# DO ZONING ELEMENTS CONSTRAIN ACHIEVABLE MULTIPLE-FAMILY RESIDENTIAL DENSITY AND SUSTAINABLE FEATURES? DESIGN ANALYSIS OF FOUR CASES IN ORANGE COUNTY, CA

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## SIGNATURE PAGE

**THESIS:** DO ZONING ELEMENTS CONSTRAIN ACHIEVABLE MULTIPLE-FAMILY RESIDENTIAL DENSITY AND SUSTAINABLE FEATURES? DESIGN ANALYSIS OF FOUR CASES IN ORANGE COUNTY, CA

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## ABSTRACT

High density dwellings support sustainability by limiting urban sprawl, consuming less building energy, increasing the use of public transportation, and confining environment degradation. Zoning provisions control development; each city's zoning codes regulates the land-use and the intensity of project development in accordance with the policies of the community's General Plan. This study examines the hypothesis that indirect elements of zoning regulations (e.g. setbacks, parking requirements) hinder the achievement of permitted density (as expressed in units-per-acre) and implementation of sustainable features. The research utilizes a conceptual modeling approach to determine the effects of indirect zoning provisions on the potential density of apartments in multiple-family residential zones of four cities located in Orange County, CA. The conceptual models determine (1) the maximum buildable units per zoning restrictions under two design scenarios, (2) the maximum buildable units after applied modifications of development standards by density bonus incentives, (3) the potential to implement sustainable features. These results are compared to the units-per-acre regulation. The models show that indirect zoning provisions allow more buildable units than the units-per-acre regulation, leading to the conclusion that indirect zoning provisions *do not* reduce density lower than the units-per-acre regulation. If cities intend to increase housing density, they should increase the units-per-acre regulation to allow developers to increase dwelling units. However, as buildings' footprint increases from building more units, it reduces the potential to implement rainwater planters, but increases the potential to implement photovoltaic panels. Changes in indirect regulations may be required to avoid reducing the potential to implement rainwater planters.

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# CHAPTER 1: INTRODUCTION

## Introduction and Problem Statement

Human settlement changes land-use and land management in relation to its environment and natural resources. The proliferation of single-family housing projects poses a critical challenge to sustainability since households are the end consumers of most natural resources (Bradbury et al., 2014). Bradbury et al. (2014) found that the number of households grew faster than population size in every country and every time period. Due to the necessity of land to supply housing, encouraging higher density dwellings in urban area, especially infill development, promotes sustainability because it prevents urban sprawl, reduces wildland urban interface (WUI), and utilizes existing infrastructure and public services.

Primary energy consumption of U.S. residential buildings per capita has been gradually increasing since the early 1980s and continued to rise (Ewing *et al.*, 2008). Even if the locations of residential buildings are not in the wildland or ecological sensitive areas, their energy consumption and carbon dioxide emission still have direct impact on global warming and climate change. Encouraging high density dwelling is challenging, but it will reduce low density residential developments (single-family housings) that consumes higher amount of energy and natural resources. High density dwellings encourage compact cities and mixed-use developments; they result in increase of population within the area. Apparently, they increase the demand of public transportation; therefore, public transportation is more easily provided due to higher demand. Moreover, they potentially prevent urban sprawl, which results in reduction of vehicle-mileage travel. Commuters reduce travelling distances from homes to town centers.

High density dwellings support regenerative habitat where everyone can lead a comfortable, productive, secure, and meaningful life without depleting resources or damaging natural systems (Lyle, 1994). Farr (2008) believes that increasing density can increase sustainability. The transition from detached to attached single-family housing or multiple-family housing reduces building energy consumption (Ewing *et al.*, 2008). High density dwelling buildings (e.g. mixed-use complex, apartments, condominium) consume less energy than low density dwelling due to lower surface-to-volume ratio. Also, the wall receives less sun radiation which ease the thermal mass control (Lyle, 1994). The amenities (e.g. pool, park, and playground) create community space for neighbor interaction and promote a sense of belonging.

Zoning regulation is essential in planning for high density dwelling. Land use zoning is one of the most potential tools planners have to endorse change in human settlement patterns (Hirt, 2013), as well as important tool of sustainable development (Jepson, 2014). Zoning and urban planning emerged from health and sanitation concerns. The original concern was that manufacturing facilities should be located away from residential zones because they are unpleasant and dangerous to the citizens. However, zoning codes in the U.S. establish far more than zones; they also regulate the intensity of development (e.g. building height and placement) (Barnett, 2011).

Each city's zoning codes regulates the land-use and the intensity of project development in accordance with the policies of the community's General Plan. Therefore, municipalities can indirectly limit or encourage certain types of developments by utilizing zoning ordinances. Inevitably, as an indirect result of serving other purposes, especially health and safety, zoning ordinances may present barriers to high density dwelling and sustainable development.

Cities can limit density by using direct and indirect zoning provisions. Direct regulation refers to units-per-acre regulation, which limits the dwelling units per acre. Indirect zoning provisions are those related to building height, building or lot coverage, building placement (e.g. setback, yard area), parking requirements, vehicular provisions, open space or landscape requirement, minimum floor area, minimum site dimension and area, wall and fence materials, architectural style, and more.

Height limits constrain the maximum height of the building. Jurisdictions may allow developments to exceed the height limits if it provides further setback from the property line. Building coverage percentage is total buildings' footprint on the site; any covered structures are considered as buildings. Lot coverage refers to the total of the building's footprint, driveways, and parking areas; any area that is not landscape area are considered as lot coverage. Some cities regulate lot coverage other than building coverage. Building placement is where the building must be place offsetting from the property line. Parking includes number and dimension of parking stalls. Vehicular provisions include dimension of driveway and ramp, aisle width, site entrances and exit, and public right-of-way.

The purposes of open space and landscape or park area are to preserve open space areas and enhance visual and environmental character of the community. Recreational open space zone provides recreational activities such as park or playground. Minimum floor area regulates the minimum floor area per dwelling units. Minimum site area or dimension refers to minimum site area of the land permitted to construct certain development. Some developments may require large street frontage width for public safety and accessibility. Zoning codes may regulate preferred building architectural design for new projects to compliment and harmonize with existing neighborhood.

Figure 1 summarizes the direct and indirect effects of zoning regulations on density.

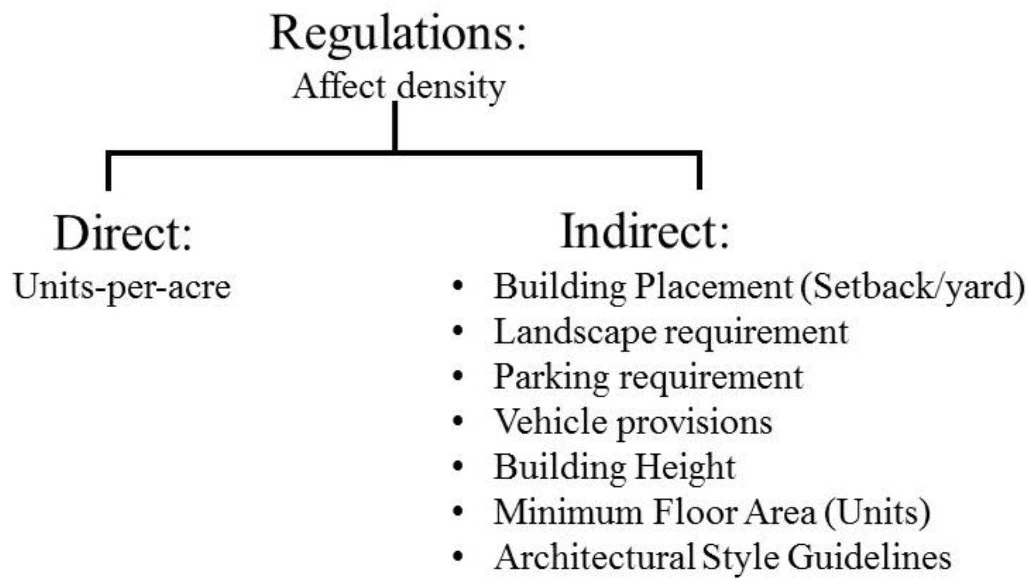



***Figure 1 - Direct and Indirect Regulations***

This study examines the hypothesis that indirect zoning provisions hinder the achievement of permitted density (as expressed in units-per-acre). This will occur if those indirect regulations are not coordinated with the units-per-acre limit. The research utilizes a conceptual modeling approach to determine the effects of indirect zoning provisions on the potential density of apartments in residential multiple-family zones of four cities located in Orange County, CA.

**Definitions**

Density: density can be perceived in two ways: first, number of housing dwelling units within the land area, or second, population by land area or housing unit. Dwelling per unit area (e.g. acre) determines the dwelling density (e.g. du/acre). Apartments are considered high density dwellings because they do not have their own footprint on the land; instead, they occupy airspace.

Dwelling Unit: one or more habitable rooms with one kitchen. The dwelling units must have common interior access to all living, eating and food preparation areas.

Floor area or net floor area: the interior floor area of a room or building

Open area: land area not covered by buildings and not arranged for vehicular use

Parking aisle: the space within parking areas by which vehicles access and depart parking stalls

Setback: the least horizontal distance between buildings and lot or property lines

Yard: an open area between buildings and lot or property lines

Front Yard: an open area between buildings and front lot or property lines

Side Yard: an open area between buildings and two or more side lot or property lines

Rear Yard: an open area between buildings and rear lot or property lines

Units-per-acre: maximum dwelling units allowed to build in one acre

# CHAPTER 2: LITERATURE REVIEW

Zoning ordinances can either hinder or support density in multifamily dwellings; they can directly limit the maximum dwelling units or indirectly constrain achievable density through other code provisions. Inevitably, as an indirect result of serving other purposes, especially health and safety, zoning ordinances may present barriers to high density dwelling and sustainable development. The better coordination of architectural design strategies and zoning provisions will support higher density multifamily housing and regenerative goals.

This literature review explains the background of zoning ordinances. It attempts to explore several studies that focus on determining suitable dwelling density, zoning ordinance provisions that impede achieving high density dwellings and sustainability, related research methods that evaluate the rationality of land-use regulations and coordination between zoning codes and other public policy goals, and a conceptual approach to create sustainable projects that can be implemented with regenerative practices.

## Dwelling Density

Since most literature that reviewed dwelling or housing density was conducted via case study approach, the preferred density or ideal dwelling units cannot be standardized in every context. It requires proper balance among population, capacity of infrastructure and transportation, land and other resources to attain suitable density. This following researches present the qualitative measure to the optimal and sustainable density. Optimal residential density cannot be defined by quantitative dwelling units alone because it is related to contexts and sustainability (Boyko et. al, 2011). After reviewing literatures, Boyko et. al (2011) concluded that density is more than a quantitative calculation that exists on its own. He developed a new conceptualization of density that integrates three factors: (1) the quality of the physical and ambient environment, (2) behaviors, perceptions and need, and (3) quantitative density calculation.

Lehmann (2016) explored the ideal density for sustainable cities that support creating highly livable, economically vibrant, mixed-use and resilient neighborhoods of the future. The research was conducted via case study approach, looking at the failure of hyper-density town in Kowloon, Hong Kong and the quality density towns in Vancouver, Sydney, and Singapore. Lehmann (2016) estimated minimum of 28 or more dwelling units per acre (70 and more dwellings per hectare) is an important benchmark for minimum densities of new sustainable developments. However, Lehmann concluded that densities should preferably be closer to 41 – 48 dwelling units per acre (100 to 120 dwellings per hectare), especially along transport corridors, to support the integration of public transport, walking and cycling to key facilities, and on-site energy generation.
By reviewing Knowles's models, Lyle (1994) concluded that a limitation on dwelling density does exist, although at a very high limit. Lyle (1994) presented Regional Plan Association (1974) that studied the relationship between density and energy consumption in New York metropolitan area; the result suggested per-capita energy consumption decreased up to a density of approximately 39 people per acre or 13 dwelling units per acre. The energy consumption increases when the density increased above 13 dwellings units per acre. However, 13 dwelling units per acre seems to have been an optimum density for that time and place.

Even though high density dwelling supports sustainability, the optimal density for each context cannot be generalized. Local jurisdictions allow different amount of maximum dwelling density; this may be due to public safety, sanitation, impact on its environment, capacity of infrastructure and transportation. For density policy to be effective, Boyko et. al (2011) suggested that it needs to be flexible and responsive to the context in which it is to be delivered.

**Background of Zoning Ordinances**

Land use zoning is one of the most potential tools planners have in order to endorse change in human settlement patterns (Hirt, 2013), as well as important tool of sustainable development (Jepson, 2014). Patalano (2001) commented that zoning ordinances often mark the starting point, or "base-line rules," for development negotiations between localities, neighbors, and developers. Zoning and urban planning emerged from health and sanitation concerns. The manufacturing facilities should be conducted away from residential zones because they are unpleasant and dangerous to the citizens. However, zoning codes in the US establish far more than land-use zones; they also regulate the intensity of development (e.g. building height and placement) (Barnett, 2011).

Each city's zoning codes regulate the land-use and the intensity of project development in accordance with the policies of the community's General Plan. State granted municipalities to regulate their own land use planning, which offers flexibility in exercising this delegated power because each situation involves unique variables that a state legislature is unable to predict (Patalano, 2001). More than 25,000 local jurisdictions in the United States have the power to adopt zoning laws, and their authority to regulate land is derived from the legislatures and constitutions of 50 states, not from the federal government (Fischel, 1998). Delegating power to jurisdictions has many advantages for the United States because it contains distinct geographies. Municipality divides regional problems into smaller sections, solves site-specific problems, makes its own decisions, prevents reoccurrence of problems in other jurisdictions, and creates its own general plan.

Fischel (1998) concluded that zoning is a product of a political process, and it serves the interests of those who control that process. Fischel (1998) addressed zoning as a collective property right that is used by the municipality to maximize the net worth of those in control of the political instrument. One of the functions of zoning is to protect property values; however, it may appear as an intervention that regulates the uses of private properties (Fainstein & Defilippis, 2016). Bernett (2011) stated that changing codes in already developed or partially developed areas are difficult because property values reflect existing regulations. Davis (1997) commented that the control of zoning ordinances tended to force each new development into predictable pattern looking like adjacent neighborhoods. However, zoning ordinances not only are able to insure the predictable result of construction, it also insures the monotony, the banality, and the environmental insensitivity (Davis, 1997).

Hirt (2013) compares European-American distinct nature of U.S. land use regulation in residential district and single-family residential. These two aspects of zoning set U.S. practice apart from Europe. The U.S. municipal land-use regulations pertain to single-family housing areas support the special status of America’s landmark detached housing form, while English’s, French’s, and German’s do not afford this exceptional legal protection of the surroundings of the single-family (Hirt, 2013). She further stated that the Europeans do not separate residential and nonresidential uses as rigidly as a “typical” U.S. zoning code, as well as, the separation of single family to multifamily housing. The Europeans did not adopt U.S. style land-use because of race and class prejudice, and the belief in the social and spatial supremacy of the single-family home (Hirt, 2013). Similarly, Talen (2005) stated that the separation is the biggest failure of the past century of American city building. Davis (1977) stated that the negative imagine of high density in the US is associated with long standing anti-urban planning mentality; the city perceived as dirty, crowded, and crime-ridden.

**Zoning Ordinance Provisions – Impediment to High Density Dwellings**

Zoning ordinances can either hinder or support density in multifamily dwellings; they can directly limit the maximum dwelling units or indirectly constrain achievable density through other code provisions. Exclusionary zoning is the practice of using land-use regulation to segregate certain race, ethnicity, or income citizen. It also can present as significant barrier to higher-density or multifamily housing. Apparently, the permitted maximum density varies among municipal ordinances.  High density or multiple-family housing is generally more affordable than low-density or single-family housing; therefore, it is likely that zoning barriers to multiple-family housing also act as barriers to affordability (Knaap et. al., 2007). Rental houses provide affordable housing for lower income who cannot afford to own a residential property.

Pendall (2000) examined how five major land use controls and one land use condition may contribute to exclusionary zoning. Pendall (2000) concluded that exclusive low-density zoning reduces rental housing in the municipalities and counties that regulated it, especially restrict residential densities to fewer than eight dwelling units-per-acre. Moreover, those low-density zones contain low populations of Black and Hispanic residents.

Knaap et. al's (2007) research concluded that exclusionary zoning is a significant barrier to higher-density, multifamily housing in major metropolitan areas throughout the United States. Knaap et. al. (2007) found that jurisdictions with more land zoned for residential development had more residential development; and jurisdictions with more land zoned for multifamily development had more multifamily development. The regulatory analysis found evidence of specific policies in some jurisdictions that directly limit the amount of multifamily housing development; these jurisdictions generally had higher incomes, higher housing prices, lower densities, and fewer multifamily housing units than their neighbors (Knaap et. al., 2007). Although, zoning policies may reduce overall density, it may not indicate exclusionary motive (Knaap et. al., 2007). Market conditions, land availability and parcelization, the provision of public service, planning goals, and existing land-use patterns are factors that limit the quantity of multifamily housing as well. Knaap et. al (2007) specified that zoning ordinances that serve as regulatory barriers are restrictions on land zoned for multifamily use, restrictions on the number of bedrooms, restriction on manufactured housing or mobile homes, minimum lot-size requirement, minimum lot-width requirements, and minimum building-size requirements.

Sussna (1973) reviewed many apartment zoning cases in New Jersey, New York, Illinois. Sussna (1973) mentioned that it is not rare to find suburban municipalities using zoning as a "birth control" device that attempts to limit the number of public school children by requiring high percentage for one-bedroom units in apartments; because one-bedroom units' dwellers are most likely single, empty-nester, and couples without children. Moreover, pre-zoning for apartments uses is a rarity in most suburban municipalities (Sussna, 1973).

**Zoning Ordinance Provisions – Impediment to Sustainable Design**

Lyle (1994) and Friedman (2007) elaborated a case study of The Village Home in Davis, California. The density of the homes is almost double compared to the surrounding area, but the incorporation of common amenities creates a strong sense of community. The circulation system intended to emphasis on pedestrian and bicycle. The streets are 22 feet wide which is less than twice the standard of the area of 44 feet. This result in lower heat collection on pavement; the design can control the microclimate by planting fruit trees along the path. When zoning code requires wide minimum pavement or street width, the paved area requires massive grading, which increases ambient heat levels and reduces vegetation coverage. For example, The Los Angeles County required two fire engines to park side by side on the small pedestrian way of the Lyle Center of Regenerative Studies. It created wide pavement area which separates group of buildings, and increases heat collection on pavement. Apparently, safety is essential in zoning and building codes; it may impede achieving environmentally conscious design.

Land use and infrastructure are arguably the most long-lasting and deterministic attributes of human settlement, but the debate on climate change tends to skip over this topic in favor of quicker solution (Farr, 2008). With the help of efficient automobiles, the urban and suburban boundary continue to expand into the wildland, desert, and wildfire area. Roads are engineered to speed the flow of automobiles, while ignoring the physical and social nature of the created space (Friedman, 2007). The segregation of land use and zoning patterns rarely have any relationship with natural character or capacities of the land (Lyle, 1994). For long term sustainability, land use and urban policy should be critically emphasized.

Zoning ordinances are complex and used for many different purposes; therefore, the same code may assist a purpose and hinder the other. Even though health and safety are prioritized in urban planning, it also presented as difficulties for regenerative land development practices. Many laws and regulations unintentionally impede regenerative practices, as an indirect result from serving other purposes (Lyle, 1994). Similar with Knaap et. al (2007), he concluded that, while the jurisdictions are trying to reach other goals, zoning policies may reduce overall density, but it may not indicate exclusionary motive.

**Explores Research and Methodology**

This section elaborates on how other studies try to prove the constraint in zoning codes and land-use regulations in various way. It explores methods to measure, assess, and compare zoning codes. It identifies limitation to the current research.

Knapp et. al (2007) conducted in-depth research on characterization of residential zoning in six metropolitan areas which are (1) Boston, Massachusetts, (2) Miami-Dade County, Florida, (3) Minneapolis – St. Paul, Minnesota, (4) Portland, Oregon, (5) Sacramento, California, and (6) Washington, D.C. First, the researchers analyzed quantitative census and zoning data to identify the characterization of residential zoning. They utilized GIS metadata and local zoning ordinances to determine total residential acreage for each jurisdiction and maximum housing units allowed by zoning provisions.

The standard comparison across jurisdictions was created by categorizing residential zones by their allowed maximum density. Then, they utilized GIS data to create two and three-dimensional maps to represent densities and various other measures in order to present the relationship among variables. Second, the researcher reviewed and evaluated local policies, general plans, and regulation. Third, the researcher interviewed local representatives to gain insight and additional information. In addition to quantitative and qualitative data, the research examined correlations between measures of zoning restrictiveness and housing production. This research's quantitative analysis of GIS data suggested that local regulations affected housing development patterns and presented that some local government have little or no land zoned for multifamily use. The qualitative analysis of local land-use regulations in several jurisdictions provides corroborating evidence that regulatory barriers exist.

The analysis of GIS and census data presents the insights on residential zones in the six metropolitan areas; however, it was not possible to identify the unique impacts of zoning, location, and time that zoning imposed barriers to high density or multifamily housing (Knaap et. al, 2007). In some area, comprehensive GIS zoning data are not available, incomplete, and poorly suited for comparative analysis. Knaap et al. (2007) recommended developing better measures of zoning barriers and supporting additional research on the effects of barriers on housing markets. This study presented overall results of the metropolitan area, but not at a local scale. GIS analysis provided suggestions of areas where regulatory barriers exist; however, case study analysis or site specific research was needed for in-depth research.

Jepson et. al (2014) examine zoning ordinances of 32 communities to determine the presence of nine sustainability principles and 53 associated regulatory items. The research only examines the ordinance contents, but not implementation. First, the researchers selected 32 communities that represented of all regions of the country. They selected large cities with more than 50,000 residents and small cities with less than 50,000 residents. The communities must have online zoning codes available, and similar municipal powers and policy options. Second, the researchers identified regulatory items that they will look for in zoning ordinances. They mainly reviewed Policy Guide on Planning for Sustainability (APA, 2000) and Policy Guide on Smart Growth (APA, 2012). Moreover, they reviewed eight other APA policy guides on aspects of sustainability, and other literature on sustainability framework. After reviewing the literature, Jepson et. al (2014) identified 53 regulatory items that these nine sustainability principles could be included in zoning ordinances; those items must be written in zoning ordinances to represent that the local jurisdictions take actions on sustainability.

The first sustainability principle is encouraging higher density development; the regulatory items for this principle are infill development, maximum lot size/minimum net density, purchase or transfer of development rights, and small lots residential development permitted. Form-based code and maximum building size or building occupancy regulatory items are in preserve or create a sense of place principle. Inclusionary or affordable housing regulatory items are in increase housing diversity and affordability principle. After the regulatory items were identified, they developed a worksheet to check the 53 regulatory items. They utilized keyword searches and a final page-by-page scan to look for the presence of the items. However, the regulatory item must contain quantitative standard to be consider “presence” in the ordinances; it would not be considered as presented if it was simply mentioned.

Jepson et. al (2014) found that the sustainability principle on encouraging higher density development presented in fewer than 15% of the zoning ordinances, and increase housing diversity and affordability is present in only 29% of the ordinances. “Purchase or transfer of development right” (PDR/TDR) and “maximum lots size” have low levels of presence. The presence of sustainability regulatory items decreases when the age of the zoning ordinances increase (Jepson et.al, 2014). They found the contradiction that while encouraging mixed use is highest level of presence, infill development is present in low level of presence. Also, reducing the use of fossil fuels is in the low level of presence. Only 40% of the communities contain quantitative standard ordinances for solar energy systems. Jepson et. al (2014) commented that the municipality decisions about alternatives to fossil fuel are driven more by the nature of a given technology and support to the commitment to reduce fossil fuels consumption. Sustainability can be achieved in ways other than zoning ordinance; however, zoning ordinances that directly address sustainability in many dimensions are more likely to achieve sustainability (Jepson et.al, 2014).

Jepson’s research focused on zoning ordinances’ level of presence; but not the implementation of ordinances. It also presented the collaboration and contradiction of the zoning codes. The research did not evaluate the extent to which these written ordinances were implemented in design and planning. The research is only an assessment for potential research, especially for the development of a sustainable approach.

Pendall (2000) examined how five major land use controls and one land use condition may contribute to exclusionary zoning. The five major land use controls are exclusive large-lot zoning, building permit caps, building permit moratorium, adequate public facilities ordinances, and urban growth boundary. The land use condition is boxed-in city, the jurisdictions that was surrounded by other incorporated areas or bodies of water.

Pendall (2000) surveyed 1,510 jurisdictions in the largest 25 metropolitan areas in the US using mail-survey method. The surveys asked whether each community employed the five major land use controls and one land use condition. He utilized 1980 and 1990 Censuses of Population and Housing to analyze the correlation between land use control and racial exclusion. Then, he examined the existence of rental housing in those lands with low population of Black and Hispanic. Pendall (2000) found that exclusive low-density zoning reduces rental housing in the municipalities and counties that regulated it, especially restrict residential densities to fewer than eight dwelling units per acre. Moreover, those low-density zones contain low populations of Black and Hispanic residents.

Talen and Knapp (2003) investigated the implementation of "smart growth" policies in land use regulation. She compared smart growth proscription with the current proscribed regulations in zoning ordinances and subdivision regulations of each jurisdiction. The analysis was based on 167 cities and 37 counties of Illinois. Similar with Jepson's research, this research assessed the degree to which the development regulations of local jurisdictions represent the principles of smart growth. Moreover, the researcher examined the prescriptive policies which focus on site-specific policies and form-based code. The prescriptive policies can encourage certain type of development as opposed to simply restricting to minimum zoning ordinance standard. While form-based code aims at compacting urban form and increasing mixed-use development, conventional zoning does not share this goal (Talen, 2013).

Furthermore, Talen (2013) extended her research to form-based code. She presented five dimensions that form-based code can achieve better-quality urbanism and help mitigate sprawl. She drew a clear distinction between the intent of zoning for sprawl versus zoning against sprawl by contrasting conventional and form-based codes. The research categorized the effects of zoning by form-based code into five dimensions: pattern, dimension, homogeneity, separation, and enclosure. While emphasizing built-form characteristics, form-based codes can be project-specific, apply only to certain areas (e.g. a central business district, transit-oriented development area), and add some form-based coding requirement to conventional zoning code. Talen (2013) conceived form-based code as one possible approach to mitigate some of the negative effects of zoning.

Garde et. al (2015) assessed the degree to which the City of Miami’s new form-based code (Miami 21) reflects the Leadership in Energy and Environmental Design for Neighborhood Development (LEED-ND) criteria by comparing to its traditional code (Ordinance 11000). The research based the work on the latest versions of Miami 21 and Ordinance 11000 available online from the City of Miami. They utilized the online version of the LEED-ND rating system as the analytical framework to evaluate the strengths and weaknesses of zoning codes in integrating key design principles.

Garde et. al. (2015) found that Miami 21 significantly encourages incorporating LEED-ND criteria into project development to than Ordinance 11000. Moreover, several LEED-

ND criteria are reflected more strongly in zones with higher densities than in zones with lower densities in Miami 21. It is more likely that projects in higher density zones will address these key criteria than projects in lower-density zones.

The findings of this study provide valuable insights for municipalities to consider zoning reform; however, this case-study method does not provide an adequate basis for generalizations. LEED-ND criteria are associated with higher density, mixed-use, and transit-oriented development. Apparently, LEED-ND criteria are not appropriate for all municipalities, especially the context of low-density neighborhood.

None of this research conducts modelling approaches to test the effects or rationality of zoning codes. The research in this literature mostly focuses on regional or large metropolitan areas (e.g. Knapp, 2007; Pendall, 2000; Talen & Knapp, 2003). Also, some research assesses and measures the coordination of the zoning codes by assigning scores and reviewing zoning ordinances (e.g. Garde, 2015; Jepson, 2014; Talen, 2013). Moreover, some research tests the correlation of the zoning codes with other factors such as population and building forms (e.g. Garde, 2015; Pendall, 2000). Therefore, an in-depth research and empirical approach are necessary to study the coordination of zoning ordinances and development intensity.

**Conceptual Approach – Regenerative Practice**

Good regenerative design must fit the natural context and operate eco-systematically; also, it will serve the purposes of regulatory agencies far better than trying to enforce a minimum standard (Lyle, 1994). Lyle (1994) suggested that supervisory agencies will probably have to require that developers hire capable interdisciplinary design teams and allow them broad scope for creative and technical thinking. This approach is like form-based code; it can be project-specific and may not completely relied on conventional zoning. Also, Rovers et al. (2008) conceptual approach can be ideal for starting sustainable housing project.

Rovers et al. (2008) purposes a conceptual approach in developing sustainable housing, which leaves rooms for different solutions within target; also, he further elaborates that concept creates more freedom for design. Ecolonia is a sustainable housing demonstration project which aims to give an impetus to sustainable building in main stream Dutch residential building (Rovers et al., 2008); the project still serves today as a model for the building industry and cooperation between state and private industry.

Communication between the state and developers is required to implement sustainability. Rovers et al. (2008) elaborates that Ecolonia was organized along two lines: first, the developer maintained contacts with the municipality, consultants, architects, and contractors. Second, groups of experts transferred their knowledge to the developer and architect; limiting the numbers of experts on specific topics for ease of coordination. The coordination of the experts had a positive effect on the application and integration of their advice, and the evaluation of the monitoring programs. The project requires an interdisciplinary approach and process; therefore, starting with conceptual allows more spaces in the developing stage (Rovers et al., 2008). Design strategies are not universal and require adaptation for specific condition. The conceptual approach from Rovers et al. allows design and planning flexibility, but it is not applicable in some conditions. The collaboration between the state and private sector require willpower, patience, time, and extensive shareholders’ commitment.

## Literature Review Conclusion

Increasing housing density supports sustainability and minimizes depletion of resources or damage to natural systems. However, land-use regulations and zoning ordinances may not support density because of the purposes of those regulations, especially health and safety. The current research methodologies that measure, assess, and compare the effectiveness of zoning ordinances provide ideas for further research. It appears that most research was conducted in extensive urban scales (e.g. metropolitan areas). Also, the implementation, applicability, and effects of the zoning codes were not assessed. Most of the current research evaluated the correlation between ordinances and other variables (e.g. race, production of housing, previous ordinances). The case-study or empirical approach to addressing barriers in zoning ordinances is necessary to determine the coordination of zoning codes and development intensity.

# CHAPTER 3: METHODOLOGY

The research utilizes a conceptual modeling approach to determine the effects of indirect zoning provisions on the potential density of apartments in residential multiple-family zones of four cities located in Orange County, CA. The four cities are City of Buena Park, Santa Ana, Irvine, and Laguna Niguel. This will be performed by (1) collecting and analyzing four cities' zoning code, (2) selecting and reviewing four existing apartment sites from each city, (3) developing conceptual models reflecting indirect zoning provisions to determine the maximum buildable units and the potential to implement sustainable features, (4) developing conceptual models reflecting modification of development standard by density bonus incentives, (5) comparing numbers of allowable units under the units-per-acre regulation, as-built units, buildable units reflecting all indirect zoning provisions, and buildable units after density incentives, (6) comparing the results among the four cities.

Figure 2 presents the summary of methodology. Direct regulation refers to units-per-acre regulation, which limits the dwelling units per acre. The as-built units are existing apartment units. Conceptual models show buildable unit after applying all indirect elements of zoning regulations and potential to implement sustainable features.

