THE FEASIBILITY OF THE SUSTAINABLE RE-DEVELOPMENT OF UNIVERSITY PLAZA

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By

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ABSTRACT

This paper investigates the feasibility of the construction of a sustainable mixed-use development from a 1950's commercial plaza. The specific commercial plaza under investigation was University Plaza in Dundas, Ontario. Incorporating sustainable building techniques, such as higher density housing, clean energy generating technologies, energy efficiency, and water conservation, a more sustainable design for the plaza was accomplished. To become more pedestrian friendly, pedestrian areas were incorporated into the design, as well as a rapid transit terminal. Using rough construction estimates, it was determined that redevelopment would cost $67.9 million ± 20% with a simple payback period of 7.8 years. Using the time value of money, a discounted payback period between 9.6 and 16.0 years was determined. As a result, the re-development project was deemed economically feasible to a reasonable degree.

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1.0 INTRODUCTION

In the wake of the announcement about an introduction of a rapid transit system to the City of Hamilton, there is a great opportunity for revitalizing the commercial sector (McGuinness, 2008). There are three planned routes to this new transit system: a north – south route, along with two east – west routes. The north – south route ranges from Hamilton Harbour to Hamilton Airport. The east – west routes will service developed areas both above and below the escarpment. The latter route will provide service from Eastgate Square to University Plaza, located in Dundas, Ontario. A map that situates University Plaza in the Greater Hamilton Area is shown in Figure 1.

Figure 1: Situational Map of University Plaza.

University Plaza was first opened in 1958 as a small "strip mall" (Ivanhoe Cambridge, 2008a). Due to the age of the plaza, it is now in need of a substantial makeover. A similar makeover had occurred in 1986, with the development of the Mashpee Commons. Mashpee Commons is located in Cape Cod, Massachusetts. This development successfully took an existing strip mall and turned it into a mixed-use development. Since then, five more mixed-use neighbourhoods have been built around the Mashpee Commons, with plans for further expansion (Mashpee Commons Limited Partnership, n.d.).

A Sustainable Development was first defined in the Brundtland report as a "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Burndtland, 1987, p.54). This definition of sustainable development was then expanded further into three parts; environmental, economical, and social sustainability. This report will investigate the redevelopment of University Plaza into a sustainable commercial and residential mixed-use development with the addition of a rapid transit terminal. In order to achieve this, this report will be restricted to the subset of sustainable housing, pedestrian issues, parking, transit, energy, water, and commerce.

2.0 DESIGN PHILOSOPHY

University Plaza, when it was first opened in 1958, was the commercial center for the University Gardens development on the northeast side of Osler Drive, along with south Dundas (Ivanhoe Cambridge, 2008a). Now, due to the development of new commercial centers, some of University Plaza's patrons have decided to use the more modern commercial centers. In order to develop increased appeal for University Plaza, a more modern design concept needs to be employed. A mixed-use commercial development is suggested for University Plaza as it will not only increase commercial retail interest in University Plaza, but it will also increase the number of patrons in the area. Redeveloping University Plaza with this new design concept will also give the area a more pleasing look, as it is currently viewed as a "concrete wasteland." The new University Plaza could become the pinnacle of commercial center designs and promote a more sustainable design philosophy. It will also develop interest from northern Dundas and southern Hamilton as people would investigate this new design, bringing more customers to the shopping center. With this increased interest and commercial space, more commercial variety could be added to University Plaza, creating even more reasons for people to visit the center.

The new University Plaza design concept will consist of designing residential condos on top of existing buildings, as well as the erection of new residential and mixed-use buildings. The design concept will also incorporate pedestrian-friendly methods of designing streets, as well as an integrated transit system and more sustainable methods of parking. The proposed University Plaza design is shown in Figure 2.

Christopher Alexander's concept of creating centers was also integrated into the design of University Plaza (Alexander, 2002). Christopher Alexander states that a center is something that has at least one axis of symmetry, draws the eye, and is reinforced by centers around it (Alexander, 2002). To create these centers, 15 properties need to be integrated into the design of University Plaza. Some of these properties relate to the entire network of buildings, while others relate to the buildings themselves. Alexander's 15 properties are:

1. Levels of scale,
2. Strong centers,
3. Boundaries,
4. Alternating repetition,
5. Positive space,
6. Good shape,
7. Local symmetries,
8. Deep interlock and ambiguity,
9. Contrast,
10. Gradients,
11. Roughness,
12. Echoes,

13. The void,
14. Simplicity and inner calm, and
15. Non-separateness (Alexander, 2002).

First, local symmetries are found everywhere in nature. According to Christopher Alexander, local symmetries can be used in the design of centers to make it appear as though they interact harmoniously with each other (Alexander, 2002). The group of proposed mixed-use buildings and apartment buildings were designed to be symmetrical on an axis running east – west between apartment buildings 3 and 4. This can be seen in Figure 2. Another property that Christopher Alexander talks about is creation of a void (Alexander, 2002). In the proposed design of University Plaza, the public green space is designed as this void, which becomes one of his centers. The public green space then becomes a local center that is reinforced by the larger center of apartment and mixed-use buildings. These buildings also create a boundary around the green space, emphasizing it and creating a strong center.

The proposed University Plaza development will create approximately 204 new households. Using an average of 2.5 people per household in the Dundas area, the population of the new development will be approximately 510 people (Statistics Canada, 2006).

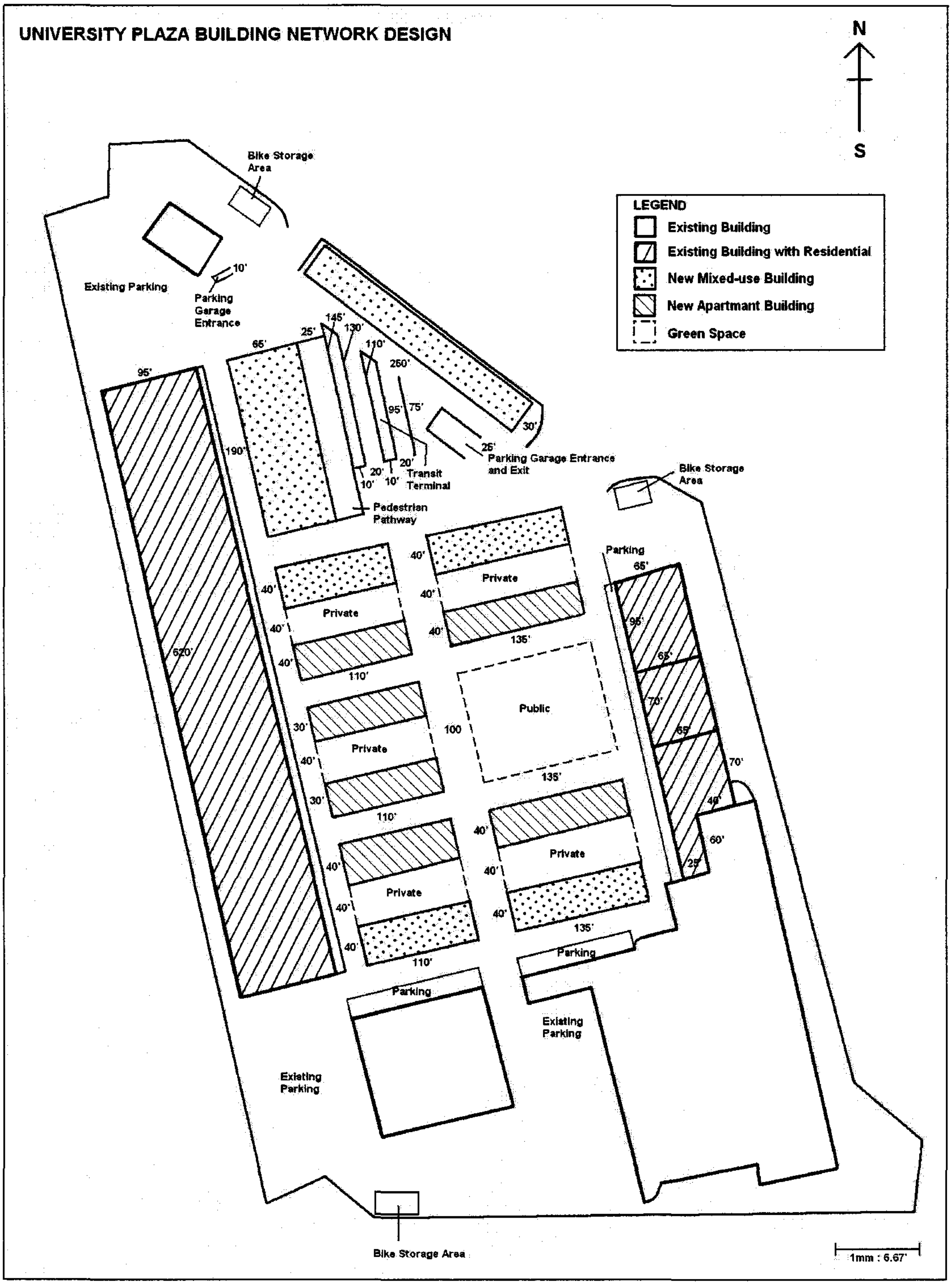

Figure 2: University Plaza Building Network Design

In order to keep commercial outlets open during the construction of the University Plaza redevelopment, it is suggested that the plaza be built in three different phases. This will be done to allow the current commercial outlets to run at normal levels, minimizing the effect on their business. It is suggested that the northern half of University Plaza be constructed in phase 1, followed by the southeastern quarter in phase 2. Finally, the southwestern quarter will be constructed in the final phase. These phases will include the construction of the underground parking facility, followed by the proposed new development.

2.1 Existing Buildings

There are 4 existing buildings in University Plaza. The buildings currently owned and operated by Ivanhoe Cambridge include a Beverly Tire store to the very north of the plaza, a western building consisting of 25 outlets, as well as a Shoppers Drug Mart in the south end of the plaza. The fourth building is the eastern building complex, which is currently owned and operated by RioCan. It is suggested that the eastern and western buildings be retrofitted to include a second storey of residential condos. This will create approximately 63,650 square feet (5,913.3 squared meters) of residential living space. It is suggested that the Beverly Tire and Shoppers Drug Mart should not to be retrofitted due to the relatively small size of these buildings, as it would be uneconomical to increase the capacity of these buildings to add a small number of residential condos. Also, it is suggested that the façade of these existing buildings be changed to recycled brick, which can be purchased from one of many recycled brick companies in the Hamilton Area. This will give the existing buildings more personality and will draw one's eye, creating interest. Using recycled brick will also reduce the amount of masonry brick waste placed in landfills. Finally, the use of recycled brick will help blend University Plaza into the surrounding community, creating a connection with that community.

2.1.1 Structural Reinforcement of Existing Buildings

In order to create a mixed-use development, residential dwellings need to be placed on top of the existing commercial fixtures. This type of development is needed to maximize the footprint of the plaza. In order to determine the amount and placement of the extra reinforcement for the existing buildings, calculations need to be done in order to determine the most efficient way of meeting the new building capacity. Unfortunately, due to confidentiality agreements, building plans for University Plaza were unavailable. As a result, it is assumed that the existing buildings are steel structures with a masonry facade.

There are three ways in which the existing steel structures can be reinforced. The first method entails reinforcing the steel members by enlarging the original cross-sections (Agocs et al., 2004). The second method of increasing the building capacity is to change the static scheme of the building, the way the forces flow through the building (Agocs et al., 2004). This is done by inserting additional members and adding stiffeners to others in order to reduce stresses in other members of the original structure. Finally, a combination of the two methods can be used in which the cross-section of the original members is increased, as well as the static scheme changing (Agocs et al., 2004). Typically, it is easier to choose the first method (Schwinger, 2007).

