Promoting Community Health by Expanding the City of Greater Sudbury's Active Transportation Network to Target Youth.

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Abstract:

As the second most obese city in Canada, the City of Greater Sudbury needs to take measures to combat this health epidemic. This paper begins by exploring the links between active transportation and community health. The current state of active transportation in the City of Greater Sudbury is then assessed and the factors that influence the adoption of active transportation are discussed. The possibility of creating infrastructure with the aim of encouraging youth to actively commute is explored, as well as are the benefits of pursuing such an aim. Cycling-specific infrastructure in the neighbourhoods surrounding schools would be beneficial and a geographic information system is used to model the roads in Greater Sudbury that could be developed to encourage youth to cycle.

Introduction:

The development of active transportation networks in the neighbourhoods surrounding schools in the City of Greater Sudbury are a benefit to the community's health. Such projects should continue to be undertaken by the city for several reasons, the first of which being that the City of Greater Sudbury has one of the highest obesity rates of any municipality in Canada. Encouraging citizens to adopt a healthy active lifestyle from a young age is a direct way the city can combat the public health crisis it is facing. The promotion of active transportation in the neighbourhoods surrounding elementary and secondary schools would target youth as its primary focus. The development of specific cycling infrastructure would be one of the most effective ways to encourage cycling as a means of active transportation in the community. By connecting the existing infrastructure to the areas around schools, not only are youth encouraged to cycle, but the current active transportation network is expanded upon for all cyclists. Once the case was made for the development of active transportation networks in the neighbourhoods surrounding schools, a geographic information system (GIS) approach was used to model a potential network. ArcGIS was used to create a map of the 'ideal' roads for the development of cycling infrastructure. These roads radiate from each of the primary and secondary schools in the City of Greater Sudbury, and link to existing cycling infrastructure. The results are analyzed and are followed by a wider discussion of issues relating to cycling in City of Greater Sudbury. Ultimately, in conjunction with the other studies that have been done to identify candidate cycle routes, this paper may serve as a reference for decision-makers when determining where to focus their efforts in promoting cycling in the city, or more specifically where to develop cycling infrastructure.

Literature Review:

Community health is an incredibly important aspect of the overall wellbeing of a city. Municipal governments need to be concerned with the welfare of the communities they are governing. The City of Greater Sudbury, located in Northern Ontario roughly 410 km north of Toronto, is one municipality that has particular cause to be concerned with the state of their community's health. Statistics Canada published the results of the Canadian Community Health Survey 2011-2012 and it identified that the City of Greater Sudbury has the second most obese population aged 18 and older in all of Canada, with 33.8% of the population having been identified as obese (Statistics Canada, 2014). When expanding to include not only the rate of obesity but for the rate of individuals who are overweight, the scope of the health problem becomes even more apparent. The Sudbury & District Health Unit identified that "60% of the population 18 years and over are considered overweight or obese" and this figure is 9% higher than the provincial average. (Sudbury & District Health Unit, 2013). The municipality's health problems are not limited to the adult population and begin at a young age. The local health unit has reported that "29% of area youth aged 12 to 17 years are either overweight or obese" and they highlight that this figure is significantly higher than the reported 21% of youth who are overweight or obese across the province of Ontario (Sudbury & District Health Unit, 2013).

The City of Greater Sudbury's designation of being 'second most obese' should be troubling for Sudburians to hear because of the massive body of research indicating that obesity is a major cause of many chronic health problems. This association suggests that due to the city's growing obesity levels, the population of Greater Sudbury will in all likelihood experience higher rates of chronic illnesses such as: "type 2 diabetes, hypertension, cardiovascular disease, gallbladder disease and certain types of cancer" (Statistics Canada, 2014). When these risks are considered it is clear that more needs to be done to improve the community's health; and address Greater Sudbury's lag in comparison to the provincial average.

The promotion of healthy active lifestyles is the most direct way to confront the obesity issue in Greater Sudbury. This approach is significant because by adopting a healthy active lifestyle a person will greatly reduce their likelihood of becoming obese, and if widely adopted this can help to reduce the rate of obesity in the community. Reducing the city's obesity rate then also reduces the community's risk of developing all of the associated chronic health problems. The focus needs to be on encouraging the community to adopt healthier lifestyles and the promotion of active transportation is one effective approach.

The Public Health Agency of Canada defines active transportation as "any form of human-powered transportation" (Public Health Agency of Canada, 2014). The Public Health Agency emphasizes that there are many ways to engage in active transportation and offer the examples of walking to a bus stop, or cycling to school or work as examples. The focus here will be to consider specifically how cycling can be promoted, as walking already receives the most attention when it comes to active living (Dill, 2009). Furthermore, much more infrastructure already exists for pedestrians than cyclists in the form of sidewalks that are widely available throughout the City of Greater Sudbury. It is perhaps also important to note that in the City of Greater Sudbury local by-laws prohibit cyclists from sharing the sidewalks with pedestrians (City of Greater Sudbury, 2010). The by-law states that "no person shall drive a vehicle on a sidewalk except for the purpose of directly crossing the sidewalk on a permanent or temporary driveway" (City of Greater Sudbury, 2010). Possible adaptations to this by-law that would encourage active transportation without jeopardizing the security of pedestrians will be considered later.

Research has shown that countries with higher levels of active transportation have the lowest obesity rates. (Basset et al. 2008) Although this study was unable to prove conclusively that active transportation was the specific cause for the lower obesity rates, the evidence strongly suggests that there is a correlation between the two. Another study found that a large majority of participants were able to achieve a weekly recommended time spent doing physical

activity by bicycling solely for utilitarian purposes (Dill, 2009). These findings suggest that bicycling for daily transportation alone can allow one to maintain the recommended healthy levels of physical activity.

There are many reasons that it is significant to be able to bicycle to maintain recommended levels of physical activity, "research in children and adolescents shows that physical activity during growing up is essential for musculoskeletal health, helps to control weight, improves self-image and autonomy, and may improve academic performance and alertness in youth" (Perez, 2010). This suggests that promoting active transportation, which unquestionably means promoting physical activity would benefit youth not only physically but mentally as well. As such, this may also help youth to better succeed in school.

Active commuting tends to be less common amongst Canadian youth compared to other countries. Data suggests that roughly a third of Canadian youth actively commute to and from school, a figure which pales in comparison to the nearly half of all youth from Australia, Scotland, England, Russia and Sweden (O'Laughlen, Pickett, & Janssen, 2011). This information implies that there is less emphasis and perhaps promotion of active transportation in Canada, particularly for Canadian youth. This reality is unfortunate because as explained previously bicycling to and from school every day is one way Canadian children can increase their daily physical activity and in doing so reduce their likelihood of obesity and risks of future health problems. If today's youth can be encouraged to adopt healthier lifestyles by actively commuting, then there is the potential to cause a shift in the attitudes of the next generations of citizens.

In deciding whether or not to actively commute to school, students are influenced by the support of their parents (Perez, 2010). Perez suggests that encouragement from parents can alter their children's perceptions of the safety environment and those perceptions are

associated with active commuting to school. For parents to encourage their children to perceive the environment as safe however, the parents themselves need to first be convinced. This is a significant obstacle for the promotion of active transportation amongst youth as “according a public input survey, 53% of residents feel unsafe cycling on the roads in the City of Greater Sudbury” (Rainbow Routes, 2010). Research in Canada has shown that individual perceptions of risk may be excessively influencing the choice to cycle (Winter et al, 2012). If perceptions affect individual decisions to cycle then this is likely also true when considering that the perception of risk in the neighbourhoods surrounding schools might affect a parent’s choice to support their child actively commuting.

