THE CORPORATION OF DELTA

COUNCIL REPORT

REGULAR MEETING

To: Mayor and Council **File No.:**
From: Engineering Department
Date: November 6, 2006

Sound Attenuation

The following report has been reviewed and endorsed by the Chief Administrative Officer.

■ RECOMMENDATION:

That the following be received for information.

■ PURPOSE:

The purpose of this report is to provide Council with a basic understanding of sound and current sound attenuation practices and specifically how it affects the Corporation of Delta.

■ EXECUTIVE SUMMARY:

Noise impacts on the community have long been a concern of Council and residents. Recent and impending developments have heightened this concern. Noise is not only a concern locally but has been recognized globally as a major health concern, with traffic related noise often being sited as a particular concern. In general terms, sound is what we hear and noise is unwanted sound.

Sound is often measured in decibels (dB) or “A-weighted levels” (dBA). The dBA scale is used to adjust for how a normal person hears. The dBA scale begins at zero, which is the faintest sound that can be heard by a person with excellent hearing. On this scale it is generally accepted that a

change of 10 dBA is perceived to be twice as loud. People tend to become annoyed when sound levels outside their homes reach 55 dBA. In Delta a major concern is traffic related noise. Traffic noise is affected by traffic volume, speed and the number of trucks in the traffic flow. The level of noise is reduced by distance, terrain, vegetation, and natural and manmade obstacles. In addition, appropriate motor vehicle control, land use control and highway planning and design can greatly reduce the impact of noise.
Noise barriers are the most common tool used in highway design to reduce noise levels and can be used to reduce noise levels by 10 to 15 dBA or perceived noise levels by more than half.

Noise barriers can be formed from earth berms, vertical walls of various materials or a combination of both. Walls can be made of numerous materials with the density of the material being the most important for sound reduction. Most materials perform equally well if they are rigid and dense enough. Therefore, noise barriers become a balancing act of cost, aesthetics, available space, maintenance and safety. The height, location, elevation and length of barriers will all impact the effectiveness of the barrier. In recent years wall aesthetics and fit within the community have become a driving force in wall design. In general, concrete, block, brick and absorptive material walls are more expensive than wood, metal, berms or berm combinations.

There are numerous documents available for determining the need for sound attenuation and its effectiveness. The most common used locally are the Ministry of Transportation (MOT) Policy and the Canadian Mortgage and Housing Corporation's (CMHC) document on Road and Rail Noise: Effects on Housing. The MOT policy uses a sliding scale of noise level change post and pre construction to determine if sound attenuation is necessary, whereas, the CMHC book sets maximum acceptable noise levels in dwellings and outdoors. In relation to the development of the SFPR the impact of the road on residential neighbourhoods will need to be closely monitored.

■ BACKGROUND:

At the November 28, 2005, Regular Council Meeting, Council received a letter from a concerned resident regarding high noise levels on Highway 17. This letter combined with obvious traffic concerns, stemming from the Tsawwassen Ferry Terminal and Deltaport prompted Council to instruct staff to review new sound attenuation technologies and practices. Additionally, with the impending construction of the SFPR it is an appropriate time to bring forward to Council information regarding sound attenuation, some sound basics and current practices

■ DISCUSSION:

Not only is noise a concern for our residents but noise is recognized world wide as a major contributor to health issues. As early as 15 years ago Health Canada labeled noise as a “real and present danger”. Many studies have linked high urban noise levels to health problems, including: headaches, stress, fatigue, insomnia, high blood pressure, heart and digestive problems, immune system problems, aggressive behaviour and learning problems in children. A very recent Health Canada survey found that road traffic noise is one of the top two types of noise identified by respondents as being highly annoying. In addition, numerous studied have found that the most pervasive sources of noise in our environment are those associated with transportation. Highway traffic noise tends to be a dominant noise source in both rural and urban settings.

