was made that every housing option (A-F) would be represented for each scenario so as to cater for a range of family sizes and preferences.

Table 4.2 Proportional Allocation of Housing Options - Scenario 1a (Low Density)

	Single Storey, Cluster A	Two Storey, Detached, Multiple Household B	Two Storey Row Housing C	Two Storey Row Housing D	Three Storey Flats E	Four Storey Flats F
% Distribution of Dwellings	75	5	5	5	5	5
Number of 248 m² stands	126	25	6	8	13	13
Number of 496 m² stands	41	10	2	3	5	5
Number of 992 m² stands	1	0	0	0	0	0
Number of 3968 m² stands	0	0	0	0	0	0
Summary of indicators						
Additional Household units on 248m²	378	101	25	25	101	151
Additional Household units on 496m²	290	77	19	19	77	116
Additional Household units on 992m²	18	5	1	1	5	7
Additional Household units on 3968m²	0	0	0	0	0	0
Additional Household Units	686	183	46	46	183	274
Additional population	2605	640	201	229	457	823
People per Habitable Room	1.2	1.2	1.1	1.3	1.1	1.1
Floor Space Rate	11	14	16	17	17	8
Garden Space per person (m²)	3.8	0.9	2.5	2.8	1.8	0.4

Table 4.10: Proportional Allocation of Housing Options - Scenario 1b (Low Density)

	Single Storey, Cluster A	Two Storey, Detached, Multiple Household B	Two Storey Row Housing C	Two Storey Row Housing D	Three Storey Flats E	Four Storey Flats F
% Distribution of Dwellings	5	75	5	5	5	5
Number of 248 m² stands	4	169	3	4	6	6
Number of 496 m² stands	1	59	1	1	2	2
Number of 992 m² stands	0	2	0	0	0	0
Number of 3968 m² stands	0	0	0	0	0	0
Summary of indicators						
Additional Household units on 248m²	11	677	11	11	45	68
Additional Household units on 496m²	8	471	8	8	31	47
Additional Household units on 992m²	0	29	0	0	2	3
Additional Household units on 3968m²	0	0	0	0	0	0
Additional Household Units	20	1177	20	20	78	118
Additional population	73	4119	86	98	196	353
People per Habitable Room	1.2	1.2	1.1	1.3	1.1	1.1
Floor Space Rate	11	14	16	17	17	8
Garden Space per person (m²)	3.8	0.9	2.5	2.8	1.8	0.4

Table 4.11: Proportional Allocation of Housing Options - Scenario 2 (Equal Proportions)

	Single Storey, Cluster A	Two Storey, Detached, Multiple Household B	Two Storey Row Housing C	Two Storey Row Housing D	Three Storey Flats E	Four Storey Flats F
% Distribution of Dwellings	16.6	16.6	16.6	16.6	16.6	16.6
Number of 248 m² stands	22	65	16	22	33	33
Number of 496 m² stands	7	23	6	7	12	12
Number of 992 m² stands	0	1	0	0	0	0
Number of 3968 m² stands	0	0	0	0	0	0
Summary of indicators						
Additional Household units on 248m²	65	262	65	65	262	393
Additional Household units on 496m²	47	187	47	47	187	281
Additional Household units on 992m²	3	11	3	3	11	17
Additional Household units on 3968m²	0	0	0	0	0	0
Additional Household Units	115	460	115	115	460	691
Additional population	426	1611	506	576	1151	2072
People per Habitable Room	1.2	1.2	1.1	1.3	1.1	1.1
Floor Space Rate	11	14	16	17	17	8
Garden Space per person (m²)	3.8	0.9	2.5	2.8	1.8	0.4

Table 4.12: Proportional Allocation of Housing Options - Scenario 3a (Quality: best overall)

	Single Storey, Cluster A	Two Storey, Detached, Multiple Household B	Two Storey Row Housing C	Two Storey Row Housing D	Three Storey Flats E	Four Storey Flats F
% Distribution of Dwellings	5	5	35	45	5	5
Number of 248 m² stands	9	27	47	81	13	13
Number of 496 m² stands	3	10	17	26	5	5
Number of 992 m² stands	0	0	1	1	0	0
Number of 3968 m² stands	0	0	0	0	0	0
Summary of indicators						
Additional Household units on 248m²	27	108	189	243	108	162
Additional Household units on 496m²	20	80	140	180	80	120
Additional Household units on 992m²	1	5	8	11	5	7
Additional Household units on 3968m²	0	0	0	0	0	0
Additional Household Units	48	193	337	433	193	289
Additional population	178	674	1483	2167	482	867
People per Habitable Room	1.2	1.2	1.1	1.3	1.1	1.1
Floor Space Rate	11	14	16	17	17	8
Garden Space per person (m²)	3.8	0.9	2.5	2.8	1.8	0.4