The work of Winter, Babul, Becker, Brubacher, Chipman and Teschke (2012) assessed perceptions of risk and then compared these with observable risks and empirical data. They believe that it is important to consider perceptions of risk because a perceived risk reduction could lead to an increase in cycling. They also indicate the importance of being aware that the development of infrastructure that is empirically safe but that is not perceived to be safe could prove to be ineffective at increasing cycling. The routes that had the greatest perceived safety for cyclists were: “off-street multi-use paths; residential streets; off-street bike paths; major streets with bike lanes; and cycle tracks” (Winter et al, 2012). The routes that had the greatest perceived risks for cyclists were: “major streets (with and without parking) and either shared lanes (with cars, buses or high occupancy vehicles) or no infrastructure at all (Winter et al, 2012).

A study by Schoner, Cao and Levinson (2015) found that in the built environment bicycle commuting was influenced by bike lanes and job accessibility. They noted that bike lanes were associated with greater participation in cycling, while job accessibility was associated with the frequency of cycling. Their research suggests that “close proximity to jobs is an important predictor in how frequently one can make that commute trip by bicycle.” (Schoner, Cao, & Levinson, 2015). It is presumably the frequency with which people must go to work is what

makes its proximity a significant factor for frequency of biking. Based on this presumption proximity to school should have a similar effect in increasing the frequency of biking amongst students. In theory, based on these findings bicycle lanes near schools will encourage more students to bike and more often. This supports other research that found that "providing …separate facilities to connect practical, utilitarian origins and destinations also promotes cycling for work, school and shopping trips, as opposed to the mainly recreational cycling" (Pucher, & Buehler, 2008). Any such bicycle lanes that are developed with more practical and utilitarian purposes in mind have the added benefit of possibly also being used for recreational purposes.

There are a variety of ways a city can promote active transportation the main one being to develop dedicated active transportation infrastructure. Several measures have already been taken to implement an active transportation network in Greater Sudbury, including the widespread development of sidewalks and crosswalks, some of which are controlled by electronic signals. Bike lanes and trails however, have been developed only in more isolated areas of Greater Sudbury in comparison to the much wider availability of sidewalks. To promote cycling as a viable means of active transportation the city needs to invest in developing more infrastructure specifically for this purpose. When considering how Greater Sudbury could best implement additional infrastructure to promote cycling, lessons can be learned from other jurisdictions.

Several European countries are very advanced when it comes to the development of their active transportation networks. In a paper titled *Making cycling irresistible: Lessons from the Netherlands, Denmark and Germany* the authors' analysis identified that the "provision of separate cycling facilities is undoubtedly the cornerstone of Dutch, Danish and German policies" (Pucher & Buehler, 2008). The authors went on to state that "the most important approach to making cycling safe and convenient… is the provision of separate cycling facilities along heavily travelled roads and at intersections" (Pucher & Buehler, 2008). The development

of bike lanes in concentrated areas is a rather recent advent in Greater Sudbury. The current bike lanes in Greater Sudbury are largely along heavily travelled roads, as with the aforementioned European countries, but most of the cycling facilities are not separated from the street. Moreover, new bike lanes are not always connecting with previous bike lanes, which has created a disconnected cycle network in Greater Sudbury. The impression is that in the City of Greater Sudbury cycling infrastructure has been treated mainly as an afterthought, added to streets that were primarily designed to accommodate motorized traffic.

Pucher and Buehler (2008) found that the provision of separate cycling facilities was not the only key to promoting cycling in several European countries. They found that these countries also have strong policies that promote active transportation and discourage driving. The City of Greater Sudbury currently only has some limited policy directing the development of its bicycling infrastructure within the city. Most of these policies are outlined in Part IV subsection 11.7 of the City of Greater Sudbury Official Plan. The four policies that relate to cycling in this subsection of the Official Plan are as follows:

> 1. The existing pedestrian and bicycle network will be maintained and expanded through the creation of additional pedestrian walkways, trails and bikeways with adequate signage throughout the City.

> 2. Development proposals will be reviewed to ensure that there is adequate pedestrian access in new developments. The City may acquire lands to provide pedestrian facilities as a condition of approval. Wherever possible, the provision of adequate bicycle facilities will be encouraged.

3. Bicycle facilities for all new road links and road widening projects will be considered based on an assessment of safety, potential usage, cost, and linkages to major employment, educational, or recreational centres.

4. The maximum level of separation of pedestrians and bicyclists from motor vehicle traffic will be achieved through good road design practices (City of Greater Sudbury, 2006).

The first policy clearly states the city's intention to create new routes for cycling. The second policy focuses mostly on pedestrians and it states that for new development proposals, adequate facilities for pedestrians will be ensured whereas adequate bicycle facilities will only be encouraged. The third policy is the most significant as it outlines several aspects that it will assess in considering adding bicycle facilities to all new road developments. Policy 4 indicates an interest in separating not only pedestrians but cyclists from motorized traffic. These four policies are an expression of the City of Greater Sudbury's desire to become a more bicycle friendly city, however it is apparent that pedestrians are prioritized.

The fact that bicycle facilities are considered based on their assessed safety, potential usage and linkages to educational centres are significant when considering the development of such facilities in the neighbourhoods surrounding schools. There is a definite potential usage for bicycle facilities in these neighbourhoods because the school boards in Sudbury have established set distances from their schools within which students are not provided with busing. These students may already actively commute to school, or have arranged other methods of transportation. Developing facilities in the neighborhoods within these distances are likely to encourage a modal shift towards cycling if they can effectively change the perception of safety. The minimum walking distances established by the school boards are listed in the table below:

Table 1 – Minimum Walking Distances

Student's Grade	Minimum Walking Distance
JK-SK	250 metres
Grades 1-3	1.0 kilometre
Grades 4-8	1.6 kilometres
Grades 9-12	2.5 kilometres

(Sudbury Student Services Consortium, 2010).

It is difficult to know how the city intends to assess the safety of a road based as stated in policy, however when considering bicycling routes where children are the intended users it seems reasonable to assume that those roads should be a priority for safety improvement. Clearly the goal of creating linkages to educational facilities is directly achievable by developing routes for children to bike to school. If such routes are to be developed then they should ideally have connections to previously established cycling infrastructure and facilities.

The city has other policies that relate to cycling, and several references to cycling can be found in the official plan, which indicate the city's intention to promote cycling. However these policies have often lacked specifics and are more guiding principles. A more concrete approach involves the City of Greater Sudbury Bicycle Advisory Panel's 'Bicycling Master Plan' which outlines suggestions for infrastructure improvements to make cycling safer and more practical. Although this plan is in draft form (and could change), it at least is something concrete for the city to consider. Once finalized the Draft Transportation Master Plan could be amended to the City of Greater Sudbury Official Plan.

Not having an official bicycling master plan has allowed cycling infrastructure to develop somewhat haphazardly. For example, there are many discontinuities in the cycle routes that

have been established. In the Bicycling Master Plan it has been identified that “the greater the connectivity and reach of a network, the more potential it has to encourage cyclists and pedestrians to use it” (City of Greater Sudbury Bicycle Advisory Panel, 2010). The current lack of connectivity that exists in many parts of the bike lane network is not helping to encourage cyclists. In the short term improved signage would at least direct cyclists from disjointed section of cycling infrastructure to another.