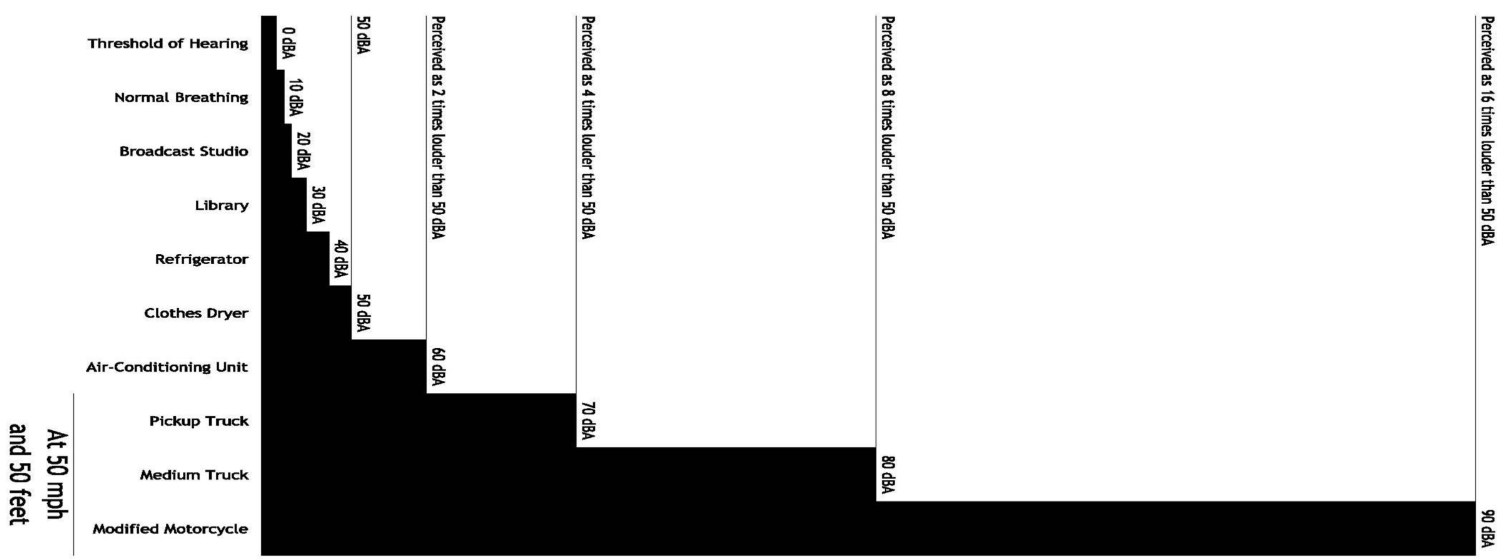
The World Health Organization (WHO) has also recognized the impact of noise as a serious health issue as opposed to just a nuisance. However, WHO have also recognized that increasing noise and the associated impacts from the continued growth in transportation systems are difficult to control and regulate, in part due to the difficulties with definition, measurement and control of excessive noise.

Sound Basics

Any discussion around sound and noise levels should begin with a basic understanding of sound and how it works. In general terms, sound is what we hear and noise is unwanted sound. The difference between what is deemed to be sound and noise is often dependent upon the listener. Sound is created when objects move, the vibrations or waves created in the air reach our ears and are perceived as sound.

Most people are familiar with sound being quantified in decibels (dB). In instances, such as traffic noise the “A-weighted levels” (dBA) are often used. This is a weighting of sound to adjust for the high and low pitched sounds and the adjustment is made to approximate how the average person hears sound. The dBA scale begins at zero, which is the faintest sound that can be heard by humans with excellent hearing. Even though, sound is perceived differently by listener it is commonly accepted that a change of 10dBA is perceived to be twice as loud. For example, 60dBA is twice as loud as 50dBA and 70dBA is 4x louder than 50dBA. Figure 1 below graphically depicts this as well as the dBA level of some normal activities. In addition, Attachment A provides a chart identifying some common sounds, their decibel rating and their potential effects. People tend to become annoyed when sound outside their home reaches 55dBA. A doubling of the number of sound sources (two horns honking instead of 1) increases noise levels by 3dB with a 3dB change being barely audible to most people.