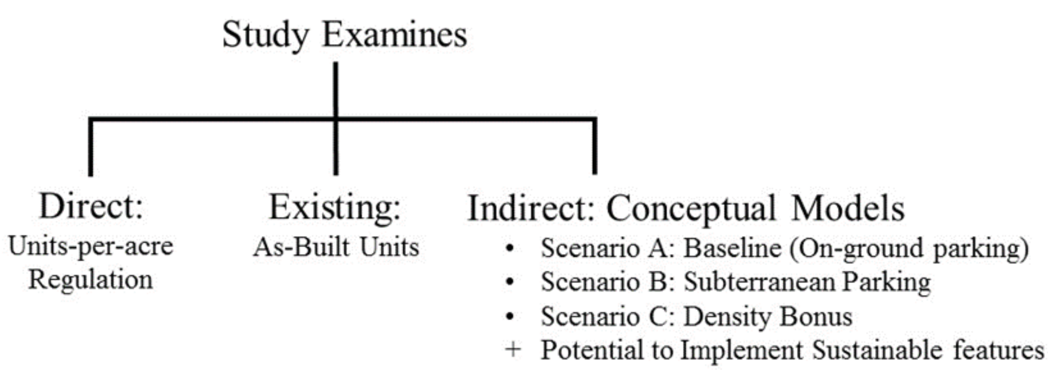



***Figure 2 - Methodology Summary***

This methodology section contains area of study, data collection and analysis, site selection, and conceptual modelling rules and structures.

**Area of Study**

Orange County is located in the Southeast area of Los Angeles County. The population was approximately three million in 2015 (U.S. Census). Figure 3 shows map of Orange County, and the dark blue line on the figure shows approximate Metrolink Orange County Rail location.


*Figure 3 - Map of Orange County*

Source: OC Almanac. Metrolink rail added.

Metrolink Orange County Rail aligns from Northwest to Southeast of the county. Metrolink provides commuter rail public transportation to Orange County, with ten stations located within the county boundary.

First, the research reviewed ten cities' population density and housing characteristic. Those ten cities have Metrolink stations. They are aligned from Northwest to Southeast of the county, which represent sequential interval of travelling distance from Los Angeles County. Buena Park is the nearest, and San Clemente is the farthest. Table 1 presents the cities' population, total land area, and population density – calculated by dividing population by total land area. It also provides the average of the ten cities' information for comparison purpose. The four shaded cities in Table 1 (Buena Park, Santa Ana, Irvine, and Laguna Niguel) were the selected cities for this study.

***Table 1 - Population Density Comparison Chart***

Source: U.S. Census (2015)

| Cities | Population (2015) | Total land area (sq. mile) | Population Density (per sq. mile) |
|---|---|---|---|
| Buena Park | 83,270 | 10.55 | 7,890.65 |
| Fullerton | 140,847 | 22.36 | 6,299.06 |
| Anaheim | 350,742 | 50.81 | 6,902.88 |
| Orange | 140,992 | 25.24 | 5,586.05 |
| Santa Ana | 355,400 | 27.52 | 12,915.18 |
| Tustin | 80,583 | 11.08 | 7,271.52 |
| Irvine | 256,927 | 66.45 | 3,866.24 |
| Laguna Niguel | 65,806 | 14.89 | 4,420.96 |
| San Juan Capistrano | 36,454 | 14.30 | 2,550.12 |
| San Clemente | 65,526 | 19.47 | 3,365.83 |
| Average | 157,654.70 | 26.27 | 6,106.85 |

Buena Park has the lowest total land area, while the population density is higher than average. Santa Ana has the highest population and population density. Irvine has the highest total land area, but the population density is below average. Laguna Niguel's population, total land area, and population density are all below average comparing to the ten cities.

Table 2 presents the cities' Housing Characteristic (2017 U.S. Census) and land-use (Cities' General Plan). It presents the percentages of existing single-family residential, 20 or more residential unit structure (20+), land-use for single-family residential, and land-use for multiple-family residential.

***Table 2 - Percentages of existing residential unit structure and land use***

Source: U.S. Census 2014 Housing Characteristic and Cities' General Plan

| Cities | 1 unit (attached and detached) (2014) | 20+ units (2014) | Existing Land Use for Single-Residential [1] | Existing Land Use for Multiple-Family [1] |
|---|---|---|---|---|
| Buena Park | 66.1% | 14.6% | 34% | 7% |
| Fullerton | 62.0% | 16.3% | 33% | 7% |
| Anaheim | 52.4% | 18.7% | No data available | |
| Orange | 67.8% | 10.6% | Total of 46% | |
| Santa Ana | 51.7% | 17.4% | 41.7% | 17% |
| Tustin | 48.3% | 15.6% | No data available | |
| Irvine | 53.9% | 22.2% | 9% [2] | 24% [2] |
| Laguna Niguel | 75.9% | 4.2% | 28.5% | 8.8% |
| San Juan Capistrano | 73.2% | 4.3% | No data available | |
| San Clemente | 69.0% | 4.8% | No data available | |
| Average | 62% | 13% | | |

[1] These data were collected from the cities' general plan which was acquired from different year.

[2] Refer to description on Irvine section.

After exploring the ten cities information, the City of Buena Park, Santa Ana, Irvine, and Laguna Niguel were selected for the study. These four cities exemplify different ranges of existing 20+ units. The cities were selected from its highest, average, and lowest existing 20+ units. The City of Santa Ana was selected because it contains the highest population and population density while the 20+ units percentage is above average comparing to the ten cities.

Moreover, these four cities align from Northwest to Southeast of the Orange County. The four cities represent sequential interval of different travelling distance from Los Angeles, the metropolitan area. These cities have different topography characters. While Buena Park, Santa Ana, and Irvine were planned in grid alignment, Laguna Niguel city master plan appears to have organic character with curved roads and streets. Buena Park and Santa Ana are older cities while Irvine and Laguna Niguel are newer. The following paragraphs are background information about the four cities.

**City of Buena Park.** According to the City of Buena Park General Plan, the existing land use percentage contains a total of seventeen categories; single-family residential acquires 34% and multiple-family residential acquires 7% of the land use. However, the City of Buena Park General Plan did not further categorize the number of dwelling units for residential attached portion; therefore, 7% of the multiple-family residential can either contain two-unit structure or more. This ambiguity also applied to Santa Ana and Laguna Niguel. The City of Buena Park locates nearest to the County and City of Los Angeles; it contains average percentage of existing 20+ units structure comparing to the ten cities. In 1887, the Town of Buena Park was a part to the City of Los Angeles County. In 1953, the City of Buena Park was incorporated in Orange County.

**City of Santa Ana.** According to the City of Santa Ana General Plan, the existing land use are distributed into six categories; single-family residential acquires 41.7% and multiple-family residential acquires 17% of the land use. Santa Ana has the highest percentage of land use acquired by single-family residential; however, it also has the highest population and population density compared to the ten cities. Therefore, it is reasonable that residential areas would covered most of the land use. Similar to Buena Park, Santa Ana was incorporated as a city in Los Angeles County in 1886 before changing to Orange County jurisdiction in 1889.

**City of Irvine.** According to the City of Irvine General Plan – Chapter 2 Land use, the general plan did not provide information on percentage of existing land use. However, researcher utilized Table A-2 Non-Regulatory Maximum Intensity Standards: Land Use Acreage by Planning Area to calculate the approximate percentage of the existing land use. According to researcher's calculation, estate dwelling (0-1 du/acre) acquires approximately 2.2%; low-density dwelling (0-6.5 du/acre) acquires approximately 6.8%; medium density (0-12.5 du/acre) acquires approximately 18%; and medium to high density dwelling (0-31 du/acre) acquires approximately 6%; and high density dwelling (0-50 du/acre) acquires approximately 0.4% of the total land use. Table 1 presents 9% on existing land use for single-family residential because estate and low-density dwelling percentages were added. Also, medium, medium to high, and high density dwelling were added, sum of 24%, for the existing land use for multiple-family residential. Though, the U.S. Census (2014) reported 53.9% (35.8% detached and 18.1% attached) in single-family residential unit, and 22% on 20+ units structure. Irvine is a master plan city. It was incorporated in 1971 as a city in Orange County.

**City of Laguna Niguel.** According to City of Laguna Niguel General Plan – Chapter 2 Land Use (2008), the distribution of land use is divided into seven types; open space is the largest portion, 39%, among other types of land use. The residential detached acquires 28.5% while residential attached acquires 8.8% of the land uses. Laguna Niguel contains the lowest percentage of existing 20+ units structure compared to other nine cities. Laguna Niguel is the first master plan city in California. It was incorporated in 1989 as a city in Orange County.

**Data Collection and Analysis**

The qualitative data (zoning codes) were collected from online municipal codes.[1] The following data were collected: floor area ratio, maximum dwelling units per acre, maximum building height, setback and offset requirement, open space or landscape ratio, private open space, minimum floor areas for one to three-bedrooms units, parking requirements for residents and guests, driveway, ramp, aisle width, roof requirement, codes related to photovoltaic (PV) panels and rainwater planters installation, and other regulations that applied in some cities. Some codes were clarified per city planners' interpretation. The data or codes were arranged in tables for constructing preliminary comparison, preparing for reviewing the four sites, and creating models.

Table 3 (next page) presents the codes related to building placement and minimum floor area requirement. All zoning codes tables present four cities' codes for comparison purposes.

[1] Buena Park Municipal Code: Title 19 Zoning, Division 4 - Chapter 19.404 - 19.448 (Ord. 1338 §14, 1996); Santa Ana Municipal Code: Chapter 41 - Zoning, Division 5 - R3, sec 41-258 -40-272 (Ord. No. NS-2111, § 29 to 49, 4-1-91); Zoning Ordinance of the City of Irvine: Division 3 - General Development Standards and Land Use Regulations, Chapter 3-37 - Zoning District Land Use Regulations and Development Standards, Sec 3-37-15 (Code 1976, § V.E-325.2.3); Laguna Niguel Municipal Code: Title 9 - Planning and Zoning, Sec. 9-1-31 to 9-1-38 (Ord. No. 99-107, §5, 2-2-99)

***Table 3 - Zoning Codes 1***

Sources: Online Municipal Codes

| Zoning Codes | Buena Park | Santa Ana | Irvine | Laguna Niguel |
|---|---|---|---|---|
| **Building Placement** | | | | |
| Zone | RM-20 | R3 - Class 3 | 2.4 Medium-High | RM |
| Building Height | 35' | 60' | 40' | 35' |
| Front Yard Setback | 17.5' | 35' | 40' | Min. 10' (Average total of 25') |
| Side Yard Setback | 10' | 25' | 10' | Min. 10' (Average total of 25') |
| Rear Yard Setback | 10' | 30' | 10' | Min. 10' (Average total of 25') |
| Building or Lot Coverage | 40% (building only) | 60% (include driveway and uncovered parking) | 70% (include driveway and uncovered parking) | Not Specify (Assume 75%) |
| Open Space or Landscape Requirement | 40% | Min. 40% or 250 Sq.Ft. per units | 30% | 25% |
| **Minimum Floor Area (Sq.Ft.)** | | | | |
| Studio | 500 | 450 | None | None |
| 1 Bedroom Unit | 800 | 550 | | |
| 2 Bedrooms Unit | 950 | 750 | | |
| 3 Bedrooms Unit | 1050 | 950 | | |
| Private open space | Included in open space | Add 90 Sq.Ft. per units for balcony area | Not Found | Not Found |
| Storage Space | Not Found | Min. 250 Cubic Feet/ Min. 4' X 8'/ not accessible from dwelling units | Not Found | Not Found |

Each city classified the residential-multiple dwelling (RM) zone differently. RM-20 means residential-multiple family zone with 20 units-per-acre limitation. R3 means multiple-family residence by which researcher selected class 3 development for this study. For Irvine, 2.4 identified Medium-High dwelling zone.

Building height restrictions are similar among Buena Park, Irvine, and Laguna Niguel; Santa Ana allows much more than others. However, Santa Ana requires more setback and yard area due to its higher building height restriction. Building or lot coverage is relating to landscape or open space requirement. Apparently, any covered structures consider as buildings. Santa Ana and Irvine include driveway and uncovered parking in their lot coverage; this means if the driveway and uncovered parking covered only 15 percent of total site area, the buildings' footprint can acquire up to 45 percent in Santa Ana and 55 percent in Irvine. The buildings' footprint can acquire the lot coverage in any percentage within the lot coverage restriction as long as the requirement for landscape were met. On the other hand, Buena Park specifies 40 percent of building coverage, excluding driveway and uncovered parking. Buena Park requires 40 percent of landscape area which allows for 20 percent of driveway and uncovered parking. If the driveway and uncovered parking acquire only 15 percent of site area, the rest of the 5 percent must be added to landscape area instead of the buildings' footprint.

Minimum floor area regulates minimum floor area per dwelling units. Irvine and Laguna Niguel do not specify the minimum floor area. Santa Ana also requires adding 90 square feet of balcony area to each dwelling units. Moreover, Santa Ana requires a storage space for each dwelling units; those storages cannot be accessible from the dwelling units.

Table 4 (next page) presents zoning codes that relate to parking and vehicular provisions. Parking is essential to the development because extensive amount of required parking stalls potentially reduces the area for constructing dwelling units.

*Table 4 - Zoning Codes 2*

Sources: Online Municipal Codes

| Zoning Codes | Buena Park | Santa Ana | Irvine | Laguna Niguel |
|---|---|---|---|---|
| **Parking Requirement** [1] | | | | |
| Studio | 2 (1 Covered) | 1 (1 Covered) | 1 (1 Covered) | 1.5 (1 Covered) |
| 1 Bedroom Unit | 2 (1 Covered) | 1 (1 Covered) | 1.4 (1 Covered) | 1.5 (1 Covered) |
| 2 Bedrooms Unit | 2.5 (1 Covered) | 2 (1 Covered) | 1.6 (1 Covered) | 2 (1 Covered) |
| 3 Bedrooms Unit | 3 (1 Covered) | 3 (1 Covered) | 2 (1 Covered) | 2.5 (2 Covered) |
| Visitor Parking | No additional | Add 25% from total of required parking | Add 1 stall per 4 dwelling unit | Add 0.5 stall per dwelling unit |
| **Parking Stalls Dimension and Driveway Width** | | | | |
| Stardard parking stalls dimension | 10' X 20' | 8'-6" X 16' | 9' X 19' uncovered / 9' X 20' covered | 9' X 18' |
| Tandem parking stalls dimension | Not found | Not found | 10' X 20' | Not found |
| Compact parking stalls dimension | 8' X 16' (limiting to 30% of total parking) | Not Found | Not applicable in residential | Not found |
| Driveway | 20'-25' | Not found (Assume 23') | Min 24' | Min 24' |
| Entrance Driveway | 25' | Not found (Assume 23') | Min 28' | 28' |
| Aisle width two-ways (90 degree) | 25' | 23' | 24' | 25' |
| **Parking Placement** | | | | |
| Uncovered parking on setback or side yard area | Permitted on side and rear yard | Not permitted | Permitted after offset 10' front yard and 5' side and rear yard | Not permitted |
| Carports/ Garage on setback or side yard area | Permitted on side and rear yard | Permitted on side and rear yard with condition [2] | Not permitted | Not permitted |

[1] Only the City of Irvine contain two types of parking requirement: ownership or rental. This table present rental multifamily building's parking requirement.

[2] The carports or garages are permitted to encroach side and rear yard only if the distance from the nearest building to the carports or garages is more or equal to setback requirement.

Standard parking stall dimensions are different among the four cities. Santa Ana requires the smallest standard parking stall dimension of 8 feet and 6 inches by 16 feet, and Buena Park requires the largest parking stall dimension of 10 feet by 20 feet. On the other hand, Buena Park allows compact parking stalls up to 30% of the total parking, which appears to be helpful. However, the stall dimension for Buena Park's compact parking is 8 feet by 16 feet which is 6 inches in width smaller than standard Santa Ana's parking stalls. Apparently, compact parking stalls will reduce total parking area for Buena Park. However, it may not be the most efficient way to utilize parking spaces because its compact parking stall dimension is nearly as large as other city's standard parking stall dimension. Only Irvine allows tandem parking stalls. Entrance driveway refers to vehicular access to the property and roadway for vehicular travel without parking stalls adjacent on both sides while parking aisle refers to the space within parking areas by which vehicles access and depart parking stalls. Table 4 (previous page) presents aisle width two-ways (90 degree) which mean two-way vehicular traffic while having 90-degree parking stall angle on both sides.

Only Buena Park and Irvine allow uncovered parking on the side and rear yard. Buena Park allows carport or garage on the side and rear yard area. Santa Ana also allows carports and garage if the distance from the nearest building to the carports or garages is more or equal to the setback requirement.

Most of the parking requirements require at least one covered parking stall per each dwelling units. By comparison, Buena Park requires two parking stalls for studio and one-bedroom unit, while other cities most likely require 1–1.5 stalls. However, Buena Park does not require addition parking stalls for visitor parking, which falsely appears to be helpful.  Table 5 (next page) presents the comparison of parking requirement for 20 dwelling units: 5 units per unit type.

*Table 5 - Parking Requirement Comparison for 20 units*

**Buena Park - Parking Requirement for 20 units**

| | | Parking requirement per unit | | Parking Requirement in Total | | | |
|---|---|---|---|---|---|---|---|
| Unit Type | Number of units | Covered | Un-covered | Covered | Un-Covered | Visitor | Total |
| Studio | 5 | 1 | 1 | 5 | 5 | No Addition | |
| 1 Bedroom | 5 | 1 | 1 | 5 | 5 | | |
| 2 Bedrooms | 5 | 1 | 1.5 | 5 | 7.5 | | |
| 3 Bedrooms | 5 | 1 | 2 | 5 | 10 | | |
| Total | 20 | | | 20 | 27.5 | 0 | 47.5 |

**Santa Ana - Parking Requirement for 20 units**

| | | Parking requirement per unit | | Parking Requirement in Total | | | |
|---|---|---|---|---|---|---|---|
| Unit Type | Number of units | Covered | Un-covered | Covered | Un-Covered | Visitor | Total |
| Studio | 5 | 1 | 0 | 5 | 0 | Add 25% to the required stalls | |
| 1 Bedroom | 5 | 1 | 0 | 5 | 0 | | |
| 2 Bedrooms | 5 | 1 | 1 | 5 | 5 | | |
| 3 Bedrooms | 5 | 1 | 2 | 5 | 10 | | |
| Total | 20 | | | 20 | 15 | 8.75 | 43.75 |

**Irvine - Parking Requirement for 20 units**

| | | Parking requirement per unit | | Parking Requirement in Total | | | |
|---|---|---|---|---|---|---|---|
| Unit Type | Number of units | Covered | Un-covered | Covered | Un-Covered | Visitor | Total |
| Studio | 5 | 1 | 0 | 5 | 0 | Add 1 stall per 4 dwelling units | |
| 1 Bedroom | 5 | 1 | 0.4 | 5 | 2 | | |
| 2 Bedrooms | 5 | 1 | 0.6 | 5 | 3 | | |
| 3 Bedrooms | 5 | 1 | 1 | 5 | 5 | | |
| Total | 20 | | | 20 | 10 | 5 | 35 |

**Laguna Niguel - Parking Requirement for 20 units**

| | | Parking requirement per unit | | Parking Requirement in Total | | | |
|---|---|---|---|---|---|---|---|
| Unit Type | Number of units | Covered | Un-covered | Covered | Un-Covered | Visitor | Total |
| Studio | 5 | 1 | 0.5 | 5 | 2.5 | Add 0.5 stall per dwelling unit | |
| 1 Bedroom | 5 | 1 | 0.5 | 5 | 2.5 | | |
| 2 Bedrooms | 5 | 1 | 1 | 5 | 5 | | |
| 3 Bedrooms | 5 | 2 | 0.5 | 10 | 2.5 | | |
| Total | 20 | | | 25 | 12.5 | 10 | 47.5 |

In total Buena Park and Laguna Niguel required the same amount of 47.5 parking stalls, while Irvine required only 35 parking stalls: 12.5 fewer parking stalls. Santa Ana required 43.75 parking stalls, which is in between those three cities. The fact that Buena Park does not require addition parking stalls for visitor parking is not helpful to the overall parking requirement when compared to other cities.

Table 6 presents zoning codes that relate to sustainable features and density bonus law incentives.

***Table 6 - Zoning Codes 3***

Sources: Online Municipal Codes

| Zoning Codes | Buena Park | Santa Ana | Irvine | Laguna Niguel |
|---|---|---|---|---|
| **Sustainable Features** | | | | |
| Planters on setback area | 18" height planters within 6' projection | 18" height planters | Permitted - no height specify | Permitted - no height specify |
| Solar Panels | Not permitted on ground level facing front street, Permitted within set back area and on roof area within building height restriction | | | |
| Flat Roof | Preferred flat roof with Pitch Roof Screen [1] | Encouraged fully built roof [1] | Permitted [1] | Preferred flat roof with Pitch Roof Screen [1] |
| **Density Bonus Law Incentive** | | | | |
| Open Space | Reduction from 40% to 38% | None | None | None |
| Set Back | 10% reduction of side and rear yard | None | None | None |

[1] Per city planners' interpretation

All cities allow rainwater planters on the setback area. Photovoltaic (PV) Panels are permitted on the roof area within building height restriction. PV Panels are not permitted facing front street due to avoiding glare from the panels to the driving vehicles. Only Buena Park specified the density bonus law incentives that will be given to the developers when they are proposing affordable units.

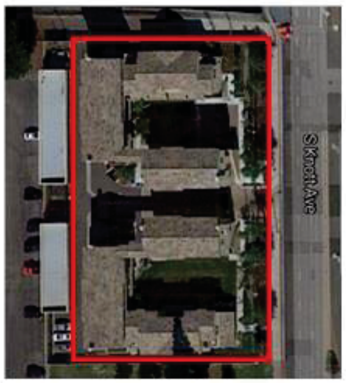
By only code comparison, one may not be able to identify which factors presents as difficulties and supports for building multiple-family dwellings. This study utilized a conceptual modeling approach to test the coordination of zoning codes in the form of collected data above.

### Sites Selection

The four sites were selected from each city for data collection and as bases for conceptual models. The initial site selection criteria are: (1) the apartments recently constructed with current zoning codes, (2) the rental market-rate apartments without affordable housing units are preferred, (3) the four sites must be similar in size among the four cities, (4) the data must be adequate, (5) the site is accessible for data collection.

The four sites were selected primarily based on the data availability. The following data were collected from this sites: existing dwelling units or as-built units, year of construction, compliance with code, applied variances or density bonuses, number of parking stalls, landscape percentage, building coverage, and on-site sustainable features. This data was acquired from the online sources, staff reports from city planners, approximate measurement from Google Earth and 2008 OC Land Use GIS measurement, and walking or driving through the sites. The researcher received staff reports on three apartments in Buena Park, Irvine, and Laguna Niguel from the cities' planner. Therefore, most of the information on those three sites were from staff reports and a few measurements from Google Earth. Table 7 and 8 (next page) presents the selected sites and sites' information.

*Table 7 - Sites Information 1*

| | Buena Park [1] | Santa Ana [2] | Irvine [1] | Laguna Niguel [1] |
|---|---|---|---|---|
| |  |  |  |  |
| Apartments Name [4] | Parkview Apartments | Sandalwood-Coco Palms Apartments | Alegre Apartments | The Vista at Laguna Luxury Apartments |
| Address | 6785 Knott Avenue, Buena Park, CA 92620 | 2101 N Ponderosa St., Santa Ana, CA 92705 | 3100 Visions, Irvine, CA 92620 | 30122 Niguel Road, Laguna Niguel, CA 92677 |
| Year Built | 2014 | 1962 | 2015 | 1984 |
| Zones | RM-20<br>Multifamily Residential Zone<br>Density - 20 du/acre | R3<br>Multifamily Residential Zone<br>Density - 35 du/acre (class 3) | 2.4<br>Medium to High Multifamily<br>Density - 31 du/acre | RM/Community Profile Area 10<br>Sub C-Chatelain<br>Multifamily District<br>Density established on a site-by-site basis |
| APN | 276-142-02 | 396-292-03 [3] | 104-413-02 | 653-012-32 |
| Site Area (acres) | 1.07 | 4.85 [3] | 3.36 | 10 |

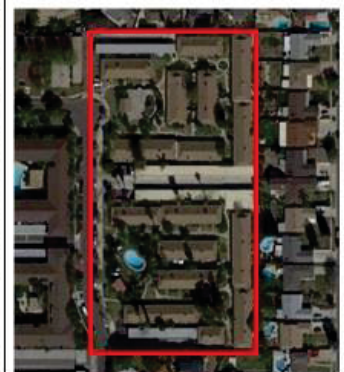
[1] Information collected from staff reports and request for planning commission action document, unless specified.

[2] Information collected from websites: www.apartments.com, www.thevistaatlaguna.com

[3] Information collected from satellite image measurement, and 2008 OC Land Use GIS measurement.

[4] All properties are rental apartments.

*Table 8 - Site Information 2*

| | Buena Park [1] | Santa Ana [2] | Irvine [1] | Laguna Niguel [1] |
|---|---|---|---|---|
| |  |  |  |  |
| Number of stories | 3 | 1 | 3 | 3 |
| Existing Units | 22 units | 60 units | 104 units | 176 units |
| Existing Units Area (Sq.Ft.) | 2 BD type 1 = 958, 964<br>2 BD type 2 = 974, 985 | 1 BD = 700<br>2 BD = 1,000 - 1,100<br>3 BD = 1,225 | 1 BD = 647, 665, 889<br>2 BD = 840, 945<br>3 BD = 1,126<br>4 BD | 2 BD type 1 & 2 = 990 [2]<br>2 BD type 3 = 1009 |
| Units-per-acre | 20 | 12 | 31 | 17 |
| Number of parking stalls | 55 | 75 | 180 | 352 |
| Parking stalls per unit | 2.5 | 1.25 | 1.7 | 2 |
| Building coverage | 36% | 47% [3] | 40% [3] | 27% [3] |
| Landscape Area | 40% | 43% [3] | 24% | 59% [3] |

[1] Information collected from staff reports and request for planning commission action document, unless specified.

[2] Information collected from websites: www.apartments.com, www.thevistaatlaguna.com

[3] Information collected from satellite image measurement and 2008 OC Land Use GIS measurement.

The size of the four selected sites are different due to geography of the cities. Only Buena Park's site (Parkview Apartments) meets all initial site selection criteria. The apartment parcel is 1.07 acre which exceed 1 acre; therefore, the developer could obtain 2 more units from site area bonus[2]. Santa Ana's site (Sandalwood-Coco Palms Apartments) was built in 1962 which is old. Irvine's site (Alegre Apartments) contains affordable units. Laguna Niguel's site was built in 1982. There were no Photovoltaic (PV) Panels and rainwater planters on these sites. Nonetheless, these sites were deemed to be close enough in characteristics to proceed with the study. (Refer to Appendix A – Sites descriptions and photos)

**Conceptual Modeling**

After above data were acquired, three scenarios conceptual models (floor plans and site plans) were drafted by researcher utilizing Auto Cad and excel programs. Three conceptual models scenarios are (1) Scenario A - baseline scenario with all parking areas located on ground level, (2) Scenario B - subterranean parking scenario with most parking area located on underground level, and (3) Scenario C - density bonus scenario that implemented three density bonus incentives.

The conceptual models were intended to determine the maximum buildable units. These models applied indirect elements of zoning codes and minimal building: only those related to health and safety. Moreover, these models did not include others aesthetic architectural design guidelines, livability consideration that not covered by building codes, and other elements. When the cities' zoning codes do not contain certain regulations, the models applied widely accepted zoning codes to the models.

[2] Title 19, Division 4, Chapter 19.408, 19.408.200 Site Area Bonus – Multifamily Zones.

All three scenarios models were developed based on the following rules:

1. Initially, in case of roof requirement is not regulated by the zoning code, the models intended to utilize flat roof to maximize the building height. However, only Irvine allow flat roof per planner interpretation. The other three cities preferred fully roof or pitched roof screen around the edge of the roof. Therefore, all models utilize the combination of pitched roof screen and flat roof at the center of the buildings.
2. The models were applied one feet finish grade from existing grade; the maximum building height was minus by one feet.
3. The height between floor to floor is 10 feet. The height between floor to ceiling is 8'-6"; the minimum height for floor to ceiling is 7'-6" per building code. The researcher decided to alter this rules for Buena Park models in order to meet building height restriction. The height between floor to floor for Buena Park is 9 feet which is permitted because the minimum height from floor to ceiling was kept at 7'-6".
4. The distance from corner rooms to fire stairs is 50 feet. The distance between fires stairs are 250 feet. With these rules, the models were hypothetically able to accommodate the occupancy load factor of 200 per R-2 apartment occupancy.
5. All models were assumed to be constructed in type 5, minimum of 8 inches wooden frame. The models set the exterior wall at 16 inches and interior wall at 10 inches.
6. Minimum floor area per unit were obtained from cities' zoning code. City of Irvine and Laguna Niguel do not specify minimum floor area. Therefore, the

models for those cities utilized Buena Park minimum floor area per researcher's judgment. Buena Park minimum floor area is higher than Santa Ana and it is similar to Irvine and Laguna Niguel existing as-built units' floor area.

7. At first, each models' scenario aimed to include all four types of unit: studio, one-bedroom, two-bedrooms, and three-bedrooms, at the same amount of 25% for each type. While researcher was working on models, those unit type percentages altered due to codes and other constraints. Some models were still able to achieve nearly 25% of each unit type. (Refer to Appendix D - Conceptual models figures and details)
8. The dwelling units' dimensions were determined from preliminary interior plan. Per building code, all bedrooms and the living room require one or more windows for natural ventilation and minimum of 8% natural light. The minimum area for first bedroom is 120 square feet and second bedroom is 70 square feet. Bedrooms must contain at least one wall of 7-foot width. Therefore, some dwelling units may exceed the zoning codes required minimum floor area due to this livability requirement.
9. Minimum of five percent of total building area was reserved for MEP, maintenance, and trash enclosure.
10. Minimum of thirty percent of total building area was reserved for circulation. The corridors are 4'-0" to 6'-0" width. Fire stairs are at least four feet width; fire stair are approximately 180 square feet Two elevators were provided at every 250 feet distance of the main corridor.

11. Scenario A was based on ground level parking. Those excluded percentage for parking landscape; the models did not locate landscape planters at parking areas.
12. Scenario B was based on subterranean parking which 10 feet height floor-to-floor was reserved for ramp length and slope. Subterranean parking plan included minimum structural wall location. Only Buena Park's, Santa Ana's and Irvine's sites were applicable for subterranean parking. Laguna Niguel's site located on slope grading which made it unpractical to construct subterranean parking.
13. Parking stalls dimension, aisle width, and ramp slope were obtained from the respective zoning code. Parking requirement for American Disability Act (ADA) and electric vehicle stalls were included in the total amount of parking stalls. However, the models did not assign the ADA and EV stalls location and paint stripes.
14. At least one vehicle entrance and exit were assigned. Width and vehicle access requirements were obtained from the respective zoning code.

