Residential Street Patterns in Winnipeg: Theory, Research, Reality and Facts

Final Report

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Residential Street Pattern Analysis

Ladco Company Ltd.

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Jacqueline East - Project Manager

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Dillon Consulting Limited

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1 EXECUTIVE SUMMARY

The lack of rigour in current local planning discussion leads to an over simplification of urban development issues. This pits those advocating the economics of an approach against those promoting an environmental or social agenda. There is limited information available to the City of Winnipeg to evaluate different development patterns, and the dialogue often relies upon planning applications and theories from elsewhere in North America and beyond. Linear infrastructure (the pipes and roads) is the most significant economic and environmental cost to the City. This study offers data reflecting the financial realities of construction, maintenance and renewal of alternate street patterns for both the land developer and the municipality, in Winnipeg.

There are three primary factors affecting the long term success of a subdivision within the overall urban context: design (of the neighbourhood), density (of uses), and diversity (of land uses). This study isolates the design element because density and diversity are not a function of the street layout and can be addressed in any development form. Two street patterns, grid and curvilinear, have been chosen to represent two different development forms that have been the subject of countless planning debates[1]. The pros and cons of the two design options are presented through both a qualitative and quantitative analysis and in the context of sustainable development.

This study of street patterns references all three pillars of sustainable development (economic, environmental, and social) in order to provide a broad perspective and a transparent approach to sustainability. The analysis focuses on several key characteristics that can be associated with each of the pillars. Critical qualitative and quantitative variables (such as traffic efficiency, energy consumption, connectivity, sociability, safety, affordability, construction and maintenance and renewal costs, and land use consumption) are compared and contrasted between the grid and curvilinear design in order to provide pertinent information to decision-makers who are adhering to a "sustainability" approach.

Environmental Considerations

Residential street patterns are a component of the overall transportation system of the city and can play a role in how motorized and non-motorized vehicles are used. This is a primary consideration in the discussion of environmental impacts as vehicle usage is a common predictor in an estimate of carbon dioxide emissions. There is, however, no evidence that street patterns alone influence vehicle usage. Factors other than neighbourhood design provide significantly greater impacts on the use of motorized vehicles. These include variables like distance to the Central Business District, local weather conditions,

[1] "Current thinking on street pattern design appears to be divided between concern for the efficiencies of infrastructure and traffic, and a consideration for aesthetics. This generally translates into a battle between conventional suburban loops and cul-de-sacs, and "traditional" grid models." (CMHC 2002)

household affluence, and general human behaviour that covers, for example, an individual's love of automobiles to the desire to minimize travel time to day to day destinations.

The grid is characterized by more intersections, facilitating one aspect of connectivity that impacts vehicular kilometres travelled (VKT) and thus carbon emissions. However, it also creates twice the concrete surface area than a curvilinear street pattern which introduces almost twice the carbon emissions for the production of concrete alone. The machinery required for maintenance of the added street area would also result in a net increase in CO_2 emissions, which must be offset in the overall equation.

A 100 acre grid pattern subdivision requires more than twice as much concrete surface area (24.1% of total land area) for services, which includes streets, sidewalks and lanes, than a 100 acre curvilinear subdivision (11.7% of total land area). This creates a significantly different measure of impervious surface area. Permeability affects the natural mechanisms for surface water run-off as well as aquifer re-charge. Additionally, an increase in impermeable surface area results in a decrease in land area available for plantings of natural vegetation which serve to sequester CO2 and create a carbon sink.

Social Considerations

There is little or no empirical evidence to suggest that residential street pattern design impacts the sociability of a neighbourhood. Research demonstrates that a combined pedestrian-vehicular roadway is not the optimum configuration to promote healthy lifestyle options at the neighbourhood level. In fact, alternative parallel transportation networks, that are intentionally designed to serve each mode, will increase walkability and provide the best options for vehicular and active transportation.

The curvilinear street pattern is better suited to address the issue of affordable housing as the infrastructure needed to create a lot in a 100 acre development costs $11,700 less than a lot in a grid street layout. Expressed another way, households in a 100 acre grid pattern consume about $30,000 each in infrastructure costs (construction of linear infrastructure only) while households in a curvilinear pattern consume about $18,300 each[2]. A population with greater income diversity can also be accommodated in the curvilinear layout due to the variety of lot sizes and market values that can be created in its design.

Economic Considerations

There is a significant impact on private sector cost associated with the construction of a grid patterned subdivision compared to a curvilinear patterned subdivision. The relative cost premium increases as the amount of developable land increases. For example, there is a 31% increase in the construction cost of a 10 acre development and a 43% increase in cost on a 100 acre development. The public sector also invests in development with the taxpayer paying up to $70,000 (current dollars) per acre extra in

[2] This is NOT the total cost of infrastructure. It is only the cost of the local linear infrastructure. The total cost of infrastructure per lot also includes costs associated with local park space, regional servicing and transportation.

infrastructure maintenance and renewal costs for a grid compared to a curvilinear development over a fifty year period.

Land is a valuable commodity. Decreasing the amount of land used for infrastructure not only decreases construction, maintenance and renewal costs, but maximizes the amount of land available as a productive factor of the local economy, including direct revenue to the municipality.

Overall, the traditional grid street pattern is not a sustainable approach to urban development in Winnipeg considering the environmental, social and economic realities of the local development impacts. Using the financial costs and benefits described in this study, the decision about a neighbourhood street pattern can be a $6.4 million (net present value) decision to a municipality over 50 years for 100 acres of land. See Table below.

Table 1: Financial Benefits and Costs to the Municipality over Fifty Years

FINANCIAL BENEFITS AND COSTS TO THE MUNICIPALITY OVER FIFTY YEARS (using key revenue and cost indicators)						
	10 acres of land		50 acres of land		100 acres of land	
	Grid	Curvilinear	Grid	Curvilinear	Grid	Curvilinear
Revenue (current$) (millions)	7.0	8.2	38.7	42.8	75.5	86.6
Cost (current$) (millions)	2.0	1.4	10.1	7.7	20.8	13.6
Total NPV (millions)	2.6	3.2	14.3	16.5	27.6	34.0
Difference NPV (millions)	.6		2.2		6.4	

2 INTRODUCTION

There is an ongoing disconnect in the dialogue between public officials and the development industry related to the costs and benefits of particular urban forms in Winnipeg. This paper presents information to clarify the real costs and benefits of the **grid and curvilinear street patterns**[3]. Quantitative information is provided in the form of Winnipeg-specific empirical data that describes real physical infrastructure costs associated with the two popular street patterns. Qualitative information is taken from current published research on residential urban form.

The motivation behind this paper is to address the continued frustration by the industry in their attempts to communicate the financial realities of construction, maintenance and renewal of alternate street patterns for both the land developer and the municipality.

The development industry focuses its resources and efforts on building the most efficient suburban residential subdivisions in response to their understanding of the current and future housing market in order to realize a return on their financial investment. The municipality represents the taxpayer and is responsible to provide a long range plan for development of the community along with policies and regulations to ensure the community is developed in a way that meets their vision, and, hopefully, if financially, environmentally, and socially sustainable, the needs of future generations.

There is limited information available to Winnipeg to evaluate different development patterns, and the dialogue often relies upon planning applications and theories from elsewhere in North America and beyond. This paper is not intended to dismiss the value of learning from best and common practises, but rather, to add local context and long term cost-benefit information to the decision-making process.

A few Winnipeggers are “speaking up” through blogs and charrettes. Theoretical concepts are emerging and have prompted some debate from the different perspectives. Energy and resources are focusing on ideological approaches rather than a consideration of best practices applied to a thoughtful evaluation of residential development in the local community context, specifically, Winnipeg.

[3] Terms identified in **bold** are defined in Section 8.

3 METHOD OF APPROACH

The research provided is two-fold, both qualitative and quantitative. The qualitative information provides anecdotal information about the pros and cons of the two street patterns, grid and curvilinear, that have been chosen to represent two different development patterns that have been subject of many planning discussions. Accepted best practise and City of Winnipeg regulations have been used to determine the development standards of the hypothetical subdivisions. These assumptions are outlined later in this section. The quantitative research focuses on comparing critical revenue streams related to residential subdivisions and associated linear infrastructure costs (**annual service, maintenance, and lifecycle**).

3.1 Qualitative Information

The qualitative component is limited to a brief review of journal articles found through an internet search and through a discussion with and search by the Institute of Urban Studies at the University of Winnipeg. The focus was the documentation of studies that compared and evaluated residential street patterns. It proved that there is limited empirical data that describes the real costs and benefits of different residential street patterns.

The main sources of available information are papers both advocating and criticizing **neo-traditional planning** (i.e. New Urbanism), which largely favours a grid street pattern (Ellis, 2002). The existing body of knowledge is predominantly based on American examples of residential development. The primary source of Canadian information was taken from Canada Mortgage and Housing Corporation (CMHC) sponsored research, particularly Fanis Grammenos' work on the concept of a fused grid street pattern.

3.2 Quantitative Information

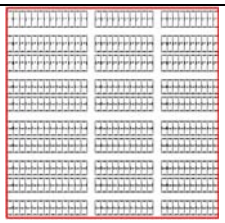
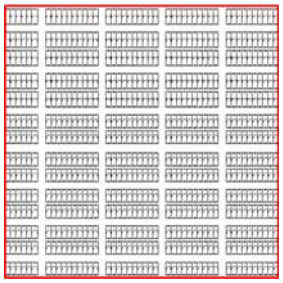
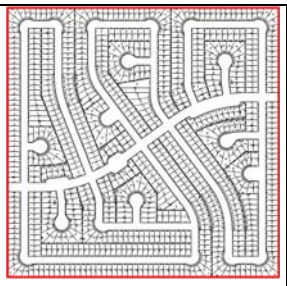
Information and data is collected on the basis of two alternate street patterns, grid and curvilinear. The two street patterns have been chosen as they are two of the most typical urban forms in Canadian cities. They also most clearly represent the two sides of the sustainability argument. In the North American context, the grid street pattern emerged first and the curvilinear pattern later. Thus, the grid pattern is often referenced as 'traditional' neighbourhood design and is prevalent in neo-traditional planning.

For the purposes of illustrating capital, maintenance, and renewal costs of linear infrastructure, Pollock and Wright Land Surveyors drafted theoretical grid and curvilinear subdivisions onto three different land parcel sizes (ten acre, fifty acre and one-hundred acre). See Table 1. Stantec subsequently provided detailed costing for the required measured linear infrastructure. See Appendix B.

The approach provides a data sensitivity analysis and adds transparency by evaluating the possibility that one pattern is superior to the other dependant on the area of land available for development. For example, the finding may have implications for choosing one pattern over the other in a smaller **infill** versus a large area **greenfield** situation.

The revenue stream considered in the comparison of quantitative data is limited to municipal property tax, which is dependent on market values of properties and housing units sold in the subdivision[4]. Development in either street pattern can provide a diversity of housing types and densities that will impact their value in the market. For these reasons, the quantitative analysis is limited to the most clearly measurable costs associated with the two street patterns, those being the hard infrastructure costs, the linear surface and underground services.

Table 2: Theoretical Grid and Curvilinear Street Patterns

GRID STREET PATTERN		CURVILINEAR STREET PATTERN	
10 ACRE SITE			
	• **60** lots • Avg lot size **4002** ft^2 with minimum lot size of 4000 ft^2 • Total assessable frontage **2404** ft with avg 40 ft per lot • Infrastructure construction cost **$1.8M** • 22.5 % site area ROWs		• **70** lots • Avg lot size **4556** ft^2 with range from 3674 ft^2 to 7031 ft^2 • Assessable frontage **2738** ft with avg 39 ft per lot • Infrastructure construction cost **$1.4M** • 11.7 % site area ROWs
50 ACRE SITE			
	• **330** lots • Avg lot size **4002** ft^2 with minimum lot size of 4000 ft^2 • Assessable frontage **13577** ft with avg 41 ft per lot • Infrastructure construction cost **$9.3M** • 23.1 % site area ROWs		• **365** lots • Avg lot size **4332** ft^2 with range from 3629 ft^2 to 9200 ft^2 • Assessable frontage **14730** ft with avg 40 ft per lot • Infrastructure construction cost **$6.9M** • 12.8 % site area ROWs
100 ACRE SITE			
	• **644** lots • Avg lot size **4002** ft^2 with minimum lot size of 4000 ft^2 • Assessable frontage **25912** ft with avg 40 ft per lot • Infrastructure construction cost **$19.3M** • 24.1 % site area ROWs		• **739** lots • Avg lot size **4388** ft^2 with range from 3617 ft^2 to 12913 ft^2 • Assessable frontage **29549** ft with avg 40 ft per lot • Infrastructure construction cost **$13.5M** • 11.7 % site area ROWs

Source: Pollock & Wright Land Surveyors

[4] The City of Winnipeg employs a market value approach to determining property assessments. For the purposes of this study, only 60% of the municipal portion of property was calculated as revenue in the cost-benefit analysis to provide a balanced equation assuming that about 60% of the municipality's costs are for construction, maintenance, and renewal of roadway infrastructure. The remaining 40% is for all other community and municipal services.

3.3 Assumptions & Limitations

The literature generally references three primary factors affecting the success of a subdivision within the overall urban context: design (of the neighbourhood), density (of uses), and diversity (of land uses). This study attempts to isolate the design element of the process. Therefore, a critical assumption behind this analysis is that the two street patterns are being compared, as much as possible, as 'apples' to 'apples', in other words, that all other things are considered to be equal. The street patterns, as illustrated, are hypothetical, i.e. both can have non-motorized intra- and inter- neighbourhood connections integrated into the subdivision design, both can have mixed land uses, high or low densities, schools, green spaces, etc.

This is a theoretical construct, but purposefully narrows the discussion to a key issue in the debate about urban form – that of the street patterns as the basic framework for a neighbourhood, and representing the most significant economic and environmental infrastructure costs to the city. Grammenos and Pollard (2005) emphasized the importance of street patterns, not only because roads are the most expensive infrastructure investment, but also because they are virtually laid in perpetuity and, as such, may leave a legacy of unsatisfactory conditions.

Several assumptions have been made in undertaking costs comparisons for linear infrastructure costs:

- The street layout for the grid pattern is based on the standards set out in the Smart ScoreCard by the Congress for New Urbanism and the U.S. Environmental Protection Agency. Specifically short block lengths are preferred for walkability and general connectivity, i.e. less than 400' is rated Excellent; 400'-500' is Preferred; 501' – 600' is Acceptable, and; anything greater than 600' is Minimal. For the purposes of this study a 400' block is provided in the grid street pattern model (Fleissig and Jacobsen, 2002). Though still too large a block to rate "excellent" with new urbanist proponents, it is at least still in the realm of "preferred". There is no typical block length in the City of Winnipeg and there are no standards in place for the development of city blocks.
- The calculations are generated on a simplistic mono-type development for comparison purposes only. Policies and market conditions that promote increased density and a mix of land uses are beyond the scope of this analysis, as both streets patterns can accommodate a mix of densities and land uses.
- The construction costs are based on 2009 dollars. In the attached report, "Assessment of the Impact on Infrastructure of Alternate Development Forms", Stantec summarizes the costs associated with the underground and surface infrastructure for each street pattern, at three different scales of development (10, 50, and 100 acres).
- The extent of infrastructure required is based on the City of Winnipeg Development Agreement Parameters and in accordance with the City of Winnipeg's Transportation Standards Manual. The exception to this policy manual is that the study assumes sidewalks on both sides of residential streets in the grid street pattern subdivision. Sidewalks on residential streets are a basic feature of traditional neighbourhood design. The policy manual requires sidewalks on local streets only when certain conditions are met.

- It is assumed that the grid street pattern includes laneways and sidewalks on both sides of residential streets and laneways, in accordance with "traditional" neighbourhood design. It is assumed that the curvilinear street pattern includes sidewalks only along collector streets, as well as service roads when single family houses are located along collector streets.
- It is assumed that regional service capacity is immediately adjacent to the development sites. No regional servicing costs have been accounted for in the site servicing costs.
- The standard road size is assumed to be 7.5 meters for residential streets, 10 metres for collector streets, 1.5 meters for sidewalks, and 5 meters for lanes and 6 meter for service roads. The construction standards in the City of Winnipeg dictate minimum cementitious content (300-340kg/cm for sidewalks and 340 kg/cm for roadways). It is assumed for the purposes of this study that all concrete throughout the subdivision is consistent at 340kg/cm.
- All underground infrastructure designs follow City of Winnipeg standard construction specifications.
- Infrastructure costs do not include design, engineering, financing, and landscaping.
- Infrastructure calculations have been made based on a sole land use - residential development, with only single family dwellings. It is assumed that lot size dimensions are comparable between the two street patterns (see Table I).
- Annual maintenance, lifecycle renewal and rehabilitation costs of street works have been provided by the City of Winnipeg Public Works Department, using their 2009 estimates.
- Annual maintenance, lifecycle renewal and rehabilitation costs of underground services (water, wastewater, and land drainage) have been provided by the City of Winnipeg Water and Waste Department, using their 2009 estimates.
- Annual maintenance, lifecycle renewal and rehabilitation costs for linear infrastructure have been illustrated over a 50 year lifetime cycle. A single dollar estimate or net present value was derived by discounting these constant dollars at a real discount rate[5] of 4%, which reflects the City's long term borrowing rate less an allowance for inflation[6].
- City of Winnipeg property tax revenue was estimated using an estimated assessed value of $205,000, based on 2003 reference year market value, for recently constructed homes (2006-2008) on average 40 foot (12.19 m) lots in new Winnipeg developments of Royalwood, Sage Creek, and Harbourview. Larger lots or amenity homes were not included which would have brought the average up to $245,000[7]. This ensures a conservative estimate for municipal revenue is used for the purposes of this study. With the City of Winnipeg portioned assessment (45%), and a municipal mill rate of .025448 (2009), tax generated per home would be $2,348.

[5] Discount rate is the interest rate used in discounting future cash flows.

[6] The inflation rate is the increase in prices for a basket of goods and services expressed on a yearly basis. The most common measure of the inflation rate is the monthly Consumer Price Index (CPI).

[7] For further comparison purposes, note that the average new home sale price for 2009 Winnipeg CMA was $360,036 (CMHC)

- Only a portion of the municipal portion of property tax revenue is accounted for in the cost-benefit analysis as only a portion of the municipal infrastructure costs are accounted for in the study, namely the surface and underground linear infrastructure. It is reasonably estimated that the construction, maintenance, and renewal of street-related infrastructure can account for approximately 60% of overall municipal costs. The balance of municipal revenues is used to build, maintain and operate other community and municipal services. Therefore, 60% of the municipal portion of property tax revenue has been used on the revenue side of the equation in order to illustrate financial impact.

