CONTENTS

1. INTRODUCTION

This report describes a recommended approach to improving bicycle facilities along University Boulevard, between Blanca Street and Wesbrook Mall.

The need for improvements has been identified for many years, through input from cyclists, pedestrians and motorists. The intent of this report is to review options for improving bicycle facilities and identify the preferred option, provide information regarding specific design issues, and identify any potential impacts associated with the preferred option for improving bicycle facilities on University Boulevard.

1.1 Transportation Objectives

Improving bicycle facilities is consistent with regional and municipal goals and objectives for transportation, as summarized below. Improved bicycle facilities are a key means of increasing the cycling mode share, and thereby reducing traffic growth, air pollution and safety concerns.

- UBC's goals and objectives for transportation, as identified in the Official Community Plan (approved July 1997), includes the statement that UBC will "promote... the use of alternatives other than the single occupant vehicle," through various initiatives, including improvements to bicycle routes and facilities.

- The City of Vancouver's Transportation Plan (approved May, 1997) states that "the growth in demand for transportation... will be accommodated by improving alternatives to the car, [including] cycling." For trips to and from UBC, the Transportation Plan identifies a target 28% increase in cycling and walking trips.

- The Greater Vancouver Regional District prepared a regional planning blueprint entitled "Creating Our Future," which recommended favouring cycling over automobiles in determining transportation priorities, and which established a target of doubling the number of

bicycle commuters in the period from 1991 to 1995.

1.2 Existing Conditions

University Boulevard is currently a divided four-lane road, with extremely narrow travel lanes — 2.78m wide as compared with a typical width of 3.65m. As a result of the narrow lane widths, cyclists have been restricted from travelling on University Boulevard, and instead are required to use a parallel off-street pathway on the south side of University Boulevard.

This pathway is inadequate for two-way bicycle travel, as well as for mixed bicycle/pedestrian use. Specifically:

- The pathway is narrow, varying in width from 1.9m east of St. Anselms Anglican Church, to 3.0m west of the church. The minimum recommended width for a multi-use pathway with high numbers of cyclists is 4.0m. The existing pathway does not meet this standard.

- The pathway surface is uneven and is in poor repair for much of its length, particularly east of the church. This creates potential for cyclists to lose control and fall, or hit other cyclists.

- The pathway is poorly-illuminated, making it difficult for cyclists to see hazards on the pavement at night.

- Trees are located immediately adjacent to the pathway, rather than the required minimum of 0.6m away from the pathway, and as a result create a hazard for cyclists riding close to the edge of the pathway.

- The bus stop at St. Anselms church is well-used, particularly by students at University Hill Secondary and persons travelling to and from the golf club. Transit passengers must walk across the pathway, creating potential conflicts with cyclists.

- Despite signs advising pedestrians to use the pathway on the north side of University Boulevard, pedestrians often use the south pathway, creating additional potential for conflicts.

- Access to and egress from the pathway at Blanca Street encourages

cyclists to travel in a manner contrary to the Motor Vehicle Act and safe cycling practices. Cyclists travel through the Blanca/University Boulevard/10th Avenue intersection against red signals, in the crosswalk, and opposing traffic on the wrong side of the road.

The existing condition of the pathway creates a liability risk for the agency or agencies responsible for the pathway. If a cyclist were to be injured in an accident or collision on the pathway, they could legitimately seek compensation on the basis that the facility they are required to use is substandard. The cost of such compensation could likely exceed the cost of improving bicycle facilities along University Boulevard.

2. OPTIONS

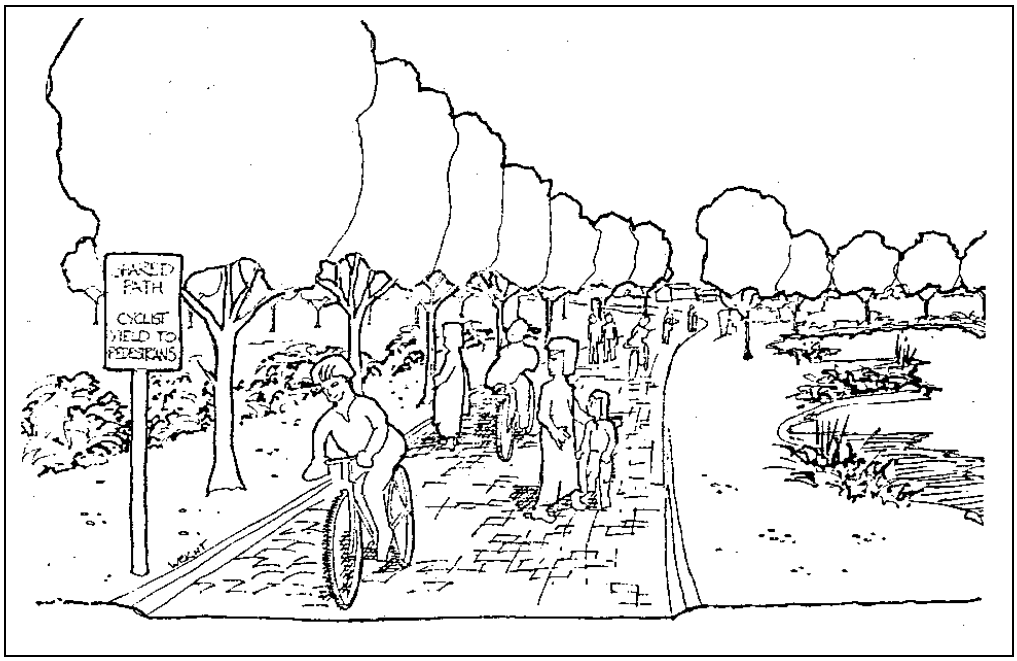
This section describes three options for improving bicycle facilities along University Boulevard — a separated pathway as at present, wide curb lanes on the roadway, and bicycle lanes on the roadway. The requirements presented for each option are consistent with current bicycle design guidelines, including those described in the following publications:

- *Interim Cycling Policy,* Ministry of Transportation and Highways, Victoria, BC, 1992.
- *Urban Supplement to the Geometric Design Guide for Canadian Roads,* Transportation Association of Canada, Ottawa, ON, 1995.
- *Community Cycling Manual,* Canadian Institute of Planners, Ottawa, ON, 1990.
- *Guide for the Development of Bicycle Facilities,* American Association of State Highway and Transportation Officials, Washington, DC, 1992.
- *Oregon Bicycle and Pedestrian Plan,* Oregon Department of Transportation, Salem, OR, 1995.

2.1 Off-Street Pathway

An off-street pathway is illustrated in Figure 1. Off-street pathways can be located parallel to a roadway, as on University Boulevard, Chancellor Boulevard and 16th Avenue, or can be located in open space away from roadways. Off-street pathways can be paved or unpaved, but are generally paved where it is desirable to accommodate cyclists, as cyclists on bicycles with narrow tires are not able to ride on many unpaved surfaces.

Figure 1
Off-Street Pathway



It is an important principle of bicycle design that off-street pathways be designed as multi-use facilities. It is not possible to restrict use of a pathway to cyclists or pedestrians only, as experience on University Boulevard, on the Vancouver Seawall and throughout North America has shown. In order to minimize the potential for conflicts, off-street pathways should be designed to accommodate all users — cyclists, pedestrians, in-line skaters, wheelchair users, runners and others.

Off-street pathways are often considered safer than on-street facilities because of the perception that cyclists are protected from automobile traffic. Although this is the case along much of the length of the pathway along University Boulevard, cyclists must still interact with motor vehicles at the Blanca and Toronto intersections, as well as at the St. Anselms Church driveway. Cyclists must also interact with pedestrians walking to and from bus stops, plus the occasional pedestrian walking along the pathway. And cyclists must also interact with other cyclists, particularly those travelling in the opposite direction.

The most comprehensive documentation of bicycle accident data is *Bicycle*

Transportation, 2nd Edition, by John Forester (MIT Press, Cambridge, MA, 1994). Several studies referenced in this document show that conflicts and accidents are actually higher on an off-street pathway than on a roadway. Most notable are findings that cycling accident rates on off-street pathways are 300% higher than the average accident rate for commuter cyclists, and that bicycle-automobile collision rates are 54% higher with a parallel off-street pathway than without.

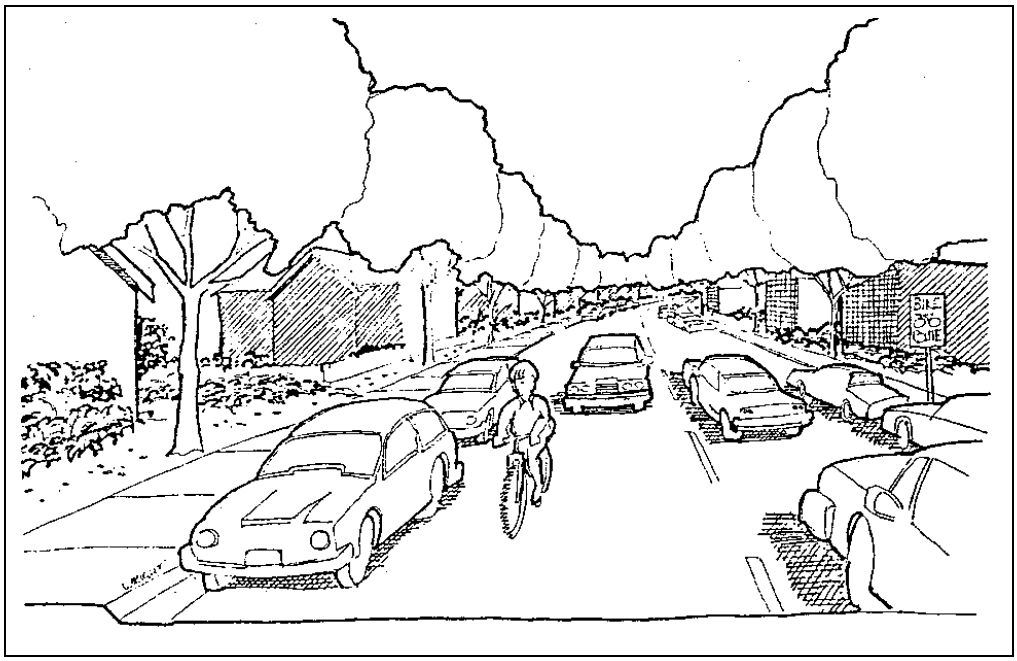
Guidelines for pathways indicate that the minimum required width is 4.0m. In addition, horizontal clearance of at least 0.6m must be provided on either side of the pathway, for a total clear width of 5.2m Upgrading the existing pathways on University Boulevard to this minimum width would require extensive reconstruction, and would require removal of many trees.