Next, there are three types of members that will need to be enlarged. These members are the beams, girders, and columns. In order to enlarge the original cross-sections of the beams and girders, the simplest and most cost-effective way is to weld rectangular HSS members to the bottom of the existing members (Schwinger, 2007). This cross-section is depicted in Figure 3 (a). Other methods include welding steel plates together in order to generate the cross-sections seen in (b), (c), and (d) of Figure 3. This will give the beams and girders the necessary

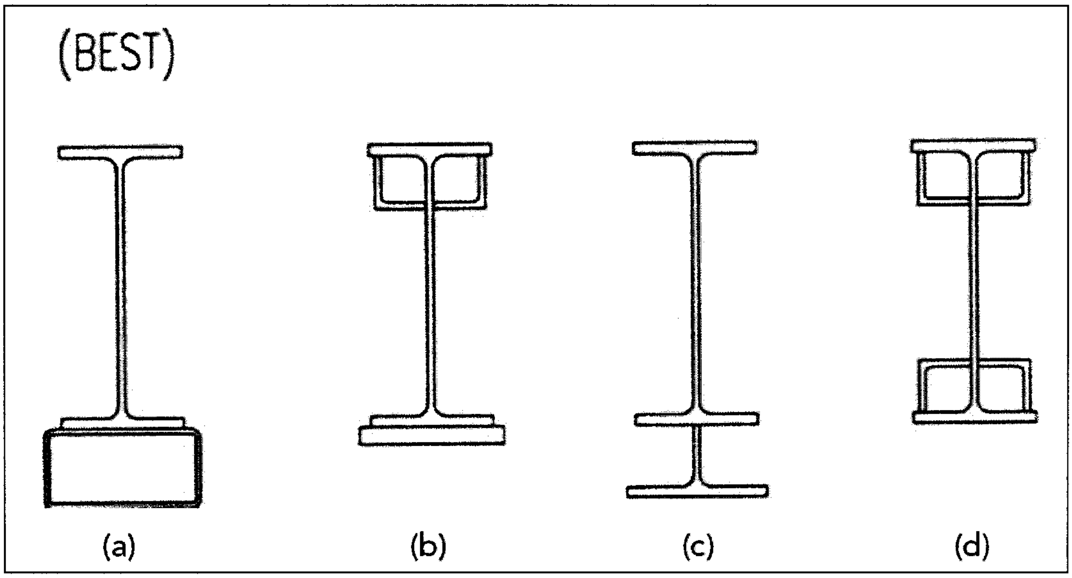

Figure 3: Methods to Reinforce Beams and Girders (Schwinger, 2007).

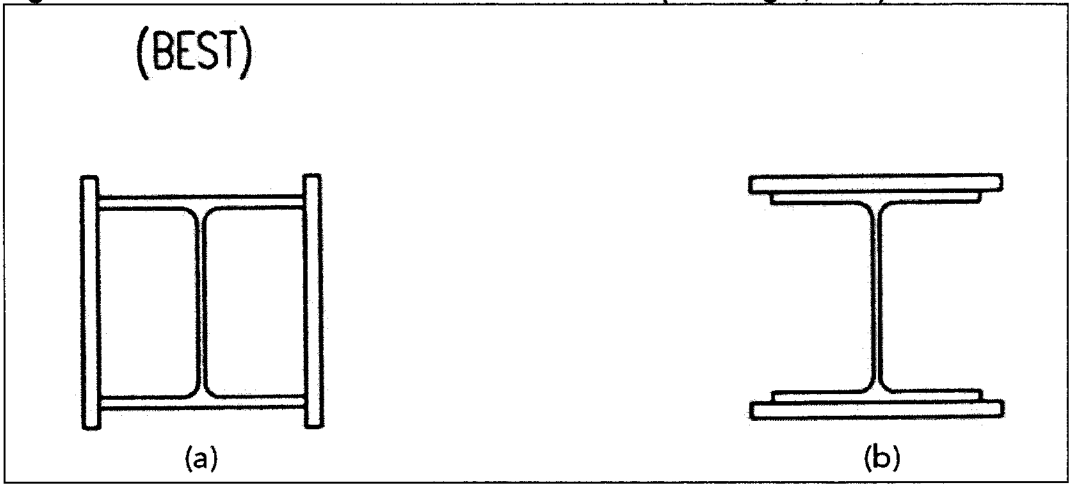

Figure 4: Methods to Reinforce Columns (Schwinger, 2007).

strength to transfer loads to the columns, and then through to the foundation. The most cost effective way of reinforcing the columns is to weld reinforcing plates to the outside of the weak axis in order to reduce the slenderness of the columns (Schwinger, 2007). This is shown in

Figure 4 (a). Another method to reinforce the columns is to weld steel plates to the flanges of the existing steel column. Finally, the capacity of the connections between the different members needs to be increased. In order to increase the capacity of the connections, larger, higher strength bolts need to be used.

Another way to increase the strength of the existing buildings is to attach the existing masonry façade to the existing building structure to help transfer some of the expected building load. There are many ways to reinforce a masonry building. First, there are four main types of masonry walls. These are:

- ungrouted, unreinforced masonry walls,
- grouted, unreinforced masonry walls,
- grouted, partially reinforced masonry walls, and
- grouted, reinforced masonry walls

An ungrouted, unreinforced masonry wall can be reinforced by simply placing some steel reinforcement bars into the masonry cavities and grouting them. For grouted walls, there are two cases. These cases are when the wall is partially grouted or fully grouted. When the wall is partially grouted, reinforcement can be placed into the empty cavities and grouted into place. When the wall is fully grouted, holes need to be drilled to allow for the placement of steel reinforcing bars. These holes should be wide enough such that the reinforcing bar can be placed, as well as mortared to the existing mortar.

One complication that may arise is the accessibility of these structural members. Due to the tight confines of some of the commercial outlets, it may be difficult to reach these members. One suggestion is to temporarily move the commercial outlets to currently vacant areas of the plaza in order to access these members.

2.1.2 Western Existing Building

The existing building on the western side of University Plaza will be retrofitted for increased building capacity as a storey of residential structures will be added on top. The footprint of the western existing building is shown in Figure 5. The building is currently 95 feet (29 meters) wide by 620 feet (189 meters) long. The width of the building will be split in two with a 10 foot (3 meter) hallway to create an eastern side and a western side. This is done to allow the footprint of the condos to become squarer. The residential condos will be between 800 and 1,200 square feet (74.3 and 111.5 square meters) in size, creating approximately 57 units.

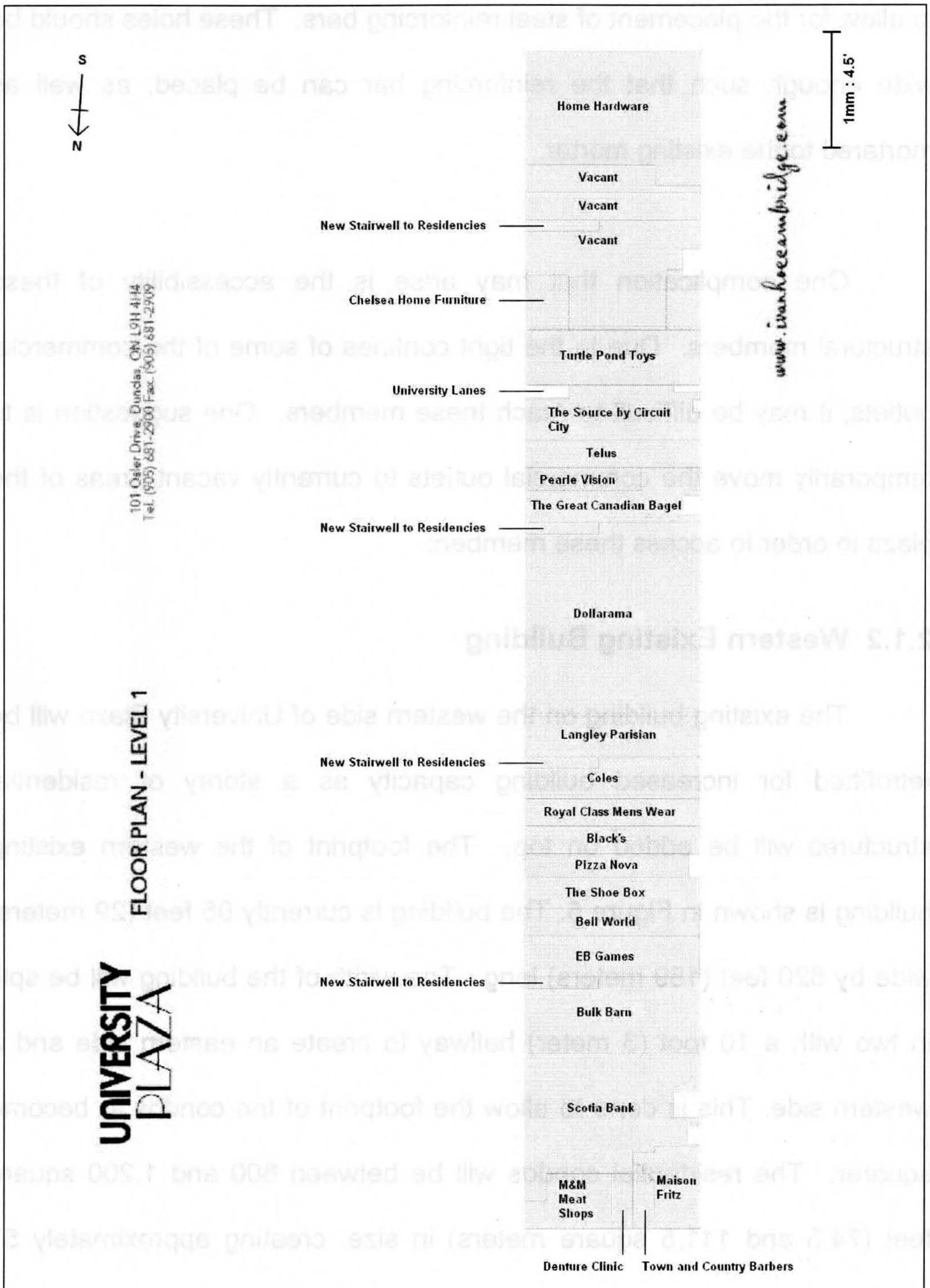

Figure 5: University Plaza West Existing Building Floor Plan (Ivanhoe Cambridge, 2008b).

This building will also be retrofitted with indoor stairwells that will be placed approximately every 150 feet (45.7 meters) to allow the tenants to have access to their homes, as well as the roof. Unfortunately, in order to add these stairwells, small areas of the existing commercial retail space needs to be used. These stairwells will span 40 feet (12.2 meters), entering from the front of the existing building to the proposed hallway. The stairwells will also be 6 feet (1.8 meters) wide. It is also suggested to place an elevator in the building that reaches from the underground parking to the roof in order to make the building more accessible to the disabled. On the roof, it is suggested that a green roof will be placed, such that each individual residential homeowner will have a private garden to attend to. These private gardens will help boost the morale of the tenants, allowing them to have a place of sanctuary. Green roofs can also be used to reduce the amount of rainwater runoff (Green Roofs for Healthy Cities North America, 2005). A potential green roof landscape that could be used on the buildings is shown in Figure 6.

Figure 6: Sample Green Roof Landscape (Calhoun School, n.d.)

