CHAPTER 8

TRAFFIC CALMING

8.1 PURPOSE OF TRAFFIC CALMING

The Institute of Transportation Engineers (ITE) defines traffic calming as a "combination of mainly physical measures that reduce the negative effects of motor vehicle use, alter driver behavior, and improve conditions for non-motorized street users." In simple terms, traffic-calming techniques are typically aimed at lowering vehicle speeds, decreasing truck volumes, and/or reducing the amount of cut-through traffic in a given area. If applied properly, these techniques result in a more pleasant environment for pedestrians and bicyclists.

Some of the most universal goals of traffic calming are as follows:

- Reducing the frequency and severity of accidents.
- Improving the quality of life in residential areas.
- Reducing negative environmental impacts of traffic such as air and noise pollution.
- Promoting walking and bicycling.

Traffic calming measures can also have the following beneficial side effects:

- Reduced need for police enforcement.
- Improved street environment (street scaping).
- Improved water infiltration into the ground.

There are two forms of traffic calming, active and passive. Active measures are described in some detail in the following sections and are usually applied after a street has been constructed to correct a perceived problem with driver behavior. Passive measures are more likely to be included during the initial design of a roadway and include such things as the placement of street trees, medians, narrower lane widths, intersection design, pedestrian bulbs and other safety features, and similar design elements. Active measures are not appropriate for the arterial network as they interfere with the purpose of arterials to move larger volumes of vehicles. However, appropriate use of passive measures may accomplish the purpose of encouraging safer driver, cyclist, or pedestrian behavior without restricting traffic flow. Arterials should be considered in any active traffic calming plan since speeding and cut-through traffic on local streets can be an indicator that the arterial network is not functioning properly. Therefore, improvements to the arterial network may be a more effective solution than active traffic calming on smaller streets.

8.2 HISTORY OF TRAFFIC CALMING

Traffic calming originated in Europe in the 1960's, specifically with the "pedestrianization" of downtown shopping areas in Germany. In the 1970's, the Dutch expanded the concept to include residential streets when they integrated motorized and non-motorized traffic. On the residential blocks, the street served as an extension of the residents' yards, and pedestrians were given priority over automobiles. Obstacles, bends, and bottlenecks were placed at regular intervals to restrict vehicle speeds to a walking pace. Finally, the German philosophy

of area-wide traffic calming emerged, which considers the entire road system in order to avoid merely shifting a problem to another location.

Over the past thirty years, a variety of traffic calming techniques have been applied in numerous European countries. More recently, these strategies have been adopted in Japan, Australia, and North America. In the United States, traffic-calming efforts have occurred throughout the country. In the northwest region, several municipalities have actively pioneered traffic calming, including the communities of Seattle and Bellevue, Washington and Eugene, Oregon. As was the case in Europe, emphasis has shifted from alleviating problems at specific locations to improving neighborhood street systems as a whole. Consequently, traffic-calming programs in the U.S. are sometimes known as Local Area Traffic Management Programs, Neighborhood Traffic Management Programs, or Neighborhood Traffic Control Programs.

8.3 Types of Traffic Calming Measures

Traffic calming measures typically fit into one of six categories: 1) passive measures; 2) deflection; 3) narrowing; 4) diversion and restriction; 5) education and enforcement and 6) signage and pavement markings. Many of the specific techniques within these categories are described below.

8.3.1 Passive Measures

There are several passive techniques that produce a calming effect on traffic. These measures are usually built into the design of the street. Examples of passive forms of traffic calming include tree-lined streets, streets with boulevards separating the sidewalks, streets with raised center medians, on-street parking, highly visible pedestrian crossings, and relatively short building set-back distances. Each of these elements has the tendency to slow vehicle speeds without actually restricting or interfering with the flow of traffic. The best results are usually obtained when two or more of these techniques are used in combination.

8.3.2 Deflection, Narrowing, Diversion, and Restriction

Descriptions of a wide variety of physical traffic calming measures, as well as the advantages and disadvantages of each are presented in the following pages. A general magnitude cost range is shown for a basic installation of each measure. These costs can increase significantly with the addition of irrigation systems and street lighting, or the acquisition of right-of-way. Beautification amenities, such as brick pavers or extensive landscaping, can also dramatically impact project costs.

When implementing these types of physical traffic calming measures, several guidelines should be taken into consideration:

1) attempt less restrictive measures before resorting to road closures and other route modifications;

2) space devices 300 to 500 feet apart in order to restrict speeds to a 20 to 25 mile per hour range; and
3) make the appropriate accommodations for drainage and snow removal, as well as considering the needs of emergency vehicles, pedestrians, and bicyclists. Road closure or obstruction, for example, can often be achieved through the use of traversable barriers that allow for the passage of bicycles, pedestrians, and emergency vehicles.

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8.3.3 Education and Enforcement

The following techniques are designed to raise public awareness of a traffic problem, and change the behaviors that contribute to that problem:

- **Neighborhood Traffic Safety Campaign** - An educational program consisting of meetings, newsletters, etc., with the purpose of informing residents of the neighborhoods' particular traffic issues and outlining safety recommendations. (This technique is not effective for traffic generated outside the neighborhood.)
- **Radar Speed Monitoring Trailer** - A portable trailer equipped to measure and digitally displays vehicle speeds.
- **Neighborhood Speed Watch Program** - A speed-monitoring program in which residents of a neighborhood measure vehicle speeds with a radar unit and record license plate numbers of those exceeding the speed limit. The registered owners are sent letters explaining the safety concerns in the neighborhood and asking them to reduce their speeds.
- **Target Enforcement** - Increased police enforcement of traffic regulations within a designated area.