According to Barnett (2011), building codes are primarily concerned with the safety and habitability of individual structures (e.g. fire resistant wall, exterior windows, safe material for indoor air quality); building codes may overlap with zoning codes in such areas as light and air requirements and minimum room sizes, but most of the issues that relate to urban design and planning are determined by zoning and subdivision. Therefore, certain building codes that minimally affect the result of buildable units will be omitted. The conceptual models were excluded fire resistant wall, American Disability Act Code, architectural design guideline, windows location, specific mechanical unit series, size, and location. The conceptual site plans were drawn with the compliance of parking requirement, driveway, and access; these site plans were not included parking area landscape percentage, water drainage, detention basin, and site grading.

For Scenario C, four conceptual models were created based on implementing three density bonus incentives on the four selected sites. Under California's Density Bonus Law, California Government Code Sections 65915 – 65918, the residential project developers can increase project density up to 35% and receive incentives in exchange for providing affordable housing units. Modification of development standard incentives (e.g. reduction of setback, landscape or open space, floor area, minimum lot size) may be requested by the developers for jurisdiction approval (Refer to Appendix B - Density Bonus Law). This scenario attempts to test the coordination between zoning codes and the modification of development standards from density bonus incentives. These scenario models determine if the buildable units can be achieved up to 35% maximum added density per density bonus law.

Scenario C conceptual models were added these following rules to the Scenario A models (Baseline) per modification of development standard by density bonus incentives:

1. All models were applied by-right parking incentives which reduce parking requirement. Instead of following the cities' zoning code parking requirement, the models provided 1 parking spaces per unit for studio and one-bedroom units, 2 parking spaces per unit for 2-3 bedroom units, 2.5 parking spaces per unit for 4 and more bedroom units, and no allowance for visitor parking requirement.
2. Second and third design incentives were intended to obtain from the cities' guideline for zoning code modification through density bonus incentives. However, only the City of Buena Park specified the incentives code which are

reduction of landscape area from 40 percent to 38 percent, and 10 percent reduction of side and rear yard for non-building floor area items (e.g. stairways, balconies, and related building supports).

3. No guideline for zoning code modification was mentioned in the zoning codes from the City of Santa Ana, Irvine, and Laguna Niguel. Therefore, those three cities models applied 20 percent deviation from side and rear yard requirements and 20 percent deviation from landscape requirements.

All three scenarios conceptual models also measured the potential to implement two sustainable features: photovoltaic panels, and rainwater planter. Photovoltaic (PV) panel or solar panel absorbs the sun radiation as a source of renewable energy to generate electricity and heating. Rainwater planters are a vegetated planter that receives runoff roof drains or adjacent paved areas. (Refer to Appendix C – Sustainable Building Design and Construction).

1. All four cities' zoning codes did not contain codes that relate to installation of Photovoltaic (PV) panels and rainwater planter. The model utilized Los Angeles Fire Department's minimum requirement for Solar Photovoltaic System Installations for model guideline. A minimum of four to six-foot-wide clear perimeter around the edge of the roofs were reserved for access and pathway; therefore, the potential area for PV panels measures after these four to six-foot-wide offset from the edges, ridges, and hips of roofs. Also, the un-covered parking areas that applicable for PV panels canopy or Solar Carport were counted as potential areas for PV panels. When the un-covered parking areas locates on

the areas where it is difficult for sunlight to access (e.g. between tall buildings), those areas were not counted as potential areas for PV panels.

2. All four cities' zoning codes did not contain codes that relate to installation of rainwater planter. The codes only specify a height limitation of 18 inches if the planters locate on the setback area. The models assigned the potential areas for six to eight feet wide and 18 inches high rainwater planters to locate adjacent to the buildings. The length of the planters was determined by the area that adjacent to the buildings.

**Limitations**

Due to a conceptual modeling approach, the research result may not be as accurate as study from professionals (e.g. architect, developer, engineer). The conceptual models were intended to determine the maximum units per cities' zoning codes on which it may disregard the livability consideration that not covered by building codes. Developers may build different projects based on market considerations unknown to the researcher.

This research is not capable of generalization. The four cities do not represent every city in Orange County. The findings are only applicable to the study areas.

# CHAPTER 4: FINDINGS

This study examines the hypothesis that indirect elements of zoning regulations hinder the achievement of permitted density (as expressed in units-per-acre). The research compares allowable units, as-built units, buildable units reflecting zoning codes, and buildable units implementing density bonus incentives. The allowable units refer to the maximum number of units permitted by units-per-acre regulation. The as-built units are the number of existing apartment units. The buildable units are the maximum number of units expressed from the following scenarios: (1) Scenario A – baseline scenario in which all parking areas located on ground level, (2) Scenario B – subterranean parking scenario that most parking areas located on underground level, and (3) Scenario C – density bonus scenario that implemented three density bonus incentives. Moreover, all conceptual models examine the potential to implement two sustainable features: photovoltaic panels and rainwater planter.

The modeling process verified whether the indirect elements of zoning codes hinder the achievement of the units-per-acre regulations. It also determines (1) the effects of development standards modifications by density bonus incentives, (2) the potentials to implement sustainable features, and (3) the factors that presents as the difficulties and supports to achieve maximum buildable units.

## Dwelling Units Result

Table 9 (next page) presents summary of the modeling process. The table includes results showing units-per-acre regulations, as-built existing units, and the three scenario models' results. Laguna Niguel does not specify allowable units-per-acre; it is determined to site-by-site basis.

*Table 9 – Summary of the Modeling Process*

| | | Buena Park | Santa Ana | Irvine | Laguna Niguel |
|---|---|---|---|---|---|
| Direct Regulation | Allowable units-per-acre (permitted density) | **20** | **35** | **31** | **Site-by-site basis** |
| Existing | As-Built Units | 22 | 60 | 104 | 176 |
| | Site Acre | 1.07 | 4.85 | 3.36 | 10 |
| | Units-per-acre | **21** | **12** | **31** | **18** |
| Scenario A - Baseline | Buildable units reflecting all zoning provisions (ground level parking) | 23 | 201 | 130 | 250 |
| | Units-per-acre | **21** | **41** | **39** | **25** |
| Scenario B - Subterranean parking | Buildable units reflecting all zoning provisions (subterranean parking) | 43 | 337 | 171 | Not applicable due to slope terrain |
| | Units-per-acre | **40** | **69** | **51** | **N/A** |
| Scenario C - Density Bonus | Buildable units reflecting all zoning provisions and density bonus incentives[1] | 2<br>27 | 237 | 150 | 281 |
| | Units-per-acre | **25** | **49** | **45** | **28** |

All scenario models resulted in a greater number of buildable units than allowable and as-built units. Also, all models resulted in greater number of units-per-acre than allowable and as-built units, except Buena Park's Scenario A models which resulted in the same amount for both. Buena Park's site area is 1.07 acre which exceed 1 acre; therefore, the developer could obtain 2 more units from site area bonus[3]. For that reason, the existing units-per-acre increased up to 21, which is 1 units-per-acre higher than permitted density. (Refer to Appendix D - model figures and details for more models' information and details)

[3] Title 19, Division 4, Chapter 19.408, 19.408.200 Site Area Bonus – Multifamily Zones.

Table 10 presents the comparison between Scenario A and restricted units-per-acre. Table 11 presents the comparison between Scenario A and existing apartment density.

***Table 10 - Comparison of Scenario A and Units-per-acre Regulation***

| | | Buena Park | Santa Ana | Irvine | Laguna Niguel |
|---|---|---|---|---|---|
| Direct Regulation | Allowable units-per-acre (permitted density) | **20** | **35** | **31** | **Site-by-site basis** |
| Scenario A - Baseline | Buildable units reflecting all zoning provisions (ground level parking) | 23 | 201 | 130 | 250 |
| | Units-per-acre | **21** | **41** | **39** | **25** |
| | Units-per-acre added from units-per-acre regulation | 1 | 6 | 8 | N/A |
| | Percentage of units-per-acre added from units-per-acre regulation | 7% | 18% | 25% | N/A |

***Table 11- Comparison of Scenario A and Existing Apartment Density***

| | | Buena Park | Santa Ana | Irvine | Laguna Niguel |
|---|---|---|---|---|---|
| Existing | As-Built Units | **22** | **60** | **104** | **176** |
| | Site Acre | 1.07 | 4.85 | 3.36 | 10 |
| | As-Built units-per-acre | 21 | 12 | 31 | 18 |
| Scenario A - Baseline | Buildable units reflecting all zoning provisions (ground level parking) | **23** | **201** | **130** | **250** |
| | Units added from as-built units | 1 | 141 | 26 | 74 |
| | Percentage of units added from as-built units | 5% | 235% | 25% | 42% |
| | Units-per-acre | 21 | 41 | 39 | 25 |
| | Units-per-acre added from as-built units-per-acre | 0 | 29 | 8 | 7 |

All Scenario A models resulted in more buildable units than allowable and existing units. Buena Park's Scenario A models resulted in 3 buildable units higher than allowable units and 1 buildable unit higher than existing units. Santa Ana's Scenario A model resulted in 141 units more than as-built units. Santa Ana's units-per-acre increased up to 41, which is 6 units-per-acre more than restricted and 8 units-per-acre more than existing. Irvine's Scenario A model resulted in 26 units more than as-built units. Irvine's units-per-acre increased up to 39, which is 8 units-per-acre higher than restricted and existing. Laguna Niguel's Scenario A model resulted in 74 units higher than as-built units. Laguna Niguel's units-per-acre increased up to 25, which is 7 units-per-acre higher than existing. These models' results show that the indirect elements of zoning regulations do not hinder the achievement of permitted density in the four cities.

Table 12 presents the comparison between Scenario B and restricted units-per-acre. Table 13 (next page) presents the comparison between Scenario B and existing apartment density.

***Table 12 - Comparison of Scenario B and Units-per-acre Regulation***

| | | **Buena Park** | **Santa Ana** | **Irvine** | **Laguna Niguel** |
|---|---|---|---|---|---|
| Direct Regulation | Allowable units-per-acre (permitted density) | **20** | **35** | **31** | **Site-by-site basis** |
| Scenario B - Subterranean parking | Buildable units reflecting all zoning provisions (subterranean parking) | 43 | 337 | 171 | Not applicable due to slope terrain |
| | Units-per-acre | **40** | **69** | **51** | N/A |
| | Units-per-acre added from units-per-acre regulation | 20 | 34 | 20 | N/A |
| | Percentage of units-per-acre added from units-per-acre regulation | 101% | 99% | 64% | N/A |

*Table 13 - Comparison of Scenario B and Existing Apartment Density*

| | | Buena Park | Santa Ana | Irvine | Laguna Niguel |
|---|---|---|---|---|---|
| Existing | As-Built Units | **22** | **60** | **104** | **176** |
| | Site Acre | 1.07 | 4.85 | 3.36 | 10 |
| | As-Built units-per-acre | 21 | 12 | 31 | 18 |
| Scenario B - Subterranean parking | Buildable units reflecting all zoning provisions (subterranean parking) | **43** | **337** | **171** | Not applicable due to slope terrain |
| | Units added from as-built units | 21 | 277 | 67 | N/A |
| | Percentage of units added from as-built units | 95% | 462% | 64% | N/A |
| | Units-per-acre | 40 | 69 | 51 | N/A |
| | Units-per-acre added from as-built units-per-acre | 19 | 57 | 20 | N/A |

All Scenario B models resulted in more buildable units than allowable and existing units. Buena Park's Scenario B models resulted in 23 buildable units more than allowable units and 21 buildable units more than existing units. Buena Park's units-per-acre increased up to 40, which is 20 units-per-acre more than restricted and 19 units-per-acre more than existing. Santa Ana's Scenario B model resulted in 277 buildable units more than as-built units. Santa Ana's units-per-acre increased up to 69, which is 34 units-per-acre more than restricted and 57 units-per-acre more than existing. Irvine's Scenario B model resulted in 67 units more than as-built units. Irvine's units-per-acre increased up to 51, which is 20 units-per-acre more than restricted and existing. Laguna Niguel site were not applicable for Scenario B modeling because the site is located on slope terrain which made it unpractical to construct subterranean parking.

Table 14 (next page) presents the comparison between Scenario C and restricted units-per-acre. Table 15 (next page) presents the comparison between Scenario C and existing apartment density.

*Table 14 - Comparison of Scenario C and Units-per-acre Density Limit*

| | | Buena Park | Santa Ana | Irvine | Laguna Niguel |
|---|---|---|---|---|---|
| Direct Regulation | Allowable units-per-acre (permitted density) | **20** | **35** | **31** | **Site-by-site basis** |
| Scenario C - Density Bonus | Buildable units reflecting all zoning provisions and density bonus incentives | 27 | 237 | 150 | 281 |
| | Units-per-acre | **25** | **49** | **45** | **28** |
| | Units-per-acre added from units-per-acre regulation | 5 | 14 | 14 | N/A |
| | Percentage of units-per-acre added from units-per-acre regulation | 26% | 40% | 44% | N/A |

*Table 15 - Comparison of Scenario C and Existing Apartment Density*

| | | Buena Park | Santa Ana | Irvine | Laguna Niguel |
|---|---|---|---|---|---|
| Existing | As-Built Units | **22** | **60** | **104** | **176** |
| | Site Acre | 1.07 | 4.85 | 3.36 | 10 |
| | As-Built units-per-acre | 21 | 12 | 31 | 18 |
| Scenario C - Density Bonus | Buildable units reflecting all zoning provisions and density bonus incentives | **27** | **237** | **150** | **281** |
| | Units added from as-built units | 5 | 177 | 46 | 105 |
| | Percentage of units added from as-built units | 23% | 295% | 44% | 60% |
| | Units-per-acre | 25 | 49 | 45 | 28 |
| | Units-per-acre added from as-built units-per-acre | 4 | 36 | 14 | 10 |

All Scenario C models resulted in more buildable units than allowable and existing units. Buena Park's Scenario C models resulted in 7 buildable units more than allowable units and 5 units more than existing units. Buena Park's units-per-acre increased up to 25, which is 4 units-per-acre more than restricted density. Santa Ana's Scenario C model resulted in 177 units more than as-built units. Santa Ana's units-per-acre increase up to 49, which is 14 units-per-acre more than restricted units-per-acre and

36 units-per-acre more than existing units-per-acre. Irvine's Scenario C model resulted in 46 units more than as-built units. Irvine's units-per-acre increase up to 45, which is 14 units-per-acre higher than restricted and existing units-per-acre. Laguna Niguel's units-per-acre increase up to 28, which is 11 units-per-acre more than existing units-per-acre. Laguna Niguel's Scenario C model resulted in 105 units more than as-built units.

The comparison between Scenario C and restricted units-per-acre (Table 14) presents the potential percentage of density added after implementing density bonus incentives. Buena Park's Scenario C model resulted in 26% added density; Santa Ana's Scenario C model resulted in 40%; and Irvine's Scenario C model resulted in 40%. Therefore, these incentives contributed to more than 35% maximum added density per density bonus law (in exchange for providing affordable housings units). Parking by-right incentive greatly reduces parking areas, where those areas can be replaced with dwelling units in all Scenario C models. The two modifications of development standard (setback and landscape deviations) have negligible effect in Buena Park's and Laguna Niguel's models and moderately effect in Santa Ana and Irvine's models.

Table 16 (next page) presents the comparison of three scenarios.

*Table 16 - Comparison of Three Scenarios*

| | | Buena Park | Santa Ana | Irvine | Laguna Niguel |
|---|---|---|---|---|---|
| Scenario A - Baseline | Buildable units reflecting all zoning provisions (ground level parking) | **23** | **201** | **130** | **250** |
| | Units-per-acre | 21 | 41 | 39 | 25 |
| Scenario B - Subterranean parking | Buildable units reflecting all zoning provisions (subterranean parking) | **43** | **337** | **171** | Not applicable due to slope terrain |
| | Units-per-acre | 40 | 69 | 51 | N/A |
| | Units added from Scenario A | 20 | 136 | 41 | N/A |
| | Percentage of units added from Scenario A | 87% | 68% | 32% | N/A |
| Scenario C - Density Bonus | Buildable units reflecting all zoning provisions and density bonus incentives | **27** | **237** | **150** | **281** |
| | Units-per-acre | 25 | 49 | 45 | 28 |
| | Units added from Scenario A | 4 | 36 | 20 | 31 |
| | Percentage of units added from Scenario A | 17% | 18% | 15% | 12% |

All Scenario B models resulted in more building units than allowable units, existing units, Scenario A, and Scenario C. Buena Park's Scenario B model increased by 87% from Scenario A – Baseline; Santa Ana's Scenario B model increased by 68%; Irvine's Scenario B model increased by 32%.

All Scenario C models resulted in more building units than allowable, existing units, and Scenario A. Buena Park's Scenario C model increased by 17% from Scenario A – Baseline; Santa Ana's Scenario C model increased by 18%; Irvine's Scenario C model increased by 15%; Laguna Niguel's Scenario C model increased by 12%.

These models show that the indirect elements of zoning regulations do not hinder the achievement of permitted density. The indirect zoning provisions (from conceptual modeling) allow more buildable units than the allowable units-per-acre regulation.

Therefore, the indirect zoning regulations do not contribute to limiting density to less than the allowable units-per-acre, except the units-per-acre limitation itself. The initial research hypothesis was not supported by the conceptual models. However, these conceptual models were developed from minimum livability standpoints covered by zoning and building codes; they may not be ideal for investors or residents. Nevertheless, none of the models provided support for the hypothesis. Apparently, units-per-acre regulation (direct regulation) limits achievement of maximum density. Of course, the question of whether these units-per-acre regulations are appropriate is not addressed in this study. It may be that higher densities are justified by housing supply and environment considerations. While units-per-acre regulation may prove useful for controlling density, it is imperative that its use is contextually thoughtful.

**Sustainable Features Results**

Table 17 presents models' result on the potential area for PV panels.

***Table 17 - Results of potential area for PV Panel***

| | | Buena Park | Santa Ana | Irvine | Laguna Niguel |
|---|---|---|---|---|---|
| Site Area (Square Feet) | | 46,540 | 211,219 | 148,722 | 471,918 |
| Scenario A - Baseline | Potential roof area for PV Panels (Square Feet) | 11,762 | 57,548 | 32,861 | 57,538 |
| | Percentage of PV panels on site area | 25% | 27% | 22% | 12% |
| Scenario B - Subterranean | Potential roof area for PV Panels (Square Feet) | 8,983 | 15,772 | 24,544 | |
| | Percentage of PV panels on site area | 19% | 7% | 17% | |
| Scenario C - Density Bonus | Potential roof area for PV Panels (Square Feet) | 11,762 | 64,142 | 36,711 | 57,538 |
| | Percentage of PV panels on site area | 25% | 30% | 25% | 12% |

The percentage of PV panels on site area offered comparable results among the four cities. Buena Park's Scenario C model resulted in the same buildings' footprint and roof area with Scenario A; therefore, the percentage remained the same. Similarly, Laguna Niguel's Scenario C model resulted in the same percentage because the added building's footprint and roof area were not practical for PV panels installation.

Santa Ana's and Irvine's Scenario C models resulted in greater percentage of PV panels on site area than the other two scenarios because the buildings' footprint and roof area increased. All models in Scenario B resulted in the least percentage of PV panels on site area because those models contain less flat roof area, and more front-street-facing pitched roof which PV panels are not permitted (due to avoiding glare from the panels to the driving vehicles). (Refer to Appendix D for roof plan)

Table 18 presents models' result on the potential area for rainwater planters.

***Table 18 - Results of potential areas for rainwater planters***

| | | Buena Park | Santa Ana | Irvine | Laguna Niguel |
|---|---|---|---|---|---|
| Site Area (Square Feet) | | 46,540 | 211,219 | 148,722 | 471,918 |
| Scenario A - Baseline | Potential areas for rainwater planters adjacent to buildings (Square Feet) | 4,259 | 9,534 | 12,097 | 13,477 |
| | Percentage of site area with rainwater planters | 9% | 5% | 8% | 3% |
| Scenario B - Subterranean Parking | Potential areas for rainwater planters adjacent to buildings (Square Feet) | 6,415 | 10,314 | 11,638 | |
| | Percentage of site area with rainwater planters | 14% | 5% | 8% | |
| Scenario C - Density Bonus | Potential areas for rainwater planters adjacent to buildings (Square Feet) | 4,127 | 9,443 | 10,383 | 13,549 |
| | Percentage of site area with rainwater planters | 9% | 4% | 7% | 3% |

The percentage of site area with rainwater planters offered comparable results among the four cities. Buena Park's Scenario C models resulted in the same buildings' footprint and roof area with Scenario A; therefore, the percentage of site area with rainwater planters remained the same. Similarly, Laguna Niguel's Scenario C models resulted in the same percentage of site area with rainwater planters because the added building's footprint area were not practical for rainwater planters. Buena Park's Scenario B model contains large interior courtyard which resulted in greater percentage of site area with rainwater planters than other two scenarios.

Santa Ana's and Irvine's Scenario C models resulted in less percentage of site area with rainwater planters than the other two scenarios because the buildings' footprint increased which reduced landscape area. Moreover, one of the density bonus incentive is reduction of 20% landscape area. Changes in indirect regulations may be required to avoid reducing the potential to implement landscape rainwater planters. (Refer to Appendix E – Sustainable features detailed results)

The models show that no zoning provisions constrain installation of sustainable features (rainwater planters and PV panels). There is flexibility to implement these features because few zoning codes regulate these features' installation. Even though solar panels were restricted to be within building height limits, the models can still fit the solar panels. Pitched roofs are preferable for solar installation, as opposed to flat roof, due to the receiving angles of sunlight. The models can fit the solar panels on the pitched roof and center of flat area.

**Effects of modification of development standard through density bonus incentives**

Parking reduction (parking by-right incentive) greatly affected the number of buildable units in all models. The models increased units by replacing units on the eliminated parking stalls area. Side and rear yard deviation slightly affected the number of buildable units in all models. Landscape percentage moderately affected in Santa Ana and Irvine models. The two deviations were slight to none affected in Buena Park and Laguna Niguel. The reduction of 2 percent landscape percentage and 10% side and rear yard for non-building floor area items in Buena Park have negligible effect. Laguna Niguel site is on an irregular 10-acre site which contains excessive amount of landscape and side/rear yard area within the Scenario A's model before applying density bonus incentive. Therefore, parking reduction is the most supportive incentive.

Applying three density bonus incentives into the model also effects the potential areas to implement sustainable features. By reducing landscape percentage, the models resulted in greater amount of building footprint which increases the roof area. The greater roof areas provided more potential areas for PV panels. However, reducing landscape area also reduce the potential area for rainwater planter. Researcher expected that the driveway area will be reduce due to less parking requirement. However, all models reflected in slightly or none driveway area reduction.

The modification of the development standard contributed to greater number of buildable units and potential area for PV panels; however, it reduces the potential area for rainwater planters. Reduction of landscape area may reduce the overall livability and sustainability. However, the balance of both sustainability and maximum density were not the purposes of this study.

**Factors that do and do not constrain density**

These factors that support and hinder achievement of the maximum buildable units were determined by the researcher's experience while working on the conceptual models. The factors that enable achievement of the maximum buildable units are (1) minimum floor area of dwelling units, (2) diversity of unit type, (3) higher building height restriction, (4) lot coverage restriction (instead of building coverage), and (5) tandem and subterranean parking.

The minimum floor area of dwelling units required by cities is lower than the as-built units' floor area. Models' scenarios utilized the minimum floor area which contributed to more units. However, this minimum floor area most likely is lower than typical market-rate apartment, which may not be luxury and ideal for developers' return on investment. The diversity of unit type allows smaller units (e.g. studio and one-bedroom) into the project which resulted in more buildable units. Most existing apartments has a few unit type, and none contains studio unit; this might be due to economic or management purposes.

Apparently, higher building height presents as a supporting factor because more dwelling units can be added. For example, Santa Ana's building height limitation is at 60 feet. Santa Ana's Scenario B model contains five dwelling floors and two subterranean parking levels. Santa Ana's Scenario A and C (both ground level parking) contains three to four dwelling floors. However, the benefit of higher building height also relates to availability of parking areas and numbers of required parking stalls.

Tandem parking and subterranean parking contributed to maximum buildable units. Tandem parking reduces the area for driveway and parking aisle. However, it is not convenient for residents as much as standard parking. Subterranean parking provides greater amount of spaces for dwelling units. However, the cost for constructing subterranean parking is high which developers most likely trying to avoid. Nevertheless, Scenario A and C resulted in more buildable units than permitted density; therefore, subterranean parking is not necessary in any sites to achieve maximum allowable units.

Lot coverage, instead of building coverage restriction, allows more flexibility for buildings' footprint to cover the lot in any percentage as long as the requirements for landscape area are met. Building coverage is total buildings' footprint on the site; any covered structures count as buildings. Lot coverage refers to the total of buildings' footprint, driveways, and parking area; any area that is not landscape area are considered as lot coverage. Santa Ana, Irvine, and Laguna Niguel regulate lot coverage instead of building coverage. With only lot coverage restriction, models utilize lot area effectively. The parking areas and driveway can be integrated on ground level, under the buildings, and allow more dwellings units on the upper levels (e.g. Irvine and Santa Ana models). However, it may contribute to denser buildings, which may be less desirable for livability; however, this practicality should be considered for high density dwellings.

The factors that hinder the achievement of the maximum buildable dwelling units are (1) parking requirements, (2) landscape, and (3) site area. Those factors occasionally presented as difficulties in one city, but not in another city.

Parking requirements present as difficulties in Buena Park, adding the fact that the site is very small. Fewer difficulties related to parking requirements occurred in Irvine because they allowed tandem parking, and require the least amount of parking stalls comparing to other cities. No difficulty occurred in Laguna Niguel because of the large site. However, Laguna Niguel requires highest amount of visitor parking stalls comparing to other cities. Parking requirements present no difficulty in Laguna Niguel due to its' large site; however, that amounts of required parking may present a difficulty on the smaller site.

Landscape area presents as difficulty in Buena Park due to it small site. When the researcher slightly altered building footprint, it greatly affected the landscape percentage. On the other hand, for other larger sites, slightly altering the buildings' footprints had negligible effect on landscape percentage. Therefore, most difficulties were more likely to present in relation to of site size, not zoning ordinances.

Given the fact that all models resulted in more buildable units than allowable units, no significant regulations or codes contributed to limiting density to less than the allowable units-per-acre, except the units-per-acre limitation itself.

# CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

This study examines the hypothesis that indirect zoning provisions hinder the achievement of permitted density (as expressed in units-per-acre) and the potential to implement sustainable features. The research utilizes a conceptual modeling approach to determine the effects of indirect zoning provisions on the potential density of apartments in residential multiple-family zones of four cities located in Orange County, CA. This research introduces new information that may help initiate changes in zoning provisions and design guidelines.

## Conclusion

First, the models show that indirect elements of zoning regulations do not reduce density lower than the units-per-acre regulation in the four cities and sites studied. All conceptual models resulted in more buildable units than allowable units. Scenario B – Subterranean Parking resulted in the greatest numbers of buildable units. If cities intend to increase density, they should increase the units-per-acre density to allow developers to increase dwelling units. The models show that no indirect zoning provisions contribute to limiting density to less than the allowable units-per-acre. However, the units-per-acre regulation (direct regulation) limits the achievement of maximum buildable units.

Second, after implementing density bonus incentives (Scenario C - Density Bonus), Santa Ana's and Irvine's Scenario C models resulted in higher than allowed maximum 35% of added density from restricted units-per-acre. The by-right parking requirement incentive greatly reduces parking area, which can be replaced with dwelling units in all Scenario C models. The two modifications of development standard (setback and landscape deviations) have negligible effect in Buena Park's and Laguna Niguel's models and moderately effect in Santa Ana and Irvine's models.

Third, after implementing density bonus incentives, the buildings' footprint increases because of landscape area reduction. Therefore, it reduces potential area for rainwater planters. On the other hand, larger buildings' footprint increases roof areas, which increase potential areas for PV panels. Changes in indirect regulations may be required to to avoid reducing the potential to implement landscape rainwater planters.

Fourth, no zoning provisions constrain installation of sustainable features (rainwater planters and PV panels). There is flexibility to implement these features because few zoning codes regulate these features' installation. However, no guidelines were provided to encourage these features.

**Recommendations to Cities**

The following is a list of recommendations to be considered which will ensure the maximum density:

1. Cities should generate these conceptual models to evaluate the indirect provisions of their zoning codes to ensure the number of buildable units is comparatively close to units-per-acre limitation.
2. Also, cities should take the opportunity to create conceptual models to determine the permissible deviations or modifications of standard development that can be given as density bonus incentives to the developers who intend to increase density by providing affordable units.
3. Cities should allow tandem parking because it reduces the driveway and parking aisle areas and utilizes parking area effectively.

4. Cities should study the demand for parking stalls requirement, especially Buena Park and Laguna Niguel. The by-right parking reduction incentive greatly reduces parking areas, where those areas can be replaced with dwelling units in all Scenario C models. Cities should consider reducing parking stalls requirement to be closer to parking by-right incentive requirements. They should consider reducing visitors parking stalls where street parking stalls can be provided within walking distance from the apartments.
5. Instead of restriction on building coverage, cities should restrict only on lot coverage. The buildings' footprint can acquire the lot coverage in any percentage within the lot coverage restriction as long as the requirements for landscape are met. This allows developers to reduce the driveway or parking area and build larger buildings. Also, the developers can integrate driveways and parking areas on ground level, under the buildings, to allow more buildable units on the upper levels.

The following is a list of recommendations to be considered which will provide sustainable features:

1. Cities should create more guidelines for landscape features.
    a. Encourage shorter driveway length adjacent to buildings to allow additional landscaping or rainwater planters acting as transition between buildings and driveways.
2. Cities should create more guidelines for Solar Carport or PV panels canopy for outdoor parking areas. Guidelines or regulations related to PV panels canopy have not been found in the zoning ordinances.

Finally, the question of whether these units-per-acre regulations are appropriate is not addressed in this study. The preferred density or ideal dwelling units cannot be standardized or generalized. It requires proper balance among population, capacity of infrastructure and transportation, land and other resources to attain suitable density. It may be that higher densities are justified by housing supply and environment considerations. However, if the cities intend to increase housing density in multiple-family residential zones, this study recommends that they should review the units-per-acre limitation whether it follows the policies of the community's General Plan.

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# APPENDIX A – SITE DESCRIPTIONS AND PHOTOS

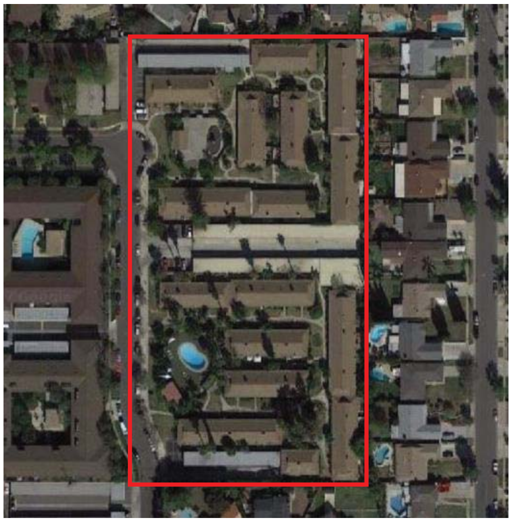
**Buena Park – Parkview Apartment**


Only Buena Park site (Parkview Apartment) meet all initial site selection criteria. It was built in 2014 with current zoning codes. The lot locates on RM-20 zone which is residential multi-family zone with 20 units-per-acre limitation. However, the apartment parcel is 1.07 acre which exceed 1 acre; therefore, the developer could obtain 2 more units from site area bonus[4]. Parkview apartment contains 22 two-bedrooms units, and 55 parking stalls. The buildings cover 36 percent and landscape area covers 40 percent of the total site area. Vehicular access (twenty-five feet driveway) to the apartments were located at the center of the site, accessing from Knott Ave. Another twenty-five feet driveway located along the parking areas and carport paralleling to the rear yard. Those

[4] Title 19, Division 4, Chapter 19.408, 19.408.200 Site Area Bonus – Multifamily Zones.