4 BACKGROUND

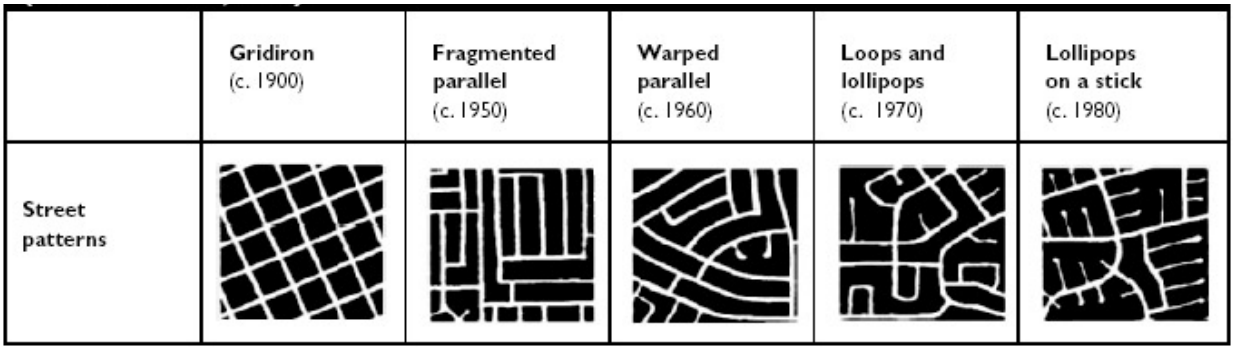
4.1 Historical Context to the Grid and Curvilinear Street Patterns

The grid pattern is characterized by streets forming right angles with each other. The pattern of vertical and horizontal streets with lanes dates back to ancient times and has been a popular European settlement pattern brought to North America. The grid pattern was perceived as problematic after the turn of the 20th century when automobile use became more prevalent and the notion emerged of segregating the use of the automobile from daily residential living environments.

By the 1960s planners and engineers devised a street hierarchy that separated residential subdivisions from the road network. Interestingly, this was somewhat of a return to medieval community forms of Arab and Moorish cities. The road network then accommodated curvilinear streets with the residential cul de sac that further isolated living spaces from vehicular movements.

The following graphic illustrates the evolution of street patterns in North America through the twentieth century:

Figure 1: Evolution of street patterns since 1900 showing gradual adaptation to the car (M. Southworth, 1997)



Source: CMHC 2002

4.2 Sustainability and Residential Street Patterns

Sustainability is the capacity to endure[8]. The premise of planning policy discussions about preferred residential street patterns is the desire to achieve "sustainability". This study references the term cautiously as it is often overused and misused to the point where its meaning is lost. Sometimes the original definition of **sustainable development** is used for expediency rather than applied with adequate rigour in a local context. Politicians, planners, and urban policy experts sometimes use the term "sustainability" to reference an ultimate public good, and sometimes it is used interchangeably with

[8] Wikipedia.

"environment". The term is easily applied to positive communication, messaging, public relations, and marketing efforts[9]. Most proponents will quickly provide the original and commonly accepted definition of sustainable development, that of the Bruntland Commission.[10]

To exacerbate the complexity of this ongoing dialogue about what sustainable community planning looks like, a small segment of urban planning literature is ripe with platitudes about the "sustainability" of neo-traditional urban forms, without adequate analysis to support the claims. One very specific issue that continues to emerge in the public dialogue about urban development in Winnipeg is the notion that traditional grid street pattern is more "sustainable" because it promotes pedestrian travel while conventional curvilinear street patterns promote automobile use. The dialogue often breaks down for two reasons:

(1) when there is a lack of information and data to support positions taken, and,

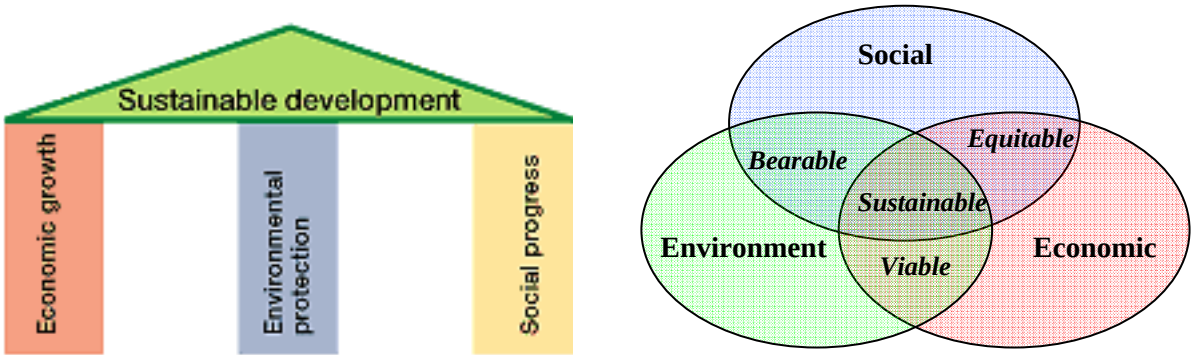
(2) when the full realm of "sustainable development" – economic, social and environmental considerations – is not respected.

Sustainable development, by definition is development that meets the needs of the current generation without impairing the ability of future generations to meet their own needs. As a corporate or organizational goal, sustainable development is often defined as the balance between environment, social, and economic factors when making a decision. The comparison between the two street patterns looks to apply consideration of this thinking to municipal decisions about local street patterns, and, thus, *sustainability*.

[9] The new OurWinnipeg 55-page Call to Action document has 67 instances of the term "sustainability" and an additional 63 uses of "sustainable". Curiously, the existing 65 page Plan Winnipeg 2020 accommodates only 9 instances of the word "sustainability" and 8 instances of the term "sustainable".

[10] The Brundtland Commission's report defined sustainable development as "development which meets the needs of current generations without compromising the ability of future generations to meet their own needs". The concept supports strong economic and social development, in particular for people with a low standard of living. At the same time it underlines the importance of protecting the natural resource base and the environment. Economic and social well-being cannot be improved with measures that destroy the environment. (World Commission on Environment and Development, 1987).

Figure 2: The Three Pillars of Sustainable Development



Source: IUCN (2006)

This study of street patterns will reference all **three pillars of sustainable development** (economic, environmental, and social) in order to provide a broad perspective. There is a specific focus on providing an example of the financial costs (economic) of construction, maintenance, and renewal of the physical infrastructure associated with the two street patterns in Winnipeg, Manitoba. This information is readily available yet not often part of the dialogue. The approach is not intended to emphasize the economic over the social and environmental, but to add salient facts.

5 ANALYSIS

The analysis will focus on several key characteristics that can be associated with each pillar of sustainability (social, environmental and economic). The authors have distilled these characteristics from the literature in order to provide a basis for objective comparison between the two street patterns.

The most relevant work found on the topic of street pattern comparisons is done by Fanis Grammenos, through his previous work with CMHC, and, more recently, through his own consultancy, Urban Pattern Associates. He compared street patterns on the basis of four criteria: tranquility, safety, connectivity, and visual delight. A key feature of Grammenos' design is the connections through parks rather than streets.

Several development characteristics are highlighted in this section, each associated with one of the three pillars of sustainable development. Commentary is provided for each characteristic as it relates to grid and curvilinear street patterns. Quantifiable comparisons are provided where available. Existing research is referenced where possible. For other characteristics, anecdotal descriptions are offered. It is the intent of this report to highlight key variables in a grid and curvilinear street pattern in order to provide additional information to decision-makers who are adhering to a "sustainability" approach.

5.1 Environmental

The environmental aspect of sustainable development takes into consideration impacts to the natural environment that result from development on the land.

5.1.1 Carbon emissions

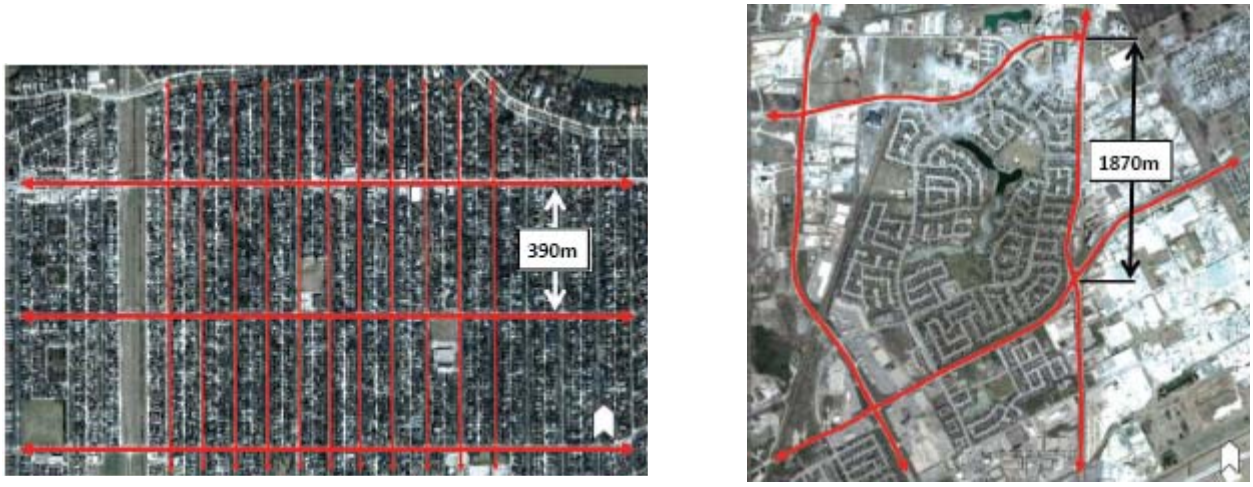
Transportation activities, including road, rail, marine, air and off-road vehicles, are Manitoba's largest source of greenhouse gas (GHG) emissions. They account for approximately 37 per cent of Manitoba's total emissions. A study completed by Transport Canada in 2006 indicated that traffic congestion in Winnipeg may cost our economy up to $104 million annually in lost time, increased fuel costs and GHG emissions. (Province of Manitoba 2008).

Commitments made by the Province of Manitoba in their Beyond Kyoto in 2007, including the adoption of Bill 15 The Climate Change and Emissions Reductions Act in 2008, and a more recent focus of tri-level government stimulus funding for active transportation (2009), sends the signal that transportation systems must be developed with a full range of environmental impacts in mind. Most of the initiatives by the Province of Manitoba target improved technologies to reduce emissions and community-based social marketing efforts to change travel behaviours.

Residential street patterns are a component of the overall transportation system of the city and can play a role in how motorized and non-motorized vehicles are used. Greater connectivity within and between neighbourhoods increases the efficiency of automobile trips, facilitates the use of public transit, walking and cycling. Stop-and-go traffic and non-constant vehicular speeds decrease the efficiency of automobile operation. There is, however, no evidence that street patterns alone influence vehicle usage.

The cul de sac lacks interconnectedness. In a curvilinear design, residential roads funnel onto a collector road thus encouraging the use of vehicles for mobility. The grid street pattern provides convenience, route options, and traffic distribution. "A more finely grained urban network serves to distribute traffic more evenly while providing improved network connectivity and improving the safety and convenience for non-motorized modes." (Fernandez and Marcus, 2009, p.32). Figure 3 illustrates two neighbourhoods in Winnipeg, one that benefits from the intersection density of a grid street pattern and a curvilinear patterned neighbourhood. The relative ease of connection into and out of the neighbourhood is evident. However, Grammenos (July 2008) found that intersection density and the presence of curvilinear patterns do not have a strong correlation with traffic performance.

Figure 3: Intra-neighbourhood connections for a grid and curvilinear neighbourhood



Comparison of River Heights (grid pattern) and Lindenwoods (curvilinear pattern) design in Winnipeg

Cox (2005) notes that there is some contradiction by proponents of the connectivity and ease of access of the grid street pattern as traffic calming measures are increasingly called for on grid streets in order to slow down and re-direct through traffic. Current best practises for the implementation of active transportation routes in Winnipeg indicate the use of traffic diverters, traffic circles, and additional stop mechanisms for motorized vehicles in order to divert and slow the speed of motorized traffic through grid-patterned neighbourhoods. These initiatives will further increase emissions from the frequent stops and starts already present in the grid street system, not to mention the emissions created from the construction of additional concrete infrastructure.

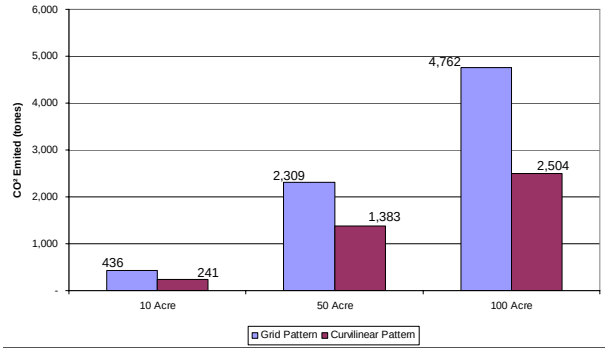
IBI Group undertook an extensive review of greenhouse gas emissions from urban travel (CMHC 2000) in Toronto and concluded that, although neighbourhood design has some influence on GHG travel emissions per household, the two strongest influencers were:

- the number of vehicles per household, which is associated with household income and number of adults in the household (a socio-economic factor); and,
- the distance to the Central Business District (for every kilometre a household moves away from the CBD, weekday VKT per household increases by approximately 1.0 km).

The IBI work is interesting in pointing out how factors other than neighbourhood design provide significantly greater impacts on the use of motorized vehicles. The IBI tool is difficult to apply to cities unlike Toronto. The urban environment in Winnipeg is drastically different in terms of density, distance, public transportation options, climate, economy and community, to name a few. For example, even the extra trucking of snow from backlanes in Winnipeg is an additional contributor to the use of motorized vehicles and emissions.

Vehicle usage is the common predictor in an estimate of carbon dioxide emissions. As there is no evidence to suggest that street pattern alone influences vehicle usage, it is also interesting to consider the carbon emissions from the production of cement. "The manufacturer of cement in Canada contributes an estimated 1.0% of total Canadian air pollutant emissions, and 1.4% of total Canadian greenhouse gas (GHG) emissions" - 12.7 million tones of CO_2 in 2006" (Cement Association of Canada 2008). Cement is the key ingredient in making concrete, the predominant material used to build the required infrastructure related to the two street patterns. For every tonne of cement produced, three quarters of a tonne of CO_2 is emitted. The concrete used in structures and roadways has 15% cement content. For a 100 acre subdivision, twice as many tonnes of greenhouse gases (4,762 tonnes versus 2,504 tonnes) are emitted from the production of the cement required for construction of grid infrastructure compared to curvilinear infrastructure.

Figure 4: Emissions from concrete production



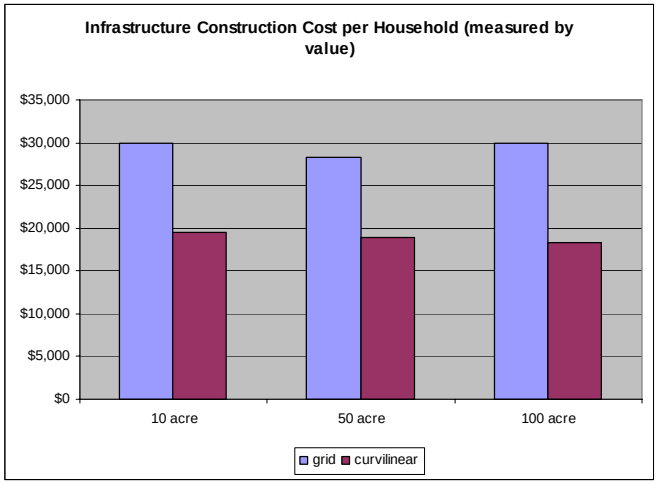
5.1.2 Ecological preservation

A study undertaken to calculate and examine the factors in a human **ecological footprint** showed that a considerable component of an individual's ecological footprint (more than 40%) is attributable to their share of infrastructure and services. For example, about one third of the CO_2 emissions attributed to our domestic activities are due to 'food miles' and the energy required to grow, process and transport produce (James and Desai, 2003). The research further demonstrated that about fifty percent of a community's ecological impact falls outside the built environment and is due to the net lifestyle impact of its residents."

Household share of local linear infrastructure dramatically increases with a fully developed grid street pattern compared to a curvilinear street pattern. On a 100 acre parcel of land, 43% more infrastructure is required to build a grid street pattern compared to a curvilinear street patterns. Using the value of the linear infrastructure to represent magnitude of built environment imposed into the land, households in a

grid pattern consume about $30,000 each in infrastructure costs (construction only) while households in a curvilinear pattern consume about $18,300 each[11]. Regardless of the neighbourhood street pattern, distance away from employment centres and other destination nodes impacts consumption of non-local linear infrastructure.

Figure 5: Infrastructure Cost per Household (Measured by value)



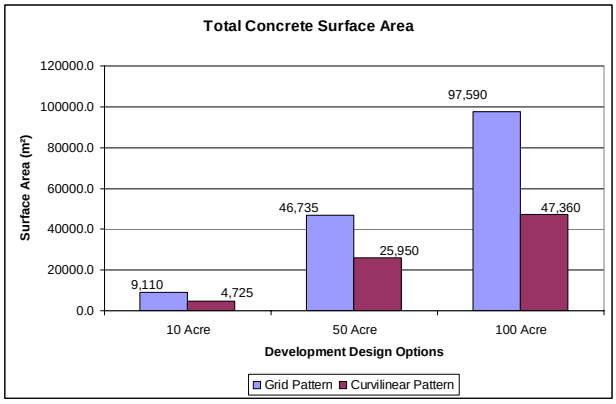
The curvilinear (with cul de sacs) street pattern offers a distinct advantage in the preservation of ecological areas. While the grid street pattern is quite invasive, imposing a grid of extensive infrastructure on the land, the curvilinear pattern can work around areas of high ecological or historic value and incorporate natural drainage systems that can dually serve to provide community green space and active transportation corridors. (Southworth and Ben-Joseph, 2004)

5.1.3 Permeability

The most significant impact urban residential development has on the environment is the initial disturbance of the natural state of the land. The degree of this impact depends on the subdivision layout and design of building footprints. It is important to minimize the loss of a porous earth surface. This is particularly important for a city built on a floodplain, like Winnipeg. Permeability affects the natural mechanisms for surface water run-off as well as aquifer re-charge. The street patterns used in this study illustrate the difference in surface area covered by concrete. On a 100 acre parcel of land, 24.1% is covered with concrete for a grid pattern and 11.7 % is covered by concrete with a curvilinear pattern. Interesting, Portland, Oregon, one of the most acclaimed cities built on a pure grid pattern, has 42% of its land area devoted to right-of-way (Grammenos and Pollard, 2009).

[11] 2009 construction costs, Winnipeg.

Figure 6: Impervious Surface Area



5.2 Social

The social aspects of sustainable development are difficult to quantify and can be both tangible and intangible. There is a school of thought that the physical design of a community can cause a social benefit. The social benefit may be valued beyond economic cost if it is a desired feature of a particular community. The community can determine that a social benefit outweighs the extra financial investment of a physical development that is not cost effective. Two issues arise when this is the case: (1) has there been objective diligence in understanding the real cost and benefit in a local context and (2) if it is an objective of public policy, how will the public share in the investment. In all cases, all three pillars of sustainability should be balanced according to the overall interests of the community.

5.2.1 Sociability

There is little or no empirical evidence to suggest that residential street pattern design impacts the sociability of a neighbourhood. The debate about grid and curvilinear street patterns is often couched in discussions about the popular suburban subdivision design (with curvilinear streets and cul de sacs) and New Urbanism (which promotes a traditional grid street pattern). Several of the principles listed in the Charter of the New Urbanism, imply the design promotes a sense of community. The claim has rarely been questioned with much academic rigor (Talen 1999, Talen 2002).

The most thorough research undertaken in an attempt to compare two built neighbourhoods in close proximity, a New Urbanist neighbourhood and a more typical suburban development, is a comparison of Kentlands and Orchard Village (Kim and Kaplan, 2004). Both residential communities are located in Gaithersburg, Maryland about 25 miles from Washington DC. The study's goal was to measure "sense of community" and the researchers employed accepted research methods, including extensive resident surveys and interviews. Four domains of sense of community (attachment, identity, social interaction, and pedestrianism) were evaluated according to 17 physical characteristics of the neighbourhood.