8.3.4 Signage and Pavement Markings

The installation of traffic control signs and placement of pavement markings constitute the most passive category of traffic calming. Signs indicating speed limits, school crossings, and dead ends can be used where appropriate to slow traffic. Pavement markings used to calm traffic include school crossings and speed limits or other legends. Some specific traffic calming techniques include:

- **Truck Route Signing** - Signs placed along streets at appropriate intervals to designate truck routes or restrict truck traffic.
- **Edge Lines** - Lines painted along the side of the road to narrow traffic lanes and/or provide shoulder space for bicycles.

8.4 VERTICAL DEFLECTION METHODS

8.4.1 Speed Bumps, Humps, Tables, and Cushions:

Speed bumps, humps, tables, and cushions are all design features which are raised above the roadway. The differences between the four types are in their geometry.

Speed bumps are the smallest and are generally 3 to 6 inches high and 1 to 3 feet long. They are typically used in parking lots and low speed residential areas. Speed bumps slow vehicles traveling at slow speeds down to approximately 5 miles per hour. Vehicles traveling at higher speeds may be impacted less by the bumps.

Speed humps are larger than speed bumps and range from 3 to 4 inches high and 10 to 14 feet long. They can be used on streets where a low speed limit is desired. Speed humps generally can slow vehicles down to approximately 15 miles per hour. If traveled over at higher speeds the vehicle will experience a severe jolting effect.

A speed table is a lengthened speed hump with a flat top. Speed tables are typically long enough so that the entire wheelbase of a car rests on the table. The design of speed tables allows for higher speeds than those of speed humps, but creates a smoother ride for larger vehicles. The height of speed tables is similar to speed humps, but the length can vary. A typical 22 foot long speed table has a design speed of approximately 30 miles per hour.

Speed cushions are a series of speed humps installed across the width of the roadway with spaces between them. The spaces are spaced so that emergency vehicles can pass between them without being affected by the bumps. Ordinary cars have smaller axels and will therefore need to travel over the bump with at least one side of their car. Speed cushions have about the same effect on slowing cars down as speed humps do while still allowing emergency vehicles to be unaffected by them.

These traffic calming measures can be placed at spaces ranging from 250 feet to 800 feet to gain a continuous effect on slowing vehicle speeds. If they are placed at distances greater

than 800 feet, there is enough room between them for driver to speed up between the devices which will limit their effectiveness.

It should be noted that speed bumps, as defined herein, should not be used on the public street system, and are more applicable to private roadway facilities, accesses, and parking lots.

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Advantages:

- Slows traffic down
- Increases safety levels
- Decreases traffic volume
- Self-enforcing
- Relatively inexpensive

Disadvantages:

- May promote speeding between them
- May increase volume on other streets
- Difficult to properly construct

Special Considerations:

- Emergency vehicles
- Drainage
- Signage
- Snow Removal

Estimated Cost:

- $1,000 to $8,000

8.4.2 Raised Intersections:

Raised intersections are flat raised areas around the intersection with ramps attaching each approach to the intersection. The ramps and/or the intersection can be made out of a textured or painted material to make them stand out visually. By raising the level of the intersection and the cross walks, the area becomes more noticeable to the driver. This creates a safer environment for pedestrians crossing at the intersection. Raised intersections are ideal in areas with heavy pedestrian traffic and on-street parking that doesn't allow for other measures to be taken.

Advantages:

- Improved safety for vehicles and pedestrians
- Can be visually appealing
- They work for the entire intersection, not just one street
- Better for emergency vehicles than speed humps

Disadvantages:

- Increases turning difficulty
- Increased maintenance
- Requires additional signage
- Less effective at reducing speeds than speed humps and speed tables
- Can be expensive depending on the materials used

Special Considerations:

- Emergency vehicles
- Drainage
- Signage
- Snow Removal

Estimated Cost:

- $4,000 to $12,500 depending on materials used and size of intersection

8.4.3 Raised Crosswalks:

Raised crosswalks are simply speed tables that have crosswalk signage and markings to allow for pedestrians to cross the roadway. The raised level of the crosswalk makes it more visible to the driver and therefore safer for the pedestrians. Raised crosswalks are ideal in locations where there is heavy pedestrian traffic and high vehicle speeds. Raised crosswalks have the advantage of slowing vehicles down who drive over them and alerting vehicles to possible pedestrian traffic in the area.

Advantages:

- Improved safety for vehicles and pedestrians
- Can be visually appealing
- Effective at reducing vehicle speeds
- Makes the crosswalk and pedestrians more visible

Disadvantages:

- May promote speeding between them
- Difficult to properly construct
- May slow down emergency vehicles

Special Considerations:

- Emergency vehicles
- Drainage
- Signage
- Snow Removal

Estimated Cost:

- $2,500 to $8,000

8.4.4 Textured Pavement:

Textured pavement can be created by either stamping the pavement or by using an alternative material like brick or cobblestone. The purpose of both methods is to create a surface that is unpleasant to drive over at high speeds due to the uneven texture of the surface. If driven over at higher speeds the texture will cause a noticeable vibration to the car, much like a rumble strip does. The variation in the surface will also cause an audible difference when driven over. Generally the pavement area that is textured is either painted a different color or the materials used are of a different color. The change in color makes the area standout visually and will alert the driver that caution needs to be taken in the area. Textured pavement creates a space that acts less as a roadway and more like a pedestrian zone causing drivers to take greater care. Warning signs can also be used in conjunction with the textured pavement to increase their effectiveness. Textured pavement can also be used to highlight crosswalks or other areas of interest.