2.1.3 Eastern Existing Building

Similar to the existing building on the western side of University Plaza, the eastern existing building will also be retrofitted for increased building capacity, in order to add a storey of residential condos. The eastern existing building is shown in Figure 7. On this building, there are three levels, due to the grade of the ground. It is suggested that the residential condos extend to the level on which the LCBO liquor store sits, as there are numerous obstacles that would hamper the construction of further condos. The building is 65 feet (19.8 meters) wide. The lengths of the three steps are 95, 70 and 70 feet (29, 21.3 and 21.3 meters), starting with the lowest level. Once again, it is suggested that the width of the building be split into two with a 10 foot (3 meter) hallway, creating more of a square footprint. On the lowest level, just above East Side Mario's, 4

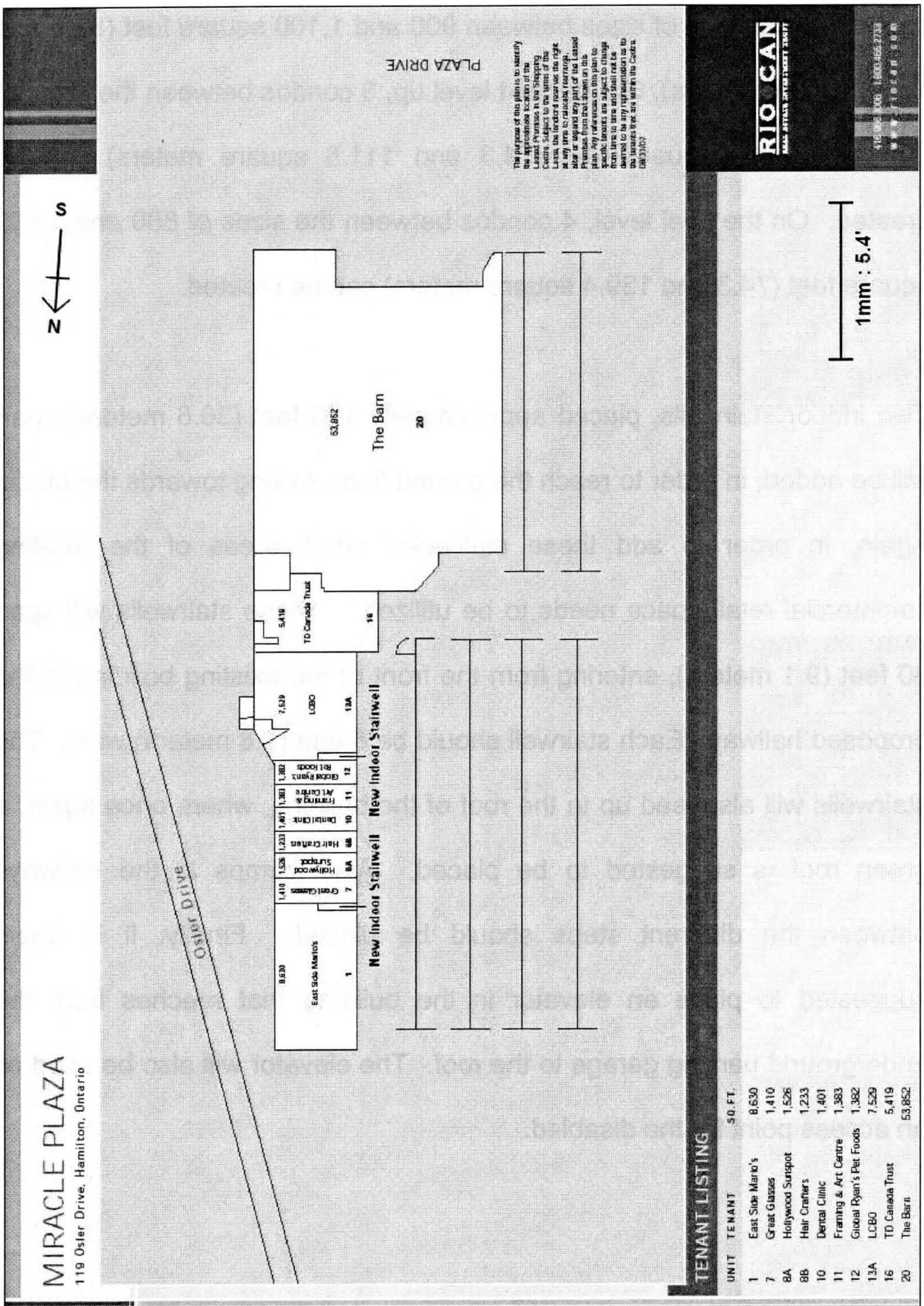

Figure 7: University Plaza East Existing Building Floorplan (RioCan, 2008).

condos can be built of sizes between 900 and 1,100 square feet (83.6 and 102.2 square meters). On the next level up, 3 condos between the sizes of 800 and 1,200 square feet (74.3 and 111.5 square meters) can be created. On the final level, 4 condos between the sizes of 800 and 1,500 square feet (74.3 and 139.4 square meters) can be created.

Two indoor stairwells, placed approximately 120 feet (36.6 meters) apart will be added, in order to reach the ground floor, exiting towards the plaza. Again, in order to add these stairwells, small areas of the existing commercial retail space needs to be utilized. These stairwells will span 30 feet (9.1 meters), entering from the front of the existing building to the proposed hallway. Each stairwell should be 6 feet (1.8 meters) wide. The stairwells will also lead up to the roof of the building, where once again, a green roof is suggested to be placed. Also, ramps in the hallways between the different steps should be placed. Finally, it is again suggested to place an elevator in the building that reaches from the underground parking garage to the roof. The elevator will also be used as an access point for the disabled.

2.2 *New Buildings*

There are two types of new buildings that are proposed in the re-design of University plaza. These types are mixed-use buildings and residential apartment buildings. The mixed-use buildings will consist of commercial retail space on the ground floor, with residential dwellings above. The residential apartment buildings will consist of multiple floors of residential dwellings. These new buildings will provide the plaza with an additional 39,450 square feet (3,665.0 square meters) of commercial retail space, along with 135,750 square feet (12,611.6 square meters) of living space. It should be noted that these values are just approximations, not taking into account wall thicknesses.

In order to be as sustainable in the design of University Plaza as possible, the type of structure should be taken into account. Structures can be made of many different materials, some of which are timber, reinforced concrete, masonry, and steel. For a structure that is three storey's high, the material used should have a high material strength. It should also have the ability to easily support an increased load if a green roof is placed. The use of a high strength building material will also decrease the amount of materials needed to build the new buildings. As a result, timber will be eliminated from the analysis as it does not have as high a material strength as steel and reinforced concrete.

The embodied energy of a material, the energy used to extract, transport and create the material, should also be used to determine the most sustainable material for the new buildings (Reardon et al., 2008). Table 1 shows the embodied energies of different materials. As it can be seen, masonry has the lowest embodied energy of the materials being considered, followed by reinforced concrete, and steel. But, these values do not take into account the amount of embodied energy per area of construction. These values are shown in Table 2. As it can be seen, steel assemblies have the lowest impact of the materials being considered, while masonry has the highest impact. As a result, all new buildings should be designed as steel structures to minimize the impact of the building on the planet, while providing the strength necessary for the loads on the building. Steel was also chosen as the building material for University Plaza due to the local availability of steel from local steel companies, as well as its recyclability after its useful life. Similar to the façades of the existing buildings, recycled brick should be used. As a result of reusing building materials, the embodied energy of the material is reduced by 95 percent on average (Reardon et al., 2008).

Table 1: Embodied Energy of Construction Materials (Lawson, 1996).

MATERIAL	PER EMBODIED ENERGY MJ/kg
Kiln dried sawn softwood	3.4
Kiln dried sawn hardwood	2.0
Air dried sawn hardwood	0.5
Hardboard	24.2
Particleboard	8.0
MDF	11.3
Plywood	10.4
Glue-laminated timber	11.0
Laminated veneer lumber	11.0
Plastics – general	90
PVC	80.0
Synthetic rubber	110.0
Acrylic paint	61.5
Stabilised earth	0.7
Imported dimension granite	13.9
Local dimension granite	5.9
Gypsum plaster	2.9
Plasterboard	4.4
Fibre cement	4.8*
Cement	5.6
Insitu Concrete	1.9
Precast steam-cured concrete	2.0
Precast tilt-up concrete	1.9
Clay bricks	2.5
Concrete blocks	1.5
AAC	3.6
Glass	12.7
Aluminium	170
Copper	100
Galvanised steel	38

Table 2: Embodied Energies of Construction Assemblies per Area (Lawson, 1996).

ASSEMBLY	PER EMBODIED ENERGY MJ/m²
Single Skin AAC Block Wall	440
Single Skin AAC Block Wall gyprock lining	448
Single Skin Stabilised (Rammed) Earth Wall (5% cement)	405
Steel Frame, Compressed Fibre Cement Clad Wall	385
Timber Frame, Reconstituted Timber Weatherboard Wall	377
Timber Frame, Fibre Cement Weatherboard Wall	169
Cavity Clay Brick Wall	860
Cavity Clay Brick Wall with plasterboard internal lining and acrylic paint finish	906
Cavity Concrete Block Wall	465
Strawbale	----

A feature that will be unique to mixed-use buildings 3 through 6, as well as the apartment buildings is that these buildings are approximately oriented east to west, with the lengths of these buildings facing south. This allows for the use of a technique called passive solar heating. Passive solar heating consists of placing large windows on the south side of the building in order for the sun to penetrate into the home (Solar Energy Society of Canada Inc, 2008). Sunshades are placed along the top of these windows in order to block the sun during certain times of the year. Sunshades are designed for solar noon, the point where the sun is at the highest point in the sky. For the environmental conditions found in Dundas, Ontario, these shades should be designed for a moderate climate. The climate found in Southern Ontario has approximately 3,500 heating degree days (HDD) (Choitti and Lavender, 2008). As a result, sunshades should be designed for the summer solstice (June 21st) (US Department of Energy, 2005). These shades should be designed such that the sun just touches the window sill at solar noon (US Department of Energy, 2005). During the summer, less heat from the suns rays will penetrate into the dwelling, allowing the home to stay cool. In the winter, the sun will be able to penetrate into the dwelling, heating the space. For the mixed-use buildings 3 and 4, as well as apartment buildings 3, 5, and 6, sunshades should be used in order to exploit the potential for passive solar heating. In the other buildings, balconies can be used as sunshades as they face outward onto the street.

In the design of the buildings, some of Christopher Alexander's properties will also be used. These properties are stated in section 2.0. First, an alternating repetition will be integrated into the design of the different buildings. Alexander believes this alternating repetition creates a sense of balance and harmony (Alexander, 2002). An illustration of the concept alternating repetition is displayed in Figure 8. Christopher Alexander also states that balanced levels of scale that are built into the design of the building can make the building appear architecturally pleasing (Alexander, 2002). Finally, the recycled brick façade on the buildings will create what Alexander calls roughness. Alexander states that roughness is when texture and imperfections are used to create uniqueness (Alexander, 2002). All of these techniques will be used in the design to create aesthetically pleasing buildings.

Figure 8: Opsedale Degli Innocenti illustrating alternating repetition (Fletcher, n.d.).

2.2.1 New Mixed-use Building #1

The first of the proposed mixed-use buildings is situated to the north of the plaza, along Osler Drive, as shown in Figure 2. This building is suggested to be a two storey building that is 250 feet (76.2 meters) long and 30 feet (9.1 meters) wide. The commercial outlets and residential housing will face outward towards Osler Drive in order to give the plaza a good appearance from the street, drawing in potential customers. Also, existing trees will be kept in front of the building, as well as along side of the building. Keeping the existing trees will help blend the new building with the existing landscape. Housing units will vary between 800 and 1,000 square feet (74.3 and 92.9 square meters), creating approximately 8 residential homes.

This building will have balconies on both sides of the building. These balconies will stretch the buildings entire length, with 2 outdoor stairwells to service the length of the building on each side. These stairwells will be placed at each end of the building in order to not interfere with the commercial outlets. In addition, an elevator should be strategically placed as an access for the disabled, as well as to the underground parking garage. Since there is little room to create private gardens on the ground floor, individual homes should have access to the roof, where a green roof should be placed for private gardens. The roof will be accessed from the outdoor stairwells, which will reach the roof, as well as the elevator.

2.2.2 New Mixed-use Building #2

The second mixed-use building, as shown in Figure 2, is situated to the north of University Plaza, next to the western most existing building. This building is suggested to also be a two storey building. The building will be 65 feet (19.8 meters) wide and 190 feet (57.9 meters) long. The width of the second floor should be split by a 10 foot hallway to create squarer homes. This split should be used to create 10 homes between the sizes of 800 and 1,200 square feet (74.3 and 111.5 square meters). The commercial outlets should also be split down the width of the building, or have entrances on both sides of the building in order to service both sides of the building. This split would also help greet customers coming on the existing transit and proposed rapid transit systems.