Not having an official plan guiding bicycling infrastructure also means that any of the new road developments are not required to provide for cycling facilities. Through the adoption of an official active transportation plan the city could dictate under which circumstances cycling infrastructure would be a required aspect of new developments and would enhance connectivity within a city-wide active transportation network. Such policies could also be used to ensure that cycling infrastructure is considered as a component of a complete street prior to development rather than as an afterthought. Even with rather weakly worded policies and not having adopted the Draft Transportation Master Plan, the City of Greater Sudbury seems to have been somewhat successful in advancing the creation of bike lanes. The fact that the City of Greater Sudbury has already begun to establish a cycle network is at least promising. There has been much talk about expanding the cycling routes in Greater Sudbury, and several committees and panels have been formed to address the issue. These indicate positive discussions but more action is needed.

One of the groups organized to address the issue of active transportation is the Greater Sudbury Sustainable Mobility Advisory Panel and they have been involved in helping the city implement recommendations for infrastructure, policy and education that were presented in the ‘Sustainable Mobility Plan’. The ‘Sustainable Mobility Plan’ was a document that was prepared in response to a request from the City of Greater Sudbury Healthy Community Cabinet and outlines recommendations to improve walking, cycling and public transit in the city (Rainbow Routes, 2010). This plan is to be superseded by the Bicycling Master Plan once the

Draft Transportation Plan is finalized. There are several possibilities and challenges outlined. One of the possibilities that was identified is the potential for a pilot project to develop active and safe routes to school as a means of getting more children to choose to actively commute to and from school (Rainbow Routes, 2010).

In the 'Bicycling Master Plan' the City of Greater Sudbury Bicycling Advisory Panel has identified that Greater Sudbury has far fewer kilometres of bicycle infrastructure than many other municipalities across Ontario. Clearly Greater Sudbury needs to 'catch up' with the rest of the province. The Bicycling Master Plan outlines four principles that should be considered when developing a good bicycling network: safety, directness, comfort and coherence (City of Greater Sudbury Bicycle Advisory Panel, 2010). Based on these criteria and community input, a list of roads that should receive cycling infrastructure development was created. Of all the roads identified in the 'Bicycling Master Plan' it was determined that Paris and Notre Dame, (MR 80) from Regent to Lasalle is the highest priority route. The list of roads they identified as high priority in the short term are:

Paris and Notre Dame, (MR 80) from Regent to Lasalle *highest priority

Falconbridge from Maley to Edison

MR 35 from Lorne to Notre Dame

Elgin Street/ Howey Drive from Mackenzie to Van Horne

Kathleen from Frood to Notre Dame

Second from Bancroft to Donna

Walford from Regent to Paris

York from Adelaide to Paris

(City of Greater Sudbury Bicycle Advisory Panel, 2010).

Methodology:

The roads suggested by the Bicycle Advisory Panel are a good start for the City of Greater Sudbury, but the Draft Transportation Master Plan must be adopted before any of the suggested developments are realized. This list presents the current areas of focus for where future infrastructure developments should occur in the short term. However, this list could be augmented to take into account proposals for cycling infrastructure in neighbourhoods surrounding schools. This is justified as the obesity problems that are facing the city start at a young age. This could also help Greater Sudbury 'catch up' with other communities in the province in terms of active commuting.

A GIS project is undertaken to model ideal candidate roads to receive cycling infrastructure developments in the neighbourhoods surrounding schools. Candidate roads are the roads that fall within the minimum walking distances to school establish by the local school boards. To promote connectivity within the framework of the existing cycling infrastructure candidate roads have to be near established cycling routes. To ensure a greater potential use, the roads that are more proximate to schools with higher enrolment are prioritized over those that would service lower enrolment schools. Using a GIS would be an effective way of developing such a network. ArcGIS was the program used due to the range of tools it offers, and specifically because of the ability to create service areas using the network analyst tool. Ideally this analysis shows where to establish new bike infrastructure in Greater Sudbury and thereby promote healthy active lifestyles in youth. Objective criteria are used to prioritize the roads which are suggested for infrastructure development.

Data were collected pertaining to all elementary and secondary schools in Greater Sudbury. There are four school boards: the Rainbow District School Board, the Sudbury Catholic District School Board, the Conseil scolaire public du Grand Nord de l'Ontario and the Conseil

scolaire catholique du Nouvel-Ontario. Information about the schools that was compiled includes their addresses, highest grade offerings and enrolment numbers. The lists of schools and their address information were obtained from each of the school boards' websites. The highest grade offered and the enrolment data were obtained from the each of the schools' websites and where this information was not published it was obtained after contacting the school boards. An excel file was created containing the data that were collected, and organized into 7 columns: School Name, Address, CMA (Census Metropolitan Area), Postal Code, Province, Highest Grade Offered and Enrolment. This excel file containing the school data was opened in SPSS and was then converted into a dBase IV file type to facilitate compatibility when imported into ArcGIS.

Base shapefiles were needed for the City of Greater Sudbury and its roads. Statistics Canada provides a great range of shapefiles available free download online. It was from Statistics Canada that both the CMA boundary shapefile and the road shapefile for the City of Greater Sudbury were obtained. After being downloaded the shapefiles were imported into a blank ArcGIS project. Following this the SPSS file containing the school data was added to the project. An address locator was created in ArcGIS using the U.S. Dual Range style locator. The Greater Sudbury road shapefile was used as the reference source against which the school addresses from the SPSS file were located. Most addresses were successfully located, however some remained unmatched and had to be geocoded manually by cross-referencing with Google Maps. Ultimately, a point layer showing school locations was created.

The next task was to create the 'service areas' for the bike networks that would start from the schools based on objective criteria. The minimum walking distances from home to school for students is used as the base distance for the bike lane 'service areas'. Students who live within a certain distance from their school are ineligible for busing to school and it is the parent's responsibility to ensure their children get to school (Sudbury Student Services

Consortium, 2010). The minimum distances for students to walk to school as established by the local school boards were presented earlier in Table 1 on page 12.

It is very likely that the streets that fall within these distance of schools are already used by children to actively commute to and from school since they cannot ride the bus and their only other options would be to get a ride from their parents or to take public transportation. It will be assumed that not all students will be in the position to get a ride to school, and it will also be assumed that the minimum walking distances are rather close to generally bother with taking public transit. Since the streets within the given distances from the schools will be used by many students to travel to school these make ideal candidates for the development of active transportation infrastructure.

The network analyst extension in ArcGIS was used to establish the 'service areas' from the schools based on the minimum walking distances. ArcCatalog was needed to create the network database from the Greater Sudbury roads shapefile. This allows for control to be calculated in kilometres. The schools were loaded on to the road network and the highest grade offered determines the extent of the service area. The schools went up to either grade 3, grade 5, grade 6, grade 8 or grade 12. The first service area of 1 kilometre was created for grade 3 schools. A second service area was calculated for the schools ending at either grade 5, 6 or 8 based on a distance of 1.6 kilometres. A third service area was calculated for schools going up to grade 12 based on a distance of 2.5 kilometres. When the network analyst was run with the specified service area distances it created specific polygons to reflect the kilometres thresholds. These service area layers show the extent of the streets that fall within the minimum walking distance of all of the schools in Greater Sudbury.