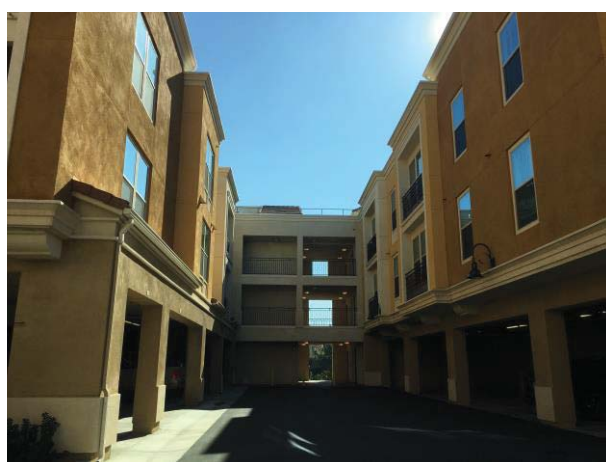
two driveways served fire truck turn around. Researcher determined that this is the best method and driveway layout for this site. Conceptual models keep this site layout for fire truck turn around purposes.

**Santa Ana – Sandalwood-Coco Palms Apartments**



This apartment was built in 1962. The parcel acres were measured from 2008 OC Land Use GIS measurement. All building coverage and landscape space were measured from satellite image. Other information was collected from www.apartments.com.

**Irvine - Alegre Apartments**



Alegre Apartments has 90 market-rate rental units and 14 very low income affordable rental units. The site received two incentives from the city from providing affordable units. The parking reduction was reduced from 205 to 180 stalls and landscape area from 30% to 24%.

**Laguna Niguel – The Vista at Laguna Luxury Apartments**

Laguna Niguel's site located on community profile area 10/ Sub C-Chatelain. The city assigned density units-per-acre on a site-by-site basis. The site is located on northeast-facing slope. The top of the slope is on the southeast alignment of the site; the slope was graded down to the northeast alignment of the site. The clusters of apartment buildings are aligned following the grading slope. Six buildings are located along the northwest alignment; four buildings are located along the Southwest alignment; and two buildings are located between those two alignment groups. All buildings are similar in size, height, and architectural design. Parking areas on located at the first floor of the buildings.

## APPENDIX B – DENSITY BONUS LAW

Under California's Density Bonus Law, California Government Code Sections 65915 – 65918, the residential project developers are able to increase project density and receive incentives in exchange for offering affordable housing units. This law provides developers persuasive tools to increase the project density and encourage the development of affordable housing. Goetz and Sakai (2015) commented that these tools are even more helpful to project economics than the density bonus itself especially the parking by-right incentives.

The local jurisdiction is required to grant one or more incentives proposed by the developer for the qualified project. In order to achieve the maximum of 35% added density and acquire the maximum of three incentives, the project must provide 15% of the buildable units to very low income units for 55 years or longer (CA Government Code Sections 65915 – 65918). The parking by-right incentive reduces parking requirement for the entire project. Modification of development standard incentives (e.g. reduction of setback, open space, floor area, minimum lot size) may be requested by the developers for jurisdiction approval. The jurisdictions are not required to approve the requested incentives that would cause a public health or safety problem, cause environmental problem, harm historical property, or would be contrary to the law (Goetz & Sakai, 2015).

Johnson and Talen (2010) surveyed 84 housing development with affordable units; they concluded that state or local government programs had played a role in enabling or requiring the developer to include affordable housing units. Developers combined available government programs, partnerships with nonprofits, and innovative design solutions to create affordable housing opportunities (Johnson & Talen, 2010). Developers are able to increase the affordability of their units by making architectural adjustments or modifying the site development. However, developers who excluded affordable housing from their developments provided many reasons on why they excluded it; one reason is a limited ability to make the architectural modifications needed for cost-effectiveness (Johnson & Talen, 2010).

# APPENDIX C – SUSTAINABLE BUILDING DESIGN AND CONSTRUCTION

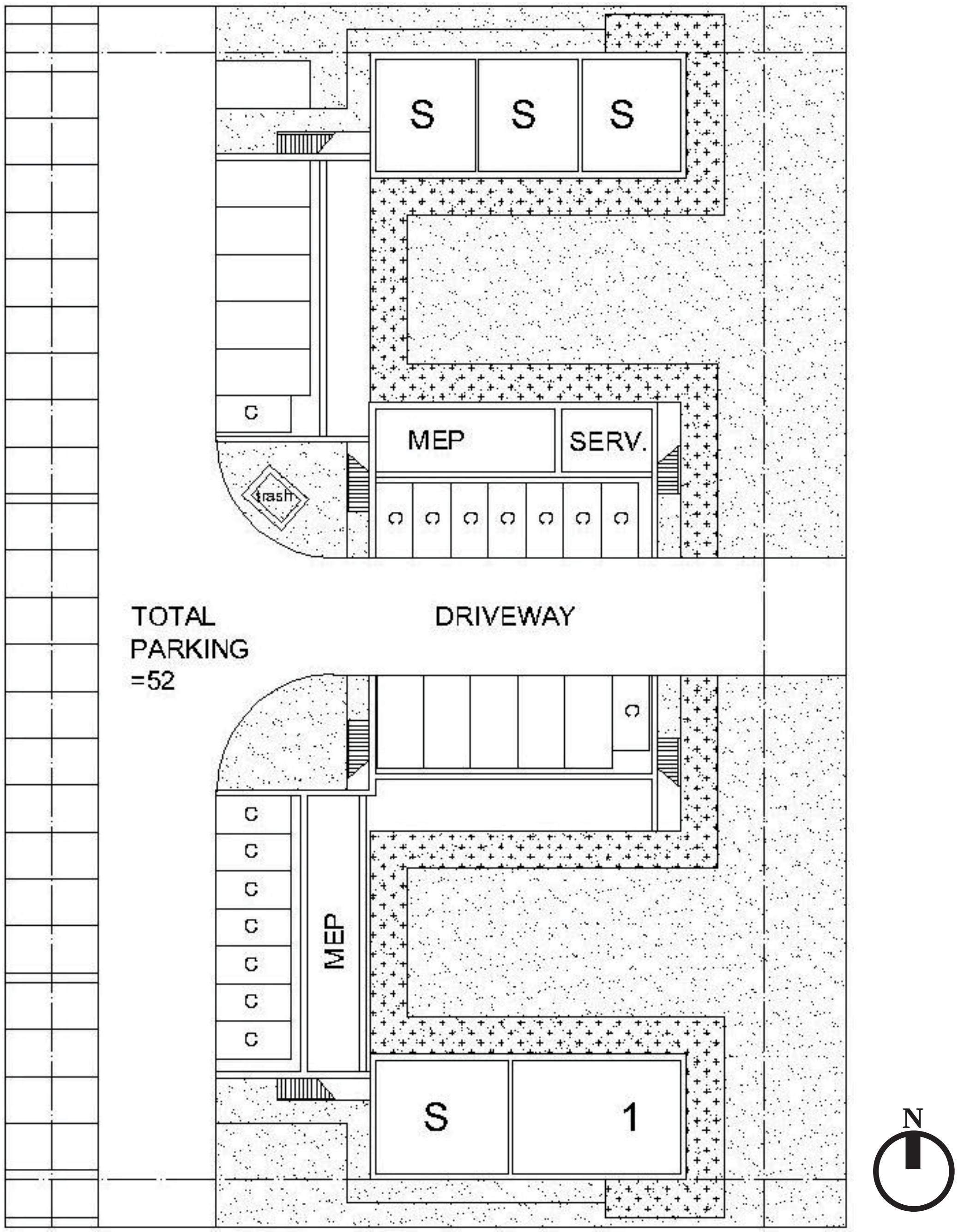
The statewide California Green Building Standards Code (CALGreen Code) represents California as a leader in green building code. It regulates buildings design and construction to reduce negative impact to the environment and encourage sustainable construction practices. Residential buildings are required to comply to Chapter 4 of this code. The five divisions on Chapter 4 are planning and design, energy efficiency, water efficiency and conservation, material conservation and resource efficiency, environmental quality. The Apparently, CALGreen Code intends to limit negative environmental impacts and promote energy efficiency in the new development; however, it does not require on-site renewable energy production and stormwater collection.

Photovoltaic (PV) panel or solar panel absorbs the sun radiation as a source of renewable energy to generate electricity and heating. The PV panel can be located on the building rooftops or ground level, and constructed as a parking canopy. Municipality and building codes do not require developers to install solar panels; however, some municipalities require reserved space on the rooftop dedicated for potential installation of solar panels.

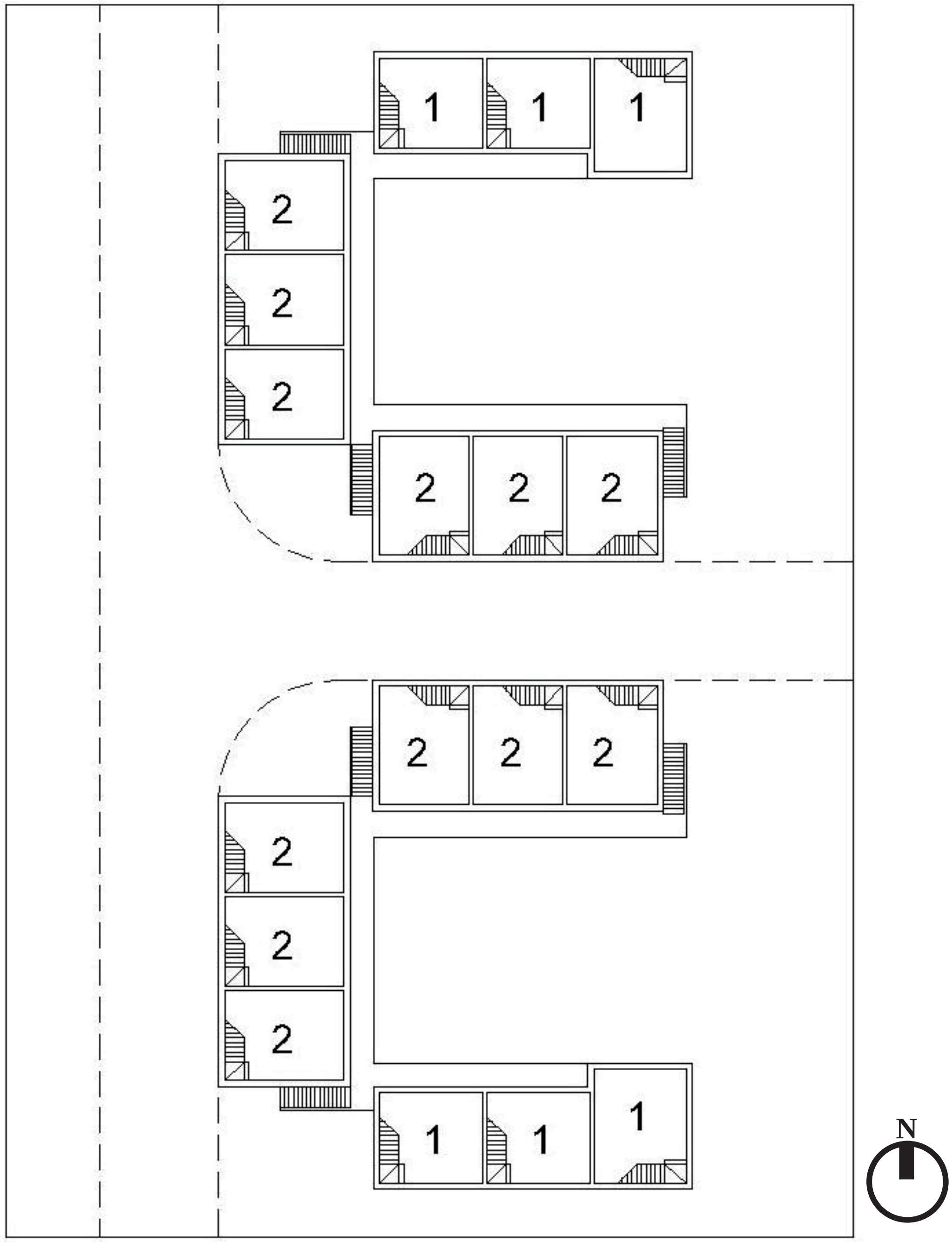
Rainwater planters are a vegetated planter that receives runoff roof drains or adjacent paved areas. The runoff water infiltrates the root zone of the vegetation and into an underlying sand or peat bed and a gravel layer. The vegetation and ground layers remove pollutants from the runoff. Storm-water planters must be implemented to the early stage of design along with building and parking layout.

## APPENDIX D – CONCEPTUAL MODELS FIGURES AND DETAILS

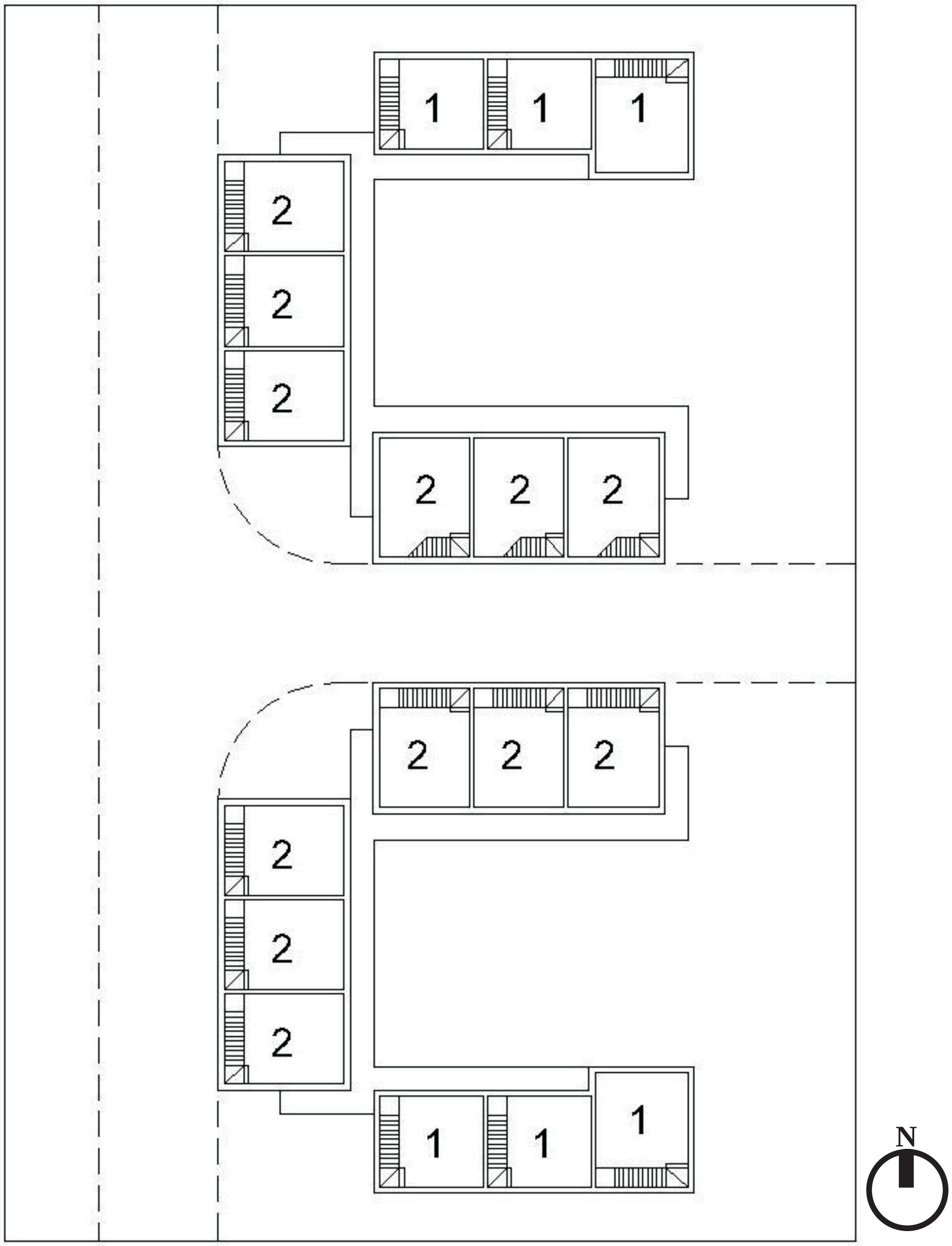
**Scenario A – Buena Park**
1st Floor Plan
Not to Scale



**Scenario A and C – Buena Park**
2nd Floor Plan
Not to Scale



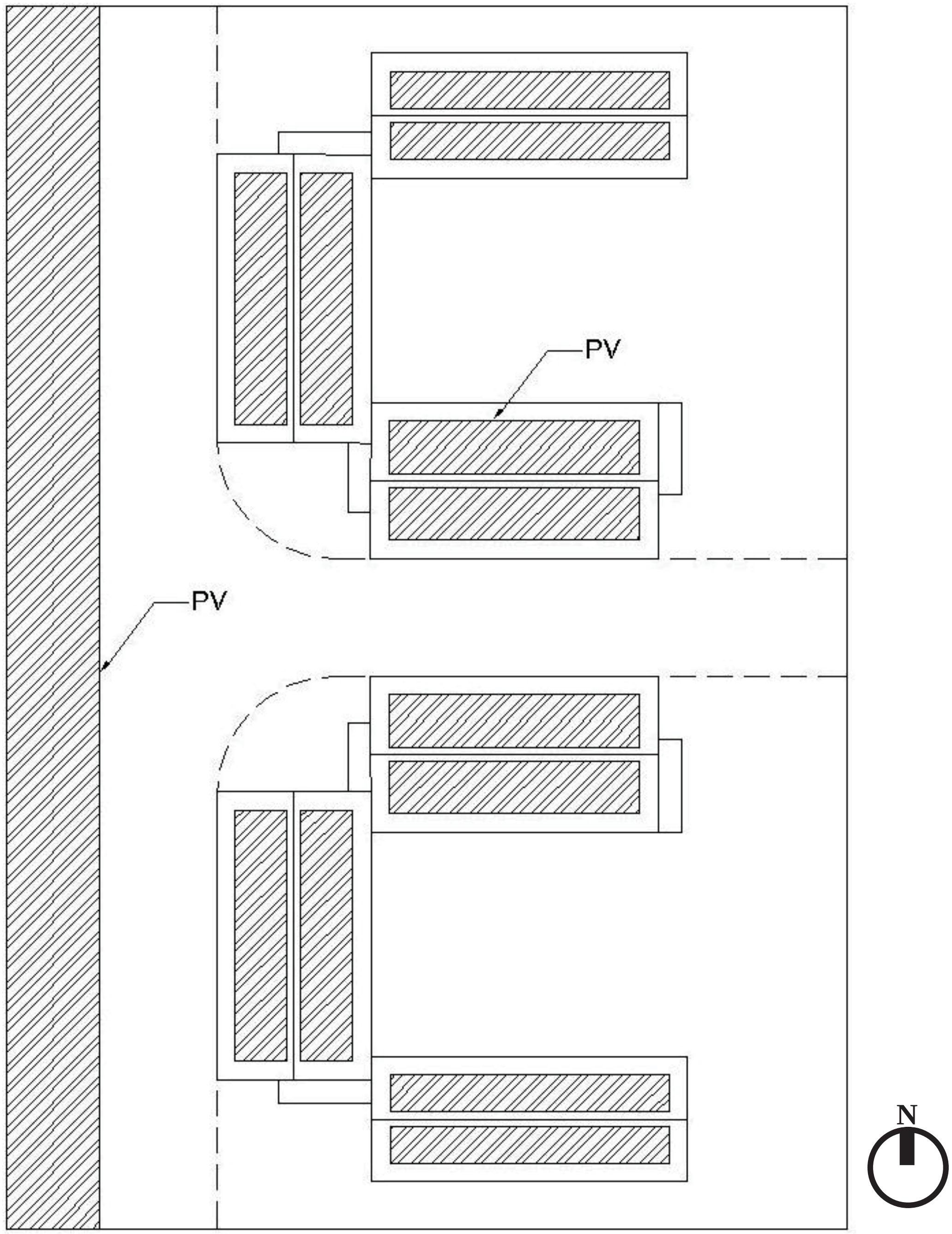
**Scenario A and C – Buena Park**
3rd Floor Plan
Not to Scale



**Scenario A and C – Buena Park**

Roof Plan

Not to Scale



**Buena Park Scenario A: Baseline**

**Unit Summary**

| Unit Type | Number of units | Percentage of Unit |
|---|---|---|
| Studio | 4 | 17% |
| 1 Bedroom | 7 | 30% |
| 2 Bedrooms | 12 | 52% |
| 3 Bedrooms | 0 | 0% |
| Total | 23 | 100% |

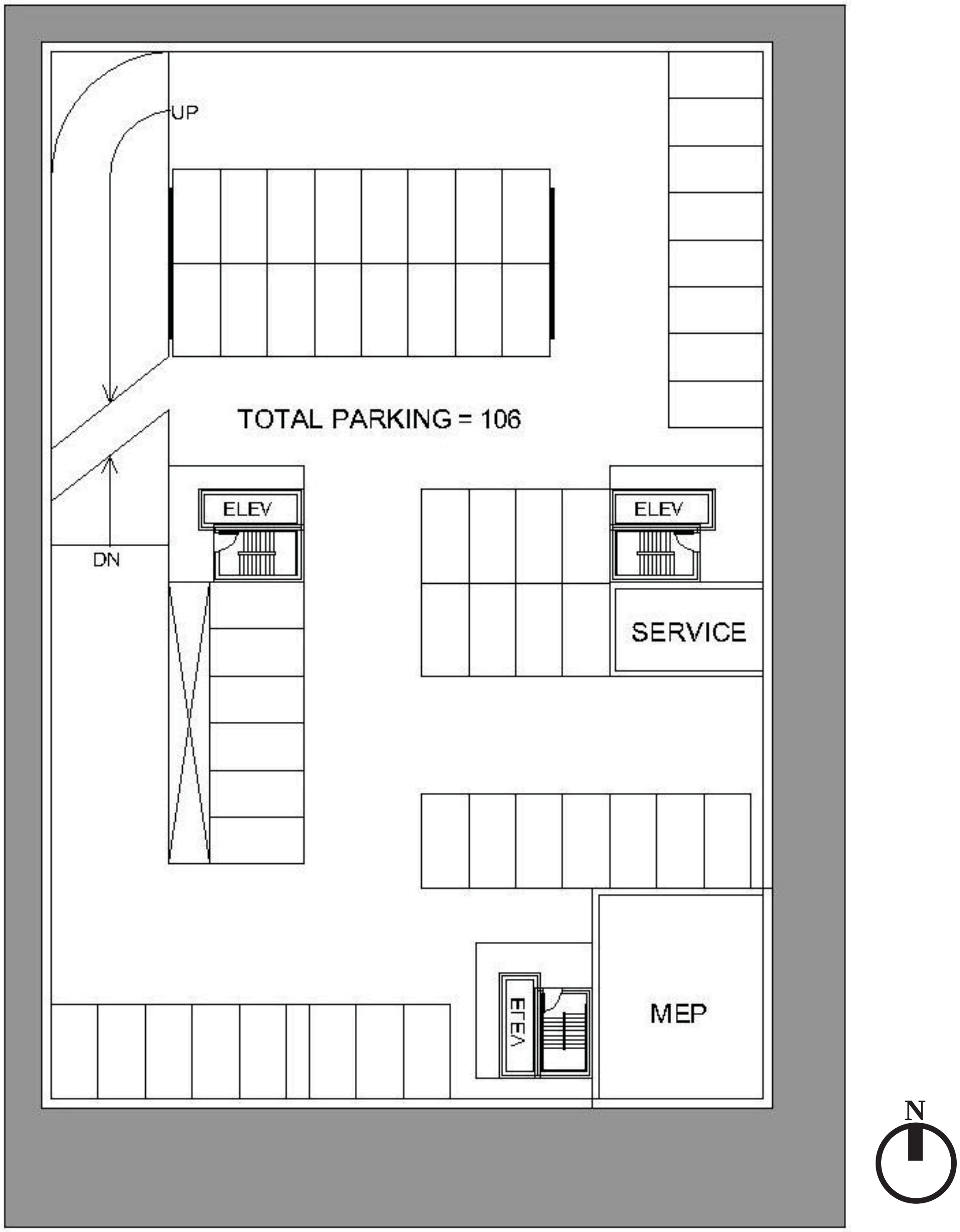
**Site Summary - Ground Level**

| | Area (Sq.ft) | Percentage on site area |
|---|---|---|
| Site Area | 46540 | 100% |
| Buildings | 12186 | 26% |
| Landscape | 18523 | 40% |
| Driveway | 10118 | 22% |

**Parking Summary**

| | Parking Requirement | | | | Model's Result | | |
|---|---|---|---|---|---|---|---|
| Unit Type | Covered | Un-Covered | Visitor | Total | Covered | Un-covered | Total |
| Studio | 4 | 4 | No Addition | | | | |
| 1 Bedroom | 7 | 7 | | | | | |
| 2 Bedrooms | 12 | 18 | | | | | |
| 3 Bedrooms | 0 | 0 | | | | | |
| Total | 23 | 29 | 0 | 52 | 26 | 26 | 52 |

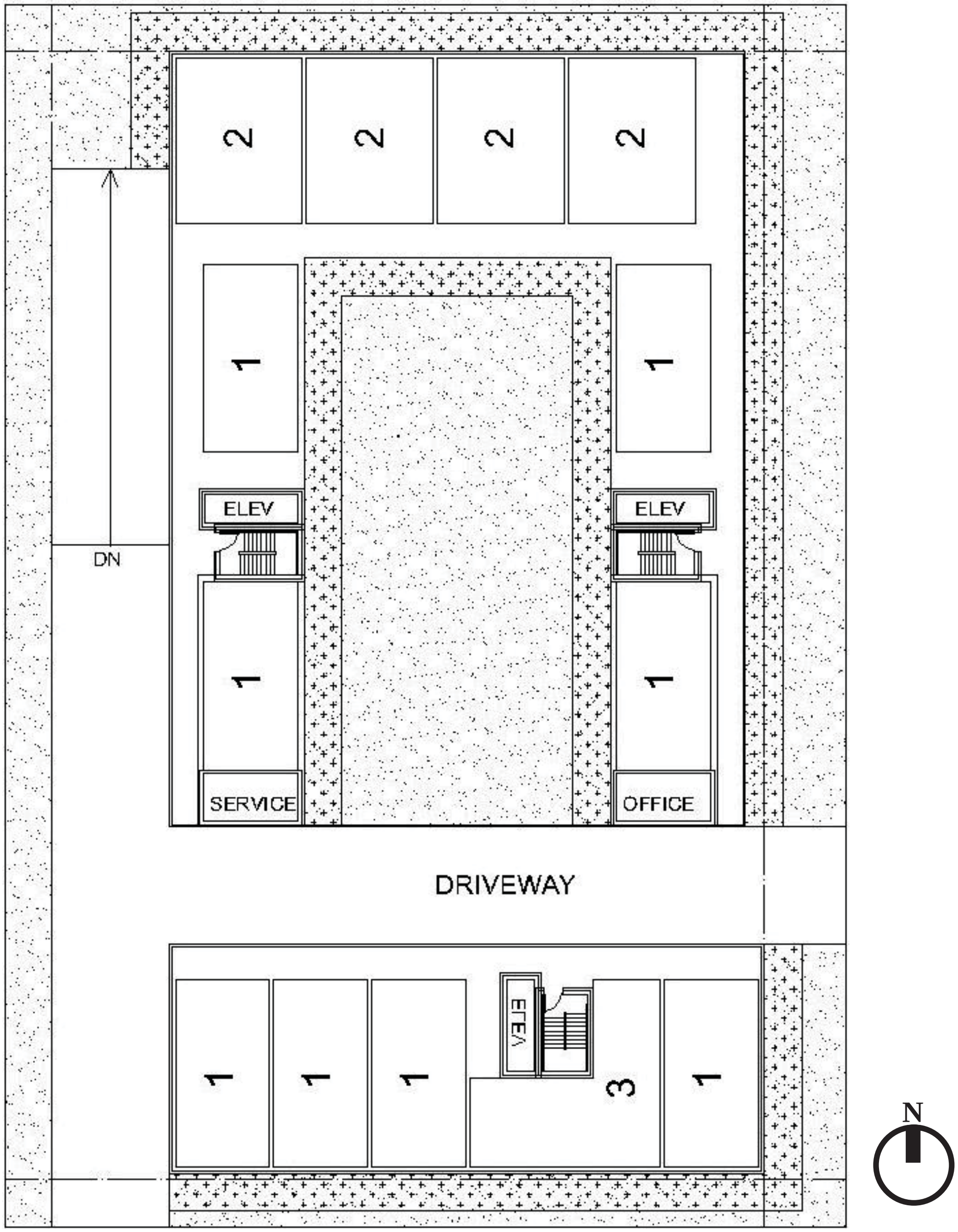
**Scenario B – Buena Park**
P1 – P2 Floor Plan (Subterranean Parking)
Not to Scale