Two indoor stairwells will service this building, along with an elevator for the disabled. These stairwells will be placed at a maximum of 150 feet (45.7 meters) apart and will exit on the north and south side of the building. Again, the elevator will service the underground parking garage. Due to lack of space for private gardens, it is suggested that green roofs be implemented.

2.2.3 Mixed-use Buildings #3, 4, 5, and 6

Mixed-use buildings 3, 4, 5, and 6 can also be found in Figure 2. All four mixed-use buildings are suggested to have a width of 40 feet (12.2 meters). Mixed-use buildings 3 and 5 are suggested to have a length of 110 feet (33.5 meters), while mixed-use buildings 4 and 6 have a length of 135 feet (41.2 meters). This was done to create a straight pathway from Plaza Drive to the gap between Shopper's Drug Mart and Metro, to gain access to parking for these buildings. Mixed-use buildings 3 and 5 will hold 8 residential homes between the sizes of 800 and 1,200 square feet (74.3 and 111.5 square meters). Mixed-use buildings 4 and 6 will be able to hold 12 residential homes of similar size. It is also suggested that these buildings be designed to carry green roofs, although they are not necessary.

Two outdoor stairwells, as well as a balcony that stretches the entire length of the building will be used service these buildings. Each building will also have an elevator for the physically disabled, as well as to access the parking garage. Each residence will also have access to a private green space that has a shared depth of 40 feet (12.2 meters).

2.2.4 Apartments

Apartment buildings 1 and 5 will have a width of 40 feet (12.2 meters) and a length of 110 feet (33.5 meters). They will also be 3 storey's high, making them able to hold a total of 12 residences. Apartment buildings 2 and 6 also will have a width of 40 feet (12.2 meters), but a length of 135 feet (41.1 meters). These two buildings have the ability to support 18 families. Finally, apartment buildings 3 and 4 can hold 12 residential dwellings as its dimensions are 30 feet (9.1 meters) wide by 110 feet (33.5 meters) long. The suggested size of these residences is between 800 and 1,000 square feet (74.3 and 92.9 square meters). The apartment buildings, like the mixed-use buildings, should also be designed to carry green roofs.

Similar to mixed-use buildings 3, 4, 5, and 6, a balcony that stretches the entire length of the building, as well as two outdoor stairwells will be used service these buildings. Each building will also have a shared private green space that has a depth of 40 feet (12.2 meters). Each building will also have an elevator for the disabled. This elevator can also be used to service the underground parking.

2.3 *Sustainable Interior Design*

In order to have a larger impact with this design, it is suggested that sustainable materials be used in all aspects of the interior design. There are a number of sustainable materials that can be used as an alternative to traditional materials.

First, flooring is a big part in interior design. In most homes, carpeting is placed. Carpeting takes considerable amounts of energy and materials to create, and afterwards is usually thrown into landfill. It is suggested to use carpets made by Interface Corporation. Interface Corporation uses “renewable materials that can be easily reclaimed and recycled, or even composted, with an overall reduction in materials used” (Interface Corporation, 2004). After the life of the carpet has passed and it is time to replace the carpet, Interface Corporation will recycle the existing carpet. The reclaimed carpet will then be used in the creation of a new carpet.

Hardwood flooring is also a popular type of flooring today. Instead of using hardwood flooring, bamboo hardwood flooring can be used. Bamboo hardwood flooring is more sustainable then using typical hardwood flooring as bamboo is able to regenerate itself without the need of replanting, unlike hardwood trees. It is also able to mature far quicker then hardwood trees. Bamboo takes approximately 3 years to mature, where hardwood trees take tens of years to mature (Environmental Building News, 1997). The cost of bamboo flooring is also comparable to other types of hardwood, typically between $4 and $8 per square foot ($43.06 and $86.11 per square meter) (Environmental Building News, 1997). Bamboo floors also have a 25 year lifetime, with some guaranteed for a lifetime (Green Building Supply, 2008).

Another part of interior design is the choice of countertops. Many types of countertops, such as granite and quartz take considerable amounts of energy extract and produce. Countertops from Vetrazzo are made from recycled glass, which is bound together using "cement, additives, pigments and other recycled materials such as fly ash - a waste by-product of coal burning power plants". Of the finished product, 85% is recycled glass, removing large amounts of glass from landfill (Vetrazzo, 2007). These countertops are made in a variety of colours and no two are alike, making them unique. These countertops will add personality to any home. One drawback is the high cost, at prices between $70 and $180 US per square foot ($753.5 and $1,937.50 US per square meter), it can compare to a high end granite countertop (Gual, 2008).

Finally, instead of using typical latex and oil based paints, it is suggested to use eco-friendly paints. Low VOC paints are completely compostable and do not have the dangerous aerosol fumes that are dispersed by typical paints today. These paints can be made from many different sources such as rainwater (AZoBuild, 2004) to soya beans and crushed rocks (Auro, n.d.).

2.4 Road Network Design and Parking

The road network for a sustainable community should focus on pedestrians and not on vehicles. In order to achieve this goal, pedestrians need to be targeted for the design. The first part of a sustainable pedestrian design is the creation of numerous paths, such that a pedestrian can move from one area to another using the most direct route, reducing travel time. Next, large pedestrian walkways are needed to allow for large amounts of pedestrian traffic. Third, a barrier between the pedestrian and motorized vehicles is needed to make the pedestrian feel safe.

2.4.1 Street Design

There will be three types of streets used in the new sustainable University Plaza design. These are depicted in Figure 9 a), b), and c). These street types are a one-way street with no parking, a one-way street

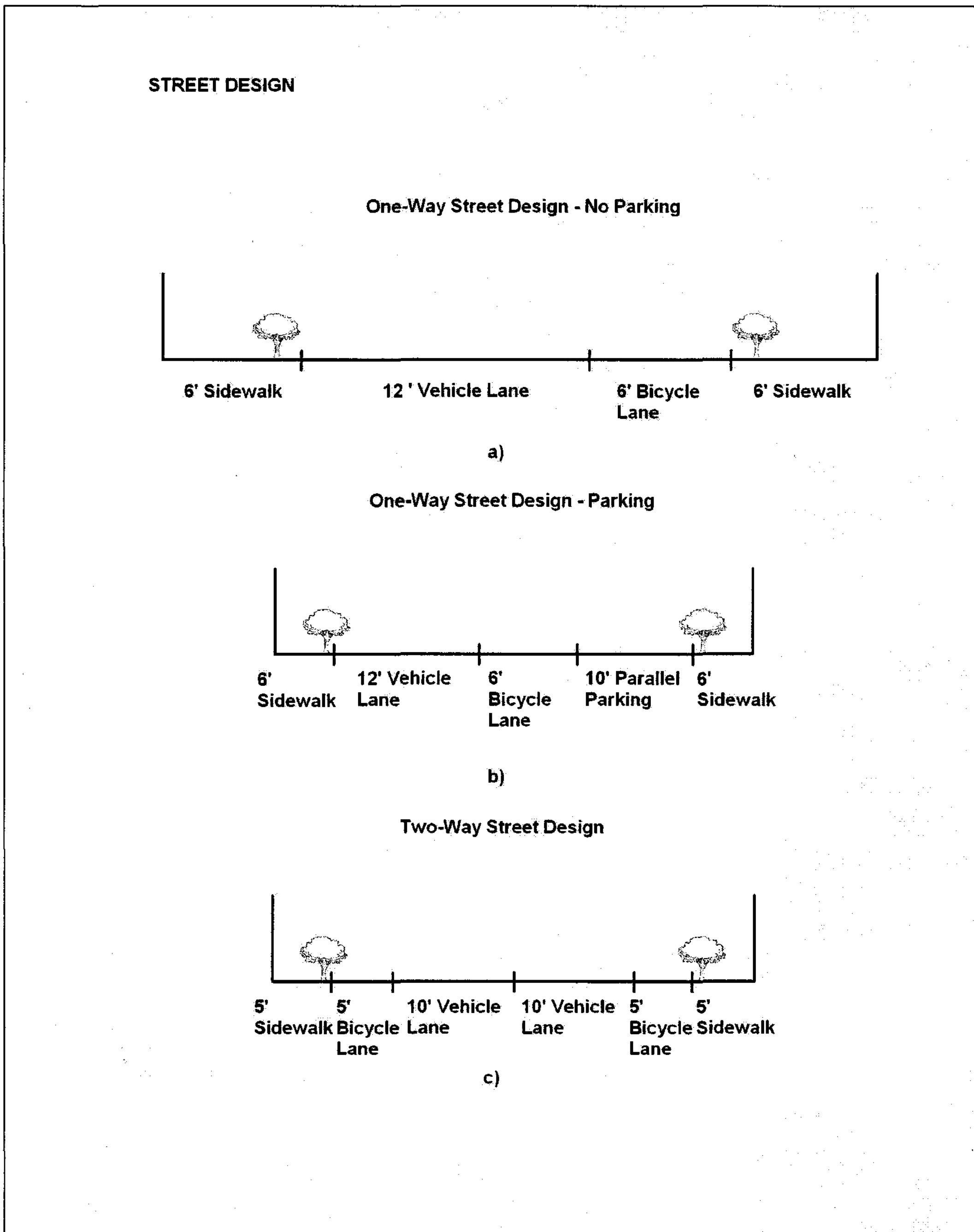

Figure 9: Street Design

with parking, and a two-way street with no parking. These streets will have a maximum speed of 30 kilometers per hour and will have speed control devices placed every 80 feet (24.4 meters) in order to keep speeds down.

The one-way street with no parking will be a total of 30 feet (9.1 meters) wide. It will consist of 6 feet (1.8 meters) of sidewalk, a 12 foot (3.7 meter) vehicle lane, a 6 foot (1.8 meter) bicycle lane and finally another 6 feet (1.8 meters) of sidewalk. The sidewalks will be lined with trees spaced approximately 2 feet (0.6 meters) from the edge of the road, and will be placed approximately every 20 feet (6.1 meters). These will be used to act as a barrier between pedestrians and vehicles, creating a safer environment for pedestrians. The trees will also bring some greenery into the plaza, creating a livelier atmosphere. The choice of a 6 foot (1.8 meter) bicycle lane came from the City of Hamilton design guidelines for bikeways. These guidelines state that it is desirable to have bike lanes that are 1.8 meters, or approximately 6 feet in width (City of Hamilton, 1999).

The one-way street with parallel parking will consist of 6 feet (1.8 meters) of sidewalk, a 12 foot (3.7 meter) vehicle lane, a 6 foot (1.8 meter) bicycle lane, a 10 foot (3 meter) parallel parking lane, and finally another 6 feet (1.8 meters) of sidewalk. The total width between buildings will be 40 feet (12.2 meters). Once again, trees will line the sidewalks. A 10 foot (3 meter) parallel parking lane was chosen as the City of Hamilton design guidelines for bikeways states that it is desirable to have combination of a bike lane and parking stalls with a width of 4.5 meters. This would equal out to approximately 15 feet. The design width of these two lanes is 16 feet (4.9 meters). This added width is to protect the bicyclist from motorists opening their car doors (City of Hamilton, 1999).

The final street designed for University Plaza is a two-way street with a total width of 40 feet (12.2 meters). This street consists of a 5 foot (1.5 meter) sidewalk, a 5 foot (1.5 meter) bicycle lane, a 10 foot (3 meter) vehicle lane, a 10 foot (3 meter) vehicle lane, a 5 foot (1.5 meter) bicycle lane, and a 5 foot 1.5 meter) sidewalk. Trees will again be placed along the sidewalk to act as a barrier between vehicle and pedestrian.

