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Analysis of missing links in Montréal's cycling network

Research project report:

Analysis of missing links in Montréal's cycling network

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Introduction

Montréal ranks as one of the most cycling-friendly cities in North America. It has one of the largest cycling networks with 748 km of cycling infrastructure in 2015 (Vélo Québec, 2015), a world-renowned bike-sharing system, BIXI, with more than 500 stations and 6000 bikes, and a large cycling population. More than one million residents of the Island of Montréal are cyclists, representing approximately 51% of the population (Vélo Québec, 2015). Furthermore, 78% of children aged three to 17 are cyclists and 53% of adults aged 18 to 74 are cyclists (Vélo Québec, 2015).

Of the one million Montréal residents who cycle, more than half, or 536,000, travel by bicycle for commuting purposes. Of those, approximately 274,000 travel by bicycle regularly, at least once per week on average (Vélo Québec, 2015). The mode share for cycling on the Island of Montréal was 2.5% in 2013, or 116,000 average daily cycling trips. This cycling activity represents an increase in cycling participation of 57% over five years between 2008 and 2013. In certain central boroughs, the cycling mode share is much higher than the average for the entire Island of Montréal. For example, the Plateau Mont-Royal borough's cycling mode share in 2013 was 10.8% and in Villeray, it was 6.4% (Vélo Québec, 2015). It is also worth noting that bicycle mode share values are under representations of cycling mode share during the cycling season. More share statistics come from the Region of Montréal's Origin-Destination (OD) telephone survey, conducted every five years. The telephone survey runs from September until December, therefore the number of respondents who report cycling decreases throughout the survey period. A McGill study attempted to account for the impact of weather on cycling mode share from OD survey results in the City of Ottawa (Nosal, Miranda-Moreno, & Krstulic, 2014). The study found that had the survey taken place on typical days during the cycling season (defined as running from May 1st to October 31st) then the cycling participation would have been approximately double. When applying the same factor to Montréal, which experiences a similar climate, an estimate of the cycling mode share on the Island of Montréal, throughout the six-month cycling season, is 5%. Central boroughs may have a cycling mode share as high as 20% during the six-month peak cycling season.

Although the Montréal cycling network is large, 748 km in 2015, not all of it provides the same level of safety and comfort to cyclists. Protected on-street cycle tracks represent only 82 km, or about 11% of the network. The entire network consists of the 82 km of on-street protected cycle tracks, 271 km of off-street bike trails, 181 km of designated roadways with with painted bike stencils (sharrows) and 214 km of painted bike lanes. Therefore, more than half of the cycling network simply consists of painted stencils or lines that offer little protection to cyclists.

In 2017, the City of Montréal joined the Vision Zero movement, subscribing to the approach that aims to reduce the number of traffic fatalities to zero. Although the number of traffic fatalities and serious injuries involving a cyclist have decreased by more than 50% in the past decade, the number of cycling deaths in Montréal has consistently remained above 20 per year and the number of serious injuries to cyclists has remained above 200 per year (SAAQ and SPVM). To fulfill its Vision Zero promise, The City of Montréal must dramatically speed up the construction of cycling infrastructure and focus on the implementation of highly secure, protected, year-round cycling infrastructure.

This objective of this report is to outline where cycling infrastructure is most needed in Montréal. The recommendations in this report can help the City of Montréal prioritize the addition of key links to the cycling network. The results from several academic studies focused on the Montréal cycling network are reported on to highlight where cycling facilities are needed based on three criteria:

- Where cyclist travel in the absence of cycling infrastructure (desire lines)
- The intersections where cyclist injuries are occurring at the highest frequency and highest rate
- Segments of cycling network that would extend or attach discontinuous segments

Methods

The methods and data used in this analysis are borrowed from peer-reviewed publications on cycling injury risk and cycling networks with case studies of Montréal. (Strauss, Miranda-Moreno, & Morency, 2015) proposed a methodology to estimate and map bicycle volumes throughout the entire network of intersections on the Island of Montréal. This was achieved by combining smartphone GPS traces (from Mon RésoVélo) and bicycle count data from long-term automatic counting sites and from manual short-term counts. (Strauss, Miranda-Moreno, & Morency, 2015) then mapped the cyclist injury risk using the mean injury frequency at intersections and the estimated bicycle volumes at intersections as a measure of exposure. (Nabavi-Niaki, Saunier, & Miranda-Moreno, 2015) proposed a methodology to identify and quantify discontinuities within a cycling network using geospatial data and a geographic information system. The methods were applied in a case study on the Island of Montréal. (Nabavi-Niaki, Saunier, & Miranda-Moreno, 2015) identified discontinuity indicators in Montréal using ArcGIS. The city's cycling network includes different bicycle facilities such as separated cycle tracks, bicycle lanes and designated pathways. The cycling facility network data was obtained from the city's open data portal on April 23, 2014.

Results

The results section consists of two separate studies, both with case studies of Montréal. The first, estimates cycling activity across the network to help determine high-risk "hotspots". The second, looks at network discontinuities, locations where the bicycle network breaks.