The residents of the neo-traditional community of Kentlands responded with much greater enthusiasm about sense of community than the suburban neighbourhood of Orchard Village. However, Kentlands residents also noted their own lack of socio-economic and ethnic diversity (Kim and Kaplan, 2004).

The study's findings conclude *with caution* that there is some evidence to support claims that neotraditional design promotes a greater sense of community, and that the broader impact of such developments needs to be better understood. The description of different resident involvement, interest, and response rates from the two communities also provides evidence of two very different populations choosing to live in their respective communities, for very different reasons – one for a dynamic and interactive relationship with neighbours and community and one for the quietude and solace of home, family and private space.

5.2.2 Health

A recent CMHC study (Grammenos, July 2008) found that the highest proportion of trips on foot is found in areas where a path is relatively more direct to nearby retail and recreational destinations on foot than by car. This implies that combined pedestrian-vehicular roadway is not the optimum configuration, but rather that a design of parallel transportation networks should be provided if the goal is to provide a built form that encourages active physical living, i.e. vehicular, cycle, pedestrian.

This is consistent with the move to focus on layered networks (Fernandez and Marcus, 2009) that provide excellent pedestrian connections and not just connected streets (Hawkins, d.u.). The study also illustrated that the grid street pattern alone, without sidewalks, had the same walk-share of trips as a loop/cul de sac neighbourhood.

The obvious policy solution to design health into community building is to ensure that all communities are developed and connected with active transportation systems. This infrastructure can be incorporated into either the grid or curvilinear street patterns, but must be done so at the planning stages or else difficult modifications are later required.

5.2.3 Housing diversity and affordability

It has been illustrated that there is approximately $11,700 per lot more linear infrastructure construction cost associated with the 100 acre grid versus curvilinear street patterns. This additional cost is a factor in the purchase price of the house. It is, therefore, a consideration when housing affordability is a desired outcome of urban form.

By its nature, the curvilinear design results in a diversity of lot sizes and configurations with a variety of values in the marketplace. This promotes a diversity of income in the neighbourhood, even in the theoretical designs used for this study, which incorporates only single family dwellings. It was an interesting observation in the Kentlands/Orchard Village study that the new urbanist Kentlands' residents made note of the lack of diversity in their neighbourhood.

5.2.4 Safety

Neighbourhood safety issues span considerations of multi-modal travel safety as well as crime prevention. There are four key strategies identified in Crime Prevention through Environmental Design (CPTED): natural surveillance, territorial reinforcement, natural access control, and maintenance.

Any neighbourhood design requires a considered approach to ensure optimum environments are created. Pedestrian/cycle pathways in curvilinear subdivisions increase safety by separating vehicular traffic from non-motorized modes, however natural surveillance is often reduced. However, with sidewalks installed, pedestrian activity and dispersed traffic increases natural surveillance.

Frequent four-way intersections of grid subdivisions increase traffic impacts and disburse traffic throughout the subdivision creating additional vehicular traffic for all residences. This access coupled with the presence of back lane access to properties also tends to invite unwanted traffic which facilitates property crimes. CPTED discourages cut-through traffic and recommends access between subdivisions be limited though not completely disconnected.

5.3 Economic

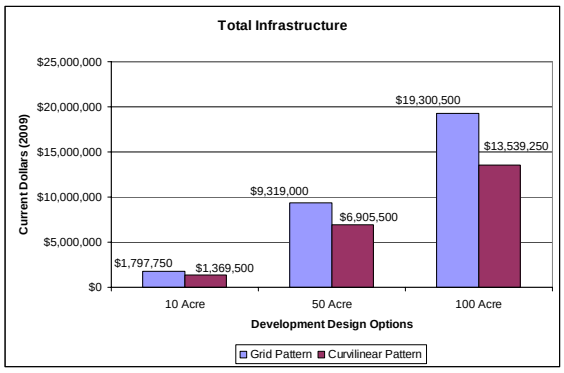
The economic pillar of sustainable development is as diverse as the environmental and social pillars. The construction, maintenance and renewal costs of the two development patterns represent most of the economic aspect illustrated in this study. Other relevant economic issues associated with neighbourhood design relate to municipal revenues collected through property taxes, the ability for the market to respond to the residential products that are designed, the attractiveness of the community to compete for global residents, and the maximization of economic productivity out of land assets.

5.3.1 Construction costs

Initial construction costs are borne by the developer[12] and are a direct factor in the final house sale price. Stantec (2009) undertook a comprehensive analysis of the costs of the linear infrastructure required to construct each of the parcel sizes into a grid and curvilinear design, as illustrated previously in this report. The infrastructure costs to develop a traditional grid street pattern subdivision with sidewalks and back lanes are significantly higher than the infrastructure costs to develop a curvilinear street pattern subdivision, 31% higher on a 10 acre parcel and 43% higher on a 100 acre parcel.

[12] Maintenance and replacement infrastructure costs are borne by the City.

Figure 7: Infrastructure Construction Costs With Lanes and Sidewalks

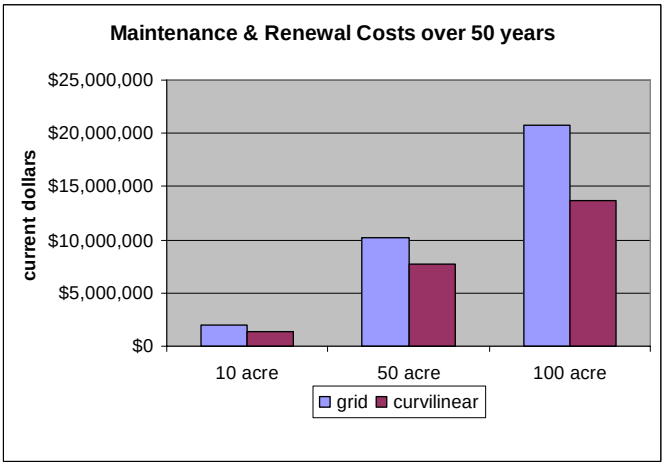


The essence of the grid street pattern as a planning ideology of traditional connectivity and legibility requires sidewalks and back lanes. The largest cost associated with the grid street pattern that is not associated with a curvilinear street pattern is the cost of sidewalks and laneways on residential streets. For analysis purposes only and to relate to some existing traditional Winnipeg neighbourhoods, Stantec further refined the construction costs by removing sidewalks from the grid design and found that the linear infrastructure costs were still higher for a grid street pattern than a curvilinear street pattern on the 50 and 100 acre parcels of land (289% and 24%, respectively Stantec's full report is attached as Appendix B.

5.3.2 Maintenance and renewal costs

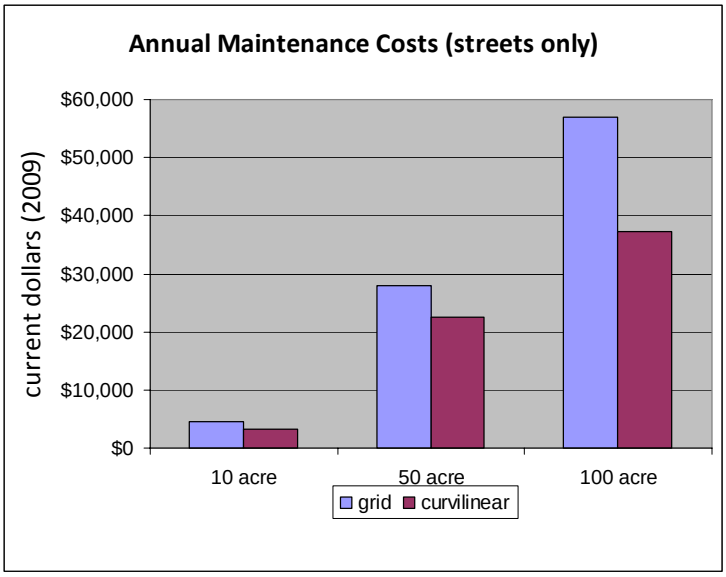
Initial construction costs are borne by the developer in Winnipeg. The additional costs are simply a factor in the final price the consumer pays for the product and, thus do not directly cost the taxpayer. However, the additional infrastructure built into the grid street pattern does translate into additional public costs in the form on ongoing maintenance and infrastructure renewal.

Figure 8: Maintenance & Renewal costs over 50 years



Over 50 years, a 100 acre grid subdivision will cost the municipality $7.2 million (in current dollars) more in maintenance and renewal costs than a 100 acre curvilinear subdivision. During that same period of time, the extra lots provided in the curvilinear design will gain the municipality $11.1 million of additional property tax revenue. In total, the decision about a neighbourhood street pattern can be a $6.4 million decision in net present value to a municipality over 50 years.

Figure 9: Annual Maintenance Costs (Streets only)



Looking to the published literature to gain insight into the costs of development patterns, we find an interesting CMHC study (Issue 26) that attempts to quantify the actual public and private infrastructure costs (both initial capital and lifecycle) associated with conventional post-war suburban development pattern and a more compact New Urbanism plan. The study uses an existing Ottawa-Carleton development site with curvilinear street pattern and relatively low residential densities. A broad picture of New Urbanism is described that includes a greater mix of land uses, higher densities, narrower right-of-ways and a modified grid system. The infrastructure costs are expressed 'per living unit'.

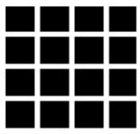
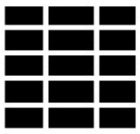
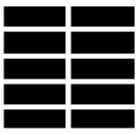
The theoretical New Urbanist design was overlaid on the existing development, that the market had already absorbed, and demonstrated lower infrastructure costs per unit. However, the infrastructure costs are significantly more per unit of land. The per unit infrastructure savings promoted in the paper is a result of increased residential densities (17.5 **UPA** in the New Urbanist design versus 8.8 UPA in the conventional design) and twice as much land devoted to commercial use in the New Urbanist design. It is a comparison of 'apples' to 'oranges'. This type of example is typical in the literature in that the existing development has been realized in the real world but the theoretical development has not been accommodated by the market. It begs the question about whether or not the market will bear the proposed residential densities and accommodate the proliferation of commercial land in every neighbourhood as advocated by New Urbanists and required in order to achieve cost-effectiveness.

5.3.3 Market Considerations

Developers will undoubtedly be drawn to respond to consumers' preferences, which define relevant market forces. The curvilinear design offers quiet, safe streets where children can play with little fear of fast-moving traffic. The grid design exists in original Winnipeg neighbourhoods and attracts those seeking an urban lifestyle in authentic character homes. In the market, home-buyers pay premium prices for the most isolated cul-de-sac lots and others will pay a premium for the century old homes on large lots in elm tree draped traditional neighbourhoods. The cost savings on construction of infrastructure pays for construction of addition public open spaces in the suburbs (Southworth and Ben-Joseph, 2004) while the true per household cost of infrastructure in original urban neighbourhoods is seldom considered and rarely acknowledged.

Land is a precious commodity over which municipalities have considerable authority. A municipality that maximizes its use of developable land that is under its authority invests wisely in a sustainable local economy. Current initiatives at the City of Winnipeg are making more land available as a productive part of the local economy[13] while decreasing the public stake in urban land. The land used for infrastructure is a portion of the City land assets that need scrutiny when new neighbourhood development patterns are considered. The following graphic illustrates the evolution of urban street patterns throughout the twentieth century. It quantifies the increasing percentage of buildable area provided as well as the decrease in land devoted to hard infrastructure.

Figure 8: Comparison of area used for streets, among five typical patterns

	 **Square grid** (Miletus, Houston, Portland, etc.)	 **Oblong grid** (most cities with a grid)	 **Oblong grid 2** (some cities or in certain areas)	 **Loops** (Subdivisions - 1950 to now)	 **Culs-de-sac** (Radburn - 1932 to now)
Percentage of area for streets	36.0%	35.0%	31.4%	27.4%	23.7%
Percentage of buildable area	64.0%	65.0%	68.6%	72.6%	76.3%

Source: CMHC 2002

Land is a valuable commodity. A decrease in land used for infrastructure not only decreases construction, maintenance and renewal costs, but maximizes the amount of land available as a productive factor of the local economy.

[13] Note City of Winnipeg efforts over the past several years to divest itself of underutilized properties for infill housing, commercial redevelopments, brownfield restoration, etc.

5.4 Relative Sustainability of Street Patterns

The following table summarized the key characteristics discussed in the above analysis:

Table 3: Summary of Street Pattern Characteristics

STREET PATTERN	GRID	CURVILINEAR
Energy consumption	• requires 2.3 lamp standards/acre	• requires 1.2 lamp standards/acre
Safety	• typically will have more intersections which will help slow traffic but also increases potential for vehicle collisions • the increased access to private property is contrary to CPTED principles	• hierarchical street network eliminates through traffic in cul-de-sacs and side streets but increases the volume and speed of vehicles on collector routes
Connectivity	• directness of pedestrian access is facilitated by virtue of street locations and intersecting pattern • sidewalks on both sides of street • Intra and inter-neighbourhood connections is facilitated by the orthogonal geometry of the streets	• connectivity must be consciously built into area structure plans (for inter-neighbourhood connections) and subdivision design (for intra-neighbourhood connections)
Ease of orientation	• the orthogonal geometry of a grid street clarifies location and direction for visitors in the neighbourhood.	• as part of a street hierarchy can alter perceptions of direction but guide movements more directly and intuitively between origins and destinations.
Sociability	• Sidewalks on both sides of the street facilitate pedestrian activity throughout the neighbourhood.	• Cul de sacs and bays allow children to play in the front yard and street without being endangered by fast moving traffic
Housing diversity and affordability	• higher infrastructure costs are incorporated into final house cost • Standard lot sized result in similar consumer for all lots	• the potential of increasing the number of units per acre lowers the per-household infrastructure cost • diversity of lot sizes and configurations can potentially result in a diversity of housing styles and sizes
Construction Costs	• average cost per acre (streets & pipes): 10 acre - $179,775 50 acre - $186,380 100 acre - $193,005	• average cost per acre (streets & pipes) 10 acre - $136,950 50 acre - $138,110 100 ac re - $135,393
Maintenance and renewal costs	• average of $164,720/acre for surface and underground works (2009 current dollars)	• average of $143,900/acre for surface and underground works (2009 current dollars)
Land drainage	• more direct connections required to regional service lines • Requires larger LDS as there is greater run-off due to additional impervious surface area	• less direct connections required to regional service lines
Assessable frontage	• less assessable frontage primarily due to corner lots resulting in less property tax revenue for the municipality	• 14% more assessable frontage resulting in more property tax revenue for the municipality
Land use efficiency[14]	• 19.32 persons/ac (44.49 persons/ha)	• 22.17 persons/ac (51.90 persons/ha)

[14] Residential density with equivalent average lot size, assuming single family development for both street patterns.

6 CONCLUSIONS

The dialogue is increasing over the impact of urban form (land use) and structure (transportation networks) on the emission of greenhouse gases, and other current environmental, social and economic issues. It is important to ensure that the theories we espouse and the models we embrace from elsewhere truly reflect a thoughtful objective analysis of the issues in a real local context.

The debate over street pattern must evolve into new solutions that meet the desires of the market as well as the long term interests of the municipality. Recent industry publications (Realty Times and HomeBuilder) are acknowledging new ideas like the fused grid. (Wade 2005 and Grammenos 2009). The Federation of Canadian Municipalities recently released Alternative Development Standards: A Guide for Practitioners (2009) which acknowledges the constraints of a pure grid system of local streets.

In the meantime, the study illustrates that there must be an acknowledgement of the merits that the curvilinear design presents in order to achieve a more sustainable future.

- A curvilinear neighbourhood has half the amount of concrete surface area that a grid pattern when a 100 acre parcel of land is assessed. Not only does this diminish construction costs by half, but it also reduces the maintenance and renewal costs to the municipality by one third. Less land area required for infrastructure in a curvilinear-designed subdivision means more land available as a productive contributor to the local economy.
- Environmental benefits of the curvilinear design include less carbon emissions from less concrete production and less motorized equipment activity for street maintenance. There is also twice the amount of permeable surface area to create a carbon sink and absorb and filter stormwater run-off in a more naturalized state while better re-charging the aquifer.
- Curvilinear neighbourhoods attract a greater diversity of residents by virtue of its broad range of lot sizes and configurations. Significantly reduced linear infrastructure costs, compared to a grid design, reduce the final cost of a home, providing greater affordability.
- Connectivity can best be achieved through a system of layered people-moving networks. There must be an acknowledgement that streets cannot and do not serve all modes of travel effectively. A well-designed curvilinear street pattern has the flexibility to ensure that priority routes are identified for each mode - transit, cycle, vehicle, truck route, and pedestrian.

The municipality must identify with clarity the principles that are desirable and that reflect the values of the community, rather than dictate any particular physical form of development. They must build partnerships with the private sector in order to fully realize opportunities for innovation and entrepreneurship. Design based solutions will be more progressive contributors than prescriptive regulations.

7 DEFINITIONS

Assessable Frontage – the full length of a parcel of land abutting the public road onto which the parcel fronts.

Connectivity – pedestrian accessibility to various parts of the community, and links between the neighbourhood and adjacent neighbourhoods.

Curvilinear Street Pattern – A street pattern that is curved. This type of street system is very common in many suburban neighbourhoods and is often characterized by a large number of cul-de-sacs. Typically, roadways are hierarchically designed with traffic channelled from neighbourhood streets to busy arterial roads.

Delight – a term used by Fanis Grammenos to describe the frequency and proximity of open green space.

Density (Gross) – an expression of development density which includes all land uses within a development as well as roads and utilities.

Density (Net) – an expression of development density which only includes land used for development and excludes land used for road right-of-ways, utilities and parks.

Ecological Footprint – a concept conceived by William Rees to communicate the amount of biologically productive land and sea area needed to regenerate the resources a human population consumes and to absorb and render harmless the corresponding waste. Using this assessment, it is possible to estimate how much of the Earth (or how many planet Earths) it would take to support humanity if everybody lived a given lifestyle. On a neighbourhood scale it can be used to communicate how many hectares of land is required to support a specific development and the inhabitants.

Fused Grid – The fused grid represents the synthesis of two traditional North American approaches to residential neighbourhood planning: the traditional, nineteenth-century grid, and the curvilinear pattern of looped streets and cul-de-sacs of modern suburbia. The goal of the fused grid is to provide a balance between vehicular and pedestrian movement, and to create safe, sociable streets and easy connectivity to community facilities. These attributes are achieved while retaining the land use and infrastructure advantages of conventional suburban plans, compared to the traditional grid.

Greenfield - a piece of previously undeveloped land, in a city or rural area and includes agricultural land

Grid (Gridiron) Street Pattern – a street pattern in which streets run at right angles to each other, forming a grid.

Infill – development which occurs on a vacant or undeveloped site which is situated between other existing developments.

Life Cycle Costing (also called Whole Life Costing) - is a technique to establish the total cost of ownership. It is a structured approach that addresses all the elements of this cost and can be used to produce a spend profile of the product or service over its anticipated life-span. The results of an LCC analysis can be used to assist management in the decision-making process where there is a choice of options. The accuracy of LCC analysis diminishes as it projects further into the future, so it is most valuable as a comparative tool when long term assumptions apply to all the options and consequently have the same impact.