Table 4.13: Proportional Allocation of Housing Options - Scenario 3b (Quality: Interior Space)

	Single Storey, Cluster A	Two Storey, Detached, Multiple Household B	Two Storey Row Housing C	Two Storey Row Housing D	Three Storey Flats E	Four Storey Flats F
% Distribution of Dwellings	5	5	5	35	45	5
Number of 248 m² stands	7	22	5	47	101	10
Number of 496 m² stands	2	7	2	15	37	4
Number of 992 m² stands	0	0	0	0	1	0
Number of 3968 m² stands	0	0	0	0	0	0
Summary of indicators						
Additional Household units on 248m²	20	81	20	142	811	122
Additional Household units on 496m²	15	58	15	102	584	88
Additional Household units on 992m²	1	4	1	6	35	5
Additional Household units on 3968m²	0	0	0	0	0	0
Additional Household Units	36	143	36	250	1431	215
Additional population	132	501	157	1252	3578	644
People per Habitable Room	1.2	1.2	1.1	1.3	1.1	1.1
Floor Space Rate	11	14	16	17	17	8
Garden Space per person (m²)	3.8	0.9	2.5	2.8	1.8	0.4

Table 4.14: Proportional Allocation of Housing Options - Scenario 3c (Quality: Exterior Space)

	Single Storey, Cluster A	Two Storey, Detached, Multiple Household B	Two Storey Row Housing C	Two Storey Row Housing D	Three Storey Flats E	Four Storey Flats F
% Distribution of Dwellings	40	5	5	40	5	5
Number of 248 m² stands	67	25	6	67	13	13
Number of 496 m² stands	22	10	2	22	5	5
Number of 992 m² stands	1	0	0	1	0	0
Number of 3968 m² stands	0	0	0	0	0	0
Summary of indicators						
Additional Household units on 248m²	201	101	25	201	101	151
Additional Household units on 496m²	155	77	19	155	77	116
Additional Household units on 992m²	9	5	1	9	5	7
Additional Household units on 3968m²	0	0	0	0	0	0
Additional Household Units	366	183	46	366	183	274
Additional population	1353	640	201	1828	457	823
People per Habitable Room	1.2	1.2	1.1	1.3	1.1	1.1
Floor Space Rate	11	14	16	17	17	8
Garden Space per person (m²)	3.8	0.9	2.5	2.8	1.8	0.4

Table 4.15: Proportional Allocation of Housing Options - Scenario 4 (High Density)

	Single Storey, Cluster A	Two Storey, Detached, Multiple Household B	Two Storey Row Housing C	Two Storey Row Housing D	Three Storey Flats E	Four Storey Flats F
% Distribution of Dwellings	5	5	5	5	30	50
Number of 248 m² stands	6	19	5	6	58	96
Number of 496 m² stands	2	7	2	2	20	34
Number of 992 m² stands	0	0	0	0	1	1
Number of 3968 m² stands	0	0	0	0	0	0
Summary of indicators						
Additional Household units on 248m²	19	77	19	19	462	1156
Additional Household units on 496m²	13	54	13	13	323	806
Additional Household units on 992m²	1	3	1	1	20	49
Additional Household units on 3968m²	0	0	0	0	0	0
Additional Household Units	34	134	34	34	804	2011
Additional population	124	469	147	168	2011	6033
People per Habitable Room	1.2	1.2	1.1	1.3	1.1	1.1
Floor Space Rate	11	14	16	17	17	8
Garden Space per person (m²)	3.8	0.9	2.5	2.8	1.8	0.4

While the proportional allocations of housing types corresponding to the scenarios could have been approximated according to the additional population or dwellings achieved, it was statistically deduced by calculating the dwelling proportions. The calculation of proportions based on additional dwellings was achieved by summing the additional dwellings and calculating the proportion for each housing type. For the quality of life scenario, the quality of life indicators were used as a guide in the formulation of proportions.

EVALUATION OF SCENARIOS

In order to choose the optimum densification scenario, a balance needs to be achieved between additional people to be accommodated, quality of life and costs. Table 4.16 contains a summary of the density, quality of life indicators and dwelling costs per scenario. The scenarios were evaluated by making trade-offs between a number of factors: the change in net and gross residential densities, building and population densities; the dwelling unit cost and the quality of life indicators. The land and demolition costs were not included as these costs would remain constant for each scenario.