Network Cycling Activity and Injury Hotspots

As discussed in the introduction, cycling activity is highest in the central boroughs of Montréal. The cycling flow heatmap in Figure 1 shows estimated cycling at intersections across the Island of Montréal. The estimates are generated by combining "ground truth" count data from automatic counters with GPS traces of cycle trips from Mon RésoVélo, a smartphone application. The network of segregated cycle tracks in Montréal have the highest cycling flows, including cycle tracks on Boulevard De Maisonneuve, Rue Rachel and Rue Berri.

The most heavily used cycling facilities tend to be where the most collisions involving cyclists occur. Figure 2 illustrates the frequency of reported cyclist collision by intersection from 2010-2014. The 27 intersections with the highest frequency of cyclist collisions are listed in Table 1. Of the 27 top intersections, 16 are located along cycle tracks. These results suggest that more could be done to ensure cyclist safety at the intersections along cycle tracks. Several countermeasures can improve safety including protected phasing at signalized intersections using bike signal heads. Protected phasing reduces the number of conflicts between cyclists and turning vehicles. Although intersections along cycle tracks are high represented in Table 1, it is incorrect to concluded that cycle tracks decrease cyclist safety. A useful measure of safety is the rate of collision, typically measured as the number of reported collisions per million cyclists. By using the cycling flow results (see Figure 1) as a measure of exposure, the collision rate was generated (see Figure 3). Note that none of the collision rate hotspots are in the central boroughs, rather, they are located primarily in the West Island. The 24 intersections with the highest bicycle collision rate are listed in Table 2. Only one of these hotspots is in the City of Montréal. The other 23 intersections are in Dollard-des-Ormeaux, Dorval, Beaconsfield, Pointe-Claire and Kirkland. The City of Montréal must work with these smaller municipalities to improve the regional cycling network.

