TRAFFIC CALMING IN HILLSIDE NEIGHBOURHOODS

CASE STUDY – PORT MOODY, B.C.

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ABSTRACT

Traffic Calming has become a common phenomenon in the Greater Vancouver Region. Many jurisdictions have adopted traffic calming programs and policies in response to resident requests for speed control and to reduce traffic rat-running. The City of Port Moody is no exception. However, the city has some geographical challenges as many residential communities are located on steep hills. Traditional traffic calming devices such as speed humps, raised crosswalks, intersection table, etc. are inappropriate on steep terrain according to the Transportation Association of Canada Guidelines for Neighbourhood Traffic Calming. Hillside terrains also pose unique challenges such as limited emergency response, transit and garbage collection routes, snow removal needs, a tendency for speeding on slopes, low cycling and walking usage and high reliance on the automobile.

The city adopted a neighbourhood traffic calming policy in 2001. The policy has been well used ever since. With only a small traffic calming budget, resources are strategically allocated to initiatives with strong local support. Traffic complaints are screened and vetted through a Traffic Safety Committee with citizen representatives before traffic calming initiatives are moved forwarded. Engineering staff employ a toolbox of hybrid traffic calming devices and development control. They work closely with developers to incorporate traffic calming into new developments, and Insurance Corporation of BC, police and local school district on road safety initiatives. With five years of experience, the city has gained a strong understanding of traffic calming intricacies in hillside environment and how to optimize limited resources. This paper will examine the Port Moody traffic calming experience and share the lessons learned.

1.0 BACKGROUND

Port Moody is located at the east terminus of Burrard Inlet in the Greater Vancouver Region. The city consists of 26 km^2 and a population of 30,000. It is surrounded by mountains to the north, the City of Coquitlam to the east and south and the City Burnaby to the west. Port Moody forms a horse-shoe around the waters of Burrard Inlet and its terrain can be described as bowl-like. There are over 1,100 hectares of regional parks and 325 hectares of city parks integrated into this urban city.

The city has seen unprecedented urban growth in the last ten years with significant residential development on the hillside above Burrard Inlet. Master planned developments are highly desirable due to spectacular views combined with close proximity to conservation areas, creeks, trails, pathways, recreational areas and other amenities. With only 30 to 40 minutes commute to downtown Vancouver, Port Moody presents an idyllic location that appeals to people seeking the west coast lifestyle.

Along with development, city growth also brought new expectations, perceptions and specifically, traffic and livability issues. Issues such as speeding and road safety present unique challenges in hillside environment.

2.0 HILLSIDE CHALLENGES

Steep slopes are defined as lands in their natural state that have a slope angle of 20% or greater for a minimum horizontal distance of 10 metres[1]. Street networks on the hillside are often designed to fit local topography, to protect environmentally sensitive areas and to minimize cut and fill grading at the site development stage. Unlike neo-traditional neighbourhoods with a grid street pattern, hillside network often resembles a "Christmas tree" pattern with many curvilinear roads, cul-de-sac's, steep grades and limited access routes. Whereas neo-traditional neighbourhoods can distribute or disperse traffic onto multiple streets in a grid network, hillside traffic is funneled onto few residential

[1] Steep Slope Development Permit Area Guidelines, City of Nanaimo, June 21, 2005

collectors and arterials available to the motorist. Common challenges are summarized in Table 1:

Table 1 Hillside Challenges

Challenge	Description
Steep Road Grades	Many collector and local roads are designed to the maximum allowable grade of 12%. Intersection k factors are usually at minimum values (2 for local and 4 for collector).
Traffic and Driveway Conflicts	Many complaints arise from residents who have difficulty exiting from their driveways; especially along busy residential collector routes. This problem is exacerbated if driveways are steep.
Limited Routes for Emergency Response, Snow/Ice Control, Waste Collection and Transit	Due to a "Christmas tree" road pattern, emergency vehicles usually have only one or two possible routes to access an incident site. Snow and ice control also require unimpeded access to key routes. Rapid and continuous snow/ice control is crucial for preventing ice build-up on steep roads. If snow or ice accumulates and becomes compacted by traffic, plowing would be extremely difficult and the road may be closed. Road designs must accommodate vehicles for emergency, snow and ice control, solid waste and recycling collection and transit services. Excessive or inappropriate traffic calming would impede these operations.
Inter-municipal Traffic and Driver Unfamiliarity with Streets	When a residential collector connects to areas outside municipal boundaries, there is low tolerance of traffic from another city. A "us and them" mentality is often created. Visitors and delivery services are more prone to get lost in hillside areas which do not use a neo-traditional street grid. Some residents are frustrated when non-local vehicles drive through their streets.
Sightline Constraints	Sightlines for motorists may be restricted due to curvilinear roadways, vertical curves, on-street parking, mid-block pedestrian crossings.