The evaluation criteria were determined and analysed for each scenario. This involved the calculation of the number of additional dwellings, household units and population achieved. The quality of life indicators (number of people per habitable room, floor space rate, garden space per person) were calculated per scenario as calculated above. The total projected population, densities achieved, dwelling costs and quality of life indicators are firstly described. This is followed by a brief discussion of the scenarios.

Total Projected Population

Table 4.17 shows the total projected units and population for each scenario. The increase ranges from an additional 9 909 people for scenario 1b to 13 931 for scenario 4. This is a considerable increase on the existing population of approximately 6 000 people in Jeppestown.

Table 4.16: Summary of Indicators per Scenario

	DENSITY								QUALITY OF LIFE			DWELLING COSTS (R)
	Additional Units	Additional Population	Net Residential Density		Gross Residential Density		Gross Town Density		People per Room	FSR (m^2)	Garden Space per Person (m^2)	
			Units/ha	People/ ha	Units/ha	People/ha	Units/ha	People/ ha				
Scenario 1a (Low density)	1417	4955	36	163	18	79	11	49	1.2	11.7	2.5	R44 239 825
Scenario 1b (Low density)	1510	4930	36	163	17	79	11	49	1.16	14.1	1.0	R51 430 598
Scenario 2 (Equal)	1957	6342	41	186	20	90	13	56	1.15	12.8	1.4	R66 281 354
Scenario 3a (Quality: best)	1493	5851	40	178	19	86	12	53	1.17	15.0	2.1	R66 251 140
Scenario 3b (Quality: Interior)	2010	6188	41	184	20	89	12	55	1.14	15.4	1.9	R82 846 794
Scenario 3c (Quality: Exterior)	1417	5302	38	169	18	82	11	51	1.20	13.6	2.4	R53 979 791
Scenario 4 (High Density)	3050	8952	51	229	24	107	15	69	1.13	10.5	0.9	R85 141 062
Existing	1317	6000	22	99	9	41	7	30	[16]1.60	-	-	-

[16] Calculated by diving the total number of people in the sample by the total number of habitable rooms in the sample. 'The sample' refers to the July 1994 socio-economic survey of Jeppestown (CSIR, 1994).

Table 4.17: Increase in Units and Population per Scenario

	Scenario 1a (Low Density)	Scenario 1b (Low Density)	Scenario 2 (Equal Proportions)	Scenario 3a (Quality: best overall)	Scenario 3b (Quality: Interior space)	Scenario 3c (Quality: Exterior space)	Scenario 4 (High Density)
UNITS:							
Additional number of units	1417	1510	1957	1493	2111	1417	3050
Existing number of units	1317	1317	1317	1317	1317	1317	1317
Less units demolished	227	227	227	227	227	227	227
projected number of units	2507	2600	3047	2583	3201	2507	4140
POPULATION:							
Additional population	4955	4930	6342	5851	6265	5302	8952
Estimated existing population	6000	6000	6000	6000	6000	6000	6000
Less Population of demolished units	1021	1021	1021	1021	1021	1021	1021
Total Projected Population	9934	9909	11 321	10 830	11 244	10 281	13 931

(Sources: Calculated from Tables 4.2; 4.9 to 5.15)

Densities Achieved

For each scenario, gross, net and town residential densities were calculated and tabulated according to the definitions provided. These densities were expressed for both population and number of dwelling units (Table 4.18).

Table 4.18: Increase in Density per Scenario

		Existing	Scenario 1	Scenario 1b	Scenario 2	Scenario 3a	Scenario 3b	Scenario 3c	Scenario 4
NET RESIDENTIAL DENSITY	**Units/ha**	22	36	36	41	40	41	38	51
	People/ha	99	163	163	186	178	184	169	229
GROSS RESIDENTIAL DENSITY	**Units/ha**	9	18	17	20	19	20	18	24
	People/ha	41	79	79	90	86	89	82	107
GROSS TOWN DENSITY	**Units/ha**	7	11	11	13	12	12	11	15
	People/ha	30	49	49	56	53	55	51	69

(Sources: Calculated from Table 4.1 and Table 4.17)

Table 4.18 shows that up to a two and a half fold increase in units and population can be achieved in Jeppestown using scenarios 1-4. For example, scenario 4 results in a net residential density of 229 pph, compared to the existing density of 99 pph. While there is not much variation between the densities achieved for scenarios 1-4, there is a marked difference between the densities of the scenarios and existing densities. Similarly, there is a significant increase in gross densities (41 pph to 107 pph for scenario 4).