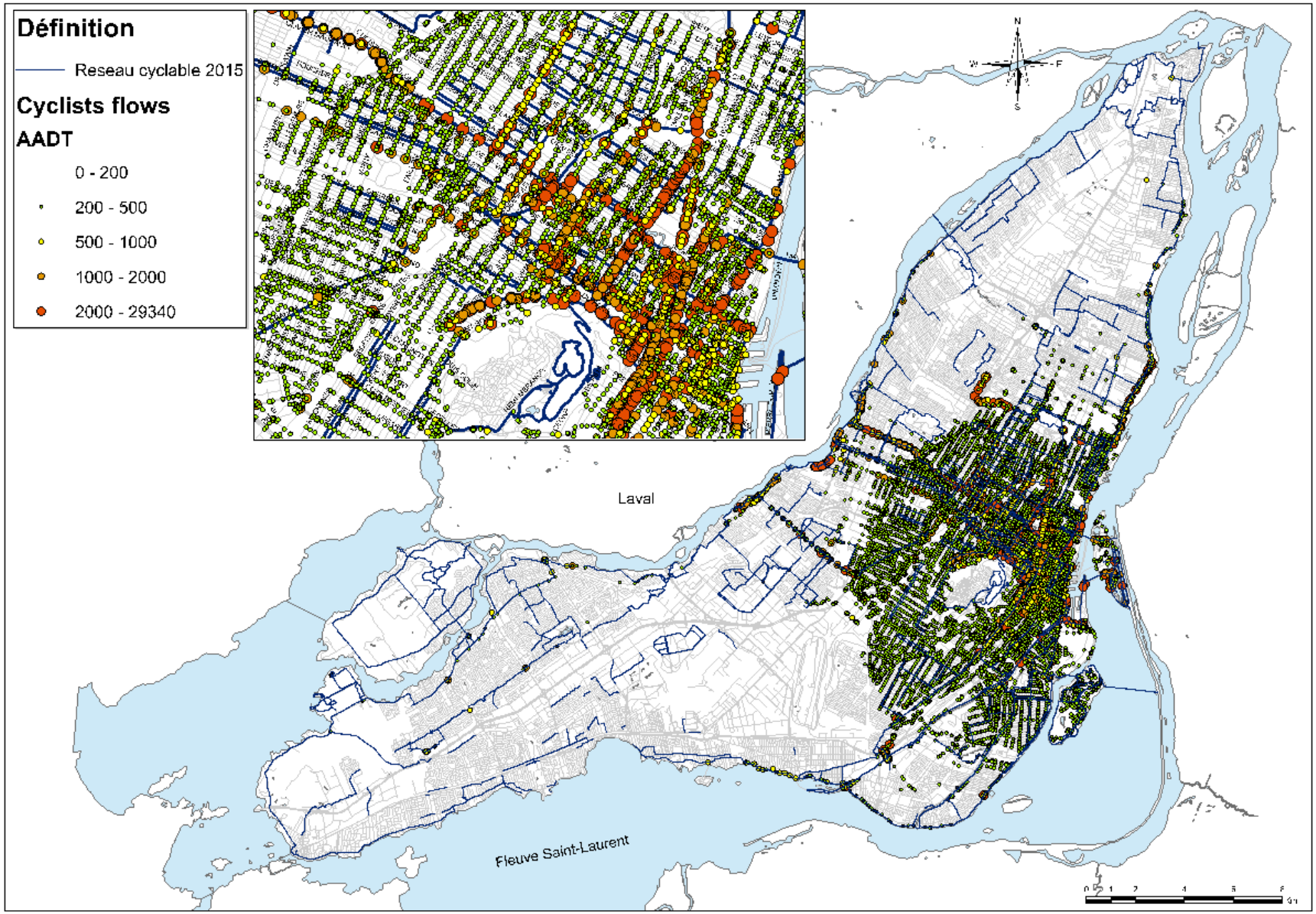

Figure 1: Montréal cycling network (2015) and intersection cycling flow heat map

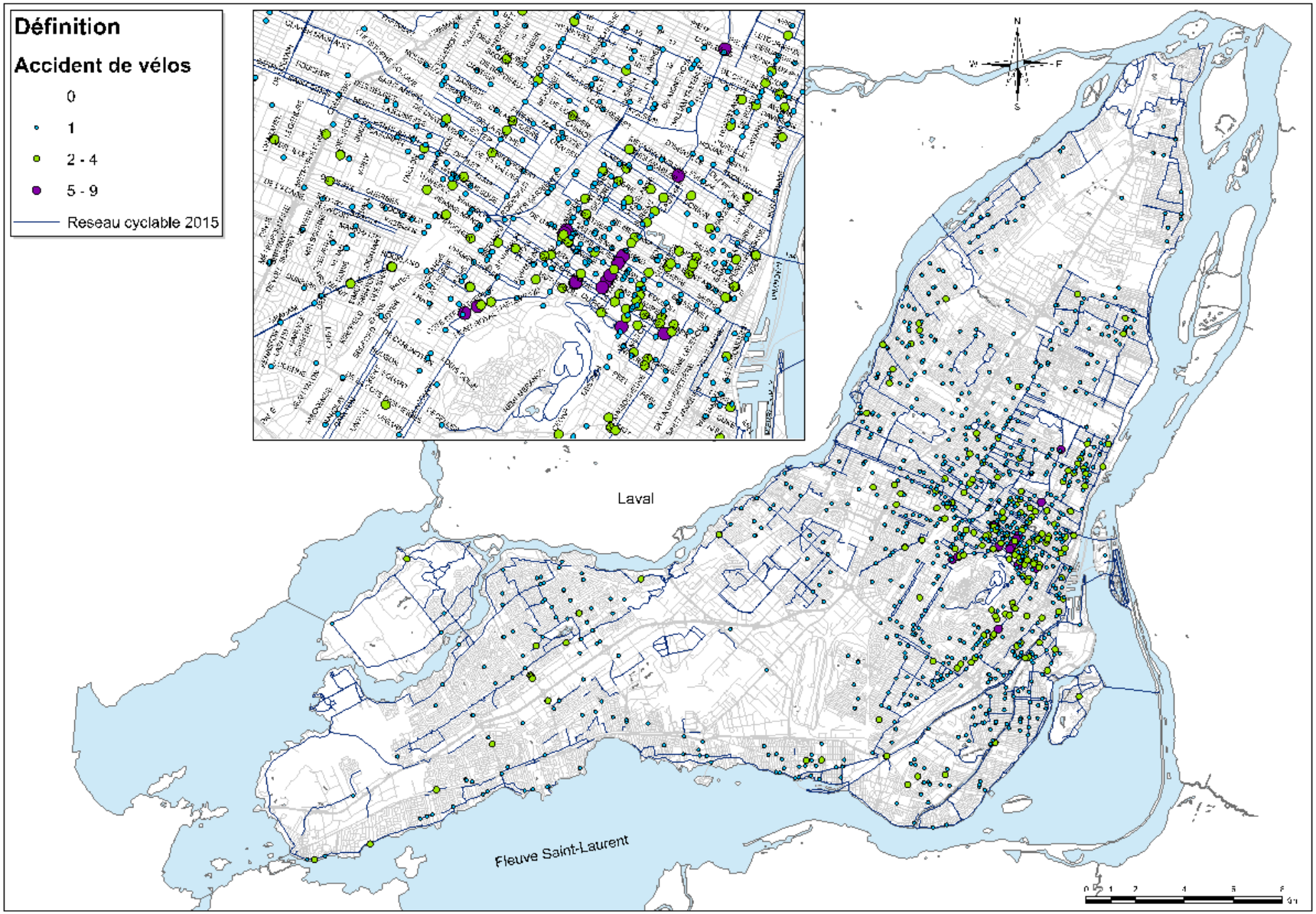

Figure 2: Frequency of reported cyclist collision by intersection from 2010-2014