Another key consideration in designing off-street pathways is design speed. For pathways which are level or have moderate grades, such as on University Boulevard, a design speed of 35 km/h is appropriate. This design speed dictates the horizontal and vertical alignment of the pathway, and — of particular importance on University Boulevard — minimum sight distances. In order to meet sight distance requirements, some trees would have to be removed in the vicinity of horizontal curves and driveways.

2.2 Wide Curb Lanes

Wide curb lanes are illustrated in Figure 2. A wide curb lane is a wider-than-usual travel lane, which provides sufficient width for cyclists and motorists to travel within the same lane, and for motorists to overtake cyclists without having to cross into the adjacent travel lane.

Figure 2
Wide Curb Lanes



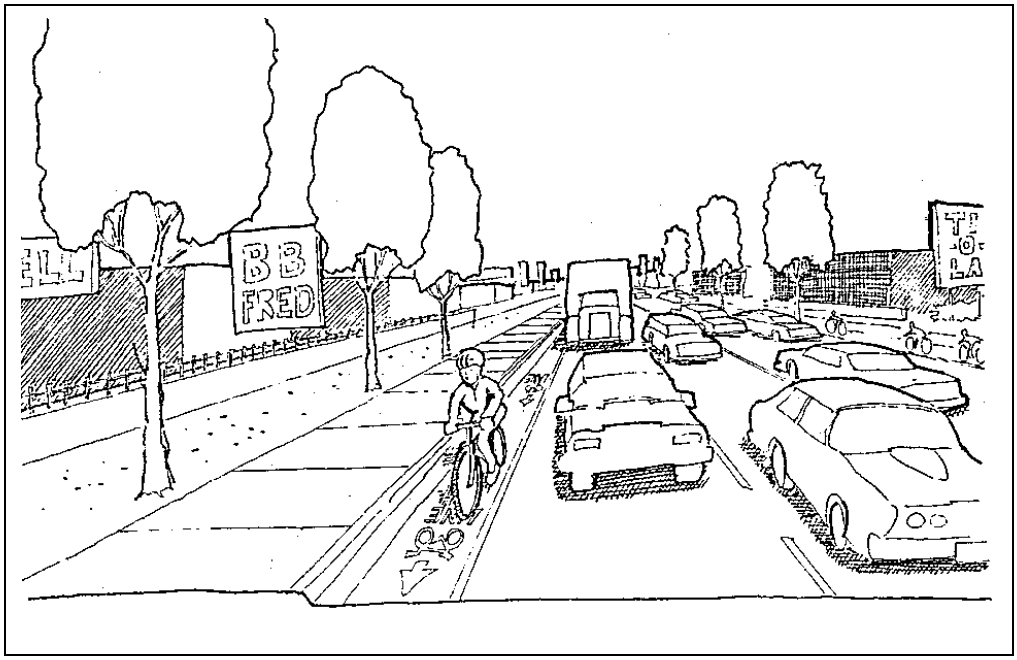
Guidelines for wide curb lanes indicate an optimum width of 4.3m, and a maximum width of 4.5m (excluding the width of the gutter pan). Lanes wider than 4.5m are not advisable, as they permit motor vehicles to travel side-by-side, and enable motorists to pass on the right.

Implementing wide curb lanes on University Boulevard would require substantial changes to the roadway, as the existing pavement width of 5.55m is too narrow for one wide curb lane plus one standard-width travel lane, and is too wide for a single wide curb lane. As it is unlikely that there would be support for widening the pavement on University Boulevard, the only feasible approach would be to narrow the pavement by 0.65m, and construct a full curb and gutter on the righthand side of the roadway.

2.3 Bicycle Lanes

As illustrated in Figure 3, a bicycle lane is a separate travel lane on the roadway for cyclists, identified with a solid white line. The white line is dashed at intersections and at bus stops to indicate where motor vehicles may cross the line to turn or to pull into and out of a bus stop.

Figure 3
Bicycle Lanes



Bicycle lanes are attractive to many cyclists because they provide a greater sense of security, although it is important to note that there is no evidence that bicycle lanes are safer than wide curb lanes. Bicycle lanes are also attractive because they provide a constant reminder to motorists of the presence of bicycles on the roadway.

