Executive Summary

This report addresses intersection and lane design for bicycle facilities. Seven intersections in the City of Groningen, Netherlands, are analyzed for the quality of their bicycle facilities. Based on these examples, the redesign of two intersections in Richmond, B.C., is recommended.

Groningen and Richmond were chosen as case studies because they are comparable in size, topography and weather. Both cities have a network of on-street bicycle facilities. Richmond's bicycle lanes end before reaching an intersection, while Groningen provides advanced intersection facilities for cyclists.

The comparison between a European city and a Canadian city can be difficult and results limited, since many factors, such as legal requirements and technical standards are different. However, a comparison is useful to illustrate possible "best practice" design solutions that can be adapted to fit local conditions.

Lane Design

Both cases, Richmond and Groningen, have a network of bikeways. All of Richmond's on-street bikeways are bicycle lanes. A list of design criteria is used in this report to evaluate the lane design of the two cities. The criteria are derived from numerous Canadian and Dutch sources. Many of the criteria are qualitative, not quantitative in

nature, and their evaluation is based on the author's subjective judgement. The criteria for lane design are the following:

Coherence of quality
Directness – as little delay as possible
Visibility – the lane should be well visible
Safety --
- bicycle traffic and pedestrian traffic should be separated
- bicycles should be travelling in the same direction as other users
- space for passing and evasive manoeuvres should be provided

Comfort -- inclines should be limited
Maintenance – bicycle lanes should be easily maintained

Most of Groningen's bicycle lanes meet the criteria of coherence and directness. The lanes are quite visible due to red pavement. To meet the criterion of safety, there are no mixed –use paths and few two-way paths. The majority of lanes meet the minimum width requirements, although some situations require lanes that are slightly narrower. Since Groningen is mainly flat, there are few inclines that inhibit the comfort of biking. Maintenance is sometimes made difficult due to small physical separations.

Richmond's bicycle lanes also meet many of the bicycle lane criteria used in this report. The lanes are coherent throughout their lengths, but are interrupted at intersections. They are relatively visible, although it can be difficult to see the white lane demarcations and pavement markers in the rain. There are no mixed-use paths or two-way paths in the city. The lanes are wide, often exceeding the minimum required widths by far. Riding is comfortable due to Richmond's flat topography, and lanes can be easily maintained.

Intersection Design

Intersection design evaluation criteria were applied to seven intersections in Groningen:

Coherence of quality
Directness – the loss of time through waiting should be minimized
Safety – the following needs to be considered
- speed differences, anticipation time, and volumes of motorized and bicycle traffic

- provision of space for encountering, passing and deviation manoeuvres

Comfort – chances of stopping should be minimized

Seven intersections in Groningen were chosen as demonstration cases:

1. Dampsterdiep/ Petrus Campersingel (Major arterial/ collector; Four-Way Green for cyclists)
2. Hoornsediep/ Parkweg (Collectors; Streaming lane and EBSL with weaving)
3. Gedempte Zuiderdiep/ Stationsstraat (Boulevard design and bus lane – uncontrolled)
4. Luebeckweg/ Europaweg (Controlled crossing of a four-lane highway)
5. Pleiadenlaan (Uncontrolled crossing of path over collector road)
6. Bakboordswal/ Loefzijde (Roundabout)
7. Bakboordswal/ Lijzijde (Uncontrolled intersection of local road and collector with bicycle lane)

The following table shows the evaluation of these intersections:

Criteria	1	2	3	4	5	6	7
Coherence							
continuous level of quality	●	◐	●	●	●	●	●
Directness							
little delay	◐	●	◐	●	○	●	●
Safety							
minimize chance of conflict through:							
speed difference among various users	●	◐	◐	●	●	●	◐
anticipation time	●	●	●	●	●	●	●
volume of traffic	◐	◐	●	●	◐	●	◐
space for encountering and deviation	◐	◐	◐	●	◐	◐	◐
Comfort							
minimize chance of stopping	◐	◐	◐	●	○	◐	○
lane width, streaming space and exit geared toward minimum traffic hindrance	●	◐	●	●	◐	◐	◐

○ does not meet the criterion
◐ meets the criterion partially
● fully meets the criterion

The Groningen intersections generally meet the best practice criteria for intersection design. Except for one intersection, the level of quality of the bicycle facility is continued across the intersection. All intersections fully or partially meet the design criteria for safety. Some intersections, such as intersection 5, compromise directness for safety, i.e., they are very safe, but are delaying the cyclist.