Dwelling Costs

For each scenario, the number of dwellings per housing type was multiplied by the cost of each housing type and summed, to obtain the total cost (Table 4.16). These costs were provided together with the plans which were used earlier in the determination of housing types, obtained from NewHco, the CSIR, and the Development Action Group. The costs provided by DAG were escalated to March 1995 prices[17].

Quality of Life

An average of each quality of life indicator was calculated for each scenario (Table 4.16). This enabled the comparison of scenarios. For **people per habitable room**, the sum of the following formula, for each housing option, was obtained and divided into the total number of additional people:

$$\frac{\text{Additional Household Units}}{\text{No. of Households per Dwelling}} \quad X \quad \text{No. of Habitable Rooms per Dwelling.}$$

For **Floor Space Rate**, the sum of the following formula, for each housing option, was obtained:

$$\frac{\text{Dwelling Size}}{\text{No. of Households per Dwelling}} \quad X \quad \text{Additional Household Units}$$

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[17] Calculated using the Haylett formula, with a non-escalatable factors of 15 percent. Escalation costs were calculated by Nellis Boshoff of the CSIR.

For **Garden space per Person**, the sum of the following formula, for each housing option, was obtained:

$$\frac{\text{Additional Household Units}}{\text{No. of Households per Dwelling}} \times \text{Garden Space per Dwelling}$$

In order to evaluate the averages calculated above, the typical values for a range of countries were obtained. Measures of overcrowding, which vary slightly from author to author, were used as a guide for the number of people per habitable room. In an inner city study of Johannesburg, Crankshaw and White (1992) settled for a strict definition of overcrowding: if there were more than two occupants per bedroom, residential conditions were described as overcrowded. The Greater London Council's housing stress index, on the other hand uses a value of more than 1.5 person per room as a measure of overcrowding (Home, 1982), while a value of greater than 1 is a possible warning of a shortage of accommodation. The US Bureau of Census defines overcrowding as a situation in which there is more than 1 resident per room (Levy, 1991). Calderwood (1962) notes that the ideal occupancy rate is 1. For the purposes of this study, a value of more than 1.5 people per habitable room was described as overcrowded.

Similarly, Floor Space Rates were compared with a range of cities and countries. Table 4.19, which contains the Floor Space Rates for a range of cities and countries, serves as a guide for evaluating the results generated for each scenario. Mitchell (1974), observes that in order to maintain adequate health standards in European countries, a minimum standard of 17m² of floor space is specified per individual. In the USA, 32m² per person was suggested as a minimum in the 1970s, compared to 4m² per person in Hong Kong (5.3m² per person as standard in 1980).

Table 4.19: Floor Space Rates for a Range of Cities and Countries

DEVELOPING CITY/COUNTRIES	FLOOR SPACE RATE (m² per person)
Hong Kong	standard since 1980: 5.3 *
Singapore	4.5-8.3 *
Tunis, Tunisia	6.5 *
Amman, Jordan	10 *
Johannesburg, South Africa:	11.1 *
White	33
Black (Formal Housing)	9
Black (informal Housing)	4.0-5.0
Asian	18
Coloured	12
Bangkok, Thailand	16.5 *
Istanbul, Turkey	17 *
Rio de Janeiro, Brazil	19.4 *
INDUSTRIAL COUNTRIES	
USA	minimum since 1950: 34 **
United Kingdom	11.25-17.46 **

* Mayo, 1993
** Cuthbert, 1985

Table 4.16 shows that in terms of people per habitable room, none of the scenarios result in a situation of overcrowding as all of the values are less then 1.5 people per habitable room. The values range from 1.13 to 1.2. The high density scenario (scenario 4) results in the least number of people per room (1.13). Scenario 3b, which emphasises interior living space, results in the next best number of people per habitable room (1.15).

In terms of FSR, scenario 3b scores well again (15.4 m² per person). This is about half of the floor space currently enjoyed by the white population in Johannesburg (Table 4.16). Scenario 3a also results in a similar amount of floor space per person: 15m². The high density scenario (scenario 4), results in the least amount of floor space per person (10.5m²) which is a similar amount to the formal housing in many black townships in Johannesburg where 9m² per person (Table 4.19) is the norm.