It was necessary to create a map layer showing infrastructure in Sudbury since such a shapefile was not readily available online. A list of the existing infrastructure was obtained from

Rainbow Routes, an organization dedicated to sustainable mobility through the development and promotion of active transportation routes in the City of Greater Sudbury. The cycling infrastructure for the city is summarized as follows:

Table 2 – Existing Road Infrastructure

Attlee (Belfry to Westmount)	Edge Line	Signed bicycle route with paved shoulder. There is a white edgeline separating cyclists and motorist.
Loach's (Regent to Armstrong)	Edge Line	Signed bicycle route with paved shoulder. There is a white edgeline separating cyclists and motorist.
Minnow Lake (Van Horne to Moonlight and the Kingsway to Bancroft)	Conventional Bicycle Lane	A portion of the roadway that has been marked for exclusive use by cyclists.
Paris (Bell Park to Ramsey Lake Road)	Raised Two-way Cycle Track	Vetically seperated from the roadway. It is designated for exclusive use by cyclists and is distinct from the sidewalk.
Regent (Bouchard to Telstar)	Sharrows	Is a shared roadway lane marking. Sharrows guide cyclists as to where they should ride within a travel lane shared by both motorists and cyclists.
Bell Park Cycle Path (Amphitheatre to Elizabeth)	Off-road	Off road route with a mixture of asphalt and dirt path on the western edge of Bell Park.

(Rainbow Routes, 2015)

These descriptions from Rainbow Routes were used to select the specific roads where infrastructure already exists. This selection was extracted from the road shapefile and used to create an 'existing infrastructure' shapefile. The Bell Park Cycle Path was not included because it does not connect to the road network. Another exception was with the edge line cycle path on Atlee road approaching Lasalle Boulevard. In this case there was a segment of the road approaching the intersection that did not actually contain any infrastructure for cyclists. It may be that having identified the section of road that actually lacked infrastructure will make it easier to isolate and explain gaps in the suggested active transportation network. This section of road that lacked the edge was one of two instances where the existing cycling infrastructure was not geocoded exactly as described in Table 1. A third exception was the inclusion of the infrastructure on Ramsey Lake Road, where there is a wide pathway separated from the roadway. This pathway is not a sidewalk, and appears on Rainbow Routes maps as a part of the Tour de Sudbury, a cycle route comprised of cycle lanes and off road trails that encircles Ramsey Lake

The Clip tool was used to isolate the roads that exist within the service areas established around each of the schools in town. Then the data were exported to a road shapefile, and imported to the project. The next step was to go into each of the newly created shapefiles' attribute tables and to isolate the main roads based on their rank. The significance of the ranks are defined by Statistics Canada as below:

Table 3 – Street Ranks

Street rank code	Street rank description
1	Trans-Canada Highway
2	National Highway System
3	Major Highway
4	Secondary Highway, Major Street
5	All other streets (not rank 1,2,3 or 4)

(Statistics Canada, 2011)

Roads with a rank of 5 presumably receive lower levels of traffic and therefore do not usually require the development of any additional cycling infrastructure. With this in mind, the Select by Attributes function was used to isolate each of the service area roads where the rank was not 5, ensuring that only 'main roads' were selected by excluding local roads. The selections were saved from each of the service area road shapefiles, and saved as new 'service area main road' shapefiles.

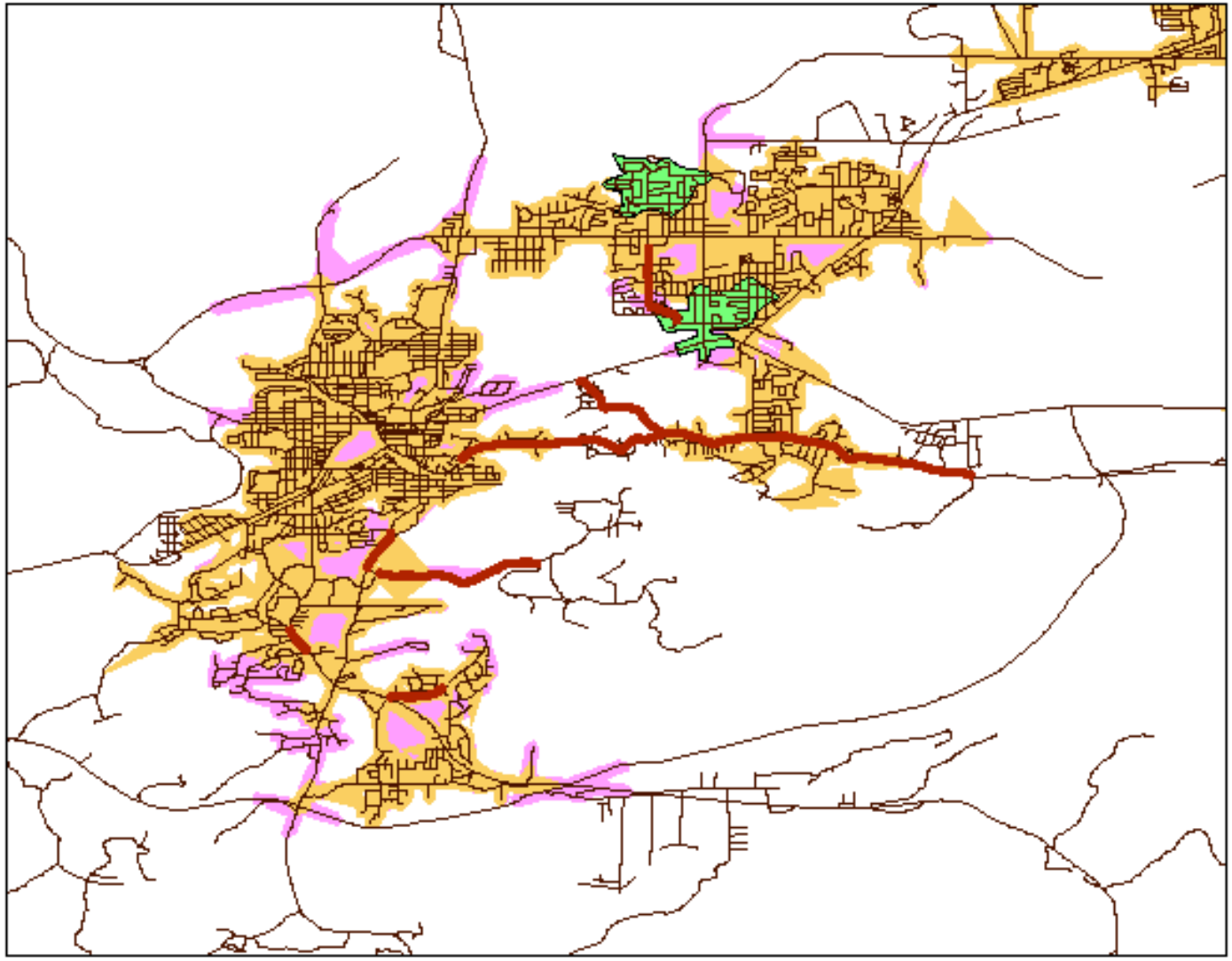
At this point the GIS had identified a large number of main roads located within the service areas. The number of these roads made it unrealistic that they could all have cycling infrastructure developed, even if it would be ideal. To further isolate the roads which should be prioritized for development, two major criteria were considered: proximity to schools and proximity to existing cycling infrastructure. The schools were separated into those with higher enrolment numbers and those with lower enrolment numbers. The attribute table for the schools was used to sort the 70 schools by enrolment, and the median was found. 300 was the number of students found to make for an appropriate cutoff that would distinguish 'high' enrolment and 'low' enrolment schools. Select by Attributes was used to select the schools with enrolment greater than 300 and the data were extracted to create a new 'high enrolment

schools' shapefile. The same steps were used to select the schools less than 300 students and create a new 'low enrolment schools' shapefile.