Advantages:

- Can reduce vehicle speeds
- Can increase driver awareness
- Provide visual and physical warnings to the driver
- Can be used to highlight most areas
- Aesthetically pleasing if properly designed

Disadvantages:

- May be difficult for pedestrians and bicyclists
- Can be very expensive depending on material and area covered
- Can add additional noise to the area
- Maintenance issues may arise

Special Considerations:

- Emergency vehicles
- Snow Removal
- Maintenance

Estimated Cost:

- Varies by design

8.4.5 Rumble Strips:

Rumble strips are grooved patterns placed in the pavement perpendicular to the direction of travel. When a vehicle passes over a rumble strip the driver receives an audible warning (rumbling sound) and feels a vibration. Rumble strips are used to alert the driver to use caution in the area or to alert them to changes in traffic characteristics. They can be painted a different color or be made of a different material than the road surface so that they stand out to the driver. This method is commonly used in high speed areas to give the driver advance warning to slow down or about an upcoming intersection.

The FHWA classifies rumbles strips into three types:

- **Shoulder rumble strips (SRS)** are the most common type and are located on the road shoulder of expressways, interstates, parkways, and two-lane rural roadways. They are intended to alert the drive when they encroach onto the shoulder.
- **Centerline rumble strips (CRS)** are located along the centerline of the roadway and are often used on two-lane rural roadways. They alert the driver that they are encroaching into the centerline.
- **Transverse rumble strips (TRS)** are installed on approaches to intersections, toll plazas, horizontal curves, and work zones. They alert the driver that they are approaching an area of concern and that they should use caution.

Advantages:

- Can reduce vehicle speeds
- Can increase driver awareness
- Provide visual and physical warnings to the driver
- Relatively inexpensive

Disadvantages:

- May be difficult for pedestrians and bicyclists
- Can add additional noise to the area
- Maintenance issues may arise

Special Considerations:

- Emergency vehicles
- Snow Removal
- Maintenance

Estimated Cost:

- $1,000 to $5,000

8.5 HORIZONTAL DEFLECTION METHODS

8.5.1 Chicane:

Chicanes are offset curb extensions that form S-shaped curves which cause a deviation in the vehicle's path of travel. They realign the road horizontally to force the driver to alter their path causing them to slow down. Chicanes can also be created by alternating parking between each side of the road. Chicanes can be effective at reducing vehicle speeds without the noise and inconvenience of speed bumps or other methods.

Advantages:

- Can reduce vehicle speeds
- Easily negotiated by emergency vehicles
- Imposes minimal inconvenience on local traffic
- Reduces pedestrian crossing distance
- Can be aesthetically pleasing

Disadvantages:

- May create opportunities for head-on conflicts
- Expensive
- If not designed properly drivers may deviate from their lane
- May lose some on-street parking

Special Considerations:

- Lighting
- Drainage
- Maintenance

Estimated Cost:

- $15,000 to $40,000

8.5.2 Traffic Circles and Roundabouts:

Traffic circles are raised circular islands placed in the center of the intersection about which drivers must navigate around. They cause vehicles to slow down through the intersection because they are forced to make turning movements. They are very effective at slowing vehicle speeds down. Pedestrian safety is also increased due to the decrease in speeds. Large vehicles may have trouble navigating around the traffic circles, especially when making left-hand turns. Traffic circles work well for low volume intersections where speeding is a common problem.

Roundabouts are larger traffic circles with splitter islands and yield signs at each entry way. They are intended for larger intersections with higher traffic volumes. Roundabouts provide refuge areas on the splitter islands which allow crossing pedestrians a place of refuge so that they only have to cross one direction of traffic at a time. Large trucks may have problems navigating around roundabouts, although the use of mountable islands or aprons helps to accommodate larger vehicles.

Roundabouts and traffic circles both slow drivers down and decrease the number of conflict points from the 32 present in a standard four-legged intersection to only 8 in a roundabout or traffic circle. The decrease in speed and number of conflict points has resulted in a reduction of 90% of fatal intersection crashes compared to signalized intersections.

Advantages:

- Vehicle speed reduction
- Increased vehicle and pedestrian safety
- No traffic signals

Disadvantages:

- May be difficult for large trucks to navigate around
- May require additional right-of-way and/or loss of on-street parking
- May cause difficulties for sight impaired pedestrians

Special Considerations:

- Emergency vehicles
- Maintenance
- Large trucks
- Signage

Estimated Cost:

- Varies based on size and materials used

8.5.3 Intersection Realignment:

This method changes the alignment of a standard T-intersection with a straight approach into curving streets that connect at right angles. The previously straight through movement through the intersection becomes a turning movement. The straight through movement through an intersection realignment is a sweeping turn that causes the driver to slow down to take the corner. Intersection realignment is one of the few traffic calming methods available for T-intersections. This method forces drivers to slow down through the intersection which makes for a safer environment for drivers on the side street.

Advantages:

- Good at reducing speeds at T-intersections
- Increases safety for motorists at the intersection
- May provide space for landscaping

Disadvantages:

- Can cause confusion regarding priority movements
- Curb realignment can be costly
- May require additional right-of-way

Special Considerations:

- Lighting
- Signage
- Drainage

Estimated Cost:

- $5,000 to $20,000

8.6 HORIZONTAL NARROWING METHODS

8.6.1 Neckdown:

Neckdowns are curb extensions put in place at intersections. They reduce pedestrian crossing distance while drawing attention to crosswalks. Neckdowns cause vehicles to slow down at intersections and around corners due to the narrower lanes. The most common place for a neckdown is in an area where there is substantial pedestrian traffic and other traffic calming methods would be unacceptable due to noise or other constraints. Neckdowns also create additional area that can be used for landscaping.