Neo-traditional Planning – a theoretical approach to urban planning advocating for traditional neighbourhood layout and design. The theory states a need for mixed land uses, a diversity of housing types and densities, and street and land uses designed to facilities walkability.

Safety - a term used by Fanis Grammenos to describe the number of "T" intersections within a neighbourhood.

Smart Growth - ULI defines smart growth as growth that is economically sound, environmentally friendly, and supportive of community liveability—growth that enhances our quality of life. Physically, Smart Growth advocates for concentrated growth in the center of a city to avoid urban sprawl and transit-oriented, walkable, bicycle-friendly land uses, including neighbourhood schools, complete streets, and mixed-use development with a range of housing choices.

Sustainable Development - sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Bruntland Commission).

Three Pillars of Sustainable Development - a representation of sustainability in which society, economy and environment form the three pillars supporting overall sustainability. The concept is based on the notion that the three pillars are needed for sustainable development and if one pillar fails then sustainability cannot be achieved.

Tranquility - a term used by Fanis Grammenos to describe the number of houses on loops and cul-de-sacs within a neighbourhood

Units per acre (UPA) – a representation of development density (gross or net) where the overall number of units within a development are divided by the total development area. Density is also often expressed as people per acre which takes the total population of and area divided by the total area.

Urban sprawl - is the unplanned, uncontrolled spreading of urban development into areas beyond the edge of a city. Contiguous and compact development does not constitute urban sprawl. Urban sprawl can be characterized by low residential densities (defined as less than 2 units per acre) and isolated commercial and employment areas. Street patterns are not a factor in urban sprawl.

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APPENDIX A

Cost Benefit of Grid and Curvilinear Street Pattern Subdivision

COMPARISON OF RELATIVE MUNICIPAL PROPERTY TAX REVENUE AND COST OF LINEAR INFRASTRUCTURE
FOR GRID AND CURVILINEAR STREET PATTERN SUBDIVISIONS

GRID 10 ACRE

REVENUE TO CITY OF WINNIPEG		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
Single Family Dwellings (SFD)	60																							
Municipal Taxes ($2348 per SFD) [1]	$2,348	84,513	84,513	84,513	84,513	84,513	84,513	84,513	84,513	84,513	84,513	84,513	84,513	84,513	84,513	84,513	84,513	84,513	84,513	84,513	84,513	84,513	84,513	84,513
Sewer and Water Utility Rates ($795 per SFD) [2]	$795	47,700	47,700	47,700	47,700	47,700	47,700	47,700	47,700	47,700	47,700	47,700	47,700	47,700	47,700	47,700	47,700	47,700	47,700	47,700	47,700	47,700	47,700	47,700
Frontage Levy ($102 per SFD) [3]	$102	6,120	6,120	6,120	6,120	6,120	6,120	6,120	6,120	6,120	6,120	6,120	6,120	6,120	6,120	6,120	6,120	6,120	6,120	6,120	6,120	6,120	6,120	6,120
Building Permits and Development Fees [4]		114,180																						
Total Revenue		252,513	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333
Cumulative Total		252,513	390,846	529,178	667,511	805,844	944,177	1,082,510	1,220,842	1,359,175	1,497,508	1,635,841	1,774,174	1,912,507	2,050,839	2,189,172	2,327,505	2,465,838	2,604,171	2,742,503	2,880,836	3,019,169	3,157,502	3,295,835

INFRASTRUCTURE COST TO CITY OF WPG	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
Underground Works																							
U/G Annual Servicing and Maintenance [5]	5,250	5,250	5,250	5,250	5,250	5,250	5,250	5,250	5,250	5,250	5,250	5,250	5,250	5,250	5,250	5,250	5,250	5,250	5,250	5,250	5,250	5,250	5,250
U/G Lifecycle Maintenance [6]															1,525								
Surface Works																							
Annual Servicing and Maintenance [7]	4,643	4,643	4,643	4,643	4,643	4,643	4,643	4,643	4,643	4,643	4,643	4,643	4,643	4,643	4,643	4,643	4,643	4,643	4,643	4,643	4,643	4,643	4,643
Lifecycle Maintenance [8]					4,414					6,692					8,828					13,384			
Total Cost	9,893	9,893	9,893	9,893	14,307	9,893	9,893	9,893	9,893	16,585	9,893	9,893	9,893	9,893	20,246	9,893	9,893	9,893	9,893	23,277	9,893	9,893	9,893
Cumulative Total	9,893	19,787	29,680	39,574	53,881	63,774	73,668	83,561	93,454	110,040	119,933	129,827	139,720	149,613	169,859	179,753	189,646	199,539	209,433	232,710	242,604	252,497	262,390

SUMMARY	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
Total Revenue	252,513	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333
Total Costs	9,893	9,893	9,893	9,893	14,307	9,893	9,893	9,893	9,893	16,585	9,893	9,893	9,893	9,893	20,246	9,893	9,893	9,893	9,893	23,277	9,893	9,893	9,893
Net	242,619	128,439	128,439	128,439	124,025	128,439	128,439	128,439	128,439	121,747	128,439	128,439	128,439	128,439	118,087	128,439	128,439	128,439	128,439	115,055	128,439	128,439	128,439
Cumulative Net	242,619	371,059	499,498	627,938	751,963	880,403	1,008,842	1,137,281	1,265,721	1,387,468	1,515,908	1,644,347	1,772,787	1,901,226	2,019,313	2,147,752	2,276,192	2,404,631	2,533,071	2,648,126	2,776,565	2,905,005	3,033,444
Net Present Value [9]	233,288	118,749	114,182	109,791	101,940	101,508	97,603	93,849	90,240	82,248	83,432	80,223	77,137	74,171	65,569	68,575	65,937	63,401	60,963	52,510	56,364	54,196	52,111
Cumulative NPV	233,288	352,037	466,220	576,010	677,950	779,458	877,061	970,910	1,061,150	1,143,398	1,226,830	1,307,053	1,384,190	1,458,361	1,523,930	1,592,505	1,658,443	1,721,844	1,782,807	1,835,317	1,891,680	1,945,876	1,997,987

CURVILINEAR 10 ACRE

REVENUE TO CITY OF WINNIPEG		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
Single Family Dwellings (SFD)	70																							
Municipal Taxes ($2348 per SFD)	$2,348	98,598	98,598	98,598	98,598	98,598	98,598	98,598	98,598	98,598	98,598	98,598	98,598	98,598	98,598	98,598	98,598	98,598	98,598	98,598	98,598	98,598	98,598	98,598
Sewer and Water Utility Rates ($795 per SFD)	$795	55,650	55,650	55,650	55,650	55,650	55,650	55,650	55,650	55,650	55,650	55,650	55,650	55,650	55,650	55,650	55,650	55,650	55,650	55,650	55,650	55,650	55,650	55,650
Frontage Levy ($102 per SFD)	$102	7,140	7,140	7,140	7,140	7,140	7,140	7,140	7,140	7,140	7,140	7,140	7,140	7,140	7,140	7,140	7,140	7,140	7,140	7,140	7,140	7,140	7,140	7,140
Building Permits and Development Fees		131,210																						
Total Revenue		292,598	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388
Cumulative Total		292,598	453,987	615,375	776,763	938,151	1,099,540	1,260,928	1,422,316	1,583,704	1,745,093	1,906,481	2,067,869	2,229,258	2,390,646	2,552,034	2,713,422	2,874,811	3,036,199	3,197,587	3,358,976	3,520,364	3,681,752	3,843,140

INFRASTRUCTURE COST TO CITY OF WPG	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
Underground Works																							
U/G Annual Servicing and Maintenance	6,300	6,300	6,300	6,300	6,300	6,300	6,300	6,300	6,300	6,300	6,300	6,300	6,300	6,300	6,300	6,300	6,300	6,300	6,300	6,300	6,300	6,300	6,300
U/G Lifecycle Maintenance															1,650								
Surface Works																							
Annual Servicing and Maintenance	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285
Lifecycle Maintenance					4,400										8,799								
Total Cost	9,585	9,585	9,585	9,585	13,985	9,585	9,585	9,585	9,585	9,585	9,585	9,585	9,585	9,585	20,034	9,585	9,585	9,585	9,585	9,585	9,585	9,585	9,585
Cumulative Total	9,585	19,170	28,755	38,340	52,325	61,910	71,495	81,080	90,665	100,250	109,835	119,420	129,005	138,590	158,624	168,209	177,794	187,379	196,964	206,549	216,134	225,719	235,304

SUMMARY	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
Total Revenue	292,598	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388
Total Costs	9,585	9,585	9,585	9,585	13,985	9,585	9,585	9,585	9,585	9,585	9,585	9,585	9,585	9,585	20,034	9,585	9,585	9,585	9,585	9,585	9,585	9,585	9,585
Net	283,013	151,803	151,803	151,803	147,403	151,803	151,803	151,803	151,803	151,803	151,803	151,803	151,803	151,803	141,354	151,803	151,803	151,803	151,803	151,803	151,803	151,803	151,803
Cumulative Net	283,013	434,817	586,620	738,423	885,826	1,037,630	1,189,433	1,341,236	1,493,039	1,644,843	1,796,646	1,948,449	2,100,253	2,252,056	2,393,410	2,545,213	2,697,017	2,848,820	3,000,623	3,152,427	3,304,230	3,456,033	3,607,836
Net Present Value	272,128	140,351	134,953	129,762	121,155	119,972	115,358	110,921	106,655	102,553	98,609	94,816	91,169	87,663	78,489	81,049	77,932	74,934	72,052	69,281	66,616	64,054	61,591
Cumulative NPV	272,128	412,479	547,431	677,193	798,348	918,321	1,033,679	1,144,600	1,251,255	1,353,808	1,452,416	1,547,232	1,638,401	1,726,064	1,804,553	1,885,602	1,963,533	2,038,468	2,110,520	2,179,801	2,246,417	2,310,472	2,372,062

1 60% (estimated portion of municipal revenue used for transportation-related infrastructure) of the municipal portion of the municipal tax revenue from a Single Family Dwelling (40 ft lots avg) 2003 average market value $205,000 X 45% portioned assessment X .025448 mill rate.
2 Water and Sewer rate of $795/per household (avg) based on City of Winnipeg 2009 Operating Budget
3 Frontage levy of $2.55 x 40ft avg assessable frontage (source: Pollock & Wright)
4 Sum of Building Permits ($1,650 X SFD) + Acreage Fees ($1,200 X Acres) + Lot Fees ($53 X # of Lots). source: Ladco
5 Underground Annual Servicing and Maintenance cost based on annual hydrant servicing (source: Water & Waste)
6 Underground Lifecycle Maintenance cost based on sewer and manhole cleaning and inspection and watermain cleaning (source: Water & Waste)
7 Surface Works Annual Servicing and Maintenance based on snow clearing and surface sweeping. Surfaces include streets, backlanes, and sidewalks.
8 Surface Works Lifecycle Maintenance cost based on joint repairs and reseals, overlays, crack seals, pothole patching, and pavement rehab. Surfaces include streets, backlanes, and sidewalks.
9 For simplicity purposes, we have assumed all cash flows are end-of-year payments and are discounted at real rate of 4%, which represents the City of Winnipeg's borrowing rate.

24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
84,513	84,513	84,513	84,513	84,513	84,513	84,513	84,513	84,513	84,513	84,513	84,513	84,513	84,513	84,513	84,513	84,513	84,513	84,513	84,513	84,513	84,513	84,513	84,513	84,513	84,513	84,513
47,700	47,700	47,700	47,700	47,700	47,700	47,700	47,700	47,700	47,700	47,700	47,700	47,700	47,700	47,700	47,700	47,700	47,700	47,700	47,700	47,700	47,700	47,700	47,700	47,700	47,700	47,700
6,120	6,120	6,120	6,120	6,120	6,120	6,120	6,120	6,120	6,120	6,120	6,120	6,120	6,120	6,120	6,120	6,120	6,120	6,120	6,120	6,120	6,120	6,120	6,120	6,120	6,120	6,120
138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333
3,434,167	3,572,500	3,710,833	3,849,166	3,987,499	4,125,831	4,264,164	4,402,497	4,540,830	4,679,163	4,817,495	4,955,828	5,094,161	5,232,494	5,370,827	5,509,160	5,647,492	5,785,825	5,924,158	6,062,491	6,200,824	6,339,156	6,477,489	6,615,822	6,754,155	6,892,488	7,030,820

24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
5,250	5,250	5,250	5,250	5,250	5,250	5,250	5,250	5,250	5,250	5,250	5,250	5,250	5,250	5,250	5,250	5,250	5,250	5,250	5,250	5,250	5,250	5,250	5,250	5,250	5,250	5,250
						24,350					22,825					22,825					24,350					22,825
4,643	4,643	4,643	4,643	4,643	4,643	4,643	4,643	4,643	4,643	4,643	4,643	4,643	4,643	4,643	4,643	4,643	4,643	4,643	4,643	4,643	4,643	4,643	4,643	4,643	4,643	4,643
	8,828					149,003	4,414									6,972		2,943			684,136					450,278
9,893	18,721	9,893	9,893	9,893	9,893	183,246	14,307	9,893	9,893	9,893	32,718	9,893	9,893	9,893	9,893	39,690	9,893	12,836	9,893	9,893	718,379	9,893	9,893	9,893	9,893	482,996
272,284	291,005	300,898	310,791	320,685	330,578	513,825	528,132	538,025	547,919	557,812	590,530	600,424	610,317	620,210	630,104	669,794	679,688	692,524	702,417	712,311	1,430,690	1,440,583	1,450,477	1,460,370	1,470,264	1,953,260

24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333	138,333
9,893	18,721	9,893	9,893	9,893	9,893	183,246	14,307	9,893	9,893	9,893	32,718	9,893	9,893	9,893	9,893	39,690	9,893	12,836	9,893	9,893	718,379	9,893	9,893	9,893	9,893	482,996
128,439	119,612	128,439	128,439	128,439	128,439	-44,914	124,026	128,439	128,439	128,439	105,614	128,439	128,439	128,439	128,439	98,642	128,439	125,496	128,439	128,439	-580,046	128,439	128,439	128,439	128,439	-344,664
3,161,884	3,281,496	3,409,935	3,538,374	3,666,814	3,795,253	3,750,340	3,874,365	4,002,805	4,131,244	4,259,684	4,365,298	4,493,737	4,622,177	4,750,616	4,879,056	4,977,698	5,106,138	5,231,634	5,360,073	5,488,513	4,908,466	5,036,906	5,165,345	5,293,785	5,422,224	5,077,560
50,107	44,868	46,327	44,545	42,832	41,184	-13,848	36,769	36,613	35,204	33,850	26,764	31,297	30,093	28,936	27,823	20,546	25,724	24,167	23,783	22,868	-99,303	21,143	20,330	19,548	18,796	-48,499
2,048,094	2,092,963	2,139,289	2,183,834	2,226,666	2,267,850	2,254,002	2,290,771	2,327,384	2,362,588	2,396,439	2,423,203	2,454,500	2,484,593	2,513,528	2,541,351	2,561,897	2,587,621	2,611,788	2,635,571	2,658,439	2,559,136	2,580,279	2,600,609	2,620,156	2,638,952	**2,590,454**

24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
98,598	98,598	98,598	98,598	98,598	98,598	98,598	98,598	98,598	98,598	98,598	98,598	98,598	98,598	98,598	98,598	98,598	98,598	98,598	98,598	98,598	98,598	98,598	98,598	98,598	98,598	98,598
55,650	55,650	55,650	55,650	55,650	55,650	55,650	55,650	55,650	55,650	55,650	55,650	55,650	55,650	55,650	55,650	55,650	55,650	55,650	55,650	55,650	55,650	55,650	55,650	55,650	55,650	55,650
7,140	7,140	7,140	7,140	7,140	7,140	7,140	7,140	7,140	7,140	7,140	7,140	7,140	7,140	7,140	7,140	7,140	7,140	7,140	7,140	7,140	7,140	7,140	7,140	7,140	7,140	7,140
161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388
4,004,529	4,165,917	4,327,305	4,488,693	4,650,082	4,811,470	4,972,858	5,134,247	5,295,635	5,457,023	5,618,411	5,779,800	5,941,188	6,102,576	6,263,964	6,425,353	6,586,741	6,748,129	6,909,518	7,070,906	7,232,294	7,393,682	7,555,071	7,716,459	7,877,847	8,039,236	8,200,624

24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
6,300	6,300	6,300	6,300	6,300	6,300	6,300	6,300	6,300	6,300	6,300	6,300	6,300	6,300	6,300	6,300	6,300	6,300	6,300	6,300	6,300	6,300	6,300	6,300	6,300	6,300	6,300
						20,225					18,575					18,575					20,225					18,575
3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285	3,285
	8,799					131,989	4,400											2,933			681,941					
9,585	18,384	9,585	9,585	9,585	9,585	161,799	13,985	9,585	9,585	9,585	28,160	9,585	9,585	9,585	9,585	28,160	9,585	12,518	9,585	9,585	711,751	9,585	9,585	9,585	9,585	28,160
244,889	263,273	272,858	282,443	292,028	301,613	463,412	477,397	486,982	496,567	506,152	534,312	543,897	553,482	563,067	572,652	600,812	610,397	622,915	632,500	642,085	1,353,836	1,363,421	1,373,006	1,382,591	1,392,176	1,420,336

24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388	161,388
9,585	18,384	9,585	9,585	9,585	9,585	161,799	13,985	9,585	9,585	9,585	28,160	9,585	9,585	9,585	9,585	28,160	9,585	12,518	9,585	9,585	711,751	9,585	9,585	9,585	9,585	28,160
151,803	143,004	151,803	151,803	151,803	151,803	-411	147,403	151,803	151,803	151,803	133,228	151,803	151,803	151,803	151,803	133,228	151,803	148,870	151,803	151,803	-550,363	151,803	151,803	151,803	151,803	133,228
3,759,640	3,902,644	4,054,447	4,206,250	4,358,054	4,509,857	4,509,446	4,656,850	4,808,653	4,960,456	5,112,259	5,245,488	5,397,291	5,549,094	5,700,897	5,852,701	5,985,929	6,137,732	6,286,603	6,438,406	6,590,209	6,039,846	6,191,650	6,343,453	6,495,256	6,647,060	6,780,288
59,222	53,643	54,754	52,648	50,623	48,676	-127	43,699	43,273	41,608	40,008	33,762	36,990	35,567	34,199	32,884	27,750	30,403	28,669	28,109	27,028	-94,221	24,989	24,028	23,104	22,215	18,747
2,431,284	2,484,927	2,539,681	2,592,329	2,642,952	2,691,628	2,691,501	2,735,200	2,778,473	2,820,082	2,860,090	2,893,852	2,930,841	2,966,409	3,000,608	3,033,491	3,061,241	3,091,644	3,120,313	3,148,422	3,175,450	3,081,229	3,106,218	3,130,245	3,153,349	3,175,564	**3,194,311**

COMPARISON OF RELATIVE MUNICIPAL PROPERTY TAX REVENUE AND COST OF LINEAR INFRASTRUCTURE
FOR GRID AND CURVILINEAR STREET PATTERN SUBDIVISIONS

