index: Gross floor area of building (measured outside exterior walls) divided by the site area including 1/2 the width of perimeter streets. Plot Ratio: Gross floor area of building (measured outside exterior walls) divided by the net site area.
Daylight considerations: measured by use of special protractors and nomograms.
Article attacks the notion that high density buildings ("high tower buildings") use land more efficiently than other built forms. Three building types investigated in earlier study: pavilion, street, court. Variations of those forms considered here. Findings: court buildings use land more economically than high buildings (see James); plot ratios & FSI allow opening up of land or increasing density. Stresses need to find new relationship between building and road, i.e roads tend to form site boundaries; can roads be incorporated into built areas to form a sequence of pedestrian spaces? "If urban land is to be developed economically, and if reliable measures of this are necessary, it is desirable to know which forms of buildings appear to make the most effective use of ground area." "A knowledge of the measures we are studying allows either for an opening up of land or an increase of density, when related to the existing plot ratio measure." (p.14)

Martin, Leslie and Lionel March, eds. *Urban Space and Structures.*London: Cambridge University Press, 1972.

* Chapter 1, pp.6ff: Martin contrasts two building forms, the pavilion and the court, each with 50% plot coverage. Demonstrates how court buildings create far more usable outdoor space compared to pavilions-contrasts "form" with "antiform" (pp. 20-21).p. 34:

  Figure 2.2 illustrates the range of population density as a function of plot ratio on a given site. By using ratios established between floor areas and square footage per person, it demonstrates how varying degrees of efficiency in the use of the space can be produced - important

in considering the relationship between plot coverage, open space and building height.

McKean, C. "Giving People What They Want? The Case Against Low Density Housing," *Royal Institute of British Architects Journal* 86, no. 7 (1979) p 341.

Mitchell, R.E., "Some Social Implications of High Density Housing", *American Sociology Review,* 36, pp 18-29.

Muth, Richard F. *Cities and Housing: The Spatial Pattern of Residential Land Use* Chicago: University of Chicago Press, 1969.

Nairn, Ian, *Outrage*. London, Architectural Press, 1955.

Newcomb, Robinson and David Gillogly "What's Ahead for High Density, Low Rise Housing?," *Buildings* 58:12 (December, 1964) pp 40-42.

Okpala, D.C. "Housing Density Standards: A Constraint on Urban Housing Production in Nigeria," *Ekistics* 45, no. 270 (1978) pp. 249-57.

* Example of application of density and coverage measures (pp. 252ff). Argues (p. 255) for higher densities (5 to 6 story walk- ups) to avoid waste of lower density housing developments. Vertical density controls equal building height controls, the purposes of which are to ensure structural stability, privacy, creating beautiful cityscape, minimizing negative externalities to neighboring developments and owners. Yet, he finds space economies in high density forms of development. Cites U.N. Proceedings of the Seminar of the Supply, Development and Allocation of Land for Housing and Related Purposes (1952) for evidence of his argument. Measures used in Nigeria: DUs/population and density/acre or hectare. Uses building plot coverage, floor area per person or per room, plus building height controls. Lateral controls, (densities/acre or hectare) used to help solve overcrowding problems esp. in Lagos--raises question of the the ability of officials to enforce regulations-- but the housing problem in Nigeria is largely an income problem and can't be resolved by regulation. BUILDING PLOT COVERAGE: in high density residential areas, usually about 50% of buildinng plot. Cultural differences apparent here: the 50% coverage allows adequate car parking, but in Nigeria only about 1 in 400 own cars! Maximum number of persons per habitable room: one person in low density areas, twp persons in highest density areas. Net residential densities expressed in: number of persons per hectare or acre; maximum number of habitable rooms per hectare or acre; maximum number of persons per habitable room.

Openshaw, S. "An Empirical Study of Some Zone-Design Criteria," *Environment and Planning* A 10:7 (July, 1978) pp. 781-794.

Ottensmann, John R. Urban Sprawl, Land Values and the Density of Development. *Land Economics* 53(4):389-400 (November 1977).

* "Proves" that denser development takes place on higher value land. Of little value on density because it uses "population" as a surrogate indicator.

Patterson, Arthur H. "Housing Density and Various Quality-of-Life Measures Among Elderly Urban Dwellers: Some Preliminary Concepts," *Journal of Population* 1:3 (Fall, 1978) pp.203-215.

Pearlman, Wolf W., "From Structure to Function: Towards a Theory of Generating Habitable Space and Urban Place," *CONTACT*, vol. 9, no. 2, Summer 1977, pp 1-23.

Rapoport, A. "Toward a Redefinition of Density," *Environment and Behavior* 7, no. 2 (1975) pp. 133-58.