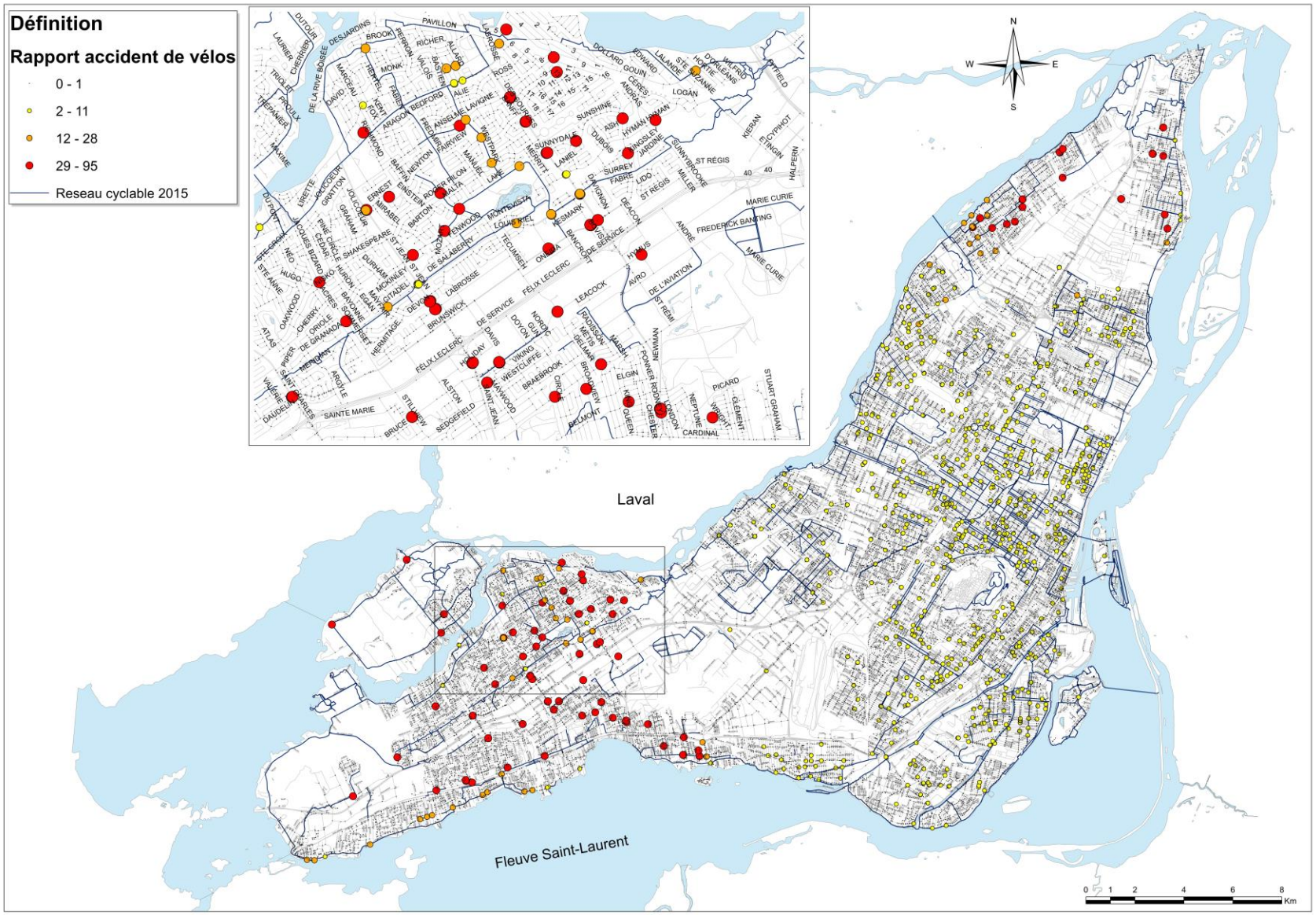

Figure 3: Collision rate involving cyclists, 2010 to 2014 (in collisions per million cycling trips)

Table 1: Rank of intersections with highest reported collision frequency 2010-2014