**Scenario B – Buena Park**

1st Floor Plan

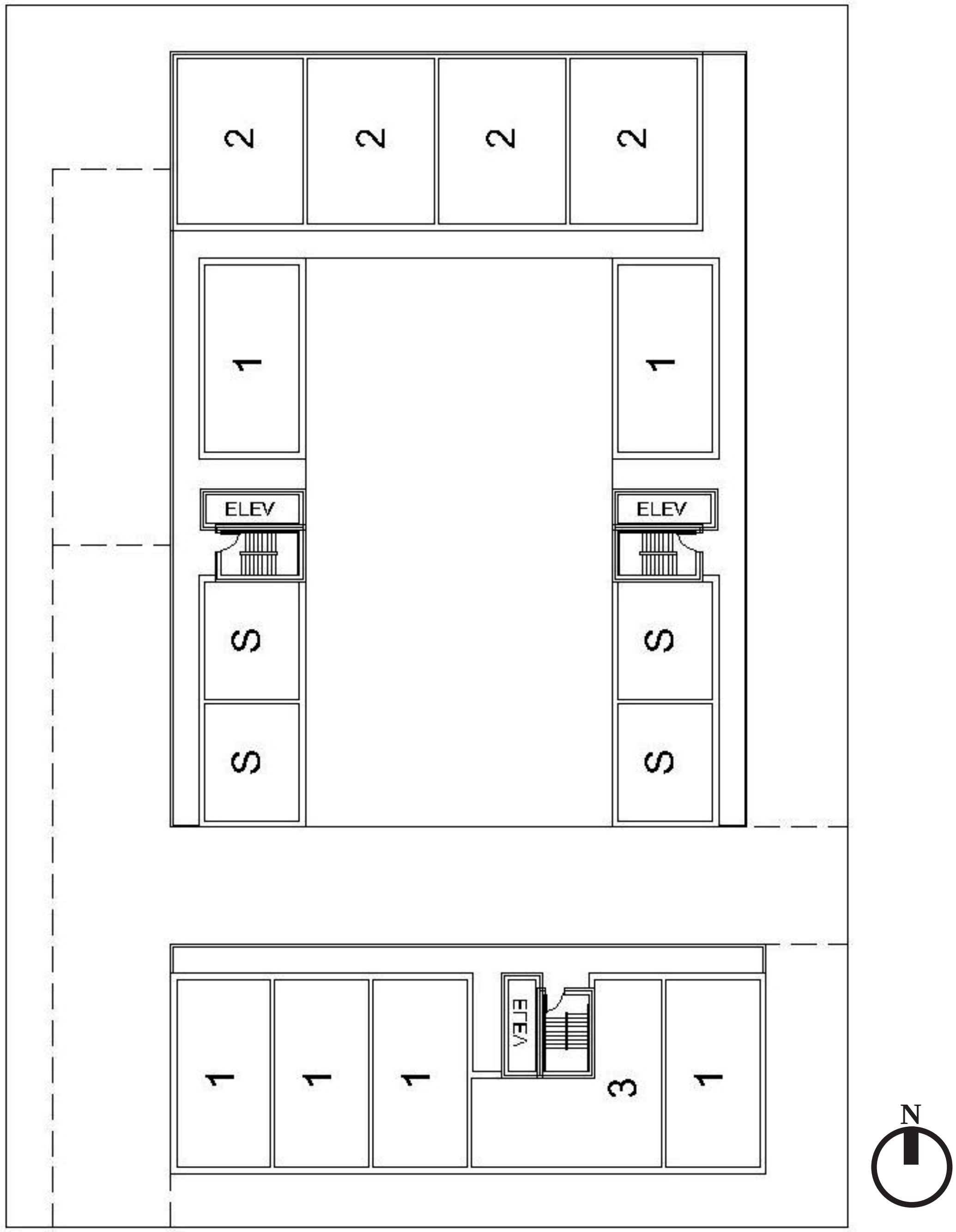
Not to Scale



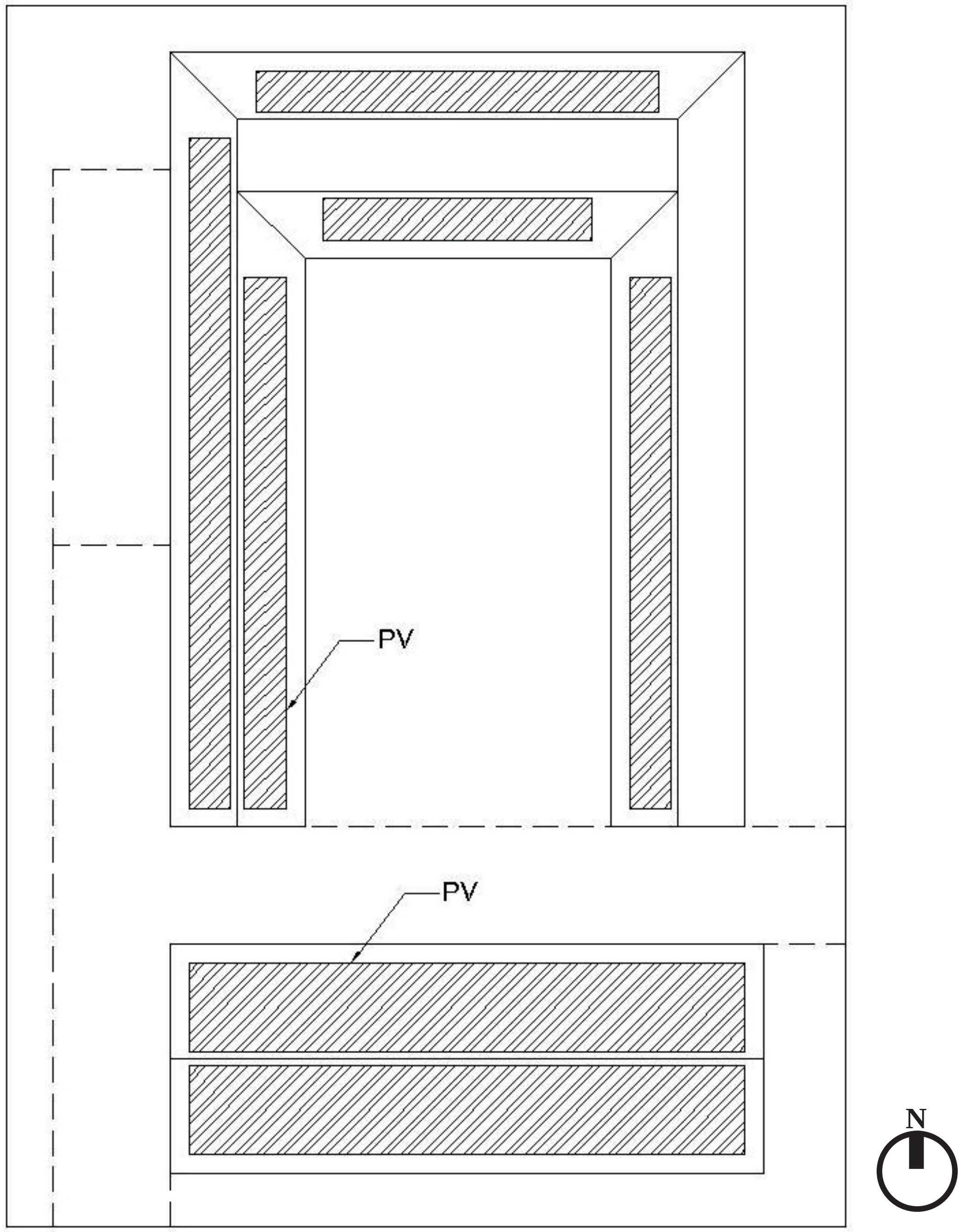
**Scenario B – Buena Park**

$2^{nd}$ – $3^{rd}$ Floor Plan

Not to Scale



**Scenario B – Buena Park**
Roof Plan
Not to Scale



## Buena Park Scenario B: Subterranean Parking

### Unit Summary

| Unit Type | Number of units | Percentage of Unit |
|---|---|---|
| Studio | 8 | 19% |
| 1 Bedroom | 20 | 47% |
| 2 Bedrooms | 12 | 28% |
| 3 Bedrooms | 3 | 7% |
| Total | 43 | 100% |

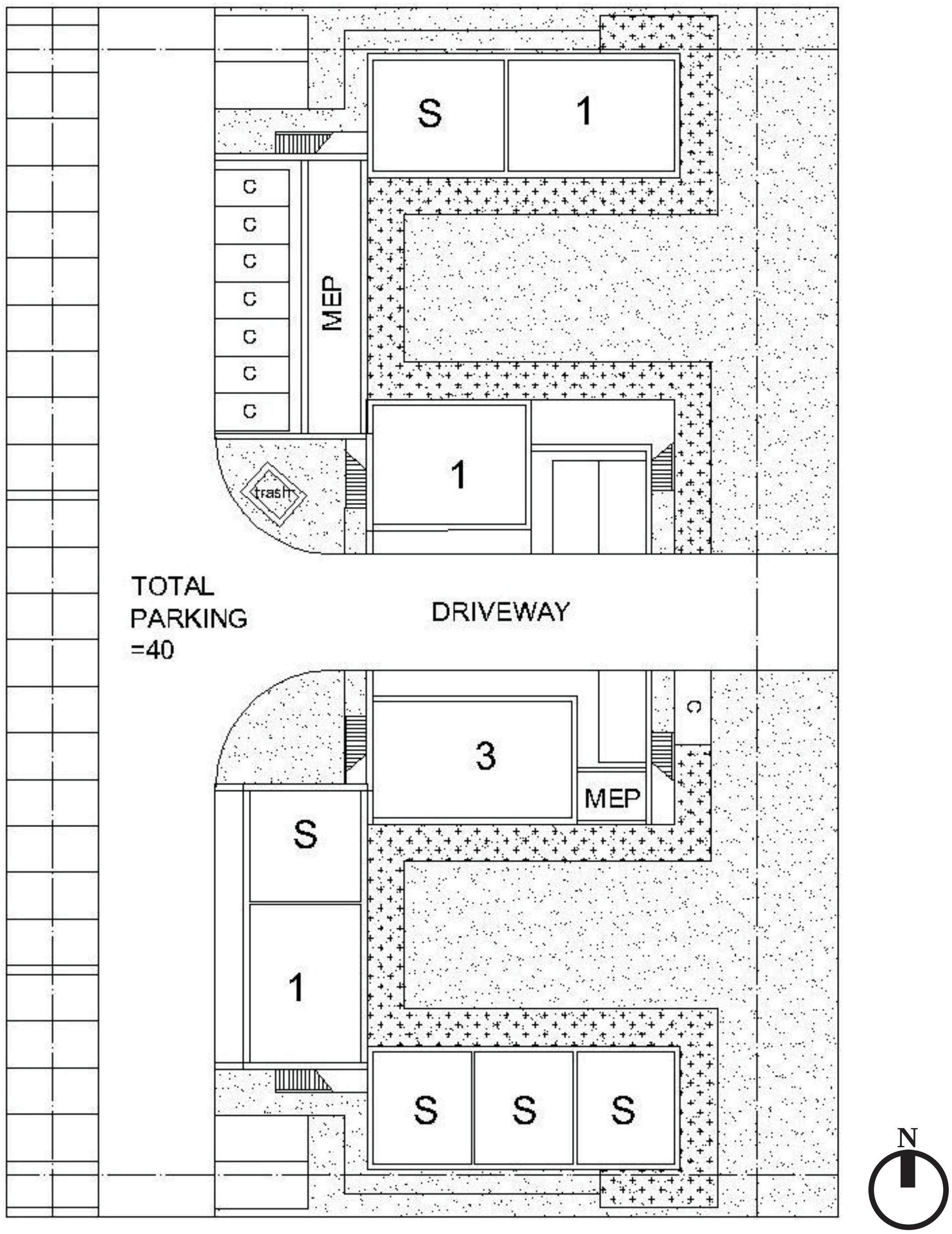
### Site Summary - Ground Level

| | Area (Sq.ft) | Percentage on site area |
|---|---|---|
| Site Area | 46540 | 100% |
| Buildings | 18484 | 40% |
| Landscape | 18646 | 40% |
| Driveway | 9163 | 20% |

### Parking Summary

| | Parking Requirement | | | | Model's Result | | |
|---|---|---|---|---|---|---|---|
| Unit Type | Covered | Un-Covered | Visitor | Total | Covered | Un-covered | Total |
| Studio | 8 | 8 | No Addition | | P1 and P2 level | | |
| 1 Bedroom | 20 | 20 | | | | | |
| 2 Bedrooms | 12 | 18 | | | | | |
| 3 Bedrooms | 3 | 6 | | | | | |
| Total | 43 | 52 | 0 | 95 | 106 | 0 | 106 |

**Scenario C – Buena Park**
1st Floor Plan
Not to Scale




Refer to Scenario A 2nd, 3rd, and roof plan for other Scenario C models.

## Buena Park Scenario C: Density Bonus

### Unit Summary

| Unit Type | Number of units | Percentage of Unit |
|---|---|---|
| Studio | 5 | 19% |
| 1 Bedroom | 9 | 33% |
| 2 Bedrooms | 12 | 44% |
| 3 Bedrooms | 1 | 4% |
| Total | 27 | 100% |

### Site Summary - Ground Level

| | Area (Sq.ft) | Percentage on site area |
|---|---|---|
| Site Area | 46540 | 100% |
| Buildings | 12320 | 26% |
| Landscape | 17760 | 38% |
| Driveway | 10118 | 22% |

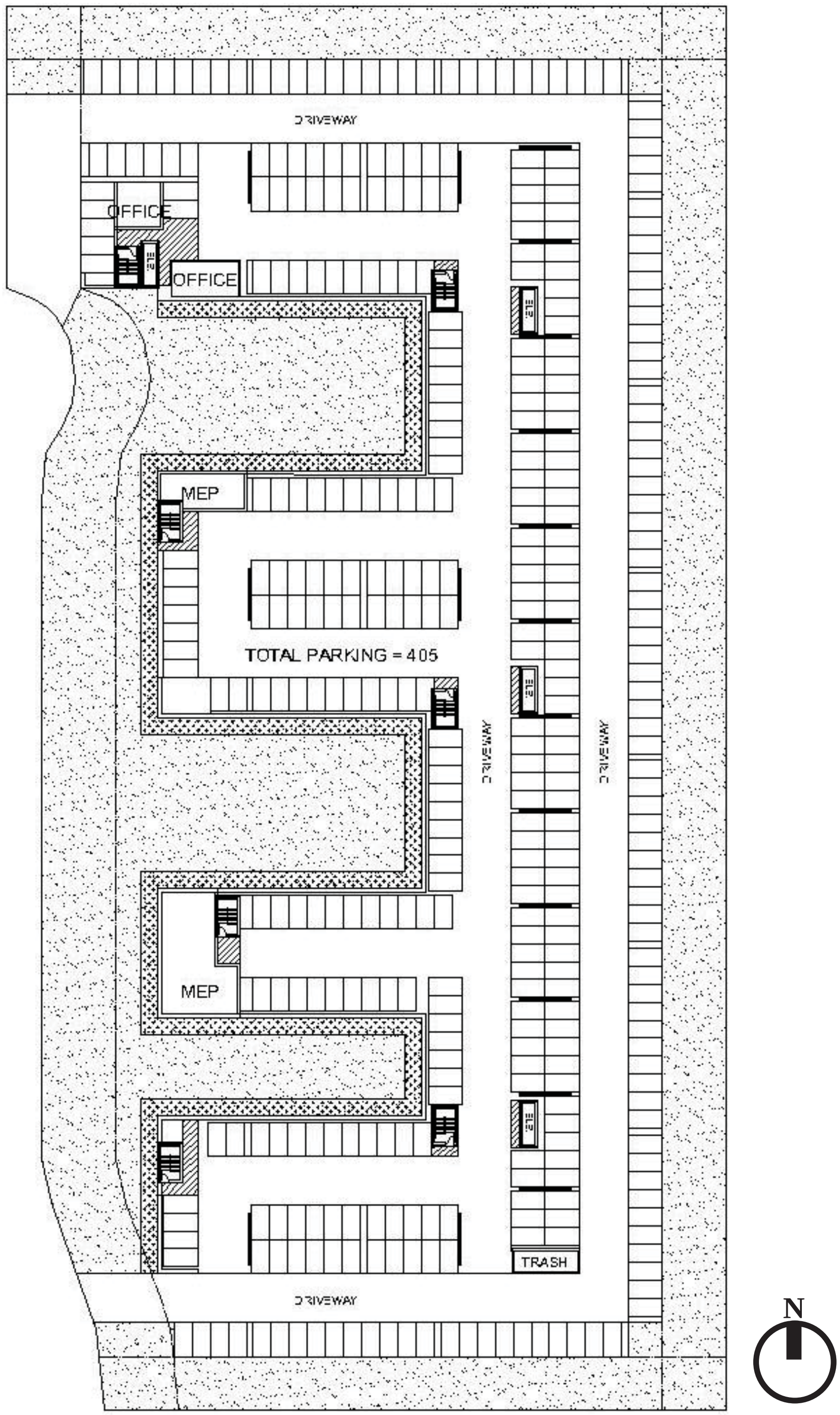
### Parking Summary

| | Parking Requirement | | | | Model's Result | | |
|---|---|---|---|---|---|---|---|
| Unit Type | Covered | Un-Covered | Visitor | Total | Covered | Un-covered | Total |
| Studio | 5 | 0 | No Addition | | | | |
| 1 Bedroom | 9 | 0 | | | | | |
| 2 Bedrooms | 12 | 12 | | | | | |
| 3 Bedrooms | 1 | 1 | | | | | |
| Total | 27 | 13 | 0 | 40 | 30 | 10 | 40 |

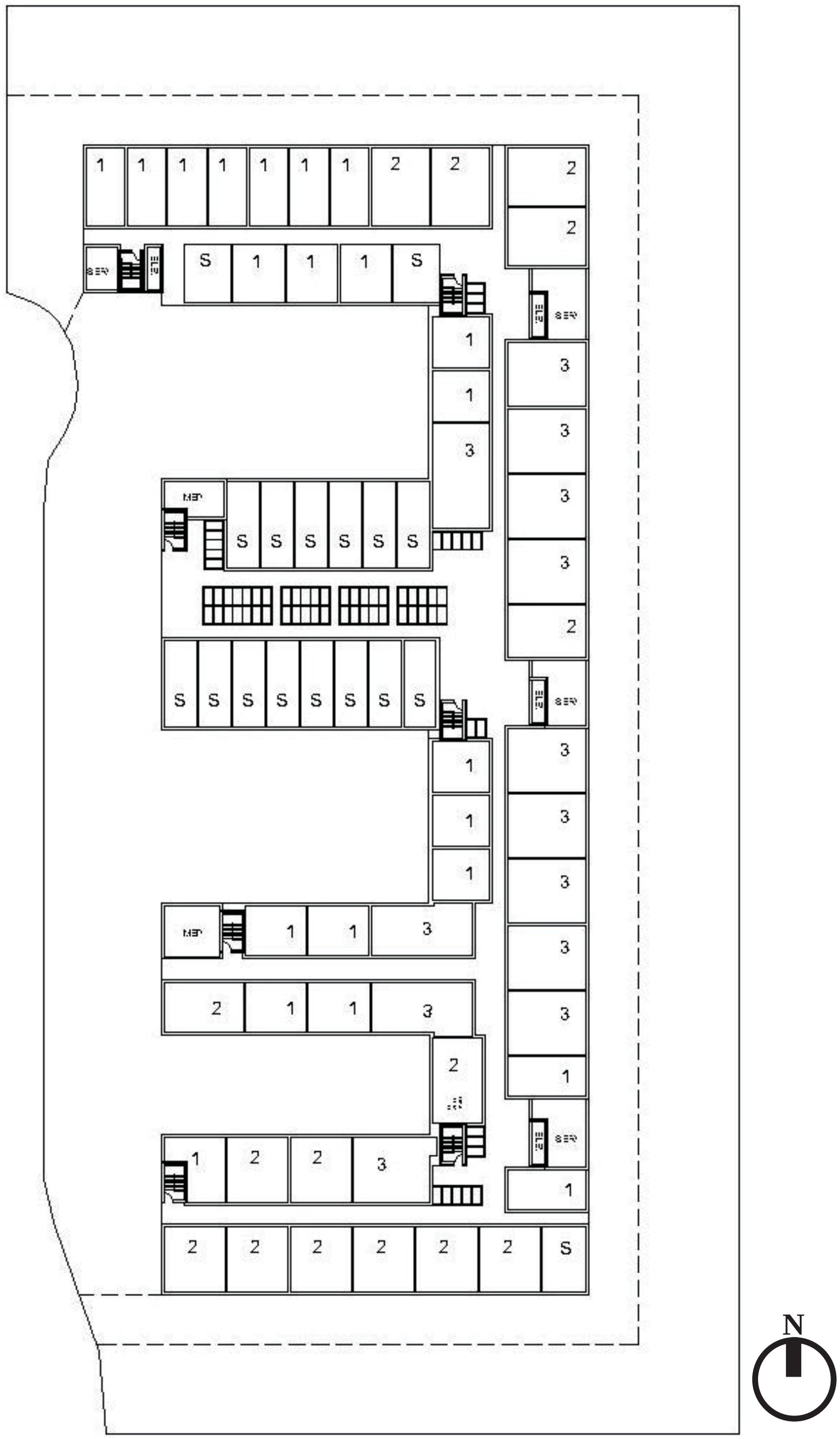
**Scenario A – Santa Ana**

1st Floor Plan

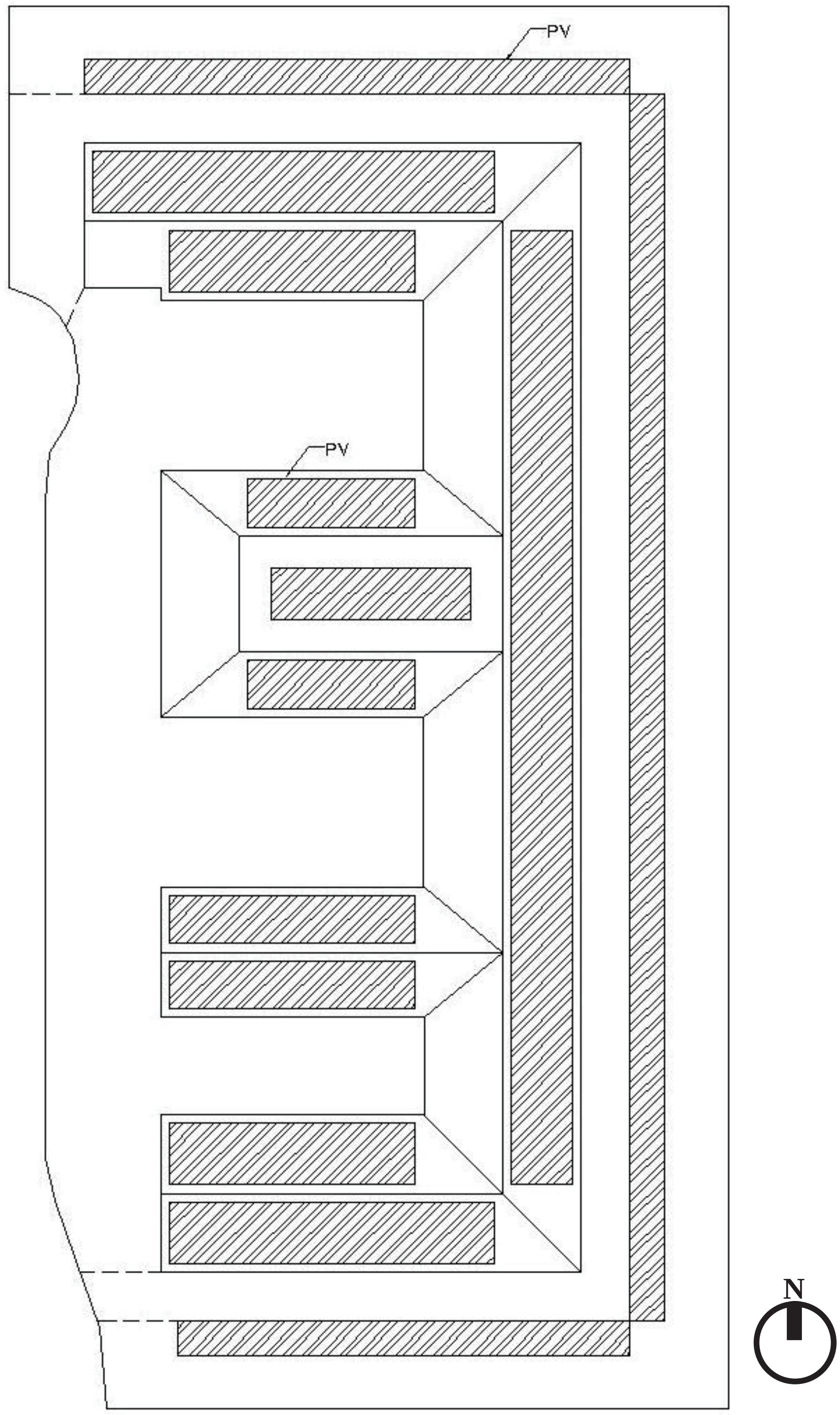
Not to Scale



**Scenario A – Santa Ana**
$2^{nd}$ – $4^{th}$ Floor Plan
Not to Scale



**Scenario A – Santa Ana**
Roof Plan
Not to Scale



**Santa Ana Scenario A: Baseline**

**Unit Summary**

| Unit Type | Number of units | Percentage of Unit |
|---|---|---|
| Studio | 51 | 25% |
| 1 Bedroom | 66 | 33% |
| 2 Bedrooms | 45 | 22% |
| 3 Bedrooms | 39 | 19% |
| Total | 201 | 100% |

| Total Units per floor (2nd-4th) |
|---|
| 17 |
| 22 |
| 15 |
| 13 |
| 67 |

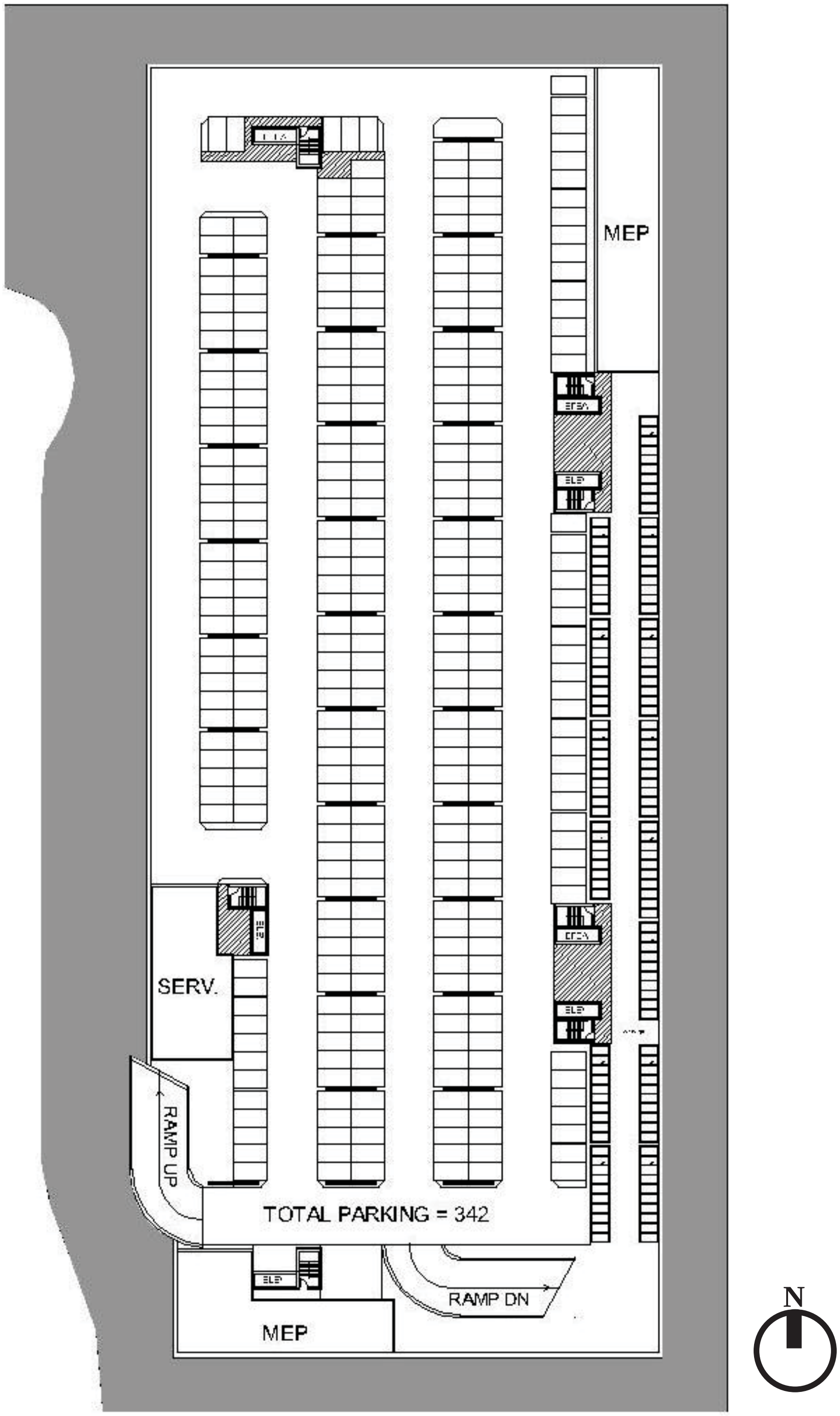
**Site Summary - Ground Level**

| | Area (Sq.ft) | Percentage on site area |
|---|---|---|
| Site Area | 211219 | 100% |
| Buildings | 82071 | 39% |
| Landscape | 84971 | 40% |
| Driveway | 27423 | 13% |

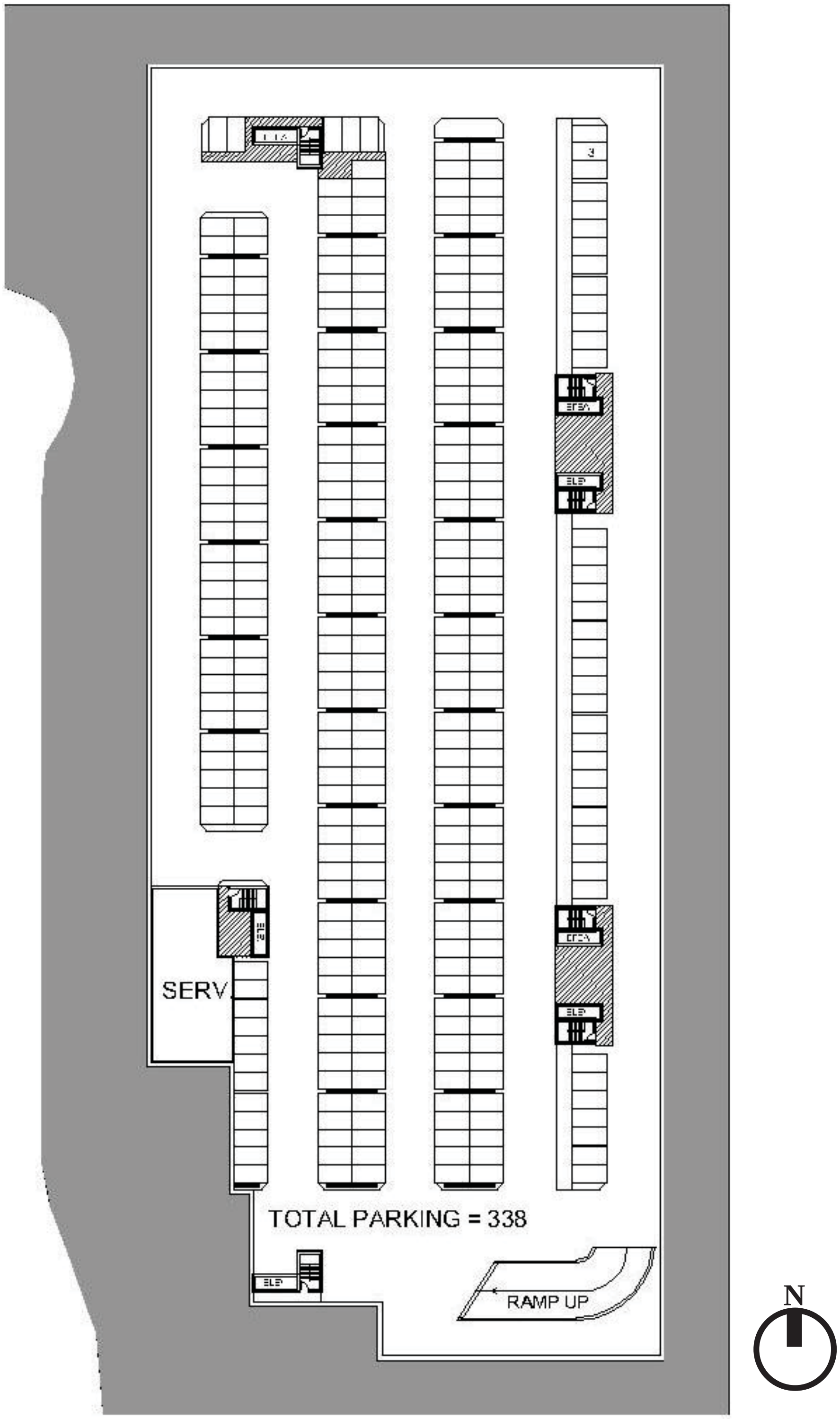
**Parking Summary**

| | Parking Requirement | | | | Model's Result | | |
|---|---|---|---|---|---|---|---|
| Unit Type | Covered | Un-Covered | Visitor | Total | Covered | Un-covered | Total |
| Studio | 51 | 0 | Total Parking Multiply 0.25 | | | | |
| 1 Bedroom | 66 | 0 | | | | | |
| 2 Bedrooms | 45 | 45 | | | | | |
| 3 Bedrooms | 39 | 78 | | | | | |
| Total | 201 | 123 | 81 | 405 | 287 | 118 | 405 |