Generally, bicycle lanes are appropriate on roadways with the following characteristics:

- Relatively high traffic volumes
- Few intersections and few turning vehicles
- No on-street parking
- Infrequent bus stops

University Boulevard meets three of these four conditions. The only feature potentially inconsistent with bicycle lanes is the bus stops, particularly the high-use ones at Blanca and the golf club (westbound) and at St. Anselms Church (eastbound). However, experience throughout North America has shown that with proper design, bus stops can be accommodated along roadways with bicycle lanes, with minimal conflicts between buses and cyclists.

Bicycle lanes are a minimum of 1.5m in width, excluding the width of the gutter pan, and for higher-use locations, may be as much as 1.8m in width. The width of the pavement on University Boulevard would permit bicycle lanes to be implemented relatively easily, by converting the roadway to one standard-width travel lane and one bicycle lane, without a need for road widening or narrowing.

If bicycle lanes were implemented on University Boulevard, pedestrians would be permitted to use both the south and north pathways along University Boulevard. It is recommended that cyclists not be prohibited from using these pathways, but that they not be directed to the pathways, either. This would permit children and other novice cyclists to use the pathways if necessary. It is expected, however, that almost all cyclists — particularly during peak commuting times — would use bicycle lanes on the roadway.

2.4 Preferred Option

Table 1 provides a comparison of the three options for improving bicycle facilities on University Boulevard, with respect to several important criteria. On the basis of this comparison, the preferred option for accommodating cyclists would be to reconfigure the roadway to incorporate bicycle lanes, for the reasons discussed below.

Table 1
Comparison of Options to Improve Bicycle Facilities

Criteria	Option		
	Off-Street Pathway	**Wide Curb Lanes**	**Bicycle Lanes**
Safety	_	_	_
Impacts	●	_	_
Cost	**$$$**	**$$$**	**$**
Short-Term Feasibility	_	●	_
Overall	●	_	_

_ = Positive _ = Neutral ● = Negative
$** = Low Cost **$$** = Moderate Cost **$$$ = High Cost

- **Safety** for cyclists would not be substantially improved by maintaining an off-street pathway, due to the potential for conflicts with motor vehicles at intersections and driveways, and the potential for conflicts with other pathway users. Wide curb lanes and bicycle lanes would improve safety for cyclists (and pedestrians) by minimizing potential conflicts.

- **Impacts** associated with an improved off-street pathway include tree removal and intersection modifications at Blanca Street to permit westbound cyclists to safely access the pathway. No significant impacts would be associated with wide curb lanes and bicycle lanes, despite reducing the number of vehicle lanes on University Boulevard to one in each direction. Traffic operations are described in detail in Section 3.3.

- **Costs** of improving the existing off-street pathway would be high due to the extensive regrading and tree removal required, as well as the cost of pathway construction. Typical construction costs for a 4.0m pathway range from $150,000/km to $300,000/km, which would mean total costs of up to $600,000.

Costs of implementing wide curb lanes would be high due to the need to narrow the roadway. Typical construction costs for such work range from $75,000/km to $100,000/km per direction, which would mean total costs of up to $500,000.

Costs of implementing bicycle lanes would be low. The only significant costs would be repainting pavement markings and reconstructing curbs at bus stops. As described in Section 4, it is estimated that total costs of implementing bicycle lanes would be $150,000.

- **Short-term feasibility** of wide curb lanes and an improved separated pathway are poor, as design issues and funding availability would make implementation in the short-term difficult. On the other hand, bicycle lanes could be implemented relatively easily, as there are few issues to be resolved and funding needs are lower.

3. DESIGN ISSUES

As described in Section 2, the recommended means of safely accommodating cyclists, pedestrians, transit buses and automobiles on University Boulevard is to reconfigure the roadway to one motor vehicle lane and one bicycle lane in each direction. Specific design features of the bicycle lanes are described in this section.

3.1 Lane Widths

As noted in Section 2, widths for bicycle lanes range from 1.5m to 1.8m, excluding the width of the gutter pan. On University Boulevard, it is recommended that bicycle lanes by constructed to a width of 1.9m, for the following reasons:

- The typical 1.5m width is *exclusive* of the width of the gutter pan, which is 30 cm to 40 cm wide. Consequently, the total width of a typical bicycle lane — from curb face to white line — is 1.8m to 1.9m. There is no gutter pan on University Boulevard. For this reason, a width of 1.9m would provide as much width from curb face to white line.

- A 1.9m wide bicycle lane provides sufficient width for a fast-moving cyclist to pass a slow-moving cyclist within the bicycle lane. In counts undertaken in November, 1997, a maximum peak hour, peak direction volume of 91 cyclists was observed on University Boulevard. During warmer months, the number of cyclists using the University Boulevard pathway is higher, and it can be expected that with implementation of bicycle lanes, the number of cyclists would also increase. The number of cyclists using University Boulevard is sufficiently high that on a regular basis, a fast-moving cyclist would encounter and wish to overtake a slow-moving cyclist.