Now that all of the necessary shapefiles had been created, Select by Location was used to identify the priority 1 and priority 2 roads for cycling infrastructure development. As previously stated, the criteria used to prioritize roads were proximity to schools and existing cycling infrastructure. Priority 1 roads were created by identifying the roads that were within 500 meters of the high enrolment schools, as well as roads that were within 500 meters of the existing cycling infrastructure. Priority 2 roads were created by identifying the roads close to existing cycling infrastructure and roads that were within 500 meters of low enrolment schools. The following three maps are presenting the existing cycling infrastructure, priority 1 roads and priority 2 roads as established here.

The GIS results have produced a rough network of main roads within the previously established service areas representing those areas where students are not provided with busing to school. The roads identified would provide greater connections between the neighbourhoods in which schools are located and the existing cycling infrastructure. The roads that have been presented are those which would presumably be the most effective at targeting youth to adopt cycling as a mode of active transportation to and from school. The roads have been classified priority 1 or priority 2 for development based on the enrolment numbers of the schools they are positioned to serve. The rationale for this was that the roads that should be prioritized for development are those that might serve the greatest number of students. An analysis of the GIS results will review the validity of the roads suggested for development.

Existing Cycling Infrastructure in the City of Greater Sudbury



Legend

- Existing Cycling Infrastructure
- Sudbury Roads
- 'Service Area' Gr. 3
- 'Service Area' Gr. 5-8
- 'Service Area' Gr. 12

0 2.5 5 10 Kilometers

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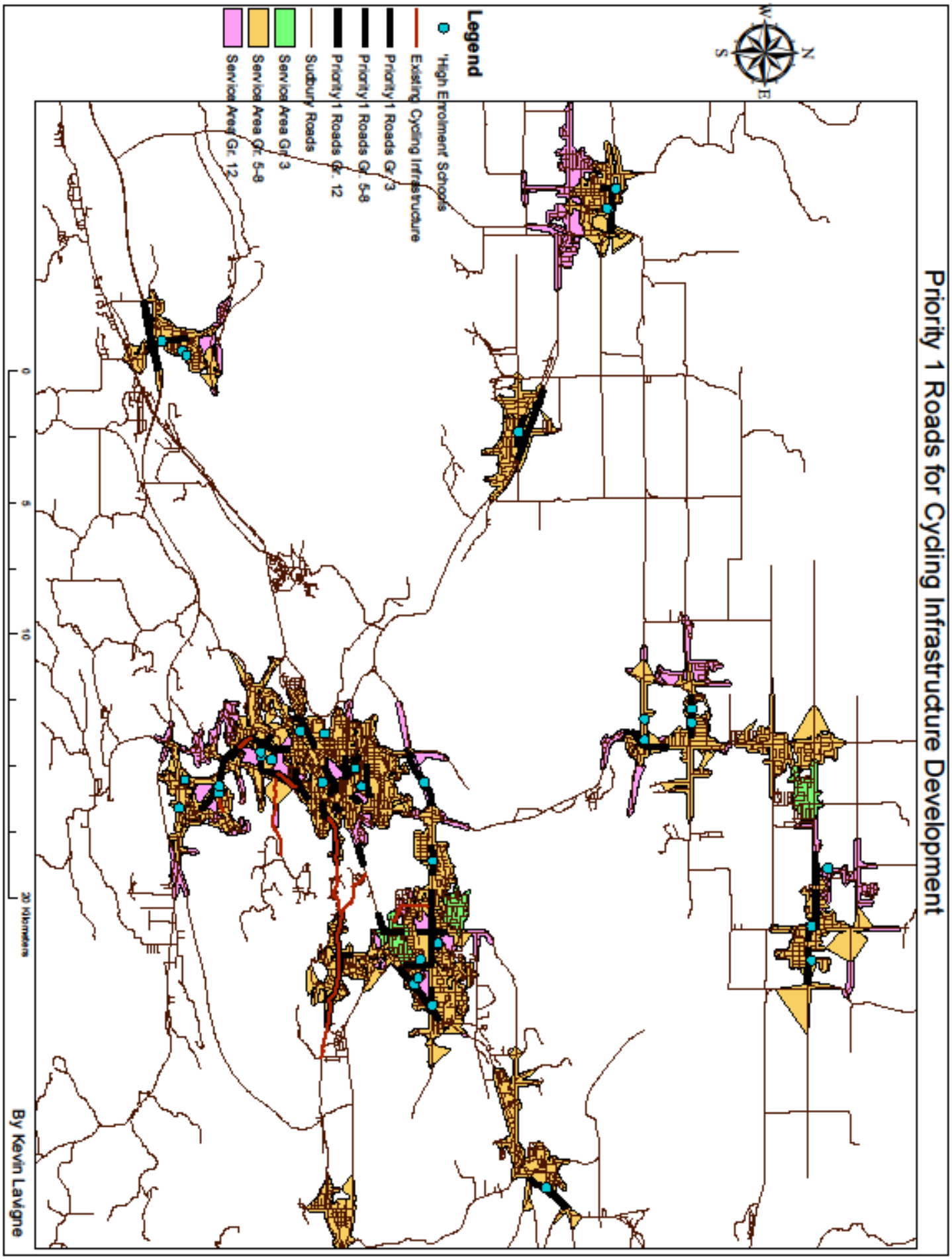
Priority 1 Roads for Cycling Infrastructure Development
Legend
'High Enrolment' Schools
Existing Cycling Infrastructure
Priority1 Roads Gr 3
Priority1 Roads Gr. 5-8
Priority1 Roads Gr. 12
Sudbury Roads
Service Area Gr 3
Service Area Gr. 5-8
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20 Kilometers
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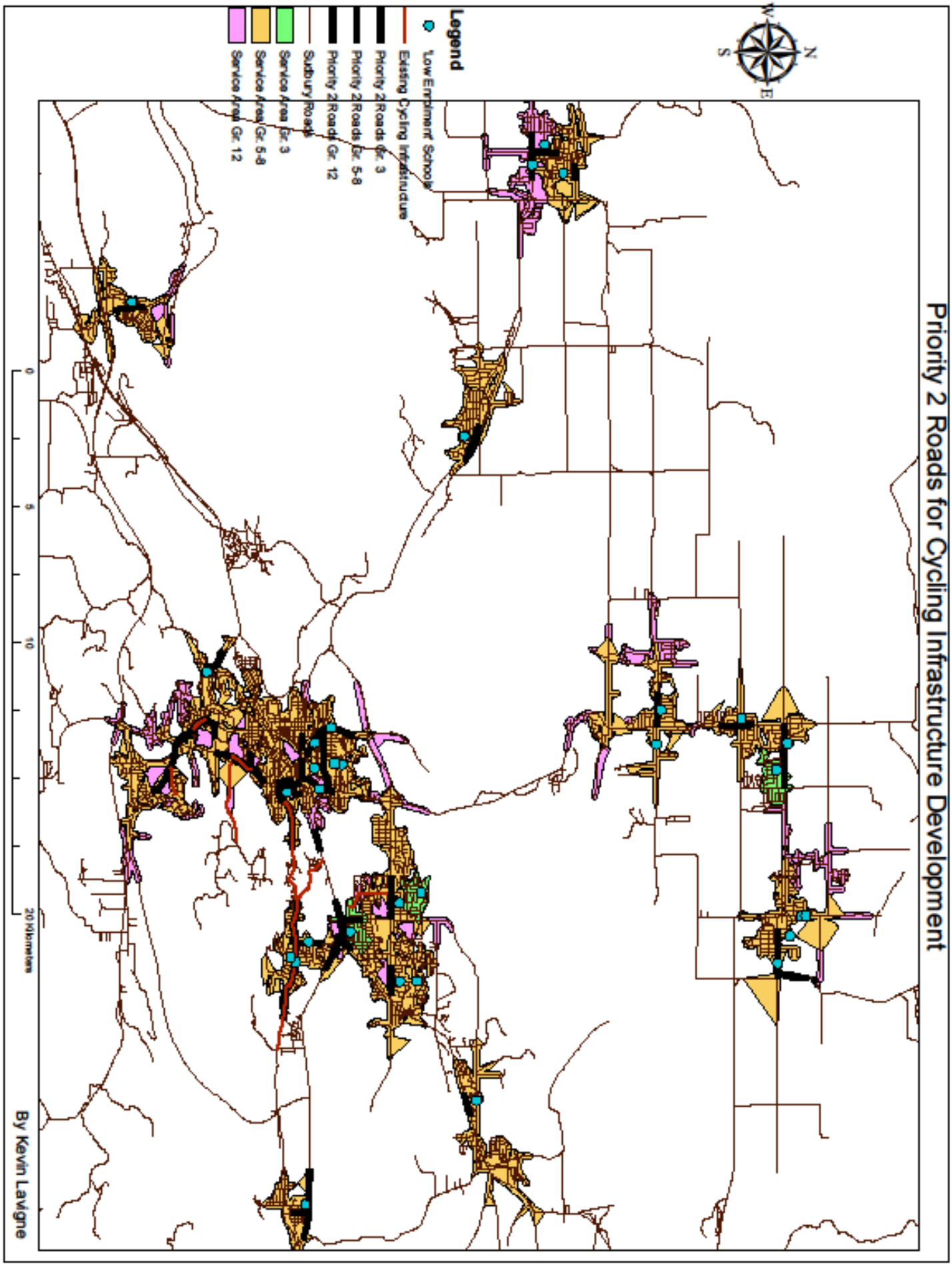
Priority 2 Roads for Cycling Infrastructure Development
Legend
Low Enrolment Schools
Existing Cycling Infrastructure
Priority 2 Roads Gr. 3
Priority 2 Roads Gr. 5-8
Priority 2 Roads Gr. 12
Sudbury Roads
Service Area Gr. 3
Service Area Gr. 5-8
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Results:

Figure 1 displays the cycling infrastructure that already exists within the City of Greater Sudbury. It can be seen that the all of the on-road and separated cycling routes have been established within fairly central parts of the city. None of the communities located in the periphery of the city have any dedicated cycling infrastructure. This is likely due to the distribution of the city's population, with more people in the core and less in the periphery. Establishing the cycling infrastructure in more highly populated areas allows for a greater potential use of any infrastructure that is developed and the same rationale is used to divide the roads suggested for development into Priority 1 or Priority 2. The 'service areas' or areas within which students do not receive busing to and from school, were included in the first map as well the subsequent maps for reference.

Figure 2 displays the priority 1 roads for infrastructure development within the 'service areas' where students do not receive busing to and from school in the City of Greater Sudbury. Again, most of the roads that are suggested for development are located fairly centrally. This is logical since most of the existing cycling infrastructure is located in more core parts of the city and GIS selected the candidate roads partially based on their connectivity to the existing network. The core parts of town are also where most of the 'high enrolment' schools' are located. In some of the more peripheral communities there are no schools with over 300 students, therefore there are only 'low enrolment' schools. Fewer high enrolment schools and no existing cycling infrastructure make the outlying communities lower priority for development compared to the core of the city. New cycling infrastructure developments in the core can serve as extension to the current network and the many 'high enrolment' schools nearby means they have the potential to serve a greater number of students.

Some of the routes identified in Figure 2 met the criteria that were established but upon closer examination it was determined that their development would not be of use to students looking to commute to and from school. Examples of this include Falconbridge Road past Spruce Street, which developing would be pointless as it would serve only to connect to a mine. Also parts of the Kingsway that were identified should be excluded because they do nothing to connect residential areas to school neighbourhoods and only connect to commercial areas.

Figure 3 displays the priority 2 roads for cycling infrastructure development that fall within the 'service areas' where students do not receive busing to and from school. Many of the roads identified as priority 2 are more dispersed throughout the city as opposed to the distribution of the priority 1 roads. This is because of the greater number of 'low enrolment' schools in the less populated peripheral parts of the city. Some of the roads identified may only serve very small populations so they may need to be considered more closely on a case by case basis. Some of these roads identified in Figure 3 overlapped with roads already identified in Figure 2. To distinguish the sections of road uniquely to be prioritized as priority 2, the priority 1 roads were overlaid above the priority 1 roads and only the visible segments were recorded.

There are many roads that have been identified by the GIS and they are presented in Figure 2 and Figure 3. To further refine the lists of priority 1 and priority 2 roads each have been subdivided into three groupings. Priority 1 roads have been divided into:

a) Roads that link to the existing cycling infrastructure

b) Roads that are disconnected to existing cycling infrastructure but would link to the roads identified in Priority 1 a)

c) Roads that are disconnected from other cycling infrastructure.

Priority 2 roads have been subdivided similarly:

a) Roads that connect to the priority 1 roads

b) Roads that would link to the roads identified as priority 2 a)

c) Roads that are disconnected from other cycling infrastructure.

The list of roads can be found in the appendix on pages 32-34. All of the priority 1 roads are located near 'high enrolment' schools. The priority 1 a) roads that have connections to the existing cycling network are the roads that have the potential to serve the greatest number of students and are those which expand the cycling network. Similarly the priority 1b) roads serve to further expand the network and should be next prioritized. 1 c) roads are disconnected segments, but nevertheless important. There are few communities in the City of Greater Sudbury that although not in the core have significant populations. Some communities such as Hanmer, Val Caron, Lively and Garson have some high enrolment schools, and there are large numbers of students in these communities that could benefit from the increased physical activity associated with cycling. These communities should not be excluded from receiving cycling infrastructure simply because they are not close enough to the current cycling network.

The roads that have been identified have the potential not only to be used by students commuting to and from school but also by other cyclists commuting along the same road as well as recreational cyclists. Schools serve as a draw after school hours because of the facilities many of them have such as sports fields, basketball courts, play structures, etc. Many elementary and secondary schools also serve as community centres. Schools occasionally host events that are open to the public, such as plays and fairs. Other organizations make arrangements with schools to use their spaces outside of class hours for a variety purposes. Events like craft shows make use of school gyms for a weekend and local sports leagues use school gyms and sports fields for their games and practices throughout an entire season. This wide range of uses give the roads identified the potential for attracting wider usage than solely

from youth commuting to and from school, even though they are certainly the target demographic

Upon analysis of the GIS results it is obvious that they should not be taken as is and implemented. This is because the GIS process is a way of focusing on the parts of streets that fall within the zones where students walk to school. It often would not be logical to establish several disconnected segments of cycling infrastructure along the same street where there is the possibility of creating one completely connected facility. In some situations the gaps between the cycling infrastructures suggested on priority 1 roads are 'filled in' by the cycling infrastructure suggested on priority 2 roads. In cases such as these, interconnected priority 1 and 2 developments should be undertaken jointly where possible to ensure the connectivity and the efficacy of the network.