Advantages:

- Reduces pedestrian travel distance
- May be aesthetically pleasing
- May slow vehicle speeds down, especially right turns
- Increases awareness of pedestrians
- Easily negotiated by large and emergency vehicles
- Creates protected on-street parking bays

Disadvantages:

- Unfriendly to bicyclists unless they are designed to accommodate them
- Landscaping may cause sight problems
- Doesn't force vehicles to slow down

Special Considerations:

- Lighting
- Signage
- Drainage
- Maintenance
- Bicyclist constraints

Estimated Cost:

- $20,000 to $80,000 for all four corners

8.6.2 Choker:

Chokers are similar to neckdowns but are placed at midblock locations rather than at intersections. They narrow the travel lanes by increasing the length of the sidewalks or by increasing landscape areas. This method creates a narrower roadway section that may cause the driver to slow down. Chokers can be installed so that they only allow for one lane of traffic to pass through at a time. Only allowing for one traffic lane on a two-lane road works well for areas that are prone to significant speeding problems; this method, however, can create problems with head-on conflicts. Chokers also provide protected parking areas and can add additional area for landscaping.

Advantages:

- If used at a crosswalk they can reduce pedestrian travel distances
- May be aesthetically pleasing
- Easily negotiated by large and emergency vehicles
- Create protected on-street parking bays

Disadvantages:

- Effect on vehicle speed is limited
- Unfriendly to bicyclists unless designed to accommodate them
- May need to eliminate some on-street parking

Special Considerations:

- Lighting
- Signage
- Drainage
- Maintenance
- Bicyclist constraints

Estimated Cost:

- $8,000 to $20,000

8.6.3 Center Island Narrowing and Pedestrian Islands:

A center island narrowing is a raised island in the center of the street that narrows the overall width of the travel lanes. When the islands have an opening and allow a crosswalk to go through them they are called pedestrian islands. The islands create a refuge for crossing pedestrians which makes it so that they only have to cross one direction of traffic at a time. This, combined with the islands also increasing visual awareness to the area, can create a safer environment for crossing pedestrians. The installation of the islands may narrow the travel lanes and cause vehicles to deviate from a straight path in order to travel around them. This may force the vehicles to slow down in the area.

Advantages:

- Increases pedestrian safety
- May be aesthetically pleasing
- Provide a refuge for pedestrians
- Possible traffic and vehicle speed reduction

Disadvantages:

- Limited reduction in vehicle speed
- May need to eliminate some on-street parking

Special Considerations:

- Lighting
- Signage
- Drainage
- Maintenance

Estimated Cost:

- $5,000 to $15,000

8.6.4 Angle Point:

Angle points are created by placing offset curb extensions on the side of the road in order to narrow the street and create angled deviations in the path of travel. Angle points cause vehicles to take an S-shaped path through the area in much the same way chicanes do. They are also similar to chokers but are shorter and are offset if installed on both sides of the street. Having to deviate from a straight path causes the driver to slow down and be more alert to the area. Angle points can require additional attention to be paid to the area which allows for safer pedestrian travel. Some designs may allow drivers to cut across and take a straight path through the angle point. This design is advantageous for emergency vehicles as they do not generally need to slow down for these zones.

Advantages:

- Minor inconvenience to drivers
- Shorter crossing distance for pedestrians
- Provide additional spacing for landscaping
- Effective at slowing vehicle speeds when used in series

Disadvantages:

- Unfriendly to bicyclists unless designed to accommodate them
- Causes conflict between opposing drivers arriving simultaneously
- Drivers may deviate from their path to cut through in a straight line
- Limited speed control if not designed properly

Special Considerations:

- Lighting
- Signage
- Drainage
- Maintenance

Estimated Cost:

- $8,000 to $20,000

8.7 DIVERSION AND RESTRICTION METHODS

8.7.1 Half Closures:

Half closures are put in place to block a single lane of traffic. They can be used to prevent vehicles from entering a road but still allow vehicles to exit the road. This is an effective means of limiting traffic on a roadway and also limiting turns off of the intersecting roadway. Half closures are generally made by extending the curb or placing a barrier to block entry. Ample signage must be put into place to alert drivers to the partial closure. Half closures are commonly used in areas where a residential road is experiencing heavy amounts of traffic due to its connection to a main road. Most of this traffic can be attributed to cut-through traffic and can be significantly decreased through the use of half closures.

Advantages:

- Reduces through traffic in one direction
- Allows two-way traffic on the remainder of the street
- Provides space for landscaping
- Two-way bicycle access can be maintained
- Emergency vehicles can drive around barrier if needed

Disadvantages:

- Reduces access for residents or businesses
- May increase trip length
- Increases volumes on other streets
- Drivers may be able to drive around the barrier

Special Considerations:

- Emergency vehicle access
- Signage
- Maintenance

Estimated Cost:

- $10,000 to $40,000

8.7.2 Full Closures:

Full street closures are created by placing barriers at an existing intersection. The full closures can be done to create a dead end or a cul-de-sac style road. An opening or trail can be placed to connect pedestrians and bicycles to the abutting road. The type of barrier used to create the closures can range from a bollard style to a full landscaped closure. A landscaped style is more aesthetically pleasing to the area, but is also much more expensive then placing bollards to stop vehicle traffic. Another method commonly used to create road closures is installing curb extensions to the roadway.

Road closures are very effective at lowering traffic volumes on the roadway. Cut through traffic can be greatly reduced through the use of full closure. It is common to use full closures to limit the amount of traffic on a residential street that was connected to a main street. By closing the connection to the main street, the traffic that previously used the residential street to connect to the main street would diminish thereby decreasing the overall traffic on that road. This does, however, create more traffic on other roads in the area since those vehicles would still have to access the main street via another street.