Surface Traction	Sharp curves on steep grades can lead to vehicles losing control and running off-road; especially during wet and icy conditions. Conversely, conservative road design speed may encourage speeding.
Reliance on Automobile and Congestion at School Zones	Commercial services are situated along the lower areas of Port Moody and regional town centres in adjoining municipalities. There are very few retail and transit opportunities within the hillside neighbourhoods. Although walking and cycling are popular recreational activities, they are still under-utilized for work and school. Consequently, the majority of residents still rely on their automobile for daily commuting and shopping. Traffic issues often arise during school drop-off/pick-up periods. Many local schools do not have adequate on-site parking and drop-off/pick-up areas. The topography of hillside areas is not conducive for large parking lots. Consequently, vehicles overflow onto streets, causing parking, sight-line and other safety issues. Congestion, illegal parking and pedestrian safety are common concerns around schools.
Noise Issues and Stop Violations	Large vehicles (e.g. buses and trucks) accelerating or braking on steep roads generate significant noise. A truck climbing uphill would be running in low gear and high RPM to overcome grades. Sometime, they fail to obey stop signs to avoid losing momentum. On the downhill direction, trucks may use engine brakes to decelerate. Some cities do not prohibit truck drivers from using engine brakes completely. Rather, advisory signs are posted to request drivers to refrain from using engine brakes. This has only limited success.
Enforcement Limitations	Traffic enforcement is also challenging in hillside neighbourhoods. Police can only set up speed enforcement units in areas where it is safe to pull over violators. Some locations are difficult to enforce due to road curves, sightlines obstructions, driveway conflicts, etc.

There is also the issue of perception versus reality. Traffic climbing or coming down steep roadways may appear to be traveling faster than they actually are to a stationary observer. This may be partly due to the noise or limited visibility. Changing someone's entrenched view or perception even with measured speed data may be difficult.

In many cases, speeding motorists reside in the same neighbourhood as complainants. For example, residents living along a collector road are strongly advocating traffic calming while residents from tributary local streets and cul-de-sac's are opposed to physical impediments on their commuting route. Some neighbourhoods are passionately divided due to different views on traffic issues.

Like many municipalities, Port Moody has a limited budget and staffing. Demand for traffic calming along with other operation and safety requests often exceeds available resources. As the backlog of traffic complaints accumulated, residents not satisfied with the city's response or delay took their concerns to council or the media. Staff often have the difficult task of prioritizing requests and managing expectations.

3.0 ROOTS OF ALL EVILS - OLD HABITS & QUICK FIXES

We found that some previous attempts to address speeding, livability and traffic safety issues were unsuccessful. In fact, some actions were creating additional problems.

Unrealistic Speed Limit

This phenomenon has been "grandfathered" in many jurisdictions including Port Moody. Speed limits were reduced as a result of complaints. However, the desired outcome of slowing traffic and changing driver habits did not materialize. It is now recognized that motorists will travel at speeds which he/she can comfortably travel on a given stretch of road regardless of the posted limit. Unrealistic speed limit also discourages police from ticketing motorists and creates a general disregard for traffic control signage.

Conservative Design Speeds

Some roads are designed for speeds in excess of what is necessary for mobility. Applying a conservative factor in the geometric design may result in a road capable of excessive speeds which leads to speeding issues.

Using Stop Sign for Speed Control

The Manual of Uniform Traffic Control Devices (MUTCD) clearly states that "Stop signs are not intended as speed control devices, and their usage should therefore be limited to control of right-of-way conflicts". A proliferation of unwarranted stop signs could lead to general disregard for stop controls. Traffic practitioners should inform their political

decision makers about perils of inappropriate use of stop signs which leads to compliance issues, safety hazards and enforcement problems. Police officers can assist in identifying inappropriate stop sign locations as they are often the same locations with enforcement issues.