Rank	NOM VOIE 1	NOM VOIE 2	BOROUGH	Reported Collisions 2010-2014
1	Boulevard De Maisonneuve	Avenue Wood	Westmount	9
2	Rue Drolet	Avenue Laurier	Plateau-Mont-Royal	9
3	Avenue Henri-Julien	Avenue Laurier	Plateau-Mont-Royal	8
4	Rue Rachel	Rue Saint-Dominique	Plateau-Mont-Royal	7
5	Rue Rivard	Rue Rachel	Plateau-Mont-Royal	7
6	Avenue De L' Esplanade	Avenue Du Mont-Royal	Plateau-Mont-Royal	7
7	Avenue Du Parc	Avenue Des Pins	Plateau-Mont-Royal	6
8	Rue Clark	Rue Rachel	Plateau-Mont-Royal	6
9	Rue De Bullion	Rue Rachel	Plateau-Mont-Royal	6
10	Avenue Jeanne-D'Arc	Rue Rachel	Rosemont-La-Petite-Patrie	5
11	Rue Saint-Urbain	Rue Evans	Ville-Marie	5
12	Chemin De La CSC	Avenue Beloeil	Outremont	5
13	Rue Drolet	Rue Rachel	Plateau-Mont-Royal	5
14	Rue Messier	Rue Rachel	Plateau-Mont-Royal	5
15	Avenue Pagnuelo	Chemin De La CSC	Outremont	5
16	Avenue Du Mont-Royal	Avenue De L' Esplanade	Plateau-Mont-Royal	5
17	Rue De La Grande-Allée	Boulevard De L' Île-Des-Soeurs	Verdun	4
18	Rue Garnier	Avenue Du Mont-Royal	Plateau-Mont-Royal	4
19	Rue Saint-Patrick	Rue Island	Sud-Ouest	4
20	Rue Workman	Avenue Atwater	Sud-Ouest	4
21	Rue Mackay	Rue Sherbrooke	Ville-Marie	4
22	Boulevard De Maisonneuve	Avenue Clarke	Westmount	4
23	Avenue Union	Rue Sherbrooke	Ville-Marie	4
24	Rue Sherbrooke	Rue City Councillors	Plateau-Mont-Royal	4
25	Avenue Laurier	Avenue De L' Hôtel-De-Ville	Plateau-Mont-Royal	4
26	Boulevard De Maisonneuve	Avenue Clarke	Westmount	4
27	Rue Ontario	Rue Saint-Dominique	Ville-Marie	4

Table 2: Rank of intersections with highest reported collision rate (collisions per million cyclist trips) 2010-2014

Rank	NOM VOIE_1	NOM VOIE 2	MUNICIPALITY	Reported collisions per million cyclist trips (2010-2014)
1	Rue Churchill	Boulevard Des Sources	Dollard-des-Ormeaux	95
2	Rue Sunnydale	Boulevard Des Sources	Dollard-des-Ormeaux	95
3	Avenue Elm	Rue Alice-Carrière	Beaconsfield	95
4	Route Stillview	Boulevard Hymus	Pointe-Claire	65
5	Boulevard Des Sources	Avenue Chanteclerc	Dorval	65
6	Avenue Delmar	Boulevard Hymus	Pointe-Claire	65
7	Rue Lake	Rue Fenwood	Dollard-des-Ormeaux	63
8	Chemin Du Bord-Du-Lac	Rue Roussin	Montréal	63
9	Avenue Labrosse	Boulevard Saint-Jean	Pointe-Claire	59
10	Boulevard Saint-Jean	Rue Devon	Dollard-des-Ormeaux	59
11	Avenue Labrosse	Boulevard Saint-Jean	Pointe-Claire	55
12	Rue Devon	Boulevard Saint-Jean	Dollard-des-Ormeaux	55
13	Avenue Holiday	Boulevard Saint-Jean	Pointe-Claire	46
14	Avenue Holiday	Boulevard Saint-Jean	Pointe-Claire	46
15	Avenue Dawson	Avenue Claude	Dorval	32
16	Avenue Dawson	Avenue Claude	Dorval	32
17	Boulevard Brunswick	Boulevard Saint-Charles	Kirkland	32
18	Boulevard Saint-Charles	Boulevard Brunswick	Kirkland	32
19	Rue Tecumseh	Rue Lake	Dollard-des-Ormeaux	32
20	Rue Tecumseh	Rue Roger-Pilon	Dollard-des-Ormeaux	32
21	Boulevard Pine Beach	Avenue Carson	Dorval	32
22	Chemin Herron	Avenue Dumont	Dorval	32
23	Boulevard Brunswick	Rue Du Marché	Dollard-des-Ormeaux	32
24	Rue Du Marché	Boulevard Brunswick	Dollard-des-Ormeaux	32

Network Discontinuities

Cycling networks can be characterized by their size and the quality of the facilities. However, another important measure to consider are the number of discontinuities in the network. As of April 2014, the Montréal cycling network was 503 km long (figure does not include designated roadways with sharrows) and had 387 discontinuities, as seen in Figure 3.