GRID 50 ACRE

REVENUE TO CITY OF WINNIPEG		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
Single Family Dwellings (SFD)	330																							
Municipal Taxes ($2348 per SFD) [1]	$2,348	464,820	464,820	464,820	464,820	464,820	464,820	464,820	464,820	464,820	464,820	464,820	464,820	464,820	464,820	464,820	464,820	464,820	464,820	464,820	464,820	464,820	464,820	464,820
Sewer and Water Utility Rates ($795 per SFD) [2]	$795	262,350	262,350	262,350	262,350	262,350	262,350	262,350	262,350	262,350	262,350	262,350	262,350	262,350	262,350	262,350	262,350	262,350	262,350	262,350	262,350	262,350	262,350	262,350
Frontage Levy ($102 per SFD) [3]	$102	33,660	33,660	33,660	33,660	33,660	33,660	33,660	33,660	33,660	33,660	33,660	33,660	33,660	33,660	33,660	33,660	33,660	33,660	33,660	33,660	33,660	33,660	33,660
Building Permits and Development Fees [4]		621,990																						
Total Revenue		1,382,820	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830
Cumulative Total		1,382,820	2,143,651	2,904,481	3,665,312	4,426,142	5,186,973	5,947,803	6,708,634	7,469,464	8,230,294	8,991,125	9,751,955	10,512,786	11,273,616	12,034,447	12,795,277	13,556,108	14,316,938	15,077,768	15,838,599	16,599,429	17,360,260	18,121,090

INFRASTRUCTURE COST TO CITY OF WPG	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
Underground Works																							
U/G Annual Servicing and Maintenance [5]	26,250	26,250	26,250	26,250	26,250	26,250	26,250	26,250	26,250	26,250	26,250	26,250	26,250	26,250	26,250	26,250	26,250	26,250	26,250	26,250	26,250	26,250	26,250
U/G Lifecycle Maintenance [6]															12,413								
Surface Works																							
Annual Servicing and Maintenance [7]	27,924	27,924	27,924	27,924	27,924	27,924	27,924	27,924	27,924	27,924	27,924	27,924	27,924	27,924	27,924	27,924	27,924	27,924	27,924	27,924	27,924	27,924	27,924
Lifecycle Maintenance [8]					24,140					46,027					39,284					206,758	4,498		
Total Cost	54,174	54,174	54,174	54,174	78,314	54,174	54,174	54,174	54,174	100,201	54,174	54,174	54,174	54,174	105,871	54,174	54,174	54,174	54,174	260,932	58,672	54,174	54,174
Cumulative Total	54,174	108,348	162,522	216,696	295,010	349,184	403,358	457,532	511,706	611,907	666,081	720,255	774,429	828,603	934,474	988,648	1,042,822	1,096,996	1,151,170	1,412,102	1,470,774	1,524,948	1,579,122

SUMMARY	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
Total Revenue	1,382,820	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830
Total Costs	54,174	54,174	54,174	54,174	78,314	54,174	54,174	54,174	54,174	100,201	54,174	54,174	54,174	54,174	105,871	54,174	54,174	54,174	54,174	260,932	58,672	54,174	54,174
Net	1,328,646	706,656	706,656	706,656	682,516	706,656	706,656	706,656	706,656	660,629	706,656	706,656	706,656	706,656	654,960	706,656	706,656	706,656	706,656	499,898	702,158	706,656	706,656
Cumulative Net	1,328,646	2,035,303	2,741,959	3,448,616	4,131,132	4,837,789	5,544,445	6,251,102	6,957,758	7,618,387	8,325,044	9,031,700	9,738,357	10,445,013	11,099,973	11,806,630	12,513,286	13,219,942	13,926,599	14,426,497	15,128,656	15,835,312	16,541,969
Net Present Value	1,277,545	653,344	628,215	604,053	560,979	558,481	537,001	516,347	496,487	446,298	459,031	441,376	424,400	408,076	363,676	377,290	362,779	348,825	335,409	228,147	308,131	298,177	286,709
Cumulative NPV	1,277,545	1,930,888	2,559,103	3,163,156	3,724,135	4,282,616	4,819,617	5,335,964	5,832,451	6,278,749	6,737,779	7,179,155	7,603,554	8,011,631	8,375,307	8,752,596	9,115,375	9,464,200	9,799,609	10,027,757	10,335,887	10,634,065	10,920,774

CURVILINEAR 50 ACRE

REVENUE TO CITY OF WINNIPEG		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
Single Family Dwellings (SFD)	365																							
Municipal Taxes ($2348 per SFD)	$2,348	514,120	514,120	514,120	514,120	514,120	514,120	514,120	514,120	514,120	514,120	514,120	514,120	514,120	514,120	514,120	514,120	514,120	514,120	514,120	514,120	514,120	514,120	514,120
Sewer and Water Utility Rates ($795 per SFD)	$795	290,175	290,175	290,175	290,175	290,175	290,175	290,175	290,175	290,175	290,175	290,175	290,175	290,175	290,175	290,175	290,175	290,175	290,175	290,175	290,175	290,175	290,175	290,175
Frontage Levy ($102 per SFD)	$102	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230
Building Permits and Development Fees		681,595																						
Total Revenue		1,523,120	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525
Cumulative Total		1,523,120	2,364,644	3,206,169	4,047,693	4,889,218	5,730,742	6,572,267	7,413,792	8,255,316	9,096,841	9,938,365	10,779,890	11,621,415	12,462,939	13,304,464	14,145,988	14,987,513	15,829,037	16,670,562	17,512,087	18,353,611	19,195,136	20,036,660

INFRASTRUCTURE COST TO CITY OF WPG	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
Underground Works																							
U/G Annual Servicing and Maintenance	27,300	27,300	27,300	27,300	27,300	27,300	27,300	27,300	27,300	27,300	27,300	27,300	27,300	27,300	27,300	27,300	27,300	27,300	27,300	27,300	27,300	27,300	27,300
U/G Lifecycle Maintenance															5,925								
Surface Works																							
Annual Servicing and Maintenance	22,488	22,488	22,488	22,488	22,488	22,488	22,488	22,488	22,488	22,488	22,488	22,488	22,488	22,488	22,488	22,488	22,488	22,488	22,488	22,488	22,488	22,488	22,488
Lifecycle Maintenance					23,739					19,400					36,571					178,478	5,478		
Total Cost	49,788	49,788	49,788	49,788	73,527	49,788	49,788	49,788	49,788	69,188	49,788	49,788	49,788	49,788	92,284	49,788	49,788	49,788	49,788	228,266	55,266	49,788	49,788
Cumulative Total	49,788	99,576	149,364	199,152	272,679	322,467	372,255	422,043	471,831	541,019	590,807	640,595	690,383	740,171	832,455	882,243	932,031	981,819	1,031,607	1,259,873	1,315,139	1,364,927	1,414,715

SUMMARY	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
Total Revenue	1,523,120	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525
Total Costs	49,788	49,788	49,788	49,788	73,527	49,788	49,788	49,788	49,788	69,188	49,788	49,788	49,788	49,788	92,284	49,788	49,788	49,788	49,788	228,266	55,266	49,788	49,788
Net	1,473,332	791,737	791,737	791,737	767,998	791,737	791,737	791,737	791,737	772,337	791,737	791,737	791,737	791,737	749,241	791,737	791,737	791,737	791,737	613,259	786,259	791,737	791,737
Cumulative Net	1,473,332	2,265,068	3,056,805	3,848,541	4,616,539	5,408,275	6,200,012	6,991,749	7,783,485	8,555,822	9,347,558	10,139,295	10,931,032	11,722,768	12,472,009	13,263,745	14,055,482	14,847,218	15,638,955	16,252,214	17,038,472	17,830,209	18,621,945
Net Present Value	1,416,665	732,005	703,851	676,780	631,238	625,721	601,655	578,514	556,264	521,763	514,297	494,516	475,496	457,208	416,027	422,715	406,456	390,823	375,792	279,883	345,037	334,078	321,228
Cumulative NPV	1,416,665	2,148,670	2,852,521	3,529,301	4,160,539	4,786,260	5,387,914	5,966,428	6,522,692	7,044,455	7,558,752	8,053,268	8,528,765	8,985,973	9,402,000	9,824,714	10,231,171	10,621,994	10,997,786	11,277,669	11,622,706	11,956,783	12,278,012

1 60% (estimated portion of municipal revenue used for transportation-related infrastructure) of the municipal portion of the municipal tax revenue from a Single Family Dwelling (40 ft lots avg) 2003 average market value $205,000 X 45% portioned assessment X .025448 mill rate.

2 Water and Sewer rate of $795/per household (avg) based on City of Winnipeg 2009 Operating Budget

3 Frontage levy of $2.55 x 40ft avg assessable frontage (source: Pollock & Wright)

4 Sum of Building Permits ($1,650 X SFD) + Acreage Fees ($1,200 X Acres) + Lot Fees ($53 X # of Lots). source: Ladco

5 Underground Annual Servicing and Maintenance cost based on annual hydrant servicing (source: Water & Waste)

6 Underground Lifecycle Maintenance cost based on sewer and manhole cleaning and inspection and watermain cleaning (source: Water & Waste)

7 Surface Works Annual Servicing and Maintenance based on snow clearing and surface sweeping. Surfaces include streets, backlanes, and sidewalks.

8 Surface Works Lifecycle Maintenance cost based on joint repairs and reseals, overlays, crack seals, pothole patching, and pavement rehab. Surfaces include streets, backlanes, and sidewalks.

9 For simplicity purposes, we have assumed all cash flows are end-of-year payments and are discounted at real rate of 4%, which represents the City of Winnipeg's borrowing rate.

24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
464,820	464,820	464,820	464,820	464,820	464,820	464,820	464,820	464,820	464,820	464,820	464,820	464,820	464,820	464,820	464,820	464,820	464,820	464,820	464,820	464,820	464,820	464,820	464,820	464,820	464,820	464,820
262,350	262,350	262,350	262,350	262,350	262,350	262,350	262,350	262,350	262,350	262,350	262,350	262,350	262,350	262,350	262,350	262,350	262,350	262,350	262,350	262,350	262,350	262,350	262,350	262,350	262,350	262,350
33,660	33,660	33,660	33,660	33,660	33,660	33,660	33,660	33,660	33,660	33,660	33,660	33,660	33,660	33,660	33,660	33,660	33,660	33,660	33,660	33,660	33,660	33,660	33,660	33,660	33,660	33,660
760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830
18,881,921	19,642,751	20,403,582	21,164,412	21,925,242	22,686,073	23,446,903	24,207,734	24,968,564	25,729,395	26,490,225	27,251,056	28,011,886	28,772,716	29,533,547	30,294,377	31,055,208	31,816,038	32,576,869	33,337,699	34,098,530	34,859,360	35,620,190	36,381,021	37,141,851	37,902,682	38,663,512

24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
26,250	26,250	26,250	26,250	26,250	26,250	26,250	26,250	26,250	26,250	26,250	26,250	26,250	26,250	26,250	26,250	26,250	26,250	26,250	26,250	26,250	26,250	26,250	26,250	26,250	26,250	26,250
						114,163					101,750					101,750					114,163					101,750
27,924	27,924	27,924	27,924	27,924	27,924	27,924	27,924	27,924	27,924	27,924	27,924	27,924	27,924	27,924	27,924	27,924	27,924	27,924	27,924	27,924	27,924	27,924	27,924	27,924	27,924	27,924
	39,284					671,205	19,642				730,966					31,307		13,095			3,044,529					2,021,936
54,174	93,458	54,174	54,174	54,174	54,174	839,542	73,816	54,174	54,174	54,174	886,890	54,174	54,174	54,174	54,174	187,231	54,174	67,269	54,174	54,174	3,212,866	54,174	54,174	54,174	54,174	2,177,860
1,633,296	1,726,754	1,780,928	1,835,102	1,889,276	1,943,450	2,782,991	2,856,807	2,910,981	2,965,155	3,019,329	3,906,219	3,960,393	4,014,567	4,068,741	4,122,915	4,310,146	4,364,320	4,431,589	4,485,763	4,539,937	7,752,803	7,806,977	7,861,151	7,915,325	7,969,499	10,147,359

24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830	760,830
54,174	93,458	54,174	54,174	54,174	54,174	839,542	73,816	54,174	54,174	54,174	886,890	54,174	54,174	54,174	54,174	187,231	54,174	67,269	54,174	54,174	3,212,866	54,174	54,174	54,174	54,174	2,177,860
706,656	667,372	706,656	706,656	706,656	706,656	-78,711	687,014	706,656	706,656	706,656	-126,060	706,656	706,656	706,656	706,656	573,599	706,656	693,561	706,656	706,656	-2,452,035	706,656	706,656	706,656	706,656	-1,417,030
17,248,625	17,915,998	18,622,654	19,329,310	20,035,967	20,742,623	20,663,912	21,350,927	22,057,583	22,764,240	23,470,896	23,344,837	24,051,493	24,758,149	25,464,806	26,171,462	26,745,062	27,451,718	28,145,280	28,851,936	29,558,593	27,106,557	27,813,214	28,519,870	29,226,527	29,933,183	28,516,154
275,682	250,343	254,883	245,080	235,654	226,590	-24,268	203,672	201,438	193,690	186,241	-31,945	172,190	165,567	159,199	153,076	119,474	141,528	133,563	130,850	125,818	-419,785	116,325	111,851	107,549	103,413	-199,394
11,196,456	11,446,798	11,701,682	11,946,762	12,182,416	12,409,006	12,384,738	12,588,411	12,789,849	12,983,539	13,169,780	13,137,835	13,310,025	13,475,592	13,634,791	13,787,868	13,907,342	14,048,870	14,182,432	14,313,283	14,439,100	14,019,316	14,135,641	14,247,493	14,355,042	14,458,455	**14,259,061**

24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
514,120	514,120	514,120	514,120	514,120	514,120	514,120	514,120	514,120	514,120	514,120	514,120	514,120	514,120	514,120	514,120	514,120	514,120	514,120	514,120	514,120	514,120	514,120	514,120	514,120	514,120	514,120
290,175	290,175	290,175	290,175	290,175	290,175	290,175	290,175	290,175	290,175	290,175	290,175	290,175	290,175	290,175	290,175	290,175	290,175	290,175	290,175	290,175	290,175	290,175	290,175	290,175	290,175	290,175
37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230
841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525
20,878,185	21,719,710	22,561,234	23,402,759	24,244,283	25,085,808	25,927,332	26,768,857	27,610,382	28,451,906	29,293,431	30,134,955	30,976,480	31,818,005	32,659,529	33,501,054	34,342,578	35,184,103	36,025,627	36,867,152	37,708,677	38,550,201	39,391,726	40,233,250	41,074,775	41,916,300	42,757,824

24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
27,300	27,300	27,300	27,300	27,300	27,300	27,300	27,300	27,300	27,300	27,300	27,300	27,300	27,300	27,300	27,300	27,300	27,300	27,300	27,300	27,300	27,300	27,300	27,300	27,300	27,300	27,300
						91,250					85,325					85,325					91,250					85,325
22,488	22,488	22,488	22,488	22,488	22,488	22,488	22,488	22,488	22,488	22,488	22,488	22,488	22,488	22,488	22,488	22,488	22,488	22,488	22,488	22,488	22,488	22,488	22,488	22,488	22,488	22,488
	36,521					555,836	18,261				890,110					1,770		12,174			2,830,403					114,281
49,788	86,309	49,788	49,788	49,788	49,788	696,874	68,049	49,788	49,788	49,788	1,025,223	49,788	49,788	49,788	49,788	136,883	49,788	61,962	49,788	49,788	2,971,441	49,788	49,788	49,788	49,788	249,394
1,464,503	1,550,812	1,600,600	1,650,388	1,700,176	1,749,964	2,446,838	2,514,887	2,564,675	2,614,463	2,664,251	3,689,474	3,739,262	3,789,050	3,838,838	3,888,626	4,025,509	4,075,297	4,137,259	4,187,047	4,236,835	7,208,276	7,258,064	7,307,852	7,357,640	7,407,428	7,656,822

24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525	841,525
49,788	86,309	49,788	49,788	49,788	49,788	696,874	68,049	49,788	49,788	49,788	1,025,223	49,788	49,788	49,788	49,788	136,883	49,788	61,962	49,788	49,788	2,971,441	49,788	49,788	49,788	49,788	249,394
791,737	755,216	791,737	791,737	791,737	791,737	144,651	773,476	791,737	791,737	791,737	-183,698	791,737	791,737	791,737	791,737	704,642	791,737	779,563	791,737	791,737	-2,129,916	791,737	791,737	791,737	791,737	592,131
19,413,682	20,168,898	20,960,634	21,752,371	22,544,107	23,335,844	23,480,494	24,253,970	25,045,707	25,837,443	26,629,180	26,445,481	27,237,218	28,028,955	28,820,691	29,612,428	30,317,069	31,108,806	31,888,368	32,680,105	33,471,842	31,341,925	32,133,662	32,925,398	33,717,135	34,508,872	35,101,002
308,873	283,294	285,571	274,587	264,026	253,871	44,598	229,305	225,691	217,010	208,664	-46,552	192,921	185,501	178,367	171,506	146,769	158,567	150,124	146,604	140,966	-364,638	130,331	125,318	120,498	115,864	83,320
12,586,885	12,870,179	13,155,750	13,430,337	13,694,364	13,948,235	13,992,834	14,222,138	14,447,829	14,664,840	14,873,503	14,826,951	15,019,873	15,205,374	15,383,741	15,555,247	15,702,017	15,860,584	16,010,708	16,157,313	16,298,278	15,933,640	16,063,971	16,189,289	16,309,787	16,425,651	**16,508,971**

COMPARISON OF RELATIVE MUNICIPAL PROPERTY TAX REVENUE AND COST OF LINEAR INFRASTRUCTURE
FOR GRID AND CURVILINEAR STREET PATTERN SUBDIVISIONS

GRID 100 ACRE

REVENUE TO CITY OF WINNIPEG		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
Single Family Dwellings (SFD)	644																							
Municipal Taxes ($2348 per SFD) [1]	$2,348	907,104	907,104	907,104	907,104	907,104	907,104	907,104	907,104	907,104	907,104	907,104	907,104	907,104	907,104	907,104	907,104	907,104	907,104	907,104	907,104	907,104	907,104	907,104
Sewer and Water Utility Rates ($795 per SFD) [2]	$795	511,980	511,980	511,980	511,980	511,980	511,980	511,980	511,980	511,980	511,980	511,980	511,980	511,980	511,980	511,980	511,980	511,980	511,980	511,980	511,980	511,980	511,980	511,980
Frontage Levy ($102 per SFD) [3]	$102	65,688	65,688	65,688	65,688	65,688	65,688	65,688	65,688	65,688	65,688	65,688	65,688	65,688	65,688	65,688	65,688	65,688	65,688	65,688	65,688	65,688	65,688	65,688
Building Permits and Development Fees [4]		1,216,732																						
Total Revenue		2,701,504	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772
Cumulative Total		2,701,504	4,186,276	5,671,048	7,155,821	8,640,593	10,125,365	11,610,137	13,094,909	14,579,681	16,064,453	17,549,226	19,033,998	20,518,770	22,003,542	23,488,314	24,973,086	26,457,858	27,942,631	29,427,403	30,912,175	32,396,947	33,881,719	35,366,491