Direct Driveways on Collector Routes

One of the most common problems associated with livability is direct driveways on residential collector routes. As urban collectors may carry up to 8,000 vehicles per day according to Transportation Association of Canada (TAC), there are potential conflicts between street traffic and driveway access. Ingress and egress problems are further exacerbated by horizontal curves, private landscaping, on-street parking, etc.

Steep Driveways

There are steep driveways (up to 30%) in mature hillside neighbourhoods. They may be tolerated in cul-de-sac's but they are problematic where there is through traffic. Drivers egress from a steep driveway is difficult due to sight-line limitation and the need to maintain vehicle control on a slope.

Proliferation of Signs

The fallacy that more is better is applicable in traffic control. Excessive speed limit signs, no-parking signs, crosswalk signs, advisory signs, no trucks signs, etc. not only distract the driver's attention from the road, it is unattractive and counterproductive.

Landscaping at Intersection

Excessive landscaping at corner lots may impede visibility. Sightlines should be protected at intersections. Appropriate species selection is also critical.

On-Street Parking on Road Curves

Although roadway is public space, residents often perceive that the street in-front of their home is their parking space. Installing no-parking zone to protect sight-line in front of residential lots is often met with opposition.

It may be difficult to avoid all of these pitfalls; especially with vocal taxpayers and politicians seeking immediate action.

4.0 ROAD TO REDEMPTION – A SIMPLE POLICY AND A FEW GOOD FOLKS

Port Moody developed a city policy on neighbourhood traffic calming in 2001 to deal with increasing requests. Essential elements include:

- Project Initiation (receive and review requests by Traffic Safety Committee)
- Preliminary screening (collect traffic data and screen through a point system)
- Neighbourhood Advising Committee
- Problem Identification
- Development of Plan and Options
- Public Education and Consultation
- Measurement of Public Support of Plan
- Presentation of Final Plan for Approval
- Two Phase Implementation
- Performance Monitoring

Vetting initial requests through a Traffic Safety Committee (TSC), consisting of informed community members and councillors, helps filter out low priority complaints. This "public" body diffuses some of the politically charged demands by taking on the role of prioritizing various requests. Consequently, the perception of staff bias is eliminated, allowing staff to focus on finding solutions for high priority locations.

Delineation of the appropriate consultation area is an important step. Consultation should focus on the neighbourhood immediately impacted by the traffic problem. People from affected streets provide value-added input for developing options and plans. Including too large of an area may invite controversies and unproductive criticisms from speeding or rat-running culprits living in peripheral areas. The TSC selects volunteers with diverse background for the neighbourhood advisory committee (NAC) and the membership is ratified by council.

In working with the NAC, the chair would guide the group to seek consensus on the problem(s). Discussions would focus on tackling the identified problem(s). Staff would ensure that options presented are consistent with best practices in the *Canadian Guide to Neighbourhood Traffic Calming*. Consultation with other stakeholders such as fire department, transit providers and public works would be included. The NAC selects from a menu of potential options developed with engineering expertise.

Once a draft plan and/or options have been presented to the public, usually via a mail-out and an open house, final adjustments would be made based on the feedback. A questionnaire with the refined plan would then be sent out to the affected area to measure public support. Residents would indicate whether they support the plan or not.

Usually two-third support is needed for a plan to be considered acceptable to the community. The result of the public questionnaire would be presented back to Traffic Safety Committee and finally to Council for approval.

A key point is to selectively implement traffic calming within available budget and staff resources. The Traffic Safety Committee agreed to process a maximum of two to three traffic calming initiative at any one time. Other requests would be placed on the waiting list.

The policy guides staff and residents through the traffic calming process. Occasional political pressures may attempt to circumvent the policy to ascertain a quick fix. However, educating decision makers and residents to follow the balanced approach as outlined in the policy is essential for long term success in traffic calming. A policy provides a framework for staff, as well as the political decision making body, to rely on when there are competing and sometimes emotionally charged demands. This policy has been used extensively in the last 6 years.

5.0 STREET MAKEOVER - CALMING EXISTING NEIGHBOURHOODS

In response to public requests, city staff have reviewed existing neighbourhoods with traffic issues and experimented with some calming measures. Reviews identify existing traffic controls which are inconsistent with best practices such as unrealistic speed limit, unwarranted stop signs, sightline obstructions, etc. Potential traffic calming measures were explored with the following findings:

5.1 Speed Humps

The *Canadian Guide to Neighbourhood Traffic Calming* recommends that speed humps should only be used on grades of 8% or less. The city adheres closely to this criteria to avoid introducing a new hazard for drivers while attempting to address a speeding problem.