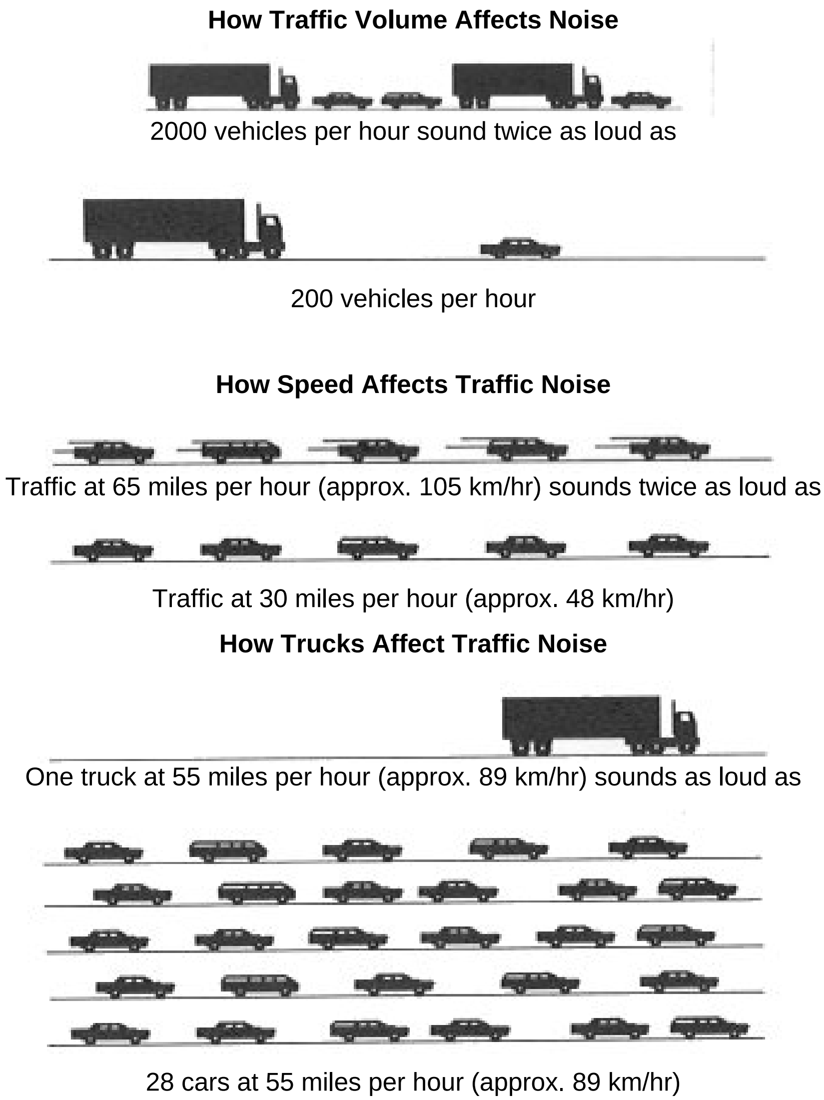
Figure 1.



Federal Highway Administration, 2006

Traffic Noise

In the context of the Corporation of Delta our main noise concern and the reason for our existing and most likely future Sound Attenuation measures is Highway/Traffic Noise. In general the level of traffic noise depends upon three things: 1) the volume of traffic – with higher volumes associated with higher noise levels, 2) the speed of the traffic – the faster the speed the higher the noise and 3) the number of trucks in the flow of the traffic – a higher volume of trucks is associated with more noise. Of specific interest to Delta are truck volumes. As demonstrated below in Figure 2 volume and speed have significant impacts on noise but more alarming is that 1 truck at 55 mph (89 Km/h) sounds as loud 28 cars at the same speed.
Figure 2.



Federal Highway Administration, 2006

In addition, steep inclines and faulty equipment on vehicles increase noise. Noise is reduced by distance, terrain, vegetation and natural and manmade obstacles. In general, people who live more than 500 feet from heavily traveled freeways do not normally have any serious problems with traffic noise, however, this will vary dependent on many conditions.

Controlling or Reducing Highway Noise

Highway noise is generally best attacked in three areas: motor vehicle control, land use control and highway planning and design. Motor vehicle control includes better/quieter design such as engine enclosures, better mufflers, traffic flow measures and enforcement of existing maintenance and operating legislation. In certain circumstances a reduction in speed may also work but a reduction of about 30 Km/h is required to make a noticeable difference.