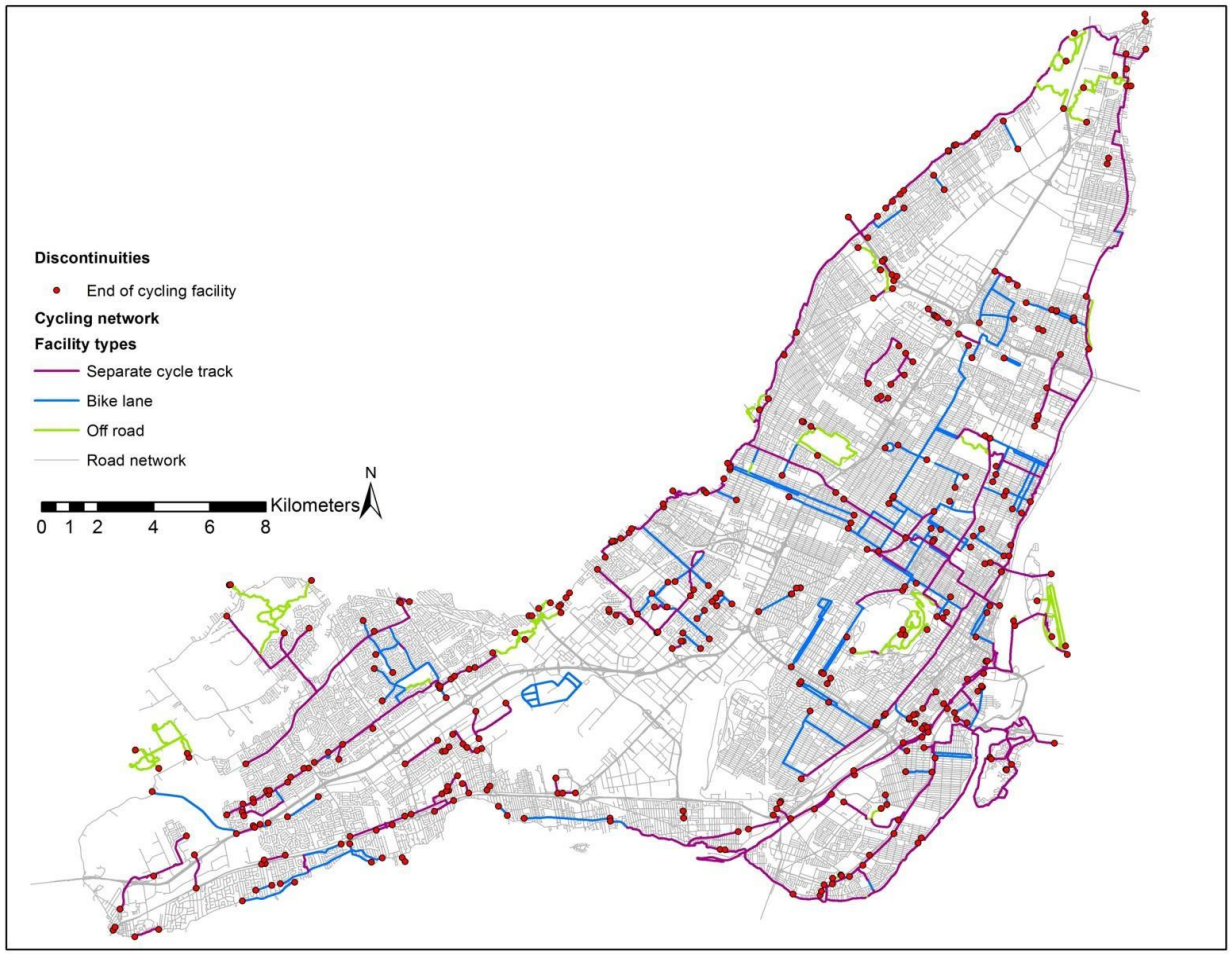

Figure 3: Cycling network discontinuities in Montréal

Table 3a, below summarizes significant quantities associated with the road and bicycle network in the City of Montréal. The table excludes designated roadways, such as roadways with sharrows, (chaussées désignées) from the bicycle facility tally. The bicycle network coverage represents only 8.5% of the road network length. Table 3b, below summarizes the rate of discontinuities on the bicycle network in the City of Montréal. On average, the Montréal cycling network has a discontinuity every 1.3km.

Table 3: Road and Bicycle Network Coverage Measures for Montréal

	(A) Road and Bicycle Network Coverage Measures for Montréal		
	Measure type	**Bicycle Facility Class**	**Measure Value**
City Density	**Surface** *(km^2)*		432
	Population density *(residents per km^2)*		4518
	Road density *(km per km^2)*		**13.6**
	Cycling facility density *(km per km^2)*		1.2
Road and Bicycle Network Summary	**Road network length** *(km)*		5861
	Bicycle facility network length *(km)*		503
	Cycling network coverage		8.5%
	Proportion of each type of bike facility in the cycling network	*Separated bike path*	**64%**
		Bike lane	20%
		Off road bike class	16%

	(B) Bicycle Network Discontinuity Indicators for Montréal		
	Measure type	**Bicycle Facility Class**	**Measure Value**
Discontinuity Measures	**End of bike facility** *(per km cycle length)*	*Separated bike path*	0.5
		Bike lane	0.3
		Off road bike class	0.1
		All end points	0.9
	Change in bike facility type *(per km cycle length)*		0.4
Total discontinuity level			1.3

The discontinuities identified by (Nabavi-Niaki, Saunier, & Miranda-Moreno, 2015)represent some opportunities for the City of Montréal to add network connectivity and continuity to improve the cycling network. The programmation 2017-2018 of the Reseau cyclables Montréal (see Figure 4 below) identifies 58 additional segments and nine upgrades to the Montréal cycling network. Of the 58-additional segment, 47 address discontinuities identified by (Nabavi-Niaki, Saunier, & Miranda-Moreno, 2015). The work done by the City of Montréal in adding these 58 segments in 2017-2018 will have a positive impact on network connectivity and allow many more cycling trips to take place on cycling facilities without interruption.