On road segments where the gradient is 8% or less, speed humps are economical options. The results of performance monitoring at two locations with speed humps are tabulated in Table 2.

Table 2 – Speed Hump Performance Results

Location	Posted Speed Limit	85th Percentile Speed Prior to Traffic Calming	85th Percentile Speed After Traffic Calming
Highview Place (local street)	30km/h	50 km/h	31-35 km/h 3 speed humps @ 70m spacing
Parkside Drive (collector street)	30km/h*	54km/h	50 km/h

* road design speed is 50 km/h

Highview Place

Parkside Drive

The *Canadian Guide to Neighbourhood Traffic Calming* recommends a pair of speed humps at spacing of 60 m to achieve a design speed of 30 km/h. This would translate to approx. 30 speed humps on 1 km roadway. Driving over 30 speed humps twice daily can be extremely irritating for even speed-conscious drivers, let alone emergency services. Establishing a more realistic speed target and using speed humps in moderation would be more widely accepted than using an aggressive calming approach to suit a few vocal residents. The speed hump spacing can be experimented using a gradual implementation approach.

The design of speed humps should consider transit needs. The city reduced the height of speed humps on collector routes from 80 mm to 65 mm based on transit request. The current practice is to uses 65mm and 80mm height for collector and local streets respectively.

5.2 Curb Extensions and Medians

Curb extension is probably the most common device used on steep slopes where speed hump is not feasible. However in some locations, curb extension alone did not produce a significant reduction in operating speed. Motorists may straddle over the centerline if there is no opposing traffic as they speed through a pair of curb extensions. To overcome this problem, the city employed a combination of curb extensions, centre medians and very narrow travel lanes (down to 3.0m width for collector roads) to discourage high speeds. This combination produced improved results as tabulated in Table 3.

Table 3 – Curb Extensions & Median Performance Results

Noons Creek Drive (Collector Road) Posted speed is 50 km/h with an advisory speed sign of 30 km/h prior to a curve. Measured 85th percentile speeds were:	
Prior to Traffic Calming:	56 km/h
With Curb Extensions Only:	54 km/h
With Curb Ext. & Medians	51 km/h

Curb extensions along bicycle routes present unique challenges. The key objective of curb extensions is to reduce speed by introducing a horizontal deflection/narrowing on the travel lane. However, provision for a bike lane (usually 1.5 m wide) would offset the effectiveness of the lane narrowing. The city has employed narrow lanes and encouraged cyclists to merge with general traffic/motorists at curb extensions.

Curb extensions also improve visibility of pedestrians at intersections, reduce the crossing distance for pedestrians, reduce vehicle turning speeds and minimize the loss of on-street parking near an intersection.

The city employed a succession of two medians and two speed humps at the Aspenwood Drive location with good performance results:

Table 4 –Medians and Speed Humps Performance Results

Aspenwood Drive (Inter-municipal Collector Road) Posted speed is 50 km/h	Measured 85th percentile Speeds
Prior to Traffic Calming:	59 km/h
With Medians & Speed Humps	47 km/h

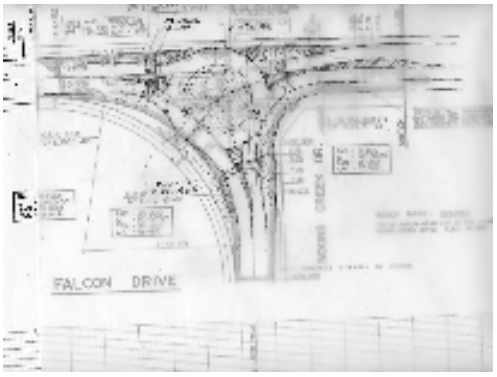
Medians reinforce driver awareness of road centerlines, especially at or near horizontal curves. Experiences indicated that devices such as raised reflective markers tend to be destroyed by snowplow operations. The city tried various products and installation methodologies with limited success.

5.3 Traffic Circles and Roundabouts

Traffic circles can be used in areas where the gradient precludes the use of speed hump. However, consideration must be given for sight-lines and for emergency vehicles; especially on key collector routes.

Introducing a new traffic circle at an existing four way stop intersection would require replacing the stop signs with yield signs. Local residents tend to develop an affinity with existing four way stops, even if they are not warranted, and may resist the change.