INFRASTRUCTURE COST TO CITY OF WPG	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
Underground Works																							
U/G Annual Servicing and Maintenance [5]	51,450	51,450	51,450	51,450	51,450	51,450	51,450	51,450	51,450	51,450	51,450	51,450	51,450	51,450	51,450	51,450	51,450	51,450	51,450	51,450	51,450	51,450	51,450
U/G Lifecycle Maintenance [6]															17,513								
Surface Works																							
Annual Servicing and Maintenance [7]	56,862	56,862	56,862	56,862	56,862	56,862	56,862	56,862	56,862	56,862	56,862	56,862	56,862	56,862	56,862	56,862	56,862	56,862	56,862	56,862	56,862	56,862	56,862
Lifecycle Maintenance [8]					52,422					84,626					92,122					331,471	6,361		
Total Cost	108,312	108,312	108,312	108,312	160,734	108,312	108,312	108,312	108,312	192,938	108,312	108,312	108,312	108,312	217,947	108,312	108,312	108,312	108,312	439,783	114,673	108,312	108,312
Cumulative Total	108,312	216,624	324,936	433,248	593,982	702,294	810,606	918,918	1,027,230	1,220,168	1,328,480	1,436,792	1,545,104	1,653,416	1,871,363	1,979,675	2,087,987	2,196,299	2,304,611	2,744,394	2,859,067	2,967,379	3,075,691

SUMMARY	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
Total Revenue	2,701,504	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772
Total Costs	108,312	108,312	108,312	108,312	160,734	108,312	108,312	108,312	108,312	192,938	108,312	108,312	108,312	108,312	217,947	108,312	108,312	108,312	108,312	439,783	114,673	108,312	108,312
Net	2,593,192	1,376,460	1,376,460	1,376,460	1,324,038	1,376,460	1,376,460	1,376,460	1,376,460	1,291,834	1,376,460	1,376,460	1,376,460	1,376,460	1,266,826	1,376,460	1,376,460	1,376,460	1,376,460	1,044,989	1,370,099	1,376,460	1,376,460
Cumulative Net	2,593,192	3,969,652	5,346,112	6,722,573	8,046,611	9,423,071	10,799,531	12,175,991	13,552,451	14,844,285	16,220,746	17,597,206	18,973,666	20,350,126	21,616,952	22,993,412	24,369,872	25,746,332	27,122,792	28,167,781	29,537,880	30,914,341	32,290,801
Net Present Value	2,493,454	1,272,615	1,223,668	1,176,604	1,088,263	1,087,836	1,045,997	1,005,766	967,083	872,717	894,122	859,733	826,666	794,871	703,423	734,903	706,638	679,459	653,326	476,919	601,246	580,805	558,466
Cumulative NPV	2,493,454	3,766,069	4,989,737	6,166,341	7,254,604	8,342,440	9,388,437	10,394,203	11,361,285	12,234,002	13,128,124	13,987,857	14,814,523	15,609,395	16,312,818	17,047,722	17,754,359	18,433,819	19,087,145	19,564,065	20,165,310	20,746,115	21,304,581

CURVILINEAR 100 ACRE

REVENUE TO CITY OF WINNIPEG		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
Single Family Dwellings (SFD)	739																							
Municipal Taxes ($2348 per SFD)	$2,348	1,040,916	1,040,916	1,040,916	1,040,916	1,040,916	1,040,916	1,040,916	1,040,916	1,040,916	1,040,916	1,040,916	1,040,916	1,040,916	1,040,916	1,040,916	1,040,916	1,040,916	1,040,916	1,040,916	1,040,916	1,040,916	1,040,916	1,040,916
Sewer and Water Utility Rates ($795 per SFD)	$795	587,505	587,505	587,505	587,505	587,505	587,505	587,505	587,505	587,505	587,505	587,505	587,505	587,505	587,505	587,505	587,505	587,505	587,505	587,505	587,505	587,505	587,505	587,505
Frontage Levy ($102 per SFD)	$102	75,378	75,378	75,378	75,378	75,378	75,378	75,378	75,378	75,378	75,378	75,378	75,378	75,378	75,378	75,378	75,378	75,378	75,378	75,378	75,378	75,378	75,378	75,378
Building Permits and Development Fees		1,378,517																						
Total Revenue		3,082,316	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799
Cumulative Total		3,082,316	4,786,115	6,489,914	8,193,713	9,897,512	11,601,312	13,305,111	15,008,910	16,712,709	18,416,508	20,120,307	21,824,106	23,527,905	25,231,704	26,935,503	28,639,302	30,343,101	32,046,901	33,750,700	35,454,499	37,158,298	38,862,097	40,565,896

INFRASTRUCTURE COST TO CITY OF WPG	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
Underground Works																							
U/G Annual Servicing and Maintenance	52,500	52,500	52,500	52,500	52,500	52,500	52,500	52,500	52,500	52,500	52,500	52,500	52,500	52,500	52,500	52,500	52,500	52,500	52,500	52,500	52,500	52,500	52,500
U/G Lifecycle Maintenance															14,188								
Surface Works																							
Annual Servicing and Maintenance	37,306	37,306	37,306	37,306	37,306	37,306	37,306	37,306	37,306	37,306	37,306	37,306	37,306	37,306	37,306	37,306	37,306	37,306	37,306	37,306	37,306	37,306	37,306
Lifecycle Maintenance					41,714					25,507					69,564					227,784	6,932		
Total Cost	89,806	89,806	89,806	89,806	131,520	89,806	89,806	89,806	89,806	115,313	89,806	89,806	89,806	89,806	173,558	89,806	89,806	89,806	89,806	317,590	96,738	89,806	89,806
Cumulative Total	89,806	179,612	269,418	359,224	490,744	580,550	670,356	760,162	849,968	965,281	1,055,087	1,144,893	1,234,699	1,324,505	1,498,063	1,587,869	1,677,675	1,767,481	1,857,287	2,174,877	2,271,615	2,361,421	2,451,227

SUMMARY	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
Total Revenue	3,082,316	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799
Total Costs	89,806	89,806	89,806	89,806	131,520	89,806	89,806	89,806	89,806	115,313	89,806	89,806	89,806	89,806	173,558	89,806	89,806	89,806	89,806	317,590	96,738	89,806	89,806
Net	2,992,510	1,613,993	1,613,993	1,613,993	1,572,279	1,613,993	1,613,993	1,613,993	1,613,993	1,588,486	1,613,993	1,613,993	1,613,993	1,613,993	1,530,242	1,613,993	1,613,993	1,613,993	1,613,993	1,386,209	1,607,061	1,613,993	1,613,993
Cumulative Net	2,992,510	4,606,503	6,220,496	7,834,489	9,406,768	11,020,762	12,634,755	14,248,748	15,862,741	17,451,227	19,065,220	20,679,213	22,293,206	23,907,199	25,437,441	27,051,434	28,665,427	30,279,420	31,893,413	33,279,622	34,886,683	36,500,676	38,114,669
Net Present Value	2,877,414	1,492,227	1,434,834	1,379,648	1,292,299	1,275,562	1,226,502	1,179,329	1,133,970	1,073,124	1,048,419	1,008,095	969,322	932,041	849,689	861,724	828,581	796,712	766,070	632,648	705,232	681,033	654,839
Cumulative NPV	2,877,414	4,369,641	5,804,475	7,184,123	8,476,422	9,751,984	10,978,486	12,157,815	13,291,785	14,364,909	15,413,328	16,421,424	17,390,746	18,322,787	19,172,476	20,034,200	20,862,781	21,659,493	22,425,563	23,058,211	23,763,443	24,444,476	25,099,315

1 60% (estimated portion of municipal revenue used for transportation-related infrastructure) of the municipal portion of the municipal tax revenue from a Single Family Dwelling (40 ft lots avg) 2003 average market value $205,000 X 45% portioned assessment X .025448 mill rate.

2 Water and Sewer rate of $795/per household (avg) based on City of Winnipeg 2009 Operating Budget

3 Frontage levy of $2.55 x 40ft avg assessable frontage (source: Pollock & Wright)

4 Sum of Building Permits ($1,650 X SFD) + Acreage Fees ($1,200 X Acres) + Lot Fees ($53 X # of Lots). source: Ladco

5 Underground Annual Servicing and Maintenance cost based on annual hydrant servicing (source: Water & Waste)

6 Underground Lifecycle Maintenance cost based on sewer and manhole cleaning and inspection and watermain cleaning (source: Water & Waste)

7 Surface Works Annual Servicing and Maintenance based on snow clearing and surface sweeping. Surfaces include streets, backlanes, and sidewalks.

8 Surface Works Lifecycle Maintenance cost based on joint repairs and reseals, overlays, crack seals, pothole patching, and pavement rehab. Surfaces include streets, backlanes, and sidewalks.

9 For simplicity purposes, we have assumed all cash flows are end-of-year payments and are discounted at real rate of 4%, which represents the City of Winnipeg's borrowing rate.

24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
907,104	907,104	907,104	907,104	907,104	907,104	907,104	907,104	907,104	907,104	907,104	907,104	907,104	907,104	907,104	907,104	907,104	907,104	907,104	907,104	907,104	907,104	907,104	907,104	907,104	907,104	907,104
511,980	511,980	511,980	511,980	511,980	511,980	511,980	511,980	511,980	511,980	511,980	511,980	511,980	511,980	511,980	511,980	511,980	511,980	511,980	511,980	511,980	511,980	511,980	511,980	511,980	511,980	511,980
65,688	65,688	65,688	65,688	65,688	65,688	65,688	65,688	65,688	65,688	65,688	65,688	65,688	65,688	65,688	65,688	65,688	65,688	65,688	65,688	65,688	65,688	65,688	65,688	65,688	65,688	65,688
1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772
36,851,263	38,336,035	39,820,808	41,305,580	42,790,352	44,275,124	45,759,896	47,244,668	48,729,440	50,214,213	51,698,985	53,183,757	54,668,529	56,153,301	57,638,073	59,122,845	60,607,618	62,092,390	63,577,162	65,061,934	66,546,706	68,031,478	69,516,250	71,001,023	72,485,795	73,970,567	75,455,339

24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
51,450	51,450	51,450	51,450	51,450	51,450	51,450	51,450	51,450	51,450	51,450	51,450	51,450	51,450	51,450	51,450	51,450	51,450	51,450	51,450	51,450	51,450	51,450	51,450	51,450	51,450	51,450
						227,438					209,925					209,925					227,438					209,925
56,862	56,862	56,862	56,862	56,862	56,862	56,862	56,862	56,862	56,862	56,862	56,862	56,862	56,862	56,862	56,862	56,862	56,862	56,862	56,862	56,862	56,862	56,862	56,862	56,862	56,862	56,862
	92,122					1,549,365	46,061				1,033,742					58,190		30,707			7,139,482					3,758,124
108,312	200,434	108,312	108,312	108,312	108,312	1,885,115	154,373	108,312	108,312	108,312	1,351,979	108,312	108,312	108,312	108,312	376,427	108,312	139,019	108,312	108,312	7,475,232	108,312	108,312	108,312	108,312	4,076,361
3,184,003	3,384,437	3,492,749	3,601,061	3,709,373	3,817,685	5,702,799	5,857,172	5,965,484	6,073,796	6,182,108	7,534,087	7,642,399	7,750,711	7,859,023	7,967,335	8,343,762	8,452,074	8,591,093	8,699,405	8,807,717	16,282,949	16,391,261	16,499,573	16,607,885	16,716,197	20,792,558

24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772	1,484,772
108,312	200,434	108,312	108,312	108,312	108,312	1,885,115	154,373	108,312	108,312	108,312	1,351,979	108,312	108,312	108,312	108,312	376,427	108,312	139,019	108,312	108,312	7,475,232	108,312	108,312	108,312	108,312	4,076,361
1,376,460	1,284,338	1,376,460	1,376,460	1,376,460	1,376,460	-400,342	1,330,399	1,376,460	1,376,460	1,376,460	132,793	1,376,460	1,376,460	1,376,460	1,376,460	1,108,345	1,376,460	1,345,753	1,376,460	1,376,460	-5,990,459	1,376,460	1,376,460	1,376,460	1,376,460	-2,591,589
33,667,261	34,951,599	36,328,059	37,704,519	39,080,979	40,457,440	40,057,097	41,387,496	42,763,956	44,140,417	45,516,877	45,649,670	47,026,130	48,402,590	49,779,050	51,155,510	52,263,856	53,640,316	54,986,069	56,362,529	57,738,989	51,748,530	53,124,990	54,501,450	55,877,910	57,254,370	54,662,781
536,987	481,777	496,474	477,379	459,018	441,364	-123,433	394,410	392,371	377,280	362,769	33,652	335,400	322,500	310,096	298,170	230,856	275,675	259,158	254,877	245,074	-1,025,557	226,584	217,870	209,490	201,433	-364,669
21,841,568	22,323,344	22,819,819	23,297,198	23,756,216	24,197,580	24,074,147	24,468,558	24,860,929	25,238,208	25,600,977	25,634,629	25,970,029	26,292,530	26,602,626	26,900,796	27,131,652	27,407,327	27,666,485	27,921,361	28,166,435	27,140,878	27,367,462	27,585,332	27,794,822	27,996,255	**27,631,586**

24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
1,040,916	1,040,916	1,040,916	1,040,916	1,040,916	1,040,916	1,040,916	1,040,916	1,040,916	1,040,916	1,040,916	1,040,916	1,040,916	1,040,916	1,040,916	1,040,916	1,040,916	1,040,916	1,040,916	1,040,916	1,040,916	1,040,916	1,040,916	1,040,916	1,040,916	1,040,916	1,040,916
587,505	587,505	587,505	587,505	587,505	587,505	587,505	587,505	587,505	587,505	587,505	587,505	587,505	587,505	587,505	587,505	587,505	587,505	587,505	587,505	587,505	587,505	587,505	587,505	587,505	587,505	587,505
75,378	75,378	75,378	75,378	75,378	75,378	75,378	75,378	75,378	75,378	75,378	75,378	75,378	75,378	75,378	75,378	75,378	75,378	75,378	75,378	75,378	75,378	75,378	75,378	75,378	75,378	75,378
1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799
42,269,695	43,973,494	45,677,293	47,381,092	49,084,891	50,788,690	52,492,490	54,196,289	55,900,088	57,603,887	59,307,686	61,011,485	62,715,284	64,419,083	66,122,882	67,826,681	69,530,480	71,234,279	72,938,079	74,641,878	76,345,677	78,049,476	79,753,275	81,457,074	83,160,873	84,864,672	86,568,471

24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
52,500	52,500	52,500	52,500	52,500	52,500	52,500	52,500	52,500	52,500	52,500	52,500	52,500	52,500	52,500	52,500	52,500	52,500	52,500	52,500	52,500	52,500	52,500	52,500	52,500	52,500	52,500
						177,563					163,375					163,375					177,563					163,375
37,306	37,306	37,306	37,306	37,306	37,306	37,306	37,306	37,306	37,306	37,306	37,306	37,306	37,306	37,306	37,306	37,306	37,306	37,306	37,306	37,306	37,306	37,306	37,306	37,306	37,306	37,306
	69,564					1,055,923	34,782				1,126,465					3,342		23,188			5,391,211					215,810
89,806	159,370	89,806	89,806	89,806	89,806	1,323,292	124,588	89,806	89,806	89,806	1,379,646	89,806	89,806	89,806	89,806	256,523	89,806	112,994	89,806	89,806	5,658,580	89,806	89,806	89,806	89,806	468,991
2,541,033	2,700,403	2,790,209	2,880,015	2,969,821	3,059,627	4,382,918	4,507,506	4,597,312	4,687,118	4,776,924	6,156,570	6,246,376	6,336,182	6,425,988	6,515,794	6,772,317	6,862,123	6,975,117	7,064,923	7,154,729	12,813,309	12,903,115	12,992,921	13,082,727	13,172,533	13,641,524

24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799	1,703,799
89,806	159,370	89,806	89,806	89,806	89,806	1,323,292	124,588	89,806	89,806	89,806	1,379,646	89,806	89,806	89,806	89,806	256,523	89,806	112,994	89,806	89,806	5,658,580	89,806	89,806	89,806	89,806	468,991
1,613,993	1,544,429	1,613,993	1,613,993	1,613,993	1,613,993	380,508	1,579,211	1,613,993	1,613,993	1,613,993	324,153	1,613,993	1,613,993	1,613,993	1,613,993	1,447,276	1,613,993	1,590,805	1,613,993	1,613,993	-3,954,780	1,613,993	1,613,993	1,613,993	1,613,993	1,234,808
39,728,663	41,273,092	42,887,085	44,501,078	46,115,071	47,729,064	48,109,572	49,688,783	51,302,776	52,916,769	54,530,762	54,854,915	56,468,908	58,082,901	59,696,894	61,310,887	62,758,163	64,372,156	65,962,962	67,576,955	69,190,948	65,236,167	66,850,160	68,464,154	70,078,147	71,692,140	72,926,948
629,653	579,341	582,150	559,760	538,230	517,529	117,318	468,173	460,082	442,386	425,371	82,145	393,280	378,153	363,609	349,624	301,452	323,247	306,349	298,860	287,366	-677,052	265,686	255,467	245,641	236,194	173,753
25,728,969	26,308,310	26,890,460	27,450,220	27,988,450	28,505,979	28,623,297	29,091,470	29,551,552	29,993,938	30,419,309	30,501,454	30,894,734	31,272,887	31,636,497	31,986,121	32,287,572	32,610,820	32,917,169	33,216,029	33,503,395	32,826,343	33,092,028	33,347,495	33,593,136	33,829,330	**34,003,083**

APPENDIX B

Stantec's Report – January 2010

Assessment of the Impact on Infrastructure of Alternate Development Forms

Prepared for:
Ladco Company Ltd.
200 - 40 Lakewood Blvd.
Winnipeg MB R2J 2M7

Prepared by:
Stantec Consulting Ltd.
905 Waverley Street
Winnipeg, MB R3T 5P4

January 2010

Project: 111211920

ASSESSMENT OF THE IMPACT ON INFRASTRUCTURE OF ALTERNATE DEVELOPMENT FORMS

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Figure 4.1 Quantity and Cost Estimate Comparison of Alternate Developments with Backlanes and without Sidewalks 4.2

ASSESSMENT OF THE IMPACT ON INFRASTRUCTURE OF ALTERNATE DEVELOPMENT FORMS

1.0 Background

Stantec Consulting Ltd. was asked to study the impacts on infrastructure of residential subdivision development forms. A comparison between a grid and curvilinear street pattern was performed. The comparison evaluated three different scales of development. The theoretical parcel sizes reviewed were 10, 50 and 100 acres. The various street configurations were provided to Stantec Consulting Ltd., which undertook an assessment of the infrastructure required to service the various alternatives. The predetermined street configurations were designed in accordance with the City of Winnipeg's Transportation Standards Manual complete with current geometric design requirements for various right-of-way classifications.

2.0 Opinion of Probable Cost

The grid and curvilinear designs were evaluated using current City of Winnipeg geometric and pavement design standards to ensure accurate costing.

The cost estimate was divided into underground and surface works. Underground infrastructure costs were divided into the following components;

- wastewater sewer,
- land drainage sewer, and
- watermain

The surface works infrastructure costs were divided into the following components;

- roadways
    - collector streets,
    - residential streets,
- backlanes,
- service roads, and
- sidewalks.

The cost estimates were prepared using 2009 construction costs.

The grid patterns were evaluated using two different alternatives;

1) backlanes and sidewalks installed on all streets within the development, and
2) backlanes installed on all streets and sidewalks installed only along lots that front a collector streets within the development.