* Conceptual distinction: physical density vs. perceived density; factors affecting perception (some are actually physical e.g. height, sight angles, etc.). Tries to distinguish between density and crowding: the former can be seen as a site measure, the latter as a measure of density within a dwelling; or, the former can be defined as a measure of persons per unit area, and the latter as a negative perception of excessive density (subjective). Perceived density has 2 aspects: physical and social. Makes a further distinction: density is the "perception and estimate of people present in a given area, the space available, and its organization, whereas crowding or isolation (which we could call affective density) is the evaluation or judgment of that perceived density against certain standards, norms, and desired levels of interaction and information. Put differently, affective density is the appraisal of certain conditions as unfavorable-the perception of the condition itself is perceived density." (pp.136-137). Cultural influences on perceptions. One must also consider function and different perceptions of density related to function (e.g. what one might not consider excessive density in an Eastern bazaar might be inappropriate for a North American shopping center). How to judge density: "density is "read" (decoded)"- certain clues are picked up from the environment. PP.138-140: list of variables which would influence one's perception of density, e.g lights, noise, presence of cars, amount of activity, the presence of "unlike" people, etc. States that areas posessing high levels of these variables will be perceived as having high densities, no matter what the absolute number of people is (i.e. "whatever the number of people per unit area"). Homogeneity of people leads to the opposite perception (pp.141-42). It is necessary to extend beyond purely physical measurements of density to include what has been called behavioral space, action space, the cognitive space. etc. (p. 147). Classifies variables: Perceptual (large building space to height, signage, lights, people, noise, smells, cars); Associational (tall or short buildings, presence/absence of gardens); Temporal (fast/slow tempo, activities over 24 hours); Physical/Sociocultural (presence/absence of

adjacent places for use such as streets, meeting places, presence/absence of nonresidential land uses, fences, courtyards, etc.); Sociocultural (high/low levels of social interaction, lack/presence of control, heterogeneity/homogeneity).

Real Estate Research Corporation. *The Costs of Sprawl* Washington, D.C. (1974) Council on Environmental Quality, the Department of Housing and Urban Development, the Environmental Protection Agency.

Schiffenbauer, A. "Design for High Density Living," *Residential Crowding and Design*, J.R. Aiello and A. Baum, eds. New York: Plenum (1979) pp. 229-40.

Sanders, W. "Zero Lot Lines Can Trim Housing Costs," *Planning* 48:4 (April, 1982) pp.15-17.

Segal, Walter. "The Use of Land in Relation to Building Height, Coverage and Housing Density" *Architectural Association Journal* 79:880. (March 1964) pp. 253-258.

* Considers heights of buildings, ground coverage, number of dwellings and measurable relations between them based on density designation of one acre. Emphasizes the spacing of buildings to preserve sunlighting access, especially with regard to "sun- starved" countries. ASssumes spacing of buildings as 2.5 times their height.

So, Frank S. and Getzels, Judith (editors). The Practice of Local Government Planning (2nd edition). Washington D.C., International City Management Association, 1988.

* Chapter 9: "Zoning" by Eric Damian Kelly (pp. 274-275): The most common early form of regulating intensity or density of development was minimum lot sizes - still a common control in single family zones. Multifamily, mixed-use and planned unit development areas specify density as dwelling units per acre, usually supplemented by minimum lot-size requirements more as bulk control. Intensity also controlled by combination of minimum lot size and bulk measurements (height and coverage). More sophisticated zoning also employs the use of floor area ratios. Density and FAR requirements should specify NET or GROSS land area - "Net" defined as " the entire site less specifies undevelopable land...", "Gross" defined as "the entire site or that portion of it devoted to a particular use". These definitions are rather under specified.

Stein, Leslie A. "The Relevance of Density Controls," *Urban Law and Policy* 1:1 (January, 1978) pp. 51ff.

* Important only for distinctions made in different definitions of density: Using houses or dwellings/acre is misleading in that the size of houses may vary. Calls number of habitable rooms/acre "accommodation density"--problem w/this definition: ignores # of people/room. Also, what is the definition of a habitable room? Furthermore, problem w/ habitable floor space/acre: does not account for # of people occupying

that floor space. More accurate definition: # of bed spaces/acre; weakness: not entirely clear--explained on p. 53. Persons per acre ("population density") does not reflect the concentration of people, as in an area of high-rise DUs. But persons per acre divided by accommodation density (# habitable rooms/acre) can provide an idea of the number of persons per habitable room ("occupancy rate"). In addition, no calculation of density accounts for the differences between daytime and nighttime use of a building or area. "The devices which control the size and shape of buildings, especially dwellings, are fairly uniform throughout the world." (p.58) No one definition of density can explain concentration. "The hallmark of all these devices, where they have been reduced to legislative form, is inflexibility". Methods of calculating building height: multiplication factor applied to street width, plot ratio, or by "building envelope"--calculation made by taking angular plane from lot line. In addition: daylight controls.

Stevens, P.H.M. *Densities in Housing Areas* (Tropical Building Studies #1) London: Her Majesty's Stationery Office, 1960.