2.4.2 Entrance Design

There are two entrances to University Plaza. These entrances are the north entrance, and the east entrance. These entrances are depicted in Figures 9 and 10. The north entrance will now be controlled by a traffic signal that will respond to pedestrians that want to cross Osler Drive. The

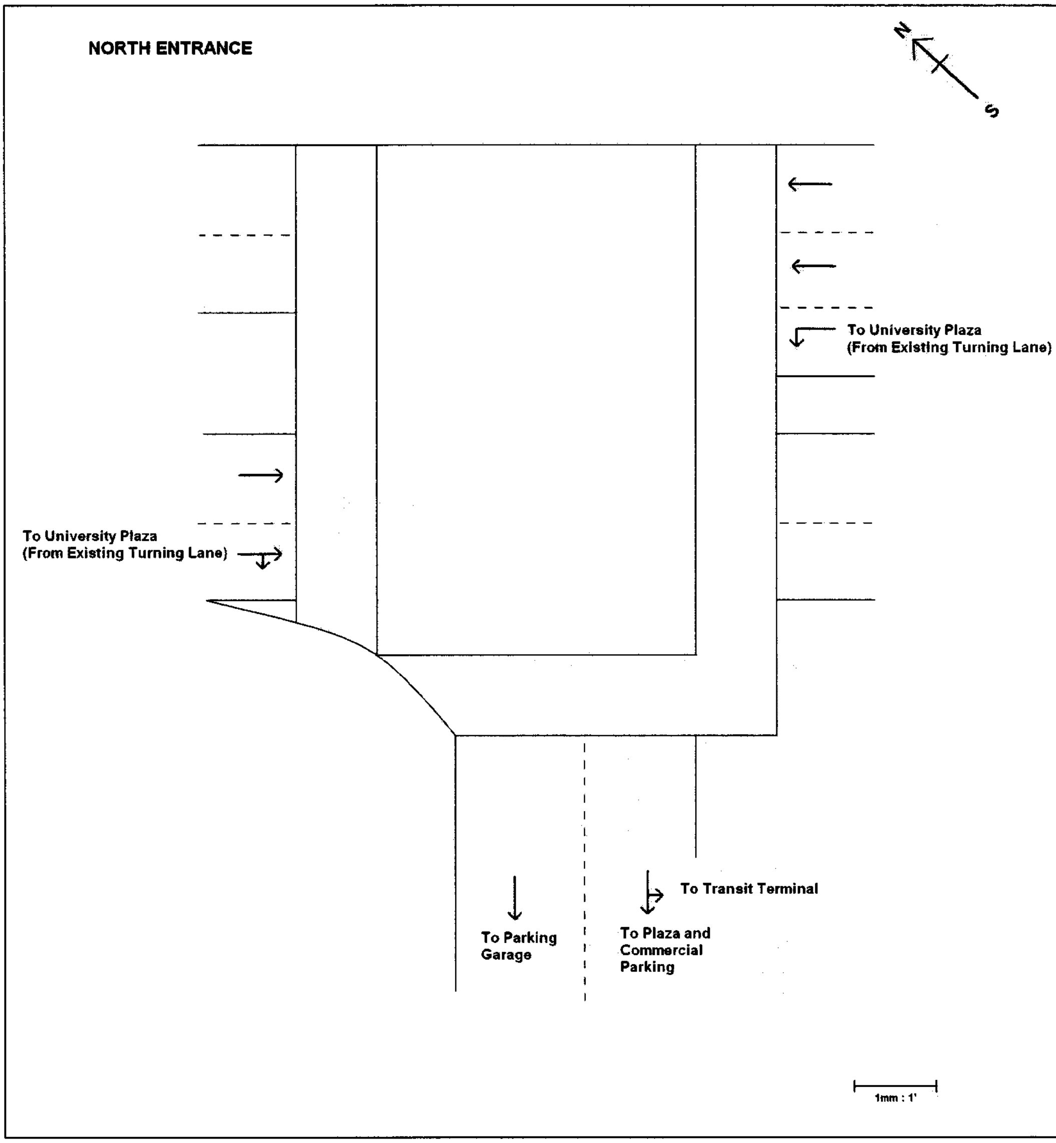

Figure 10: North Entrance Design

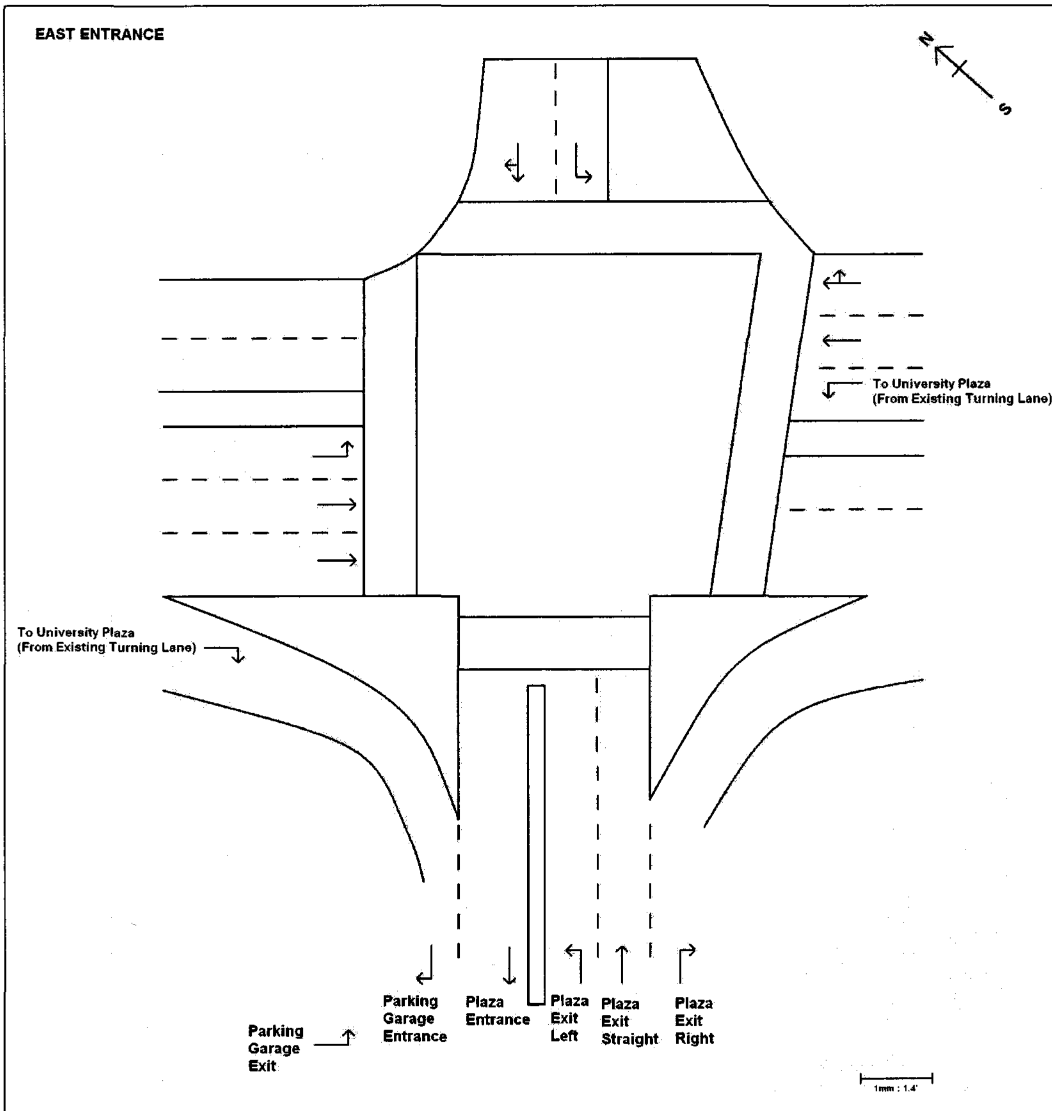

Figure 11: East Entrance Design

south entrance will continue to operate under the existing traffic signal system.

The north entrance to University Plaza will serve as an entrance to the plaza. This entrance enters onto a one way street. This one-way street will lead to three areas. The right-hand side of this street has Beverly Tire, as well as some commercial parking. The entrance to the new underground parking will also be found on the right-hand side. On the left-hand side is the placement of the new transit terminal. If followed straight, this will lead to existing commercial outlets. The eastern entrance will serve as both an entrance to the plaza, as well as an exit. When entering the plaza, the entrance to the new parking garage will be on the right. If followed straight, this will lead the individual to the commercial center. The exit of the parking garage will be situated beside the entrance. A stop sign will be used upon the exit of the garage to control traffic. The exit of the plaza will not change, consisting of one lane to exit left towards Dundas, one lane to continue going straight, entering the University Gardens survey, and one lane to turn right towards Hamilton.

2.4.3 Vehicle Flow Design

The vehicle flow design showed in Figure 12 illustrates the flow of traffic on the streets in University Plaza. The road along the western existing building is a one way street flowing down towards Shoppers Drug Mart. This street circles around the south side of the plaza and then along the east side of the plaza. There is also a north-south two-way street that moves through the center of the plaza. There are two east-west one-way streets that flow between the Apartment buildings. The northern most of

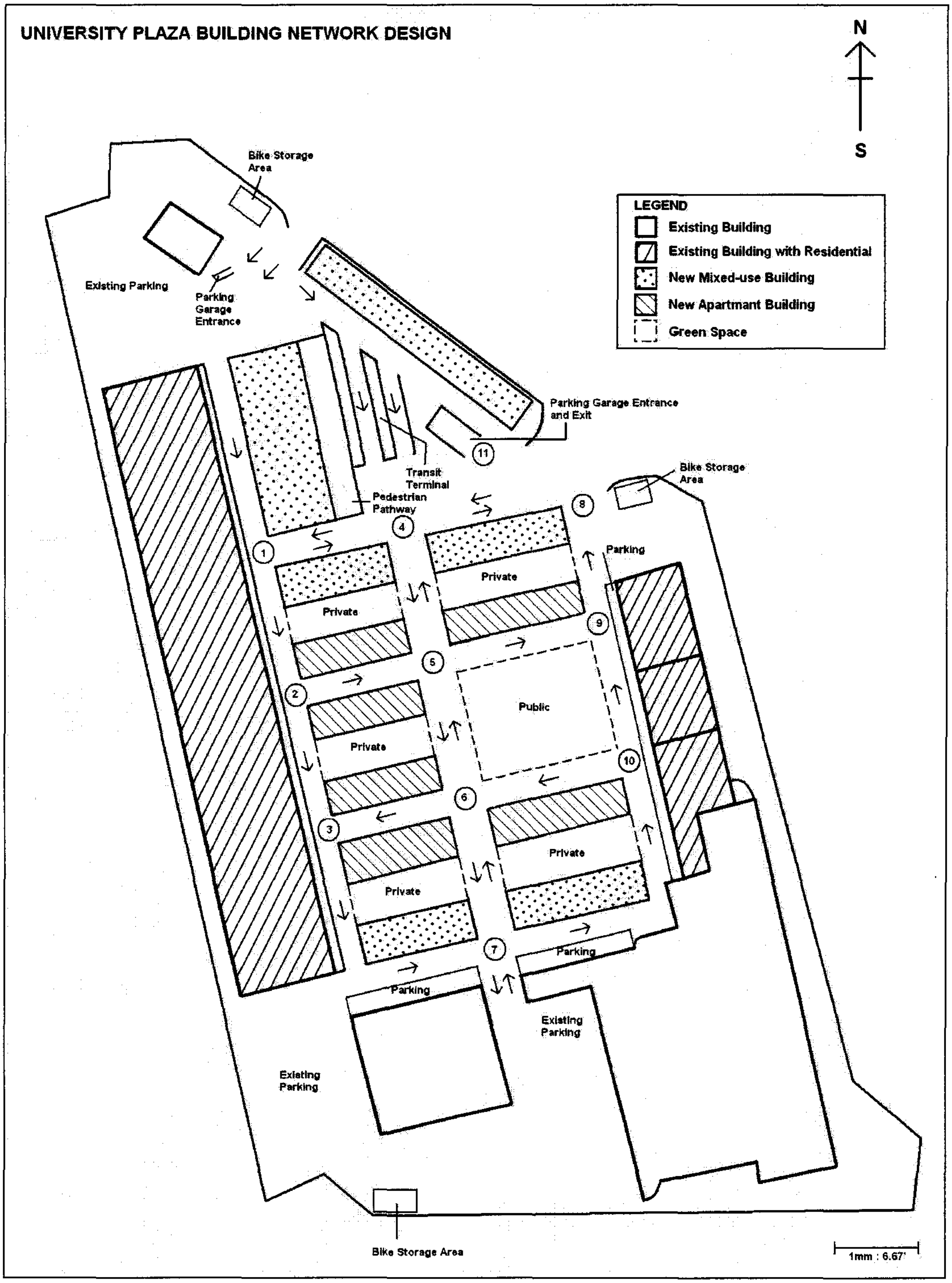

Figure 12: University Plaza Traffic Flow Diagram

these streets flows east, while the southern most flows west. Stop signs will be located throughout the plaza road network in order to reduce the risk for accidents. There are 11 intersections in the proposed University Plaza design. At intersections 1, 2, 3, 4, 9, and 10, there will be all-way stop signs placed. These will serve two functions. First, they will act as a way to slow down traffic and prevent accidents. They will also act as crossing agents for tenants and customers. At intersections 5, 6, and 7, the north-south two-way street will have the right of way as there will be one-way stop signs for vehicles moving east or west. At intersection 8, the east-west direction will have the right of way, resulting in a stop sign for the north direction. Finally, there will be a stop sign for people leaving the parking garage, at intersection 11.