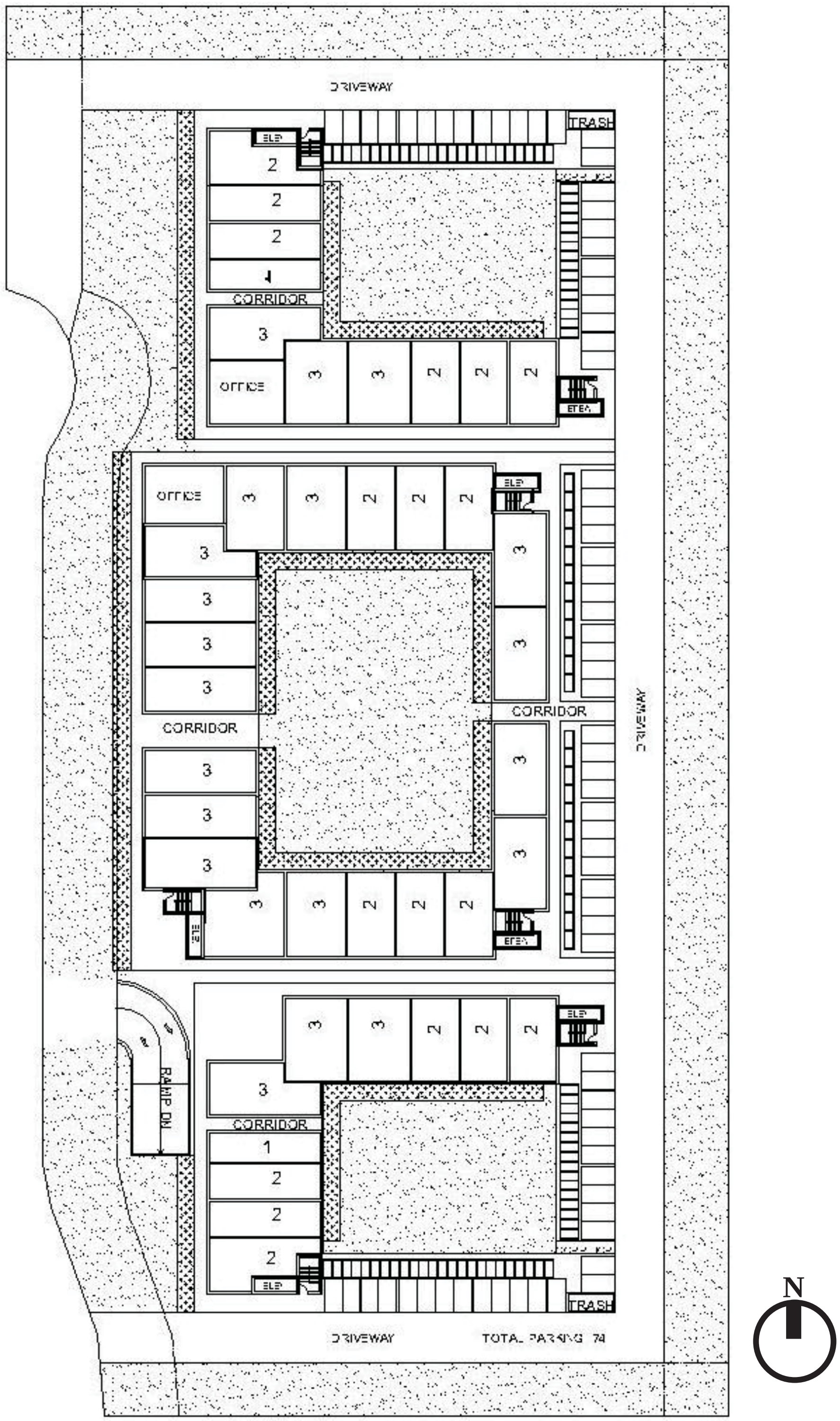
**Scenario B – Santa Ana**
P1 Floor Plan
Not to Scale



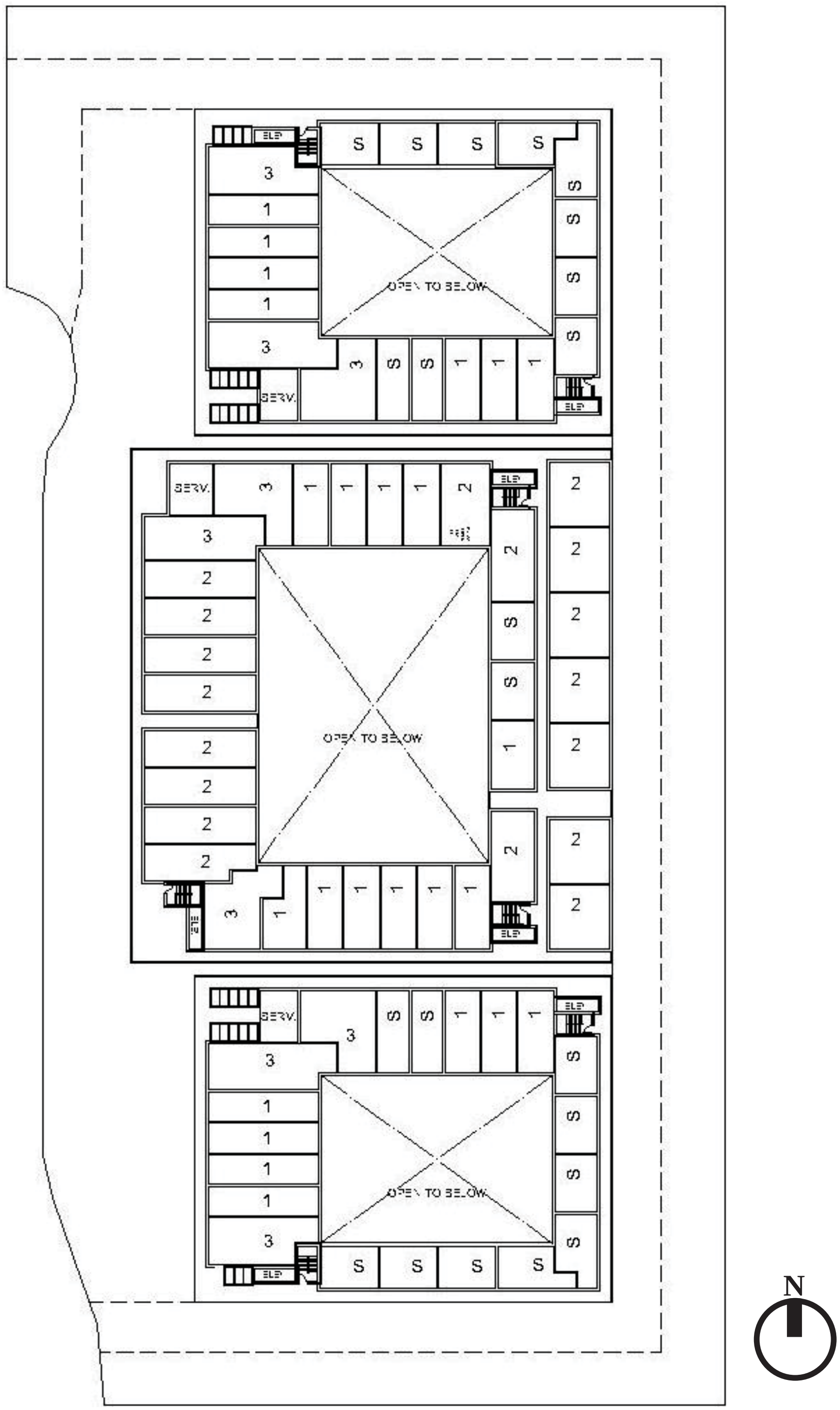
**Scenario B – Santa Ana**
P2 Floor Plan
Not to Scale



**Scenario B – Santa Ana**
1st Floor Plan
Not to Scale



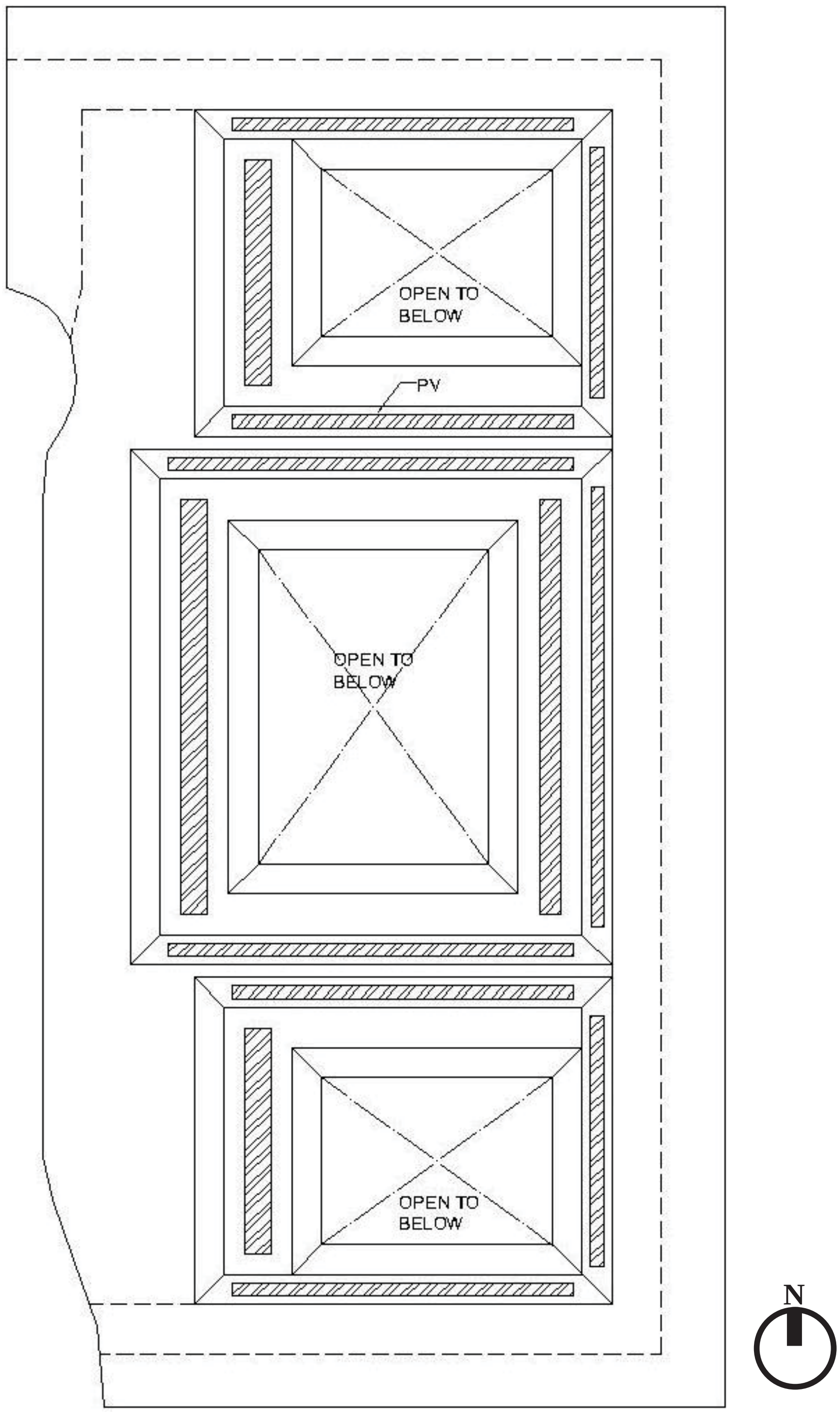
**Scenario B – Santa Ana**
2nd – 5th Floor Plan
Not to Scale



**Scenario B – Santa Ana**

Roof Plan

Not to Scale



**Santa Ana Scenario B: Subterranean Parking**

**Unit Summary**

| Unit Type | Number of units | Percentage of Unit |
|---|---|---|
| Studio | 88 | 26% |
| 1 Bedroom | 102 | 30% |
| 2 Bedrooms | 90 | 27% |
| 3 Bedrooms | 57 | 17% |
| Total | 337 | 100% |

| Total Units per floor (2nd-5th) | Total Units on 1st floor |
|---|---|
| 22 | 0 |
| 25 | 2 |
| 18 | 18 |
| 9 | 21 |
| 74 | 41 |

**Site Summary - Ground Level**

| | Area (Sq.ft) | Percentage on site area |
|---|---|---|
| Site Area | 211219 | 100% |
| Buildings | 80547 | 38% |
| Landscape | 93709 | 44% |
| Driveway | 29421 | 14% |

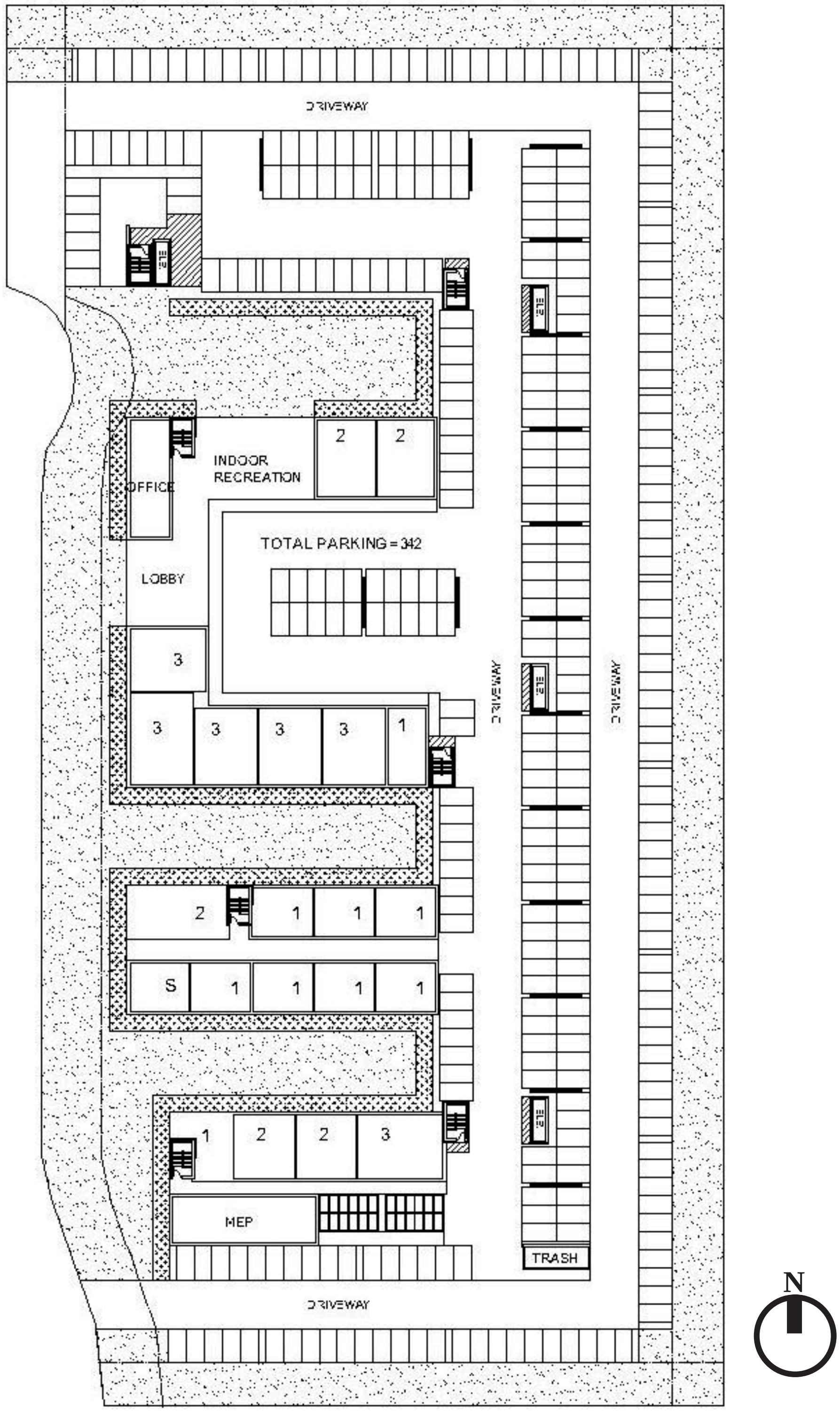
**Parking Summary**

| | Parking Requirement | | | | Model's Result | | |
|---|---|---|---|---|---|---|---|
| Unit Type | Covered | Un-Covered | Visitor | Total | Covered | Un-covered | Total |
| Studio | 88 | 0 | Total Parking Multiply 0.25 | | P1, P2, 1ST | | |
| 1 Bedroom | 102 | 0 | | | | | |
| 2 Bedrooms | 90 | 90 | | | | | |
| 3 Bedrooms | 57 | 114 | | | | | |
| Total | 337 | 204 | 135.25 | 676 | 754 | 0 | 754 |

**Scenario C – Santa Ana**

1st Floor Plan

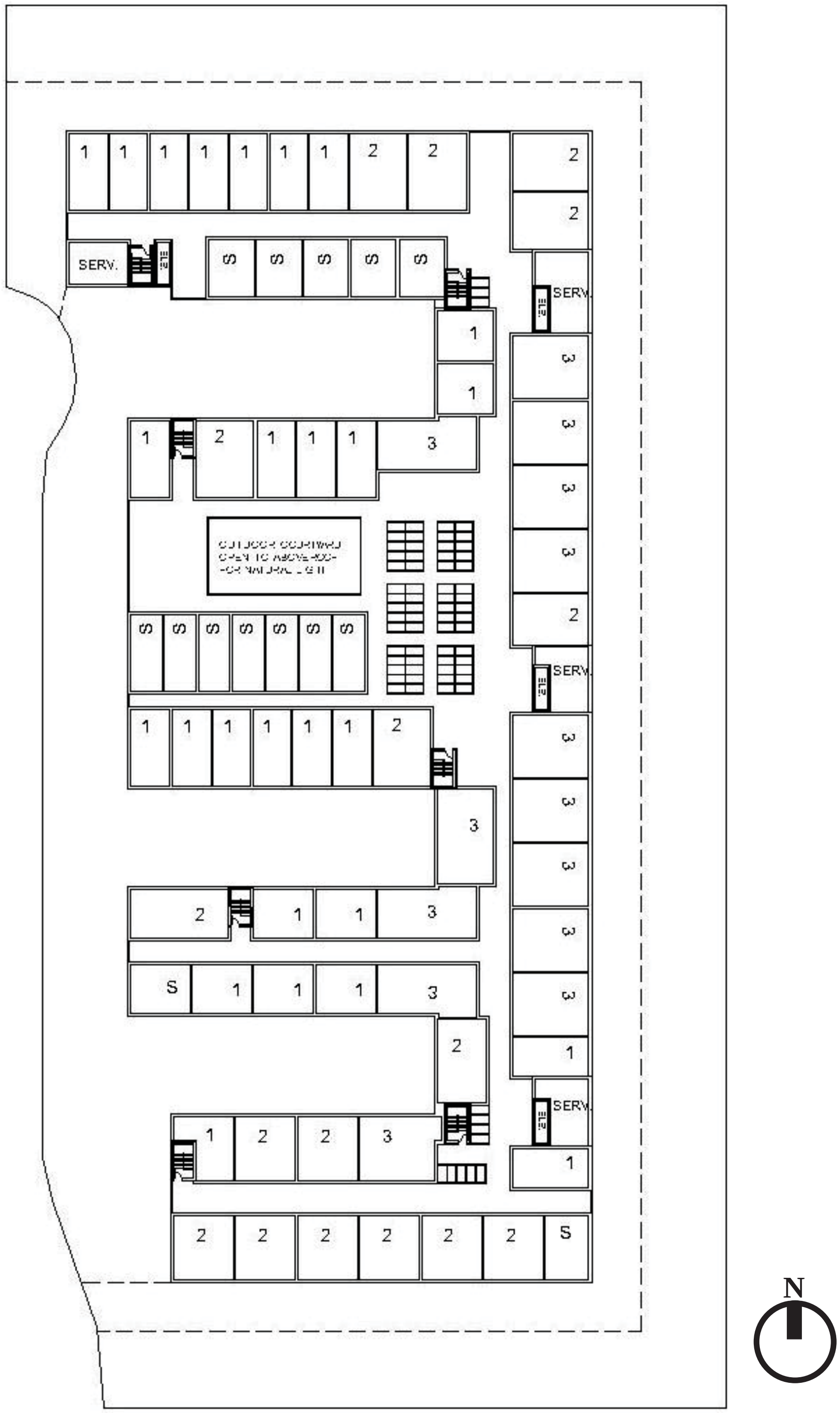
Not to Scale



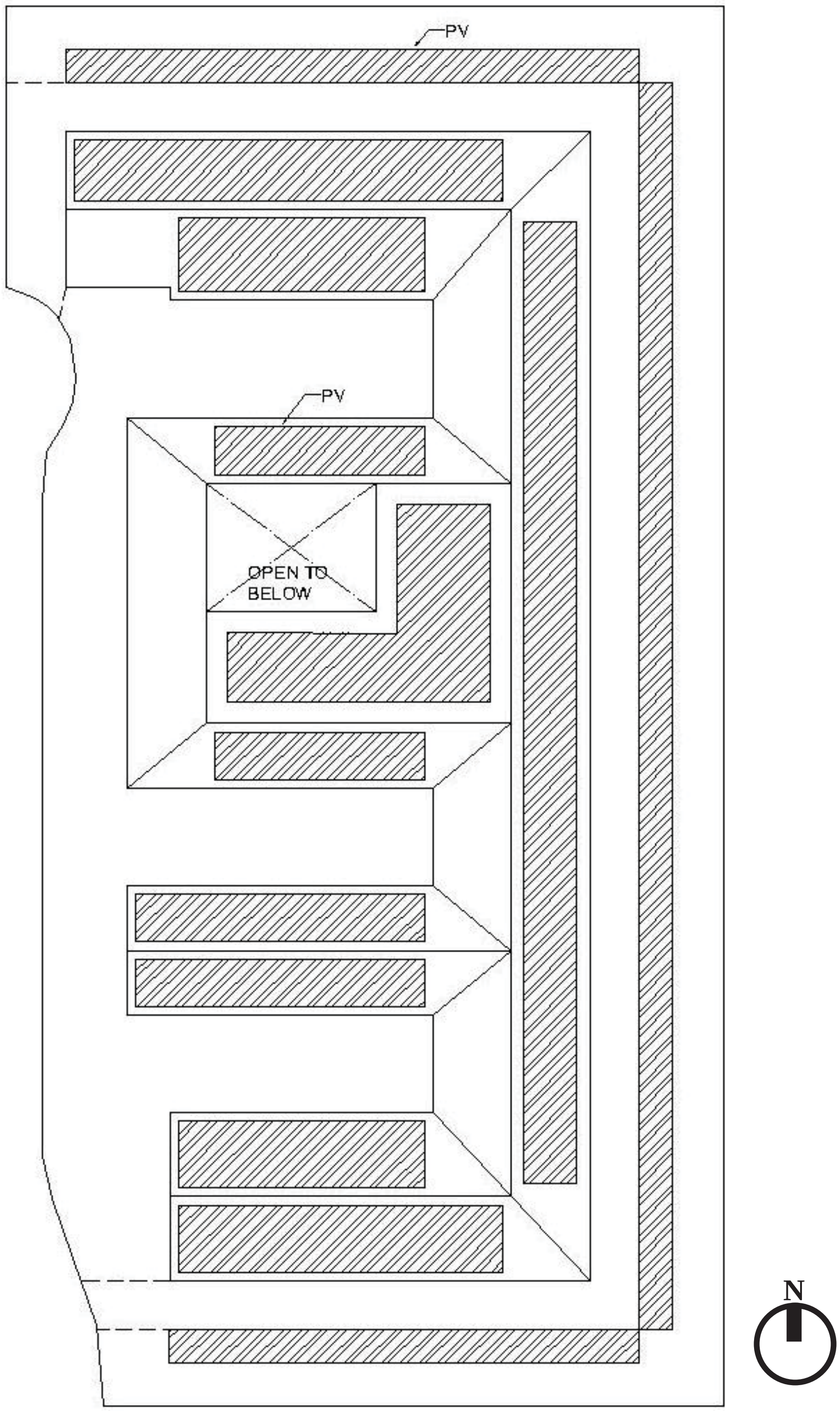
**Scenario C – Santa Ana**

$2^{nd}$ – $4^{th}$ Floor Plan

Not to Scale



**Scenario C – Santa Ana**
Roof Plan
Not to Scale



## Santa Ana Scenario C: Density Bonus

### Unit Summary

| Unit Type | Number of units | Percentage of Unit |
|---|---|---|
| Studio | 43 | 18% |
| 1 Bedroom | 90 | 38% |
| 2 Bedrooms | 56 | 24% |
| 3 Bedrooms | 48 | 20% |
| Total | 237 | 100% |

| Total Units on 2nd - 4th floors | Total Units on 1st floor |
|---|---|
| 42 | 1 |
| 81 | 9 |
| 51 | 5 |
| 42 | 6 |
| 216 | 21 |

### Site Summary - Ground Level

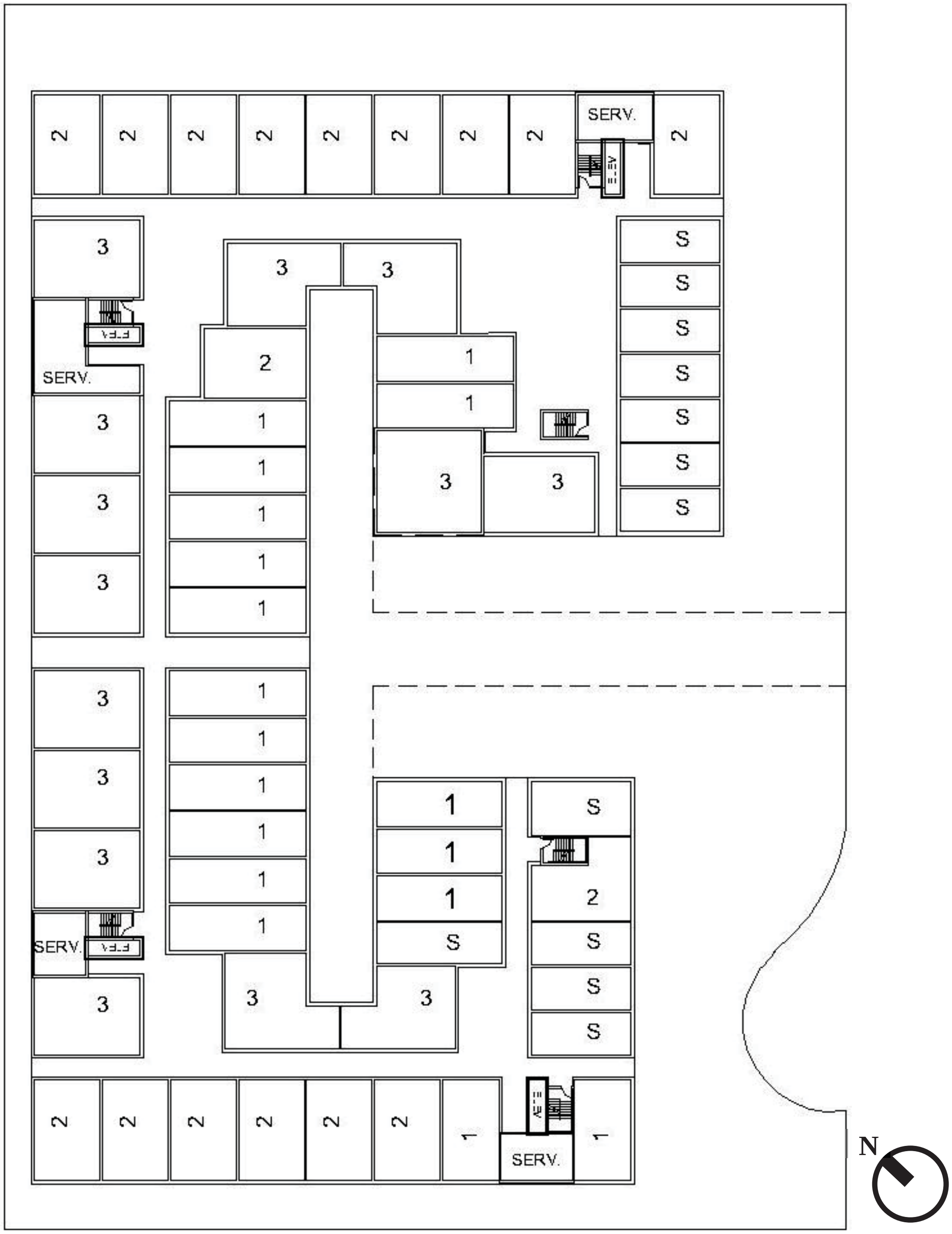
| | Area (Sq.ft) | Percentage on site area |
|---|---|---|
| Site Area | 211219 | 100% |
| Buildings | 97153 | 46% |
| Landscape | 69352 | 33% |
| Driveway | 27507 | 13% |