Advantages:

- Eliminates through traffic
- Improves safety for all street users
- Can still have pedestrian and bicycle access
- Can be aesthetically pleasing

Disadvantages:

- May inhibit emergency vehicles
- Reduces access to properties
- May increase trip lengths
- Increases volumes on other streets
- Can be expensive

Special Considerations:

- Emergency vehicle access
- Signage
- Drainage
- Maintenance

Estimated Cost:

- $15,000 to much higher depending on design

8.7.3 Diagonal Diverters:

Diagonal Diverters consist of a barrier being placed diagonally across a four-legged intersection which interrupts the traffic flow across the intersection. The traffic is diverted away from and is not allowed to drive straight through the intersection. The diverter gets rid of conflict points caused by thru traffic and turning movements within the intersection. They also discourage non-local traffic flow in the area, but still allow for local traffic. This method is effective in areas where there are problems with cut through traffic. The diverter needs to be visible enough to alert the driver to slow down and make the turn.

Advantages:

- Eliminates through traffic and reduces traffic volumes
- Not a full road closure
- Provides space for landscaping
- Reduces traffic conflict points
- Increases pedestrian safety
- Can include bicycle path connection

Disadvantages:

- May be an inconvenience to area businesses or residents
- May inhibit emergency vehicles
- Can be expensive if done as a retrofit
- Cause circuitous routs

Special Considerations:

- Emergency vehicle access
- Lighting
- Signage
- Drainage
- Maintenance

Estimated Cost:

- $10,000 to $80,000

8.7.4 Median Barriers

Median barriers are put in place in the middle of intersections to restrict cut-through movements at a cross street. They also restrict left-turns onto the cross streets from the main street. Putting a median barrier in place will reduce the number of conflict points and therefore increase the safety of the intersection. The barrier can be used as a pedestrian refuge for people wanting to cross the main street. This, along with the reduction in left-turns, increases pedestrian safety at the intersection. Median barriers also reduce traffic volumes on the side streets while increasing the traffic flow on the major street since there will no longer be vehicles stopping to take left-turns at the intersection. This type of barrier can work well in areas where the side street has turned into a popular cut-through street or in areas where there are problems with people stopping to make left-turns. The median barrier does restrict all vehicles, including emergency vehicles. However, the barrier can be designed so that emergency vehicles can travel around them if needed.

Advantages:

- Lowers traffic volumes on the side street
- Provides space for landscaping
- Reduces traffic conflict points and increases safety
- Increases pedestrian safety

Disadvantages:

- May be an inconvenience to area businesses or residents
- May inhibit emergency vehicles
- Require additional street width on the major street

Special Considerations:

- Emergency vehicle access
- Lighting
- Signage
- Drainage
- Maintenance

Estimated Cost:

- $15,000 to $20,000 per 100 feet

8.7.5 Forced Turn Islands:

Forced turn islands are small traffic islands placed at intersections to restrict and channelize turning movements. They are generally put in place to block left-turn and through movements while still allowing for right-turn movements. This method is commonly used where smaller side streets intersect with a larger major street. Heavy left-turn or through traffic off of side streets can cause safety and traffic problems for the area. Restricting the movements from the side streets can increase the safety and traffic levels of the intersection. Forced turn islands are common place for parking lots or similar areas that have multiple entrances and exits. The islands encourage people wanting to turn left or go straight out of the area to use the designated intersections that don't have the forced turn islands; the designated intersections are generally larger safer intersections.

Advantages:

- Provides space for landscaping
- Reduces traffic conflict points and increases safety
- May reduce cut through traffic
- Causes vehicles to use designated intersections

Disadvantages:

- May be an inconvenience to area businesses or residents
- Driver may be able to maneuver around the island
- Diverts traffic to other roads
- May inhibit emergency vehicles
- May increase cornering speeds

Special Considerations:

- Emergency vehicle access
- Lighting
- Signage
- Maintenance

Estimated Cost:

- $4,000 to $8,000

8.7.6 Gateway:

A gateway is an entry treatment to the roadway or surrounding area that creates a sense of passage or change in traffic conditions to the area. Gateways can consist of vertical elements such as posts, trees, bushes, signs, poles, or columns. They can also be formed using curb extensions, changes in pavement color or type, or any other method that creates a sense of entry into an area. Gateways can cause a small reduction in traffic volume because they can make drivers feel uncomfortable about entering the area. A slight speed reduction can also be achieved through the use of narrowing the roadway at the gateway. Safety levels in the area may be increased as well since attention would be drawn to the area.

Advantages:

- May slow vehicle speeds
- Highlights the intersection
- Increased pedestrian safety
- Aesthetically pleasing
- Does not inhibit emergency vehicles
- Possible small volume reduction

Disadvantages:

- Increased maintenance
- May have limited effect
- Can increase the difficulty level to maneuver the area
- Can be very expensive

Special Considerations:

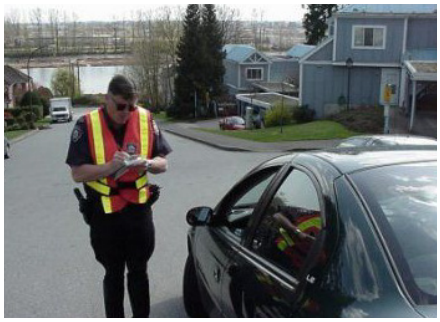
- Lighting
- Signage
- Drainage
- Maintenance

Estimated Cost:

- $4,000 to much higher depending on design

8.8 OTHER CALMING METHODS

8.8.1 Police Enforcement:



Increasing the level of police enforcement on streets that are prone to speeding problems can be an effective way to reduce the number of speeding vehicles. Additional police enforcement can help to discourage drivers from breaking speed limit laws in the area. The speed reduction, however, usually is only reduced for a short period of time or as long as the enforcement is maintained. In order to have a long term effect on speeding, police enforcement must be enforced on a repetitive non-routine basis while having signage and/or brochures in the area to indicate that enforcement will be increased in the area. There can be significant budget and manpower constraints to having continual police enforcement. Using police personnel to enforce speed limits is typically a low priority for police departments. The cost of enforcing speed limits on a continual basis can be unjustifiable.