Some of the routes that have been identified by the GIS are also identified in the Draft Master Plan. Interestingly, the main road identified by the Bicycling Master Plan in need of bicycling infrastructure is also one that was identified as a priority 1 a) road in the GIS. Paris Street, having been identified as a main priority in both instances should definitely be developed to encourage cycling, Second Avenue and Elgin Street are two other roads that were suggested for development in both this study and the Bicycling Master Plan. The extent of the street suggested to be developed is greater in the Bicycling Master Plan, however this study is considering a focus on the parts of the street that are near schools so that is to be expected. The creation of new cycling infrastructure along the street segments that are suggested here can be later expanded upon by the plans set forth in the Bicycling Master Plan, or these findings can be used to support the complete development of the roads as imagined in the Bicycling Master Plan.

Conclusion and Discussion

There is a clear need for the City of Greater Sudbury to increase its efforts to manage levels of obesity in the community. Promoting active transportation within the city is a significant way of improving the community's health. Youth are an ideal demographic to encourage to commute actively as part of a long term solution to combat obesity rates. Developing cycling infrastructure in the neighborhoods surrounding schools will encourage youth and their parents that cycling to school is a safe choice, and improve the likelihood of individuals adopting cycling to commute actively. The roads that have been identified in Figure 2 and Figure 3 should be considered a priority for cycling infrastructure development with only a few exceptions. Such developments need to occur alongside the implementation of new policies that are more encourage cycling as well as the adoption of an official plan to direct how and where any new cycling infrastructure is developed.

The city has a variety of possible choices when it comes to deciding what type of cycling infrastructure it would like to implement on any of the suggested streets. When determining which infrastructure is appropriate for the roads that are suggested to be prioritized for cycling infrastructure development, it should bear consideration that the riders that are primarily being targeted are youth. These riders would ideally require infrastructure that accommodates cyclists of lower abilities, meaning wider lanes for on-street lanes or better yet, separated facilities. It is recommended that infrastructure such as 'sharrows' be reserved for local roads, as they are the least adequate facilities available to cyclists and based on the literature are the least likely to encourage cycling. It is important to note that this is the type of infrastructure that has been chosen for implementation on Regent Street, and that this situation is not ideal. . 'Sharrows' on Regent Street may prepare traffic to expect cyclists on the road, however this choice of infrastructure seems unlikely to persuade youth nor their parents to perceive that it is safe cycling the heavy volumes of traffic the road receives. Any new separated-cycling infrastructure on Regent Street in particular seems like it would be difficult in places due to how

close the buildings front on the sidewalks. The limited space that exists to expand in some transportation corridors may make some of the suggested roads impossible to develop and this is an area for future study. In instances such as this, where it may not be feasible to properly accommodate cyclists on road, the alternatives of separating them from the road should be considered.

The city has a by-law in place that strictly prohibits cyclists from riding on sidewalks, however there is the potential for the city to create 'shareways' in specific areas. The idea of a 'shareway' encapsulates a shared laneway that can be used by all modes of active transportation. Such a lane could be implemented to replace a sidewalk. Painted 'signage' on the ground can be used to instruct proper etiquette, for example instructing cyclists to pass on the right hand side and pedestrians to walk on the left or vice versa. Such types of shared infrastructure are not a new design, and are widely used in many parts of Europe. With proper education on etiquette, including the use of bells by cyclists to forewarn pedestrians of their being passed, there is a possibility that 'shareways' could be implemented rather easily in situations where on-road options for cyclists are impractical.

Another option would be to implement a by-law similar to one that Mississauga has in place, where bicycles with tires under 50cm in diameter are permitted on sidewalks (City of Mississauga, 2013). This by-law allows younger children the option to ride off the road, which can be safer for them as they learn to ride and develop their confidence. Having this option would also increase the perceived safety of cycling to parents who would then be more likely to allow their children to bike to school. This type of by-law change would not allow all students to ride on the sidewalks, only the younger and smaller students which would likely encourage kids to start cycling at an even younger age. The implementation of progressive by-laws in conjunction with the implementation of a cycling infrastructure network has the potential to greatly encourage cycling amongst youth.

This analysis is only meant to be used as a guiding tool for decision-makers who will ultimately be determining where to invest in developing future cycling infrastructure. As such, there are some limitations to this paper which should be acknowledged. The focus is on the development of active transportation networks along existing roadways. It must be recognized that there are some active transportation links that exist off-road. Such links include bicycle-specific infrastructure that exists completely off-road, the only example of which is the Bell Park Cycle Path. The off-road cycle path through Bell Park at one end connects to local roads which have no cycling infrastructure and at the other end connects with the separated two-track cycle lanes which run along Paris Street to Ramsey Lake Road. Although this is the only example of an official off-road cycle route, there are a variety of other trails across the city which while not explicitly maintained for cycling, do not prohibit cycling. These trails can be used to expand on the other road-focused cycling infrastructure that has already been established as well as the routes that have been proposed here.

It is recommended that decision-makers consider the locations and conditions of trails that might accommodate cyclists as well as the roads that have been identified here. It may be in some circumstances that the existence of a local trail that cyclists can access may reduce the need for cycling infrastructure on a particular nearby roadway. Conversely it may be found that having certain trails nearby that are accessible by cyclists expands the cycling network and makes nearby roads more appealing for development as a further expansion to the network. Some trails may be too difficult to accommodate riders of all abilities, and this aspect must also be taken into thought if considering trails as a substitute for other infrastructure development, particularly when considering infrastructure that is targeted at youth.

It is also important to recognize that the initial establishment of new cycling infrastructure can only be one part of a larger effort to promote cycling as active transportation in the City of Greater Sudbury. There remain many obstacles to cycling in even in areas where specific infrastructure has been developed. Studies have shown that many “cyclists and

potential cyclists report safety concerns related to motor vehicle traffic and poor weather" (Winter et al, 2012). Due to the icy road conditions that the city experiences every winter, the city organizes trucks to spread salt and sand on the roads to increase traction for motorized traffic. Much of the sand that is spread in the winter is then plowed into the snowbanks that accumulate beside the roads, and in the springtime when those snowbanks melt large quantities of sand are left in the bike lanes. The amount of sand in the bike lanes in early Spring make them particularly dangerous to cyclists, as in spots where the sand is thickest it is possible for cyclists' bike tires to slip in the sand and that has the potential to cause cyclists to crash. This possibility is made even more dangerous due to the fact that most of the bike lanes in the city exist on-road next to motorized traffic. There is a need for the city to be proactive with road sweeping in the early spring. It is important when street sweeping occurs that the dirt not only be swept into the bike lanes, further increasing the difficulty for cyclists but swept out of the bike lanes as well. With some planning, the areas with cycling infrastructure could be designated high priority for street sweeping to ensure that these facilities are in good conditions for the cyclists they have been designed to accommodate.