- During periods of rain, water accumulates at the righthand side of the roadway in some locations on University Boulevard. A bicycle lane 1.9m in width would provide additional width for cyclists to

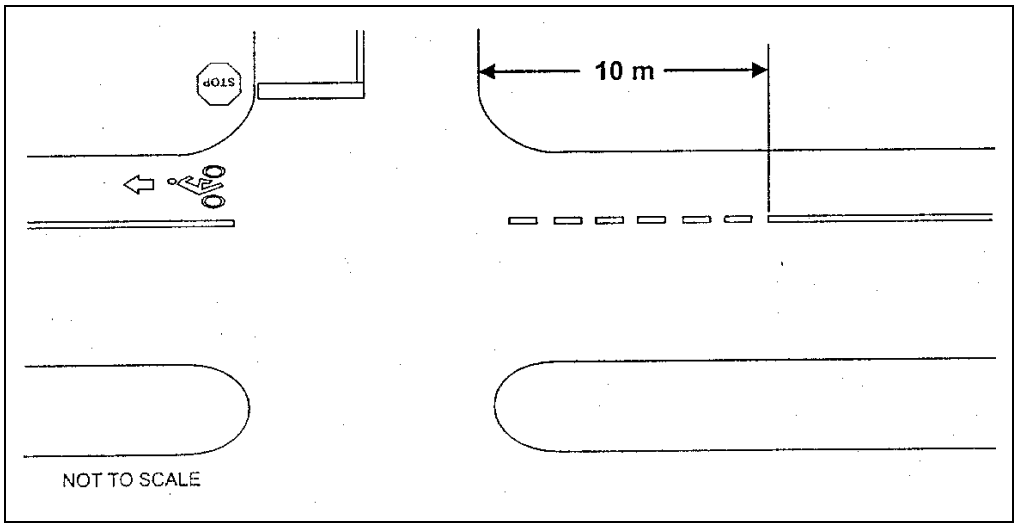
manoeuvre and avoid locations where water has accumulated.

The recommended 1.9m width for bicycle lanes is consistent with the Ministry of Transportation and Highways' *Interim Cycling Policy* (December, 1992), as well as with design guidelines provided in other publications referenced in Section 2.

3.2 Intersections

The solid white line which separates the bicycle lane from the motor vehicle lane should be dashed through intersections to indicate where motor vehicles may cross the line to turn to and from University Boulevard. The white line should be dashed for 10m in advance of unsignalized intersections, and should be discontinued through the intersection, as illustrated in Figure 4.

Figure 4
Bicycle Lane Markings at Intersections



Left turn bays would be required at the signalized intersections at Wesbrook Mall and at Blanca Street. Because there is not sufficient road width to accommodate a left turn bay plus a travel lane and a bicycle lane, modifications to the bicycle lanes would be required, as described below.

- The westbound bicycle lane should be discontinued at Western Parkway, one block before Wesbrook Mall. West of Western Parkway, two travel lanes would be provided, as at present. Cyclists would share the travel lanes with motor vehicles. Because traffic is generally moving slowly in this location, sharing the travel lanes would not likely create difficulties for cyclists nor conflicts with motor vehicles.

- The eastbound bicycle lane should be discontinued approximately 40m in advance of Blanca Street. Two travel lanes would be provided eastbound for the 40m length of University Boulevard approaching the Blanca Street intersection. Discontinuing the bicycle lane would permit cyclists to merge left into the lefthand travel lane in order to turn left at Blanca Street, or remain in the righthand travel lane in order to continue straight through the intersection.

The change to one westbound travel lane west of Blanca Street would require changes to the laning on westbound 10th Avenue east of Blanca Street, in order to reduce the number of eastbound through lanes to one lane from the existing two lanes. The recommended means of reconfiguring the westbound approach would be with a dedicated left turn lane and a shared through/right turn lane.

3.3 Traffic Operations

As described in Section 3.2, reconfiguring University Boulevard to one lane in each direction plus bicycle lanes, would require reconfiguring the westbound approach at the Blanca/10th Avenue/University Boulevard intersection to one through lane. City of Vancouver staff have expressed concern that this might result in congestion at the intersection, which might in turn encourage motorists to short-cut along nearby residential streets.

In order to determine whether traffic congestion would result, an operational analysis of the Blanca/10th Avenue/University Boulevard intersection was undertaken. This analysis was based on an intersection traffic count provided by the City of Vancouver, conducted on Tuesday, September 24, 1996. At this time of year, UBC is in full session, and traffic volumes on roadways to and from UBC are relatively high. Consequently, this traffic count can be considered representative of "worst case" traffic

conditions.

The traffic signals at the Blanca/10th Avenue/University Boulevard intersection are pre-timed (rather than actuated by the presence of vehicles), and operate on a 65-second cycle length. This cycle length was used in the analysis. As well, it was assumed that heavy vehicles account for 2% of all traffic, that the grade on Blanca Street is approximately 2%, that right turns on red would not occur, and that peak hour factors range from 0.9 to 0.95 (the peak hour factor is a measure of the peaking which occurs during the hour).

The analysis of traffic operations at the Blanca/10th Avenue/University Boulevard intersection is summarized in Table 2. The analysis indicates that converting University Boulevard to one lane in each direction *would not have a significant effect on traffic operations* at the Blanca/10th Avenue/University Boulevard intersection, and *would not result in congestion*. Consequently, there is no likelihood that short-cutting via neighbourhood streets would increase.