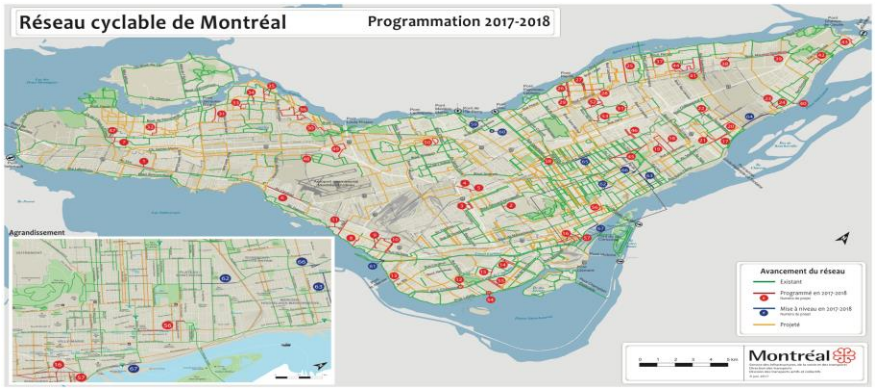

Figure 4: Programmation 2017-2018 : Réseau cyclable de Montréal (Source, Ville de Montréal)

Recommendations for Montréal's Cycling Network

Although the 2017-2018 cycling network improvement program will improve connectivity in several boroughs across the City of Montréal, the growth in the network remains insufficient. The City of Montréal must commit more resources and more road space to the cycling network grow it at a faster pace. In terms of length, the bicycle network covers only 8.5% of the entire road network length. Furthermore, many of the most important arterials on the Island have no cycling infrastructure. Major arterials have high cycling flows for the same reason they have high vehicle flows: they provide direct routes across the Island of Montréal and numerous destinations (employment, institutions, shopping, etc..). Safe and direct cycling routes along arterials are needed. Both north-south and east-west connections need to be enhanced.

A total of 12 north-south connections are proposed totaling 61 km of cycling facilities (See Table 4) and 12 east-west connections are proposed totaling 114 km of cycling facilities (See Table 5). These facilities have been chosen because they represent strategic and direct north-south and east-west connections. Many of these arterials represent strong desire lines, roads with large flows of cyclists despite no cycling infrastructure. For example, intersections along Boulevard Saint-Laurent, have average daily cycling tips ranging between 1000 and 6000. Most of the proposed connections have average flows of at least 1000 cycle trips per day at major intersections. Several of these proposed connections, such as Boulevard Cavendish Rue Industriel and Boulevard Henri-Bourassa, have a relatively low cycling flow, however, the areas near these roads are severely underserved and in needed of increased access to the cycling network. Several of the proposed facilities are on roads that are listed as intersections with the most cyclist collisions over the five-year period from 2010 and 2014. These include Avenue Atwater, Rue Ontario, Rue Sherbrooke, and Avenue des Pins. Several of the proposed connections would extend or connect existing bikeways. For example, the proposed extension of Chemin de la Côte-Saint-Catherine, a relatively short extension, would effectively connect the cycle track along Avenue du Parc with the existing cycle track along Chemin de la Côte-Saint-Catherine.

The City of Montréal has proposed spending $30M per year for the next three years to add 50km of cycling facilities per year. It is recommended that the City takes a more aggressive approach and plans for 100km of new cycling facilities per year. Thus, the proposed 24 connections, totaling 175 km, could be completed in two years (starting in 2018-2019), with an additional 25km for other segments deemed a priority.

Table 4: Proposed north-south cycling connections

Street	Range of Estimated Flows	From – To (Cross-Streets)	Length	Type of Infrastructure
Boulevard Cavendish	200 – 300	Boulevard De Maisonneuve O to Boulevard Thimens	9.5 km	Segregated and parking protected
Victoria	200 – 1800	Rue Saint-Catherine to Rue Jean Talon O	4.9 km	Mix of Segregated and painted lanes
Avenue Atwater	700 – 3500	Lachine Canal to Avenue du Docteur-Penfield	3.6 km	Segregated
Rue Guy / Chemin Côte des Neiges	300 – 1000	Rue William to Rue Jean-Talon O	6.7 km	Segregated and parking protected
Chemin de la Côte-Saint-Catherine / Mount-Royal	1000 – 2200	Rue Villeneuve to Avenue du Parc	1.1 km	Segregated
Rue Peel	500 – 2500	Rue de la Commune O to Avenue des Pins	2.6 km	Segregated
Rue Jeanne-Mance	500 – 1500	Avenue Viger to Avenue des Pins	1.6 km	Mix of Segregated and painted lanes
Rue Saint-Laurent	1000 - 6000	Avenue Viger to Boulevard Henri-Bourassa	11 km	Segregated and parking protected
Rue Saint-Denis	800 - 3500	Boulevard René-Lévesque E to Rue Beaubien E	5 km	Segregated
Rue Champlain/ Avenue Émile-Duployé	300 - 1200	Boulevard René-Lévesque E to Rue Rachel E	1.8 km	Mix of Segregated and painted lanes
Angus Yards Rail Line	N.A.	Rue Ontario E to Rue Masson	3 km	Off-Street Path
Boulevard Pie IX	200 - 700	Rue Notre-Dame E to Boulevard Henri-Bourassa E	10.2 km	Segregated