### Parking Summary

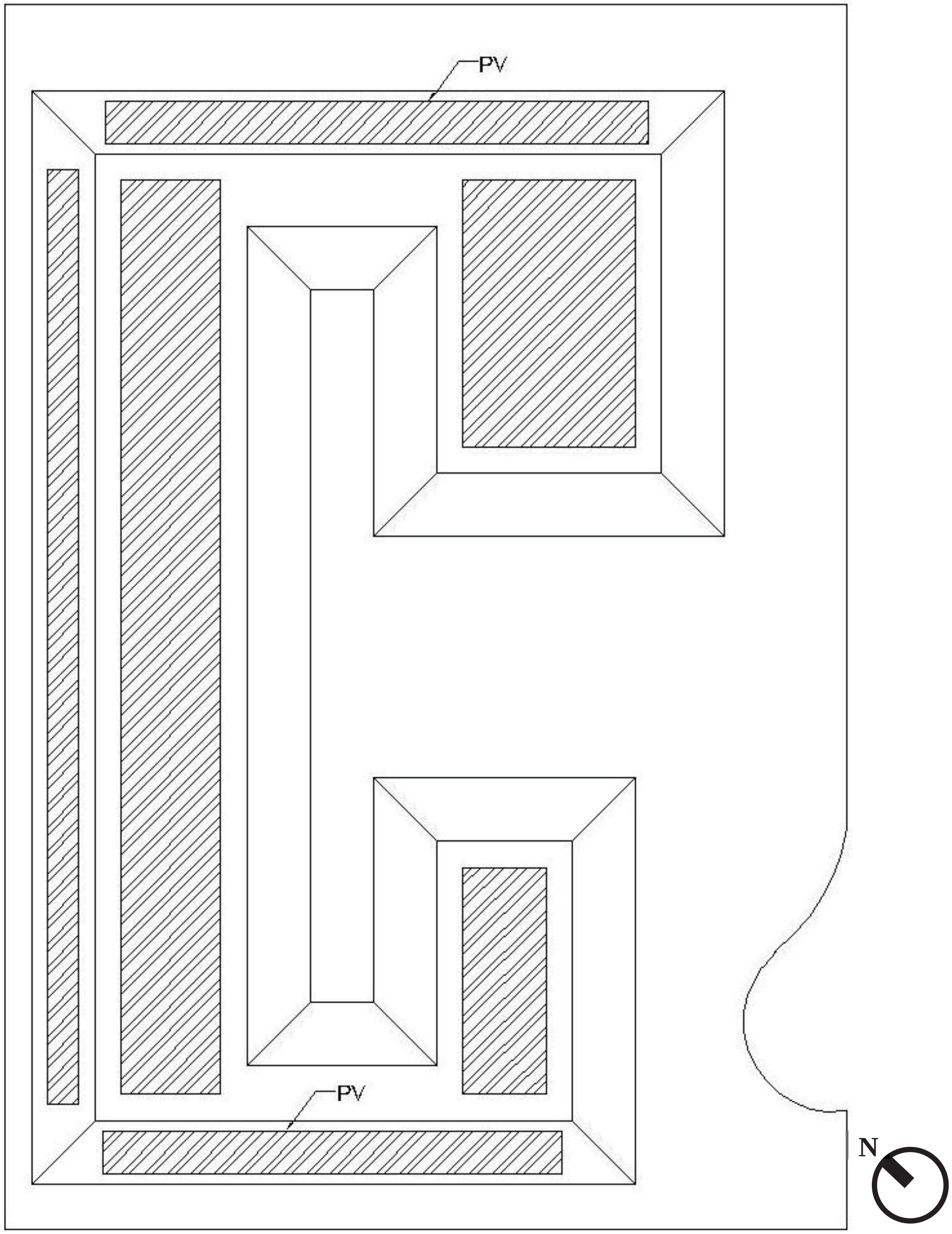
| | Parking Requirement | | | | Model's Result | | |
|---|---|---|---|---|---|---|---|
| Unit Type | Covered | Un-Covered | Visitor | Total | Covered | Un-covered | Total |
| Studio | 43 | 0 | No Addition | | Including Solar Carport | | |
| 1 Bedroom | 90 | 0 | | | | | |
| 2 Bedrooms | 56 | 56 | | | | | |
| 3 Bedrooms | 48 | 48 | | | | | |
| Total | 237 | 104 | 0 | 341 | 342 | 0 | 342 |

**Scenario A – Irvine**
1st Floor Plan
Not to Scale

**Scenario A – Irvine**
$2^{nd}$ – $3^{rd}$ Plan
Not to Scale



**Scenario A – Irvine**
Roof Plan
Not to Scale



**Irvine Scenario A:Baseline**

**Unit Summary**

| Unit Type | Number of units | Percentage of Unit |
|---|---|---|
| Studio | 28 | 22% |
| 1 Bedroom | 38 | 29% |
| 2 Bedrooms | 36 | 28% |
| 3 Bedrooms | 28 | 22% |
| Total | 130 | 100% |

| Total Units on 2nd - 3rd floors | Total Units on 1st floor |
|---|---|
| 24 | 4 |
| 36 | 2 |
| 34 | 2 |
| 28 | 0 |
| 122 | 8 |

**Site Summary - Ground Level**

| | Area (Sq.ft) | Percentage on site area |
|---|---|---|
| Site Area | 148722 | 100% |
| Buildings | 85351 | 57% |
| Landscape | 44988 | 30% |
| Driveway | 11523 | 8% |

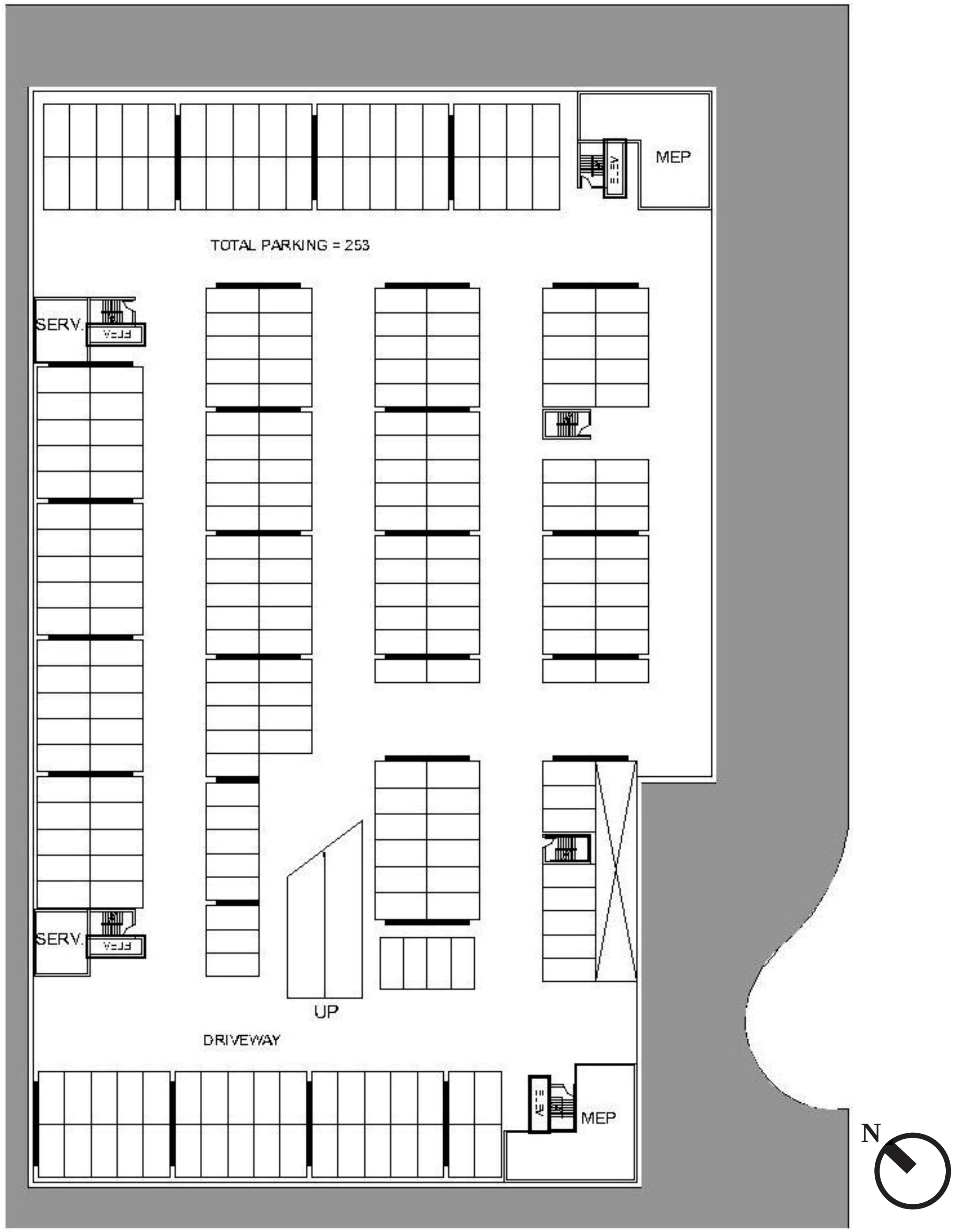
**Parking Summary**

| | Parking Requirement | | | | Model's Result | | |
|---|---|---|---|---|---|---|---|
| Unit Type | Covered | Un-Covered | Visitor | Total | Covered | Un-covered | Total |
| Studio | 28 | 0 | 1 stall per 4 unit | | | | |
| 1 Bedroom | 38 | 15.2 | | | | | |
| 2 Bedrooms | 36 | 21.6 | | | | | |
| 3 Bedrooms | 28 | 28 | | | | | |
| Total | 130 | 64.8 | 32.5 | 227 | 201 | 26 | 227 |

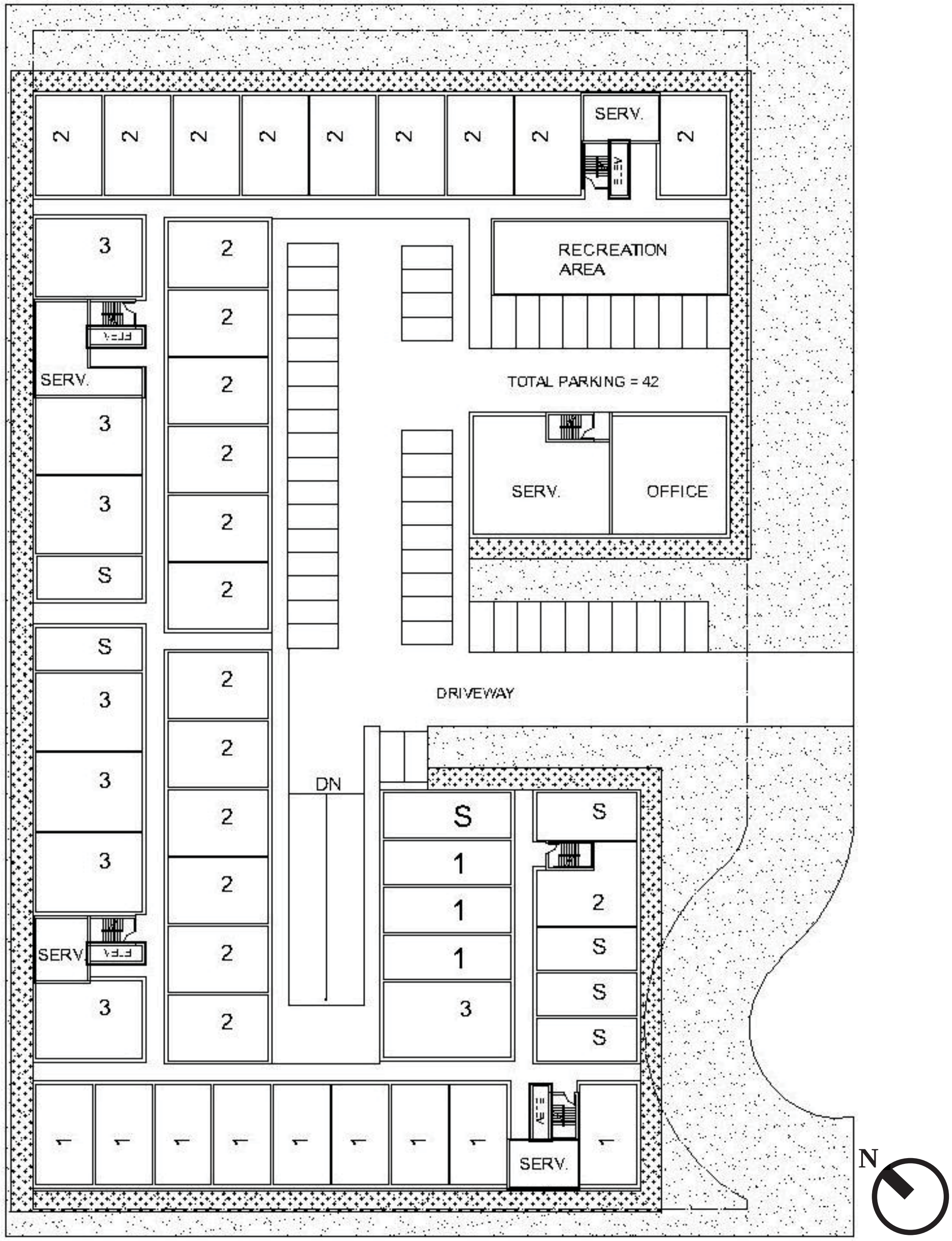
**Scenario B – Irvine**

P1 Floor Plan

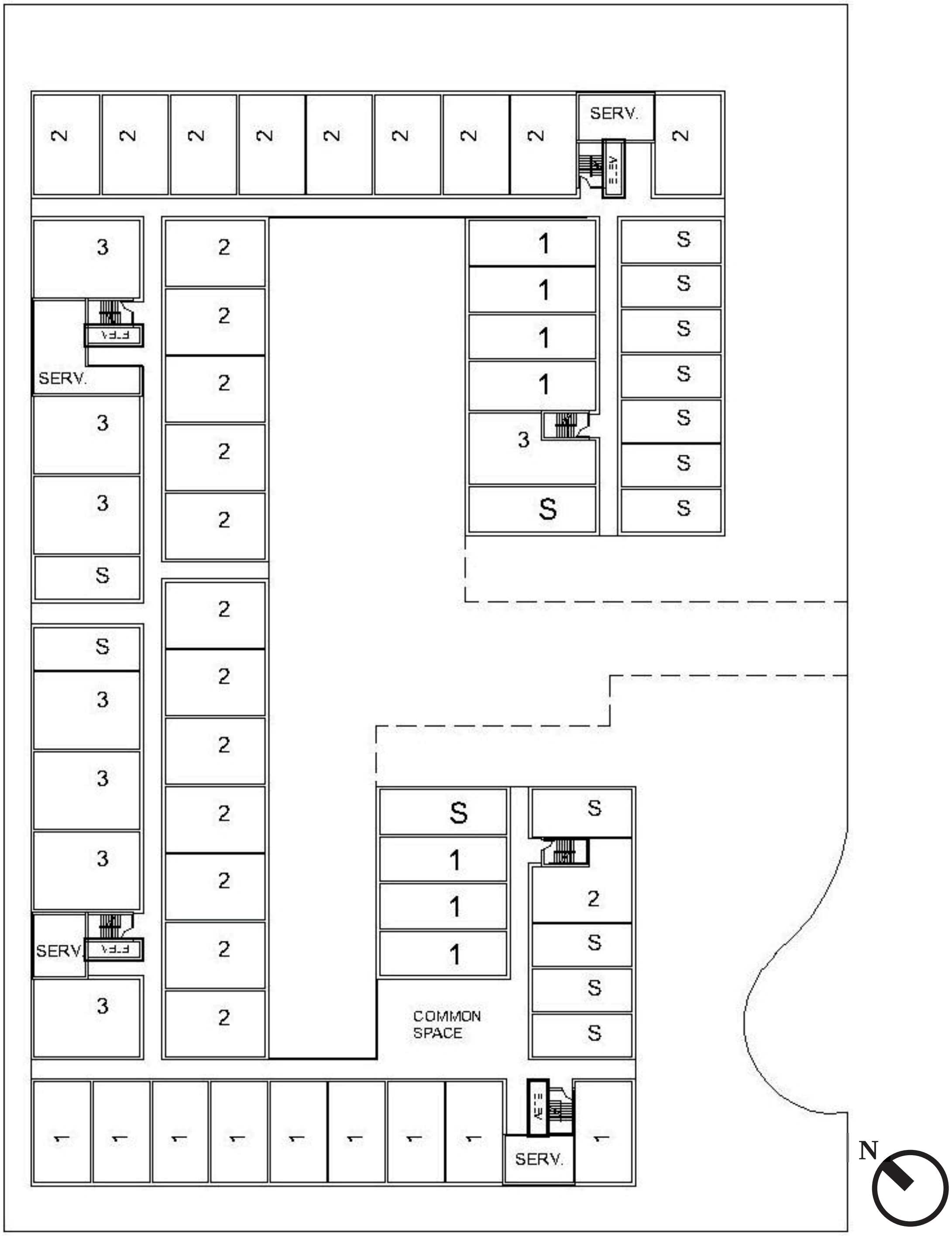
Not to Scale



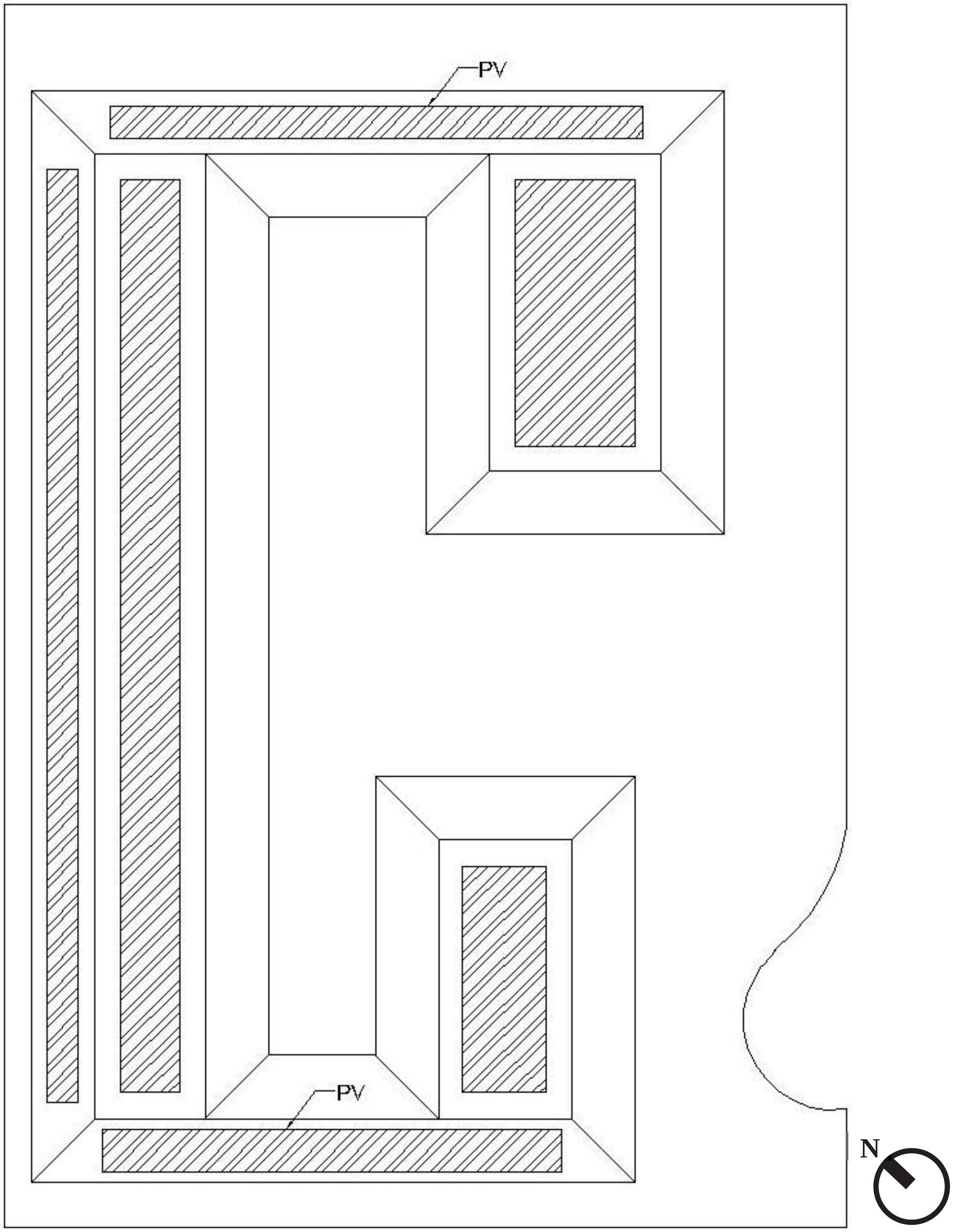
**Scenario B – Irvine**
1st Floor Plan
Not to Scale



**Scenario B – Irvine**
$2^{nd}$ – $3^{rd}$ Floor Plan
Not to Scale



**Scenario B – Irvine**
Roof Plan
Not to Scale



**Irvine Scenario B: Subterranean Parking**

**Unit Summary**

| Unit Type | Number of units | Percentage of Unit | Total Units on 2nd - 3rd floors | Total Units on 1st floor |
|---|---|---|---|---|
| Studio | 37 | 22% | 30 | 7 |
| 1 Bedroom | 44 | 26% | 32 | 12 |
| 2 Bedrooms | 66 | 39% | 44 | 22 |
| 3 Bedrooms | 24 | 14% | 16 | 8 |
| Total | 171 | 100% | 122 | 49 |

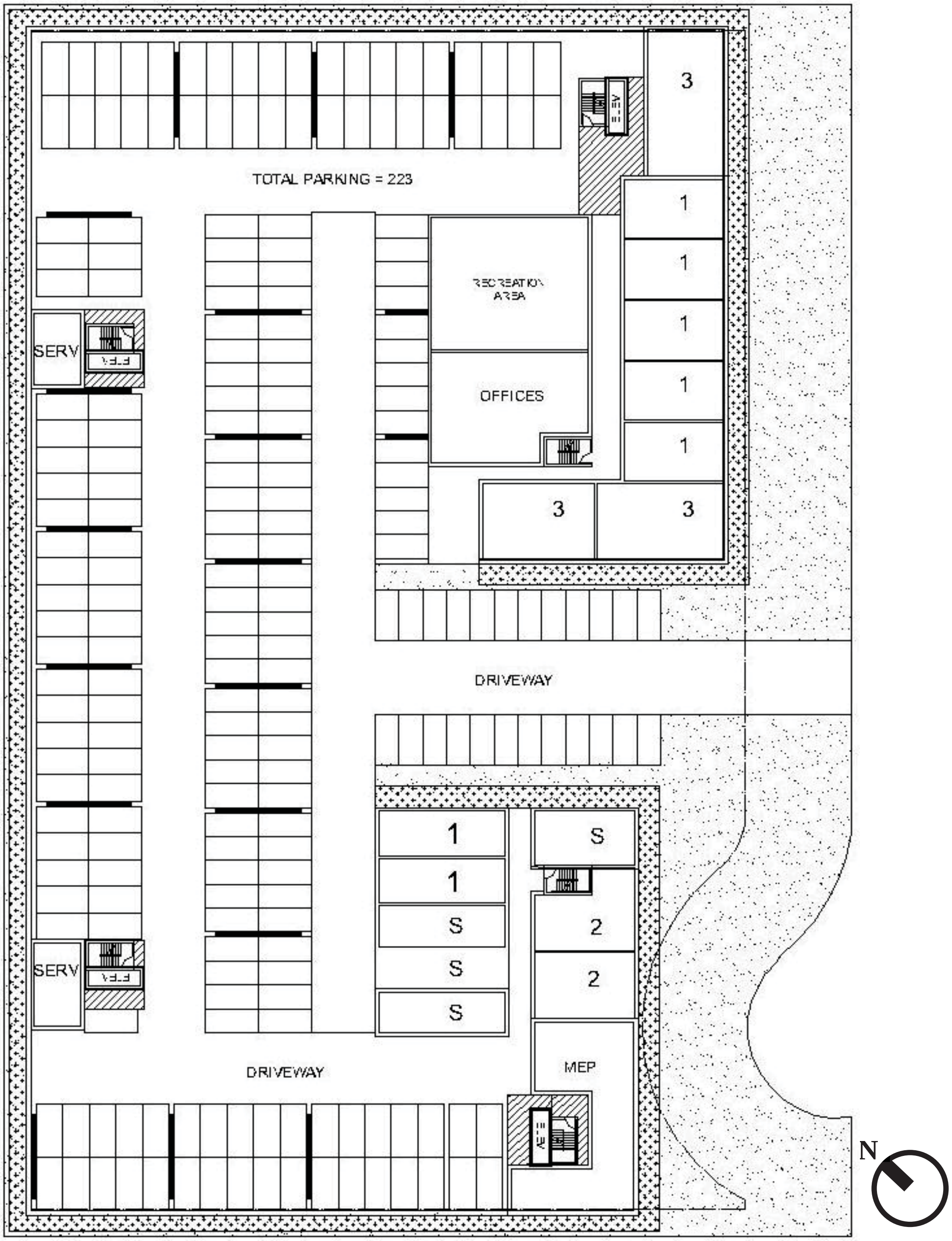
**Site Summary - Ground Level**

| | Area (Sq.ft) | Percentage on site area |
|---|---|---|
| Site Area | 148722 | 100% |
| Buildings | 74528 | 50% |
| Landscape | 45326 | 30% |
| Driveway | 18779 | 13% |

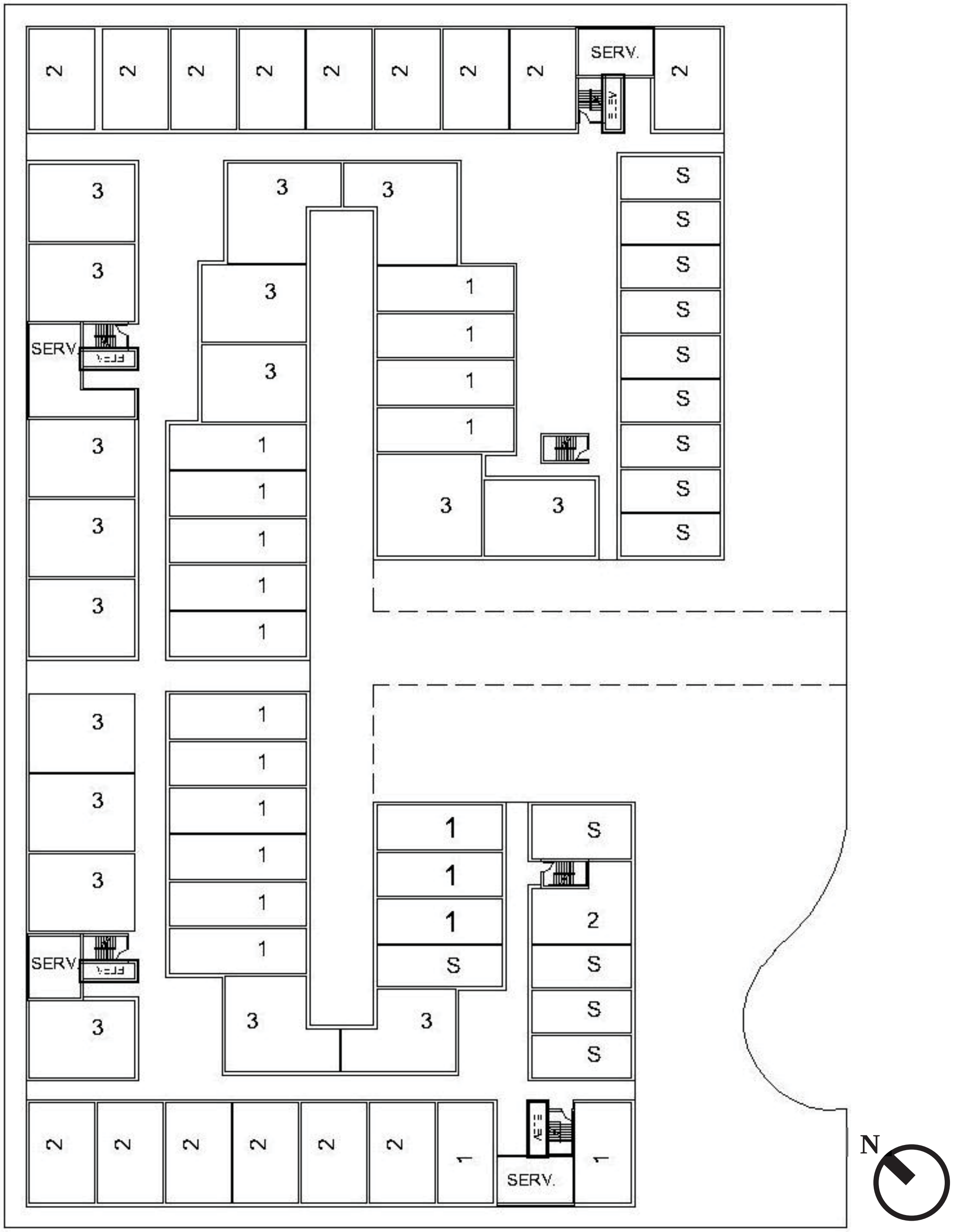
**Parking Summary**

| | Parking Requirement | | | | Model's Result | | |
|---|---|---|---|---|---|---|---|
| Unit Type | Covered | Un-Covered | Visitor | Total | Covered | Un-covered | Total |
| Studio | 37 | 0 | 1 stall per 4 unit | | | | |
| 1 Bedroom | 44 | 17.6 | | | | | |
| 2 Bedrooms | 66 | 39.6 | | | | | |
| 3 Bedrooms | 24 | 24 | | | | | |
| Total | 171 | 81.2 | 42.75 | 295 | 253 | 42 | 295 |

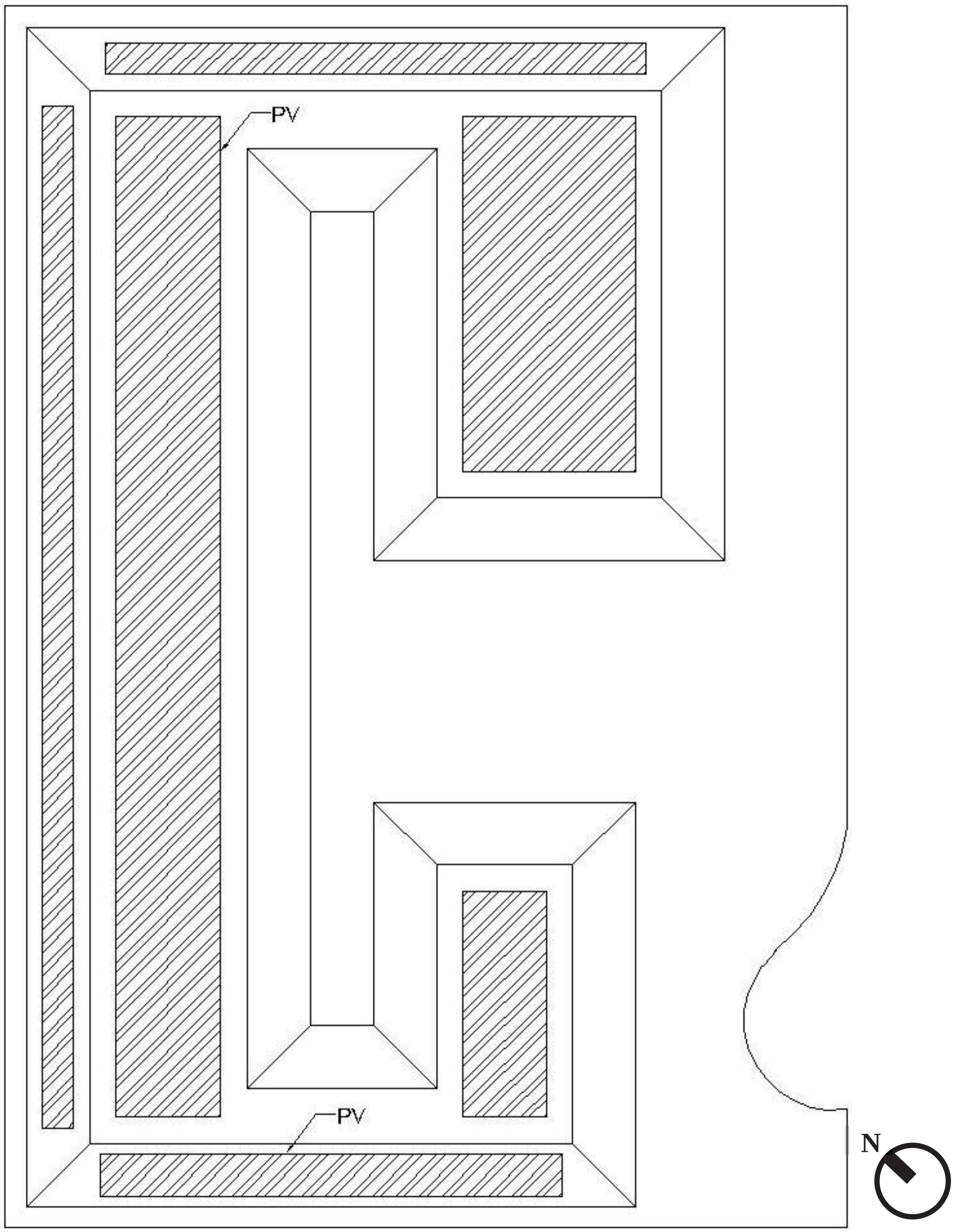
**Scenario C – Irvine**
1st Floor Plan
Not to Scale