Congestion and delay are measured by "level of service," which is rated from "A" (free flow conditions) to "F" (gridlock). In urban areas such as Vancouver, levels of service "A" through "D" are typically considered acceptable, and levels of service "E" and "F" are considered unacceptable.

Currently, the levels of service at the Blanca/10th Avenue/University Boulevard intersection during the AM and PM peak hours are "B." With the conversion to one lane in each direction on University Boulevard, levels of service would remain "B" for all movements. The average stopped delay per vehicle on the westbound approach would increase by 3.5 seconds during the AM peak hour, and by 0.3 seconds during the PM peak hour — neither of which are significant increases in delay.

Table 2
Traffic Operations at Blanca/10th Avenue/University Boulevard

Approach	Level of Service (Avg. Stopped Delay/Vehicle, seconds)			
	Existing (Without Bicycle Lanes)		Proposed (With Bicycle Lanes)	
	AM	*PM*	AM	*PM*
Westbound	B (6.1)	*B (5.3)*	B (9.6)	*B (5.6)*
Eastbound	B (5.0)	*B (6.8)*	B (5.1)	*B (7.0)*
Northbound	B (13.9)	*B (13.6)*	B (13.9)	*B (13.6)*
Southbound	B (14.3)	*B (13.5)*	B (14.3)	*B (13.5)*
Overall Intersection	**B (8.7)**	***B (8.4)***	**B (10.2)**	***B (8.7)***

3.4 Bus Stops

There are four bus stops on westbound University Boulevard between Blanca Street and Wesbrook Mall, and three stops eastbound, as summarized below.

- Blanca Street (westbound).
- University Golf Club (westbound) and St. Anselms Anglican Church (eastbound).
- University Chapel (westbound), and on the south side of the roadway opposite the chapel (eastbound).
- Allison Road (westbound and eastbound).

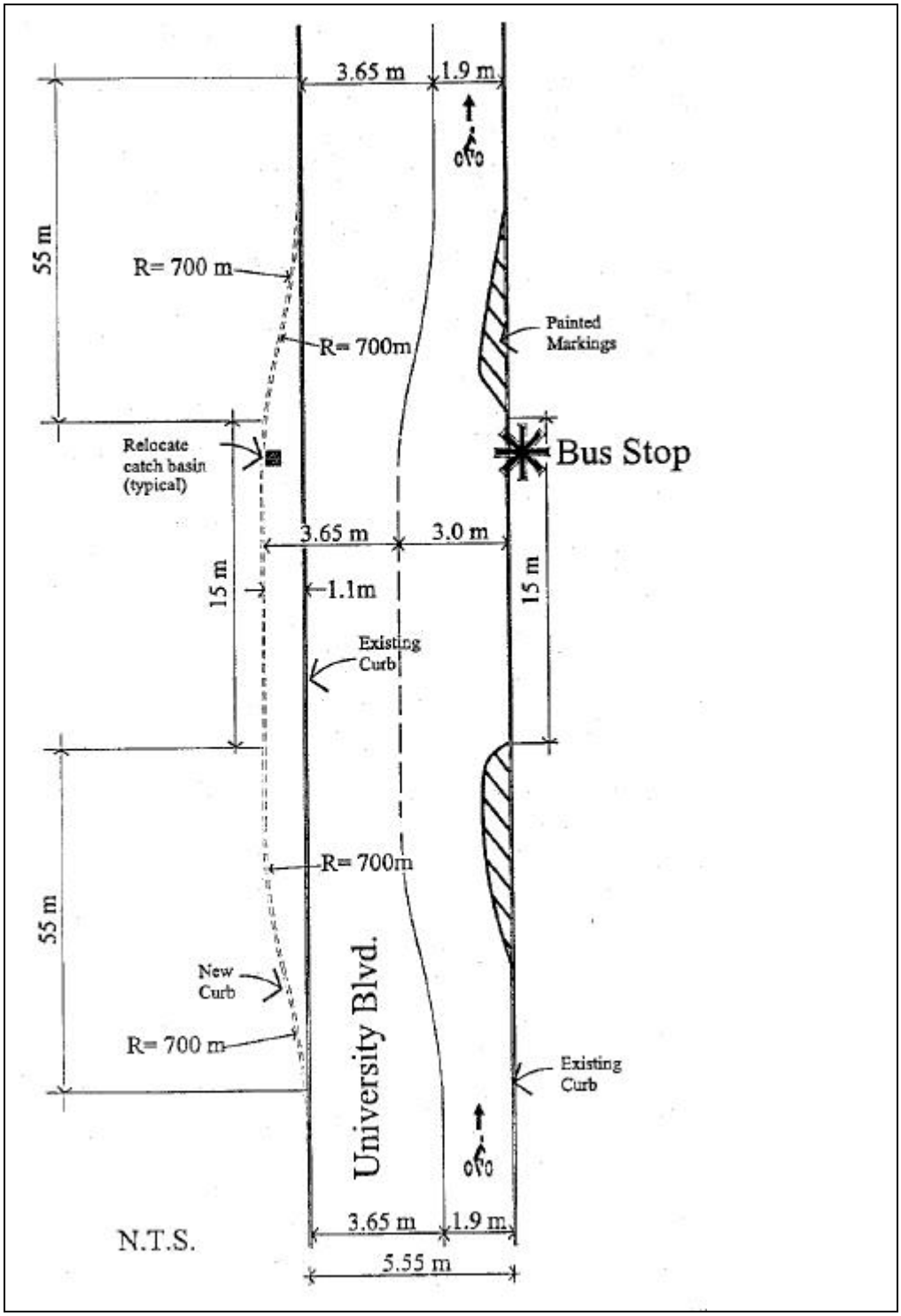
Currently, buses stop in the righthand travel lane, and as a result traffic in the righthand lane is obstructed until the bus pulls away from the bus stop.