Table 4.16 shows that the amount of garden space per person (m²) varies from 0.9m² for the high density scenario to 2.5 for scenario 1a (low density scenario). While it is difficult to assess from the literature what an acceptable amount of garden space should be, in South

Africa large gardens have been the norm, particularly among the white population (Van Niekerk, Konya and Scott, 1972; Lamont, 1991).

In evaluating the scenarios against each other, it becomes clear that there is no scenario that scores well in all the criteria. While the high density scenario scores well in terms of people per room (1.13), it falls down on FSR, garden space per person and dwelling costs. However, an additional 8 952 people will be able to be accommodated in Jeppestown, and net and gross residentia' densities will increase significantly. Gross residential densities will be increased to 107 pph which is approximately the minimum gross density needed to support an activity corridor of 2km - 1km on either side of the activity spine (CSIR, 1991). Whether or not Jeppestown residents would want a high proportion of four storey flats is another issue that needs to be considered since families with children are likely to prefer to live near ground level. While only the ground floor unit has a private living area, all of the units have direct access to the street (Appendix 10). The four storey units comprise a mixture of one, two and three storey units so that the needs of single persons living alone to large families with children are met.

The low density scenarios (1a and 1b), which contain a high percentage of single and two storey units, contribute significantly to increasing residential densities. They result in a doubling of net and gross residential densities. Concerning quality of life scores, these scenarios achieve satisfactory results for people per room, FSR and garden space per person. Although scenario 1a results in the highest number of people per habitable room (1.2), this is far from being described as overcrowded. The low density scenarios result in the lowest dwelling costs - almost half that of the high density scenario.

Perhaps the scenario which results in the best overall result, in terms of density, quality of life aspects and costs, is scenario 3a. This scenario, which predominantly makes use of two types of two storey row housing, achieves an additional 5851 people while achieving a pleasant living environment in terms of people per room, FSR and garden space per person. The dwelling costs are significantly lower than the high density scenario. Another advantage of this scenario is that each unit is extendible and has a private garden.

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This chapter has described the methodology developed in constructing a model for the testing of the feasibility of increased residential densities in inner city areas. The suburb of Jeppestown, Johannesburg was used to illustrate the model. The model included four main steps: the description of existing conditions, the identification and quantification of land suitable for densification and the development and evaluation of scenarios. The model made use of spreadsheets and GIS technology which enabled the rapid updating and editing of maps, as well as the testing of the implications of densification scenarios. In Jeppestown, the model showed that for each scenario, high scores could not be achieved for all of the indicators. While the high density scenario, for example, scores well in terms of people per room (1.13), it falls down on FSR, garden space per person and dwelling costs. However, a doubling of population is possible and net and gross residential densities will increase significantly. Even the low density scenarios (1a and 1b), which contain a high percentage of single and two storey units, contribute significantly to increasing residential densities. Scenario 3a results in the best overall result, in terms of density, quality of life aspects and costs. In all scenarios, however, the population could be doubled whilst maintaining reasonable levels of privacy, living space and private recreational space.

CHAPTER 5: SUMMARY AND CONCLUSION

This thesis has described a tool for South African planners and urban policy makers to determine the feasibility of increasing residential densities by achieving a balance between higher residential densities, quality of life and affordable costs. In attempting to develop this model, three main bodies of literature were examined. The first looked at shifting ideas relating to the nature of cities, the second, the advantages and disadvantage of higher residential densities, and the third, ways and methods in which residential densities can be increased.

The literature revealed that ideas relating to the nature of cities have changed over time and have been influenced by a range of factors. Since the turn of the century, two opposing views on appropriate residential density have emerged: one advocating low density as an optimum, and another promoting higher residential densities. Planners have moved beyond the low density notion of garden city ideas, which focused on aesthetics and generous space standards. Recent thinking focuses on higher density, efficient and cost-effective developments. Factors that have influenced residential densities include affordability, topography, family size and structure and preferences. The literature also revealed that local conditions and circumstances affect the planning at which densities take place.

The second body of literature examined the advantages and disadvantages of higher residential densities. While there have been some reservations concerning increases in residential densities, most of these concerns relate to high rise developments, not necessarily higher density residential developments. The advantages of higher residential densities relate mostly to cost savings and increased accessibility to urban facilities, which makes inner city locations ideal for increasing residential densities.

A third issue which arose in the literature deals with the ways in which densities can be increased. While there is a significant body of literature that describes case studies where infill, subdivision and redevelopment policies have been implemented, this literature is of a fragmented and piece-meal nature with regard to details of the empirical method of