2.4.4 Parking

In order to meet the parking needs for the plaza, it is suggested that an underground parking area be installed underneath the new development. The existing parking that is being replaced by new development accounted for approximately 630 spaces. It should be noted that as many as half of these parking spaces were not used during peak commercial times. The design of the parking garage is shown in Figure 13. The parking garage will supply 202,700 square feet (18831.4 square

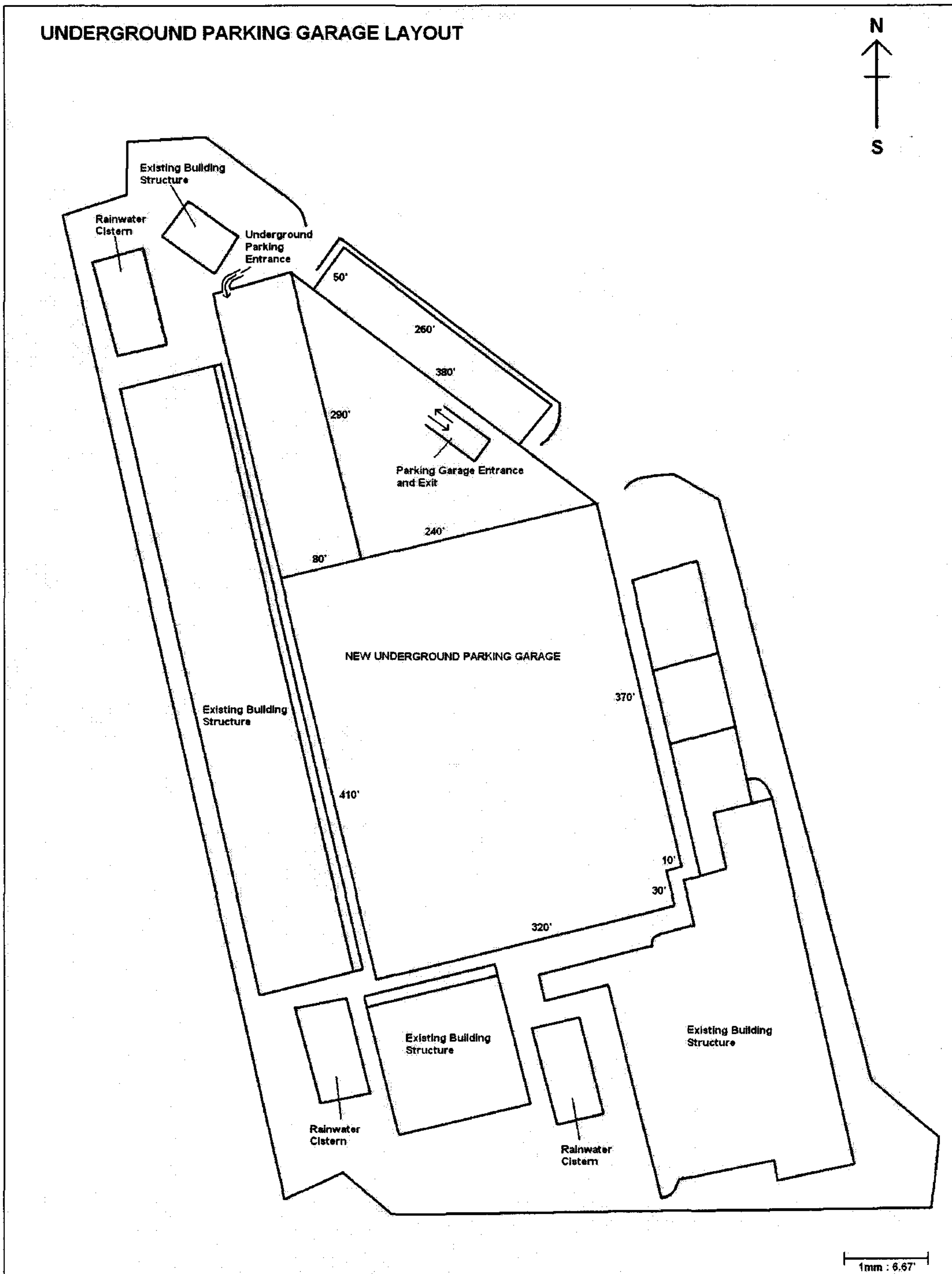

Figure 13: Underground Parking Garage Design

meters) of parking area. The parking garage will have two entrances. The North entrance will act as an entrance only and as a result, will only be 10 feet (3 meters) wide. The east entrance to the parking garage will act as an entrance and an exit. It will consist of one lane to enter and two lanes to exit. These lanes will be 9 feet (2.7 meters) wide. The parking garage's left exit lane will allow vehicles to turn left to exit the plaza using the eastern entrance's left exit lane. The parking garage's right exit lane will also allow vehicles to turn left to exit the plaza using the eastern entrance's straight and right exit lanes. The parking garage's right exit lane lane will also allow vehicles to turn right to enter University Plaza.

Parking space dimensions will be determined by following the same approach as the City of Toronto. According to the City of Toronto (2008), parking spaces should be 18.4 feet (5.6 meters) long by 8.5 feet (2.6 meters) wide. In addition, access aisle widths for these parking spots need to be 20 feet (6.1 meters) wide. For parallel parking, the space needs to be 22 feet (6.7 meters long by 8.5 feet (2.6 meters) wide (City of Toronto, 2008). This will account for approximately 440 new spaces. Assuming a household average of 1.5 vehicles, 307 of these spaces will be used by tenants. This leaves approximately 133 vehicle spaces in the underground parking lot for commercial use, as well as for the new rapid transit system.

Along the edges of the existing buildings, stairwell exits from the underground parking lot will be placed approximately every 200 feet (61 meters). There will also be ramps at these exits for the disabled. In areas where new buildings are being built, the elevators from these buildings can also service the underground parking lot. These will be used to get customers and tenants from the underground parking lot to the commercial outlets and households.

There is also some existing parking beside Metro, Shoppers Drug Mart and M&M Meat shops that was not readily utilized. Under this new plan, these parking spots will become readily used. Some extra handicap spaces will also be added in these areas for the disabled. Also, new parallel parking will be placed along the eastern existing building, as well as some parking in front of Metro. These parking spots will add approximately 235 parking spots, bringing the total number of parking spots for commercial use and transit use to 368. This is believed to be enough parking for transit and commercial purposes as there will be more of an emphasis for people to use more sustainable modes of transportation. These modes could include pedestrians walking and cycling from the rail trail, which is located to the south of the plaza. Also, more commercial business will come from individuals that use the transit system, as opposed to using their vehicles.

2.5 Pedestrian Design

In order to be pedestrian friendly, a number of techniques were integrated into the re-design of University Plaza. First, due to the estimated number of new occupants to University Plaza, it is believed that a public green space is required. This proposed green space is another focal point of the University Plaza design. The size of the public green space is 1350 square feet (125.4 square meters). The public green space is designed to create a connection throughout the community. It will be a place where many people can meet and enjoy themselves with their neighbours. It will also become a place where employees of the different commercial outlets can come and enjoy their breaks. It will consist of public gardens, public benches, as well as an outdoor play set for young children.

Next, bike storage centers will be provided in three areas of University Plaza to promote cycling as a mode of transportation to the plaza. These storage centers will consist of lockers where individuals can store their bicycles. These areas will be free of charge and will be accessed by key. The keys to the storage lockers will be available from the commercial outlets nearest to the storage area (Beverly Tire, East Side Mario's and Shoppers Drug Mart). There will also be signs posted to make the tell cyclists where to receive the keys. The first bike storage area will be located at the north entrance of University Plaza, along the side of Beverly Tire. A bike storage area will also be provided at the east entrance of University Plaza, next to East Side Mario's. Finally, a bike storage building, along with some showers will be placed behind Shoppers Drug Mart, near the western entrance from the rail trail. This is due to the large number of cyclists that use the rail trail daily.

Finally, a 25 foot (7.6 meter) wide pedestrian walkway between the new mixed-use building 2 and the transit terminal will be placed. This can become a pedestrian center where coffee shops and food vendors with outdoor patios can be placed. Trees will be placed spatially along the path to provide more greenery to the area. A garden, placed around a fountain, can also be situated on this walkway to give a welcoming sight for those entering the plaza from the public transit terminal.

3.0 TRANSIT DESIGN

To build on the pedestrian design of University Plaza, a transit terminal will be built in the north half of the development. Since the design of the transit terminal was done independently of the type of rapid transit system that will actually be integrated into the City of Hamilton, both light rail and rapid bus transit were considered in the design of the transit terminal for University Plaza. This section will highlight the aspects of this transit infrastructure.

3.1 Transit Terminal Design

The entrance to the transit terminal for transit traffic will be from the north entrance of University Plaza. Transit traffic that flows west towards downtown Dundas will continue to stop on the north side of Osler Drive, across the street from University Plaza. Transit traffic that is currently a part of the University Plaza transit loop will continue as normal and will stop in the transit terminal. Transit traffic that flows east from Dundas will now enter University Plaza and will stop at the transit terminal. This will reduce the traffic along Osler Drive as they will no longer need to wait for a bus. Finally, the new rapid transit system will also enter University Plaza and stop in the transit terminal.

The total size of the transit terminal will be 8,700 square feet (808.3 square meters). The transit terminal will consist of two 20 foot (6.1 meter) wide lanes. Along the western side of these transit lanes, sidewalks will be placed. These sidewalks will be 10 feet (3 meters) wide and will have 6 foot (1.8 meter) wide shelters placed along the length of the sidewalk. The existing transit will be serviced by the eastern lane, while the new rapid transit will be serviced by the western lane. This design is beneficial to both the rapid bus transit and the light rail transit systems as the transit terminal will have wide lanes to accommodate multiple transit types. Also, there are no confusing entrances and exits to the terminal, making it accessible to both types of transit. These two lanes all exit towards the eastern entrance of University Plaza. Parking for the terminal will be found in the new underground parking lot. Pedestrian entrances to this parking lot can be found in the buildings adjacent to the transit terminal. These entrances will be marked by signs.

3.2 Transit Type

There are two types of rapid transit systems that the City of Hamilton is currently looking at. These two types are a rapid bus transit system and a light rail transit system. Currently, the Province of Ontario has planned to grant the City of Hamilton two-thirds of a total $300 million in funding to help pay for this rapid transit system (Stewart, 2008).

The City of Hamilton currently employs a limited rapid bus system called the B-Line Express Busses (Stewart, 2008). As a result, there is already an infrastructure in place for a full rapid bus transit system. Creating a rapid bus transit system that is superior to the current rapid bus system would cost approximately $480 million for two of the specified routes (Stewart, 2008). Also, operating costs of the rapid bus transit system would equal approximately $80 per vehicle per hour (Stewart, 2008). To ensure that the rapid bus transit system can function to the highest standards, dedicated transit lanes should be installed in the downtown area of Hamilton. This would improve the quality of the existing transit system.