With bicycle lanes, buses would pull into the bicycle lane, and stop at the bus stop. During this time, cyclists in the bicycle lane would stop, or if there was no traffic in the adjacent motor vehicle lane, would pass the bus on the left.

BC Transit has indicated concern that with this approach, the left rear corner of a bus stopped at a bus stop would protrude into the motor vehicle travel lane, and as a result, a vehicle could hit the bus. At other locations where bus stops are located on roadways with bicycle lanes, a bus bay with a minimum width of 3.0m is provided, so that buses can pull completely out of the motor vehicle lane when stopping at the bus stop.

To create 3.0m wide bus bays on University Boulevard would require widening the roadway 1.1m. In order to avoid impacting trees and pathways adjacent to the roadway, it would be preferable to widen the roadway into the centre median, as illustrated conceptually in Figure 5. This would require reconstructing approximately 125m of the lefthand curb, and paving an additional 80 m^2 of roadway surface. The design illustrated in Figure 5 includes a 50:1 taper for the jog in the roadway — this taper is sufficiently long to ensure that motorists follow the roadway alignment, rather than continuing in a straight path over the bicycle lane. The white line identifying the bicycle lane would be dashed for 10m in advance of the bus stop and for the length of the bus stop.

Figure 5
Proposed Roadway Design at Bus Stops



The resulting configuration would eliminate BC Transit's concerns, and would avoid obstructing the motor vehicle lane. As noted earlier, cyclists travelling in the bicycle lane would either stop and wait for the bus to pull away from the bus stop, or would pass the bus on the left if there were no traffic in the motor vehicle lane.

3.5 Catchbasins

There are numerous catchbasins along University Boulevard, located at the righthand side of the roadway, in what would be the bicycle lane.

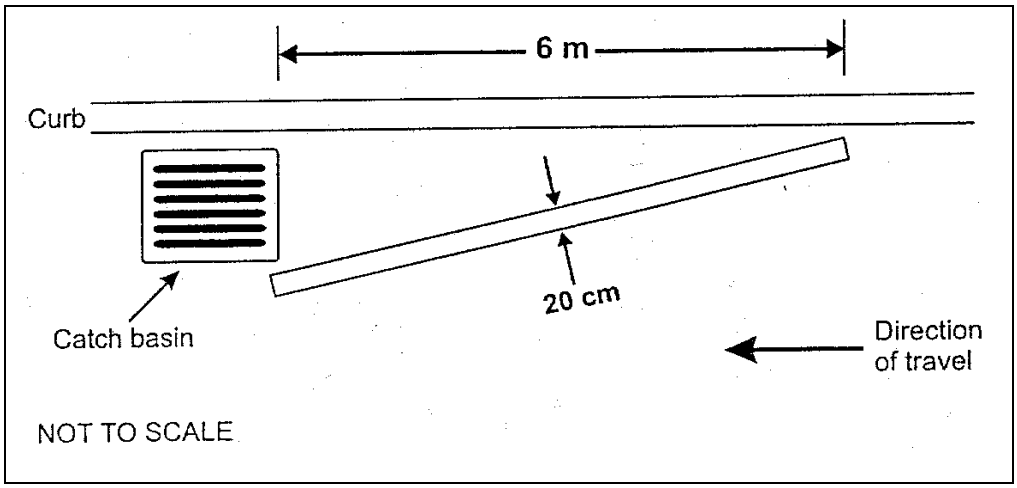
Without modifications, the catchbasins would present a hazard to cyclists, as they are approximately 40 cm wide, and the majority are located 1 to 3 cm below the level of the road surface. Openings in the catchbasins are oriented parallel to the direction of travel, and are wide enough that a bicycle wheel with narrow tires could fit into the opening.
The primary means of minimizing potential hazards associated with the catchbasins is to ensure that the bicycle lane is sufficiently wide to provide 1.5m of road surface within the bicycle lane to the left of each catchbasin. This means a total width of 1.9m for the bicycle lane, as recommended in Section 3.1.

When University Boulevard is eventually repaved or reconstructed, it would be desirable at that time to raise the catchbasins to the level of the road surface, and replace the existing metal grates with grates incorporating "bicycle friendly" openings.

In the interim, it would be necessary to identify each catchbasin with pavement markings, so as to direct cyclists to the left of the catchbasins, rather than over the catchbasins, as illustrated in Figure 6.