The city selected a roundabout design to replace a two-way stop control at a tee-intersection along a hillside collector route. Geometrics and sightlines were verified by a roundabout specialist. The roundabout would accommodate larger emergency vehicles and discourage high speeds on a slip lane of the intersection. The proposed configuration is shown below:



5.4 Other Methods

On-street parking along a local road provides a calming effect by narrowing the roadway. On-street parking should be permitted if there are no sightline issues or other safety concerns.

Pavement grooving is an effective method to improve vehicle traction on sharp horizontal curves on downhill grades during wet conditions. The longitudinal V-shape grooves at approximately 6 mm depth provide micro-channels for surface drainage; thus improving the coefficient of friction. The life of a groove treatment is approximately 5 years.

Adequate lighting should be provided to promote pedestrian activities. Although the city uses a lower design lighting level for developing hillside neighbourhoods (i.e. 0.7 lux versus 4 lux), higher illumination level is desirable at intersections. Regular landscape maintenance is needed to ensure lighting is not obstructed.

Providing pedestrian-friendly crossings improves livability. Most curb letdowns are located at the 45 degree angle of a curb return. Sometimes, this may direct a pedestrian in a wheelchair, scooter or with a stroller to walk onto the busy adjoining travel lane. A practical strategy is to employ two letdowns at each curb return; thus reducing the pedestrian's exposure to adjacent traffic.

Truck traffic has been a common complaint for hillside neighbourhoods. As mentioned in Table 1, many cities do not ban the use of engine brake due to potential liability and enforcement issues. Advisory signs to refrain from using engine brakes have not been very effective. The city also employs regulatory signs based on the noise bylaw. Construction traffic is prohibited from entering residential areas outside of the permitted work periods. This has reduced many truck noise complaints in the early morning hours.

The city has not used chicanes for traffic calming due to difficulty on two-way streets. In addition to conflicts with driveways, there were concerns that chicane may increase the risk for head-on collisions on two-way streets.

The city reviewed the use of convex mirrors for locations with sightline limitations. Convex mirrors are often used in parking garages around blind corners. However, they are not common on public roadways. Mirrors are not desirable as they can easily be displaced on public roadways. More importantly, subjects such as moving vehicles are closer than they appear on a convex mirror. This would pose a serious hazard for the viewing driver when he/she is judging the available gap.

The 3 E's of traffic safety (Education, Engineering, and Enforcement) is a holistic approach to tackling traffic calming issues. Promoting education as an initial step helps improve driver awareness of speeding issues, establish realistic expectation for local residents and establish safety practices around schools and parks. The city has also partnered with police, Speed Watch and Insurance Corporation of British Columbia on several safety awareness programs. Physical calming devices are usually implemented after initial educational period. The 3 E's are generally applicable in all traffic calming initiatives.

5.5 Maintenance

Regular maintenance is crucial to ensure that calming devices remain effective. Operational costs including landscaping features should be considered during the selection of devices. Traffic calming to some extent does affect the efficiency of snow and ice control operations and some operators may not be familiar with various traffic calmed areas. A snow/ice control map with highlighted locations of traffic calming devices helps prepare operators for working within traffic calmed areas.

6.0 NEW BEGINNINGS - CONSIDERATIONS IN NEW DEVELOPMENTS

New development provides an opportunity to incorporate traffic calming into a subdivision rather than adding them as corrective measures afterward. Experiences gained from existing neighbourhoods help to identify potential problems in new developments. Devices suitable in existing neighbourhoods such as speed humps, curb extensions, and medians can also be integrated into development plans. This proactive approach promotes a more attractive integration of traffic calming into the development, minimizes future complaints, avoids the time consuming traffic calming process, and leverages developer contribution to traffic calming costs. Some considerations are listed below.

6.1 Frontage Road, Shared Driveways, Turnarounds

The city now employs every effort to discourage direct single family driveways onto collector routes. Narrow frontage roads, shared driveways and on-site turnarounds are practical alternatives to direct driveway connections. Even with topographical constraints, a narrow (5 m wide pavement) frontage road was employed on a hillside collector route after lengthy negotiations with the developer. See figures below.

Forest Park Way Frontage Road

Forest Park Way Short Frontage Road

6.2 Subdivision Layout

Subdivision planning should ensure minimum intersection spacing is achieved. This is crucial for hillside areas where sight-lines are limited by horizontal and vertical curves. Long cul-de-sac's with high traffic can be avoided by providing alternative access connection.