Another issue concerning cycling in the City of Greater Sudbury with regards to seasonality is the winter weather and road conditions that pose a serious obstacle for cycling for a good part of the year. Bicycles are much harder to pedal and control in snow than on solid ground as they have much less traction. Once snow begins to be plowed towards the shoulders of roads as the winter season progresses, the roadways become narrower and leave less room for cyclists. In the case of a separated cycle track that runs parallel to the road such as on Paris Street, the snow being plowed is piled up onto the curb and buries the cycle track. The cycle-track on Ramsey Lake Road, being separated from the road, is likely the only cyclist route that could possibly be maintained clear throughout winter.

There have been recent advancements in bicycle design to improve performance in tough terrain such as sand or snow. Several companies have begun to sell extra-wide and

gripped bicycle tires, and these types of tires seem to have grown in popularity in recent years. Although adaptations like these extra-wide bicycle tires may not solve all of the problems facing cyclists in the wintertime, they will increase the safety of cyclists who do choose to ride in difficult winter conditions by providing them with greater traction. The city could consider educating the public about the possibilities of winterizing one's bicycle. Having extra traction would be particularly useful in early winter, as it may allow more cyclists to continue to ride in the bike lanes for longer into the season. Extra traction would be useful in early spring as well when large amounts of sand can be found in bike lanes, reducing the likelihood of slipping.

There are a number of other obstacles that cyclists face when attempting to commute via designated laneways. There are many instances where bike lanes are used in disregard of cyclists in favor of other temporary uses. For example, it is not uncommon for cars, trucks and buses to pull over into the bicycle lanes and stop. Often with city buses and school buses the stops are very temporary and not a significant disruption for cyclists, however many cars and trucks not only stop but park in the cycle lanes. Parked cars in bike lanes pose a significant obstacle for cyclists are they are unwittingly forced to merge into traffic to go around them or dismount and pass on the sidewalk, and as explained earlier some riders are less comfortable riding in traffic and may have chosen their route with the intention to travel where there was available cycling infrastructure.

Another obstacle is that construction companies often place signage to warn motorists of upcoming construction directly in the bike paths. Road work is common much of the year in Greater Sudbury and temporary signs are erected quite frequently. Road work is commonplace in Greater Sudbury due to the high prevalence of potholes. Drivers can often be seen attempting to swerve around potholes, sometimes moving over into the oncoming lane or into the bicycle lane to do so. This type of motorist behavior is understandable, however can make it more uncomfortable for cyclists to ride on the side of the road. It may be that where possible separated cycle tracks such as the ones on Paris Street should be considered for development,

as these would offer some degree of separation and protection to cyclists from motorized traffic.

Another issue faced when considering developing cycling infrastructure in Greater Sudbury is having to cope with streets that were designed with no consideration given to the needs of cyclists. Traffic calming measures have been implemented in several neighborhoods across Greater Sudbury, including curbs that extend outward into the roadway to narrow the laneway at spots. These types of designs which are meant to slow the flow of motorized traffic but have the adverse effect of forcing cyclists from their lane into a bottleneck with other traffic. This case is true of the bike lane on Atlee Avenue, where the lane is painted on the side between the traffic calming installations which intermittently disrupt the flow of traffic completely within the bike lane.

Cyclists also must consider whether or not their destination has available bicycle parking. Elementary and Secondary schools generally provide bike racks for students to lock their bikes to during the course of the day. This alleviates one concern for students who are considering to bike to and from school.

Considering all the hazards and obstacles that cyclists face in the City of Greater Sudbury it becomes understandable why the rate of cycling is as low as it is. Hopefully if these challenges are kept in mind throughout the planning and implementation of a cycling network then potential solutions can be brought forward. This paper considers some of the difficulties faced by the City of Greater Sudbury and attempts to present a potential network of roads that could be developed as part of the solution. It has become clear that infrastructure needs to be guided by policy and official planning. Before the city can hope to establish an effective and connected network of cycling infrastructure a Master Transportation Plan needs to be implemented.

Appendix

The list of roads indicated as those which would benefit from receiving cycling infrastructure are presented below:

Priority 1 Main Road Segments:

a) That link directly to existing cycling infrastructure:

Second Avenue: Bancroft to Margaret.

Howey, Morris and Elgin: Van Horne to Druides.

Paris: York to Facer and Paris: Ramsey Lake Road to Walford.

York: Paris to Gloucester.

Regent: Remington to Telstar and Regent: Bouchard to York.

Lasalle: Lauzon to Auger* not quite connected, but very close.

b) That link to roads connecting directly to existing cycling infrastructure (listed above):

Walford: Regent to Paris.

Martindale: Regent to Marcel.

Barrydowne: Fairbum to Woodbine.

Auger: Lasalle to Gemmell

c) That are disconnected from the existing cycling infrastructure:

Falconbridge: Goodwill to Spruce* (the results say to go further but doing so would serve no purpose) and Falconbridge: Auger to Emily.

Lasalle: Falconbridge to Rose Marie and Lasalle: From Montrose to Drummond and Lasalle: Frood to Crescent Park.

Barrydowne: Kingsway to Gemmell.

Kingsway from Barrydowne - excluded because although within the service area is in a solely commercial zone and another disconnected Kingsway segment excluded.

Elgin: Romanet to Durham.

Brady: Douglas to Minto and Brady: Solidarity to Carleton.

Notre Dame: Ste. Anne to Jogues.

Elm: Elgin to Alder.

Lorne: Elm to Applegrove and Lorne: Regent to Martindale.

Frood: Elm to Baker.

Kathleen: Antwerp to Caron.

Martindale: Lorne to Lawson.

Main: Ninth to Highway 17.

Highway 17: Main to Santala. * (past Main excluded)

Regional 35: Swedlund to just past Rose.

Notre Dame: Landry to Champlain.

Municipal Road 80: Fleming to Fifth.

Main: St. Jean to Justin.

Municipal Road 80: Emily to Gatien.

Municipal Road 80: Centennial to Notre Dame. (Should connect with above road)

Notre Dame: Municipal Road 80 to Cote.

Cote: Notre Dame to Chenier and Cote: Carl to Regional 84.

Priority 2 Road Segments:

a) That connect to priority 1 road segments:

Second: Margaret to Carmichael Village.

Kingsway: Third to Barrydowne.

Falconbridge: Donna to Churchill.

Lasalle: Rose Marie to Lansing.

Elgin: Druides to Romanet.

Brady: Carleton to Charette and Brady: Solidarity to Romanet.

Notre Dame: Ste. Anne to Elm and Notre Dame: Jogues to Nolin.

Elm: Elgin to Paris and Elgin: Elm to Massachusetts and Elm: Alder to Cypress.

Kathleen: Caron to Notre Dame and Kathleen: Antwerp to Frood.

Frood: Baker to Burton.

Regional 35: Swedlund to Notre Dame.

Main: St. Jean to Municipal Road 80.

Cote: Chenier to Carl and Cote: Regional 84 to Radar.

Regional 84: Cote to Linden.

b) That link to roads connecting to priority 1 road segments (listed above):

Paris: Worthington to Cedar.

c) Disconnected road segments:

Highway 17 - excluded as it seems unnecessary.

Main: From Highway 17 to Pine.

Falconbridge: Pilotte to Eva.

Kelly Lake: Southview to Copper * (past Copper excluded as the area is an industrial zone).

Notre Dame: From Jolette to Swedlund.

Route 144: St. Onge to Michael.

Errington: Route 144 to Morin.

Nickel: Riverview to Third.

Third: Nickel to Mine.

Mine: Third to Warsaw.

Municipal Road 80: Josephine to Alexandre and Municipal Road 80: Desmerais to Elmview.

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