**Scenario C – Irvine**
$2^{nd}$ – $3^{rd}$ Plan
Not to Scale



**Scenario C – Irvine**
Roof Plan
Not to Scale



## Irvine Scenario C: Density Bonus

### Unit Summary

| Unit Type | Number of units | Percentage of Unit |
|---|---|---|
| Studio | 32 | 21% |
| 1 Bedroom | 47 | 31% |
| 2 Bedrooms | 34 | 23% |
| 3 Bedrooms | 37 | 25% |
| Total | 150 | 100% |

| Total Units on 2nd - 3rd floors | Total Units on 1st floor |
|---|---|
| 28 | 4 |
| 40 | 7 |
| 32 | 2 |
| 34 | 3 |
| 134 | 16 |

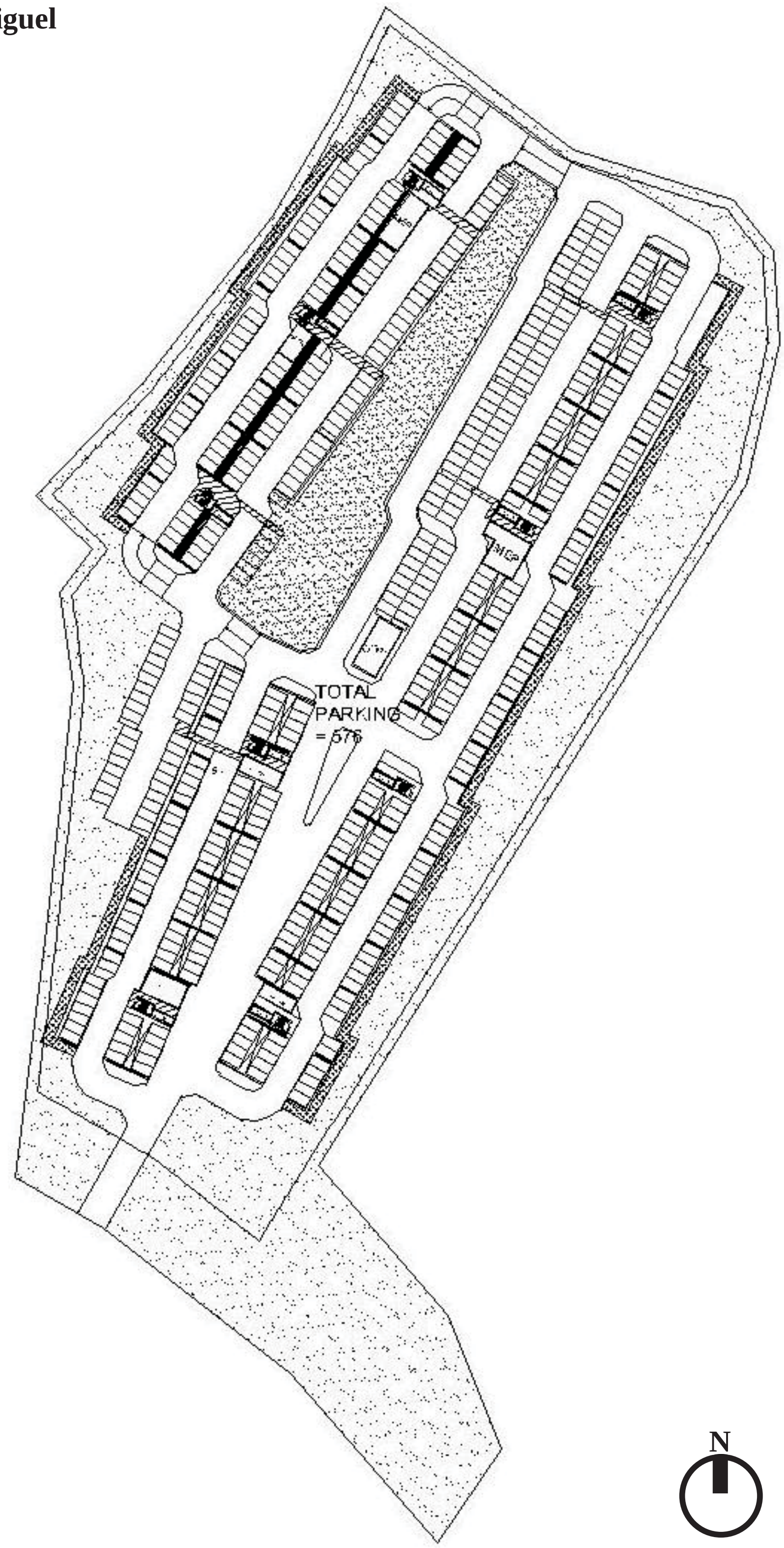
### Site Summary - Ground Level

| | Area (Sq.ft) | Percentage on site area |
|---|---|---|
| Site Area | 148722 | 100% |
| Buildings | 94238 | 63% |
| Landscape | 35456 | 24% |
| Driveway | 12476 | 8% |

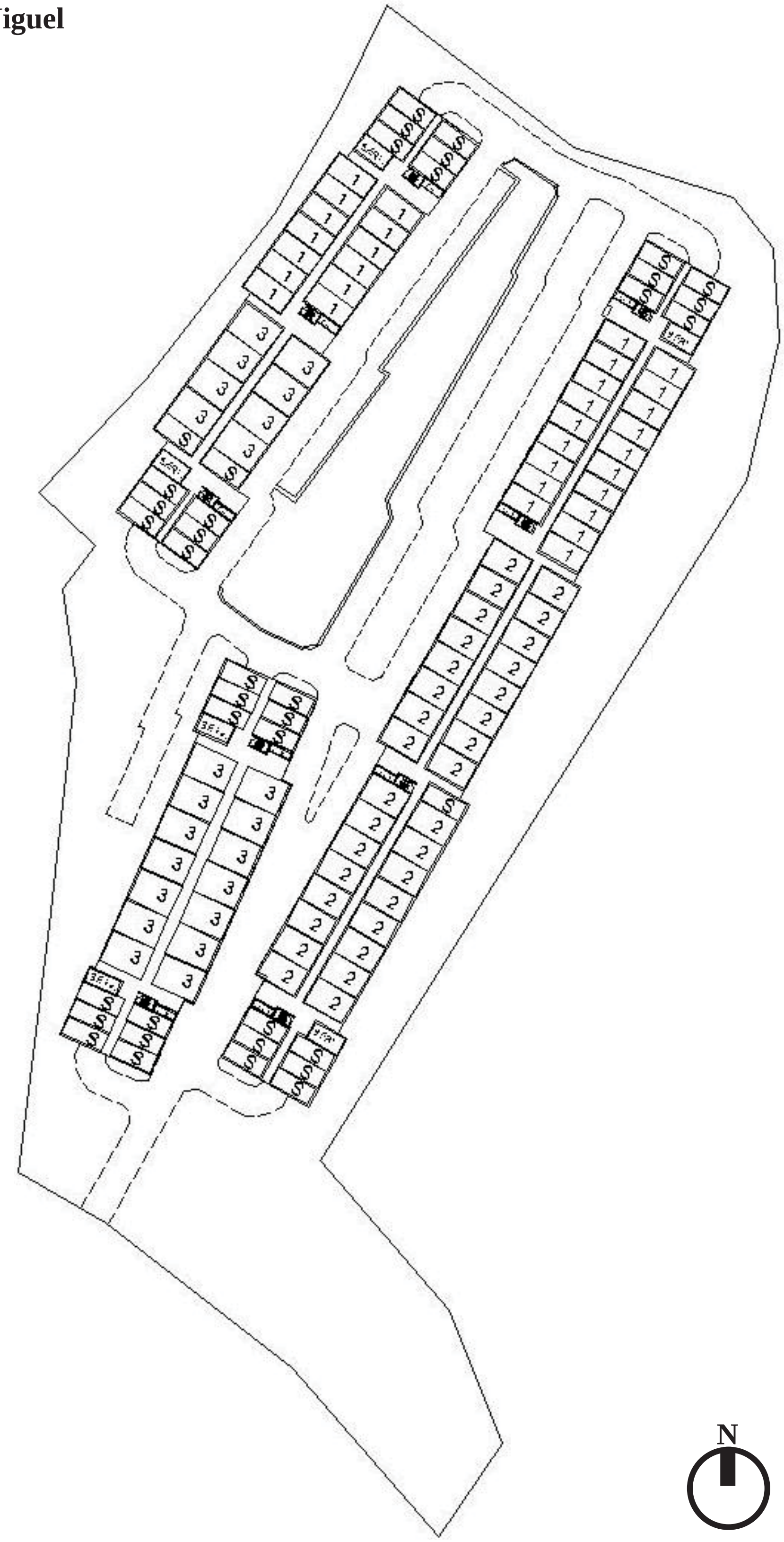
### Parking Summary

| | Parking Requirement | | | | Model's Result | | |
|---|---|---|---|---|---|---|---|
| Unit Type | Covered | Un-Covered | Visitor | Total | Covered | Un-covered | Total |
| Studio | 32 | 0 | No Addition | | | | |
| 1 Bedroom | 47 | 0 | | | | | |
| 2 Bedrooms | 34 | 34 | | | | | |
| 3 Bedrooms | 37 | 37 | | | | | |
| Total | 150 | 71 | 0 | 221 | 199 | 24 | 223 |

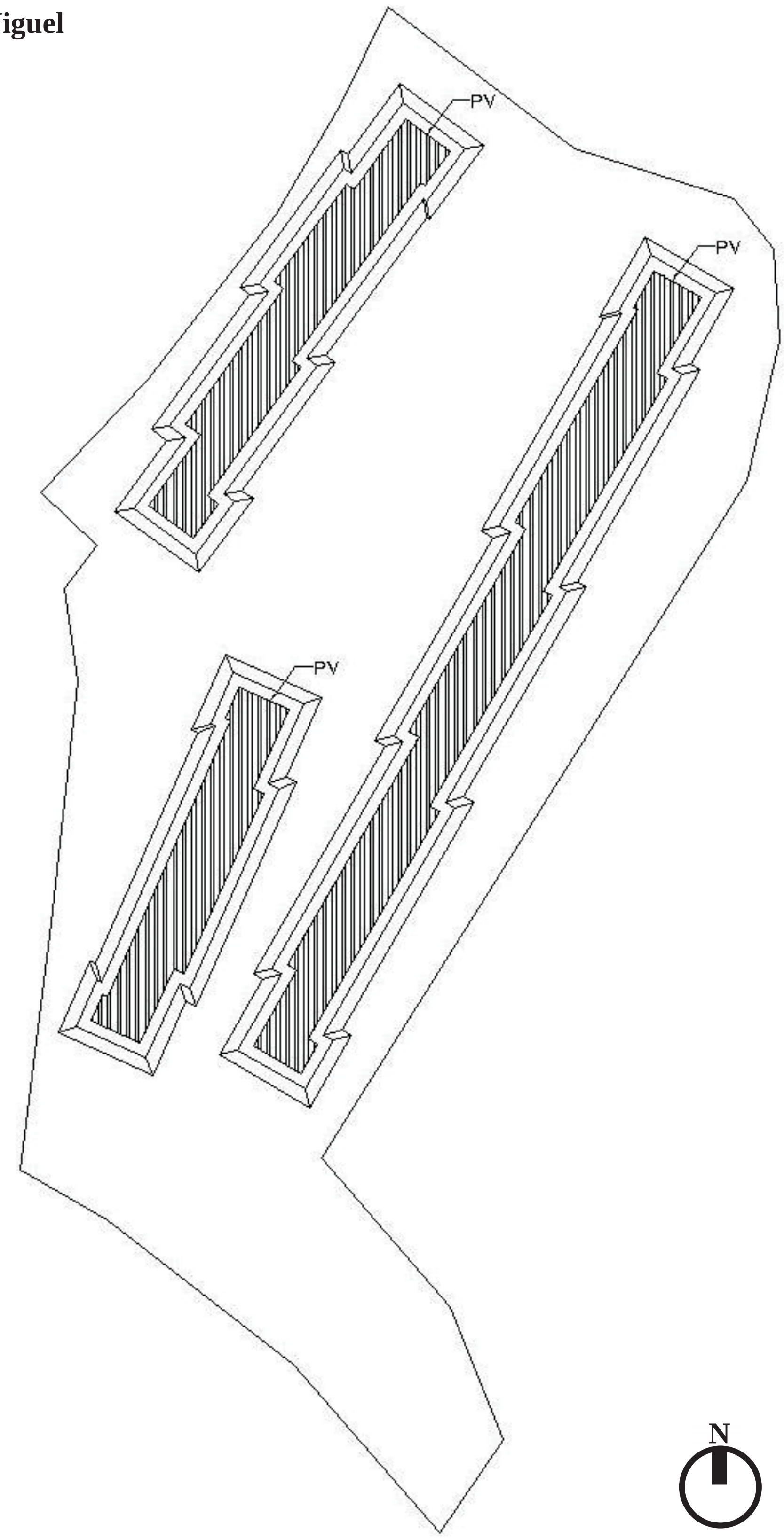
**Scenario A – Laguna Niguel**
1st Floor Plan
Not to Scale



**Scenario A – Laguna Niguel**
$2^{nd}$ – $3^{rd}$ Floor Plan
Not to Scale



**Scenario A – Laguna Niguel**
Roof Plan
Not to Scale



**Laguna Niguel Scenario A: Baseline**

**Unit Summary**

| Unit Type | Number of units | Percentage of Unit |
|---|---|---|
| Studio | 78 | 31% |
| 1 Bedroom | 64 | 26% |
| 2 Bedrooms | 64 | 26% |
| 3 Bedrooms | 44 | 18% |
| Total | 250 | 100% |

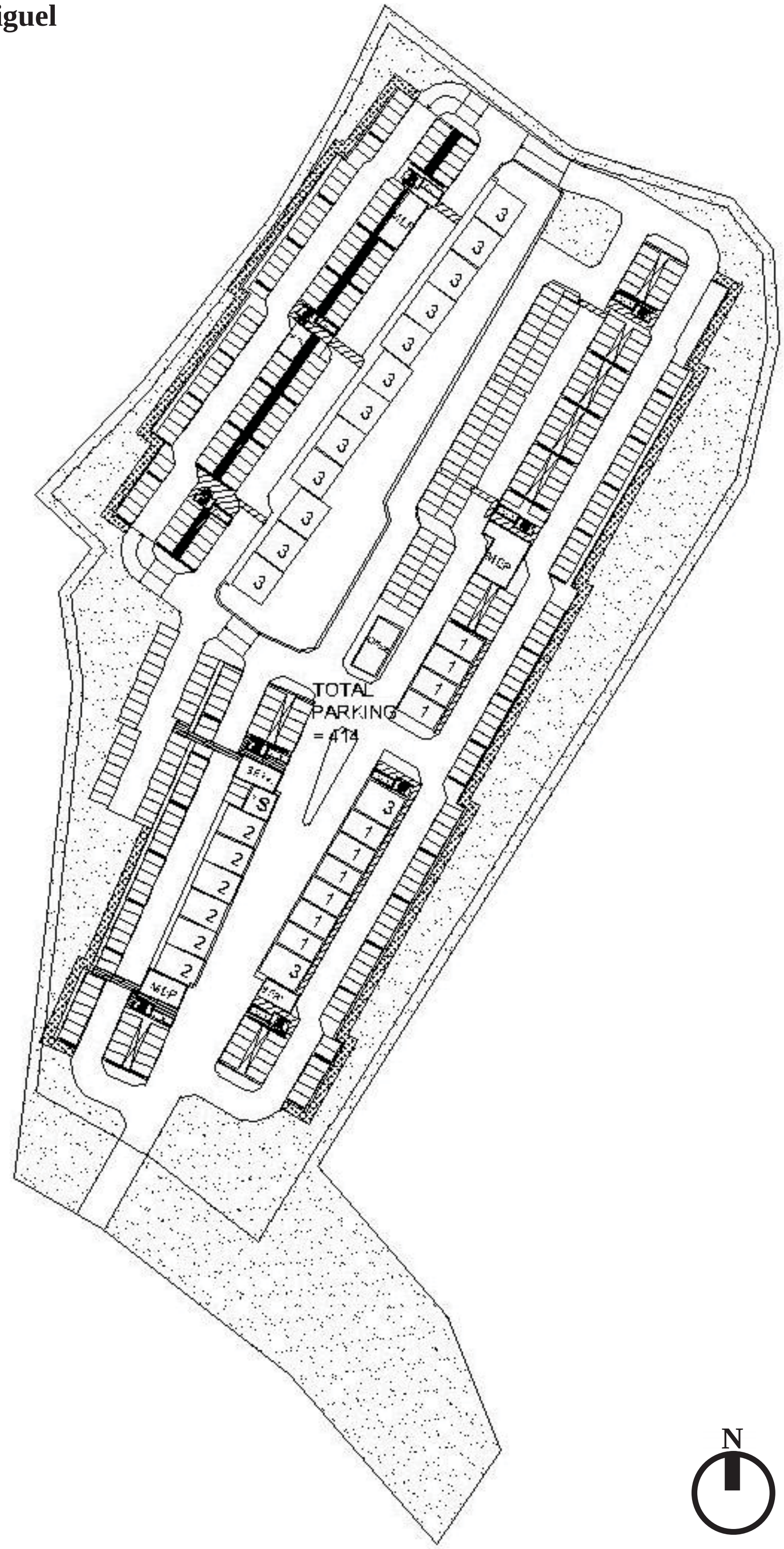
**Site Summary - Ground Level**

| | Area (Sq.ft) | Percentage on site area |
|---|---|---|
| Site Area | 471,918 | 100% |
| Buildings | 156035 | 33% |
| Landscape | 201,131 | 43% |
| Driveway | 95723 | 20% |

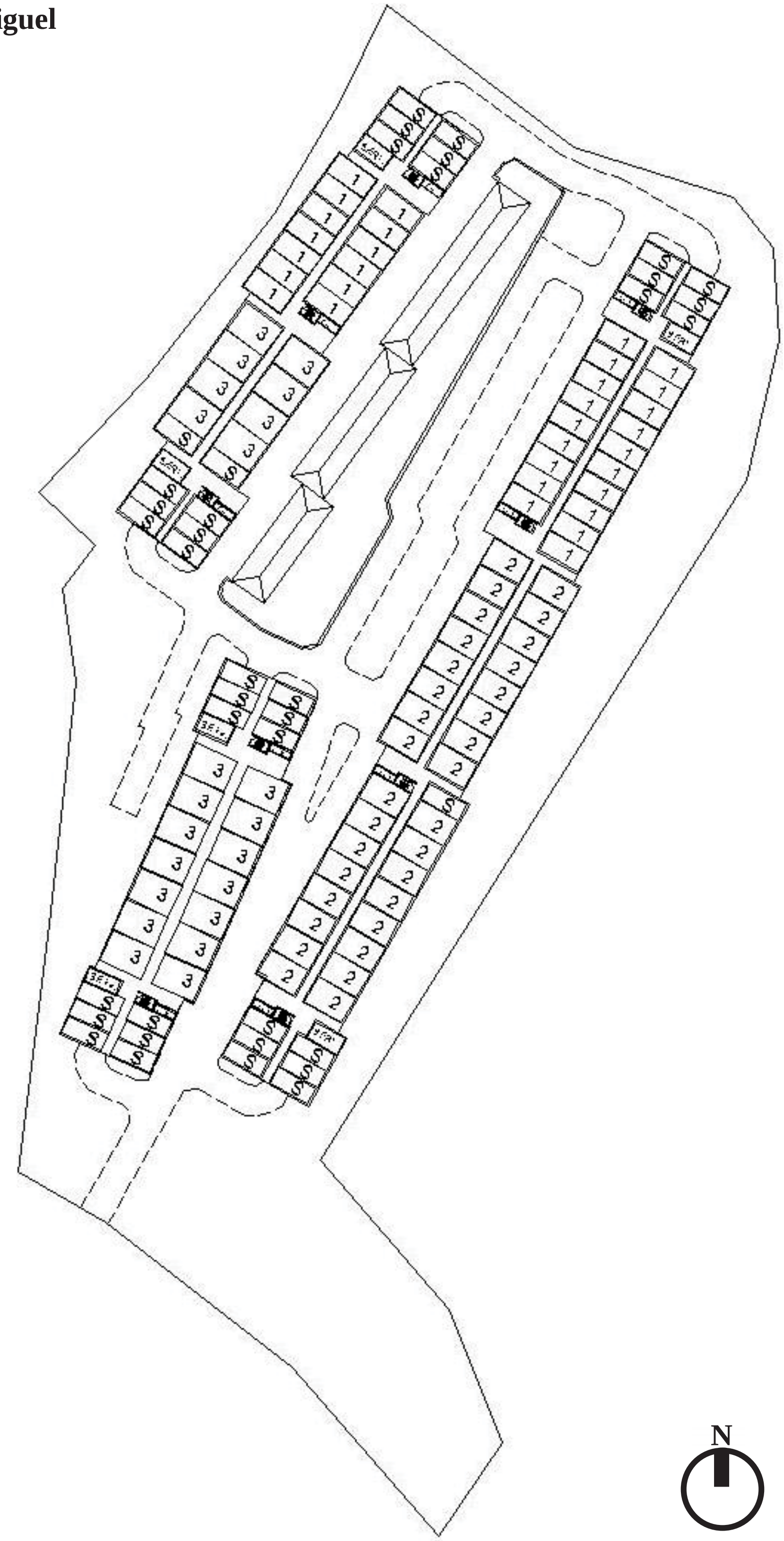
**Parking Summary**

| | Parking Requirement | | | | Model's Result | | |
|---|---|---|---|---|---|---|---|
| Unit Type | Covered | Un-Covered | Visitor | Total | Covered | Un-covered | Total |
| Studio | 78 | 39 | 0.5 stall per unit | | | | |
| 1 Bedroom | 64 | 32 | | | | | |
| 2 Bedrooms | 64 | 64 | | | | | |
| 3 Bedrooms | 88 | 22 | | | | | |
| Total | 294 | 157 | 125 | 576 | 418 | 158 | 576 |

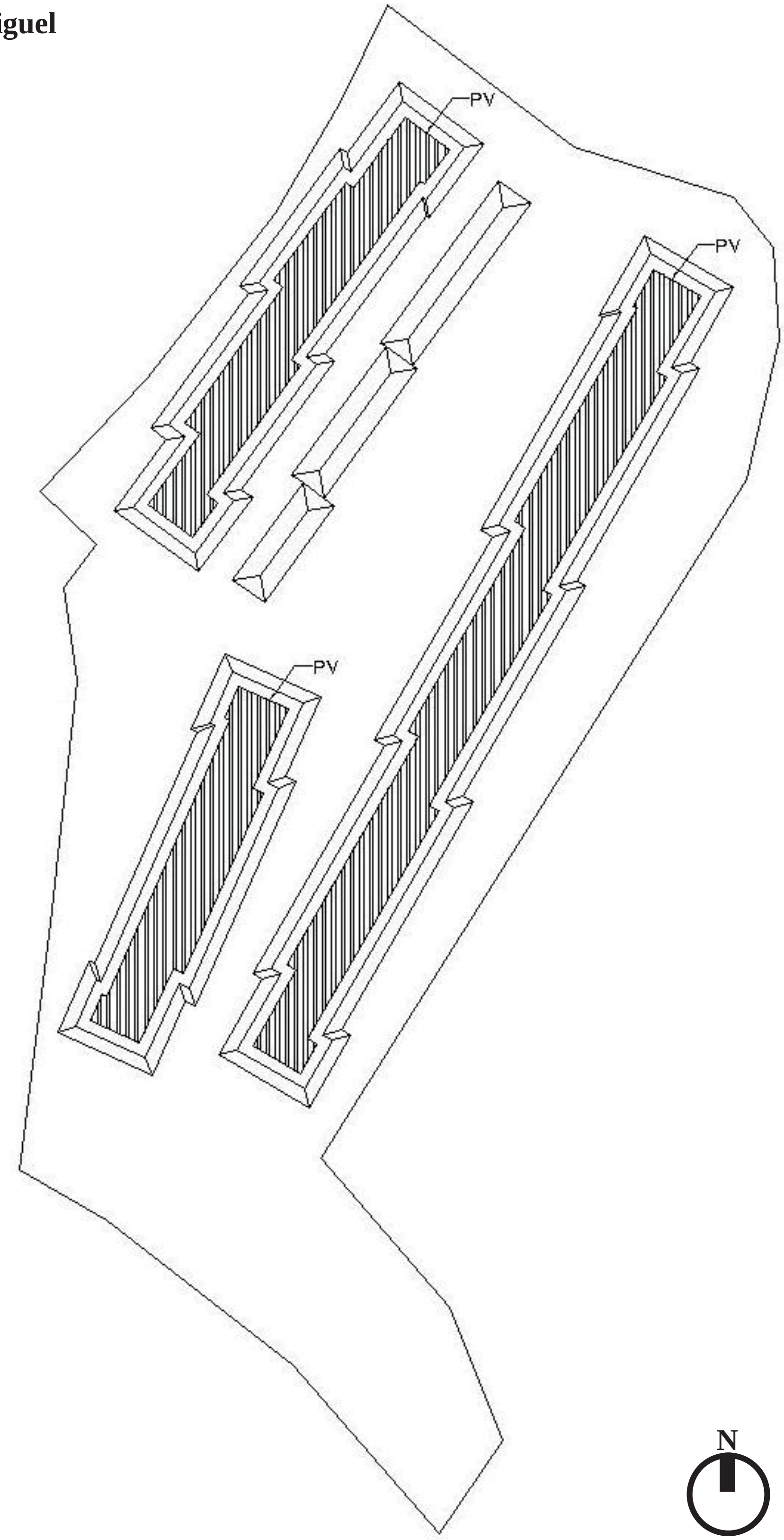
**Scenario C – Laguna Niguel**
1st Floor Plan
Not to Scale



**Scenario C – Laguna Niguel**
$2^{nd}$ – $3^{rd}$ Floor Plan
Not to Scale



**Scenario C – Laguna Niguel**
Roof Plan
Not to Scale



**Laguna Niguel Scenario C:Density Bonus**

**Unit Summary**

| Unit Type | Number of units | Percentage of Unit |
|---|---|---|
| Studio | 79 | 28% |
| 1 Bedroom | 74 | 26% |
| 2 Bedrooms | 70 | 25% |
| 3 Bedrooms | 58 | 21% |
| Total | 281 | 100% |

**Site Summary - Ground Level**

| | Area (Sq.ft) | Percentage on site area |
|---|---|---|
| Site Area | 471,918 | 100% |
| Buildings | 170783 | 36% |
| Landscape | 176,816 | 37% |
| Driveway | 94523 | 20% |

**Parking Summary**

| | Parking Requirement | | | | Model's Result | | |
|---|---|---|---|---|---|---|---|
| Unit Type | Covered | Un-Covered | Visitor | Total | Covered | Un-covered | Total |
| Studio | 79 | 0 | No Addition | | | | |
| 1 Bedroom | 74 | 0 | | | | | |
| 2 Bedrooms | 70 | 70 | | | | | |
| 3 Bedrooms | 58 | 58 | | | | | |
| Total | 281 | 128 | 0 | 409 | 316 | 98 | 414 |

## APPENDIX E – SUSTAINABLE FEATURES DETAILED RESULTS

### PV Panels Detail Summary

| | | Buena Park | Santa Ana | Irvine | Laguna Niguel |
|---|---|---|---|---|---|
| Site Area (Square Feet) | | 46,540 | 211,219 | 148,722 | 471,918 |

| | | | | | |
|---|---|---|---|---|---|
| Scenario A - Baseline | Total Roof Area (Square Feet) | 17,386 | 98,824 | 85,351 | 156,035 |
| | Percentage of roof area on site area | 37% | 47% | 57% | 33% |
| | Potential roof area for PV Panels (Square Feet) | 11,762 | 57,548 | 32,861 | 57,538 |
| | Percentage of roof area covered by PV Panels | 68% | 58% | 39% | 37% |
| | Percentage of PV panels on site area | 25% | 27% | 22% | 12% |

| | | | | | |
|---|---|---|---|---|---|
| Scenario B - Subterranean Parking | Total Roof Area (Square Feet) | 18,483 | 82,618 | 76,596 | |
| | Percentage of roof area on site area | 40% | 39% | 52% | |
| | Potential roof area for PV Panels (Square Feet) | 8,983 | 15,772 | 24,544 | |
| | Percentage of roof area covered by PV Panels | 49% | 19% | 32% | |
| | Percentage of PV panels on site area | 19% | 7% | 17% | |

| | | | | | |
|---|---|---|---|---|---|
| Scenario C - Density Bonus | Total Roof Area (Square Feet) | 17,386 | 109,540 | 94,238 | 170,783 |
| | Percentage of roof area on site area | 37% | 52% | 63% | 36% |
| | Potential roof area for PV Panels (Square Feet) | 11,762 | 64,142 | 36,711 | 57,538 |
| | Percentage of roof area covered by PV Panels | 68% | 59% | 39% | 34% |
| | Percentage of PV panels on site area | 25% | 30% | 25% | 12% |

**Rain Planters Datail Summary**

| | | Buena Park | Santa Ana | Irvine | Laguna Niguel |
|---|---|---|---|---|---|
| Site Area (Square Feet) | | 46,540 | 211,219 | 148,722 | 471,918 |

| | | | | | |
|---|---|---|---|---|---|
| Scenario A - Baseline | Total Landscape Area (Square Feet) | 18,523 | 84,971 | 44,988 | 201,131 |
| | Percentage of site area with landscape | 40% | 40% | 30% | 43% |
| | Potential area for rainwater planters adjacent to buildings (Square Feet) | 4,259 | 9,534 | 12,097 | 13,477 |
| | Percentage of landscape area with rainwater planters | 23% | 11% | 27% | 7% |
| | Percentage of site area with rainwater planters | 9% | 5% | 8% | 3% |

| | | | | | |
|---|---|---|---|---|---|
| Scenario B - Subterranean Parking | Total Landscape Area (Square Feet) | 18,646 | 93,709 | 45,326 | |
| | Percentage of site area with landscape | 40% | 44% | 30% | |
| | Potential area for rainwater planters adjacent to buildings (Square Feet) | 6,415 | 10,314 | 11,638 | |
| | Percentage of landscape area with rainwater planters | 34% | 11% | 26% | |
| | Percentage of site area with rainwater planters | 14% | 5% | 8% | |

| | | | | | |
|---|---|---|---|---|---|
| Scenario C - Density Bonus | Total Landscape Area (Square Feet) | 17,760 | 69,352 | 34,546 | 176,816 |
| | Percentage of site area with landscape | 38% | 33% | 23% | 37% |
| | Potential area for rainwater planters adjacent to buildings (Square Feet) | 4,127 | 9,443 | 10,383 | 13,549 |
| | Percentage of landscape area with rainwater planters | 23% | 14% | 30% | 8% |
| | Percentage of site area with rainwater planters | 9% | 4% | 7% | 3% |