Advantages:

- Effective at slowing vehicle speeds down
- Widely accepted
- Increases safety level of the area

Disadvantages:

- Requires continual enforcement
- Not of high priority to police departments
- Expensive

Special Considerations:

- Signs
- Continual enforcement

Estimated Cost:

- Varies

8.8.2 Decreased Speed Limits:

Decreasing speed limits in an area prone to speeding is a simple low cost approach to trying to deter drivers from breaking the speed limit. However, the posted speed limit is generally ignored by the driver. Drivers generally travel at speeds they consider reasonable and are often influenced by other drivers in the area. There is usually little to no affect on vehicle speeds by simply lowering the speed limit in the area. To have an effect on vehicles, the lower speed limits must be accompanied by other means of speed control. These other means could be increased law enforcement, speed bumps, or any other method that would help promote lower speeds in the area. Decreasing speed limits in areas such as school zones is common and does tend to have some effect on speeding. The effect can be much higher by using law enforcement to help monitor the area. Outside of a school zone, a speed zone study may be required to make a decreased speed limit enforceable.

Advantages:

- Low cost
- Useful when done in conjunction with other speed control methods
- Useful in areas such as school zones

Disadvantages:

- Little to no effect on vehicle speeds when done alone
- Often times ignored
- Requires additional measures

Special Considerations:

- Signs
- Enforcement
- Maintenance
- May require a speed zone study

Estimated Cost:

- Minimal

8.8.3 Variable Speed Display Board:

Variable speed display boards are commonly placed in areas that are prone to high levels of speeding. The boards display the speed limit for the road to the driver and also have built in speed sensors that detect and display their actual speed. Their current speed is then displayed on the board to alert the driver to how fast they are going compared to the actual speed limit in hopes that they will keep their speeds at or below the speed limit. The board can have a computer on them that can be used to detect what time of day the most number of people are speeding in an area so that additional enforcement can be placed there if needed. The boards basically run themselves and can be powered off of batteries or by solar power. The portable boards work well for moving to different areas where speed is of concern. Permanent boards can also be installed at problematic locations. One concern with these boards is that it may encourage certain groups of drivers to speed if not monitored.

Advantages:

- Widely accepted
- Basically run themselves
- Can save data and be used to determine problem areas and times
- Works as a driver education method
- Portable

Disadvantages:

- May require additional enforcement
- Can encourage speeding of some groups of drivers
- Vandalism may occur
- Limited effectiveness when not used in conjunction with additional enforcement

Special Considerations:

- Signing
- Enforcement level
- Maintenance

Estimated Cost:

- $10,000 to $20,000

8.8.4 Pavement Markings:

Pavement markings can be used for anything from on-street parking, to accentuating already existing features, to creating new features. Using pavement markings to indicate areas where on-street parking would occur creates a safer parking environment and also directs traffic in the area. A slight speed reduction may occur if the travel lanes are narrowed due to the markings. When pavement markings are used to accentuate already existing features, they can make the features look bigger and give advanced warning about them. Pavement markings can also be used to create turning lanes and to direct traffic flow without having to use expensive medians or curbs.

Pavement markings are generally not overly effective on vehicle speed reduction unless they create the impression of a narrowed roadway. While pavement markings don't force drivers to act, they do give them guidance on how to act.

Advantages:

- Inexpensive
- Can accentuate already existing features
- Can help create areas of caution
- Gives guidance to the drives

Disadvantages:

- Limited effect on vehicle speed reduction
- Must be maintained
- Not easily visible under snow or water

Special Considerations:

- Maintenance
- Signage
- Visibility

Estimated Cost:

- Varies

8.9 COUNTY SPECIFIC TRAFFIC CALMING

Implementing traffic calming measures along county roadways can be a challenging task. Techniques that work along high-volume low-speed city roadways may not work along rural routes. Special care must be given to the type of traffic calming measures installed along rural routes. For instance, installing speed bumps along a straight road with a high design speed may cause vehicles to slow down to cross the bumps, however they may also cause an increase speeding between the bumps to make up for lost time.

A list of suggested traffic calming measures for rural routes along with a short description of each is found below:

- **Transverse Rumble Strips** are perpendicular groves cut into the roadway that provide an audible sound and vibration that is felt inside the vehicle. They are used to alert the driver to use caution in the area or to alert them of changes in the traffic characteristics. Transverse rumble strips are often installed to warn the driver about approaches to intersections or of an upcoming crosswalk. See **Section 8.4.5** for more detail on rumble strips.

- **Decreased Speed Limits** are commonly used in areas such as school zones. Decreasing speed limits in school zones is common and does tend to have some effect on speeding. However, it is recommended that other speed control measures be used in conjunction with decreased speed limits to have the maximum effect. Simply reducing the speed limit, especially outside of school zones, may have little effect on speeding vehicles when used alone. See **Section 8.8.2** for more information on decreased speed limits.

- **Variable Speed Display Boards** can be used to help deter speeding. These boards display the posted speed limit and the actual speed of the driver. The boards can be equipped with computers that keep track of the speeds of vehicles so that it can be determined what time of day there is the highest rate of speeding. These boards are generally most effective when used with other speed control measures, such as increased police enforcement. Using the variable speed display boards alone generally has an initial effect on speeding vehicles; although this tends to diminish the longer the signs are in place. See **Section 8.8.3** for more information on variable speed display boards.