3.0 With Backlanes and Sidewalks

The first alternative evaluated in this assessment of the impact on the infrastructure, is that of grid patterned developments which have backlanes and sidewalks along both sides of every street, both collector and residential streets. The curvilinear patterned developments have sidewalks along both sides of the collector streets only. They have no backlanes throughout the entire development; however have service roads which are present for lots fronting collector streets. This alternative most closely represents the current grid pattern found throughout the City of Winnipeg. The table found on the following page shows the quantity, estimated cost and a percent increase between the two types of developments, grid and curvilinear. The table has been broken down into various individual aspects of infrastructure, which are further discussed in the following sections of the report.

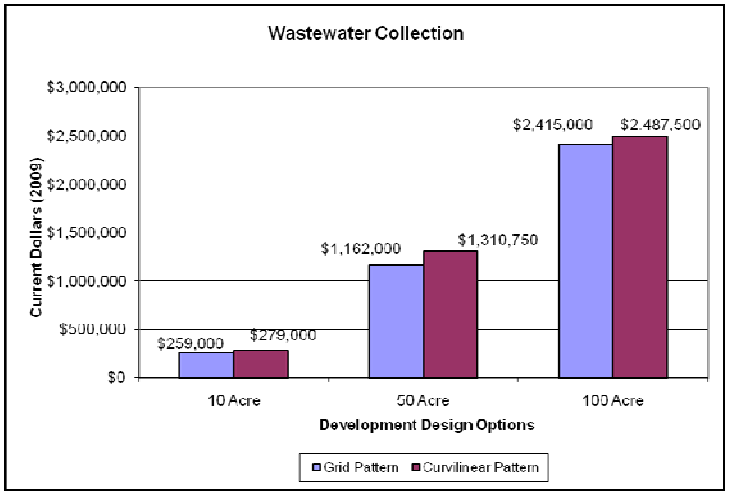
FIGURE 3.1 – QUANTITY AND COST ESTIMATE OF ALTERNATE DEVELOPMENTS WITH BACKLANES AND SIDEWALKS

		Area					
		10 ac. Grid Pattern	10 ac. Curvilinear Pattern	50 ac. Grid Pattern	50 ac. Curvilinear Pattern	100 ac. Grid Pattern	100 ac. Curvilinear Pattern
Wastewater Sewer	Lengths (m)	610	680	2760	3135	5120	5775
	Cost Estimate	$259,000	$279,000	$1,162,000	$1,310,750	$2,415,000	$2,487,500
	Percent Increase (%)		**7.7%**		**12.8%**		**3.0%**
Land Drainage Sewer	Lengths (m)	825	465	3550	2180	7775	4470
	Cost Estimate	$348,750	$206,750	$1,653,750	$1,026,500	$4,013,750	$2,328,500
	Percent Increase (%)	**68.7%**		**61.1%**		**72.4%**	
Watermain	Lengths (m)	610	660	4965	2370	7005	5675
	Cost Estimate	$335,250	$387,000	$1,929,250	$1,739,250	$3,488,500	$3,587,250
	Percent Increase (%)		**15.4%**	**10.9%**			**2.8%**
Underground Total	Cost Estimate	$943,000	$872,750	$4,745,000	$4,076,500	$9,917,250	$8,403,250
	Percent Increase (%)	**8.0%**		**16.4%**		**18.0%**	
Roadways							
Collector	Areas (m²)	n/a	n/a	4498	4746	6362	6933
Residential	Areas (m²)	4510	4725	20167	18870	47498	36755
	Cost Estimate	$473,250	$496,750	$2,731,750	$2,631,750	$5,847,750	$4,815,250
	Percent Increase (%)		**5.0%**	**3.8%**		**21.4%**	
Lanes	Areas (m²)	2940	n/a	13219	n/a	24733	n/a
	Cost Estimate	$273,750	n/a	$1,267,250	n/a	$2,301,250	n/a
Service Road	Areas (m²)	n/a	n/a	n/a	1112	n/a	1944
	Cost Estimate	n/a	n/a	n/a	$117,750	n/a	$208,500
Sidewalks	Areas (m²)	1658	n/a	8848	1222	18998	1726
	Cost Estimate	$107,750	n/a	$575,000	$79,500	$1,234,250	$112,250
	Percent Increase (%)			**623.3%**		**999.6%**	
Surface Works Total	Cost Estimate	$854,750	$496,750	$4,574,000	$2,829,000	$9,383,250	$5,136,000
	Percent Increase (%)	**72.1%**		**61.7%**		**82.7%**	
Total	Cost Estimate	$1,797,750	$1,369,500	$9,319,000	$6,905,500	$19,300,500	$13,539,250
	Percent Increase (%)	**31.3%**		**35.0%**		**42.6%**	

3.1 UNDERGROUND INFRASTRUCTURE

3.1.1 Wastewater Sewer

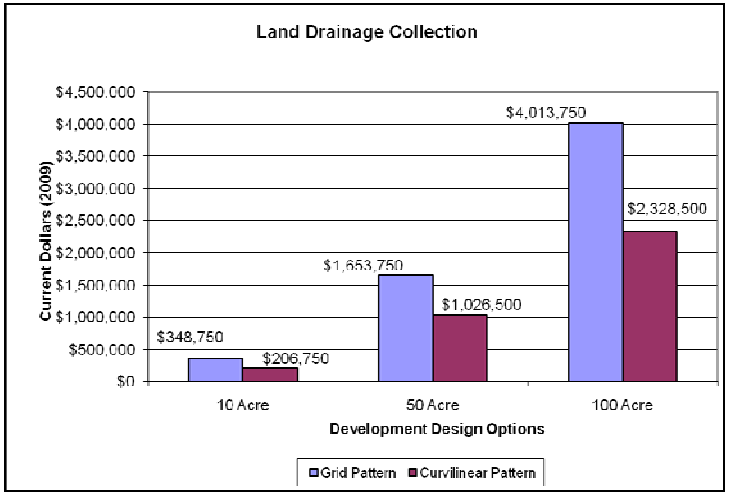
- The curvilinear pattern requires slightly more pipe for the 10, 50 and 100 acre developments (11.1%, 13.6%, and 12.8%, respectively).



3.1.2 Land Drainage Sewer

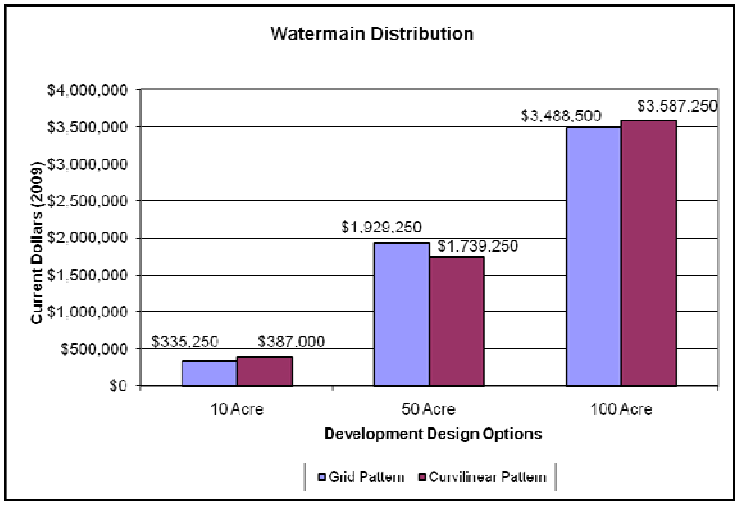
- The grid pattern requires more pipe than the curvilinear pattern for all three of the development areas; 10, 50 and 100 acres (77.4%, 62.8% and 73.9% respectively).

- The grid pattern requires more land drainage infrastructure because of the increase in roadways and backlanes, compared to the curvilinear pattern. The increase in pipe size is required to accommodate the increased amount of impervious area in the developments.



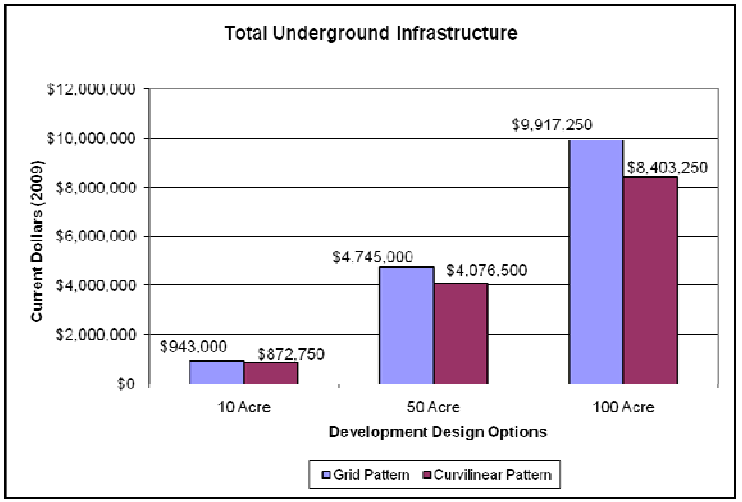
3.1.3 Watermain

- The curvilinear pattern requires more pipe (8.2%) at a higher cost (15.4%) for the 10 acre development.
- The grid patterns at the larger scale, 50 and 100 acre developments, require more pipe (109.5% and 23.4%, respectively). The grid costs are higher for the 50 acre development (10.9%) and lower for the 100 acre development (2.8%).
- The watermain pipe quantity only accounts for the mainline pipe and not the lot service pipes whereas the cost of the infrastructure does include the services to each lot. The curvilinear pattern for all three sized alternatives has more lots than that of the gird pattern development. With more lots, there are additional lots servicing costs.



3.1.4 Summary of Underground Infrastructure

- The overall cost of the 10, 50 and 100 acre grid patterned development alternatives are higher (8.0%, 16.4%, and 18.0% respectively) than the curvilinear pattern. There are more lots in the curvilinear patterns and therefore even less cost per lot.



3.2 SURFACE WORKS INFRASTRUCTURE

The surface works infrastructure cannot be compared as easily as the underground infrastructure, as the grid patterns have backlanes while the curvilinear developments have service roads. Therefore those components will not be analyzed on an individual basis. However, as these components are crucial to the overall surface works; their associated quantities will be included in the overall comparison of the surface works surface area and the cost comparison of the surface works and the total comparison.

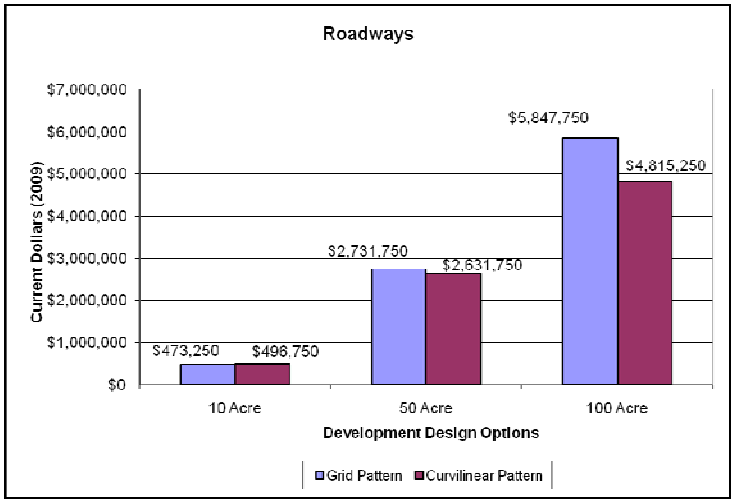
3.2.1 Roadways

- Roadways include only collector streets and residential streets (not backlanes and service roads). The graph shown on the right depicts the sum of the cost associated with collector streets and residential streets.

- The grid pattern requires more concrete surface area for the 50 and 100 acre developments (6.9% and 29.2%, respectively) for residential streets.

- The curvilinear pattern requires slightly more concrete surface area for the 50 and 100 acre developments (5.5% and 9.0%, respectively) for collector streets.

- The 10 acre curvilinear pattern development does not have a collector street and all streets were designed to a residential streets standard, resulting in a greater amount of concrete surface area (4.8%) than the grid pattern development. This shows that it is difficult to utilize the smaller development sizes using the curvilinear pattern style.

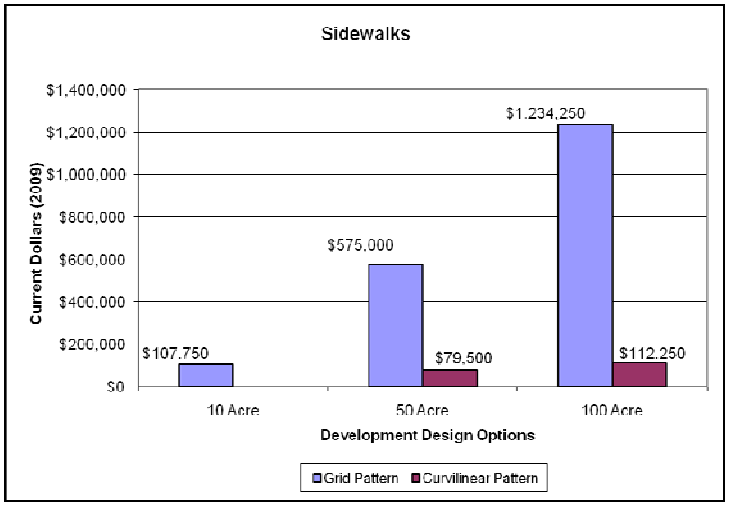


3.2.2 Sidewalks

- The City of Winnipeg requires sidewalks on either side of collector streets. This alternative, with both backlanes and sidewalks incorporates sidewalks on both sides of the street for the grid pattern and only along the collector street for the curvilinear pattern development.

- Since the 10 acre curvilinear pattern does not have a collector, no sidewalks are required.

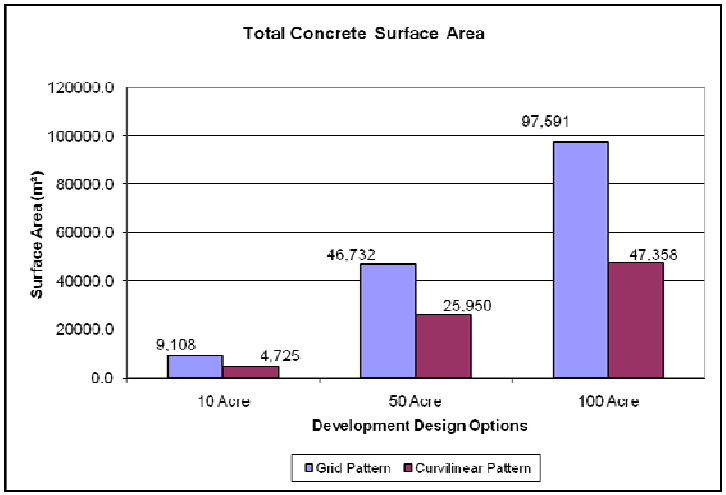
- The grid pattern requires more concrete surface area for the 50 and 100 acre developments.



3.2.3 Summary of Surface Works Infrastructure

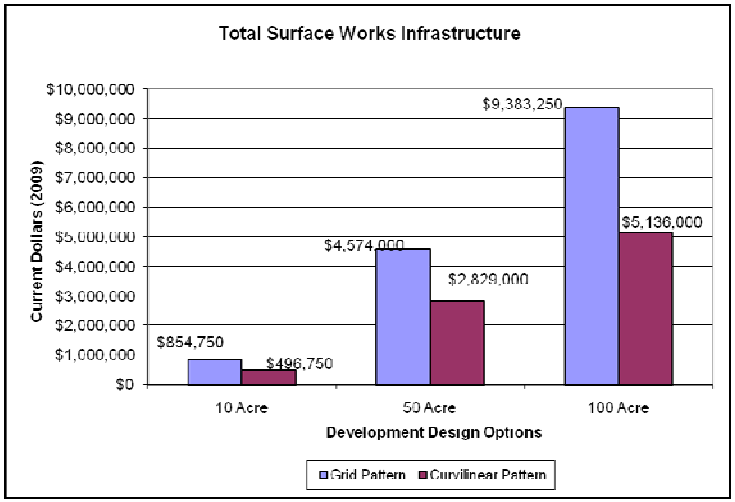
3.2.3.1 Surface Area of Concrete Surface Works

A comparison of the backlanes as an individual component of this study is difficult as the curvilinear pattern developments do not contain any. However the curvilinear pattern developments have service roads where there are lots facing collector streets. The backlanes have an affect on the ultimate surface area and volume of concrete used and its associated cost and thus should be considered in the evaluation of the overall surface works infrastructure. The following values; 92.8%, 80.1% and 106.1%, correlate with the concrete surface area increase in 10, 50, and 100 acre grid pattern alignments versus curvilinear pattern.



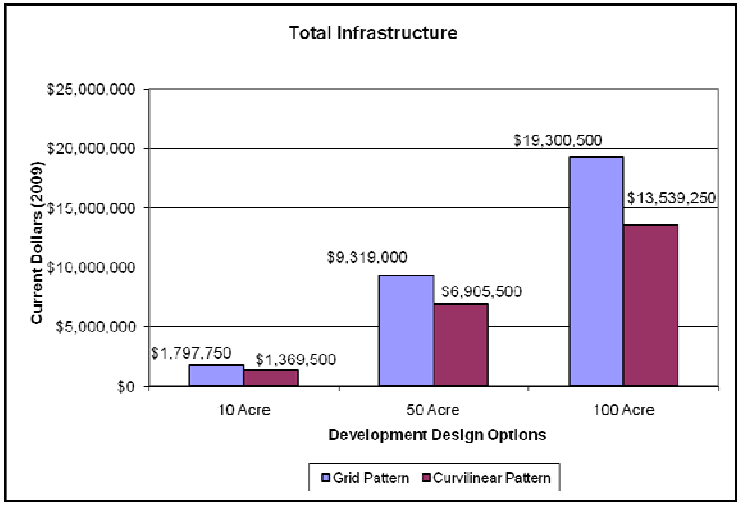
3.2.3.2 Total Cost Comparison of Surface Works

- The overall cost estimate for the total surface works is higher (72.1%, 61.7%, and 82.7%) for the 10, 50 and 100 acre grid pattern respectively, with the inclusion of backlanes and service roads.



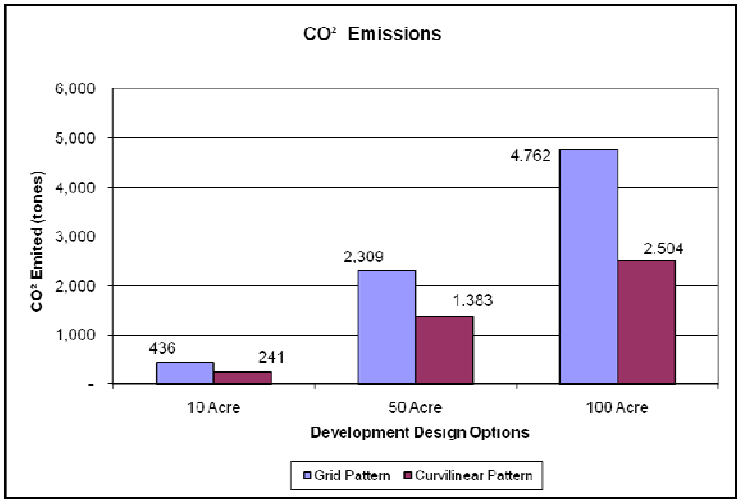
3.3 TOTAL COST OF INSTALLATION OF INFRASTRUCTURE

- The cost of all infrastructure installation of a grid street pattern is greater for the 10, 50 and 100 acre pattern (31.3%, 35.0% and 42.6% respectively).