As well, the openings in the existing catchbasins should be modified to be "bicycle friendly" by welding small-diameter metal bars across the openings, perpendicular to the direction of travel. This would prevent bicycle wheels with narrow tires from falling into the openings.

Figure 6
Pavement Markings at Catchbasins



3.6 Signage and Pavement Markings

Bicycle lanes should be identified with a solid white line 20 cm wide, which should be located such that the centre of the line is 1.9m from the curb face. Raised reflectors should not be used to delineate the bicycle lane, as these can cause a cyclist to lose control if the wheel of a bicycle hits the reflector.

As described in Sections 3.2 and 3.4, the white line should be dashed at intersections and bus stops. Dashes should be 50 cm long, with gaps between dashes also 50 cm long. The white line should also be discontinued through intersections.

Bicycle symbols should also be used to identify the bicycle lane. These incorporate a symbol of a cyclist accompanied by an arrow, as illustrated in Figure 7. Bicycle lane stencils should be placed on the pavement every 350m, and should also be placed immediately after each intersection. Stencils should not be placed in locations where motor vehicles will frequently drive across them, as this would quickly wear the stencils away.

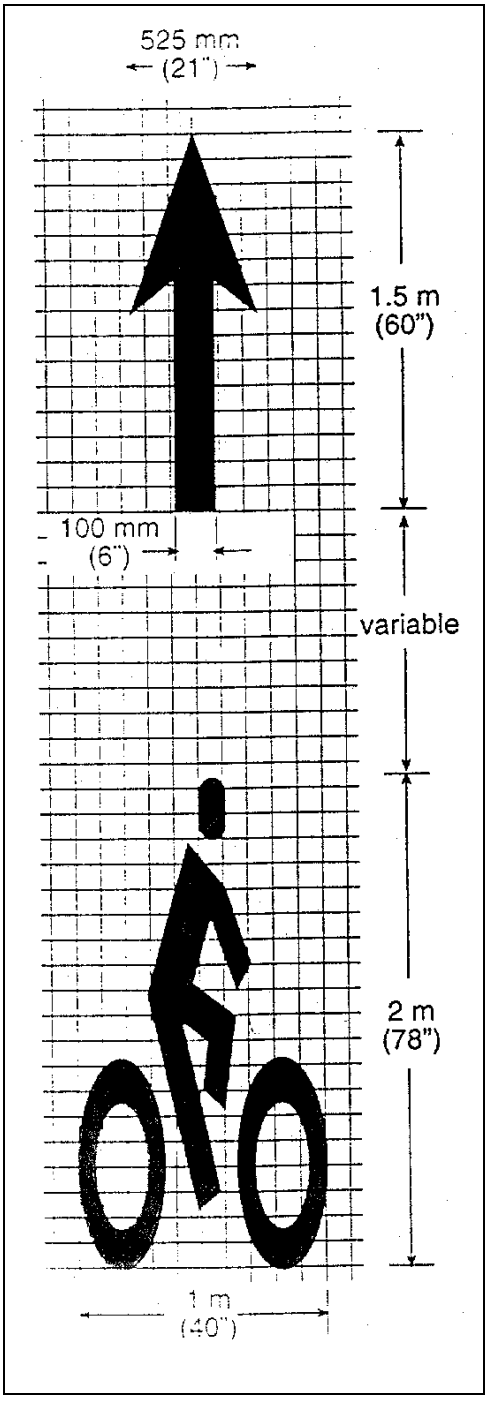
The following signs should be installed along University Boulevard, in accordance with the *Manual of Uniform Traffic Control Devices for Canada* (MUTCDC). These are illustrated in Figure 8.

- "Bicycle Route" signs (MUTCDC IB-23) should be used along University Boulevard to identify the roadway as a designated bicycle route. A tab can be included with the name of the route (such as "University").

- "No Parking" and "No Stopping" signs (MUTCDC RB-51 and RB-55) should be used along University Boulevard to discourage motorists from parking in the bicycle lane.

- "Bicycle Lane Ends" signs

Figure 7
Bicycle Symbol



would be required westbound at Western Parkway and eastbound 40m in advance of Blanca Street. Particularly in the eastbound direction, these signs should be accompanied by warning signs stating "Caution — Cyclists Merging."

- "Bicycle Warning" signs (MUTCDC WC-7) should be used on cross-streets, where these streets intersect University Boulevard, so as to advise motorists of the presence of bicycles on University Boulevard.

Figure 8
Signs

4. COSTS

The costs of implementing bicycle lanes along University Boulevard are estimated to be approximately $150,000, as summarized in Table 3.

Table 3
Estimated Costs for University Boulevard Bicycle Lanes

Item	Estimated Cost
Pavement markings (include grinding old paint)	$20,000
Road widening at bus stops (four bus stops)	$75,000
Signage	$5,000
Weld bars to catchbasins	$10,000
Contingency and engineering	$40,000
Total	**$150,000**

It is important to note that these costs represent estimated order-of-magnitude costs only, and were prepared without benefit of a survey or as-built data, nor a detailed design.