- **Pavement Markings** can be used to call attention to already existing features or can be used to create new features. Pavement marking can be used to create on-street parking or bike lanes or they can be used to make a visually narrower lane. They can also be used to call attention to existing features making them look bigger or give advanced warning about them. Pavement markings can also be used to alert the driver to change their driving behavior. Messages such as "SLOW" or "SCHOOL ZONE" can be placed on the roadway to let the driver know they are entering an area with changing traffic characteristics. Generally pavement markings and signage are

used in conjunction to have the maximum effect. See **Section 8.8.4** for more information on pavement markings.

- **Signs** indicating speed limits, school crossings, school zones, or ones warning about curves or approaching intersections can be used where appropriate to help aid in traffic calming. Signs can help provide warning to changes in the traffic characteristics of the roadway. Installing signs, however, does not guarantee compliance; they merely help aid the driver in their decision making process. They should generally be used to call attention to existing features or changing conditions.

8.10 Incorporating Traffic Calming in New Street Designs

Roadway designs for new development should be appropriate for the intended function of each street or street segment. Those designed to function as part of the major street system (major collectors and arterials), should be designed primarily to move traffic in as efficient, convenient, and safe a manner as possible. Local streets and residential collectors, on the other hand, should be designed to provide access to properties while discouraging through-traffic and higher travel speeds that often accompany it. As a result, new developments should include traffic calming strategies to reinforce the appropriate functions of local streets. These would include layout and connectivity of street systems and pedestrian/bicycle facilities, intersection treatments, and basic design standards for width, curvature, parking, and landscaping. Specific traffic calming features which are easily incorporated into the design phase include: gateway treatments; street narrowing; short block lengths; small corner radii; surface valley gutters; "T" intersections; roundabouts; and landscaping to create a "closed-in" environment.

Traffic calming design characteristics should be incorporated into the City's development review and annexation review processes. Proposed developments or requests to annex would be reviewed by staff to determine whether or not traffic-calming improvements are appropriate for any given location, what strategies are best suited, and what design details are appropriate. The process should be designed to pro-actively assist developers in utilizing traffic strategies to improve quality of life in their developments, while minimizing or eliminating costs for retrofit efforts. Because of the long-term effects of original roadway layout and construction, the City may wish to coordinate with the County to incorporate traffic calming into its development review process.

8.10.1 Multi-Jurisdictional Cooperation

In some cases, traffic problems may be located near a City/County line, or may be caused by conditions outside the City limits, such as on the State highway system or at the State complex. For these reasons, it is desirable for the City to have cooperative agreements with the County and the State government. Cooperative agreements would enable this process to cross jurisdictional boundaries. Other agencies would take an active role in the traffic calming process and participate in financing permanent solutions when deemed appropriate.

8.11 TRAFFIC CALMING PROGRAM SUMMARY

The Traffic Calming Program for the greater Bozeman area should provide a regular and ongoing opportunity for neighborhoods to nominate, test, and implement improvements to address problems with the local street network. The process should be standardized to minimize administrative effort and cost, while ensuring that improvements are necessary, effective and safe. The process should be repeated as necessary to ensure that resident concerns are addressed with reasonable timeliness, and that projects are advanced in an orderly and efficient manner. Sample forms necessary throughout this procedure are included in the Appendix for easy access by the public.

Traffic calming is a physical construction designed to reinforce the perceived need for caution by the user of the transportation system. The primary responsibility for safe use of the streets lies with the individual driver, cyclist, or pedestrian. The need for physical traffic calming devices indicates a consistent occurrence of failure by the transportation user to appropriately interact with their surroundings.

It is likely that the large majority of traffic calming issues will focus on traffic problems that occur within the city limits. Therefore, this program has been developed with the City in mind. It is also very possible that similar problems will arise within the County jurisdiction. In those cases the same program should be implemented with the County, assuming the same role applies as that described for the city.

Traffic calming projects depend on the strong support by residents in the immediate area. Traffic calming methods should also be used only to address real, rather than perceived, problems. For these and other related reasons, traffic calming projects should meet several criteria before being considered for implementation.

The Traffic Calming Program is a three-phase process consisting of 12 individual steps. The main activities of each of the phases are as follows: Phase I) identification and verification of a traffic problem; Phase II) selection and implementation of educational activities and enforcement techniques; and Phase III) selection and implementation of physical traffic calming measures. Each phase requires the participation of the neighborhood residents, the City, and the City Engineering Department.

In the first phase, the residents are responsible for contacting the City, identifying their concerns, and submitting a project application. At this point the City Engineer will make initial contacts with the residents, and conduct informal meetings to better understand the nature of the problem. The City Engineer will then perform preliminary studies to validate the perceived problem, and determine whether or not the process should advance.

During Phase II, the City Engineer will facilitate a neighborhood meeting at which the City will present a range of appropriate educational activities and enforcement alternatives. The City Engineer will work with the neighborhood residents to identify a preferred solution. The residents will then be responsible for circulating a petition and fostering support for the identified solution. Phase III responsibilities will be divided similarly to those in Phase II,

although the solutions being discussed at this point will be applicable physical devices. When a permanent solution is selected, the City Engineer will determine the appropriate funding sources based on the nature of the problem. Traffic calming projects will be financed on a case-by-case basis. Residents should expect to pay some portion of the cost of installing permanent traffic calming devices in their neighborhood.

8.12 TRAFFIC CALMING PROGRAM FOR EXISTING STREETS

The following is a sample three-phase procedure for implementing traffic calming measures on existing facilities. In order to accommodate seasonal changes, special events or any other irregular circumstances, the process may be altered or accelerated at the discretion of the City Engineer. The City's traffic calming program for existing streets is intended for application to local streets only.