Land use control includes requiring reasonable distances between existing roads and new developments, promoting the use of less noise sensitive land uses near highways, soundproofing of new developments and/or other abatement measures. These issues unlike many motor vehicle control issues are within the control of local governments. For example, in the recent development at Sanderson's nursery on 64th Street, Delta required a noise impact study on the proposed development and requested that adequate noise abatement was installed as part of the development.

The third aspect of control and likely the most relevant issue for Delta right now is Highway Planning and Design. Similar to what has been developed for the SFPR most new highway improvements would include a Noise Impact Assessment, to evaluate the potential noise problems associated with the project. If noise is anticipated to be a problem some noise reduction measures can be considered. These include buffer zones, constructing barriers, depressing the road, physical relocation of the proposed infrastructure, planting vegetation, and managing traffic. In addition, more work is now being done with quiet pavement designs. However, some of these designs work less well with different vehicle combinations and volumes and may lose effectiveness over time. It appears that more research is needed on their overall benefit.

Buffer zones are large undeveloped spaces bordering highways in excess of normal right of way requirements. These create a visually appealing buffer as well as physical separation from the noise. The downfall of such zones is the cost of such land requirements and the limitation of adequate space when building near existing neighbourhoods or developments.

Noise barriers are the most common method of sound attenuation used and can effectively reduce noise levels by 10 to 15 dBA. In effect they can reduce perceived noise by more than half. The effects of diffraction over the wall limit any real further benefit to the walls. The following chart indicates the likely traffic noise reduction attainable:

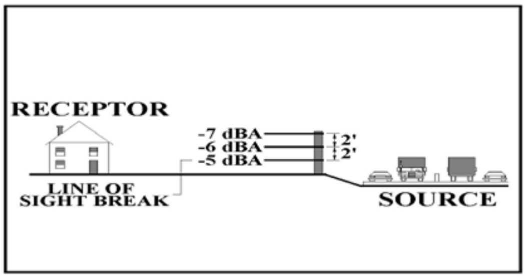
Reduction in Sound Level	Degree of Attainability
5 dBA	Easily Attained
10 dBA	Attainable
15 dBA	Very Difficult
20 dBA	Nearly Impossible

Noise Barriers

Barriers can be formed from earth mounds at road side (earth berms) or from high vertical walls of various materials or a combination of both. For noise barriers to work they must be high enough and long enough to block the view of the road. Therefore, they do little good for hillside homes. In addition, any openings in walls to permit passage lessen the effectiveness of the walls. Noise barriers can often mitigate fully the impacts of highway widening projects but not very often those involving new alignments or substantially different projects. Barriers also help neighbourhoods reduce litter, dirt, spray and the view of the highway, however, they may also create problems with shading, feelings of enclosure, movement in/out of neighbourhoods and air movement. Some generally acceptable principles regarding noise barriers include the following;

The **barrier height** must at a minimum break the line of sight between the source and the receptor of noise. A barrier that just breaks this line of sight will provide a 5 dBA reduction in traffic noise. Each additional two feet in height reduces traffic noise by 1dBA. However, at a certain point no additional benefit is received. It is this height requirement that makes the benefit of barriers on second stories or hill side homes limited.

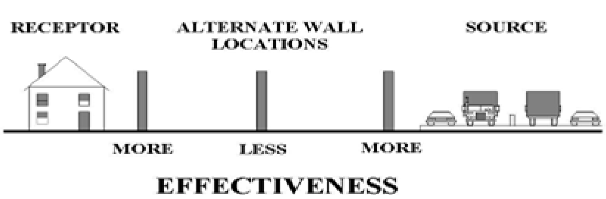
Figure 3.



Illinois Department of Transportation

The **barrier location** is most effective closest to the source or closest to the receiver. The effectiveness of earth berms are often affected due to their size and the need to build them away from the source of the noise and the receiver.

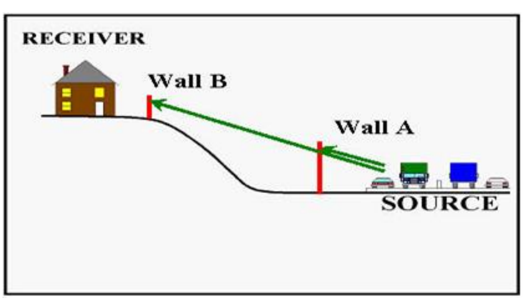
Figure 4.