The maximum slope for municipal roads is 12% although a lower gradient is desirable. Transitional profile is needed for reduced gradient at intersections. In areas where the road grade would exceed 12%, development may not be feasible. One alternative is to designate non-conforming streets as internal/private roads if other services such as garbage/recycling are addressed. Private streets up to 15% grade are feasible in cluster home developments or bare-land strata sites. Clear and visible street signs are necessary for visitors and delivery service.

Pedestrian network is an important component of subdivision plans. A well-connected pedestrian pathway system with consideration for traffic movements would minimize future safety issues. Including curb extensions at pedestrian crossings would improve sightlines and reduce crossing distance. Planners should anticipate where sidewalks are needed and consult local school representatives where possible.

6.3 Road Design

Some existing roads were conservatively designed for speeds higher than the posted limit, resulting in drivers traveling faster than the neighbourhood is comfortable with. In order to mitigate the dichotomy of operating and posted speeds, engineers are encouraged to select a design speed that matches the desired operating speed. Design speed of 40 km/h and 50 km/h are considered ideal for a residential local and collector streets respectively.

The city policy stipulates that physical devices such as speed humps, traffic circles, chicanes, etc. are not appropriate on arterial routes. Road diets and narrow lanes are possible measures to address traffic problems along arterial corridors. A hillside arterial road (David Avenue) was planned for an ultimate 4 lane width with interim pavement width for two lanes. The 4-lane construction between two established residential areas would require significant cut/fill and offsite hauling. After an in-depth traffic study indicated that two lanes would meet foreseeable demand for at least 20 years, this urban arterial road was re-designed and constructed with two lanes and excess fill was used to construct a noise/visual mitigation berm on remaining road allowance. Open graded asphalt was also employed to further reduce traffic noise. Building excess lanes in anticipation for long-term traffic demands may not always be necessary and would increase maintenance costs.

In most situations, the city found that super-elevation is not necessary for residential collector and local streets. A crown centerline cross-section promotes the driver's expectation that the road is designed for low speed within an urban environment.

Identifying on-street parking and landscape restriction areas is important for protecting sight-lines in new subdivisions, especially along horizontal curves with driveway connections or pedestrian crossings. No-parking signs should be erected prior to marketing of adjacent housing. A restrictive covenant that limits plant heights along lots frontage can be incorporated into the subdivision plan and attached to each lot's title.

7.0 FRUGAL SPENDING

The city generally funds traffic calming in existing neighbourhoods, if it has public support, rather than charging local residents under local improvement bylaws. Since traffic calming can be controversial, there is no point rubbing salt into the wound of those residents opposed to it by charging them as well. This would avoid introducing another controversy to the traffic calming debate that could be challenged in the political arena.

Setting an annual budget limit for traffic calming turned out to be strategic for the city. Requests were assessed by the Traffic Safety Committee and prioritized in consideration of available budget and staffing resources. Expectations of residents were managed accordingly.

A clear benefit of incorporating traffic calming into new developments is that the capital cost is funded by developers. The cost would likely be nominal, or may even result in cost savings for the developer. Reviewing development plans with an eye for traffic calming is necessary to ensure old habits and short-term fixes are not repeated in new areas.

8.0 CONCLUSION

Traffic calming is an effective tool to address safety and livability concerns in residential neighbourhoods. However, implementing traffic calming on steep hills requires consideration of local topography and effectiveness of various devices. Some devices and practices are not appropriate in a hillside setting. The City of Port Moody found that certain devices are more suited to the steep terrain and employed them in accordance to the *Canadian Guide to Neighbourhood Traffic Calming* (TAC) for existing and new residential areas. Staff worked closely with developers to incorporate traffic calming into new neighbourhoods.

A key component is to adopt and adhere to a clear, simple traffic calming policy. The City of Port Moody has a Traffic Safety Committee (TSC) with citizen representatives to screen complaints and prioritize traffic calming initiatives before submission to council. The TSC engages local stakeholders, staff, police force, Insurance Corporation of B.C. and school representatives on traffic issues. Although the city budget is small, traffic calming projects are generally funded by the city or developers.

Understanding the performance of various calming devices in the hillside environment, differentiating between perception and reality and laying out realistic expectation are necessary in the early phase of the process. A holistic approach including subdivision planning, public consultation, engineering options, education, enforcement and funding strategy is essential to successful traffic calming planning and delivery.

9.0 REFERENCES

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