TCC #10

8.12.1 Phase I

Step 1: A Citizen contacts the City Engineering Department about a traffic problem. The City Engineer responds by sending the Citizen information about the Traffic Calming Program and an Investigation Request Form.

Step 2: The Citizen completes the "Investigation Request Form" and returns it to the City Engineer. The form should include a description of the problem and location, as well as the signatures of 10 other neighborhood residents from separate households who agree that the problem exists. A Neighborhood Contact is also identified on the form. After receipt of the form, the City Engineer contacts neighborhood residents to discuss the nature of the perceived problem. The information gathered in this step helps determine the types of studies needed to be performed in Step 3.

Step 3: The City Engineer conducts a field review of the location, and collects the appropriate data in order to determine whether or not the perceived problem actually exists. In most cases, accident records should be reviewed, and traffic volumes measured. Depending upon the nature of the complaint, a speed study, truck count, or cut-through study may also be appropriate. In order to be considered for a traffic calming project, the location must have traffic volumes of at least 800 vehicles per day. It must meet at least one of the following criteria: three or more accidents in a 12-month period; an 85th percentile speed that is at least five (5) miles per hour over the posted speed limit; or truck volumes exceeding 10 percent of the total traffic volume.

After the field data is collected and reviewed, the City Engineer informs the Neighborhood Contact of the results. If the location does not meet the above criteria, the City Engineer meets with neighborhood residents to review the study results and discuss other options. At this point, the Traffic Calming Program is concluded. If the problem location meets the

required criteria, the City Engineer reviews the Phase II process with the Neighborhood Contact.

8.12.2 Phase II

Step 4: The City Engineer determines the boundaries of the affected neighborhood. Neighborhood boundaries will typically follow arterial streets or other natural breaks. The City Engineer schedules a neighborhood meeting to discuss possible Phase II solutions to the problem. The City Engineer gives the Neighborhood Contact a map of the designated boundaries so he/she can inform area residents of the meeting. At the meeting, the City Engineer presents a range of appropriate measures. Potential Phase II measures will emphasize the least intrusive measures, consisting of enforcement, educational activities, and/or minor physical changes (brush trimming, and sign or pavement marking installation).

Step 5: The Neighborhood Contact circulates a Phase II Petition within the defined boundaries. The petition identifies the proposed education and enforcement techniques, and asks residents to indicate their approval. If the petition is not signed by 40 percent of the property owners within the defined neighborhood, the process is terminated. If the petition is signed by at least 40 percent of the property owners, the City and/or Neighborhood will then implement the Phase II measures.

Step 6: Approximately 90 days after implementation of the Phase II measures, the City repeats the data collection efforts. (This 90-day period may be modified by the City to accommodate seasonal conditions and other factors.) If the problem has been resolved, the education and enforcement activities can be tapered off and the process concluded. If the situation arises again at a later date, as confirmed by data, the process can begin again at Step 6.

8.12.3 Phase III

Step 7: If the traffic problem has not been resolved by the Phase II measures, the City Engineer conducts an engineering study to determine a range of appropriate physical improvements to the location. Initially, less restrictive measures such as vertical or horizontal deflection of the roadway are preferable to roadway obstruction techniques.

Step 8: The City Engineer schedules a neighborhood meeting to review the Phase III improvement options. The Neighborhood Contact is responsible for notifying area residents about the meeting. The City Engineer facilitates the neighborhood meeting. Based on resident input, a preferred solution is selected from the range of possible solutions. If a temporary version of this traffic-calming device is not practical, proceed to Step 11.

Step 9: If a temporary traffic-calming device is suitable, the Neighborhood Contact circulates a Phase III Petition for Temporary Measures. The process ends if the

petition is not signed by 50 percent of the property owners within the defined boundaries. If at least 50 percent of the property owners sign the petition, the City constructs a temporary version of the preferred traffic-calming device.

Step 10: After one year, the City repeats the data collection process to determine whether or not the temporary device is effective. If it is found to not be effective, the City Engineer notifies the Neighborhood Contact, and the device is removed. The process can then be repeated from Step 7.

Step 11: If the temporary device is effective, the City Engineer develops a preliminary design and cost estimate for a permanent traffic calming device(s), and determines who will finance the permanent solution. The City then provides Neighborhood Contact with this information and indicates that the area property owners are receptive to a Petition for Permanent Measures.

Step 12: The Neighborhood Contact circulates a Phase III Petition for Permanent Measures, which includes a copy of the preliminary design and cost estimate, as well as an explanation of financial responsibility. If the petition is not signed by 70 percent of the area property owners, the process is terminated and any temporary devices removed. If at least 70 percent of the property owners sign the petition, the City Engineer performs a final design, and constructs a permanent traffic-calming device.

There are numerous points at which the traffic calming implementation process can be terminated due to lack of neighborhood support. Should neighborhood sentiment change at a later date, the process may be resumed at the same step where it left off.

8.12.4 Project Costs

Traffic problems on existing streets are usually caused by one of the following situations: poor initial street design; inadequacy of the major street network; or commercial and/or residential development adjacent to the neighborhood. The cost of financing traffic calming projects to resolve such problems should be distributed accordingly. As part of the initial investigation, the nature and cause of the traffic problem will be identified. The City will use this information to determine the appropriate division of project costs and identify who (the City, neighborhood residents, developers, other parties) may be involved in paying for the traffic calming measures.

The costs of Steps 1 through 11 will be borne by the City. Permanent Phase III construction (Step 12) will be financed by some combination of neighborhood contributions, development fees, and funds from other sources.

8.12.5 Removal of Permanent Traffic Calming Devices

Refer to the local policy for removal of a permanent traffic calming device. The neighborhood residents will be responsible for paying the cost of removing traffic calming devices.