Illinois Department of Transportation

The **barrier elevation** is affected by the elevation of the ground between the source of noise and the receiver and determines the overall necessary height of the wall. In the following example Wall B does not have to be as high as Wall A to provide the same benefit. This is because Wall B is located at a higher elevation and still blocks the line of sight and therefore sound in this situation. Wall B however, has the potential to adversely impact views from affected homes.

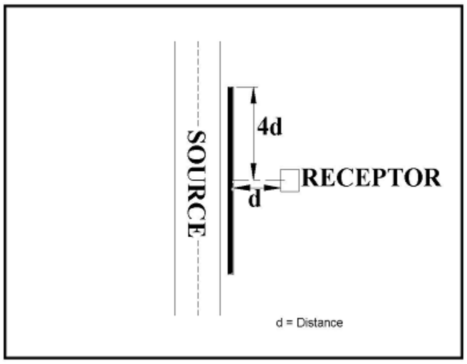
Figure 5.



Illinois Department of Transportation

The **barrier length** needs to be long enough to prevent sound traveling in behind the wall. Similar to the height of the wall the length of the wall should be sufficient to block the view of the receptor and the noise source. In general the barrier should extend past the receptor 4x the distance between the receptor and the barrier to be effective.

Figure 6.



Illinois Department of Transportation

Berms

Earth berms are often used as they are very natural looking (can be planted), relatively inexpensive (if sufficient land is available) and can be quite effective. The problem with earth berms is that there is often inadequate room available to build them, land purchases if available are quite costly and they are generally limited to approximately 25 ft in height. The effectiveness of earth berms is affected by their shape (slope), height, covering material and distance from the receiver or sound generator. In general, testing has shown that the gentler the slope of a berm the more likely that sound will travel over the top of the berm and into the zone behind the berm that is being protected. It is this phenomenon that often allows vertical walls or steeper berms to perform better. In addition, the size and slope of a berm dictate how close the wall can be built to the receiver or noise source and thereby potentially affecting the performance of the berm. Therefore, the very size of earth berms may have some impact on their ability to be effective.

Planting vegetation on the face of berms can have minor benefits due to their absorption effects but if the vegetation is allowed to overtop the crest of the berm or noise barrier it will cause sound to be reflected down towards the receiver behind the wall and thereby reducing barrier performance. Plantings by themselves do not provide effective barriers for sound unless they are very dense and thick. A 200 ft thick planting of vegetation that is high enough and dense enough would be required to achieve a 10 dBA reduction in noise. For the most part it appears that plantings provide more of a psychological and visual barrier than an acoustical one.

Walls

Walls as barriers can be quite effective and installed in areas of limited space. However, walls can be expensive and may require more maintenance. Due to the structure of most walls the height is often limited to 25 feet(7.5m) (MoT policy limits to 3m). Walls can be made out of numerous materials, including wood, metal, transparent materials, blocks, concrete, bricks, various recycled materials (tires, plastics, etc.) and various absorptive materials. In a review of many states and Federal legislation including the U.S. Department of Transportation, it appears that most materials are accepted as barrier walls and most guidelines do not specify what materials to use. For the most part walls of different materials perform equally well if they are rigid and dense enough. At a weight of 20kg per square meter and if they are free from any significantly gaps or cracks, most of the above materials are equally effective acoustically. Materials can also be reflective or absorptive, reflective is less effective with barriers on both sides of the road closer than 100ft.

Therefore, walls as barriers become a balancing act of cost, durability, aesthetics and maintenance. In recent years the aesthetic appearance of walls has received greater attention. Studies have shown that the perceived effectiveness of walls can be altered by the walls aesthetic appeal to the affected community. For a wall to not be perceived as a waste of money there should be community buy in to the design. As much as possible walls should reflect the character of their surroundings. The following information is being provided on the general benefits of some differing materials:

Concrete – Almost half of the walls constructed in North America are concrete. Concrete is one of the most durable products it withstands temperatures, intense sunlight, moisture, ice and salt. Concrete is, flexible in design (raked, broomed, aggregate, stamped, molded, etc), comes precast, and allows for a range of installation techniques. However, concrete can be expensive, labour intensive to install and structurally heavy for some applications.