Two intersections in Richmond were selected for analysis. The intersection Garden City Rd./ Alderbridge Way was selected because it is a very busy intersection close to the downtown area. It currently has bicycle lanes running north and south on Garden City Rd., and the construction of bicycle lanes on Alderbridge Way is planned for the future. Design solution 2 from Groningen – a Four-Way Green for cyclists – is recommended for this intersection. This design accommodates bicycle traffic coming from four directions and has the potential to handle future higher volumes of bicycle traffic. The second intersection at Williams Road and No. 1 Road is an intersection with lower traffic volumes. There are bicycle lanes on Williams Rd., and none are planned for No. 1 Rd. in the near future. The proposed design features for this intersection are Extended Bicycle Streaming Lanes (EBSLs) with weaving on Williams Rd. (used for Intersection 1 in Groningen). This design is appropriate for a less busy intersection with facilities on one road only.

The following table summarizes how the existing intersections and their new designs meet the above listed design criteria:

1a: Intersection Garden City Rd. / Alderbridge Way: Existing Design
1b: Intersection Garden City Rd. / Alderbridge Way: Proposed Four-Way Green Phase
2a: Intersection Williams Rd. / No. 1 Rd.: Existing Design
2b: Intersection Williams Rd. / No. 1 Rd.: Proposed EBSL and Streaming Lane

Criteria	1a	1b	2a	2b
Coherence				
continuous level of quality	○	●	○	◐
Directness				
little delay	◐	◐	◐	●
Safety				
minimize chance of conflict through:				
speed difference among various users	○	●	○	◐
anticipation time	○	●	○	●
volume of traffic	○	●	◐	●
space for encountering and deviation	◐	◐	◐	●
Comfort				
minimize chance of stopping	◐	◐	◐	◐
lane width, streaming space and exit geared toward minimum traffic hindrance	◐	●	◐	●

○ does not meet the criterion
◐ meets the criterion partially
● fully meets the criterion

The redesigned intersections show substantial improvement on most evaluation criteria. The following two fold out illustrations demonstrate the existing and the new designs.

The redesigned intersections illustrate how best practice design solutions from a different setting can be modified to fit a local situation. However, there are various obstacles to the realization of the proposed design solutions. Besides requiring financial means, the designs have to be checked for compliance with Richmond's legal requirements and standards. However, even if the immediate redesign of these intersections is not feasible, a number of recommendations can be made to the City of Richmond to improve intersections in the long run:

1) The City of Richmond should examine existing municipal, provincial and federal standards and legal requirements to determine which design features can be implemented within the existing framework.
2) If the standards and requirements do not accommodate the bicycle as a viable mode of transportation, the City should change its standards and lobby for change at other levels of government.
3) To learn more about other cities' standards, Richmond should initiate technical staff exchanges with cities that have been successful in accommodating the bicycle, such as Groningen. Richmond staff, as well as regional or provincial staff could assemble best practice guidelines from leading cycling cities and test them for B.C. adoption. The Province or Region could finance test sites to evaluate different design solutions.
4) Where budgets allow, Richmond should consider advanced design solutions that are used in other cities. Adapt advanced solutions to local needs, i.e. to local legal requirements and technical standards for lane widths, traffic signal phasing, etc.
5) Whenever an intersection is redesigned, attempt to accommodate cyclists as much as possible. Little change that makes cycling safer or more convenient is better than no change at all.
6) Continue to promote and develop other crucial components of cycling, such as end-of-trip facilities and bike-and-ride options.

By improving bicycle facilities in intersections in the long run, cycling will have a better chance to become a viable mode of transportation. The safer and more convenient cycling is made for as many people as possible, the more it will establish itself as a mode of transportation in its own right, with appropriate legal status, technical standards and adequate funding.