3.4 CO^2 EMISSIONS

For the environmental side of the comparison the quantity of CO^2 emitted for the production of concrete was compared. Based on the City of Winnipeg Construction Standards, the minimum cementitious content is 300 kg/cm or 340 kg/cm for sidewalks and 340 kg/cm for roadways and sidewalks. For this study we will assume that 340 kg/cm is consistent for all concrete throughout the developments. Therefore concrete production for the grid pattern alignment causes the emission of 81.0%, 66.9%, and 90.2% more CO^2 than the curvilinear pattern for the 10, 50, and 100 acre respectively.



4.0 With Backlanes and Without Sidewalks

The second alternative evaluated in this assessment is that of grid developments which have backlanes along collector and residential streets, while the sidewalks have been removed, except along both sides of the collector street. The curvilinear patterned developments remain unchanged; they have sidewalks along both sides of the collector streets only. They have no backlanes throughout the entire development; however have service roads which are present for lots fronting collector streets. The table found on the following page shows the quantity, estimated cost and a percent increase between the two types of developments, grid and curvilinear. The table has been broken down into various individual aspects of infrastructure, which are further discussed in the following sections of the report.

ASSESSMENT OF THE IMPACT ON INFRASTRUCTURE OF ALTERNATE DEVELOPMENT FORMS

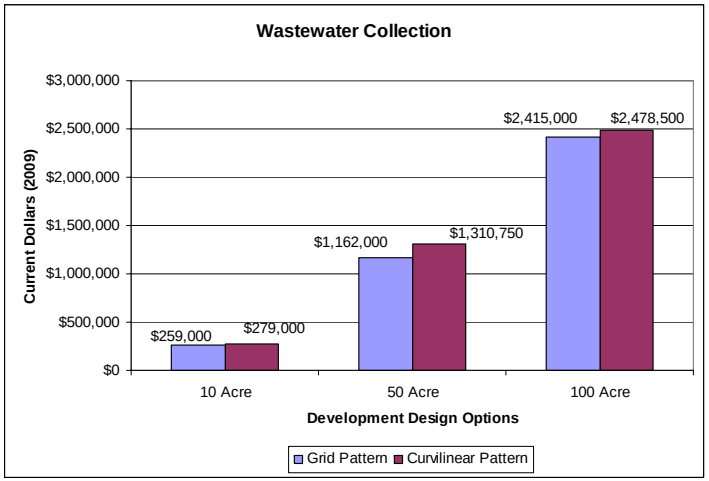
FIGURE 4.1 – QUANTITY AND COST ESTIMATE OF ALTERNATE DEVELOPMENTS WITH BACKLANES AND WITHOUT SIDEWALKS

		Area					
		10 ac. Grid Pattern	10 ac. Curvilinear Pattern	50 ac. Grid Pattern	50 ac. Curvilinear Pattern	100 ac. Grid Pattern	100 ac. Curvilinear Pattern
Wastewater	Lengths (m)	610	680	2760	3135	5120	5775
Sewer	Cost Estimate	$259,000	$279,000	$1,162,000	$1,310,750	$2,415,000	$2,487,500
	Percent Increase (%)		**7.7%**		**12.8%**		**3.0%**
Land Drainage	Lengths (m)	825	465	3550	2180	7775	4470
Sewer	Cost Estimate	$348,750	$206,750	$1,653,750	$1,026,500	$4,013,750	$2,328,500
	Percent Increase (%)	**68.7%**		**61.1%**		**72.4%**	
Watermain	Lengths (m)	610	660	4965	2370	7005	5675
	Cost Estimate	$335,250	$387,000	$1,929,250	$1,739,250	$3,488,500	$3,587,250
	Percent Increase (%)		**15.4%**	**10.9%**			**2.8%**
Underground	Cost Estimate	$943,000	$872,750	$4,745,000	$4,076,500	$9,917,250	$8,403,250
Total	Percent Increase (%)	**8.0%**		**16.4%**		**18.0%**	
Roadways							
Collector	Areas (m²)	n/a	n/a	4498	4746	6362	6933
Residential	Areas (m²)	4510	4725	20167	18870	47498	36755
	Cost Estimate	$473,250	$496,750	$2,731,750	$2,631,750	$5,847,750	$4,815,250
	Percent Increase (%)		**5.0%**	**3.8%**		**21.4%**	
Lanes	Areas (m²)	2940	n/a	13219	n/a	24733	n/a
	Cost Estimate	$273,750	n/a	$1,267,250	n/a	$2,301,250	n/a
Service Road	Areas (m²)	n/a	n/a	n/a	1112	n/a	1944
	Cost Estimate	n/a	n/a	n/a	$117,750	n/a	$208,500
Sidewalks	Areas (m²)	n/a	n/a	1347	1222	1904	1726
	Cost Estimate	n/a	n/a	$87,750	$79,500	$123,750	$112,250
	Percent Increase (%)			**10.4%**		**10.2%**	
Surface Works	Cost Estimate	$747,000	$496,750	$4,086,750	$2,829,000	$8,272,750	$5,136,000
Total	Percent Increase (%)	**50.4%**		**44.5%**		**61.1%**	
Total	Cost Estimate	$1,690,000	$1,369,500	$8,831,750	$6,905,500	$18,190,000	$13,539,250
	Percent Increase (%)	**23.4%**		**27.9%**		**34.4%**	

4.1 UNDERGROUND INFRASTRUCTURE

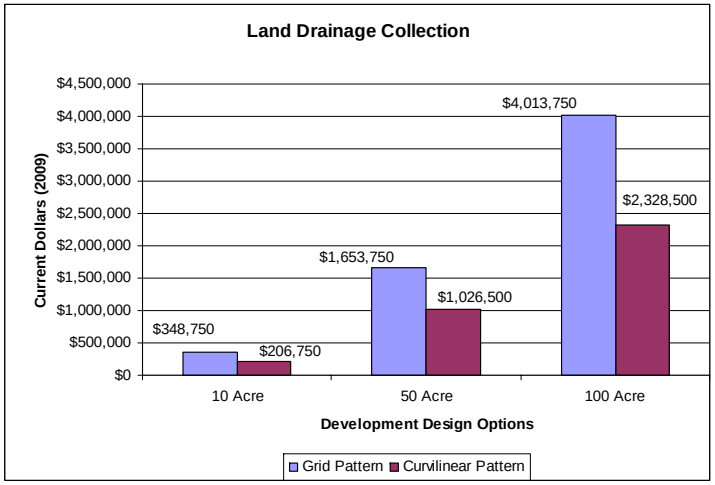
4.1.1 Wastewater Sewer

- The curvilinear pattern requires slightly more pipe for the 10, 50 and 100 acre developments (11.1%, 13.6%, and 12.8%, respectively).
- With the removal of sidewalks the quantity of wastewater sewer remains the same for the various sizes of developments (as the alternative with sidewalks).



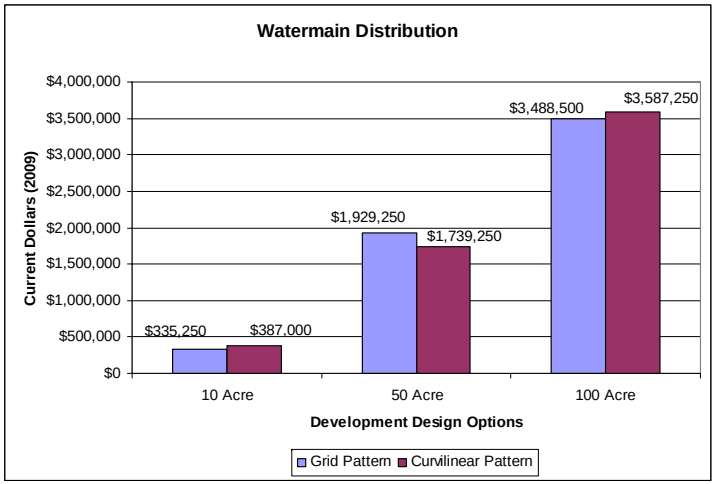
4.1.2 Land Drainage Sewer

- The grid pattern requires more pipe than the curvilinear pattern for all three of the development areas; 10, 50 and 100 acres (77.4%, 62.8% and 73.9% respectively).
- The grid pattern requires more land drainage infrastructure because of the increase in roadways and backlanes, compared to the curvilinear pattern. The increase in pipe size is required to accommodate the increased amount of impervious area in the developments.
- With the removal of sidewalks there is slightly less impervious area; however this does not result in smaller pipe sizes.



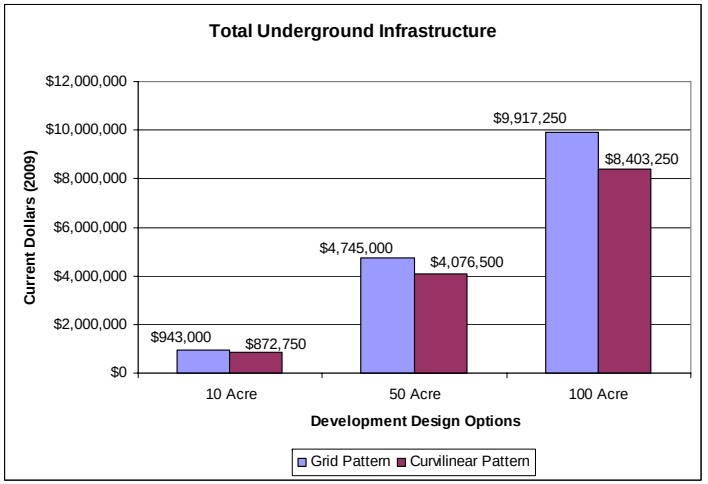
4.1.3 Watermain

- The curvilinear pattern requires more pipe (8.2%) at a higher cost (15.4%) for the 10 acre development.
- The grid patterns at the larger scale, 50 and 100 acre developments, require more pipe (109.5% and 23.4%, respectively). The grid costs are higher for the 50 acre development (10.9%) and lower for the 100 acre development (2.8%).
- The watermain pipe quantity only accounts for the mainline pipe and not the lot service pipes whereas the cost of the infrastructure does include the services to each lot. The curvilinear pattern for all three sized alternatives has more lots than that of the gird pattern development. With more lots, there are additional lots servicing costs.



4.1.4 Summary of Underground Infrastructure

- The overall cost of the 10, 50 and 100 acre grid patterned development alternatives are higher (8.0%, 16.4%, and 18.0% respectively) than the curvilinear pattern. There are more lots in the curvilinear patterns and therefore even less cost per lot.
- The underground infrastructure is not affected by the inclusion or removal of sidewalks.



4.2 SURFACE WORKS INFRASTRUCTURE

The surface works infrastructure cannot be compared as easily as the underground infrastructure, as the grid patterns have backlanes and the curvilinear designs have service roads. Therefore those components will not be analyzed on an individual basis. However, as these components are critical to the overall surface works consideration; their associated quantities will be included in the overall comparison of the surface works surface area and the cost comparison of the surface works and the total comparison. In addition, the sidewalks have been removed from the design, except where lots that front a collector street.

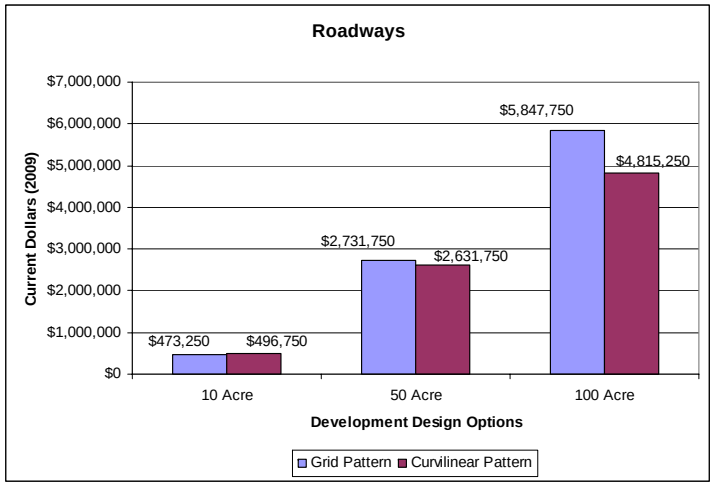
4.2.1 Roadways

- Roadways include only collector streets and residential streets (not backlanes and service roads). Since this is the case, the removal of sidewalks does not affect the roadways. The graph shown on the right depicts the sum of the cost associated with collector streets and residential streets.

- The grid pattern requires more concrete surface area for the 50 and 100 acre developments (6.9% and 29.2%, respectively) for residential streets.

- The curvilinear pattern requires slightly more concrete surface area for the 50 and 100 acre developments (5.5% and 9.0%, respectively) for collector streets.

- The 10 acre curvilinear pattern development does not have a collector street and all streets were designed to a residential streets standard. A greater amount of concrete surface area (4.8%) is required for the curvilinear pattern, than the grid pattern development. This shows that it is difficult to utilize the smaller development sizes using the curvilinear pattern style.

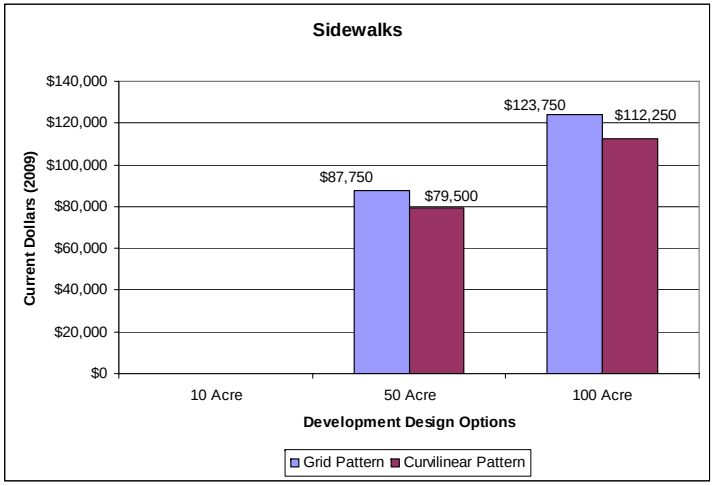


4.2.2 Sidewalks

- The City of Winnipeg requires sidewalks on both sides of collector streets. This alternative, without sidewalks, still must incorporate sidewalks on both sides of the collector streets in both developments.

- Since the 10 acre patterns do not have collector streets, no sidewalks are required.

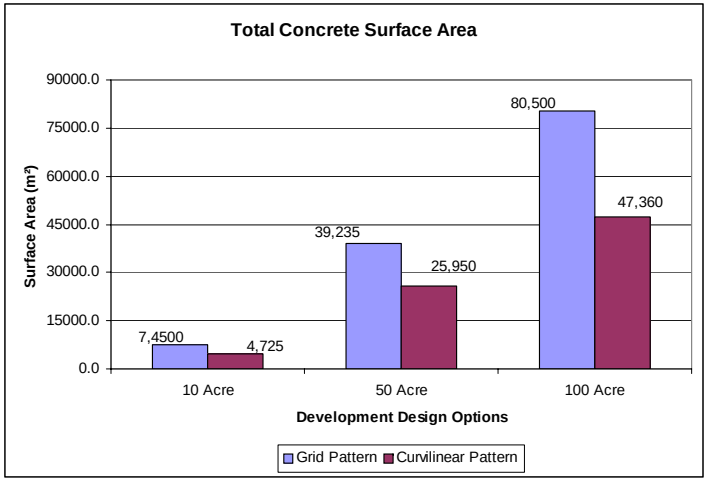
- The grid pattern requires more (10.4% and 10.2%) concrete surface area for the 50 and 100 acre developments, respectively.



4.2.3 Summary of Surface Works Infrastructure

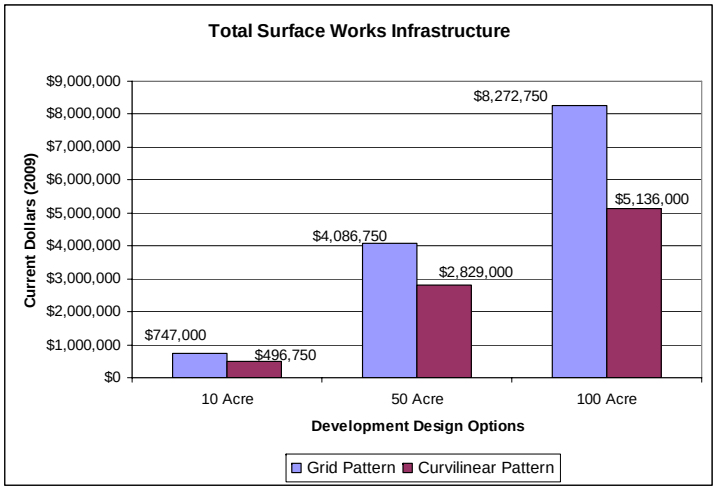
4.2.3.1 Surface Area of Concrete Surface Works

A comparison of the backlanes as an individual component of this study is difficult as the curvilinear pattern developments do not contain any. However the curvilinear pattern developments have service roads where there are lots facing collector streets. The backlanes have a drastic affect on the ultimate surface area and volume of concrete used and its associated cost and thus should be considered in the evaluation of the overall surface works infrastructure. The following values; 57.7%, 51.2% and 70.0%, correlate with the concrete surface area increase in 10, 50, and 100 acre grid pattern alignments versus curvilinear pattern.



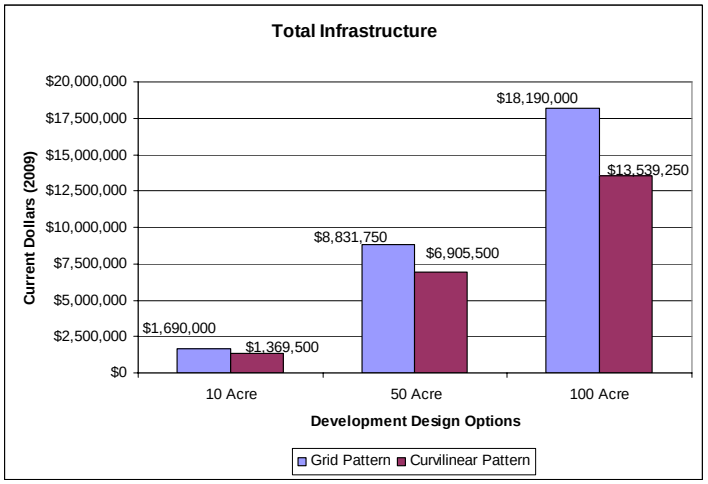
4.2.3.2 Total Cost Comparison of Surface Works

- The overall cost estimate for the total surface works is higher (50.4%, 44.5%, and 61.1%) for the 10, 50 and 100 acre grid pattern respectively.



4.3 TOTAL COST OF INSTALLATION OF INFRASTRUCTURE

- The cost of infrastructure installation for the grid pattern is greater for the 10, 50 and 100 acre developments (23.4%, 27.9% and 34.4% respectively).



4.4 CO^2 EMISSIONS

For the environmental side of the comparison the quantity of CO^2 emitted for the production of concrete was compared. Based on the City of Winnipeg Construction Standards, the minimum cementitious content is 300 kg/cm or 340 kg/cm for sidewalks and 340 kg/cm for roadways and sidewalks. For this study we will assume that 340 kg/cm is consistent for all concrete throughout the developments. Therefore concrete production for the grid pattern alignment without sidewalks causes the emission of 57.7%, 48.5%, and 67.0% more CO^2 than the curvilinear pattern for the 10, 50, and 100 acre respectively.