Brick and Masonry Block – Flexible in size, colour, texture and design. These installations are easily adapted to most ground contours but can be heavy, are labour intensive, expensive and require a constant reinforcement and tie back to a foundation.

Wood – Is relatively inexpensive to install, can blend in well with natural environments and is flexible in design and colour. A major deterrent for using wood is it's durability and high maintenance costs. It is also more difficult to keep gaps on wood small enough and find wood dense enough to provide adequate acoustical performance.

Metal – Offers weight advantages when needed, can be installed relatively inexpensively. Appearance is often industrial, does not always accommodate vegetation close-up, can produce glare and has some long-term maintenance concerns.

Composite materials – New materials are regular being introduced and often warrant further testing and consideration. The combining of different materials has the tendency to affect the performance, durability and possibly even the safety characteristics of the final product. Resistance to shattering tends to deteriorate over time, can be a maintenance concern, they are often not structurally sound, some materials can burn or be damaged by heat and flames and they can be adversely affected by sunlight.

Berm/Wall Combinations

In addition, to adding height and possibly better performance berm/wall combinations are often preferred as the berm face is easily planted reducing the visual dominance of the barrier wall. Again, it is important to note that when vegetation is allowed to overtop the wall, the vegetation will tend to scatter sound back down behind the barrier and reduce its effectiveness. Berm/Wall combinations have the possibility of reducing costs and the overall height of the actual wall. Berm/ wall combos also use less land than comparable height berms. Attachment B, provides pictures of some of the many barrier options currently available and in use.

Barrier Costs

Providing a cost per metre of varying barrier types is extremely difficult for a number of reasons: Delta and the lower mainland have limited track records with the various materials, installation costs vary based on site conditions and construction costs are changing so quickly in today's market. However, what we can provide is a general scope of costs and the relative costs of some materials over others. The table below comes from a 2004 survey of costs done by the U.S. Department of Transportation, the information has been converted to Canadian dollars and per square metre costs. What becomes abundantly clear is that concrete, block, brick and absorptive walls are substantially more expensive than wood, metal, berms or berm combinations. Some further research suggests that newer absorptive technologies are becoming even more expensive. Additionally, once a wall gets higher than 3m the prices increase substantially due to structural support and installation issues.

Construction Material Noise Barrier Cost by Unit

(2004$/Square Metre)

Concrete	Block	Wood	Metal	Berm	Brick	Combination	Absorptive
$254	$302	$157	$169	$73*	$302*	$133	$254

* Average of previous years costs as no 2004 data was available.

For the limited current information that we could attain locally, the price relationship between the products remains the same. Recent quotes for concrete fences range from $300 per lineal metre for 1.2m high fence to $600 for 3m high. Even though, MoT does not support 4m installations, we have recent information from a job in the Queensborough area. The 4m installation was quoted at $900/m for Allan Block, $950/m for Concrete Fence, $1,250/m for Durasol (absorptive, cement with wood fibres) and $1,800/m for Acoustax (Absorptive, sandwich panel). Attachment C provides an example of order of magnitude costs to complete a wall on the East side of Hwy 17 in Ladner.

Evaluating the need for Sound attenuation and its effectiveness

Since 1989, the Ministry of Transportation & Highways (MoTH) has had a noise impact mitigation policy in place, which applies to all new or upgraded freeway or expressway projects. The policy was revised in 1993 and is now administered by B.C. Ministry of Transportation (MoT). For mitigation to occur under the MoT policy, mitigation must be warranted (based on predetermined standards), feasible, cost effective and widely supported by the affected residents. To determine whether or not a project is warranted MoT uses a sliding scale of maximum noise level increases that are permitted to accompany new or upgraded projects before mitigation measures must be considered. The rational for this sliding scale is that a 5dBA increase in noise will have a larger impact on an already noisy neighbourhood than in one that is relatively quiet. The sliding scale uses Leq (24) which is the average sound energy exposure over a 24 hour day and states that if and where, after 10 years of the project completion the total predicted noise level, expressed in terms of Leq(24) is:

> Between 55 and 65 dBA, and exceeds the corresponding pre-project (baseline) noise level by an amount which varies from 10 dBA at a pre-project level of 45 dBA, to 3 dBA at a pre-project level of 62 dBA,or
>
> > 65 dBA or more and exceeds the corresponding pre-project level by at least 3 dBA

Attachment D, graphically represents the noise policy criteria. To be considered cost effective under MoT's policy mitigation measures generally have to reduce noise levels at ground floor, front row noise receiver locations by 5dBA and have an installed cost of not more than about $15,000 (1993 dollars, inflating @ 3%/year equals $22,000 in 2006) per affected residence. Staff feels that this figure may be somewhat low when compared to American States that are often referring to numbers between $25,000- $30,000 U.S. as reasonable figures. The final decision is made by the Province. The MoT policy does have separate guidelines for schools. The policy states that mitigation for schools must be considered if during normal school hours the Leq(1 hr) exceeds 47 dBA. This is an average within 1 hour of time that exceeds 47 dBA.

MoT supports the use of berms, walls or berm/wall combinations. Berms have often been the preferred choice by MoT due to their natural appearance and low cost. MoT limits wall heights to 3m and requires any mitigation to achieve average noise reductions of 5dBA or better.

Another often referred to document locally is the Canada Mortgage and Housing Corporation's (CMHC) book on Road and Rail Noise: Effects on Housing. Specifically, the book outlines acceptable noise levels in certain areas in the house and yard for residential neighbourhoods. Attached as Attachment E, is an excerpt from the book outlining some typical activity noise levels and general reactions to them. The guidelines established in the book are often referenced in noise studies and targeted as acceptable noise levels. Unlike the MoT policy this book establishes maximum acceptable noise levels of road and traffic noise in dwellings and the associated outdoor activity levels. Whereas, MoT bases their needs for abatement on the measured pre and anticipated post construction noise levels, then sets standards based upon the degree of change. Therefore, instances can arise that are viewed as unacceptable by CMHC but would not warrant mitigation under MoT's policy.

In relation to the SFPR development Gateway's impact study to date has identified the Highway 17 South option as having the least impact on residents as it is located further away from the heavier populated areas of Ladner. However, the study does concede that both the construction and operation of the SFPR has the ability to adversely affect residents. The study also suggests that the use of quiet pavement on the South alignment option should mitigate all needs for further mitigation (barriers) in South Delta. North Delta will feel a bigger impact especially during construction than Ladner. This requires close monitoring. The study indicated that further evaluation is needed once more detailed design is provided.

■ CONCLUSION:

Possibly more important than the actual material used, is the design of the barrier and the fit of the barrier with the community and its surroundings. Consideration must also be given to the actual installation cost as well as future maintenance costs of the barrier. All barriers are a compromise between, maintenance, space, cost, aesthetics and safety. In relation to Delta and the future SFPR staff feel that close monitoring of this development is warranted.

Ian Radnidge, P. Eng.,

Director of Engineering
Department submission prepared by: Sean McGill, Manager of Engineering Finance and Administration

■ **ATTACHMENT:**

A. Graphical Representation of Common Sounds
B. Barrier Photographs
C. Indicative Costs for Sound Attenuation Highway 17
D. Graphical Representation of MoT's Noise Policy
E. CMHC Excerpt on Noise Levels

Reference List

Canadian Mortgage and Housing Corporation, 1986. *Road and Rail Noise: Effects on Housing.* Canada.

Federal Highway Administration, 2006. *Highway Traffic Noise.* Prepared for US Department of Transportation, http://www.fhwa.dot.gov/environment/htnoise.htm , Accessed April 19, 2006.

Illinois Department of Transportation, 2006. *Highway Traffic Noise – Abatement Evaluation.* http://www.dotstate.il.us/desenv/noise/part3.html , Accessed April 19, 2006.

Wakefield Acoustics Ltd., 1993. *Revised Policy for Mitigating the Effects of Traffic Noise from Freeways and Expressways.* Prepared for Highway Environment Branch, Ministry of Transportation and Highways. ■