A light rail transit system would entail numerous changes to the current road network that is currently in place in the City of Hamilton. Due to the volume of traffic found in downtown Hamilton, it may be challenging to turn all one-way streets into two-way streets. As a result, rapid train transit would need to be installed on both Main Street and King Street. To be able to install the infrastructure for this type of transit, certain lanes of the proposed route would need to be dug up. This would also create a large amount of waste asphalt that could easily be used as a coarse aggregate for the foundation of the new road network in the City of Hamilton, which is desperately needed. Installing the infrastructure for this type of transit on two of the three proposed routes would cost approximately $1.1 billion, while creating numerous problems on the current road network (Stewart, 2008). Operating costs are approximately $175 per vehicle per hour (Stewart, 2008).

4.0 SUSTAINABLE ENERGY AND WATER EFFICIENCY

Another major part in applying sustainable community design principles to University Plaza is reducing the dependencies on external energy sources. Reducing the dependency on external energy can reduce the environmental impact of the community. There are numerous techniques in which a community can reduce its energy dependency. These techniques include creating energy in sustainable ways and reducing energy use by using more energy efficient devices.

4.1 Sustainable Energy

There are many different technologies to create energy in sustainable ways. The use of small-scale wind turbines can be a cheap and effective way to generate power for a development such as University Plaza. Another technology that can be used is solar photovoltaic (PV) cells, which are typically used in conjunction with wind turbines. This section will discuss these technologies further.

4.1.1 Wind Energy

One technology that can be used at University Plaza to create energy is wind turbines. Although wind power can be generated anywhere the wind blows, small-scale wind turbines need a constant wind source of approximately 4.0 to 4.5 meters per second in order to start generating electricity effectively. (Queens Printer for Ontario, 2008). From

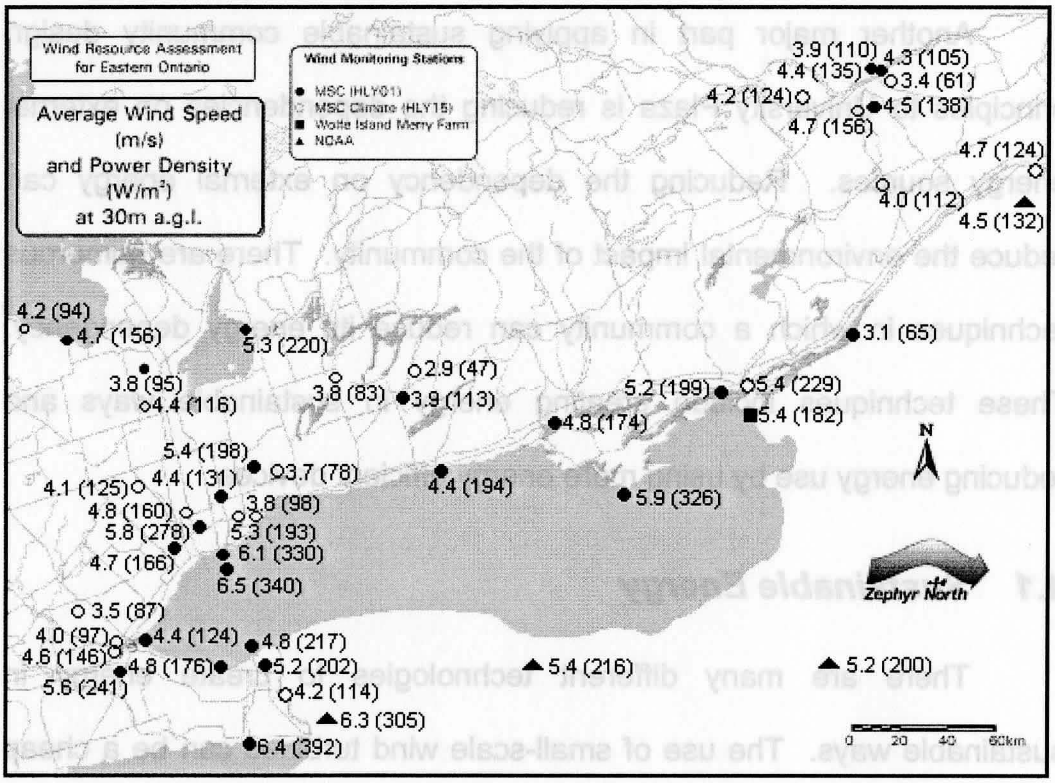

Figure 14: Wind Map for Eastern Ontario (Queens Printer for Ontario, 2008 (source: Natural Resources Canada/Zephyr, North Corporation.))

the wind map for Eastern Ontario in Figure 13, it can be seen that the town of Dundas has an average wind speed between 4.0 and 4.6 meters per second, which is at the threshold for generating wind energy.

Small wind turbines typically cost between $3,300 and $6,000 per kilowatt (CanWEA, 2007). On top of this cost, maintenance costs of approximately $1,150 to $3,300 per year per turbine will be incurred (CanWEA, 2007). These types of wind turbines have a lifetime of 20 to 25 years before they need to be replaced (CanWEA, 2007). Some drawbacks to using a wind turbine for generating power for a development such as University Plaza is that the noise and visual esthetics that are created by the wind turbine are unappealing and typically drive away potential nearby occupants. Due to the limitations of this design stage, a more detailed wind analysis should be done as part of a second stage detailed design.

4.1.2 Solar Energy

Solar PV cells could also be used in the redevelopment of University Plaza. PV solar cells can be used in every climate and can generate a very large amount of electricity in a very small amount of surface area. In order to maximize the potential for the PV solar cells, they should be oriented to the south and should be at an inclination "from the horizontal equal to the latitude of the site minus approximately 20 degrees" (National Green Specification, 2008).

Solar PV cells are a very expensive investment as they cost between $8,000 and $12,000 per kilowatt of capacity (Solarbuzz, 2006). The typical lifetime of a solar PV cell is 20 years and sometimes greater (European Photovoltaic Technology Platform, n.d). Also, solar energy systems need to use an AC power converter as the energy is collected in DC power (Solar Home, 2008). Due to the limitations of this design stage, a solar analysis can be done as part of a second stage detailed design.

4.1.3 Alternative Clean Energy

An alternative to these technologies is to purchase electricity from Bullfrog Power, which creates electricity by using green technologies such as wind and hydro power. Bullfrog Power clients draw power from the local power supply and Bullfrog Power supplies that same amount of power to the Ontario power system. This electricity purchased at a cost of $0.089 per kilowatt hour (Bullfrog Power, 2008). This price is higher then the current price of electricity, which ranges between $0.05 and $0.059 per kilowatt hour (Ontario Energy Board, 2008). Also, the electricity is purchased on a fixed contract, in which the price of electricity does not fluctuate and contracts can be cancelled to any time (Bullfrog Power, 2008).

4.2 Energy Efficiency

Along with purchasing clean energy, a decrease in the amount of energy used by University Plaza can help develop a clean image for the plaza. There are a number of techniques that can be utilized to decrease the amount of energy used by the plaza. The typical energy use breakdown is shown in Figure 14.

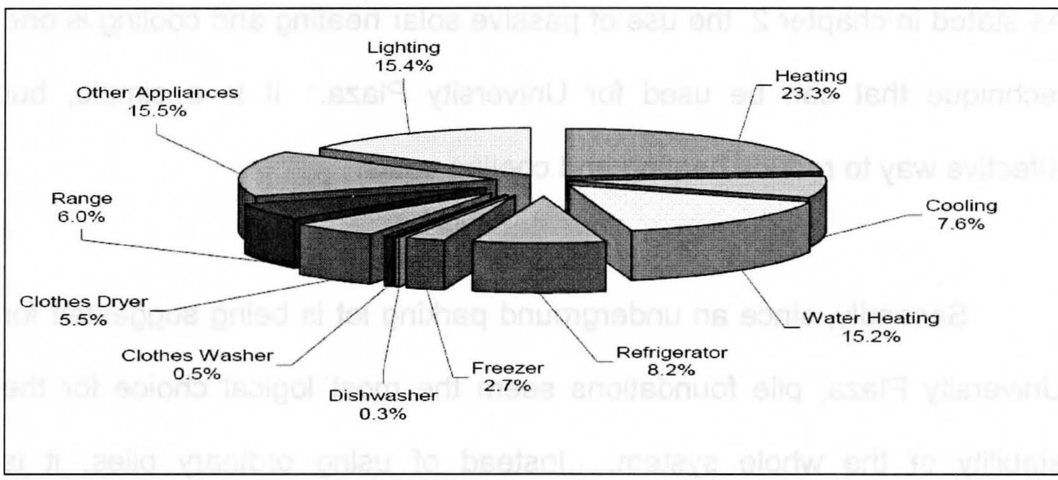

Figure 15: Energy Use Breakdown in a Typical Ontario Household (ICF Consulting, 2005).

4.2.1 Efficiency Through Heating and Cooling

In terms of energy use, heating and cooling of a house is the biggest contributor to the amount of electricity used in a household. In order to reduce the amount of electricity used, two techniques will be used in order to provide the heating and cooling needs for the plaza.

The first technique to be used is the use of passive solar heating. As stated in chapter 2, the use of passive solar heating and cooling is one technique that can be used for University Plaza. It is a simple, but effective way to reduce heating and cooling costs.

Secondly, since an underground parking lot is being suggested for University Plaza, pile foundations seem the most logical choice for the stability of the whole system. Instead of using ordinary piles, it is suggested geothermal energy piles be installed in order to reduce the electricity needs for heating and cooling. The concept of using geothermal energy piles is to use the naturally radiant heat in the ground in order to keep a building at a constant temperature (US Department of Energy, 2006b). Since energy piles are extensions of regular pile foundations, additional costs for energy pile foundations are relatively low (The Solarserver, 2008).

A final, but very simple method of ensuring energy efficiency through heating and cooling is to make sure that there is a sufficient amount of insulation. Ensuring that enough insulation is used during construction can reduce the amount of heat transferred through the building. This means minimizing the amount of heat lost during the winter and gained during the summer.

4.2.2 Water heating

A substantial amount of energy is needed to heat water for a residential household. From Figure 14, it can be seen that water heating accounts for approximately 15.4 percent of a households energy use. Solar water heating is one of the most cost effective renewable technologies to integrate into building design. This is because there are only two main components; the solar collector and the hot water storage tank. Modified standard water heaters can also be used as storage tanks as they can draw latent heat energy from the solar collector, as well as electrical energy from the electrical grid. Although solar water heating systems cannot replace the total demand for water heating, it can be reduced by two thirds (US Department of Energy, 2006a). The most economical and effective type of solar water heating system is the passive Thermosyphon system (US Department of Energy, 2006a). This system uses

> "the natural convection of warm water rising to circulate water through the collectors and to the tank (located above the collector). As water in the solar collector heats, it becomes lighter and rises naturally into the tank above. Meanwhile, the cooler water flows down the pipes to the bottom of the collector, enhancing the circulation" (US Department of Energy, 2006a).

Since the climate of the area contains freezing periods, insulated piping should be used in order to guard against frozen pipes. The type of fluid in these types of systems is a glycol fluid (US Department of Energy, 2006a). These systems should be placed on the roofs of the buildings where the tenants can have easy access to them as during the winter, snow can collect and will need to be cleared.

4.2.3 Appliances and Lighting

Appliances and lighting account for the rest of the energy use in a home. There are a couple techniques that can be used to decrease the energy use in the home. The first technique that can be used is use of Energy Star rated appliances. Since appliances are purchased by the tenants, it would be unfair to regulate that only Energy Star appliances are to be used in the plaza. Therefore, it will be suggested by the plaza management, upon the sale of the residential apartments that Energy Star appliances should be used by its tenants.