* Analysis of criteria affected by changing density requirements, including health factors (water, sanitation and waste disposal, light, sunshine, air, noise, living space) social factors (private open space, priacy, protection, community facilities) technical factors (fire risk, available building land, access, ground cinditions) and economic (land cost, locational factors, cost of essential services, availability of building materials, skills and equipment). Analyzes each of these variables (pp 12- 14) in terms of effects on each of them if density is density is reduced or increased. Table 2 (p. 14) draws comparison of average floor space rates per person, ranging from 24 sq. ft./person in Hong Kong squatter settlements (1955) to standards set by the Ministry of Housing and Local Government for social housing in England (1953) of 185 sq. ft./person.Relevant definitions: Housing Area: "The area of land actually developed or to be developed for houses and including: (i) all house Plots; (ii) All communal open space, i.e. any small public or private open spaces for the enjoyment and use of nearby households and not for the purpose of the neighborhood as a whole;(iii) half the width of any street on which land mentioned in (i) or (ii) abuts, except that where a curtilage abuts on a principal traffic road only 20 ft of the width of that road is included.Housing area density: "The total number of persons to be accommodated in the housing area divided by the housing area in acres. It is expressed as persons per acre.Floor Space Rate: The ratio of floor space to the number of inhabitants in a house or group of houses. It is expressed as square feet of floor space per person.Housing are ratio: The total floor space within the housing area divided by the housing area in square feet. Access index; The percentage of the housing area used for roads, footpaths or other means of public access not forming part of a house plot.Open space index: The percentage of the housing area used for small communal open spaces intended solely for the enjoyment and use of nearby households and not for the purposes of the community as a whole.Communal sevices index: The total percentage of the housing area used for access and open space.

Stokols. D. "On the Distinction Between Density and Crowding: Some Implication for Future Research," *Psychological Review*, 1972, 79, 275-277.

Sussna, Stephen "Residential Densities or a Fool's Paradise," *Land Economics* 2 (1973) pp. 1-13.

* Density, as defined in Planning the Neighborhood (see), is "the number of units (persons, families, dwellings or rooms) per acre (or square mile)." Sussna uses the number of housing units or people for a specific area of land. Defines GROSS LAND AREA as an entire acre or parcel of land and NET LAND AREA as only that portion specifically devoted to residential uses, excluding streets, community facilities, open spaces and recreational areas. Purpose of "bulk" controls: to assure adequate daylighting, to control population density, provide open space. Cites a HUD International Brief that found that new community densities in the U.S. average about 2.5 living units per gross acre and often go as high as 5 lu/ga (Forest Hills has 8.2 lu/ga). Makes an important comparison of population and density standards for ideal communities on p. 9 including Le Corbusier, Wright, Goodman and Goodman's Communitas and others.

Tieh-Yeu Huang. "Planning for High Density Housing: Physical and Behavioral References. *CPL Bibliography, no.97.* Chicago: Council of Planning Librarians, 1982.

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U.S. Federal Housing Administration *Minimum Property Standards for Multifamily Housing* Washington, D.C.: U.S. Government Printing Office (1971).

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Whyte, W.H. *Cluster Housing.*

Windsor, D. A Critique of "The Costs of Sprawl." *Journal of the American Planning Association*, 45(3):279-292, July, 1979.

* p. 284: Table 3: Residential Density Assumptions of the "Costs of Sprawl" Breaks down scale of analysis to neighborhood prototypes (1000 DUs) and community prototypes (10,000 DUs) with population, school children, floor area in square feet, floor area per resident. total floor area, gross unit density per acre and net unit density per acre. These measures are divided by typologies: single family conventional, single family clustered, townhouse clustered, walk-up apartment, high-rise apartment. Caveat in using these measurements for comparative purposes: densities range from 2 DUs/A (gross) for single family (2 DUs/A net) to 10 DUs/A (gross) for high-rise apartments (30 DUs/A net)-- all at the neighborhood level. However, floor area drops from 1600 sq. ft for single family housing to 900 for high-rise units. These assumption introduce lower standards for living space. Furthermore, The Costs of Sprawl doesn't "isolate density and planning from other important sources of variation in development costs or impacts, particularly floor area.

Wingo, Lowdon, ed. *Cities and Space: The Future of Urban Land.* Baltimore: Johns Hopkins Press, 1964.

Yeung, Yue-Man. High Rise, High Density Housing: Myths and Reality. *Habitat International* (Vancouver) 2(5/6):587-594 (1977).

* Distinguishes between external density measures (overall measure of the number of persons per unit area of land) and internal density (unit area per person or the number of persons per room). Cites United Nations (1962) Statistical Indicators of Housing Conditions suggestion of an average density on one person per room as the maximum in which one could maintain a sense of privacy, with three or more persons per room as a measure of crowdedness. Older resettlement housing in Hong Kong used standard of 24 sq. ft./person, with high standard housing built using 35 sq. ft./person. Maintains that high-rise housing does not necessarily result in less living sapce (internal density) and more people/unit area (external density).

Zehner, R.B.and R.W. Marans "Residential Density, Planning Objectives and Life in Planned Communities," *Journal of the American Institute of Planners* 39 (1973) pp. 337-45.