Table 5: Proposed east-west cycling connections

Street	Range of Estimated Flows	From – To (Cross-Streets)	Length	Type of Infrastructure
Rue Saint-Jacques	400 - 1700	Rue de Courcelle to Boulevard Saint-Laurent	4.7 km	Segregated and parking protected
Rue Saint-Antoine	300 - 1200	Rue de Courcelle to Rue Berri	5.5 km	Segregated and parking protected
Boulevard René-Lévesque	1000 - 1600	Avenue Atwater to Rue Berri	3.5 km	Segregated
Rue Ontario	1000 - 2400	Rue Saint-Urbain to Rue Viau	6 km	Mix of Segregated and painted lanes
Rue Sherbrooke and Rue Notre-Dame (Repentingny)	500 - 3400	Avenue Westminster (Sherbrooke) to Boulevard Notre Dame-des Champs (Repentigny)	34 km	Mix of Segregated and painted lanes
Avenue des Pins	500 - 1700	Chemin de la Côte Des Neiges to Rue Saint-Denis	2.9 km	Segregated and parking protected
Boulevard Saint Joseph	600 - 2200	Chemin de la Côte-Saint-Catherine to Boulevard Pix-IX	5.3 km	Segregated
Rue Jean-Talon	300 - 1600	Boulevard Decarie to Boulevard des Galeries-d'Anjou	14 km	Segregated and parking protected
Boulevard Hymous	0 - 100	Boulevard Saint-Charles to Boulevard Alfred Nobel	8.6 km	Segregated
Rue Sauve	300 - 800	Boulevard de l'Acadie to Boulevard Saint-Michel	5.1 km	Segregated and parking protected
Rue Industriel	0 - 100	Boulevard Saint-Michel to Boulevard Lacordaire	3.4 km	Painted Lanes
Boulevard Henri-Bourassa	0 - 100	Boulevard de l'Acadie to Rue Sherbrooke	21 km	Segregated

Estimating Costs

The costs per kilometer of bike facilities depends on many factors and ranges enormously, especially where separated facilities are concerned. Factors that can impact the cost include: whether the facility is being implemented as a retrofit to an existing street; if the street is being reconstructed with raised bicycle lanes, which entails moving curbs and sewers and modifying roadway and sidewalk drainage profiles.

However, one thing is for certain, segregated cycle tracks (Figure 5, middle) are an order of magnitude more expensive than parking protected facilities (Figure 5, left) or bollard delineated facilities. Costs of segregated cycle tracks typically range between $500,000 and $2,000,000 per kilometer, whereas the combined cost of bollards, signage and street markings typically costs roughly $30,000 per kilometer. The importance of creating a large, safe and connected cycling network merits a significant proportion of the City's transportation budget. However, if the cost of adding roughly 100 km of cycle track per year to the cycling network is cost prohibitive, then some of the additional segments can be completed with a lower budget by implementing parking protected or bollard delineated facilities. These facilities could eventually be made more permanent with concrete and planters. From the safety perspective, it may be more effective to spend limited budgets on improving intersections with the use of bicycle signal heads (see Figure 5, right) and fully-protected phasing; since most collisions involving cyclists occur at intersections.

Figure 5: left, parking protected cycling facility (Clark); middle, cycle track at underpass (Saint-Laurent); right, bicycle signal head (Saint-Laurent)

Conclusions

Most cyclists prefer traveling on dedicated bike facilities. The quality of a cycling network is typically measured by the length and coverage of its road network, but also its connectedness; discontinuities are barriers for cyclist. It is important to address discontinuities to improve cycling facilities and to increase the number of cyclists in the city. The City of Montréal has taken steps towards addressing discontinuities. The Programmation 2017-2018 réseau cyclables Montréal, includes 58 additional segments of cycling facilities, of which 47 address discontinuities identified by (Nabavi-Niaki, Saunier, & Miranda-Moreno, 2015). Although the 50 km of additional cycling segments proposed by the City of Montréal in 2017-2018 will improve the network, it is not sufficient. Many of Montréal's most important arterials have no cycling infrastructure. Despite the lack of infrastructure, thousands of daily bike trips take place on these major roads, making these roads clear desire lines. The City has promised to make cycling safer and more popular in its cycling plan: Montréal, ville cyclables Plan-cadre vélo: sécurité, efficience, audace. The objectives stated in this document are only achievable through bold action – the cyclists of Montréal, representing more than half of the population, deserve a safe and connected network across the Island of Montréal.

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