Similar to the appliances, energy efficient lighting can be used to reduce energy use, but cannot be regulated in households and commercial outlets. Energy efficient CFL light bulbs, as well as fluorescent tubes can be used. Once again, it can be suggested to use energy efficient lighting in the plaza.

4.3 Rainwater Capture

Another major component of creating a sustainable community is reducing its water use. There are many different techniques that can be used to reduce water use in a development such as University Plaza. First, green roofs will be used to reduce the amount of rainwater runoff. Unlike regular roofs, the foliage on green roofs is able to productively use rainwater to grow plants. This reduces the amount of rainwater runoff from a building. The leftover runoff can be collected in underground cisterns and used in toilets, water used for cleaning, in addition to irrigation. These cisterns can also collect rainwater from roofs that do not have green roofs, as well as from the ground. Due to the nature of the collected water, it is suggested that the water be filtered and disinfected before it is used. These cisterns will be placed in three areas of University Plaza. The first will be placed to the north of the western existing building. It will service and collect water from the northern half of

University Plaza. The second will be placed to the west of Shoppers Drug Mart. This cistern will service and collect water from the south-western quadrant of University Plaza. The final cistern will be placed between Shoppers Drug Mart and Metro and will service the rest of the plaza. These can be seen in Figure 12. The water cisterns will be designed such that they will be able to service the entire plaza. They will be designed by a professional at a later phase of the design.

4.4 Water Efficiency

Another way to decrease water use is to increase water efficiency in the household. Current household statistics show that homeowners typically use 50 percent of water for indoor use and 50 percent for outdoor use (RésEau, 2006). Of the indoor use, 65 percent is used in the bathroom, with the rest used in the kitchen and laundry room (RésEau, 2006). As a result, water efficiency can be achieved by using water efficient technologies.

First, ultra low flow toilets will be installed in all residences and commercial outlets. Ultra low flow toilets use 1.6 gallons of water per flush, reducing the amount of water used per flush by at least 11 gallons per flush over toilets installed in the early 1990's (RésEau, 2006). Also, water efficient shower heads and facets will be installed to reduce water use by approximately 50 percent over regular technologies (RésEau, 2006).

Water efficient appliances and can also be installed in the home to reduce water use. Installing a water saving dishwasher can reduce water use by 25 percent (RésEau, 2006). Installing a horizontal axis clothes washer instead of a vertical axis washer can cut water use by 40 percent (RésEau, 2006).

5.0 PRELIMINARY ECONOMIC INVESTIGATION

To determine if the University Plaza sustainable re-development is economically feasible, a preliminary economic investigation needs to be completed. Although approximate estimates will be used in this investigation, it will provide a sense if the new design can be a profitable venture for the two companies. This investigation will include preliminary costing for the underground parking garage and new buildings. It will also take into account the structural building capacity increase of the existing buildings to carry the new load of residential homes. It will also look at sources of revenue. Finally, this investigation will determine payback periods for the parties involved to determine if the redevelopment is feasible. It should be noted that since this is a preliminary investigation, all of the values in this investigation are rough estimates. As a result, final totals will have a 20% error bounded around them. All calculations for the economic investigation can be found in the Appendix.

5.1 Costs of Re-Development

The largest cost to this new development will be the cost of the buildings. Two different costs will be applied for the new buildings as there are both commercial and residential developments. For residential spaces, a cost of $150.00 per square foot ($1,614.60 per square meter) will be applied (Carrick, 2008a). For commercial spaces, because they require less attention to detail then residential spaces, they will cost less to build. As a result, a construction cost of $130 per square foot ($1,399.32 per square meter) will be applied. Finally, in order to increase the structural capacity of the existing buildings that are going to be built upon, a cost of $100 per square foot ($1,076.40 per square meter) will be applied. As a result, the total cost for the construction of the new commercial and residential spaces will be approximately $44.7 million.

Another major cost of the new design will be the addition of an underground parking garage. Parking garages are expensive, but can be effective in reducing the footprint of a development, as well as keeping a clean, attractive image. Typical costs for an underground parking garage range between $50 and $85 per square foot ($528.20 and $914.94 per square meter) (Carrick, 2008b). As a result, a cost of $65 per square foot ($699.7 per square meter) will be applied for an underground parking structure. Therefore, the parking structure will cost approximately $13.2 million.

Other costs of the development will include the road network, water cisterns, and transit terminal and landscaping. Also, due to the infrastructure for water, sewers, and natural gas already being in place, it is assumed that the cost for these will be smaller then in the construction of a new development. It is approximated that the costs for the rest of the development will be $10 million.

Therefore, adding these three costs together, the University Plaza development will have an approximate capital cost of $67.9 million ± 20%.

5.2 Revenues

Revenues will come as both the sale of the residential spaces, as well as the lease of the commercial spaces. Since this development will be labeled as a sustainable neighbourhood, it can be assumed that there will be great interest in living and working in the plaza. A major selling point for these spaces will be the decreased operating and living costs, which will result in a savings for the tenants. As a result, slightly higher selling prices and leases can be charged by the owners of the plaza.

The first source of revenue for the plaza will be the selling of the residential homes. In the City of Hamilton, a current selling rate of $154.22 per square foot ($1,660.00 per square meter) of residential (US Condo Exchange, 2008). Since this development will be a sustainable neighbourhood, a 10% increase over the current selling rate can be applied. This increase would make the selling rate of the sustainable house $169.64 per square foot ($1,826.00 per square meter). As a result of the selling of these condos, the plaza will make approximately $34.4 million.

The other source of revenue for the plaza will be the leasing of the retail floor space. Leasing rates for commercial retail floor space of similar types can be estimated to be $18.00 per square foot ($193.75 per square meter) per year (Blair Blanchard Stapleton Commercial Realtors, 2008). Therefore, $4.3 million of leasing revenue can be collected per year.

5.3 Payback Period

In order to determine if the sustainable redevelopment of University Plaza is feasible, payback periods need to be determined using simple engineering economic theories. First, using a simple payback period, it was determined that the University Plaza re-development into a sustainable community would have a payback period of approximately 7.8 years. Next, discounted payback periods were determined by rearranging the series present worth factor for different interest rates, i. To simplify this investigation, it was assumed that the costs, c, as well as the revenue for residential dwellings, r, would occur at one single time, time 0. Next, the annual rent from the commercial retailers, a, would be added as an annuity. As a result, the discounted payback period, n, could be determined from the following formula:

Equation 1: Discounted Payback Period (Fraser et al., 2006).

$$n = \frac{\ln\left(\frac{1}{1 - \frac{(c-r)i}{a}}\right)}{\ln(1+i)}$$

From this formula, it was determined that the University Plaza redevelopment into a sustainable community would have a discounted payback period between 9.6 and 16.0 years for interest rates of 4 to 10 percent. This is summarized in Table 3.

Table 3: Discounted Payback Period in Years

Interest Rate	4%	6%	8%	10%
Payback Period in Years	9.6	10.9	12.8	16.0

A payback period of this length should be expected as no large project such as this would have an immediate payback. A maximum of a 15 year payback period for such a development would be acceptable, making the project feasible. After this payback period, due to the increased commercial retail space, the owners of the plaza would receive larger profits. Finally, due to the new sustainable development, increased attention would be placed on the plaza owners, increasing commercial interest in their other ventures.

6.0 CONCLUSIONS AND RECOMMENDATIONS

With more and more focus from the media on climate change and peak oil, innovative developments such as University Plaza will increasingly become more viable in order to reduce our human impact on the planet. With the ever growing population and the limited supply of resources, reducing human dependency on these resources is essential. Increased residential density and proximity to shopping and transit infrastructure can significantly reduce these dependencies. Use of cleaner types of energy such as wind, solar, and geothermal are becoming more cost effective and should now be integrated into any new design. Creating a more pedestrian friendly environment creates increased pedestrian activity, and in turn, reduces vehicle use. Although sustainable community re-development could be associated with large capital costs, these costs are recoverable within a reasonable payback period, as shown through the re-development of University Plaza.

Due to the limitations in this preliminary design phase, many aspects need to be more fully considered in a second stage design phase. First, alternate designs for University Plaza can be investigated, including feasibility studies into the total re-development of University Plaza. Next, more detailed drawings of the redesigned University Plaza need to be created. These drawings include detailed floor plans for the residential and commercial outlets by an architect, as well as structural drawings by a civil engineer. After all drawings are accepted by the engineer and the construction manager, a more detailed cost analysis can be done. Project schedules and funding options can be determined and an estimated date of completion can be determined. Also, traffic studies can be done to determine the impacts of the increased traffic to University Plaza. Finally, more detailed investigations into wind and solar energy should be completed before decisions are made on their possible integration.

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APPENDIX

Building Area Calculations

Table 4: Building Areas

BUILDING	LENGTH	WIDTH	COMMERCIAL STOREYS	RESIDENTIAL STOREYS	RESIDENTIAL HALLWAY	COMMERCIAL FLOORSPACE	RESIDENTIAL FLOORSPACE	HALLWAY FLOORSPACE	TOTAL FLOORSPACE
	feet	feet				square feet	square feet	square feet	square feet
MU1	250	30	1	1	0	7500	7500	0	15000
MU2	190	65	1	1	1	12350	10450	1900	24700
MU3	110	40	1	2	0	4400	8800	0	13200
MU4	135	40	1	2	0	5400	10800	0	16200
MU5	110	40	1	2	0	4400	8800	0	13200
MU6	135	40	1	2	0	5400	10800	0	16200
TH1	110	40	0	3	0	0	13200	0	13200
TH2	135	40	0	3	0	0	16200	0	16200
TH3	110	30	0	3	0	0	9900	0	9900
TH4	110	30	0	3	0	0	9900	0	9900
TH5	110	40	0	3	0	0	13200	0	13200
TH6	135	40	0	3	0	0	16200	0	16200
EXW	620	95	0	1	1	0	52700	6200	58900
EXE*	258.077	65	0	1	1	0	14194.24	2580.77	16775.01
TOTAL						39450	202644.2	10680.77	252775

*Effective length of building

Economic Analysis

COSTS

COST FOR NEW CONSTRUCTION

TYPE	TOTAL FLOORSPACE (SQUARE FEET)	COST PER SQUARE FOOT	COST
COMMERCIAL	39,450	$130	$5,128,500.00
RESIDENTIAL	141,325	$150	$31,998,750.75
TOTAL	180,775		$37,127,250.75

COST FOR RETROFITTING EXISTING BUILDINGS

BUILDING	EXISTING FLOORSPACE (SQUARE FEET)	COST PER SQUARE FOOT	COST
EXW	58,900	$100	$5,890,000.00
EXE	16,775	$100	$1,677,500.50
TOTAL	75,675		$7,567,500.50

TOTAL COST FOR BUILDINGS **$44,694,751.25**

PARKING GARAGE

PARKING GARAGE AREA (SQUARE FEET)	202,700
PARKING GARAGE COST PER SQUARE FOOT	$65.00
PARKING GARAGE COST	**$13,175,500.00**

APPROXIMATION OF OTHER COSTS **$10,000,000.00**

TOTAL COST **$67,870,251.25**

REVENUES

RESIDENTIAL

SELLING PRICE PER SQUARE FOOT	$169.64
TOTAL RESIDENTIAL FLOORSPACE (SQUARE FEET)	202,644
REVENUE FROM HOMES	**$34,376,973.31**

COMMERCIAL

RENT PER SQUARE FOOT	$18.00
TOTAL COMMERCIAL FLOORSPACE (SQUARE FEET)	238,100
REVENUE FROM COMMERCIAL PER YEAR	**$4,285,800.00**

SUMMARY

TOTAL COSTS				$67,870,251.25
IMMEDIATE REVENUE FROM SELLING OF HOMES				$34,376,973.31
NET COST				$33,493,277.94
REVENUE FROM COMMERCIAL PER YEAR				$4,285,800.00
SIMPLE PAYBACK IN YEARS				7.81
INTEREST RATE	**4%**	**6%**	**8%**	**10%**
DISCOUNTED PAYBACK IN YEARS	**9.56**	**10.86**	**12.75**	**15.96**